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Open Access **RESEARCH PAPER**

Shrimp Farming Practices and Its Impact on Biodiversity in Bangladesh

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Abstract

The study evaluated the sustainability, economic and environmental aspects of organic shrimp farming in Bangladesh. The educational level of the household head, the size of the flock, and the farmer's understanding of organic shrimp production all had a favorable and significant impact on the farmers' decision to adopt organic shrimp production. Cause-effect-mitigation analysis pointed out that organic shrimp farming could mitigate the adverse effects on environment caused by traditional shrimp farming. Use of chemical fertilizers and hazardous chemicals destroy the natural pond environment as a result overall production often become hampered, the farmers face economic loss and moreover, the biodiversity of that area also destroyed. Organic shrimp farming does not allow any chemical treatment, even artificial feed of shrimps and wild caught PL (post larvae) are used for stocking. This method rather supports the farmers to prepare natural compost and bokashi for regular use in the shrimp farm which does not affect the overall production of shrimp, farmers make profit due to saving of the input cost (chemical fertilizers and hazardous chemicals) and this method is safe for the biodiversity as well. Control or extensive farming system does not use any input, after drained out the pond in some case few farmer (highest 10%) use lime as very low dozes. Stocked both wild catch and hatchery produced post larvae in the pond and gher. The present research tried to find out which shrimp farming practices conserve or protect more biodiversity in the pond and gher. The study suggests that in order to decrease the threat of disease outbreak, good management procedures should be implemented and farmers should be trained to follow the work instructions and principles of organic shrimp production.

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1. Introduction

Shrimp plays an important role in the economy of Bangladesh. It is the second largest export industries after garments from which Bangladesh earned as US$ 456 m in the year 2006 (BFFEA, 2008). Among shrimp producing countries, Bangladesh ranks fourth with respect to area of shrimp farming and sixth in volume of production. The fisheries sector including shrimp, contributes about 6% to the national GDP and 5% to the national export earnings. Shrimp alone contributes about 93% of sectoral export earnings and 4.99% of the national earning item in Bangladesh (DoF, 2007).

Due to its detrimental environmental and socioeconomic effects, this haphazard and uncontrolled shrimp farming is generating a lot of discussion. This essay first looks into the nature of the negative effects of unrestricted shrimp farming in the nation's coastal regions (Afroz and Alam, 2013).

In 1994 white spot disease spread throughout the semi-intensive farms and extensive farms. Most invest or incurred heavy losses in successive years and outsiders lost interest in this business. Freshwater shrimp or Golda farming started in the mid 1970's and achieved steady growth during the late 1980's and 1990's.

According to Hossain and Hasan 2017 assessment, the main spatial risks associated with shrimp farming in southwest Bangladesh include the degradation of the local environment, water logging and salinization of the water and land, the flow of materials and nutrients, and the effect on the local biodiversity. Based on this analysis and extensive stakeholder involvement, several approaches are suggested to improve and streamline the environmental performance of shrimp farming in Bangladesh.

Shrimp culture is an age-old practice in the coastal areas of Khulna, Satkhira, Bagerhat and Cox's Bazar districts. In the past trapped tidal water in low-lying intertidal lands by constructing small dykes and harvested shrimp and finfish after three to four months. There was no stocking of fry under this system and only wild seeds of shrimp and fish carried by tidal waters were allowed to grow without any form of management. Shrimp species harvested included Black tiger shrimp (*Bagda*), Brown shrimp (*Horina*), Indian white shrimp (*Chaka)* and Giant freshwater shrimp (*Golda*). Gross sales of traditional shrimp increased by 1.87% in comparison to control shrimp (Sarkar *et al.,* 2019).

The shrimp culture system steadily grew between the end of the 1970s and the beginning of the 1980s. Farmers started

selectively stocking shrimp post larvae (PL) captured from the wild in addition to catching natural shrimp seeds. The less fortunate coastal residents took advantage of this new job opportunity and started collecting PL from the coast. The government began implementing infrastructure development plans in the middle of the 1980s, along with initiatives to spread technology more widely and provide financial incentives to producers and processors.

Between 1979 and 1999, 10 distinct programs under DoF provided the industry with financial and technical help from international development partners such the World Bank, Asian Development Bank, FAO, and ODA (UK) (Nuruzzaman, 2006).

Therefore, the study's specific goals were to: i) estimate the amount of organic shrimp produced; ii) analyze the factors that influence farmers' adoption of organic shrimp production; iii) compare the environmental effects of organic and conventional shrimp farming; and iv) discuss the opportunities and challenges as well as suggest policy options for sustainable organic shrimp production in Bangladesh.

2. Materials and Methods

2.1 Study Area:

Geographical Location and Selection of the Study Area

With a total area of 3858.33 km^2, Satkhira District is located in the deltaic plain and is bordered to the north by Jessore District, the south by the Bay of Bengal, the east by Khulna District, and the west by Pargana District in West Bengal. The Satkhira region of Bangladesh is located in the southwest of the country and is part of the Khulna division. It is bounded by the rivers Bathna, Kalinda, Kapotakha, Jumuna, Hariabhanga, Raymongal, Coxali, Morichap, etc., as well as other tributaries (Figure 1) (Banglapedia, 2011). It is many years since shrimp cultivation has been in practice following traditional method at Satkhira in Bangladesh. This cultivation was about to get caused as the coastal dam was established in 1965. Shrimp cultivation starts without following scientific method in Satkhira, Kaliganj, Shyamnagar, Ashashuni and Debhata after 1971, due to high rising price and the demand of world market. The cultivated area gets expanded due to profitable business. The people of this area get involved much into this business. This cultivation has been improved much in Satkhira.

2.2 Sampling Technique:

Simple random sampling technique has been followed in the study area to collect data (Table 1 and Figure 2).

Table 1 Number of farms and area (ha) under the study areas

Name of Upazila	Number of Farms with Area (ha)					
	Organic farm	Organic farm area	Traditional farm	Traditional farm area	Control farm	Control farm area
Assasuni	5	3.1	5	2.6	5	4.2
Kaliganj	5	8.3	5	7.5	5	7.6
Shyamnagar	5	3.4	5	4.2	5	6.6
Total	**15**	**14.8**	**15**	**14.3**	**15**	**18.4**

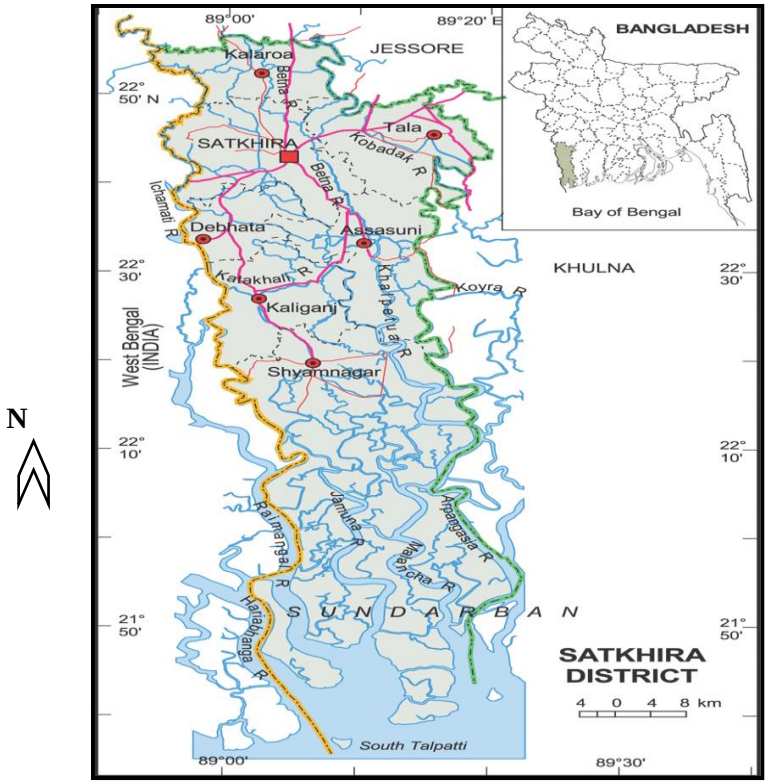

Figure 1: Study area in Satkhira, Bangladesh

Figure 2: Shrimp Farming Gher in the study area

2.2 Key Informant

To understand the expert opinion key informant were selected in the different sub district with different category of people. The Sub district (Upazila) Fisheries officer, NGOs representative and social elite person were selected as key informant. At first personally meet with them and later on after mobile talk convenience time were selected for the discussion with key informant. Same questionnaires were follows during collection the information from the key informant which use for farmer survey. In addition, supplementary questions were asked to the key informant to know and understand their opinion about the different farming practice income and production. Department of Fisheries (DoF) keeps the document on yearly basis regarding the production and average income of the total farm of the particular Upazila. The NGOs representative also has the aquaculture activities in the field, so they had also the idea about the farming operation. The social elite person had their own farm and they also suggest the local fellow farmer about the production of shrimp.

2.3 Case study

Case study conducted each of three different categories of farmer from three Upazila. Educated and proper understanding farmer were selected as case study purpose. Semi structure interview processes were followed during conduct the case study. All farmers keep their farm record in the farmer record book. The farmer record book checks time to time during collect the quarterly information. For the re check the information every farmer mobile number collected and accordingly contacted with them.

2.4 Focus Group Discussion (FGD)

FGD conducted through open group discussion in the field. Three groups were selected in the three-sub district with three different culture practices such as organic, traditional and control /extensive farming farmers. Each group 10-15 farmer was present in each focus group discussion. Participants were selected with different age between 19-58. In the group three different culture practice farmer were present. During the FGD open question were asked to the all participant to understanding the present shrimp farming practice in their community. It was also asked them about the benefit of the shrimp farming. Then it was asked them which farming practice they are thinking was benefit for them and why. Farmer was discussed by themselves and sometimes they argue with their fellow farmer opinion and after the long discussion they come to a consensus. During this focus group discussion, it was asked to the farmer compare between paddy and shrimp farming, effect of ecology and biodiversity of different shrimp farming practices.

(a)

(b)

(c)

(d)

Figure 3(a-d): Premitive harvesting system through from natural sources

2.5 Organic Shrimp Farming (OSF) Methods in Bangladesh

Organic shrimp farming does not allow any chemical treatment, even artificial feed of shrimps and wild caught PL (post larvae) are used for stocking. This method rather supports the farmers to prepare natural compost, Bokashi for regular use in the shrimp farm which does not affect the overall production of shrimp, farmers make profit due to saving of the input cost (chemical fertilizers and hazardous chemicals) and this method is safe for the biodiversity as well. Organic farmers produced product is certified product by third party of EU and Netherlands.

Input used for the organic shrimp production as-

i). Cow dung, Rice polish, Broken rice and Bokashi

ii). Compost with Yeast, Flat Rice and tenone

iii). Mustard oil cake, Lime, Zeolite, Liquid bokasi and Molasses

2.6 Traditional Shrimp Farming (TSF) Method in Bangladesh

Use inorganic and organic fertilizer during pond preparation and culture period. e insecticide and pesticide as require. Farmers are allowed to stock wild catch PL. There is no obligatory for the greening the dike. No proper post-harvest treatment for the maintain the quality of the product. Not necessary to maintain the product traceability. No need to follow the proper documentation process. Traditional farmers produced

products are not certified product (Figure 3a - 3d).

Input used for the traditional shrimp production as-

i). Cow dung with TSP, Indian oil and Wood dust

ii) Mustard oil cake with DPA, Tobacco dust and Wheat

iii) Poultry Drop with Heledon, Potassium permanganate and Tobacco dust

iv) Neem Oil Cake with Urea and Thiodine Kartap

2.7 Control and Extensive Shrimp Farming Method (CSF) in Bangladesh

Farmer are not used any input in his pond except lime. Farmer can stock both hatchery produced and wild catch PL. It is not mandatory that farmer has to greening the dike. No need to maintain proper post-harvest treatment. No need to maintain the product traceability. Only stocking and harvesting. Control farmers produced products are not certified product.

3. Results and Discussion

3.1 Key informant

To evaluate the information on traditional, organic, and extensive shrimp farming practices that was gathered through key informants. The following individuals were taken into consideration for the key informants of this study based on their professional and educational backgrounds, social standing, connections to aquaculture, and capacity for influence within the local community. Information gathered from the main informant to gauge community members' comprehension of ecological and biodiversity effects, as well as the effects of organic, conventional, and controlled shrimp farming on livelihood. The community social elite persons are very well known about the organic, traditional and control shrimp farming practices in their locality. They have the better understanding regarding the different shrimp farming production technique, environmental, ecological impact as well as biodiversity issues. Organic shrimp farming practices is the new intervention in this area and it is growing well. Despite the numerous negative effects of shrimp farming, it is nevertheless advised that adequate planning, regulation, and farmer motivation be used to create environmentally friendly shrimp farming and preserve sustainable agricultural production techniques in Bangladesh's coastal regions (Uddin and Nasrin 2013). According to the relevant government employee, local leader and influential social elite person opinion, organic shrimp farming practice can ensure the sustainable, ethical and environmental free shrimp product from Bangladesh.

3.2 Case study

To assess biodiversity as well as environmental impact of different shrimp farming practices case studies were

conducted with organic, traditional and control shrimp farmers. Farmer were selected on random basis but important given to select motivated, educated and interested farmer for conduct case study. Each farming category one and total three farmers were selected for conduct case study in study area. The following farmers were considered for case study purposes.

3.3 Organic farmers

Farmer used the chemical fertilizers in the farm during traditional farming practices as a result pond fertility rate really decreased gradually which is not happening anymore after entering into the organic shrimp farming practices. They stocked the PL from the organic certified hatchery but before that they used wild catch PL from the river or natural sources. Both of the organic farmers followed the dike greening activities. The dike greening and stocked organic certified PL are the organic standard and if the organic farmer not follow those issues then they will sanction form organic producer group member. Farmers mentioned that in the past they used different kinds of chemical as well as pesticides that's why there were no wild animals in their farm. But at present they does not use any chemical fertilizer in the culture system so there are now different kinds of wild animals appear like birds, crabs, frogs, snake and also other crustaceans.

The organic farmer used the chemical fertilizers in the farm during traditional farming practices as a result pond fertility rate really decreased gradually which was not happening anymore after entering into the organic shrimp farming practices. Farmers mentioned that in the past they used different kinds of chemical as well as pesticides that's why there were no wild animals in their farm. But at present they did not use any chemical fertilizer in their farm. So, there were no different kinds of wild animals like birds, crabs, frogs, snake and also other crustaceans appear (Figure 4a - 4i). Due to saline water intrusion the numbers of trees were gradually decreasing. The controlled/extensive farmers described that they did not use any kind of chemical fertilizer as well as other fertilizer and formulated feed.

The adoption of better management practices (BMPs) throughout the entire crop cycle, collective commitment to BMPs, effective management of disease pathogens, reduced environmental and social impacts, and carrying capacity-based production are requirements for sustainable shrimp farming (Dhar *et al.* 2020). Accordingly, they did not act any negative impact in regards of environmental issue. As they did not use any chemical or artificial input in their

farm, so they got good quality shrimp and other shrimp species by which they fulfil the nutritional requirements of their family.

3.4 Organic shrimp farming

Family based brackish water polyculture is generating additional income for the farmer. Sales to the local market increases the independency from international market fluctuation and the protein supply of the local population. Polyculture also has the positive impact on protein supply in the community (5a - 5g).

(a) *Liza parsia & Lates calcarifer* **(b)** *Oreocaromis mossambica* **(c)** *Glossogobius giurus*

(d)*Metapenaeus monoceros* **(e)** *Lates calcarifer* **(f)** *Rhinomugil corsula*

(g) Crabs: *Parathelphusa convexa* **(h)** *Taenioides cirratus* **(i)** *Penaeus monodon*

Figure 4(a-i): Biodiversity protected in organic and control farming

(a) Heron: *Ciconia ciconia*

(b) Frog

(c) *Tilapia nilotica* & *Liza parsia*

(d) *Telescopium telescopium & Cerithidea cingulata* and different species of mollusks

(e) *Oreocaromis mossambica*

(f) *Therapon jarbua*

(g) *Xenentodon cancila*

Figure 5(a- g): Biodiversity protected in organic farming

Figure 6: Biodiversity protected in organic farming area.

Farmer has to make the dike green at least 50% of the total farm dike otherwise farmer will be sanctioned from the organic certification. This is the standards of the certification body that organic farm dike has to make green with trees or vegetable or grass. Organic farmer not allow to use pesticide or insecticide in the pond due to this fact during drained out the pond lots of bird found grassing in the pond bottom (Figure 5a -5g & Figure 6 - 9).

Certified organic: A new prawn paradigm in Bangladesh (Source: www.iucn.org).

Avoid: Traditional Farming for Biodiversity

Figure 7: Biodiversity protected in organic Farming

Figure 8: Compost used in organic farm for increasing natural productivity

Figure 9: Rapid growth of benthos community grown by using organic compost

Wild catch from the river post larvae is not allowed for organic production. Only certified hatchery PL has to be stocked. Before hatcheries were developed in Bangladesh, shrimp farming had to rely on wild caught Post Larvae (PL) with negative impacts on the environment, because of the so called 'by catch' that is dominated by cnidarians, molluscs and other crustaceans than *P. monodon* and fish larvae. This was the reason for the Department of Fisheries (DoF) to ban the wild fry collection in Bangladesh in Sept. 2000 (DoF, 2002).

Organic farmer used natural home-made compost in their farm which allow to produce natural feed in the pond. The fertile waters of the Sundarbans allow the culture of shrimp based on natural alimentation without additional feed.

According to a study by Dhar *et al.*, 2019 organic shrimp production in Satkhira, Bangladesh, was very profitable with a yield per hectare of 383 pounds and a benefit-cost ratio of 1.91. Additionally, they looked at cause-effect mitigation and concluded that organic shrimp farming could lessen the negative environmental consequences brought on by conventional shrimp farming. They confirmed the sustainability of organic shrimp production in terms of energy use, environmental protection, commercial viability, and social and political equity.

3.5 Traditional farmers

Traditional farmers admitted that some environmental structures have been changed. At present there are limited numbers of empty land in this area for children play ground. In the past migration birds were found in the farm area but recently the number has decreased. Due to saline water intrusion, the numbers of trees are gradually decreasing. Both the farmers described that in the past they have different varieties species of shrimp (Harina, Chaka, Goda, Rosnaetc), fish (Vateki, Tere, Parsea, Khorkulo etc) and crab found in the farm as well as nearby farm canal or river. Nowadays, all those shrimp, fishes and crabs which come through the natural water flow in the farm has been tremendously decreases. They pointed out that now they stocked parsea (*Liza parsia*) fingerling in their pond but in the past natural grown fingerling was sufficient for the culture.

(a) Farmer using chemical in farm.

(b) Amconus (Insecticide bottle) which is destroying gher diversity

(c) Farmer spraying insceticide in prawn farming Gher

(d) Farmer spraying pesticide in Gher

(e) Suntas (Insecticide packet)

(f) Cartap (Pesticide packet) Cartap is a pesticide that was first introduced into the market in Japan in 1967.

Figure 10(a - f): Traditional farmer using insecticide in farm

(a) *Dead Liza parsia & Lates calcarifer*

(b) *Dead Liza vaigiensis* after using insecticide

(c) Dead carp & Mulets sp.

(d) Dead Eel collecting after using insecticide

(e) Dead carp after using insecticide

(f) Collected dead eel (*Monopetrus cuchia*)

Plate 11(a -f): Biodiversity destroyed in traditional farm using insecticide

Traditional farmer used various kind of insecticide at the end of the culture season for catch all the shrimp and fish. For this all kind of animal are killed due to used this lethal insectided. This insecticides are very strong and all kind of organism come out from water and pond bottom to water surface or pond bottom mud surface. It killed even Amphibian and Reptilies also.

Cropping diversification, nursery development, zoning for coastal aquaculture, infrastructure development, enforcement of laws and regulations, and bolstering of extension services were all suggested by Alam (2002) as ways to improve present farming methods. Shrimp aquaculture-related individuals and institutions still need to be made more aware of the FAO Code of Conduct's existence, importance, breadth, and purpose.

(a)*Metapenaeus monoceros* **(b)** M*etapenaeus monoceros* **(c)** *Penaeus monodon*
Liza parsia & Mystus gulio

(d) *Liza parsia &. Liza vaigiensis* **(e)** Carp &Telapia **(f)** *Taenioides cirratus*

Figure 12(a - f): Biodiversity conserve in control farming

3.6 Extensive farmers

Farmers described that they do not use any kind of chemical fertilizer as well as other fertilizer and formulated feed. So, there are no numbers of negative impacts in regards of environmental issue (Figure 12a - f). Today the main problem for the shrimp farming is viral disease and once it attacked then kill all shrimp. Based on their experienced they pointed out that if they can keep the natural environment for the shrimp then there is a less chance to disease attack. Accordingly, they cannot act any negative impact in regards of environmental issue. But they never compromise with poor quality PL

stocked in their farm. They mentioned that they used both hatchery and wild catch PL. As they do not use any chemical or artificial input in their farm, so they get good quality shrimp and other shrimp species through which they fulfil the nutritional requirements of their family. According to Washim *et al*., 2022, by enhancing the management procedures in large-scale shrimp farming ghers, the production of shrimp can be significantly increased.

Focus Group Discussion (FGD) is the easiest way to share and collect information from the community people. The village people feel comfortable to discuss together various community related issues. For this reason, present research conducted focus group discussion in the study area with community people to understand biodiversity and environmental impact of shrimp farming practices. The FGD was held with a group of farmers who are involved in many kinds of small profession besides shrimp farming, at Tiger club, Kazla in Nalta union under Kaligonj Upazilla, Satkhira District. This FGD location was surrounded with plain land and not so far from coastal area and about 60% peoples were literate from this locality. During selection of focus group member participant age considered to get the accurate information. In this focus group participant age range was 28-67 years.

The focus group member narrated that their father or grandfather started the aquaculture but during that time culture was primitive and they only allow natural water in the farm. To get more production farmers used different kind chemical fertilizer, insecticide and pesticide. But recently starting organic and control/extensive shrimp farming practices not used chemical fertilizer or lethal ingredients. Group member informed that due to use of lethal insecticide by traditional farmers all kind of organisms are killed. They highlighted that they found dead crabs, snake, frog etc., after used the insecticide (Figure 13 - 15).

Figure 13: Use of insecticide result dead fish

Figure 14: Live crab catching after using insecticide

Figure 15: Women, men, and children catching fish, shrimp, and eel after using insecticide.

In the focus group meeting, farmers mentioned that several negative impacts on the ecosystem can change the natural biodiversity. Although they know chemical inputs have a negative impact, they are continuously using such inputs in the pond. They are also mentioned that other wild animals like frogs, snakes, and crustaceans are also now found in the pond insufficiently. In previous times different kinds of birds were seen than present. They also mentioned that, in their locality due to the saline water intrusion many types of trees are not growing properly. Among the participants three farmers thought were by using chemicals the wild animals are decreasing in pond, three other participants told that natural vegetation is not growing properly by traditional farming system, two participants reported that pond productivity is decreasing, and rest of the participants mentioned the change of natural ecosystem. Focus group member pointed out that during paddy cultivation, farm side canal they caught different kinds of freshwater finfish and other shrimp species but now those kinds of fish & shrimp natural production has decreased. Traditional farmers used various kinds of lethal input during the culture period of shrimp and at the end of the culture period to harvest all kinds of organisms by killing. By using this lethal insecticide, they kill the eggs and fingerling of finfish and other organisms that were taking shelter in the pond's bottom holes. During the discussion group member informed that new extension people from different insecticide seller companies come to the locality and they promote or motivate farmers to use insecticide. Because of this promotional activity many farmers use insecticides to get good results but they are losing every year. Organic farming practices does not allow to get chemical fertilizer, insecticide and

pesticide rather it protect nature by greening the dike and not allowing wild stock PL.

Paul (2011) mentioned that socioeconomic factors such as the displacement of traditional livelihoods, social unrest, and market fluctuations are impeding the sustainable growth of shrimp farming in Bangladesh. Environmental effects such as the deterioration of mangroves, saltwater intrusion, sedimentation, pollution, and disease outbreaks are also discovered to be barriers to the growth of sustainable shrimp farming. Future expansion of shrimp farming is threatened by inappropriate management strategies and inadequate plans for the quality of the water, the seed supply, the availability of irrigation systems, and the availability of fisheries resources, in addition to institutional flaws. As a result, he made a significant contribution to determining the course that alternative research could take and how it might affect the long-term viability of shrimp farming.

According to Afroz and Alam (2013), unplanned and haphazard shrimp farming is the subject of intense controversy because of its detrimental effects on the environment and the economy. Additionally, they investigate the adverse effects that illegal shrimp farming in the nation's coastal region may have.

5. Conclusion

In coastal Bangladesh, groups that raise shrimp have made a name for themselves as significant economic contributors. It has been demonstrated that shrimp farming may be a sustainable type of farming, accessible not just to rich elites but also to middle and lower classes, by attempting to avoid many of the negative impacts that were once connected with it. We now conclude that the appropriate actions must be taken to halt the increasing environmental and coastal ecosystem damage.

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