Journal of Fisheries International 2 (2): 162-170, 2007

Factors Affecting *Penaeus monodon* Yield in Extensive Farming System in Southwest Bangladesh

S.M. Nazmul Alam
Department of Social Science, Curtin University of Technology,
GPO Box U1987 Perth, Western Australia 6845, Australia

Abstract: An investigation of the factors affecting *Penaeus monodon* yields was carried out from extensive shrimp farming system in southwest Bangladesh. Data were collected from 82 shrimp farms between January and August 2002. A questionnaire survey along with PRA tools were conducted in gathering information. It was found that the surveyed shrimp farms accured economic losses. *Penaeus monodon* yielded 146.39 kg ha^{-1} to 153.12 kg ha^{-1} against expected 250 kg ha^{-1} to 400 kg ha^{-1}. The return to the total cost was US$ 0.012-0.015. According to the results, the factors affecting the shrimp yield are old aged farms, inadequate water exchange, shallow water, accessing bad water, salinity fluctuation, unstable soil and water parameters, variable stocking density, absence of quality post larva and competition by non-target species in the shrimp farm. The results also indicated that shrimp farmers accured consequences as a result of disease outbreak in 2001-2002. Farmers responded to combat diseases in the areas through pre-harvesting (83%), sun-drying of ponds (43%), increasing use of pesticides (15%) and conversion of land into paddy (12.19%). Employment loss, repayment of loan default, break up of group farms (60%), revenue loss and flee of farmers (6%) to the neighbouring country were encountered as a result of socio-economic consequences. Widespread disease outbreaks and consequent heavy losses to farmers are thus challenging the sustainability of shrimp aquaculture in Bangladesh.

Key words: Disease, factors, management, shrimp, virus, yield

INTRODUCTION

Shrimp culture has become a primary crop in many parts of the coastal area in Bangladesh and has become the second largest export earner due to high demand and the price of shrimp in the global market (DOF, 2001). The black tiger shrimp (*Penaeus monodon*) is cultured predominantly under extensive farming systems and the annual yield ranges from 100-200 kg ha^{-1} (Alam, 2002). Around 80% of the shrimp culture area is located in the southwestern Khulna region, while the rest is located in the southeastern part (Cox's Bazar) of the country.

Shrimp farms in the coastal districts of Bangladesh have been often accompanied by a number of factors, which has led to the production and economic loss. Disease problems have been identified an important consideration in shrimp culture over the past few years. Since 1994 disease has become a regular phenomenon and a serious threat to coastal shrimp farming in Bangladesh. The first viral epidemic outbreak occurred in 1994 in semi-intensive shrimp farms in the Cox's Bazar region, (Larkins, 1995) semi-intensive shrimp farms had to abandon their culture operation. In 1996, the diseases appeared in Khulna region and about 90% of extensive shrimp farms were affected and thus caused a 20% loss in the total shrimp production in the country (Chowdhury and Muniruzzaman, 2003). Likely there were disease outbreaks in the following years resulting great loss in the production (Table 1).

About 13,284 metric tons of cultured shrimp valued at US$ 80.14 million were lost due to disease DOF, 2002. In 1997-98, the total shrimp export quantity suddenly dropped from 25,742 metric tons to 18,630 metric tons due to the incidence of disease. However, in 1999-2000, the export quantity again increased to 28,514 metrc tons when disease did not affect the crop severely (DOF, 2001).

Unfortunately, the disease again reduced the shrimp production (about 25%) in 2001 very severely in the southwestern coastal regions. The disease was primarily diagnosed as White Spot Shrimp Virus (WSSV) associated with other viral and bacterial pathogens. Due to the haphazard horizontal expansion of coastal shrimp farming, the coastal ecosystem has been degraded and has become prone to disease outbreaks during the last few years (Hossain and Lin, 2001). Although shrimp culture has created a substantial economic and social

Table 1: Disease occurrence in coastal shrimp aquaculture in Bangladesh

Year	Types of shrimp farm affected	Location	Intensity of affected area (%)	
			Farms	Production
1994	Semi-intensive	Cox's Bazar	80	50
1995	Semi-intensive	Cox's Bazar	100	80
1996	Improved extensive and extensive	Khulna and Cox's Bazar	80-90	20
1997	Improved extensive and extensive	Khulna and Cox's Bazar	20-30	3-5
1998	Improved extensive and extensive	Khulna and Cox's Bazar	30-40	10-12
1999	Improved extensive and extensive	Khulna and Cox's Bazar	20-22	5
2000	Improved extensive and extensive	Khulna and Cox's Bazar	15-20	2-4
2001	Improved extensive and extensive	Khulna and Cox's Bazar	80-90	25

Source: Modified from Chowdhury and Muniruzzaman (2003)

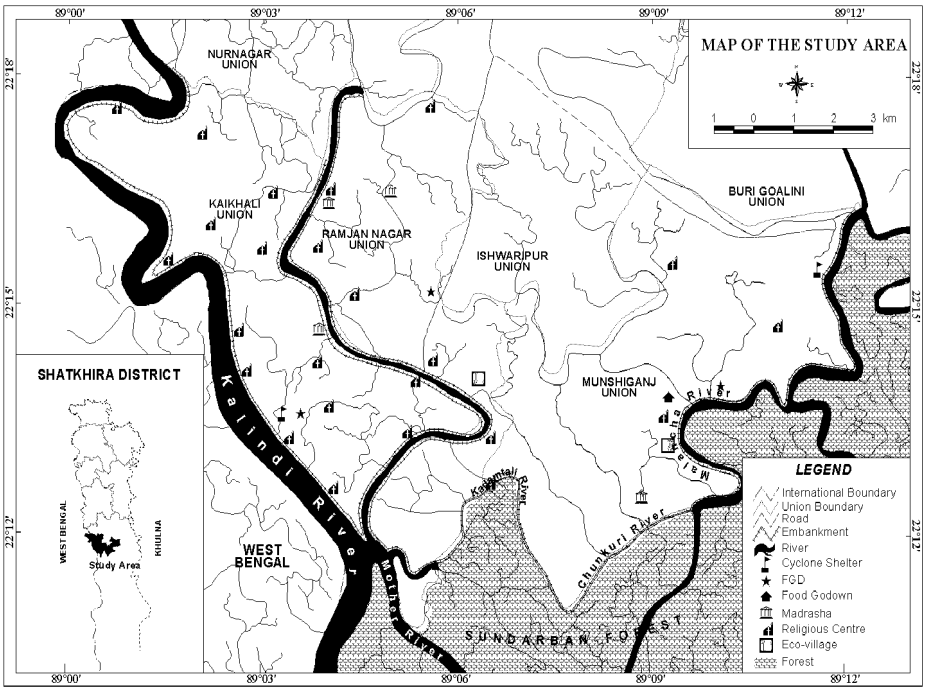

Fig. 1: Map of the study area

transformation in the coastal belt of Bangladesh (Islam, 1999; Rahman *et al*., 1995) during 80s and 90s but continued problems with disease and environmental concerns have contributed to the lower productivity of shrimp resulting in poor living conditions and economic losses of the small-scale farmers.

The farm ownership patterns under extensive shrimp farm system are complex and also vary from area to area in Bangladesh. The major categories of shrimp farm ownership as defined by Caritas (1997) are:

Individual owner: In which the land in the farm is owned and operated by one person.

Group farm: In which the land in the farm is owned by a number of persons who pay active roles in operating the farm.

Outsider lease: In which the land in the farm is leased out by the owners to a person or persons living outside the polder area.

Considering the difficulties faced in the shrimp culture area the present study was conducted to ascertain the various factors for the lower productivity and analyse their likely consequences.

MATERIALS AND METHODS

The study area is situated at 22°11'-22°17'N and 89°03'- 89°12'E, in a brackish water area of southwestern Bangladesh (Fig. 1). Administratively it is located in three Unions (Munshiganj, Ramjannagar and Koikhali) under Shyamnagar Upazila of Satkhira District in Bangladesh.

The data were collected between January and August 2002 in 82 farms from 509 existing shrimp farms in the study area. Random sampling was employed in choosing the samples. A questionnaire was developed using both open and close-ended questions. It consisted of 15 questions divided into 5 sections, which were:

- Farm profile (farm size, years of shrimp farming, types of practice).
- Farming calendar (activities, sources and preferences of fries, stocking and harvesting strategy).
- Farm management (stocking, water quality and disease management).
- Production economics (yield, gross return, gross margin).

Eighteen interviews with potential individual shrimp farmers and key informants (Upazila and District level Fisheries and Agriculture Officers, experts) were undertaken. A checklist was developed using open-ended questions (land use changes, water quality, social, economic and environmental consequences, suggestions) to collect the perception of the respondents on low production of shrimp. Twelve Focus Group Discussions were held with shrimp farmers and Participatory Rural Appraisal tools like observations, seasonal calendar and trend analysis were employed to collect qualitative data. The financial analysis was done adopting standard techniques of Shang (1990).

RESULTS

Shrimp farms and scattered settlements occupy land along the periphery of the embankments. Here year-round shrimp culture has been practiced since two decades. About 55-60% of the land has been used for shrimp farming, 25-30% for agriculture and 5-10% for homesteads. The remainder consists of roads, canals and ponds. The shrimp culture starts during February and continues up to the end of November. The remaining two months is kept fallow for drying. The land used under paddy was mostly single cropped land. The paddy cultivation period takes place between June and September. After the paddy, the land became fallow and turned to grazing land for the cattle. Lack of irrigation facility and dried up of the inside riverbed were the causes for not being able to cultivate paddy round the year. The land around homestead was used mainly for vegetables gardening.

The farms with an area of over 10 ha, 5 ha and below 5 ha are considered as large, medium and small farms by the people in the locality. The largest farm in the area was 39 ha that belonged to an outside lessee while the smallest farm ranged from 0.2-1.4 ha and belonged mostly to individual farmers. Activities start with the preparation of the fields, which involves building or repairing of dykes surrounding the farm and installing or repairing the sluice gates for water exchange. The farmer makes multi-stocking of fries, which usually takes place at around every new moon and full moon. During stocking at the 5th or 6th time they start harvesting the shrimp. After each harvesting they then replenish the stock. The cultural species is the black tiger shrimp, *Penaeus monodon*, but other species of shrimp like *P. indicus, P. marguencis, Metapenaeus monoceros* and *M. brevicornis* are also introduced naturally with the intake of water. Disease outbreaks caused by virus attacks due to poor water management of the shrimp farms, lack of scientific and systematic knowledge of shrimp culture and management are the major problems in the shrimp sector of the area. The trend of shrimp production under the Upazila has gradually decreased from 360 kg ha^{-1} in 1993 to 85 kg ha^{-1} in 2001 due to disease interruptions. The identified factors affecting the improvement of the management system of shrimp culture have been presented in Fig. 2.

Farms are very old: The surveyed farms and the remaining shrimp farms in the study area were found to be very old in general except for a few new farms. Sixty one percent of the farms carried out shrimp farming activities for more than 20 years, 23% for 15-19 years, 10% for 10-14 years and the remaining (6%) for less than 10 years, respectively.

Water exchange: The surveyed farms exchanged water through the sluice gate constructed by wood or concrete. 95% of the respondents used the same gate as drainage and flushing purposes. Very few (3%) had separate drainage and flushing gates. A few of the farms used pump machine to intake the water due to higher land elevation inside the farms. The water volume of the farm was routinely exchanged by all the surveyed farms during 4-6 days at every lunar cycle. In case of unwanted occurrences farmer exchanged water at any time. Almost all the surveyed farms had shallow water in the ponds, ranging from 0.3 meter to less than one meter. Most of the respondent (75%) experienced salinity variation throughout the year. The highest salinity in the water was 24 ppt during May and lowest was 6 ppt in October 2001.

Soil and water characteristics: The characteristics of the soil and water have been distinctly noticed. (CDI, 2000) The soil texture consists of clay and silty clay with mostly neutral to slightly acidic condition (pH 5.4-8.0). Clay dominates over silt (36%) and sand (2%). The variation of

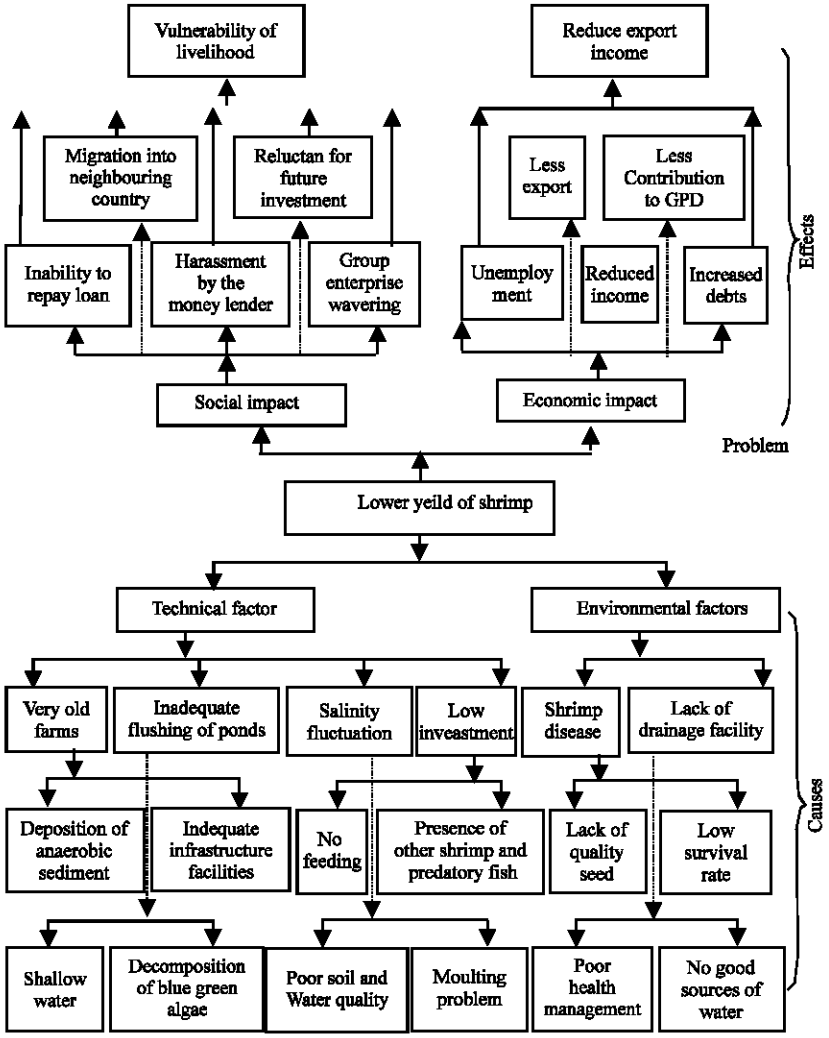

Fig. 2: Cause and effect analysis of lower yield of shrimp

soil pH between shrimp farm and agricultural land are quite distinct in most location, being lower in agriculture area. The soil salinity in the study area varied from 2.8 ppt to 13 ppt. The salinity in agricultural land soil content varied from 2.8 ppt to 4 ppt and salinity in the shrimp field is recorded as 13 ppt. during March 2000. Organic matter content is higher in agriculture and middle area but lower in shrimp farm with an average of 2.72%. The nutritive elements such as N, P, K and Ca are lower to moderate whereas Mg, S and B are moderate to high. Fertility status of the soil including organic matter content is moderate to high and overall soil fertility in agriculture area is low to moderate but soil salinity is the major concern for agriculture.

The water quality parameters also showed variations in salinity, water temperature, transparency, ammonia, nitrite and dissolved oxygen contents. According to the CDI, (2000) average pH level (7.8 to 6.5) was observed from high to low saline area but carbon di-oxide content increased from high saline (16.67) to low saline area (21.67) and nitrite content decreased from high saline (0.103) to low saline area (0.071). The very low level oxygen (1.5 mg L^{-1}) in some places was also noticed in the study because of shallowness of the water that deteriorating bottom condition.

Stocking density and the feeding: Shrimp farms under different ownerships were found stocking varied number of fries. The farmers stocked shrimp PL directly to grow out ponds. The farmers under all categories practiced shrimp fry stocking more than five times in their ponds and harvested for several times (16 times and more) in their farming calendar. However, the shrimp are not fed with supplementary feed in this system.

Table 2: Comparison of shrimp farm economics by farm ownership category

Items	Unit	Shrimp farm ownership category		
		Individual (n = 35)	Group (n = 31)	Outsider (n = 16)
P. monodon yield	kg.ha^{-1}	146.39	153.12	151.86
Expected production	kg.ha^{-1}	250	250	400
Gross yield	kg.ha^{-1}	322.11	317.40	238.79
Total cost	US$.ha^{-1}	1084.40	1043.16	1140.11
Gross return	US$.ha^{-1}	854.69	921.17	842.03
	Minimum	71.03	116.38	481.36
	Maximum	2216.29	1726.15	1192.32
Gross margin	US$.ha^{-1}	(229.70)*	(121.99)*	(298.08)*
	Minimum	(1627.86)*	(1229.08)*	(106.65)*
	Maximum	1100.78	1279.20	1134.58
Return to total cost	US$	0.013	0.015	0.012
Total labour	Nos.ha^{-1}	33	26	15
Return to labour	US$	6.96	4.69	19.87

* Figures in the parenthesis indicate negative profit

Table 3: Method, frequency and sample size of health check by category

Method of checking	Individual (n = 35)	Group (n = 31)	Outsider (n = 16)
Frequency of checking (%)			
Weekly	00	00	33
Fortnightly	03	03	00
Monthly	03	00	00
Randomly	94	97	67
Sample size (%)<5			
05-10	11	29	00
11-15	66	48	33
16-20	20	19	33
21-25	03	03	00
>25	00	00	33
Types of health check (%)			
Body colour	100	100	100
Appendages	03	00	00
Colour of gills	06	00	00
Size variation	91	100	100
Gut externally	91	100	66
Means of checking (%)			
Using net	83	94	100
Hand	6	6	00

It revealed that the smaller farm stocked higher than those of large sized farm. The individual shrimp farmers preferred to stock the farm with more density of fry (19,642 fries ha^{-1}) than the other categories. The outside farmer with the largest amount of area stocked only 13,437.39 fries ha^{-1}. Overall the average stocking density in the study area is 17,110.42 fries ha^{-1}. On an average the farmers stocked 1.8 fry m^{-2}.

The varied survival rate of shrimp post larvae by different category was observed in the present study that depicted loss of 76 % of post stock PL. The large farm under outside lessee had the highest survivability of the PL (45%). The individual and the group farmers had received 24 and 26% of PL survivability, respectively.

Poor water quality: There were no good sources of water. Many shrimp farms were developed in unplanned way with hardly infrastructure arrangements. If one farm is attacked with disease the nearby farm automatically infected with the same. 20% of the respondent farms had to depend for water from others gateway.

Competition by other species: There were presence of unwanted finfish and other shrimp, which competed with the natural food in the shrimp farm. It is revealed that 52% of the total yield came from *P. monodon*, while the rest 19 and 29% came from other shrimp and finfish, respectively. By value, 85% came from the *P. monodon*, while 8% and 7% came from other shrimp and finfish, respectively. The horn shell mollusk (*Cerithedia cingulata*) was also in abundant in the shrimp farm, which was also a competitor of shrimp in sharing the food.

Economic factors: Disease outbreaks resulted in economic losses to the respondent's farmers. In all the surveyed categories, farmers received negative profit from their crop. The individual farmers received 146.39 kg ha^{-1} against their expectation of 250 kg ha^{-1}, while the outside lessee got 151.86 kg ha^{-1} against their expectation (Table 2). The total cost by the farmers categories ranged from US$ 1,043.16-1,140.11 ha^{-1}, which included farm preparation, fertilizing, fries, labour, lease rent, interest of the capital, respectively. However, the return was lower than the investment. The return was US$ 854.69 ha^{-1}, US$ 921.17 ha^{-1} and US$ 842.03 ha^{-1}, respectively by the individual, group and outside lessee, which indicated loss from the enterprise in that year. The return to the total cost ranged US$ 0.012-0.015.

Strategy response to disease outbreaks: Farmers under all categories maintained checking of shrimp growth randomly and throughout the production cycle. Each time 15-20 shrimp were checked using cast net and hand. The body colour, size variation, external gut and the shell were checked by all categories of farmers. All categories used a combination of checks. The method, frequency and

sample size of health checking used by all categories of farmers are presented in Table 3. Over 90% of the farmers from individual and group categories checked the sample randomly while in outside category the farmers checked weekly (33%) and randomly (67%), respectively. The individual category checked all the possible symptoms in shrimp. Gills were not checked by other category of farmers. Shrimp diseases have become a regular occurrence in the study area since 1995 with little or in epidemic way. The affected farmers had also taken following measures to cope with the shrimp diseases.

Pre-harvesting: The affected farmers had taken different measures to cope with the shrimp diseases. Most of the farmers (83%) harvested early when shrimp disease occurred in their own or their neighbour's farms. Water quality improvement measures were not practiced besides exchange of water during tidal variation.

Sun-drying of ponds: When the extent of the disease was severe farmers (45%) reduced all the water and let the bottom of the farm dry under the sun. The remaining shrimp took refuge in the canal along the periphery of the farm. After drying, the pond was filled again with the brackish water and restocking at lower density to recover part of their early loss.

Conversion of land and use of disinfectant: Ten farmers (12.19%) had changed a portion of the farm into paddy culture during the monsoon period to avert the risk of disease. Few Farmers (15%) had a tendency to use disinfectant like Thiodan (ingredients: Endosulfan 35% and emulsifiers 65%), Dimicron, etc during the appearance of the diseases.

DISCUSSION

Shrimp farms in the study area have experienced around two decades of culture. For a prolonged culture period a layer of anaerobic sediment deposited on the pond bottom and micro-organism consumed more oxygen and produced high quantity of Carbon-di-oxide, Hydrogen Sulphide, Ammonium Nitrogen and Nitrite Nitrogen which are very harmful to shrimp (Funge, 1997).

The affect of siltation over time has made ponds and waterways more shallow resulting in reduced availability of water for flushing and in the pond. Both of these effects have influenced productivity of the system. Siltation was more severe in ponds, which were constructed on elevated land that received water during full and new moons. Ponds having such characteristics are unsuitable for shrimp farming and production has become deteriorated over time. Lack of good arrangement of infrastructure facilities like sluice gates, canals in the area has also limited the access of water.

This tidal affect allows the intrusion of brackish water into inland areas. In the study area the rivers are tidal and salinity existed throughout the year with seasonal variations and this makes it suitable for brackish water aquaculture. The tidal fluctuation decreases both in daily amplitude and the spring tide peaks during the new and full moons (twice daily). This had effectively limited the amount of water that can flush the ponds. Pond flushing on the other hand is of great important, as the new water carries nutrients; organic matter and larval animals into the ponds. This nutrient source is vital for the traditional pond systems that usually have no other nutritional input. The limitation of nutrients is one of the reasons for low production as a whole (Funge, 1997).

P. monodon is highly tolerant of brackish water during its juvenile and young stages. Adult shrimp are also tolerant to low salinity water. The species does not perform well when salinity drops below about 5 ppt. Below this point, feeding behaviour is reduced and there are affects on the animal concerned with the moulting process (FAO, 1997). The result of this is that the hard-shelled animals become affected by bacterial infection. Shrimp might be able to moult, but the ultimate effect is usually mortality, often associated with soft shelling which were acute findings in the study area. Since the moulting peak coincides with the full moon harvesting period the farmers usually observed high mortality.

The effect of white spot virus disease (SEMBV) on a pond might also become more severe if shrimp are exposed to externally low salinity. It is thought that this is because this virus affects the epithelial tissues of the gills that are concerned with salt and water regulation in the shrimp. Animals affected with white spot virus die quickly if the salinity is reduced rapidly. Low salinity water often has low alkalinity and rainwater has extremely low hardness. The result of these two factors is low concentrations of bicarbonate/carbonate and calcium/ magnesium in the water. These ions are critical for survival since they have a role in the animals' physiology, particularly the moulting process. Low salinity could also create unfavourable environmental condition (Wahab *et al*., 2003).

Acid soils in the area lowered the alkalinity of brackish water resulting in soft shelling of the shrimp. Typically the solution to acid soils was the application of limes (CaO to neutralise, $CaCO_3$ to improve alkalinity). Most of the shrimp farmers did not use lime during the culture period, but they used lime during preparation of the ponds. The action of that application is consumed

with the passing of the days and requires more applications (Funge, 1997). Especially the low water exchange ponds required increasing amount of lime applications.

The farmers make multi stocking of shrimp fries up to 5-8 times and make partial harvest up to 16-18 times in the study area (Alam *et al*., 2003). After each harvesting the farmers then replenish the stock. Overall the average stocking density in the study area is 17,110.42 fries ha^{-1}, which was in the range of findings (15,000 to 40,000 fries ha^{-1}) by Hoq *et al*. (1997). Fry quality has a major impact on production and the profitability of a shrimp farm. Stocking larger post larvae (PL 15-25) can also improve survivability due to more developed to disease resistance, stronger benthic feeding behaviour and improved predator resistance. Farmers usually preferred to stock wild fry and where there is a scarcity they go for stocking hatchery bred fries where the quality assurance is questioned.

This finding of low survivability also support the findings of Karim and Stellwagen (1998) that revealed a post stocking wastage of 80% PL in extensive shrimp farming system. The higher mortalities were found during early stage (50-70 counts kg^{-1}) of shrimp culture period. Moreover, the likely presence of several predatory fish species reduced the yield of shrimp. Alam (2004) and Beveridge (1984) also reported that finfish and mollusk in extensive shrimp farming significantly reduced nutrients in aquatic ecosystem. The presence of *Lates calcarifer* (8%) and *Mystus gulio* (16%) in the surveyed farms are predatory in nature (Naser *et al*., 1991) and devoured shrimp species. Competition between shrimp species undoubtedly limited *P. monodon* yield. Besides, there was no supplemental feeding. Sometimes, phytoplankton and this excessive plankton died and caused an unhealthy situation in the ponds.

Farmers did a little monitoring on shrimp health management. The only time that the shrimp are seen is during harvesting period of new and full moon. Any losses between capture periods are rarely observed, unless there was a mass mortality of shrimp at the pond edge. Since shrimp tends to moult around the lunar periods that is the maximum stress to the shrimp and therefore farmers were likely to observe any related mortalities of shrimp. In many cases the moulting delays until an improvement in water quality occurs (Larkins, 1995).

Usually, the stressful conditions in ponds did not occur individually. In most cases several stressful conditions occurred at the same time as their effect on the pond environment was linked. The result of these combinations of stresses was usually more severe than any one individual stress. It was evident from the FAO (1997) survey that bacterial diseases and stress symptoms due to poor pond environment appeared to be a significant contributory factor to the recurrent mortality. Moreover, there was no quality assurance system developed to ensure that farmers are receiving good quality of post larvae from the hatcheries.

In shrimp farms profit was also highly sensitive to sale price. Shrimp were harvested at too small stage and incurred less profit. Most of the surveyed farms experienced harvesting small sized shrimp (50-70 count kg^{-1}) because of diseases. Similarly, any effect of markets on shrimp price would definitely influence farm viability. The small sized harvested shrimp had to sell at a lower price (US$ 3.24-4.61 kg^{-1}) at the farm gate and thus incurred negative profit for their investment.

Begum and Alam (2002) observed that the price of land in the shrimp cultured area has become constant due to the negative impact of disease. Between 70s and 80s land cost was US$ 1,470 kg^{-1}. The price then jumped to US$ 4,410-5,880 kg^{-1} during later half of mid 80s to the mid 90s and has since remained stable. Outside people have lost interest in entering into this sector because of disease risk.

In the study area, the individual farmers converted highly elevated land of the shrimp farm into paddy land by putting a dike across the two lands. The paddy fields then hold rain water in the canal, which was re-excavated at the periphery during preparation of the shrimp farm. The average yield of paddy from the shrimp land accounted 1,583.26 kg ha^{-1} while the yield from the plain land paddy was almost double than that of paddy in shrimp (2,701.42 kg ha^{-1}). The gross margin was also more than double in plain land paddy (US$ 245.17 ha^{-1}) than paddy in shrimp lands (US$ 106.93 ha^{-1}). The cost and benefit ratio in plain land paddy was 2.65 while it was 2.23 in case of paddy in shrimp field. This has becoming a popular in the area. Although the income from this pattern is almost half than that of mono paddy cultivation in the area the farmers think of this system an additional income. If the facility for fresh water exists, the small-scale shrimp farmers probably sift their activities into paddy cultivation.

The farmers in the study area had suffered a wide range of negative social impacts due to disease outbreak of shrimp in 2001. Both crop and employment experienced losses. 90% of the respondent farmers restocked at lower density immediately after loss and recovered part of their early losses. During disease outbreaks massive unemployment occurred mainly for part time labourers.

Farmers lacked money to pay for leases and other essential inputs. Shrimp farming is a capital intensive and

in most cases farmers had to borrow money from different sources with interest. Any negative result on the farming sector affect in corresponding losses with other linked industries. As many farmers purchased fry on credit, their inability to repay these debts in a timely fashion caused an adverse law and order situation in the area. Five (6%) farmers have migrated into the nearby country to avoid harassment by the moneylenders. Fear of recurrent disease made the farmers rethink their future investment in shrimp culture.

The unity and the trust among the members in the group enterprise became wavering and 60% of those farms have been broken into individual farms. These new farms again faced problems with water management systems.

CONCLUSION

The profit that the farmers generated from shrimp culture is not efficient from the point of economic return. Farmers started shrimp culture activity by seeing and learning from their neighbour. This poor understanding of management put the farmers into trouble in many cases. After 1994, the farmers could not achieve good return from the sector and in 2001, due to disease problem many small-scale farmers couldn't stand. They are associated with a number of debts from moneylender to fry collectors. Although the yield and the return are, however, not satisfied, yet the enthusiastic local people are participating in shrimp farming. The diversity of cropping pattern in shrimp farming land with introducing paddy cultivation is one of the initiatives to overcome the losses of disease outbreak.

The contribution from the shrimp culture, in general has received the credit of export earnings, creating local employment, facilitating growth of associated industries and services etc. However, environmental deterioration has triggered widespread disease outbreaks and consequent heavy losses to farmers thus challenging the sustainability of shrimp aquaculture. In view of the increasing need and pressure for environmental conservation and social equity, emphasis is laid on developing socially oriented and environment-friendly aquaculture.

ACKNOWLEDGEMENT

The research was performed through a study attachment with the Asian Institute of Technology (AIT), Thailand. The author likes to express sincere thanks to Prof. C. Kwei Lin, Dr. Amararatne Yakupitiyage and Dr. Harvey Demaine of Asian Institute of Technology, Thailand for their supervision during the research work. Grateful acknowledgement is paid to DANIDA for providing research grant and heartfelt thanks to many people who assisted and participated during interview and discussion sessions.

REFERENCES

Alam, S.M.N., 2002. Shrimp Based Farming Systems in South-western Coastal Zone of Bangladesh. M. Sc. thesis (AQ02-20). Integrated Tropical Coastal Zone Management. Asian Institute of Technology, Bangkok, Thailand, pp: 102.

Alam, S.M.N., 2004. Contribution of non-target species in shrimp farming system in Bangladesh. Bangladesh J. Zool., 32: 69-75.

Alam, S.M.N., M.J. Phillips and C.K. Lin, 2003. Shrimp harvesting technology on the southwest coast of Bangladesh. Aqu. Asia, VIII: 29-30.

Begum, A. and S.M.N. Alam, 2002. Social and Economic Impacts of Shrimp Disease among Small-Scale, Coastal Farmers and Communities in Bangladesh. In: Primary Aquatic Animal Health Care in Rural, Small-Scale, Aquaculture Development (Eds.), by Arthur J.R., M.J.R. Phillips, P. Subasinghe, M.B. Reantaso, I.H. MacRae, FAO Fisheries Technical paper. Rome, Italy, pp: 191-200.

Beveridge, M.C.M., 1984. Cage and pen fish farming. Carrying capacity models and environmental impact. FAO Fisheries Technical Paper, Rome, Italy, 255: 133.

Caritas, 1997. Ownership and participation in shrimp culture under Third Fisheries Project (Shrimp Component). Dhaka, Bangladesh, pp: 45.

CDI (Caritas Development Institute), 2000. Base line survey of brackish water resources and environmental situation in Shyamnagar, Satkhira. Prepared to supplement the Sustainable Environment Management Program (SEMP) of Caritas. Outer Circular Road, Dhaka, Bangladesh, 178: 2.

Chowdhury, M.B.R. and M. Muniruzzaman, 2003. Shrimp disease and its consequences on the coastal shrimp farming in Bangladesh. Proceeding of the workshop on environmental and socio-economic impacts of shrimp farming in Bangladesh. BAU-NORAD, Dhaka, Bangladesh, pp: 39-48.

DOF (Department of Fisheries), 2001. The dynamics and diversity of the shrimp farming in Bangladesh. Shrimp sector technical review. Draft final report. Dhaka, Bangladesh, pp: 63.

DOF (Department of Fisheries), 2002. Fish Fortnight Publication. Department of Fisheries. Ministry of Fisheries and Livestock. Dhaka, Bangladesh, pp: 130.

FAO (Food and Agriculture Organization), 1997. Disease prevention and health management of coastal shrimp culture. TCP/BGD/6714, Field Document. Food and Agriculture Organization of the United Nations, Bangkok, Thailand, 1: 52.

Funge-Smith, S.J., 1997. Disease prevention and health management in coastal shrimp culture. TCP/BGD/6714 (A). Bangladesh consultancy mission report.

Hoq, M.E., M.S. Ali, M.R. Shaha and G.C. Halder, 1997. Field evaluation of traditional shrimp farming in the south-western region of Bangladesh. J. Asiatic Soc. Bangladesh, 23: 21-27.

Hossain, M.S. and C.K. Lin, 2001. Land Use Zoning for Integrated Coastal Zone Management: Remote Sensing, GIS and RRA Approach in Cox's Bazar Coast, Bangladesh. ITCZM Publication Series. Asian Inst. Tech. Bangkok, Thailand, 3: 25.

Islam, M.S., 1999. Social and institutional aspects of shrimp-rice farming in Bangladesh. Paper presented in the workshop on Economic, social and environmental implications of shrimp-rice integrated farming system in Bangladesh held on 1999 at BIDS, Dhaka, Bangladesh.

Karim, M. and J. Stellwagen, 1998. Final Report on Fourth Fisheries Project: Shrimp Aquaculture. (Preparatory Phase for National Fisheries development Programme). Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh.

Larkins, P.E., 1995. Disease problems of cultured brackish water shrimp and fresh water prawns in Bangladesh. Working document Vol. I and II, Department of Fisheries, Matshya Bhaban, Dhaka, Bangladesh.

Naser, M.N., M.M. Hossain and M. Shafi 1991. A checklist of the fish fauna for the brackish water ponds of Paikgacha. J. Natural Studies, 1: 73-81.

Rahman, A., M.A. Islam, I. Roy, L. Azad and K.S. Islam, 1995. Shrimp culture and environment in the coastal Region. Bangladesh Institute of Development Studies. Dhaka, Bangladesh.

Shang, Y.C., 1990. Aquaculture economic analysis: An introduction. World Aquaculture Society, Baton Rouge, Louisiana, USA.

Wahab, M.A., A. Berghem and B. Braaten, 2003. Water quality and partial mass budget in extensive shrimp ponds in Bangladesh. Aquaculture, 218: 413-423.