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Sanitary and Phyto-Sanitary Barriers to Trade and its Impact on the Environment

The Case of Shrimp Farming in Bangladesh

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Executive Summary

1. Shrimp is the second largest source of export from Bangladesh. In the late 1980s, the shrimp industry grew out of a major non-traditional item of export from Bangladesh. Commercial culture of shrimp increased rapidly in the coastal belt of Bangladesh and it went through several stages of transformation.

2. There are now approximately 37,397 farms cultivating *bagda* (tiger shrimp) with an average farm size of 4.5 ha. Twenty-five thousand tons of *bagda* was produced in 2001. *Bagda* production has increased by 20 per cent per annum in the last fifteen years. There are 124 shrimp processing factories in Bangladesh sited mostly in Khulna and Chittagong and about 60 hatcheries, mostly in Cox's Bazar. There are also 30,000 ha of land under *galda* (sweet water shrimp) production that produced 11,942 tons in 2001. Because *galda* farms are generally smaller than *bagda* mud (averaging 0.28 ha and four ha respectively), they support a greater proportion of poor and marginal farmers.

3. There are 105,000 *galda* farms, mostly located in the Khulna division although this method of cultivation is spreading rapidly in other parts of Bangladesh. Unlike brackish water cultivation of *bagda* (tiger shrimp, *Penaeus monodon*), freshwater *galda* cultivation is not restricted to the coastal regions and is expanding at a rate of 10–20 per cent per annum. Moreover, *galda* shrimp (fresh water scampi, *Marobhrachium rosenbergii*) farming is usually done on family farms by small farmers who have transformed their tiny plots of agricultural land into shrimp-cum-rice farms.

4. There are 600,000 people employed in the shrimp sector in Bangladesh generating US$301 million annually, from *bagda* and *galda* farms (US$243 million from *bagda* alone). Yet the industry suffers from significant production inefficiencies and is exposed to important social and environmental risks.

5. One of the risks has emerged out of sanitary and phyto-sanitary agreements and subsequent standardization of production and processing methods using HACCP (Hazard Analysis and Critical Control Point) methods. As of now, HACCP is applied on the processing plants, but to ensure the quality of production and to reduce risks, shrimp farms are also required to adopt HACCP methods. Processing plants, being the large investors and the ultimate risk taker in the business, have already adopted the procedures mentioned in HACCP, but it has been quite difficult for them to impose the same on the small shrimp farms. Overall, the industry is in crisis—low production capacity at plants and very low yield at the shrimp farms.

6. The farming community lacks capital, education, and also motivation to accept changes under the current market conditions. This study has shown that, while most of the shrimp farmers are aware of the risks in the business, they are also not very active to adopt the standards. It was also found that most farmers need to be trained regarding the impact on shrimp quality of the use of chemicals during crop production.

7. Using field data, the study developed a simulation exercise to show that, under the current situation, the trend in the industry is toward intensive shrimp farming. This will threaten the ecosystem and the social fabric in rural Bangladesh and increase social conflicts. Consequently, an alternative strategy has been devised and found feasible.

8. The alternative is to provide training to the farmers and make them aware of the risks in the business, create meaningful liaison with the processing plants and reduce inefficiencies in production. This is a more socially-desirable response to resolve the current crisis in the industry.

9. The result of the study was presented at a national workshop in Dhaka and during presentation of the report at the workshop it was further observed that stakeholders of the shrimp industry lack a common understanding of their roles and responsibilities. Moreover, there exists severe mistrust between the farmers and the processors. High rate of marketing margin is also a genuine problem. These are all rooted in the overall lack of awareness and information at the primary level of production. It is, therefore, suggested that a multi-stakeholder dialogue process may be initiated by a neutral organization to buildup the trust between them. The objective of the dialogue will also include developing a common policy prescription for the industry to make it environmentally sustainable.

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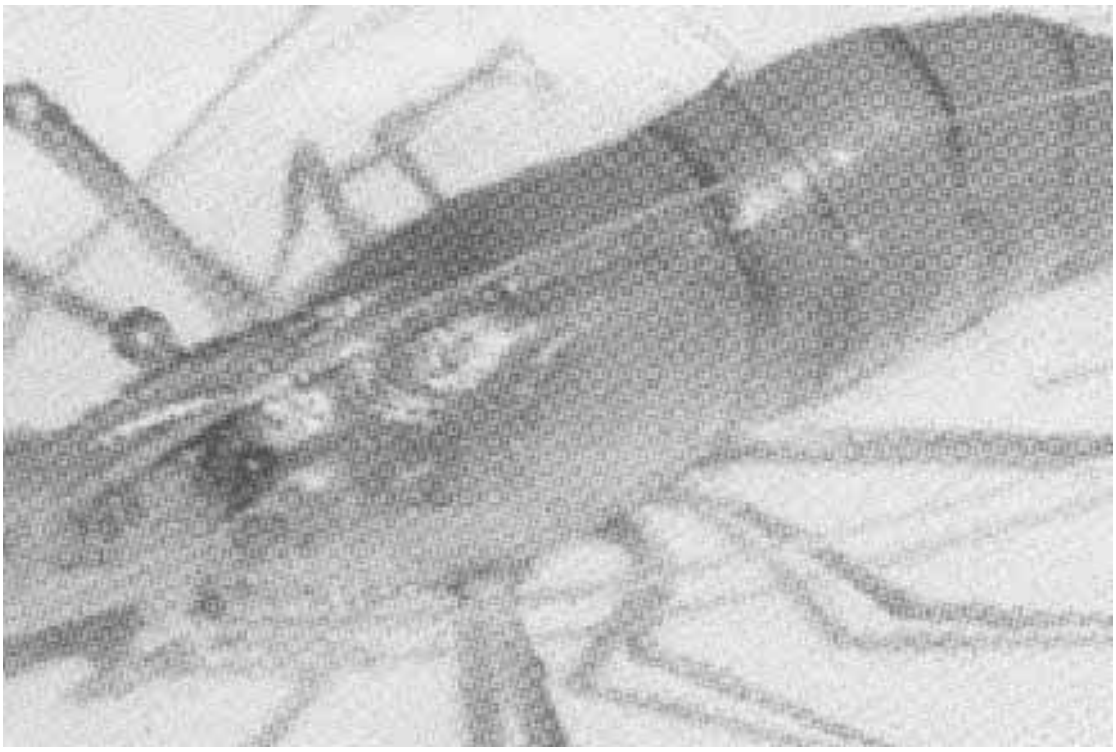

1. Introduction

A major non-traditional item of export from Bangladesh is shrimp cultured in the brackish water of the coastal areas. Except in the Sundarban Reserve Forest areas, the government has leased out coastal land for the development of shrimp ponds.

There are now approximately 37,397 farms cultivating *bagda* (tiger shrimp) with an average farm size of 4.5 ha. Twenty-five thousand tons of *bagda* was produced in 2001. *Bagda* production has increased by 20 per cent per annum in the last fifteen years. There are 124 shrimp processing factories in Bangladesh mostly in Khulna and Chittagong and about 60 hatcheries, mostly in Cox's Bazar. There are also 30,000 ha of land under *galda* (sweet water shrimp) production that produced 11,942 tons of galda in 2001. Because *galda* farms are generally smaller (averaging 0.28 ha compared to four ha of *bagda*) *galda* cultivation supports a greater proportion of poor and marginal farmers.[1]

There are 105,000 *galda* farms mostly located in the Khulna division although this method of cultivation is spreading rapidly in other parts of Bangladesh. Unlike brackish water cultivation of bagda, freshwater *galda* cultivation is not restricted to the coastal regions and is expanding at a rate of 10–20 per cent per annum.

Roughly 33 per cent of the shrimps grown in Bangladesh are exported. Though shrimp fetch a large amount of foreign exchange through exports, it is not an unmixed blessing.

[1] Ministry of Fisheries and Livestock, *Shrimp Aquaculture in Bangladesh – a vision for the future*, October 2, 2002.

According to a recent strategy paper of the government of Bangladesh, "Shrimp farming is a key element in the economy of Bangladesh. Currently, Bangladesh produces 2.5 per cent of the global production of shrimp, and the shrimp sector is the second largest export industry. There are 600,000 people employed in the shrimp sector in Bangladesh generating US$301 million annually, from *bagda* and *galda* farms (US$243 million from *bagda* alone). Yet the industry suffers from significant production inefficiencies and is exposed to important social and environmental risks."[2]

The shrimp belts of Bangladesh are located in the coastal districts of Chittagong, Cox's Bazar, Khulna, Shatkhira and Bagerhat. These districts have experienced a major change in land use patterns since 1982. During this period, the southwestern belt experienced an increase of area under shrimp culture at the rate of 16.6 per cent per annum, while the rate of increase in the southeastern belt had been 5.3 per cent per annum. The reason for rapid expansion of shrimp culture in Khulna and Satkhira is the existence of natural spawning ground of the *bagda chingri* (salt water shrimp) PL in the rivers near the Sundarban forest. Over-exploitation of PL from rivers is causing depletion of fish resources in the area.[3]

Construction of coastal polders by the Water Development Board and subsequent failure to manage the water flows has created opportunities for safe shrimp culture inside the polder. The shrimp culture season is between January and September.

While these polders had successfully protected farmers from regular intrusion of saline water via tides from the rivers, as the shrimp farms grow, the contiguous farms are subjected to the risk of intrusion of saline water (from breach in pipelines, canals, etc., through which water is exchanged between the rivers and the shrimp ponds). At the same time, trapped saline water in shrimp ponds tends to increase the soil salinity. Also, microorganisms that contributed to the augmentation of soil nutrients cannot survive under saline waterlogged conditions. This reduces yields from agricultural crops. As a result, more and more of the contiguous agricultural plots are converted into shrimp ponds.

However, since price and quantity risks associated with shrimp farming are higher than that of crop farming, acute social conflicts have also surfaced in these districts, threatening the social fabric of rural Bangladesh.

All these phenomena have brought about changes in the livelihood of the peasants—many had to give up farming and take up jobs in which they are not entirely comfortable. Inhabitants of the locality have turned into environmental refugees. This research is a study of coastal Bangladesh to see the impact of "pink gold" farming on the livelihood and the environment of coastal Bangladesh.[4]

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[2] Ministry of Fisheries and Livestock, *Shrimp Aquaculture in Bangladesh – a vision for the future*, October, 2002.

[3] Md. Giasuddin Khan cited that the shrimp PL fishery, the estuarine setbag net (ESBN) fishery (which catches juveniles) and the shrimp trawl fishery (which catches brood shrimps) as the three most destructive coastal fisheries. Over fishing of these fisheries has occurred to the extent that fishing in the artisanal sector is no longer remunerative. The penaeid shrimp stock in particular is over-exploited in all three fisheries but the fry fishery in particular which removes an estimated 90 per cent of the *panaeus monodon* fry stock. The ESBN fishery further reduces the chances of recruitment to the offshore adult stock. (DFID, 2003)

[4] Shrimp is popularly known as "pink gold" in developing countries where shrimp exports are a major source of foreign exchange earning for the economy.

WTO and SPS agreements

While the quest for growth in earning the precious foreign exchange for developing countries is on, importing countries have imposed rules on health safety and hygiene standards to deal with the threat on domestic health and sanitation problems posed by these imports. The enactment and application of these types of rules is governed by WTO's SPS agreement.[5]

The SPS agreement provides the framework for nations to impose trade restrictive measures based on consideration for protecting life or health of animals, plants, and humans. The SPS agreement calls for harmonization of standards within the guidelines and principles set by three international agencies: Codex Alimentarius Commission (established by FAO to promote standards related to food and agriculture), the International Office of Epizootics and organizations working within the framework of International Plant Protection Convention and it instructs these three organizations to monitor the standards so that they can be harmonized. Countries are free to exceed international standards, but if they do they need to fulfill a number of requirements, including basing them on a scientific justification, performing a risk assessment, minimizing adverse trade effects, etc.

However, a group of World Bank researchers studying the health standards for trade reported in the *Financial Times* on October 26, 2000 that EU regulations on food safety are based on the precautionary principle, which justifies restrictions or regulations on food imports even if the scientific risks to health remain unproven. According to them, the EU insists on tighter standards than recommended by Codex (*Financial Times*, October 26, 2000).

Use of food safety standards on imports of food items effectively restricts market access of the developing countries. For many developing countries, it is an uphill battle. First, it has raised the cost of production. Second, it becomes difficult for many of the developing nations to comply with the standards given the level of education of the farm operators and their poverty. The agriculture sector is largely an unorganized sector in these economies. Providing a source of stable income to their farmers was already a great challenge to many of the developing countries and with foreign food safety standards imposed on them, the problem has multiplied. Third, the exporters of shrimp are more organized than the shrimp producers. So, as risks of doing business have increased, exporters might attempt to shift the burden to the farmers (by controlling the market and regulating the demand). And in most cases, this would create chaos in the industry. The producers at the bottom of the production layer are likely to be affected most.

Driven by poverty and underdevelopment, the governments in these countries might now relax or may not enact appropriate regulations to protect the domestic environment. Such an economically important sector warrants patronization by the government for promotion and not restriction. Since SPS measures affect the source of foreign exchange supplies to the economy, governments might relax application of domestic regulations, so that exporters become price competitive in the international markets. It is also likely that governments might relax rules related to environmental protection.[6] It might also be possible that governments in these countries

[5] The agreement was signed to harmonize sanitary and phytosanitary measures on as wide a basis as possible. It stipulated that members shall base their sanitary or phytosanitary measures on international standards, guidelines or recommendations, where they exist. It further adds that sanitary or phyto-sanitary measures which conform to international standards, guidelines or recommendations shall be deemed to be necessary to protect human, animal or plant life or health.

[6] For example, if the environment departments relax the requirement for disposal for wastes into the rivers, these exporting firms would be able to save some money.

would not be able to impose some of the environmental restrictions to help the foreign exchange earning sector.[7] Such a position, if found to be true, would mean that the environments of the developing countries are being traded (indirectly) with health and safety standards of the importing nations.

Given the above, we could envisage the following situations. First, since compliance to the SPS agreement rests with the exporters it is likely that shrimp exporters would try to minimize the risk of rejection (of shipments) and so they would take some mitigating measures. This typically includes updating the processing facilities to conform to the standards. Second, it might be difficult to impose standards at the primary level of production (due to unawareness and low income of the farmers) and so shrimp exporters might eventually prefer to control their shrimp production and go into intensive cultivation of shrimp by themselves. Finally, shrimp farmers, who foresee problems of selling their shrimps to exporters, might diversify their production strategies to reduce risks.

All of the above activities would mean that the first best options are avoided and both parties have adopted the second best options to deal with SPS regulation. The first best option for them is to increase awareness at the primary level of production, help the farmers and agents involved during transportation and storage to maintain the standards (required under HACCP[8] rules), and to avoid further intensification of the shrimp farming practices.

The objective of this paper is to analyze the shrimp industry of Bangladesh and to understand their coping strategy to deal with SPS measures.

The research problem

The government and the shrimp export industries of Bangladesh spent a large sum of money to upgrade the export plants and to monitor compliance of standards set by the importing nations under the SPS agreement. Most of those standards involved the use of HACCP standards for ensuring food safety—a standard that has been approved by the Codex Alimentarius Commission.

Under the provision of harmonization of the standards, the Codex commission has suggested the use of HACCP methods to monitor and maintain food safety standards.

Hazard Analysis and Critical Control Point (HACCP) is a method for maintaining a quality standard and is applicable at all stages of production. In the case of shrimp production, exporters need to comply with the standard starting from production at the farm level. As of now, it has not been applied at the farm level and only the exporters are legally liable to bear the risks of export for any possibility of non-compliance of standards. It has been argued by the industry that if HACCP is applied at all the stages of shrimp production and processing, production would become more efficient and also less expensive, and the risks of non-compliance with the standards would be greatly reduced.

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[7] For example, the government of Bangladesh could not effectively impose the ban on collection of shrimp-fry from rivers because women who are involved in this activity are the poorest of all.
[8] Discussion on HACCP is in the next section.

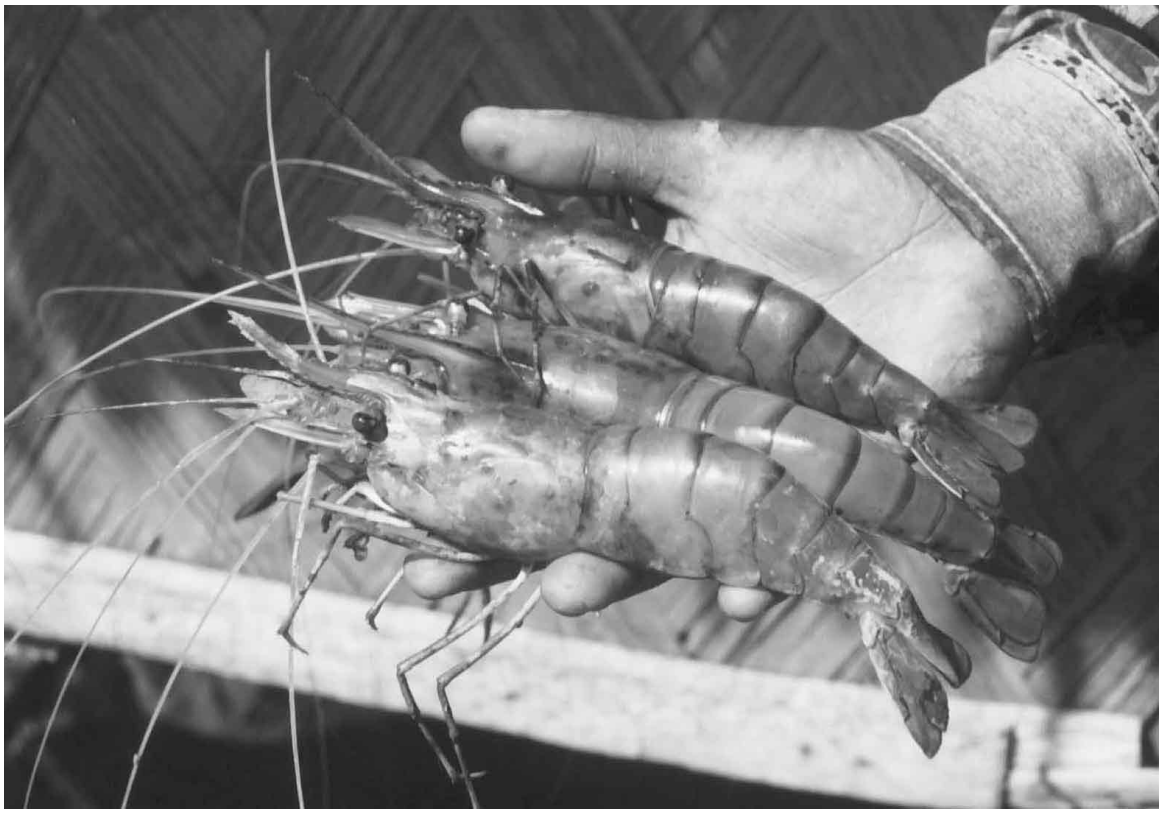
For shrimp farms, such measures would mean that they also need to upgrade their production method—a likely implication is to move from semi-extensive farming to intensive farming. If this happens, the net burden will fall on the environment since intensive shrimp farming will further aggravate the local environmental risks.

Traditional or extensive shrimp farms use large areas of land in its low-density ponds and use tidal waters to collect shrimp fry (they can also use fry from hatcheries). It they transform mangrove forest lands into shrimp farms, the impact on the environment is destruction of mangrove forests. Except in the southwest region of Bangladesh, this has not been the case.

Intensive farming, on the other hand, occurs away from the mangroves but it increases risk of epidemics in the adjacent aquatic regions. Intensive farming is also responsible for causing irreversible damage to the land and forests because of its waste disposal practices.

In Bangladesh, shrimp farmers still use their land for shrimp-cum-crop production (traditional farming) and such activities take place away from the mangrove forests in the southeast region. In the southwestern region, shrimp farms have been accused of having destroyed the mangrove forests (mostly because these forests were not listed as a "protected area" and the government allowed shrimp farms to take lease of land in this area).

This research is expected to highlight the net impact of SPS measures on the shrimp industry and to develop a coping strategy for small-scale local shrimp producers. The study will also recommend strategies that can minimize the adverse environmental impacts on the shrimp industry as a whole.



2. The shrimp industry and its regulations

Shrimp farming, which is at the bottom layer of shrimp production, has a very high degree of diversity both in terms of species, production practices and management of the farms. Besides, there are significant differences between farms in any country depending on their age and ownership characteristics. Shrimp farms are often classified into extensive (low-input systems characterized by low stocking densities, little or no external nutritional inputs, tidal water exchange and shrimp yields of less than 500 kg/ha/yr); semi-intensive (use of fertilizers combined with supplemental feeding, intermediate stocking, occasional pumping of water and yields of 1–2 tons/ha/yr); and intensive systems (high stocking density, formulated complete feeds, aeration and water pumping with yields of more than 2 tons/ha/yr). Given this classification, shrimp farms in Bangladesh are generally classified in the extensive farming category. Most of these farms are "traditional" with little or no mechanization. An important consideration when discussing shrimp farming is the diversity of farming systems in operation as well as location, size, management and the people involved. Shrimp farming also supports a large number of associated industries, including input suppliers (hatchery operators, manufacturers and suppliers of feeds, equipment, chemicals, etc.), and families and businesses dealing with post-harvest handling and processing, distribution, marketing and trade. This diverse and sometimes fragmented industry structure has to be considered in assessments of the nature of the industry and in the implementation of improved management practices.

International regulations applicable for the shrimp industry

Rapid growth of shrimp farming around the world raised concern among researchers and environmentalists about the impact of shrimp farms on the coastal ecosystem and particularly on mangroves. So, subsequent to the FAO organized Cancun Conference on Responsible Fishing in 1992 and the 1992 United Nations Conference on Environment and Development (UNCED), FAO was requested by its member countries to draft an International Code of Conduct for Responsible Fisheries. Accordingly, many experts and representatives from governments, intergovernmental and non-governmental organizations participated in several FAO technical consultations and in the 1993 and 1995 sessions of the FAO Committee on Fisheries for formulation of the Code. The Code was finally adopted by government representatives attending the 28th Session of the FAO Conference on October 31, 1995 (FAO, 1995). The codes are known as the Code of Conduct for Responsible Fisheries (CCRF).

In formulating and negotiating the Code, it was recognized that many developing countries continue to face significant development problems, and that the special economic and social circumstances prevailing in these countries would need to be given due consideration. The Code, therefore, calls—in Article 5—for efforts and measures to address the needs of developing countries, especially in the areas of financial and technical assistance, technology transfer, training and scientific co-operation. Special efforts should be made, particularly in the areas of human resource development.

The Code envisaged that governments should have a legal framework that applies specifically to coastal aquaculture, including shrimp culture. Given the complexity of the legal and institutional issues involved, governments should opt for a single comprehensive new or amended coastal aquaculture law, including provisions extracted from the existing laws. Where this is not feasible, governments should ensure the insertion of clear provisions specific to coastal aquaculture within each existing law or regulation. Before deciding whether new legislation is necessary or existing legislation should be amended, governments should collect, study and analyze the existing laws and regulations that are likely to apply to coastal aquaculture. In Bangladesh, the industry is still regulated by the rules of the fisheries sector. Separate codes for coastal fisheries do not exist at the moment.

In the process of drafting a legal framework for coastal aquaculture, including shrimp culture, governments should have regard for the following principles:

- coastal aquaculture legislation must be framed into the whole fabric of related laws and regulations including those addressing coastal area management and should be the result of an interdisciplinary and consultative process involving the stakeholders;
- laws and regulations should be sufficiently flexible to respond to short-term needs while having a long-term orientation contributing to maintaining ecological balance;
- the legal framework should ensure that livelihoods of local communities and their access to coastal resources are not adversely affected by coastal aquaculture developments; and
- there should be equivalence between laws and regulations governing coastal aquaculture including permitting, restrictions and monitoring, with those governing other users of coastal areas, wetlands, mangroves and water.

Governments should ensure that an effective institutional framework at the local and national levels, as appropriate, be established for sustainable coastal aquaculture development and

management. Where possible, governments should envisage the establishment of a single aquaculture management authority, which would be responsible for the development and management of coastal aquaculture and deal with all issues relating to this activity.

Where a single aquaculture management authority cannot be created, governments should set up an appropriate administrative framework with a view to ensuring coordinated development and management of sustainable coastal aquaculture.

Because there is a need to provide for laws and regulations which are practical and worth enforcement, governments should set forth, as appropriate, monitoring and inspection schemes as well as appropriate effective sanctions for violations and non-compliance with relevant legal measures in force.

Sanitary and phyto-sanitary measures

Sanitary and phyto-sanitary measures are usually imposed on products for health reasons. They can be applied to protect even domestic livestock from harmful exposure to pests or diseases. In general, they are often designed to protect the consumers from hazards but the general standards are set *to protect human, animal, plant life or health*. Under the SPS agreement, members shall play a full part, within the limits of their resources, in the relevant Codex Alimentarius Commission, the International Office of Epizootics, and the international and regional organizations operating within the framework of the International Plant Protection Convention, to promote within these organizations the development and periodic review of standards, guidelines and recommendations with respect to all aspects of sanitary and phyto-sanitary measures.

The international standards, guidelines, and recommendations are:

- for food safety – the standards, guidelines and recommendations established by the Codex Alimentarius Commission relating to food additives, veterinary drug and pesticide residues, contaminants, methods of analysis and sampling, and codes and guidelines of hygienic practice;
- for animal health and zoonoses – the standards, guidelines and recommendations developed under the auspices of the International Office of Epizootics;
- for plant health – the international standards, guidelines and recommendations developed under the auspices of the Secretariat of the International Plant Protection Convention in cooperation with regional organizations, international organizations and their subsidiary bodies, in particular, the Codex operating within the framework of the International Plant Protection Convention; and
- for matters not covered by the above organizations – appropriate standards, guidelines and recommendations promulgated by other relevant international organizations open for membership to all Members, as identified by the Committee.

In practice, it is the food safety standards (for protection of human health) that played the most significant part during implementation of SPS.[9] Importing countries have so far restricted import of food products from developing countries on the grounds of non-compliance with food safety standards such as discovery of banned chemicals found in the shrimp-lots and for not implementing HACCP methods (at the processing level) in the export sector.

[9] In the shrimp industry of Bangladesh, shrimp exports are rejected mostly due to presence of harmful substances not due to environmental reasons.

To deal effectively with violation of health and safety standards, shrimp exporters were asked (by the importing nations) to comply with HACCP methods of monitoring and auditing.

HACCP method of food safety monitoring

HACCP was originally developed by NASA to prevent any hazards that could cause illness or injury during space flights. During the 1970s and in early 1980s, a number of industries applied the HACCP system. From this experience, it was concluded that the HACCP system is good for preventing micro-biological, chemical and physical hazards and it was, therefore, recommended by the Codex Alimentarius, a code of food standards for all nations, developed by FAO.

HACCP, therefore, focuses on three specific hazards: 1) Micro-biological hazards, 2) Chemical hazards, and 3) Physical hazards. In the food industry, it is applicable at three stages: the primary production stage (e.g., the shrimp farmers), the processing stage (e.g., the shrimp processing plants), and the wholesale and retail stage. In the shrimp industry, the first two stages are in the exporting country, ex., Bangladesh, while the third stage is controlled in the importing country, ex., the U.S. or the EU.

In each stage of production, the HACCP system defines the critical control point, and provides a set of standards to be followed. In the case of the shrimp industry of Bangladesh, the processing plants are, at the moment, subjected to this system. The primary producers, the shrimp farmers, are yet to be subjected to this system.

HACCP in Bangladesh

Shrimps exported to the U.S., Canada and Europe from any country must pass the food and safety standards set by these countries, failing which the importing countries could impose trade restrictions. Bangladesh came under an EU ban[10] in 1997. The Frozen Food Exporters, to comply with the regulations under HACCP, spends $2.2 millions per year and the Government of Bangladesh spends on average $225 thousands to maintain a HACCP monitoring program. At the same time, it has been estimated that a total cost of $17.6 million would be necessary to upgrade facilities to comply with HACCP requirements (Cato and Limos dos Santos, 2000 and Rahman, 2000). SPS monitoring programs under HACCP regulations include inspecting shrimp farms and monitoring feed, drug and chemical use, inspecting and monitoring processing plants, and pre-shipment inspections and certification. In Bangladesh, however, most of the monitoring activities start at the processing plants.

The extensive shrimp farms, which are predominant in Bangladesh, because of their smaller size cannot afford to implement the monitoring mechanism required under HACCP. At the same time, these family-operated farms are not at all compatible with the frozen food exporters (intensive producers), who can pay for the monitoring activities under HACCP rules. Due to

[10] In July 1997, the European Commission imposed a ban on imports of shrimp products from Bangladesh into the EU on the ground that exports of this commodity did not meet the stringent provisions of EC's HACCP (*Hazard Analysis Critical Control Point*) regulations. The ban *originated from (a) concerns* as regards standards in areas related to health safeguards, quality control, infrastructure and hygiene in the processing units, and (b) *lack of trust* in the efficiency of the controlling measures carried out by designated authorities in Bangladesh, in this particular case, the Department of Fisheries (DoF). (Rahman, 2000). Subsequently, the ban was withdrawn under an agreement whereby shrimp exporters need to upgrade their processing plants and the government to issue a certificate of compliance.

increased costs, exporters of shrimp may either demand better quality shrimp (thereby reducing the risk of making a shipment that may be rejected) to reduce the costs of meeting the standards. The burden of SPS is, thus, passed on to the shrimp farms through the market.

To deal with the burden, shrimp farms might gradually need to intensify their operation. Thereby, shrimp farming might gradually transform into semi-intensive or intensive farming. In general, the local poor farmers will lose out while the wealthy shrimp cultivators will gain from this.

While intensive farming practices have some advantages, researches have shown that intensive shrimp farming causes irreversible damage to land and the environment. Environmental problems related to shrimp farming include: destruction of mangrove forests, thereby aggravating the effects of hurricanes, typhoons and flooding on local people and reducing the level of protection of habitats for some sea life, migrating birds and plant life; death of fish fry due to collection of shrimp-larvae from natural sources; and, increase in salinity due to monoculture of shrimp, etc. However, intensive farming, which has a higher yield per hectare, is a more efficient way to deal with SPS rules.

Some of the requirements for SPS measures are costly, time-consuming and also resource-intensive. Considering these, the SPS Agreement requires a certain amount of advance notice of new measures, so that exporters can adjust to compliance.

It is, therefore, argued that high compliance costs of SPS regulations might accelerate the process of intensification of shrimp farming practices leading to increase in the risks of ecological damage, degradation of land and increase in social conflicts.

3. Research method

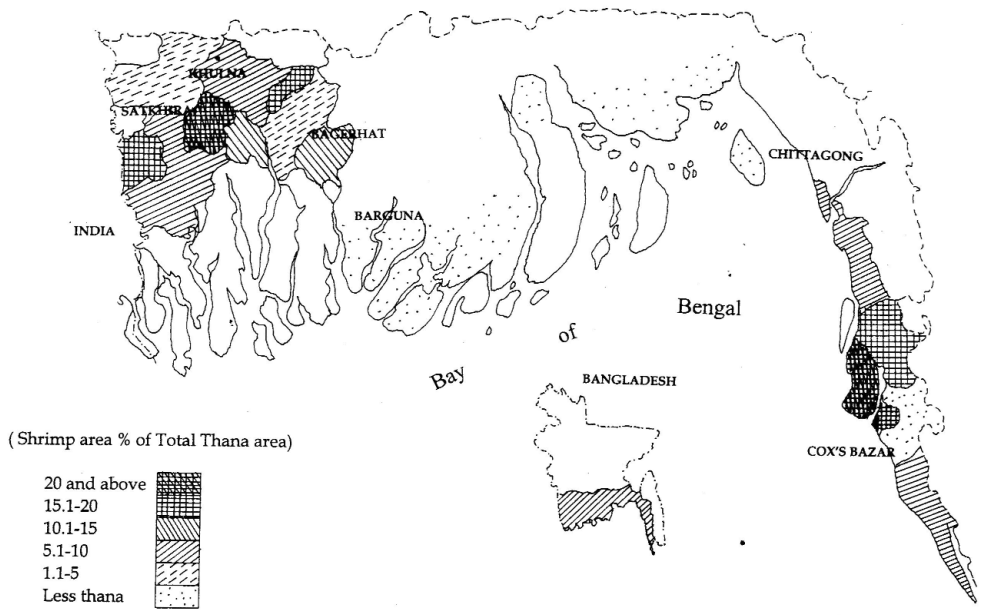
To study the implications of implementing HACCP methods at the shrimp farm, we have employed the following methods of research:

- questionnaire survey with shrimp farmers
- questionnaire survey with shrimp processors, and
- questionnaire survey involving local people related to shrimp farming.

The results of these surveys and our analyses are presented in the following sections.

4. Shrimp farms in Bangladesh

Shrimp cultivation area of Bangladesh



Most of the shrimp farms are located in the coastal belts of Bangladesh. The intensity of their operation is shown in the map above. For the purpose of this research we have interviewed 64 shrimp farms from Cox's Bazar, Khulna, Satkhira and Bagherhat districts. The questionnaire is enclosed in Appendix A. Separate questionnaire surveys on 23 shrimp processing farms and on 50 shrimp-related farm workers were conducted between September 2003 and March 2003.

Socio-economic profile of shrimp farmers

Table 1: Primary occupation of shrimp farmers surveyed

		Frequency	Per cent	Valid per cent	Cumulative per cent
Valid	Gher owner	51	79.7	81.0	81.0
	Gher-land owner	4	6.3	6.3	87.3
	Gher operator	3	4.7	4.8	92.1
	Local shrimp trader	2	3.1	3.2	95.2
	Shrimp middlemen	3	4.7	4.8	100.0
	Total	63	98.4	100.0	
Missing	System missing	1	1.6		
	Total	1	1.6		
Total		64	100.0		

Source: Field Survey

Most of the shrimp farm operators are *gher*-owners in these areas (shrimp ponds are locally called *ghers*). They also maintain a larger family size than average Bangladeshis (between seven and nine members). Only 25 per cent of them have families of seven or less members, 50 per cent have families with nine or less members and 75 per cent have families of 10 or less.

Figure 1: Ownership pattern of shrimp ponds

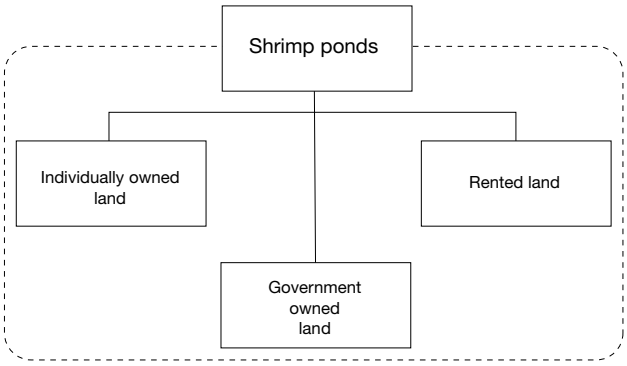


Table 2: Gross annual income of shrimp farmers (in taka)

	Frequency	Per cent	Valid per cent	Cumulative per cent
Between 20,000 and 30,000	2	3.1	3.1	3.1
Between 30,000 and 50,000	6	9.4	9.4	12.5
Between 50,000 and 75,000	4	6.3	6.3	18.8
Between 75,000 and 100,000	5	7.8	7.8	26.6
Between 100,000 and 150,000	11	17.2	17.2	43.8
Between 150,000 and 200,000	5	7.8	7.8	51.6
Between 200,000 and 300,000	5	7.8	7.8	59.4
300,000 and above	26	40.6	40.6	100.0
Total	64	100.0	100.0	
Total	64	100.0		

Source: Field Survey

In terms of income classification, these farmers, on average, earn an annual gross income of between Tk.150,000 and 200,000. This is a much higher income level compared to the average income of the people of Bangladesh (which is $376 or Taka 22,296). Table 2 presents the income classification of shrimp farmers included in the survey. Most of the farmers in the survey have been in this profession for more that 10 years and thus represent a relatively informed group of farmers.

Average length of experience of the people surveyed is nearly 13 years while 25 per cent of them have experience of 10 years or less, and 50 per cent of them have experience of 10 to 15 years.

About 17 per cent of the shrimp farmers have mentioned that they have a second occupation and it is again in the shrimp sector. They are either shrimp traders, or workers in shrimp farms.

In terms of their level of education, a large majority of them did attend primary school and some even completed Secondary and Higher Secondary levels of education (Table 3). Consequently, it is observed that shrimp farmers are relatively more educated compared to their farmer cohorts, who are mostly illiterate.

In terms of the number of fish ponds (locally named *gher*) operated by these farmers, we found that on average, 56 per cent of them operate one *gher* only. Another 38 per cent of these shrimp farmers operate two shrimp ponds. Their *gher* sizes, however, vary significantly. Nearly 25 per cent of them have an average size of one acre. These are known as *pocket gher* and are operated by individual families. 50 per cent of them operate *ghers* of 1.68 acres or less and 75 per cent operate *ghers* of seven acres or less. These larger *ghers* are owned by multiple families. The average age of these fish ponds is nearly 15 years. Eighty-five per cent of them operate their *ghers* on lands owned by them while only 12 per cent have rented land for shrimp farming and the rest occupied government *khas* (land under the ownership of the Ministry of Land).

Table 3: Level of education of the shrimp farmers

	Frequency	Per cent
Illiterate	3	4.8
Primary	29	46.8
High School	15	24.2
Secondary	13	21.0
Higher Secondary	1	1.6
Higher Studies	1	1.6
Total	62	100.0

Source: Field Survey

Shrimp farming in practice

How do they produce shrimps? What do they use for feed? Where do they collect their fry? These are the questions that shrimp farmers are frequently asked to judge the impact of shrimp cutter on the environment. We had several questions in the questionnaire to obtain feedback in this regard.

Multi-species production

In terms of shrimp farming, it has been observed that most of the shrimp farmers produce more than one type of fish in their ponds (a general characteristic of extensive shrimp farming). Farmers use multiple products to reduce their risks. We have observed that 50 per cent of them produce *bagda* (black tiger shrimp or *Penaeus monodon*),[11] 66 per cent produce *galda* (fresh water scampi or *Macrobrachium rosenbergii*), and 62 per cent produce other fish in their pond. On average, their intensity of fish species in a pond is 1.79.

[11] Black tiger shrimp represents 70 per cent of Bangladesh's export, fresh water scampi represents 15 per cent of the exports and the rest are either brown shrimp (*metapenaeus monoceros*) or Indian white shrimps (*penaeus indicus*).

Cost of production

The cost of pond preparation comes to nearly 85,000 taka[12] (the median). This is a one-time cost for a shrimp farmer and is applicable for the first timers in shrimp farming. Other costs include cost of post-larvae, cost of fertilizer, cost of feed, cost of security, and other management costs (see Table 4 for details).

Table 4 shows that for 25 per cent of the shrimp farmers, the initial cost of pond preparation (for roughly one acre of land) is 32,500 taka. This increases to Tk.85,000 if we include 50 per cent of the shrimp farmers of the survey who operate roughly 1.68 acres of land per pond. Cost of post larvae for the median shrimp farmers is nearly 20,000 taka per annum while other costs of production are nearly 10,000 taka per month. It varies between 5,000 to 18,000 taka per month for a large majority of shrimp farmers.

Table 4: Cost of pond preparation

	Number	Percentiles		
		25	50	75
Cost of pond preparation	60	32,500.00	85,000.00	300,000.00
Cost of fertilizer	41	2,000.00	3,000.00	5,000.00
Cost of post larvae	60	6,000.00	20,000.00	65,000.00
Monthly cost of feed	40	1,000.00	2,000.00	3,750.00
Other costs	59	1,000.00	5,000.00	10,000.00

Source: Field Survey

Source of shrimp fry

Shrimp farms have been accused of destroying other fish species in open waters. This is because shrimp fry are collected from nearby spawning grounds and fry of other fish species get killed during the process of shrimp fry collection.

This practice has been in vogue in many countries where shrimp production has expanded in the last few decades. Consequently, a ban on shrimp fry collection from open waters becomes a necessity. In Bangladesh, such a ban was imposed in September 2000. However, it could never be strictly enforced due to resistance from the fry collectors; nearly 450,000 fry collectors are operating in the coastal zones of Bangladesh. This year, the government has again begun working on effecting the ban.

Table 5: Sources of post larvae for shrimp farms

	Count	Per cent of responses	Per cent of cases
Rivers	3	2.6	4.9
Local markets	41	35.0	67.2
Local hatcheries	5	4.3	8.2
Non-local hatcheries	13	11.1	21.3
From vendors	55	47.0	90.2
Total responses	117	100.0	191.8

Source: Field Survey

[12] 1 US$ = 59 Taka (2003)

Table 5 shows that most of the shrimp farms collect post larvae (PL) from more than one source. The most dominant source for PL collection is still open waters (either from local markets or from local fry vendors or directly from rivers). Hatcheries supply only 15 per cent of the PL needs. Ninety per cent of shrimp farmers still buy shrimp fry from local fry vendors, who usually collect them from the local villagers. These villagers, in general, collect shrimp fry from the nearby rivers and creeks. Price of local fry is much higher than fry from hatcheries. This is due to high demand for local fry that have a much lower death rate.

Shrimp-cum-paddy farming

Table 6: Farming type in Bangladesh

Farming type	Count	Per cent of responses	Per cent of cases
Shrimp-cum-agricultural farming	38	71.7	73.1
Only shrimp farming	12	22.6	23.1
Shrimp cum salt farming	3	5.7	5.8
Total responses	53	100.0	101.9

Source: Field Survey

It has been argued that shrimp farming has been expanding in the coastal regions, forcing farmers to adopt the new farming mode instead of rice crops. In some cases, there were conflicts between paddy farmers and shrimp cultivators. However, Table 6 shows that a large majority of farmers use shrimp-cum-agricultural production in their shrimp ponds.

This fish-cum-agricultural production requires a unique type of land preparation, where fish (mostly non-shrimp) are pushed into a side-ditch during the cropping season. The side-ditches are so constructed in a paddy field as to ensure continuous shrimp-cum-crop farming for a sustained period. There are some shrimp-cum-salt farmers (from Cox's Bazar region)—a practice, which manifests the presence of high salinity in the nearby soil. Under shrimp-cum-paddy farming, farmers grow one crop of paddy and another of shrimp alternately.

Field survey data shows that most of the land was converted from agricultural use to shrimp farming (Table 7). However, some fallow, forestland, and also dried riverbeds were converted to shrimp farming ground in some areas.

Table 7: Land use pattern before shrimp farming began

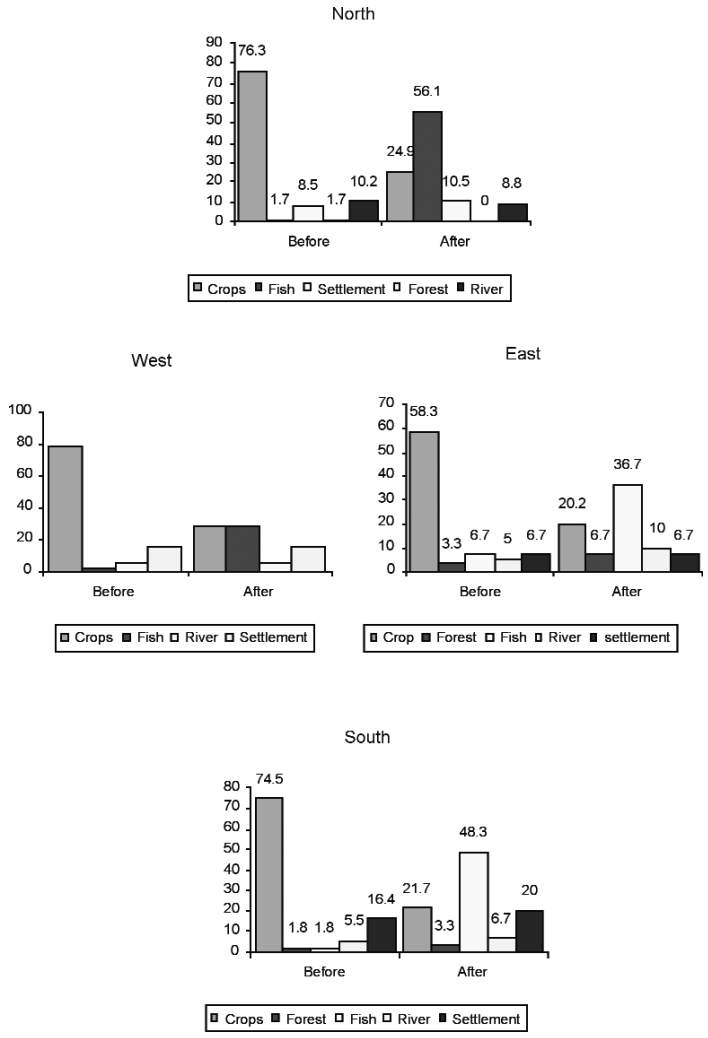
Land used for	Count	Per cent of response	Per cent of cases
Agriculture	55	87.3	94.8
Forest	1	1.6	1.7
Fallow land	6	9.5	10.3
River bed	1	1.6	1.7
Total	63	100.0	108.6

Source: Field Survey

Changes in land use after shrimp

While shrimp farming has undoubtedly increased the income of farmers in coastal zones, it has also gradually altered the land use pattern from all-agricultural to more shrimp farming in an area where shrimp farming began. This is a manifestation of the gradual adoption process. Figure 2 shows that the big gainer is aquaculture. Success of shrimp farming in one crop fields has gradually led others in the neighborhood to adopt not only shrimp farming but also to mix crop with aquaculture over time. The impact on forest, however, is found to be minimal and this is consistent with the fact that the mangrove forest in the Sundarban has not been converted to shrimp farming. However, in Cox's Bazaar region, this was not the case. Here, lease of forestland was allowed by the government to establish shrimp farms. The significant difference is that the Sundarban forest is a protected area while the Cox's Bazar mangrove forest is not a protected area.

Figure 2: Changing pattern of land use around a shrimp farm



Source: Field Survey

Income from shrimp farming

As has been mentioned, shrimp farming has been a very lucrative means to increase the income of farmers at the local level; we have seen some graduation into shrimp farming. Over the past few decades, this has been move evident. In our survey, it has been found that although shrimp farmers still continue to grow crops along with shrimp, their share of income from crops has been diminishing. On average, 70.3 per cent of the shrimp farmers surveyed during this research earn between zero and 15 per cent of their annual income from other sources. About 24.3 per cent of the farmers have reported that between 15 and 30 per cent of their income comes from non-shrimp sources (Table 8).

Table 8: Share of income from non-shrimp sources

	Frequency	Per cent
0–15 per cent	26	40.6
15–30 per cent	9	14.1
30–50 per cent	2	3.1
Total	37	57.8
System missing	27	42.2
Total	64	100.0

Source: Field Survey

Such changes are due to complementarities between shrimp farming and fish farming. Survey data also show that nearly 25 per cent of the tiger shrimp farmers earn less than 200,000 taka a year from tiger shrimp. This is 70,000 taka for *galda* shrimp and 10,000 from aquaculture of other fish. It has been found that the median gross income of a tiger shrimp farmer is 400,000 taka while it is 100,000 for *galda* farmer and 22,500 for a white fish farmer. Clearly, *galda* farmers are small operators who mostly use small ponds to cultivate shrimp. Although white fish are clearly the least profitable, it is widely farmed with shrimp by small farmers. White fish has ready-made local markets so it is a less risky product.

Table 9: Per acre cost of production by shrimp farms

		Annual cost		Monthly cost	
		Pond construction	Fertilizer application	Feed cost	Other costs
Bagda	Mean	96,333.10	12,674.4094	590.85	19,041.40
	N	29	16	13	28
	SD	303,851.86	44,822.90	497.90	87,752.71
Galda	Mean	40,432.45	3,300.93	2,018.99	2,233.95
	N	39	34	36	38
	SD	23,706.63	4,965.07	2,995.55	2,572.21

Source: Field Survey

Table 9 shows cost of production per acre by type of shrimp farm. It shows that *bagda* farms have more fixed costs and more operating costs than *galda* farms. This proves the general hypothesis that *bagda* shrimp farms are concentrated more in the hands of the rich people whereas *galda* shrimp farms are mostly in the hands of poor homestead farmers. Table 10 shows the income classification by shrimp farm type. It is evident from the table that *galda* shrimp farming is not only less costly (in terms of initial costs), it is also a less risky venture. Table 10

also shows that all types of shrimp farmers are using white fish as a part of their joint production. It shows 21 of 27 *bagda* shrimp farmers and 33 of 35 *galda* farmers produce white fish in their ponds.

Table 10: Income by types of shrimp farms

		Income per acre from		
		Galda Shrimp	**White fish**	**Bagda Fish**
Bagda	Mean	47,708.26	55,309.93	80,595.14
	N	8	21	27
	SD	45,313.03	216,536.68	121,519.57
Relative income risk	Coef. of variation	94.97%	391.50%	150.77%
Galda	Mean	79,788.25	44,023.07	145,607.00
	N	35	33	9
	SD	36,166.07	171,724.70	196,287.29
Relative risk	Coef. of variation	45.33%	390.07%	134.80%

Source: Field Survey

Feed and medicine used

The cost of shrimp production data has already shown that the only input the shrimp farmers in Bangladesh use to produce shrimp is fertilizer. According to our survey, a typical shrimp farm in Bangladesh usually uses no chemicals (but they use lime to curate the ponds each year) during farming in the ponds. Moreover, instead of applying medicines (like antibiotics) to fight diseases, shrimp farms have resorted to a risk management strategy of producing more than one type of fish (usually in separate ponds). This is less costly and, perhaps, it prevents the farm from going bankrupt in case of an outbreak of disease in the shrimp ponds.

Equipment of a shrimp farm

The study also found that the number of tools or equipment used by a typical shrimp farm in Bangladesh is very little. Table 11 shows that all farms are equipped with locally-made bamboo baskets that are washable. Very few, as low as 10 per cent of the farms, have plastic containers to transport shrimp from farms to the processing stations. Roughly, 25 per cent of them have rickshaw vans to transport shrimp to the nearest landing station. The one large firm that we have surveyed has motorized transport vans to move shrimp to the processing unit.

Table 11: List of equipment in a shrimp farm

Equipment	**Count**	**Per cent of responses**	**Per cent of cases**
Bamboo baskets	59	70.2	100.0
Plastic containers	6	7.1	10.2
Platform to keep shrimp	2	2.4	3.4
Richshaw van	15	17.9	25.4
Ice boxes	1	1.2	1.7
Motorized vehicle without freezing unit	1	1.2	1.7
Total	84	100.0	142.4

Source: Field Survey

This list of equipment for shrimp excludes other equipment that farmers use during crop production. In other words, this list is additional equipment that shrimp farmers need to produce shrimp in their ponds.

To understand why these shrimp farmers need so little equipment, let us examine the activities that a typical shrimp farm completes during shrimping (Table 12).

Table 12 shows that, on average, a shrimp farm completes three of the four jobs listed in the table. They all accomplish one function without failure and it is releasing the post larvae of shrimp that is vital for shrimp production. Even application of urea is done by only 54.1 per cent of the farmers. We have already discussed the sources of fry collection.

Table 12: Activities needed for shrimping

Activity	Count	Per cent of response	Per cent of cases
Ploughing	42	22.1	68.9
Urea application	33	17.4	54.1
Releasing PL	61	32.1	100.0
Bank preparation	54	28.4	88.5
Total	190	100.0	311.5

Source: Field Survey

The shrimp they sell

It has been found that 50 per cent of the farms sell their produce to local traders[13] while the rest goes directly to the processing farms. It was found that a large majority of shrimp farmers sell their shrimp at sizes of eight to 30 (number of shrimps per kg.; Table 13). The price of shrimp is inversely related to its size, meaning the larger shrimp fetch more money. Considering the price sensitivity to shrimp size, one would expect that shrimp farmers would wait until all the shrimp are of equal size to earn maximum return. Instead, most of them sell shrimp in three sizes. This implies a more risk aversive behavior of the farmers (who cannot wait and risk the probability of death due to diseases) and it may also be evidence of distress sale of shrimp by small farmers.

Table 13: Size of shrimp

Size per kg	Count	Per cent of response	Per cent of cases
Size 5	1	.9	2.9
Size 8	24	20.7	70.6
Size 12	28	24.1	82.4
Size 20	33	28.4	97.1
Size 30	30	25.9	88.2
Total	116	100.0	341.2

Source: Field Survey

Shrimp farms and environmental awareness

The study found that except for one large farm, none of the shrimp farms have any idea of the HACCP rules. This is true despite the fact that an official of the Ministry of Fisheries visited

[13] Local traders after sorting and grading usually sell their products to both in local markets and to processors.

73.7 per cent of the shrimp farms in the month prior to this survey. This number is, surprisingly, less than the number of local traders who visited their farms in the same period. However, only 30 per cent of the farms had a visitor during the period.

To understand the impact of shrimp farms on the environment, the survey posed a set of questions regarding farmers' opinions related to awareness, understanding and the linkage between environment and shrimp farms in their locality. Table 14 summarizes the results.

Table 14: Shrimp farmers' opinions on shrimp farming and its impacts

Statement	Per cent agreed	Per cent disagreed[14]
Shrimp farming is affecting the availability of post larvae in the locality	93.5	4.8
Shrimp farms are destroying the mangroves in the locality	63.3	3.3
Snails and other shellfish are now less available	59.7	3.2
Land is more saline now than before	55.7	32.8
Livestock in the area are decreasing	44.3	41.0
People are migrating out of the area for more jobs/work	3.4	67.2
Less jobs are available for farm workers in the area	11.9	50.8
More jobs for shrimp farm workers	90.0	3.3
More shrimp-related business	96.7	1.7
Less farm business in the area	7.1	42.9
Shrimp farming is a risky business	90.6	–
Shrimp diseases are more frequent in the area	90.6	–
My farm has been affected by disease	92.2	–
We use more lime now to fight the disease	79.3	–
I use lime to fight the diseases	78.6	–
I should give up crop farming	96.4	–
I want to know more about shrimp farming	96.4	–
I would like to convert to all shrimping—year-round	87.3	–
I need more funds to do this	94.4	–
I need more information on health and hygiene rules	100.0	–
I would prefer to lease land for more shrimping	90.6	1.9
I would like to buy more land for shrimp farming	94.6	–
I need more information on chemicals and medicines	100.0	–
I need more information on quality of PL from hatcheries	81.3	–
I want to buy processed feed	79.1	–
I want to use natural feed—I would buy	46.3	–
I want to use natural feed—I would collect	10.3	46.2
Natural feed is less costly	70.3	8.1
Natural feed is better than processed feed	82.9	4.9
Agricultural farming is less profitable than shrimp farming	98.0	2.0
Forest is less profitable than shrimp farming	92.2	7.8
Agriculture is less profitable than forest	37.3	60.8
Department of Fisheries need to guide shrimp farmers	100	–
Processing plants need to guide shrimp farmers	100	–
More loan money from banks is needed for shrimp farming	98.3	–
Shrimp farming is like industrial production	89.5	1.8

[14] Agreed + disagreed + no comment = 100%

Table 14 gives some interesting observations. First, shrimp farmers are aware of the negative impact of shrimp farming on the environment. For example, 93.5 per cent of the shrimp farmers agreed that availability of post-larvae for shrimp ponds from natural sources is diminishing. The local price of natural post larvae is much higher than the price of PL from hatcheries but the high mortality rate of PL from the hatcheries is still working as a deterrent.

Table 14a: Statement: Mangroves are converted into shrimp farms

	Cox's Bazar	Khulna	District Bagerhat	Satkhira	Total
Agree	100.0%	38.9%	57.1%	77.8%	63.3%
Disagree		5.6%	4.8%		3.3%
No comment		55.6%	38.1%	22.2%	33.3%
	100.0%	100.0%	100.0%	100.0%	100.0%

Except for Cox's Bazar, shrimp farmers are divided on the issue of conversion of mangrove forests into shrimp farming. Table 14a explains this in more detail. In Satkhira, the quality of mangrove forests have been deteriorating and much private land that previously held mangrove forest is also being converted. Overall, there seems to be some agreement that some mangrove forest lands are being brought into shrimp farming (except in Khulna).

There is, however, no consensus among the shrimp farmers on increase in soil salinity in the area. Secondary data, however, did show an overall increase in the soil salinity in the coastal zone (much of it is due to the shortage of fresh water flow into the Sundarban area during the dry season as the major river Gorai dries up). In addition, due to the continuation of shrimp-cum-agriculture production method, land salinity may not have increased as much as it would have been with only shrimp farming.

There were some *a priori* notions that, due to shrimp farming, much of the fallow land has been taken up for shrimp culture and so the number of livestock head in the area may have been reduced. There was no evidence to establish this and only 44 per cent subscribed to this kind of statement.

Similarly, shrimp farming communities did not accept that shrimp farming has reduced availability of farming jobs or that people are migrating out of these regions in search of jobs. On the contrary, people have opined that shrimp farming has added new jobs in this new thriving sector as it has given rise to more business in the area (through forward and backward linkage effects).

A striking revelation that the survey brought forth is that shrimp diseases are on the rise. Nearly 92.2 per cent of the shrimp farmers stated that there were diseases in their farms. What do they do in case of such outbreaks of diseases?

The survey found that most of them use lime and potassium to treat the diseases. Yet, it may be noted that the EU ban was imposed on the grounds that harmful substances were discovered in shipments of shrimp exported from Bangladesh. During discussion with the farmers, it was revealed that such contamination (like presence of pathogens, chloramphenicol, etc.) were likely to have come from pesticides used during crop production in the same field. However, it has also been asserted by some experts that pesticide residues cannot be present in soil after the heavy rainfall, when shrimp production takes place.

Nearly 79.7 per cent of the farmers used lime or lime and potassium to treat sporadic outbreak of diseases (Table 15). Also, farmers wanted to know more about fighting diseases and basic hygiene rules to produce better shrimp.

Table 15: Treating diseases in a shrimp farm

	Frequency	Per cent
Lime	44	68.8
Lime and potassium	7	10.9
Total	51	79.7
System missing	13	20.3
Total	64	100.0

Source: Field Survey

Finally, most shrimp farmers seemed ready to convert their farms exclusively into shrimp farms. This intent was expressed by 96 per cent of the farmers. This is despite the fact that 90 per cent of the shrimp farmers considered it to be a "risky business."

A large majority of them are interested in using processed feed. Interviews also revealed that most of them considered processed feed a more balanced diet for shrimp than natural feeds (though this is not shown in the survey results). In addition, natural feed is getting to be costlier everyday.

More than 90 per cent of the farmers are even inclined to lease or purchase land for more shrimp culture. Consequently, the writing on the wall is clearer now than ever before. Shrimp culture in the coastal belts has increased income of the people. A relatively more enlightened group of people (with a higher level of education than the paddy farmers) are involved in this type of farming. Over the past 15–20 years, they have acquired enough experience to take up this "risky business" and are now ready to take up more land for shrimping. Tiger shrimp farming is more profitable than other types of fish farming and so more land in the coastal belt would be taken up for shrimping. However, the speed of its growth will be affected by higher land prices.

Experience in shrimping and price of land would eventually lead this industry towards intensive shrimp culture. And this is something that would worry a lot of environmentalists. However, at the moment, the impact on the local environment is somewhat limited.

5. The processing firms

Shrimp processing is a high-cost industry. In Bangladesh, there are nearly 124 shrimp processing firms located in Chittagong and Khulna (some of them are no longer operating). These firms are the backbone of the shrimp exports from Bangladesh and they take the ultimate risk of the business. Processing firms are usually fitted with freezing, washing and processing units to process shrimp for exports.

Table 16: Daily processing capacity and used capacity

	percentiles		
	25	**50**	**75**
Capacity in tons per day	12.0000	19.0000	23.5000
Used capacity per day (t)	3.5000	5.0000	10.5000

Source: Field Survey

Twenty-one processing farms (all of them operating) were surveyed using a questionnaire for the purpose of this research. All of these firms have an income higher than 300,000 taka per year. Twenty-five per cent of them have been operating since 1986 or earlier, 50 per cent of them have been in the export business since 1990 or earlier and 75 per cent of them have been in the export business since 1994 or earlier.

These farms can process, on average, nearly 23.5 tons of shrimp a day. Of the 21 processing firms, 25 per cent have a daily capacity of 12 tons or less, 50 per cent with a capacity of 19 tons or less and 75 per cent, 23.5 tons or less. However, none of them was found to be operating at its full capacity. Table 16 shows that they are mostly processing at less than 50 per cent of their daily capacities.

In general, HACCP rules are applied to all of these firms and many of them are fully aware of the food health safety requirements.

Table 17: Investment for establishment of the refrigeration unit and the chemical laboratory

	Percentiles		
	25	50	75
Cost of refrigeration unit	2,550,000	5,500,000	28,325,000.00
Capacity of refrigeration unit	11.9052	22.0000	460.0000
Lab establishment cost	600,000.0	800,000.0	1,600,000.000

Source: Field Survey

The survey shows that all of these processing firms have their own refrigerated vans for transportation of processed shrimp and some even have insulated vans in addition. All of them have chemical laboratories to conduct tests when necessary and on average they spent 150,000 taka to establish a laboratory. On average, 25 per cent of the firms spent 2.5 million taka for establishing refrigeration units with a capacity of nearly 12 tons. Table 17 shows the details.

Table 18 shows that most of the firms established their quality control department to comply with the HACCP rules (per cent of cases in Table 18 is more than 100 on this item). At the same time, all of them had at least one person from each firm trained on HACCP rules to deal with the SPS-related issues. Some of them attended more than one training course and some firms have more than one trained person.

Table 18: On upgradation of processing units for HACCP compliance

Items upgraded	Count	Per cent of responses	Per cent of cases
Quality control department	25	24.0	119.0
Training	40	38.5	190.5
Dress	10	9.6	47.6
Modern machinery	8	7.7	38.1
Fleck ice	7	6.7	33.3
Reconstructed building	3	2.9	14.3
Sewage system	4	3.8	19.0
Sanitation	2	1.9	9.5
Doctors	2	1.9	9.5
Water treatment	2	1.9	9.5
Refrigerator	1	1.0	4.8
Total responses	104	100.0	495.2

Source: Field Survey

It has been found that nearly 50 per cent of them upgraded the dress code of workers, 38 per cent of them upgraded laboratory machines, 14 per cent needed to renovate their factory building and 19 per cent had to adjust their sanitary facilities to comply with the HACCP rules. Table 19 shows that training costs vary from Tk.17,500 to Tk.77,500 for most of the firms. While operating costs for HACCP compliance varies from 800,000 to 2,000,000 taka for a large majority of the firms.

Table 19: Operating costs for HACCP compliance

	Percentiles		
	25	50	75
Training cost	17,500.00	50,000.00	77,500.00
Operating cost per month	800,000.0	1,300,000	2,000,000
Other machinery costs	1.0000	1.0000	1.7500

Source: Field Survey

The next issue was to find out how much of their capacity has been utilized. Surprisingly, however, it was observed that most of the firms operated for less than 60 days in a year. This is a significant number given the fact that the monthly operating costs of these firms are quite large. At the same time, it was found that nearly 25 per cent of their processed shrimp was not exported. In most cases, this indicates either a rejection rate or failure to comply with HACCP rules for export. None of the firms surveyed has officially acknowledged the use of any chemical agents except salt and distilled water during processing.

Table 20: Amount of export and processing tonnage

	Percentiles		
	25	50	75
Export in the last year	575.0000	1025.0000	1411.4446
Tons processed last year	745.0000	934.0000	1752.8718

Source: Field Survey

In terms of employment generation, workers at the processing unit comprise male and female, skilled and semi-skilled persons while the managerial positions are mostly filled by men.

Table 21 shows the list of equipemnt used in a shrimp processing firm. It shows that most of the firms are equipped with boots and gloves for workers, plastic containers, fish washing units, hand washing facilities, ice producing unit, freezing unit, doctors, chemical laboratory, dress for workers, health checkup kits for workers, water plants, etc. These are the basic requirements for HACCP compliance.

Table 21: List of equipment in a shrimp processing farm

Dichotomy label	Count	Per cent of responses	Per cent of cases
Boots and gloves	21	6.2	100.0
Plastic containers	21	6.2	100.0
Bamboo baskets	3	0.9	14.3
Platform to keep shrimp	21	6.2	100.0
Hand-washing facilities	21	6.2	100.0
Chlorine to wash hands	21	6.2	100.0
Freezer van	20	5.9	95.2
Ice producing unit	21	6.2	100.0
Freezing unit	21	6.2	100.0
Motorized vehicle without freezing unit	5	1.5	23.8
Shrimp washing unit	21	6.2	100.0
Packaging unit	7	2.1	33.3
Water plant	21	6.2	100.0
Chemical lab	21	6.2	100.0
Doctor for workers	21	6.2	100.0
Dress for workers	21	6.2	100.0
Washing unit	19	5.6	90.5
Health checkup facilities	21	6.2	100.0
Processing and packaging unit	9	2.7	42.9
Others	1	0.3	4.8
Total responses	337	100.0	1,604.8

Source: Field Survey

Environmental risks

It has already been mentioned that shrimp exports have been a very sensitive issue around the globe. The major allegation against shrimp exporters comes from environmentalists on the grounds that it is destroying mangrove forests. On top of this, they are blamed for creating social tensions as well as degrading the local environment. Consequently, exporters are under strict public regulation. Our survey shows that, on average, each firm had more than three visitors in the last six months (Table 22).

Table 22: Visitors in last six months

Visitors from	Count	Per cent of responses	Per cent of cases
Processing unit person	4	5.3	19.0
Local traders	13	17.1	61.9
Ministry of Fisheries	17	22.4	81.0
Ministry of Environment	6	7.9	28.6
Exporter association	17	22.4	81.0
University researchers/students	10	13.2	47.6
Local visitors	6	7.9	28.6
Others	3	3.9	14.3
Total responses	76	100.0	361.9

Source: Field Survey

To study the awareness of the processing firm owners, we posed them the same set of questions as we did the shrimp farmers. Their responses are shown in Table 23.

Table 23: Shrimp processors' opinions on shrimp farming and its impacts

Statement	Per cent agreed	Per cent disagreed[15]
Local shrimp post larvae are become less and less available	50.0	30.0
Mangroves are converted to shrimp farms	50.0	50.0
Snails and other shellfish are now less available	10.0	50.0
Land is more saline now than before	10.0	45.0
Livestock in the area are decreasing	15.0	65.0
People are migrating out of the area for more jobs/work	5.6	83.3
Less jobs are available for farm workers in the area	57.1	42.9
More jobs for shrimp farm workers	100.0	–
More shrimp-related business	100.0	–
Less farm business in the area	91.7	–
Shrimp farming is a risky business due to diseases	92.3	7.7
My farm has been affected by diseases	40.0	40.0
We use more lime now to fight the disease	81.8	–
I use more lime now to fight the diseases	83.3	–
We should give up crop farming	100.0	–
We should monitor shrimp farms more closely	88.9	–
I am interested in buying shrimp from farms that I know	75.0	16.7
I would lend money to promote more shrimp production	75.0	16.7
I should start producing my shrimp	90.9	–
I would prefer to lease land for more shrimping	75.0	–
Government should invest more in developing shrimp farmers	100.0	–
I need more information on chemicals and medicines	92.9	–
Shrimp farm-related conflicts are up in the area	7.1	42.9
Agricultural farming is less profitable than shrimp farming	66.7	11.1
Forest is less profitable than shrimp farming	50.0	50.0
Agriculture is less profitable than forest	50.0	37.5
Department of Fisheries needs to guide shrimp farmers	91.7	8.3
Processing plants need to guide shrimp farmers	100.0	–
More loan money from banks is needed for shrimp farming	100.0	–
Shrimp farming is like industrial production	100.0	–

Source: Field Survey

Analysis of the statements above reveals that shrimp processing firms are now more inclined to go into shrimp farming. This is a tendency, hypothesized in this research, that has significant environmental implications.

Large shrimp farms are very difficult to manage and extensive shrimp farming is comparatively riskier than intensive farming. This is due to the fact that in an intensive method of production, a more controlled environment has to be imposed to control diseases.

[15] Agreed + disagreed + no comment = 100%

Moreover, intensive farming has a limited lifetime and after each cycle of six to 10 years, intensive farms need to replace their soil. Dumping of polluted soils (full of pathogens and chemicals) into rivers or in open waters is likely to destroy the local environment and would affect the aquatic biodiversity in the area. This clearly increases the environmental risks.

The big question is whether mandatory compliance of SPS rules through adoption of HACCP schemes induces a process that would eventually establish the possibility of intensive shrimp farming in the area. If this is the case, then it is important to take note of the current institutional framework of environmental standards and examine whether it is capable of withstanding the pressure this would create. The pressure is in terms of local producers who are forced to adopt a health standard far above their ability, and consequently, whether the domestic authority may becomes less motivated to apply a second additional pressure in terms of domestic environmental standards on the environmental front. We examine this issue in following section.

6. Non-shrimp farmers in shrimp areas

As it has been mentioned before, expansion of shrimp farming in rural Bangladesh has led to an increase in social discord in the region. This has been raised by several NGOs (Nijera Kari, for example, has accused shrimp farming of leading to an increase in violations of human rights in coastal zones of Bangladesh). The primary accusation is that expansion of shrimp farms means more money in rural areas and so it increases incidences of violation of established social norms. It has also led to an increase in joblessness among rural people, thus creating social unrest.

Against this backdrop of accusation, the opinions of the local people linked with the shrimp industry were collected and the results are presented in Table 24. It is important to analyze these opinions to understand the future of shrimp farming in the area. What is clear, from a glimpse at the table, is that there is an agreement between the farmers and the local people over some situations, but there are also significant disagreements between them.

It is evident from their response that most of them (non-shrimp farmers) would also like to take up shrimp farming since they recognize the fact that shrimp farming as a *profitable venture*. However, access to capital has remained a problem for most of them. Most of them have agreed that less and less jobs related to crop farming are available in the area as the shrimp industry expands.

Consequently, local people are eager to learn about shrimp farming, a clear sign of the future changes in the farming practices in the area. To them, shrimp farming is one of the most profitable activities that is followed by crop farming and then forest resource harvesting. Consequently, it can be argued that people are likely to transform forestland and agricultural land into shrimp lands over time. However, information about shrimp farming and the availability of credit are the two major stumbling-blocks faced by them.

Similarly, most of them believe that shrimp farming is a risky business (compared to crop farming) and so, unless the markets are more integrated, it is unlikely that such transformation will take place.

Table 24: Opinion of local people on shrimp farming

Statement	Per cent agreed	Per cent disagreed[16]
Local shrimp post larvae are becoming less and less available	89.8	2.2
Mangroves are converted to shrimp farms	28.6	2.0
Snails and other shellfish are now less available	75.5	2.0
Land is more saline now than before	38.8	28.4
Livestock in the area are decreasing	32.7	49.0
People are migrating out of the area for more jobs/work	76.5	26.5
Less jobs are available for farm workers in the area	2.0	22.4
More jobs for shrimp farm workers	73.5	26.5
More shrimp-related business	93.9	6.1
Less farm business in the area	2.2	19.6
Shrimp farming is a risky business due to diseases	93.9	6.1
I need to buy land for shrimp farming	2.1	–
I should give up crop farming	60.4	39.6

[16] Agreed + disagreed + no comment = 100%

Statement	Per cent agreed	Per cent disagreed
I should monitor shrimp farm more closely	66.7	33.3
I should convert my land to all shrimping	50.0	50.0
I need more money for better shrimp farming	39.6	–
I prefer to lease my land for shrimp farming	2.0	–
I need information on health rules	77.1	–
Shrimp farms buy natural feed	43.8	–
I need more information on chemicals and medicines	58.3	–
I need more information on quality of PL from hatcheries	58.3	–
Shrimp farms collect natural feed from rivers, lakes, etc.	12.5	–
Natural feed is more costly	20.8	–
Natural feed is better than produced feed	35.4	–
Agricultural farming is less profitable than shrimp farming	58.3	–
Forest is less profitable than shrimp farming	72.9	–
Agriculture is less profitable than forest	2.0	79.6
Department of Fisheries needs to guide shrimp farmers	66.7	–
Processing plants need to guide shrimp farmers	70.8	2.1
More loan money from banks is needed for shrimp farming	60.4	–
Shrimp farming is like industrial production	64.6	–

A comparative analysis of opinions

Table 25 presents a comparative analysis of opinions expressed by shrimp farmers, shrimp processors and the local people.

It shows that there are some points where all three groups agree and some points where they disagree. At the same time, their degree of agreement or disagreement differs. An agreement supported by 75 per cent or above in each group is labeled as significant agreement, an agreement supported by 50 per cent or above is labeled as agreement and vice versa. Using such a qualitative scale, Table 25 summarizes the agreements and disagreements. It should be clear that the opinion was taken in March 2003 from all the respondents who were party to this research.

With regard to the affect of shrimp farming on the environment, expressed in terms of more pressure on shrimp larvae from the rivers, collection of snails from wetlands and destruction of mangroves, there exists some degree of differences in their opinion. Shrimp farmers and non-shrimp farmers agree (nearly 90 per cent of them) with the statement that *shrimp farming is affecting the availability of post larvae in the locality*. Interestingly, only 50 per cent of the shrimp processors agree with this statement. This difference may be interpreted as *ignorance* of the shrimp processors regarding farming practices and the local supply of PL from rivers and creeks.

Regarding the increase in soil salinity due to shrimp farming, all the parties (shrimp farmers, non-shrimp farmers and processors) disagree that shrimp farming is linked with an increase in salinity in the area. Such an opinion is not unexpected, given the fact that the source of fresh water supply into the region usually dries up during the dry season and it is linked with both withdrawal and diversion of water from the Ganges by India, and silt accumulation in the river beds in the northern parts. The fact remains that the salinity frontier in the region has been traveling north since the operation of the Farakka barrage in India.

With regard to the impact of shrimp farming on the availability of grazing land and the total supply of livestock in the region, all parties again seem to disagree with the statement that livestock is decreasing in the region. Our field survey also corroborated this. The reason being that shrimp farms are still used for grazing after harvesting the crops and grazing is not a problem as long as shrimp-cum-paddy or extensive shrimp farming exists in the region.

Table 25: Comparative analysis of opinion of shrimp farmers, shrimp processors, and local people on shrimp farming in coastal areas

Statement	Shrimp farmers		Processing firms		Local people		Comments
	% agreed	% disagreed[17]	% agreed	% disagreed	% agreed	% disagreed	
Shrimp farming is affecting the availability of post larvae in the locality	93.5	4.8	50.0	30.0	89.8	2.2	Significant agreement between shrimp farmers and local people. Whereas shrimp farmers and local people agree on this, processing farms seem be less aware of the fact that shrimp farms are affecting the availability of PL in the locality.
Shrimp farms are destroying the mangroves in the locality	63.3	3.3	50.0	50.0	28.6	2.0	Agreement between shrimp farmers and shrimp processors. Almost all of them seem to agree that shrimp farming does not affect mangroves.
Snails and other shellfish are now less available	59.7	3.2	10.0	50.0	75.5	2.0	Agreement between all groups. Significant difference in opinion exists among local people and the farmers.
Land is more saline now than before	55.7	32.8	10.0	45.0	38.8	28.4	Not much disagreement among farmers, processors and local people.
Livestock in the area are decreasing	44.3	41.0	15.0	65.0	32.7	49.0	While farmers and local people have somewhat agreed on the fact that shrimp farming has not decreased livestock in the area, processing farms tend to believe that livestock has decreased.
People are migrating out of the area for more jobs/work	3.4	67.2	5.6	83.3	76.5	26.5	While farmers and processors tend to say that people are not migrating out of the local area due to shrimp farming, locals agreed with this opinion.
Less jobs are available for farm workers in the area	11.9	50.8	57.1	42.9	2.0	22.4	While farmers and local people at the rural level disagreed with this statement, processors tend to agree with it.

[17] Agreed + disagreed + no comment = 100%

Statement	Shrimp farmers		Processing firms		Local people		Comments
	% agreed	% disagreed[17]	% agreed	% disagreed	% agreed	% disagreed	
There are more jobs for shrimp farm workers	90.0	3.3	100.0	–	73.5	26.5	All agree with this statement.
There is more shrimp-related business	96.7	1.7	100.0	–	93.9	6.1	All agree with this statement.
There is less farm business in the area	7.1	42.9	91.7	–	2.2	19.6	Farmers and local people tend to disagree while processors agree with this.
Shrimp farming is a risky business	90.6	–	92.3	7.7	93.9	6.1	All agree with this.
Shrimp diseases are more frequent in the area	90.6	–	40.0	40.0	42.2	2.2	Farmers are more in agreement with this statement than others. Others may not be as informed as the farmers are, since the farmers are generally affected by it.
I should give up crop farming	96.4	–	100.0	–	60.4	39.6	While shrimp farmers and the processing people agree with this very strongly, local people are somewhat restrained in supporting the statement.
I would prefer to lease land for more shrimping	90.6	1.9	75.0	–	2.0	–	Shrimp farmers and processors agree with this.
Need more information on chemicals and medicines	100.0	–	92.9	–	–	–	Farmers and processors agree with this statement very strongly.
I need more funds to do this	94.4	–	75.0	16.7	39.6	–	The tone of agreement to this state is stronger in the case of shrimp farmers and processors than that of local people.
I need more information on health and hygiene rules	100.0	–	90.9	–	77.1	–	All agree with this statement.
Agriculture is less profitable than forest	37.3	60.8	50.0	37.5	2.0	79.6	Shrimp farmers and local people agree with this statement more strongly that the processors.
Forest is less profitable than shrimp farming	92.2	7.8	50.0	50.0	72.9	–	Farmers and local people agree more strongly than the processing farm owners.
Agricultural farming is less profitable than shrimp farming	98.0	2.0	66.7	11.1	–	–	

With regard to the affect of shrimp farming on employment, income and on trade and commerce in the region, all of them (shrimp farmers, non-shrimp farmers, and processors) agree that more jobs are being created in the region due to shrimp farming. There is also a strong agreement among them about the risks involved in shrimp farming.

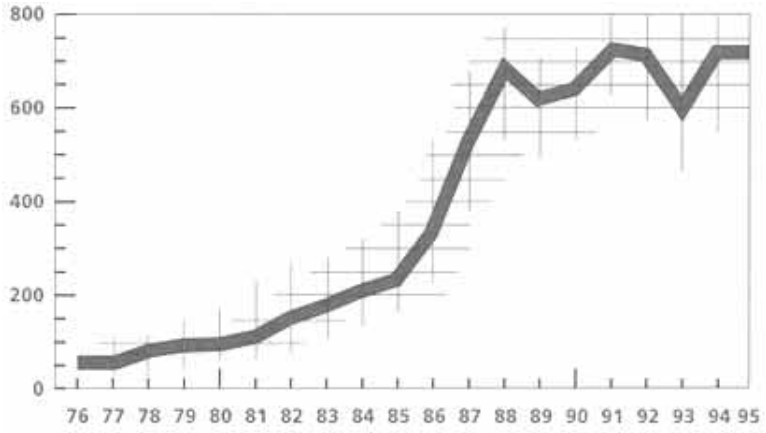
On the incidence of diseases in shrimp farms, farmers have more information and more then 90 per cent of them reported that shrimp diseases are more frequent in their area. Contrary to them, others seem to have less idea about it and hence did not agree to this statement.

A large majority of shrimp farmers and processors are ready to replace cropping with shrimping compared to non-shrimp farmers. The former groups are also more eager to expand their shrimp-related activities; however, they need much greater access to financing to accomplish this. At the same time, all of them (shrimp farmers, processors and non-shrimp farmers) have mentioned that they need to have more information on shrimp-diseases and ways to deal with them.

Shrimp farmers and processors consider shrimp farming more profitable than crop farming. On the other hand, except for processors, both shrimp and non-shrimp farmers agreed with the statement that agriculture is more profitable than forests, implying their willingness to shift forest land (owned by them) into agriculture.

Consequently, we may conclude that there exists a situation at the rural level which is favorable to shrimp farming even though the current productivity of shrimp farms is far less then normal and they are clearly inefficient in terms of their utilization of resources. Our data has shown that income from shrimp farming is much higher than from crop farming in the area.

Furthermore, shrimp processors have expressed that they would prefer to "buy" shrimp from their own/known farms or they would like to lease land for shrimp farming. At the same time, credit constraint is the most binding factor for expansion of shrimp farming by rural people. Considering them together, it is evident that a vertical integration may ultimately occur in this industry. This implies a gradual progression towards *intensive shrimp culture*. Evidently, high compliance costs related to HACCP and the risks of rejection by the importing countries have contributed to this. If shrimp operations are integrated vertically then we know that the impact on the environment would be much more severe. The question is, can we foresee an alternative to this in terms of a coping strategy. To determine this, we used a simulation exercise and the result is presented in the next section.



7. The regulations on exports

In terms of export regulations, Bangladesh has banned the following items for export:

- prawns and shrimp, except frozen and processed; and
- shrimp of count 71/90 and sizes below for sea water and 61/70 and sizes below for fresh water, excluding two varieties (Harina and Chaka).

In addition quality control licenses issued by the Bangladesh Standards and Testing Institute are required to export shrimp and prawns (except frozen de-veined or cooked).

In terms of environmental laws, the Bangladesh Environment Act 1992 and Bangladesh Environmental Regulation of 1997 provide the legal cover to monitor environmental impacts of economic activities completed within the country.

Shrimp processing firms are listed in *orange-B* category and are required to complete Initial Environmental Examination (IEE) before establishment. In addition, they are required to submit an effluent treatment plan and an environment management plan to the Department of Environment before obtaining the Environmental Clearance Certification. In the Environment Policy of 1992 of the Government of Bangladesh, it has been stipulated that the government would ensure sustainable use of resources.

It is clear that while shrimp processing plants are subjected to environmental regulations, shrimp farming, as such, is not under the control of the Department of Environment. Given the fact that most of the farms are still practicing extensive farming practices for production of shrimp, this is not at all unexpected.

However, as has already been mentioned before, shrimp exporters are also subjected to SPS and are required to comply with the HACCP procedure to secure export markets abroad (in the U.S. and in Europe).

Simulating a coping strategy for the shrimp industry

Cato and Santos (2000) in a study based on a survey of 19 shrimp processing plants in Bangladesh during April 1998, concluded that the average plant has invested US$239,630 to upgrade to the minimum technical and sanitary standards.

This study, involving 21 shrimp processing farms, show that an average plant has invested US$ 227,450.97 to upgrade its capacities to comply with the HACCP. The expenditure of the median size plant in our survey is around 63 lakh taka or US$105,882.35.

Table 26: Fixed cost of HACCP compliance by processing plants

	25 Percentile	50 Percentile	75 Percentile	Average
HACCP Investment		**In lakh Taka**		
Lab plus refrigeration unit	31.50	63.00	296.00	1,654.25
Training	0.18	0.50	0.78	0.69
Operating costs	8.00	13.00	20.00	22.75
Capacity per plant				
Capacity per year (ton)	564.00	901.55	1,115.08	1,115.08
Operating days in a year (actual)	47.00	47.45	47.45	47.45
Installed capacity (ton/day)	12.00	19.00	23.50	23.5
Used capacity (ton/day)	3.50	5.00	10.50	12.14
		per ton in 000 taka		
AFC for HACCP @ installed capacity	5.62	7.04	26.61	148.42
AFC for HACCP @ used capacity	19.26	26.77	59.57	287.29
		in 000 taka		
Local price (taka) per ton (size 25)	450	450	450	450
AFC as per cent of price/ton (for installed capacity)	1.248%	1.565%	5.914%	32.981%
AFC as per cent of price/ton (for used capacity)	4.279%	5.948%	13.237%	63.843%

Source: Survey

Cato and Santos (2000) found that an additional US$37,525 in investment is anticipated to complete the upgrading for a total of US$277,155 per plant to be fully in compliance with the minimum (basic) technical and sanitary standards. They further found that an average plant expects to spend US$34,875 each year to maintain a HACCP plan.

This study of 21 plants found that, on average, each plant spent US$ 5,042 for training and US$ 15,126.05 per month to operate the plant as per HACCP system. Considering these, an average processing plant spent US$232,492.97 to upgrade their plant and US$181,512.60 per year to comply with the HACCP system. In terms of the average addition to their operating costs,[18] this is equivalent of US$150 per ton of shrimp produced in Bangladesh. In terms of shrimp price, it is currently 32.98 per cent of the price of shrimp (average figure in Table 26) for an average processing farming operating 47.45 days per year and processing shrimp up to the installed capacity. If, however, we take the current used capacity rate, it is around 63.84 per cent (Table 26).

[18] Fixed costs were spread equally in 10 years in this calculation.

Since there is a large variation in the size of the processing plants, the calculation for different percentiles of firms is presented in Table 26. Consequently, the median firm (50 per centile) in our sample, had invested 63 Lakhs in lab and refrigeration units to comply with HACCP rules and had spent 50,000 taka for training of staff (fixed costs). They operate for about 47.45 days per year and their operating tonnage per day for this period was nearly 19 tons.

Considering this, Table 26 shows that a processing plant's average fixed costs of HACCP compliance stand between 1.24 per cent and 5.91 per cent of the export price if the firms operate at their installed capacity. Table 26 also shows that at the existing rate of capacity utilization, HACCP compliance cost ranges from 4.27 per cent to 13.63 per cent of the export value. Such a high cost of compliance is likely to accelerate a change in the structure of the entire industry. Shrimp processors, in order to reduce risks, might opt for further intensification of production.

In a competitive export market, this cost push needs to be analyzed. For this, we developed a stylized scenario with the following assumptions:

- a processing plant would incur the fixed costs to comply with the HACCP system; and
- processing plants were found to be operating at below 13 per cent of their capacity (for a median-size firm the volume of processed shrimp is around 1,026 tons a year against their annual capacity of 8,080 tons).

For the purpose of analysis, several scenarios are projected.

Scenario 1—Business-as-usual – shrimp farms will be producing as they are doing now but will comply with the HACCP rules.

Scenario 2—Expanding usage of capacity – processing plants will try to minimize the cost-push impact through expanding their business operations from 13 per cent to at least 50 per cent.

Scenario 3—Shrimp farms react to meet the increased demand for shrimp (via scenario 2) through intensifying their activities.

Figure 3 and Table 26 present the simulated results. The baseline scenario is that, at the current yield rate, each processing firm requires a command area of 6,989 acres of land if they continue exporting at their current level of exports (of a median-size exporter). According to our simulation exercise, HACCP compliance cost would be equivalent of 4,911 taka per ton.

If, however, the exporting firms can expand their export quantity to another 50 per cent of their capacity, then land requirement for shrimp farming would go up to 13,972 acres per processing plant. Such an expansion would, however, reduce their average HACCP compliance cost to 2,455 taka per ton.

On the other hand, if exporting firms could expand their export quantity to their full processing capacity, land requirements per firm would go to 53,762 acres and the compliance cost would go down to only 638 taka per ton.

It is clear from this simulation that expansion of export quantity will remain a major goal for the processing firms. If they pursue this, the conflict over land use at the rural level would definitely go up and it may become politically infeasible.

For the processing firms, the alternative is to intensify shrimp farming through the use of technology to increase the yield per acre. Our simulation exercise shows that if shrimp farms could increase their yield by only 1.5 ton per acre per year, then a processing firm would be able to export at their capacity by utilizing only 6,630 acres of land per processing plant.

In our current baseline scenario, we have seen that each processing plant has a command area of nearly 6,989 acres of land, so to export at the 100 per cent capacity level, almost all the land within its command area needs to be brought *under intensive farming* to achieve this target. Clearly, the impact on the environment will be severe. Since shrimp farming is not under any kind of regulatory structure, we expect huge costs on the local environment if this occurs. For an economy like Bangladesh, where land is scarce, such a large-scale transformation of farming practice would impose an enormous threat to its biodiversity.

We have, therefore, created an alternative scenario. Current yield per acre of land in Bangladesh shrimp farms is substantially low. Most experts at the field level agreed that it is possible that these farms can easily double their yield if they implement better management of their operation. to this proposition. If this happens with the same amount of land, it is possible to achieve exports at 50 per cent capacity of the processing plant. This would reduce their per unit compliance cost to nearly 50 per cent. Over time, if it is possible to further increase their yield without further intensifying the farming practices, the impact on the environment would be minimized.

In Figure 3, it has also been shown that the land requirement is highest under the current method of shrimp farming. The unit cost of compliance is at a minimum when the processing firm utilizes its capacity to 100 per cent. At the same time, if shrimp farming is converted into intensive farms, the land requirement will not change significantly. Therefore, the hypothesis that shrimp farming is likely to be intensified now seems more tenable than ever before.

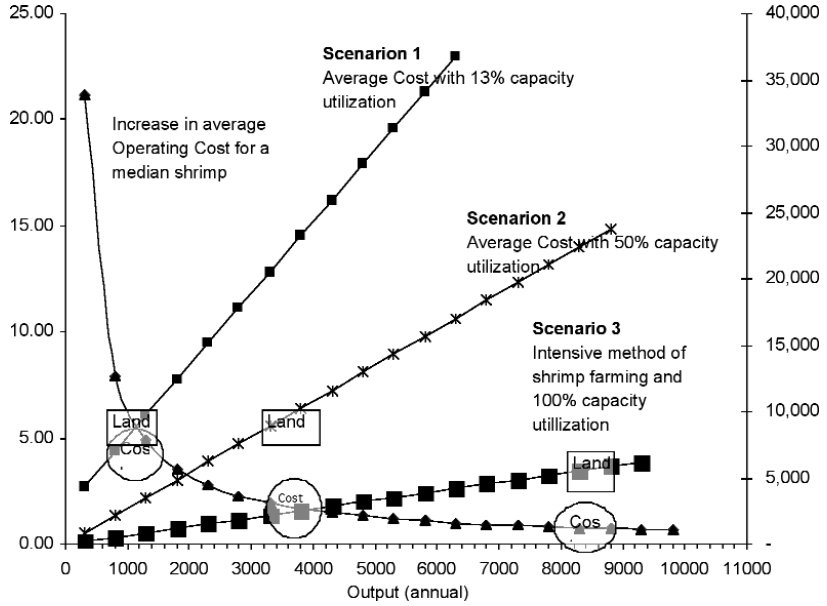
Simulation results show that, if we are to halt further expansion of shrimp farms in the coastal belts (to protect environment), farming practices must be improved immediately and without a supervised and monitored environment, such an expansion would create social unrest and increase the risk of environmental degradation.

Table 27: Summary of simulation results on shrimp processing and compliance with HACCP rules

Options	Additional cost per ton of processing (000 taka)	Footprint on land per plant (for median size) (in acres)	Comments
Business-as-usual			
Shrimp plant produce at their current level of output (1293 tons per year, on average)			For each shrimp processing farm, a huge land area is required. Only intensification of farming practice would be able to release land for other uses.
Shrimp farms continue extensive farming practice (produce roughly 185 kg per acre)	4.911	6,989.19	
Shrimp farms continue extensive farming practice but double their yield per acre (produce roughly 370 kg per acre)	–	3,495.0	
Shrimp farms adopt intensive farming technique (1.5 tons per acre)	–	862.0	
Shrimp farms increase their capacity utilization to 50 per cent			
Shrimp farms continue extensive farming practice (produce roughly 185 kg per acre)	2.455	13,972.4	Due to higher compliance costs, processing farms need to extend their number of operating days. If they expand it by 50 per cent then land requirement would simply double.
Shrimp farms continue extensive farming practice but double their yield per acre (produce roughly 370 kg per acre)	–	6,989.0	
Shrimp farms adopt intensive farming technique (1.5 tons per acre)	–	1724.0	
Shrimp farms increase their capacity utilization to 100 per cent			
Shrimp farms continue extensive farming practice (produce roughly 185 kg per acre)	0.638	53,762.99	Utilization of installed capacity at the processing plant is necessary to reduce impact of fixed costs (compliance costs). This means even more land for shrimp farming.
Shrimp farms continue extensive farming practice but double their yield per acre (produce roughly 370 kg per acre)	–	26,881.0	
Shrimp farms adopt intensive farming technique (1.5 tons per acre)	–	6630.8	

Source: Computer simulated result by Enamul Haque

Figure 3: Simulated result to find coping strategy



Source: Computer simulation by Enamul Haque

8. Concluding observations

It has already been discussed that shrimp processors are working at a level which is below their capacity and this is due to the fact that shrimp is not available for processing. Such a supply shortage will eventually make the whole industry a sick industry with large debts from financial institutions. Already, processing firms are asking the authorities to put a halt in licensing more processing plants.

On top of this, it is clear that shrimp processing firms have incurred a significant amount of fixed costs to upgrade their plants to conform to HACCP rules. Based on their current level of production and the current productivity of shrimp farms, it appears that for each processing plant, nearly 2,828 ha (or 6,989 acres) of land is required. Our simulation exercise also shows that when shrimp farms adopt intensive farming, the land requirement per firm would go down to 348 ha (or 862 acres).

However, if shrimp farmers can increase their yield by improving their management practices (through training and information), the land requirement per firm would go down. If the processors, at the same time, expand their current level of processing then, of course, land requirement would increase. It has been shown that if shrimp farms could double their yield per acre, then shrimp processors could increase their processing capacity up to 50 per cent without bringing new land under shrimp farming. This is a significant positive step.

At this point, if processing farms would like to produce at their capacity level, the land requirement under shrimp farming would increase to nearly 10,878 ha per firm. This would mean a significant rise in the acreage under shrimp. Such an increase in land under shrimp cultivation would be possible if more land is converted from other uses, including conversion of mangrove forest land. The alternative is to further intensify shrimp production and this would mean that the current land acreage under shrimp would be sufficient to support all the shrimp processing plants in the country. At the same time, we note the environmental and social risks related to intensive shrimp farming.

Considering these, this study has highlighted that the shrimp industry in Bangladesh is currently in a state of transition. Yield has been very low at the farm level, a majority of the farmers are poor farmers and are not fully aware of the SPS rules. The risks of export trading to the EU or the U.S. are borne by the exporters (or the processors) and they have already been under stricter regulatory frameworks. At the same time, they are operating at a very low level of their capacity (only 13 per cent of their processing capacity). Higher risks posed by SPS regulations and high costs of compliance to HACCP standards at the processing level bring an additional burden to the processing firms. It is also clear from this study that it would be difficult for the government to impose stricter rules on farmers to protect the environment. Against this backdrop, processing firms might find it convenient to integrate all operations of shrimp farming under one umbrella and install intensive farming practices. This is a very likely scenario. Processors have already expressed this in their opinions and our simulation exercise also predicts it.

Under this scenario, government should consider imposing a stricter environmental guideline on shrimp farming and on conversion of land. At the same time, it is also important that current shrimp lands are properly managed and their yield rate increased to an acceptable level. Research has shown that extensive shrimp farms can produce up to 500 kg of shrimp per acre. For this, building awareness among farmers about the effects of shrimp farming on the environment, improving management skills for management of ponds, supplying information on HACCP

rules and training of farmers would be necessary. These steps, while increasing yield, would also help farmers to fetch more value per unit of output and reduce risks of rejection during exports. On the whole, this is more efficient than intensive shrimp farming.

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