Indigenous Knowledge Applications in small-scale Shrimp Farming, Profitability Analysis and Challenges in Achieving SDGs: A Study on South-western Part of Bangladesh

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ABSTRACT

This study attempts to identify the application of indigenous knowledge of shrimp farmers that has passed through generations. In each step of the shrimp production process, such as pond preparation, seed selection, water management, disease management, feeding practices, and harvesting techniques, farmers use indigenous knowledge from one generation to another to gain sustainability. Knowledge is orally transmitted through imitation and demonstration. This study also examines the profitability of small-scale (land size less than 250 decimals or 7.5 bighas) shrimp farming in the Tala subdistrict of Satkhira district. Farmers try to minimize the cost of production and maximize profits. The primary data were collected through interviews with shrimp farmers and focus group discussions. The total number of respondents in the interviews was 35, with 10 farmers in a group discussion. The study found that shrimp farming is financially profitable (per bigha) in the study area. We obtain the mean net revenue per bigha as 1162.71 tk. The challenges in achieving the SDGs for the local community of shrimp farmers were also identified in our study. The challenges include poverty eradication, lack of quality education, gender inequality, and substantial environmental damage.

Keywords: Indigenous knowledge, Shrimp, Profitability, SDGs, Challenges.

INTRODUCTION

'Indigenous knowledge' is considered as the social capital of the farmer. Due to the unavailability of modern technology, Bangladeshi farmers follow the traditional method of shrimp farming and use their indigenous knowledge. These traditional methods typically do not entail pond preparation, liming, fertilization, predator control, or artificial feeding. Consequently, productivity is low, water exchange is irregular, and water management is poor. The steps of shrimp cultivation are as follows. First, farmers prepare ponds to release fry. Subsequently, they collect fries from Mokam (Fry market), buy fries, and release them as soon as possible. They grow shrimp by laboring, feeding, and monitoring the farms. Then, they send shrimp to the market for sale, and brokers buy them and send them to local markets and fish processing companies. Finally, fish-processing companies sell these products in global markets. Farmers follow these production steps from generation to generation and earn their livelihoods from year to year.

There are some advantages in terms of land use and improvements in protein production and export earnings

of shrimp production in Bangladesh; therefore, it is one of the fastest-growing fishery industries. Shrimps are considered one of the most important commodities in the global fishery trade (Bhaskar et al., 1995). In the world market, they command a leading position by virtue of their increasing demand and competitive international prices. Because it offered a huge immediate economic return, shrimp farming showed a booming expansion and soon became a million-dollar industry (Islam et al. 2004a, b). Owing to the auspicious climate and availability of space, shrimp aquaculture has developed mainly in tropical and subtropical coastal lowlands, especially in the southwestern part of Bangladesh. Khulna, Bagerhat and Satkhira districts are the main areas, which is suitable for shrimp production. In particular, Bagda (English name: Black tiger) and Golda (English name: Freshwater Prawn) have gained a lot of demand worldwide. The study area, named the Tala subdistrict of Satkhira district, is located at 22.7500°N 89.2500°E and has a total area of 344.15 km2. (Wikipedia). A large number of farms produce shrimp because of the availability of land and brackish water, favorable climate and soil conditions, and geographical location.

LITERATURE REVIEW

Chowdhury and Khairun (2014) studied "farmers' local knowledge of extensive shrimp farming systems in coastal Bangladesh". They found that shrimp farmers in the area were farming by using their indigenous knowledge, which they have achieved many years of history of traditional culture. In our study area, we also found that farmers used their indigenous knowledge to produce shrimp, and the production process was traditional.

Shawon et al, (2018) conducted a study on the production of shrimp where they considered shrimp as a part of the blue Revolution for the geographic features of the southwest coastal area. This study aimed to determine the socioeconomic status and financial profitability of small-scale shrimp farming in the coastal areas of Bangladesh. Financial profitability has been measured from various perspectives. They found that small-scale shrimp farming was profitable. The benefit-cost ratio, gross profit margin, net profit margin, and break-even point indicate that small-scale shrimp farming is profitable in the study area. They suggested that small-scale shrimp farmers should continue their business and not lease their land to large farmers. They also concluded that a large number of farmers were in the prime age group. The study revealed that the family size of the farmers was medium (65%), and the main occupation of shrimp farmers was 40%.

Rahman and Rakibuzzaman, (2021) found that traditional knowledge across the world plays a unique and important role in conserving our earth, ecosystem, biodiversity, and climate change adaption as well as protecting our own cultural heritage by which one particular community can enable resilient their livelihood.

Rahman (2018) conducted a study on the socio-cultural life of folksongs on Kutubdi Island. The analysis and the results of this study prove that even though research is insufficient regarding the coastal culture and life scenario of the common people, they have an enriched tradition and heritage.

Gazi (2019) studied the problems and prospects of shrimp cultivators in the coastal area of Bangladesh. This study has been conducted in three districts, named Bagerhat, Khulna, and Shatkhira districts of Bangladesh. A total of 200 respondents who had been cultivating shrimp were selected randomly for many years. This study concentrated on problems that disrupt the shrimp culture and solutions in specific areas of shrimp farmers, but the whole problem of shrimp farming has not been included in this study. This study has identified that shrimp cultivators are facing problems that are eroding the benefits of shrimp culture, including shrimp fry remaining sick, higher price of shrimp fry, infection of virus, pollution of water, lower price during the sale of shrimp, high price of feed, lack of proper transportation system, traditional process of shrimp culture, and lack of monitoring bodies of culture.

Several studies have been conducted on shrimp production and cultivation. These cover various areas of shrimp production. However, studies related to indigenous knowledge of farmers and the profitability of

farmers are few.

Research objectives

The specific objectives of this study are as follows:

1) Analyze the application of indigenous knowledge of shrimp farmers for sustainability in the study area.

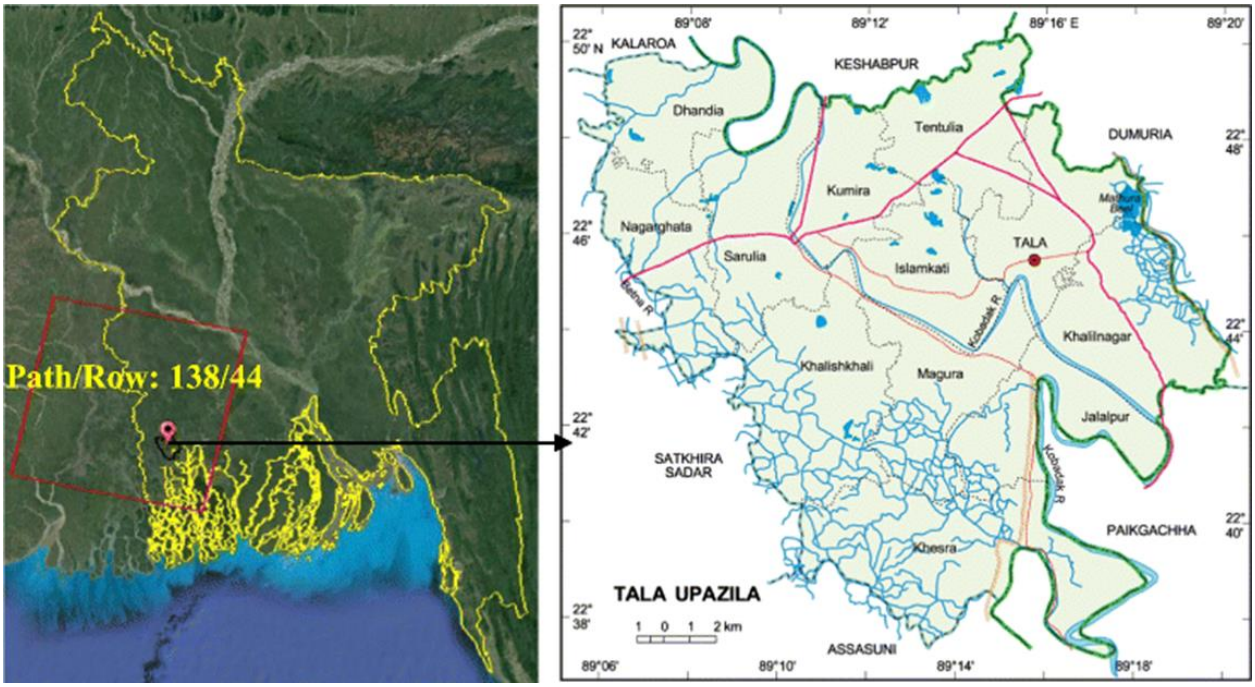
2) Assess the profitability of shrimp production and factors that affect the profitability of shrimp production in the study area.

3) Challenges in achieving SDGs for the shrimp farmers' local community

MATERIALS AND METHOD

Because of the auspicious climate and availability of space, shrimp aquaculture has developed mainly in tropical and subtropical coastal lowlands, especially in southwestern Bangladesh.

Figure 1: Geographical location of the study area



Two types of shrimp have been cultivated in this study area:

1) Brackish water shrimp: Three species of brackish water shrimp are cultivated here. Such as:

1. Bagda (*Penaeus monodon*)
2. Chaka (*Penaeus indicus*)
3. Horina (*Metapeneus monoceros*)

2) Freshwater shrimp: Only one kind of freshwater shrimp cultivated here is Golda (*Macrobrachium rosenberhii*).

Farmers in the study area use their indigenous knowledge to produce shrimp. By incorporating traditional methods, using little or no technology, they have been producing shrimp for approximately 50 years.

Through these production activities, they earn money and maintain their families. A large number of small-scale shrimp cultivations are available.

All twelve unions of the Tala subdistrict have purposively selected for the study because shrimp cultivation occurs there more or less. It is not possible to conduct a survey of all producers due to time and resource limitations. A total of 35 producers havebeen selected for the interviews. Data are collected using a structured questionnaire through interviews conducted in October 2022.This studyuses both qualitative and quantitative data. Through focus group discussions, we havelearned about the application of indigenous knowledge to shrimp farmers.

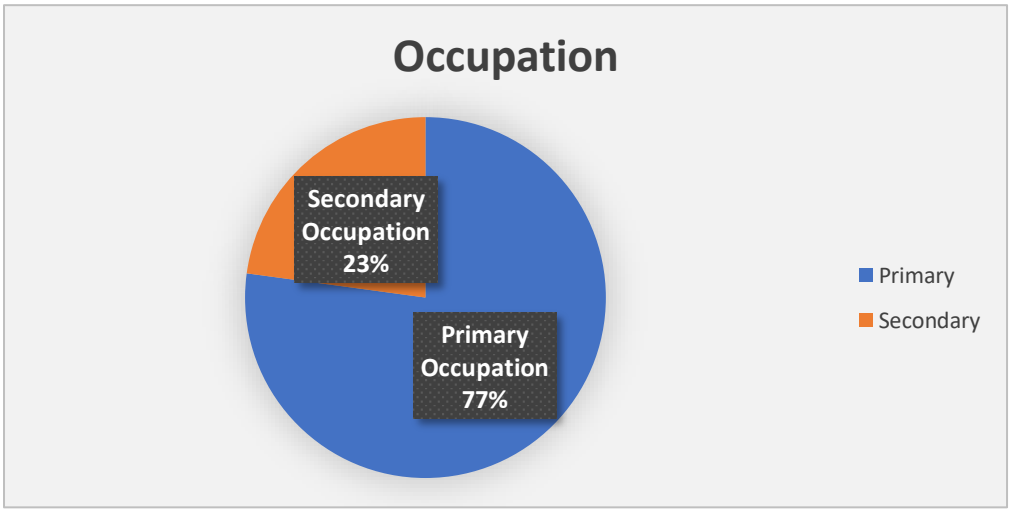
Table 1: Number of respondents.

Union	**Respondents**
Sadar (Tala)	5
Jalalpur	3
Nagarghata	2
Kumira	3
Islamkati	3
Sarulia	3
Dhandia	2
Khalishkhali	3
Magura	3
Tetulia	2
Kheshra	2
Khalilnagar	3

The study also uses secondary data collected from related articles, books, journals, and economic reviews.

The figure below shows the occupational distribution of the respondents. 77% of the respondents' primary occupation is shrimp farming, and the remaining respondents' secondary occupation is shrimp farming. Therefore, most of the farmers maintain their families by cultivating shrimp.

Figure 2: Occupational distribution of the respondents



Source: Field survey

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The study finds profitability or net revenue using the following formula: Net revenue is the difference between total revenue and total cost.

NR=TR-TC…..... (1)

Where, NR=Net revenue

TR=Total revenue

TC=Total cost

Total revenue is the monetary value of the total final output of the production of shrimp. It is expressed as follows: –

TR=P*R…..... (2)

Where P= Price

Q= Quantity

Production cost is the cost incurred in various stages of cultivation of shrimp.

TC=TFC+TVC…..... (3)

Where, TC=Total cost

TFC=Total Fixed Cost

TVC=Total Variable Cost

To identify the factors that affect the value accruing to the shrimp farmers a multiple regression model has been run. The dependent variable in this case is considered as the net revenue. A number of explanatory variables are identified and included in the model consisting of both the socio-economic characteristics of the respondents and the various inputs employed in the shrimp cultivation.

Generally, a multiple regression model with k independent variables can be stated as:

$Y=B_0+B_1X_1+B_2X_2+B_3X_3+B_4X_4+ui$

X_1=age

X_2=experience

X_3=firm size

X_4= Total Variable Cost

X_5=Total Fixed Cost

Where the X_1, X_2, X_3, X_4, and X_5 are the explanatory variables and the Bs are partial regression coefficients showing partial effects.

The empirical model specification is done in our case as the dependent variable is considered as the net

revenue and the explanatory variables are the age, experience, firm size, total variable cost, and total fixed cost.

To ensure the regression model is correctly specified and in line with the assumptions of Ordinary Least Square (OLS), a number of regression diagnoses were conducted.

A multicollinearity test is also done to ensure that the assumption of no correlation between variables is not violated.

RESULTS AND FINDINGS

In this section, we will discuss different variables alone with their tabulation and also, we present graphically.

Table 2 shows the age distribution of the respondents. One respondent isaged between 21 to 24 years. Five respondents are aged fall between 25 to 32. Between the 33 to 39 range, 15 respondents are found. This interval has the highest frequency. Five respondents areaged between 40 to 47. And 8 and 1 respondents are in the age category 48 to 54 and 55 to 62 respectively. The highest percentage of respondents falls between the age interval 33 to 39 which is 42.9%. The lowest percentage falls between the ages 21 to 24 and 55 to 62 which is 2.9%. So, the maximum number of farmers are in the middle age group.

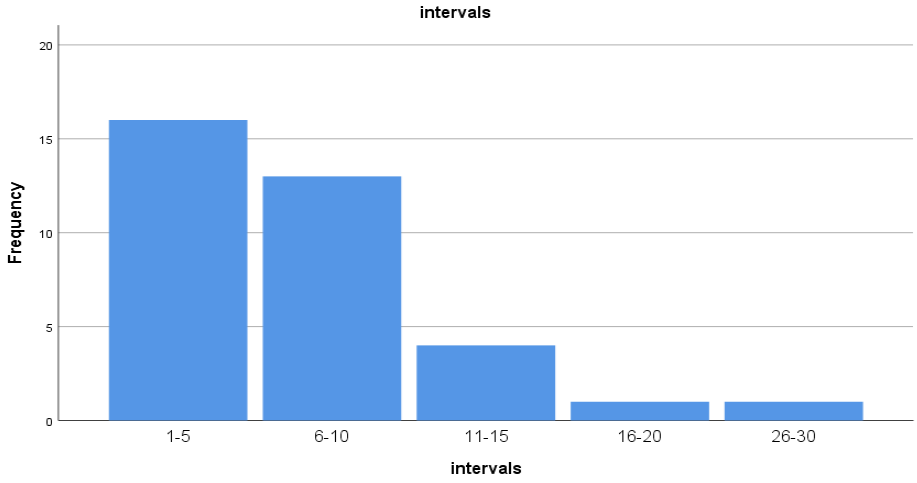
Table 2: Land characteristics of the respondents

Land characteristics	Percentage
Own	65
Lease	35
Total	100

Source: Field survey

The above table shows the characteristics of land used by respondent shrimp farmers. We can see 65% of the respondent uses their own land. We can also see 35% of the respondent uses leased land. So, the highest percentage of respondents use their own land. Most of the small-scale shrimp farmers use their own land to cultivate shrimp, as a result, they have no lease in cost.

Figure 3: Year of experience in shrimp farming of the respondent



Source: Field survey

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The above figure shows the Year of experience in shrimp farming of the respondent. From this bar diagram, we can see the highest 16 respondents have experience of 1 to 5 years of shrimp farming.

Farmers' Indigenous knowledge for sustainability

Indigenous knowledge is considered the social capital of the farmer. It is their main asset to invest in the struggle for survival, to produce food, to provide shelter, and to achieve control of their own lives (Senanayake, 2006). On the other hand, sustainability is not an old concept. Indigenous peoples have practiced elements of sustainable living for generations by being in tune with the natural environment and its limits, cycles, and changes. This understanding is usually referred to as traditional ecological knowledge, or the deep knowledge and beliefs about relationships between people, plants, animals, natural phenomena, landscapes, and the timing of events in a specific ecosystem. Indigenous peoples have long been adept at sustainable living due to their awareness of the natural world's boundaries, cycles, and changes. Traditional ecological knowledge, also known as the profound knowledge and beliefs about the interactions between people, animals, plants, and natural phenomena as well as about landscapes and the timing of events in a particular ecosystem, is the term most often used to describe this understanding. The application of indigenous knowledge in my study area is described below:

1. **Pond Preparation**: The farmers use their indigenous knowledge to prepare shrimp ponds. They understand the variations of seasons, quality of water, and ecological condition of water, allowing them to make informed decisions about stocking density, feed management, and water exchange. By laboring himself or employing labors the farmers prepare ponds. However poor pond preparation leads to a small amount of production.

Figure 4: A pond of a shrimp farm

Source: Field survey

2. **Seed Selection**: Indigenous knowledge guides farmers in selecting the right species whether the pond is *Penaeus monodon* or *Metapeneus monoceros* and sources for shrimp seeds. Territorial adaptability, disease resistance, and growth potential are the important factors of their seed selection. Sometimes

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improper seed selection reduces profit. Seed should be selected based on the ambience of the pond.

3. **Water Arrangement:** Farmers' local knowledge helps them to manage water quality in the ponds. This includes managing salinity levels, maintaining oxygen levels, and controlling disease outbreaks. Scientific measures are not undertaken in this case. As a result, the production of shrimp falls. For example, the oxygen level of water can fall due to poor water management.
4. **Disease Control:** To identify common shrimp diseases and to treat them, farmers' indigenous knowledge plays an important role. Modern treatment measures are also used to prevent diseases. Yellowhead viral disease, white spot syndrome, and Black gill are the diseases shrimps are affected mostly. According to collected data about 95% of the shrimps are affected by white spot syndrome. But sometimes traditional preventive measures lead to reduce production of the shrimps.
5. **Feeding Practices:** Farmers follow specific feeding practices based on their local knowledge. Farmers use locally available feed sources effectively by incorporating indigenous knowledge. Traditional feeding practices often spoil the pond's water. Consequently, the profitability of farmers and the production of shrimp decreases.
6. **Harvesting Techniques:** Local knowledge is applied in determining the best time for shrimp harvesting. This knowledge considers factors like the growth of shrimp, demand of the market, conditions of weather, and availability of transportation.

Figure 5: Harvesting of shrimps

Source: Collected

7. **Community-Based Practices:** Farmers learn from one another and pass down indigenous knowledge through generations. So local communities are fully informed about the production process, marketing process, and pricing process through generations.
8. **Environmental Sustainability:** Indigenous knowledge is important for attaining sustainability, but it should be monitored with scientific research and modern techniques to ensure the long-term sustainability of shrimp production and minimize negative environmental impacts. For example, water salinity rises in my study area because of the production of shrimp year after year. So modern technological measures should be implemented to cope with negative impacts on the environment.

Profitability analysis

For calculating the net revenue first of all we calculate the total revenue producer per bigha. Then we calculate the total cost of the producer per bigha. Finally, we calculate net revenue by subtracting total cost from total revenue. Here we consider 35 respondents' total cost, total revenue, and net revenue.

The below table shows the variable cost items per bigha of shrimp production.

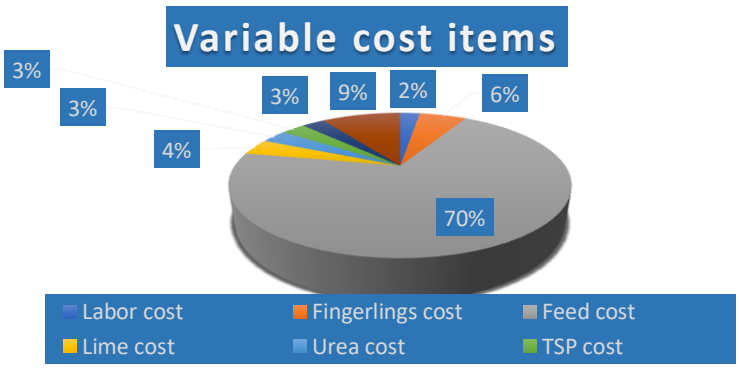
Table 3: Variable cost items

Inputs	Maximum	Minimum	Mean	Standard deviation
Fingerlings cost	1800	500	1065.71	297.423
Feed cost	18600	700	12862.86	3461.327
Lime cost	900	400	671.09	134.220
TSP cost	800	150	520.34	155.006
Manure cost	900	200	509.29	130.057
Miscellaneous cost	2500	1000	1768.57	443.098
Labor cost	900	0	443.14	304.329
Urea cost	800	375	565.71	177.430

Source: Field survey

The table shows the highest mean cost from all variable cost items is feed cost (12862.86 tk per bigha) and the maximum feed cost is 18600 tk per bigha. The standard deviation of feed cost is the highest which means it varied mostly from farmer to farmer because of their land size and number of shrimps. The minimum labor cost we have found is 0. Because the farmers labor on their own farms.

Figure 6: Variable cost items



Source: Field survey

The above figure shows the variable cost items 70%. So, the feed cost item is affected by the total variable cost mostly. Other variable cost items and feed costs aggregately affect the net revenue of the farm. The following table shows the minimum value, maximum value, mean value, and standard deviation of total cost, total revenue, and net revenue.

Table 4: Net revenue per bigha (35 shrimp farms) of shrimp production

	Minimum	Maximum	Mean	Standard deviation
Total revenue	17750	51750	37489.43	10593.490
Total cost	15100	53200	36326.71	9000.232
Net Revenue	-26700	16900	1162.71	9846.477

Source: Field survey

The table shows the mean net revenue per bigha is 1162.71 tk. So, shrimp farming is a profitable enterprise in the study area. The maximum and minimum net revenue is 16900 and -26700 tk. per bigha respectively. The study found the mean net revenue is 1162.71 per bigha. So, shrimp farming is financially profitable.

To assess the factors that affect the net revenue of a shrimp farm a regression analysis is conducted here. Here assume that net revenue is a dependent variable and age, experience, farm size, Experience, total variable cost, and total fixed cost and independent variables.

Variables	Standardized coefficient beta	t	Sig.
(constant)		1.428	.164
Age	.101	.535	.597
Farm size	.274	1.191	.243
Experience	.025	.137	.892
TVC	-.149	-.791	.435
TFC	-.475	- 2.019	.053

Dependent Variable: Net revenue

R-squared= .197

Adjusted R-squared= .059

A multiple regression test is conducted to analyze the relationship between the dependent variable (net revenue) and explanatory variable (Age, total variable cost=TVC, total fixed cost=TFC, firm size, experience=Exp).

Here, R-squared= .197 which is the multiple coefficient of determination that shows the goodness of fit or how well the theoretical observation fits the empirical observation.

The regression analysis finds the regression coefficient of total fixed cost (- 0.475) is negative. It indicates that a 1 unit increase in the cost of total fixed cost keeping other factors constant, will decrease gross returns by 0.475 units and only this variable is statistically significant. The analysis also finds that age, experience, and farm size are positively related to net revenue. The total variable cost has a negative impact on net revenue and is statistically insignificant.

Challenges in achieving SDGs for the shrimp farmers' local community

The United Nations Sustainable Development Goals identify 17 different goal categories and demonstrate a breadth of topics where sustainability can be applied. Now we analyze the goals that are related to our findings.

1) Poverty alleviation: The first goal of SDGs is to "End poverty in all its forms everywhere". We find the mean net revenue per bigha of a farmer is 1162.71 tk. This income is sufficient for maintaining their and their families' basic needs. But the living standard of the farmers is very low.

2) Formal education: We find 60% of the farmers have 0 to 5 years of schooling. About 37.1% of the farmers have secondary-level educational qualifications. We get only one respondent who has higher

educational qualifications. So, most of the farmers have no or little educational qualification. If the farmers are highly educated, their productivity will rise.

3) Gender equality: The study didn't find any female shrimp cultivators in our study area. There may be some social obstacles that influence females not to cultivate shrimp. Gender equality is one of the vital goals of SDGs.

4) Water and sanitation: According to farmers in some areas easy access to drinkable water is difficult for them. Because of the shrimp firming, those area's water salinity has risen. So, they have to depend on deep tube-well which is located far away from their firm. A healthy sanitation system is also absent in those areas.

5) Climate change: Long-term Shrimp farming degrades water quality and soil structure. Salinity and acidity can be increased due to a lack of proper water management.

6) Social equity: Fair wages, safe working conditions, and benefits of marginalized farmers are neglected in the study area. Equitable opportunity should be ensured here.

7) Lack of modern technology: The farmers are lagging behind in using modern technology. They often fear to use modern technology. As a result, production is poor, viral diseases affect profitability, and production cost is higher.

8) Food safety: It is very important to meet food safety standards for exporting shrimp farmers. However, farmers are unable to maintain food safety in those areas.

To ensure long-term viability, sustainable development in Bangladeshi shrimp production entails putting socially and environmentally responsible practices into practice. Important tactics comprise:

1) Improved farm management: Implementing responsible farming techniques to limit the negative effects of shrimp farming on the environment, such as minimizing water pollution and habitat damage.

2) Water quality management: Keeping an eye on and preserving the quality of the water to avoid contamination and illnesses that could result in the overuse of pesticides and antibiotics.

3) Certification programs: To guarantee adherence to sustainability standards, it is advised to participate in certification programs such as the Aquaculture Stewardship Council (ASC).

4) Conservation of biodiversity: Preserving and repairing mangrove forests and other coastal ecosystems that are essential to shrimp farming and serve as home to a variety of species.

5) Social responsibility: Making sure that labor laws are followed, showing respect for local communities

6) Technology adoption: Reducing water usage and environmental effects by implementing cutting-edge technology like recirculating aquaculture systems (RAS).

7) Tightening and enforcing laws: Laws that regulate land usage, water quality, and shrimp farming procedures should be ensured.

Maintaining the long-term viability of the shrimp-producing business in Bangladesh requires sustainable growth that safeguards the environment and supports local populations.

Policy suggestions

We recommend some policies to improve shrimp production. Some policy suggestions are given below:

1. The price of shrimp should be readjusted from time to time safeguarding justice to producers of shrimp.
2. A formal training session has to be conducted to get skilled farmers.
3. Easy access to agricultural credit needs to be ensured.
4. A modern watering system should be implemented in my study area
5. Proper steps should be taken to reduce diseases affected by shrimp.
6. Quick transportation systems should be ensured.
7. Formal education programs need to be implemented.
8. Women's involvement in this sector should be encouraged.
9. Proper measures regarding water salinity problems are a crying need for sustainable development.

CONCLUSIONS

Most of the farmers in the coastal area incorporate their local knowledge in pond preparation, seed selection, water management, disease management, feeding practices, and harvesting techniques to produce shrimps. Local knowledge is passed through generations, which is orally transmitted, or transmitted through imitation and demonstration. This knowledge plays a vital role in sustainability. Farmers' livelihood depends on their indigenous knowledge. The findings of the study concluded that shrimp farming is financially profitable. The profit is not sufficient for a higher standard of living. There are many challenges to achievingthe SDGs of farmers' local communities. The challenges are poverty alleviation, lack of quality education, gender inequality, and substantial environmental damage.

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