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Coastal Shrimp Aquaculture Systems in Southwestern Bangladesh

S.M.N. ALAM[1] and M.J. PHILLIPS[2]

[1]*169 West Agargaon*
Department of Social Sciences
Shere Bangla Nagar, Dhaka-1207
Bangladesh

[2]*Network of Aquaculture Centre in Asia-Pacific*
Kasetsart University Campus
Ladyao, Jatujak, Bangkok, 10900
Thailand

Abstract

A study was conducted between January and April 2002 with a detailed farm survey to describe the coastal shrimp farming practices and management among the different categories of farm ownership (individual, group and outside) in southwestern Bangladesh. The current farming practice was characterized by extensive culture systems with low input use, leading to low productivity levels. The different farm management practices were noticed among the different categories of farm ownership. The average farm size varied among individual (2.28 ha), group (4.59 ha), and outside lessee (19.56 ha). The production systems include multistock and multiharvest throughout the year. Inputs provided into the pond with an average depth of 0.7 m water were mainly limited to improper ratio of lime, cow-dung and fertilizer. All the categories maintained an average stocking density of 1.7 fry•m^{-2} for *Penaeus monodon*. The outside lessee stocked less quantity and achieved higher survival rate than the other two categories. Due to disease prone each category achieved variable yield. The individual and group farmers preferred other shrimp and finfish in the shrimp farming systems to increase biomass and to avert the risk of diseases while the outside lessee concentrated on *P. monodon* culture. Poor disease control mechanism prevailed in the area.

Introduction

The contribution of coastal aquaculture, particularly black tiger shrimp (*P. monodon*, Penaeidae) culture, to both rural and national economies is a major source of export earnings and employment in the coastal areas. The shrimp is the second highest foreign income earner. Bangladesh has a large area of coastal tidal land of which 0.143 million hectares of land has been brought under brackish water shrimp aquaculture. In 2001-2002 the country produced 65,579.42 metric tons of shrimp of all kinds and exported 30,209 metric tons of frozen shrimp and earned 1,447.8 crore taka (DOF 1903).

More than 600,000 people are somehow engaged in backward and forward activities of shrimp aquaculture.

Coastal shrimp aquaculture in Bangladesh is mainly confined to two regions, namely: Khulna and Chittagong. At present 80% of the shrimp farms are located at the southwest (Khulna) region while the rest are located in the southeast (Cox's Bazar region) and other coastal areas. Due to difference in water salinity in the southwest and southeast region, the culture practices and production period of shrimp in the two areas are different (Fig. 1). In the southwestern region culture practices also vary due to salinity variances in the water. Alternate shrimp-paddy farming is followed in some areas of the Khulna region.

Following this pattern, one crop of transplanted Aman is grown between September and November during monsoon season when the water of the river becomes fresh and sweet. From February to August a crop of shrimp is cultured, when the water of the surrounding rivers becomes saline. In areas under the Satkhira district, shrimp farming continued almost year round due to the presence of moderate to high salinity in the water (Alam 1902).

The ownership pattern for shrimp farm is complex and varies from area to area in Bangladesh (Caritas 1997). The major categories of shrimp farm ownership are:

a) Individual owner: The land is owned and operated by one person. The landowner invests cash according to his capability and enjoys total returns from the farms.

b) Farmers group: The land is owned by a number of persons who all play an active role in operating the farm. They contribute land and money and do the farming jointly. They share the returns from the farm, proportionate to their contribution of land, cash and physical labor.

c) Outside lessee: The land is leased out by owners to a person or persons living outside the polder. The outsiders provide capital, and usually set up shrimp farms taking most of the land from small and medium landowners. They usually ally themselves with neighboring medium size landowners by taking their land and giving them a share in the farm operations and income. This is done to gain influence over the land and control over the local people.

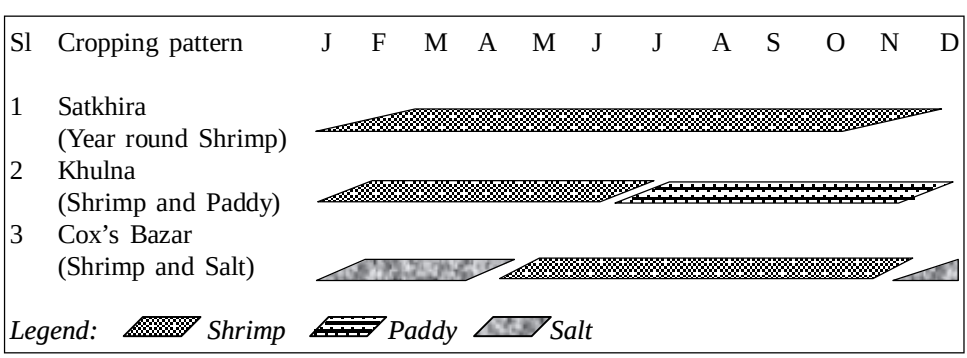

Fig. 1. Cropping pattern of shrimp culture in Bangladesh

There exists literature and studies on shrimp farming systems (extensive and semi-intensive) as a whole and in majority of cases, it is believed that the culture practiced by the different farm owners are similar. The present findings emphasized more in depth study of shrimp farming and management practices under different categories of farm ownership arrangement in the southwestern Bangladesh.

Materials and Methods

The study area is situated at 22º11'- 22º17'N and 89º03'- 89º12'E, in a brackish water area of southwestern Bangladesh, which is administratively located in Munshiganj Union under Shyamnagar Upazila of Satkhira District. The study is based on primary and secondary data sources. Data were collected from January to August 2002 from 35 individual farms, 31 group farms, and three outside lessee farms. A questionnaire was developed using both open and close-ended questionnaires. Random sampling method was employed in selecting the sample population from the sample size. There were farms of different crops under different ownership arrangements and these were set up all over the study area. Careful investigation was made to identify the potential farms. In some cases cluster category of individual or group shrimp farms were found and additional selections were reserved in case of refusal to interviewed.

All information and data gathered from the field were combined and summarized in tabular form and classified according to farm ownership arrangements. Collected data was stored, explored and analyzed using Microsoft Excel, SPSS for Window and Microsoft Word program to present results and discussion.

Results and Discussion

Socioeconomic characteristics of the respondents

Respondent types

Most of the respondents in the survey, were the owners (49.27%) of the farm, followed by the heads (36.23%) and managers (14.49%) respectively.

Experience

All of them had years of actual experience in their respective shrimp farms. About 49% of the individual farmers with smaller farm size had 6-10 years of experience, while 23% of the same category had 1-5 years of experience. Only 6% gained 16-20 years of experience in shrimp farming. In group farming with moderate farm size, 17 (55%) groups had 6-10 years of

experience, while nine (29%) groups were found with 11-16 years of experience. Only one group (3%) had 16-20 years of experience. In outside lessee farming with largest farm size, two (67%) respondents had 6-10 years experience, while only one (33%) had less than 5 years experience. This indicated that group farming were splitting, and more individual farmers were moving into this entrepreneurship and had limited experience with shrimp culture.

Education

Literacy of the respondents was considered as a conducive factor to boost up farming practices. In this study, five levels (illiterate, primary, secondary, higher secondary and graduate) of literacy were identified. Among the degrees of literacy, highest attainment were found in primary level with 55% in individual, 62% in group, and 33% in outside lessee farmers. The next level was secondary attaining 31%, 13% and 67% in individual, group and outside lessee respectively.

Occupations

It was observed that almost 100% of the respondents under each category had shrimp farming occupation as the primary occupation, while the same respondents had agriculture as their secondary occupations. One hundred percent of the respondents followed the technology used by their neighbors. During the survey period, farmers achieved negative profit, as outbreak of diseases severely affected the production during 2001.

Geographic and climatic environment

Climate

The area has a subtropical monsoon climate with a moderate rainfall that has significant effects on the fluctuating level of salinity and hydrology, and these in turn critical on shrimp and paddy cultivation. The four main seasons are premonsoon (March-May), monsoon (June-September), post-monsoon (October-November) and dry winter season (December-February). The premonsoon is characterized by southerly winds, high temperatures and evapotranspiration rates and by occasional thunderstorms and northwesterly winds. The monsoon brings heavy rainfall, high humidity and cloud cover. The post-monsoon is hot and humid, with occasional thunderstorms, cyclones and storm surges. The dry winter season is characterized by cool, dry and sunny weather.

Average climatic data indicates that the monsoon occurs from May, averaging 225 mm rain, to October, averaging 110 mm, with a peak in June, averaging 410 mm. During the dry season by contrast December normally is without rainfall. Throughout the year the relative humidity is high, ranging from 74% in March to 88% in July. The mean monthly air temperature range from 18ºC in January to 27ºC in August, with an average maximum

temperature of 25ºC in January and 34ºC in May. The major natural hazards in the area are cyclones, tidal bores, saline intrusions, drainage congestion and drought. All these limit effective agriculture activities and degrade the surface water quality, causing distress to livestock and humans (CDI 1900).

Hydrology

The study area is intersected by many rivers and canals, the larger are termed *nodi* or *gang* and the smaller, *khals*. The two main rivers are the Kalindi and Kholpetua, flowing south to the Bay of Bengal through many distributaries in the Sundarbans, with the Kadamtala, Dumkoli, Chunkuri and Malancha being smaller rivers between them. These rivers all have tidal reaches in their lower stretches, and these affect their hydrology by damming back water each high tide. Water from shrimp farms is drained into the rivers through 12 sluice gates and 170 mini-flushing gates. Currently however most internal canals in the area are silted up and have been obstructed by shrimp farm dykes, causing poor drainage and waterlogged conditions on the land.

Soil characteristics

The predominant soil texture is clay and silty clay, with mostly slightly acid to alkaline conditions (pH 5.4-8.0). Clay dominates over silt (36%) and sand (2%). There is less variation in soil pH in agricultural areas than there is in shrimp farming areas. Conversely there is a greater variation in soil salinity (up to 13 ppt) in shrimp farming areas than in agricultural areas (2.8-4 ppt). Organic matter contents are higher in agricultural areas, and lower (about 2.7%) in shrimp farming areas. The N, P, K and Ca levels are low to moderate in shrimp farming areas, whereas Mg, S, and B are moderate to high. In agricultural areas the overall soil fertility is low and soil salinity is the major hazard to be overcome.

Water quality

There is a noticeable lack of variation in the water quality over the study area, with a high degree of uniformity of salinity, water temperature, transparency, ammonia, nitrite and dissolved oxygen content. The low level of oxygen at 1.5 mg•l is due to the shallow depth of the water and deteriorating bottom conditions. Water salinity is lowest in the agricultural areas and highest in the shrimp farming areas and ponds. The average pH level at 6.5 to 7.8 is observed throughout the different salinity areas, but the carbon dioxide content increases from highly saline (16.67) to lower saline (21.67) areas. Nitrite content also decreases from highly saline (0.103) to lower saline (0.071) areas (CDI 1900). A variation in salinity is also noticeable throughout the year, with the highest salinity at 24 ppt in May and the lowest at 6 ppt in October.

Shrimp farming

Shrimp farming is an age-old traditional practice in the study area. Farmers use their own lands that were formerly rice fields. Farming refers to the natural rearing process in its simplest form. All the interviewed farmers have grow out ponds. The main species used in coastal aquaculture is the black tiger shrimp, *Penaeus monodon*.

Farming period starts from February to the end of November using multiple stocking and multiple harvesting methods. In shrimp monoculture a series of activities are needed for successful growth of shrimp (Fig. 2). All the respondent farmers under different categories performed almost the same type of management activities, for pond preparation and grow out. However, the farm size, the application rate of fertilizer, stocking density of PL, and water exchange rates varied from farmer to farmer. The farming practices under individual, group, and outside category are discussed in the following sections.

Farm location and characteristics

In coastal aquaculture the position of the farm is an important factor. All the investigated farms were found in the inter-tidal range. Farm design was highly dependent on the characteristics of the site selected. There was no so-called unique design followed by any category of shrimp farmer. One hundred percent of the farmers from all categories followed the open system, with no treatment ponds. Bottom topography of the surveyed farms was irregular.

All the farms were within the range of 145 meters from the main river of the area. The average water depth in the pond was 0.61 meter. Generally 11-13 cm. of water height is reduced at every 14-15 days interval. 20-30% of the pond water volume is exchanged during tidal regimes and farm effluents discharged directly to the common flushing cum drainage canal.

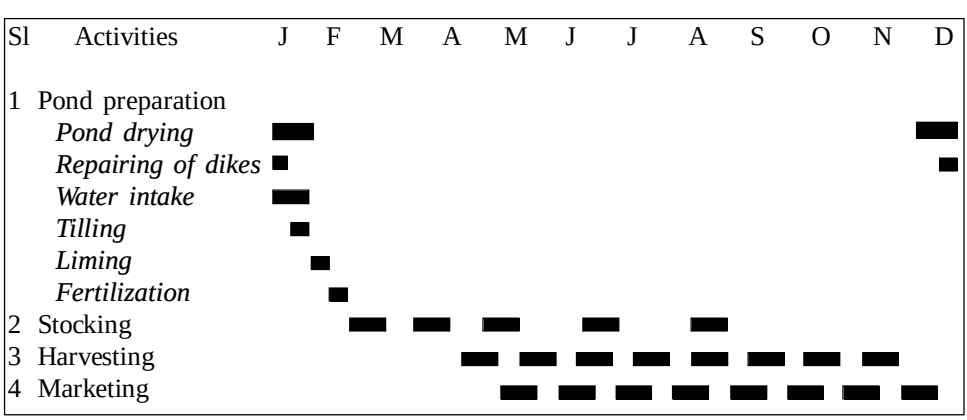

Fig. 2. Activities calendar of shrimp farming

The shape of the farms was mostly found rectangular or irregular with large surface area. The variation of the farm size in the different categories was distinctly noticed in the study area. The actual farm size was highly variable. The average area used by the surveyed category for shrimp culture was 8.81 ha (Table 1). Farms under individual category were generally smaller in size (2.28 ha) followed by group farm category (4.59 ha). The largest size of the farm was found under outside lessee. The mean size of the farm under this category was 19.56 ha. The range of the farm size was 10.80 ha-36.44 ha.

Overall the average size of the shrimp farm in the area was 8.81 ha which was lower than the findings (10 ha. in Shyamnagar Thana) by Hoq et al., (1997). In other Upazilas under the Satkhira District he found the farm area below 50 ha (average 27 ha). The BCAS (2001) census in the five polders found that about 93% of shrimp farms under five polders were below 10 ha in size. Caritas (1997) reported that 88% of the shrimp farms in the four polder areas were less than 10 ha. Siriwardena (1997) documented a total of 10,236 shrimp farms having an average area of 12.7 ha. According to DOF, however the total number of tiger shrimp farm was 15,218 with an estimated average farm size of 9.5 ha during 1999-2000 in the four coastal districts covering nearly 99% tiger shrimp farms. The findings from the study revealed that the farm sizes were becoming smaller day by day and most of the farms were operated by individual or group enterprise.

Pond management

Pond preparation is an important activity at the start of each culture period. Almost every farmer the locality practiced pond preparation. Pond dikes are constructed manually up to a height of about 0.4-1.2 m (average 0.7 m) and the width of the dike vary from 0.2-0.7 m. The dikes are built by excavating the topsoil adjacent to the dikes. Thus shallow canals along the periphery of the dikes are created to retain water and act as shrimp refuge.

Sludge removal

The sediment waste from the farm was removed manually, and dumped on the top or outside the dyke. Generally there was no huge sludge produced from this farming system. Decayed grass, debris, and algae to some extent were removed at this stage.

Table 1. Size of the shrimp farm by different categories

Size (ha)	Individual (n=35)	Group (n=31)	Outside (n=03)	All (n=69)
Mean	2.28	4.59	19.56	8.81
SD	1.78	3.65	14.61	4.76
Minimum	0.27	1.21	10.80	0.27
Maximum	9.99	14.57	36.44	36.44

Pond drying

Drying of pond's bottom is an important aspect for the successful growth and survival of the organisms. Generally the water of the old shrimp pond is washed away by the end of November and left to sundry for a month. The large farms applied ploughing using a tractor after drying while the smaller farms took water after drying and ploughed by tractor. During this time the farmers repaired the dikes, sluice gate, guardshed and other infrastructure.

Water intake

After drying and tilling the pond was filled with tidal water up to six inches. The smaller farmer usually took ploughing at this stage. Water is raised at interval of putting each input. There was a tendency among the individual and group farmers to spray thiodan, a kind of liquid insecticide (ingredients: endosulfan 35% and emulsifiers 65%) at the first intake of water to kill unwanted organisms from the farm. The applied dose was 70-100 $gm \cdot ha^{-1}$.

Liming

Following drying and filling the farm with tidal water, agricultural limestone ($CaCo_3$) was applied after two days of insecticide application to neutralize organic acid. The average application rate of lime under all categories was 82.82 $kg \cdot ha^{-1}$. The individual category used lower rate of lime (67.37 $kg \cdot ha^{-1}$) compared to other categories. The limestone was put in a drum with water for the whole night and sprayed all over the farm the following day.

Fertilization

The last activity for pond preparation before shrimp fry stocking was to fertilize the pond for producing natural food. After 3-5 days of liming the pond was applied with semi dried cow dung. The outside farmer used the highest quantity of cow dung (1,058.72 $kg \cdot ha^{-1}$) than those of individual (830.42 $kg \cdot ha^{-1}$) and group (792.99 $kg \cdot ha^{-1}$) categories. Inputs like Urea, Triple Super Phosphate (TSP), Di Ammonium Phosphate (DAP), Muster cake and others like Zinc and potash were used by the different categories for improving pond productivity (Fig. 3).

Shrimp fry stocking management

Sources and preferences of fry

Fry quality has a major impact on production and the profitability of a shrimp farm. Therefore farmers have to select good quality seed at the age

of PL 15-25 to ensure profitable harvest. Stocking larger post larvae can improve survivability due to more developed resistance to disease, stronger benthic feeding behaviour and improved predator resistance. There were two sources of fry i.e. wild and the hatchery bred fry. One hundred percent of the farmers under each category first preferred wild fry because they are stronger in nature, readily available, and adjusted to the local water parameters. When there was shortage of wild fry and the price hiked up, shrimp farmers were compelled to buy hatchery bud fry regardless if prices.

Stocking density

Shrimp farms under different ownerships were found to stock with varied number of fry. Majority of the farmers under all category stocked shrimp PL directly to grow out ponds, while a few of them nursed fry in nursery pond before transferring to grow out ponds.

Table 2 showed the stocking density by all categories. It revealed that the smaller farm stocked more than those of large sized farm. The individual shrimp farmers preferred to stock the farm with 19,642 fry•ha^{-1} than the other categories. The outside farmer that holds the largest amount of area stocked only 13,437.39 fry•ha^{-1}. Overall the average stocking density in the study area was 16,696.55 fry•ha^{-1} which was within the range of findings (15,000 to 40,000 fry•ha^{-1}) by Hoq et. al. (1997). On the average the farmers stocked 1.7 fry•m^{-2}. Results of ANOVA depicted that the mean stocking densities under individual category are significantly ($P < 0.05$) higher than that of outside category.

Table 2. Stocking density (fry•ha^{-1}) of shrimp fry by different categories

	Individual (n = 35)	Group (n = 31)	Outside (n = 3)	All (n=69)
Mean	19,642.40	17,009.86	13,437.39	16,696.55
SD	5,353.23	4,924.14	9,927.01	5,303.45
Minimum	9,880.00	8,295.71	2,799.89	2,799.89
Maximum	29,107.74	27,544.24	22,454.55	29,107.74

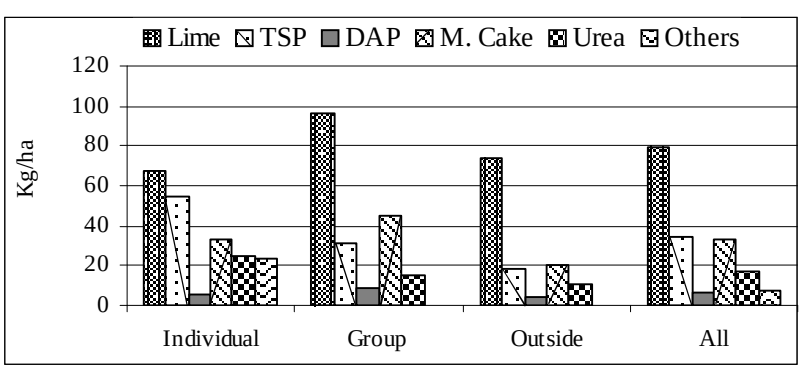

Fig. 3. Use of fertilizers by different categories

Stocking method

Farmers under different categories often tested samples of hatchery bred fry rather than wild fry. Farmers of all categories counted PL at the farm gate using white melamine spoon and a bowl. A sample of hatchery bred fry were put into a bowl and acclimatized to pond water for 20 minutes. In some cases the fries were put into a net hapa and their survival rate was checked for 24 hours and then released into the pond.

Frequency of stocking

In the study area farmers under all categories practiced shrimp fry stocking more than five times in their ponds and harvested for several times (more than 16 times) in their farming calendar. This was due to availability of year round saline water in the nearby rivers and canals. Almost all categories of shrimp farmers completed stocking between February and April and harvested between April and November.

Survivability

The varied survival rate of shrimp post larvae by different categories was observed in the present study that depicted loss of 76% of post stock PL. The large farms under outside category had the highest survivability of the PL (45%) while the individual and the group farmers received 24 and 26% of PL survivability respectively. This finding also support the findings of Karim and Stellwagen (1998) that coastal shrimp aquaculture represented an estimated 20% survival of the stocked post larvae, revealing a post stocking wastage of PL The higher mortalities were found during the early stage (50-70 nos•kg^{-1}) of shrimp culture period.

During rainy season high loading of silt created an unfavourable pond environment of shrimp. Such practices could lead to post-stocking mass mortality of post larvae leading to immediate limitation of potential yield and increased susceptibility to diseases leading in the environment. Thus timing of stocking played a key role in shrimp culture with respect to increase productivity and sustained good health of shrimp. The trend of avoiding stocking and extending culture cycle into unfavourable months of the year was quite evident in the study area in all categories of farmers.

Water exchange

The surveyed farms exchanged water through the sluice gate made of wood or concrete. The smaller farms generally used wooden gate while the large farms used both wooden and concrete gate. Both gates are controlled by a wooden shutter. Majority of the farms used the same gate for drainage and flushing purposes. Very few had separate drainage and flushing gates. A few of the farms used pump machine for water intake due to higher land elevation inside the farms. The water volume of the farm was routinely ex-

changed every 4-6 days at every lunar cycle. In case of unwanted occurrences farmer exchanged water any time.

Health and disease management

Farmers under all categories checked shrimp growth randomly and throughout the production cycle. Each time, 15-20 shrimp were checked using cast net and hand. The body color, 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 shown 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%). The individual category checked all the possible symptoms in shrimp. Gills were not checked by other categories of farmers. Shrimp diseases have become a regular occurrence in the study area since 1995. The farmers of all categories admitted the occurrence of shrimp diseases in 2001 (Table 4).

The affected farmers had also taken different measures to cope with shrimp diseases. Most of the farmers harvested early when shrimp disease occurred in his or neighbor's farms. Farmers had a tendency to use chemicals like Thiodan during the occurrence of diseases. Water quality improvement measures were not practiced besides exchange of water during tidal variation. When the extent of the disease was severe farmers reduced all the water and let the bottom of the farm to dry up under the sun. The remaining shrimp took refuge into the canal along the periphery of the farm. After drying, the pond was filled again with brackish water and stocking also took

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

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

place. Some farmers had transformed a portion of the farm into paddy culture during monsoon period to avert the risk.

For whatever type of disease, the farmers used to associate it to viral disease. In 2001, majority of the shrimp farms experienced with red body color and food deficiency. A few (10%) experienced white spot diseases. The shrimp disease occurred at the age of 15-20 gm. and occurred from May onward. Other diseases causing high mortality were tail rotten. Farmers reported no diseases in other shrimps and fin-fishes.

This view is often supported by the Department of Fisheries. In 2001, there was evidence of shrimp diseases and this was reported by many GoB and consultants. The reports depicted that the observed trends in disease outbreaks indicating production losses and shrimp diseases were managed poorly. The deterioration of the pond environment played a key role in putting shrimp in a stressful condition. Among the poor farm management practices–shallow pond depth, bad water quality, no feed, presence of thick submerged weeds and vegetation were sharply marked. There was also high temperature (34.5°C in May) and rainfall (411mm in June) prevailing at that time.

It was evident from the FAO (1997), TCP/BGD/6714 survey that bacterial diseases and stress symptoms due to poor pond environment appeared to be a significant contributory factor to the recurrent mortality. As per results of the mentioned survey high incident of pale and red discoloration of the body and tail rot with swollen edge indicated deteriorated bottom and pond environment.

Harvesting and marketing management

Harvesting, the last activity of shrimp culture is carried out after 90-120 days of extensive shrimp farming. Harvesting usually takes place during full and new moon of a lunar cycle. A cycle consists of 5-7 days. During that period, used farm water is drained out to the canal. Then fresh tidal water from the canal is introduced into the farm. The shrimp becomes excited and starts moving towards the entry point of the tidal water as shrimp, by their habits like to swim against the rush of current. The following methods were practiced in harvesting farmed shrimp in the study area.

Table 4. Occurrence and types of diseases in shrimp culture by category

Diseases	Individual (n=35)	Group (n=31)	Outside (n=03)
Disease occurrence (%)			
Yes	94	94	100
No	06	06	00
Disease condition (%)			
Red color	26	10	33
Virus	17	10	00
Soft shell	49	62	67
Loss of appendages	01	02	00

GAI method

A very small portion of the farm is converted into a rectangular shaped harvesting area. This area is prepared at the adjacent of the canal by all categories of farmers. The individual and farmer groups built the area using soil made dikes all around. One wooden gate is placed in the inner dike of the area to control the flow of water from both sides. The outside lessees built all the dikes and bottom using concrete materials to ease the harvesting process. A bamboo fence used by individual farmers is laterally placed a short distance from the canal to prevent escaping of shrimp and other fishes. The well off farmers, either individual or group category now use plastic pipe to make this fence for durability and longevity. The total harvesting area is locally called GAI. Figure 4 shows the diagram of a GAI. Shrimp enter into the catchment area through a narrow passage in the fence, and these cannot go back to the rearing area of the farm. While inflow of the water has become stationary, catching of shrimp is then started by cast net. The outside lessee sometimes drags the cast net, as the bottom is smooth due to concrete materials. Lastly the water in the catchment area is totally drained out and the last piece of shrimp is caught manually. This system is repeated during a lunar cycle.

Trap method

Trapping is another way of harvesting shrimp. Some bamboo traps, of various sizes (standard 2 ft x 2.5 ft x 2 ft) is placed at 8-10 feet intervals from the periphery to inside the farm. Fine meshed net is attached to each of the set up trap. These are set up into the deeper area of the farm. During flow of tide the shrimp usually moves towards the edge of the dike and happens to enter into the traps. The traps are then checked at certain breaks and shrimps are taken out and placed inside again. This system continues until the end of each lunar period. The large shrimp farms specially the outside lessee usually set up the traps frequently where shrimp during tidal wave are unable to move to the GAI.

Net method

Cast net is engaged for harvesting shrimp when fewer amounts of shrimp is caught in the GAI or in the Trap. The farm owner engages the

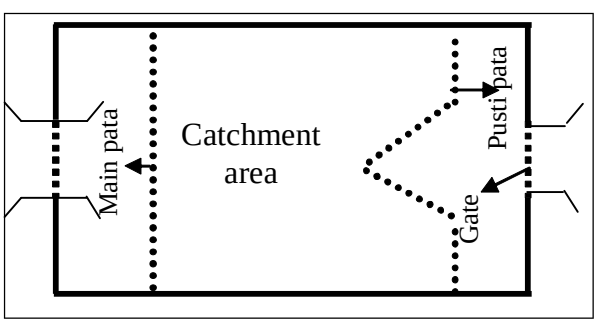

Fig. 4. Schematic diagram of a *GAI*

help of some cast net owners. The netters stand close to each other and cast the net together. Thus they move forward casting nets all over the farm and shrimp is thus harvested. Particularly large farm owners (outside lessee) employ this technique at the end of season.

Marketing

The harvested shrimp are kept in different kinds of bamboo crates or coops. The shrimp are then washed with water and placed in a heap to be ready for sale at the farm gate. The buyer comes to the farm gate, haggle and settle the selling price. Sometimes selling through auction takes place due to the presence of a number of buyers. The winning bidder occasionally shares the lot with other fellow buyers who came to bid and thus keep social harmony in the locality. The head-on shrimp are then taken into the local depot for icing and are forwarded to the processing plant within the shortest possible time for beheading and onward dressing.

Yield from the shrimp farms

The findings from the surveyed farms suggested a variable yield of *P. monodon* ranging from 146.39 kg•ha to 153.12 kg•ha with a mean yield of 150.45 kg•ha by different categories indicating lower productivity. Among the total yield of the shrimp farms, an average of 51% of the total weight came from *P. monodon* only while the rest (18% and 31%) came respectively from other shrimp and finfish.

Various authors have quoted different production rates irrespective of culture practice (62-206 $kg \cdot ha^{-1} \cdot yr^{-1}$ [Rahman et. al. 1994]; 97.4-225.6 $kg \cdot ha^{-1} \cdot yr^{-1}$ [Hoq et. al. 1997]). The FAO (1997), TCP/BGD/6714 project also recorded lower productivity of shrimp (125.15 $kg \cdot ha^{-1} \cdot yr^{-1}$) and other fishes in their survey.

According to FAO (1997), *P. monodon* contributed 50%, while the other shrimp contributed 25% in the total farm production. The rest (25%) came from finfish. The present findings also found variations among the species and by category. The average contribution from the *P. monodon* is 51%. The outside farm owner received 63% of *P. monodon* production while the individual and group farmers received 46% and 48% respectively. This indicates that the outside farm owner paid more concentration on *P. monodon* production than the other two categories. The individual and the group farmers preferred to produce other shrimp (22% and 21%) and finfish (32% and 30%) to increase total biomass and to avert risk of diseases than the outside farm owner (12% and 25%).

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