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Freshwater prawn farming in Bangladesh: history, present status and future prospects

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Abstract

Within the overall agro-based economy in Bangladesh, freshwater prawn (*Macrobrachium rosenbergii*) farming is currently one of the most important sectors of the national economy. During the last two decades, its development has attracted considerable attention for its export potential. Freshwater prawn farming offers diverse livelihood opportunities for a large number of rural poor. Although the prospects for prawn farming are positive, it requires some research and development activities for long-term sustainability. This paper provides an overview of freshwater prawn farming in Bangladesh.

Keywords: freshwater prawn, *Macrobrachium rosenbergii*, Bangladesh

Introduction

Bangladesh is considered one of the most suitable countries in the world for giant freshwater prawn (*Macrobrachium rosenbergii* De Man 1879) farming, because of its favorable resources and agro-climatic conditions. A sub-tropical climate and a vast area of water bodies provide a unique opportunity for the production of *Macrobrachium* spp. Twenty-four species of freshwater prawns including 10 species of *Macrobrachium* are found in Bangladesh (Table 1). However, only *M. rosenbergii* has significant aquaculture potential and is commercially cultured (Akand & Hasan 1992; Ahmed 2001; Muir 2003a).

Freshwater prawn (*M. rosenbergii*) farming is currently one of the most important sectors of the national economy and during the last two decades, its development has attracted considerable attention because of its export potential. The prawn and shrimp sector as a whole is the second largest export industry after readymade garments, generating US$380 million annually and 5.6% of the total value of exports [Department of Fisheries (DOF) 2006]. There are 1.2 million people employed in prawn and shrimp production and a further 4.8 million household members are associated with the sector (USAID 2006). Unfortunately the export value and the number of people involved in prawn farming is not known because statistics often do not distinguish between prawn and shrimp.

Despite the growth of this sector, a number of issues are important for freshwater prawn farming in Bangladesh including production technology, socioeconomic and environmental aspects – all of these are important parameters of sustainability. This paper reviews the emergence and recent development and future prospects of *M. rosenbergii* farming in Bangladesh. The aim of this paper is to highlight key issues determine sustainable prawn farming to meet the international market, environmental and social challenges.

History of development

History

In Bangladesh, freshwater prawn farming first started in the southwest region in the early 1970s (Mazid 1994). After the independence in 1971, locals learnt to catch prawn fry from people on the other

Table 1 *Macrobrachium* species in Bangladesh

English name	Scientific name	Local name	Reference
1. Giant freshwater prawn	*Macrobrachium rosenbergii*	Golda chingri	Akand and Hasan (1992), Mirza and Ericksen (1996), Saifullah, Rahman, Jabber, Khan and Uddin (2005)
2. Monsoon river prawn	*Macrobrachium malcolmsonii*	Chotka icha	
3. Oriental river prawn	*Macrobrachium nipponense*	Icha/chingri	
4. Freshwater prawn	*Macrobrachium villosimanus*	Dimua icha	
5. Freshwater prawn	*Macrobrachium mirabilis*	Lutia icha	
6. Freshwater prawn	*Macrobrachium birmanicus*	Thengua icha	
7. Freshwater prawn	*Macrobrachium rude*	Goda icha	
8. Freshwater prawn	*Macrobrachium dayanus*	Kaira icha	
9. Freshwater prawn	*Macrobrachium lamarrei*	Icha	
10. Freshwater prawn	*Macrobrachium dolichodactylus*	Icha	

side of the Ichamati River, on the border between Bangladesh and India, at Debhata in the Satkhira district (BOBP 1990). It was Hormuz Ali who introduced the technique of wild prawn fry collection.

Around 1978, a few well-off local farmers in the Fakirhat area of Bagerhat district (Fig. 1) began to experiment with stocking prawn postlarvae in carp ponds. These innovators experimented with construction design, feeding, stocking and other technical aspects and profited well (Kendrick 1994). Finally a few pioneers, some time between the late 1970s and the mid 1980s, developed the first prawn cultivation in rice fields in low lying agricultural land. The name most frequently raised as the 'father of freshwater prawn farming' is Keramat Ali of the Fakirhat area in Bagerhat district (Rutherford 1994).

In the late 1980s, this farming practice began to be adopted widely in the original location in the Fakirhat area, where prawns were grown along with carps and rice (Kamp & Brand 1994). By around 1987, a few local farmers first converted their low lying lands and rice fields into *gher* (prawn farms are locally known as *gher*) for prawn cultivation (Kendrick 1994). Since then the pace of adoption increased dramatically as more farmers watched their neighbors profiting from prawn cultivation and decided to begin prawn farming as well (Rutherford 1994). The news soon spread to other areas, and farmers in other parts of Bagerhat district began to adopt this new technology. Although it has developed strongly in other areas, the number of prawn farms and farmers are still the highest in the Fakirhat area. Potential returns for prawn farming are good and farmers have been attracted by its potential as an income earner. For the people of Fakirhat, proudly called 'the Kuwait of Bangladesh', prawn production was reported to have increased subsistence farmers' incomes considerably (Kendrick 1994).

The early innovators tended to be large and middle size farmers, but increasing numbers of small and marginal farmers also started prawn farming (Rutherford 1994). The expansion of prawn cultivation has been dramatic, and since 1990 adoption has accelerated, spreading to other southwest districts such as Khulna and Satkhira (Fig. 1). Since the early 1990s prawn farming has become one of the financially most attractive investment opportunities in these areas (Ahmed 2001). In recent years (since 2000) the increase in demand for prawn in the international market has attracted many fish farmers to prawn cultivation in different parts of Bangladesh. As a result, prawn farming has also developed in southern Bangladesh, mainly Noakhali and Patuakhali districts and north-central Bangladesh, mainly Mymensingh district (Asaduzzaman, Wahab, Yi, Diana & Lin 2007).

Institutional role

Freshwater prawn cultivation practice has developed as an indigenous technology, with no planning and little support or assistance from any outside sources, including the government (Kamp & Brand 1994). The DOF and non-government organizations (NGOs) were slow to respond to the opportunities of the sector (Rutherford 1994). However, some donor-funded projects have shown interest in promoting prawn culture, for example, the CARE-supported Greater Options for Local Development through Aquaculture (GOLDA) project, Greater Noakhali Aquaculture Extension Project (GNAEP) and the Agro-based industries and Technology Development Project (ATDP). Recently the WorldFish Center and Winrock International have become active in the sector.

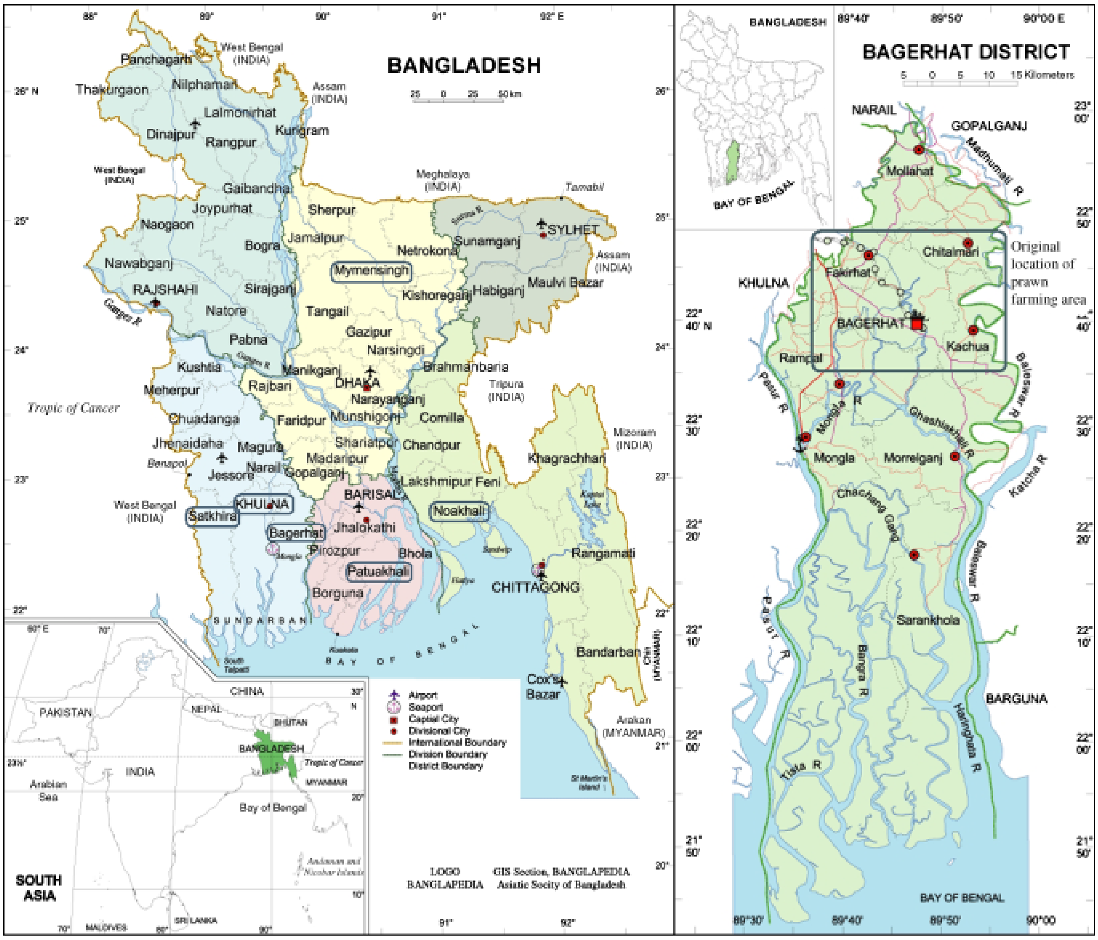

Figure 1 Map of Bangladesh showing the prawn farming districts and original location of prawn farming area in Bagerhat.

The CARE GOLDA project operated in southwest Bangladesh mainly Khulna, Bagerhat and Satkhira districts between 1996 and 2001 with funding from Department for International Development (DFID), UK. The project provided technical assistance to small-scale farmers to increase their incomes and improvement of socioeconomic conditions. The project also provided training to 15 000 resource poor farmers and credit through partner NGOs (Finan, Biswas & Muir 2001). The GNAEP was a Danish International Development Assistance (DANIDA) supported project working from 1998 to 2006 in the Noakhali area in southern Bangladesh. From 2002, the project focused on integrated prawn farming to achieve a more positive impact on poverty alleviation by increasing income of the poor farmers (GNAEP 2006; USAID 2006). By 2006, over 11 000 mainly small-scale farmers were engaged in prawn culture.

Prawn farming area and farm size

Culture area

Around three-quarters of prawn farms are located in the southwest part of Bangladesh which has been identified as the most important and promising area for prawn culture, because of the availability of wild postlarvae, favorable resources and climatic conditions, such as the availability of ponds, low lying agricultural land, warm climate, fertile soil, and cheap and abundant labor (Haroon 1990; Ahmed 2001). In 2002, there were an estimated 105 000 prawn farms in Bangladesh, of which 75 000 (71%) were located in the southwest (Muir 2003a). At that time, there were 30 000 ha of land under prawn farming (Williams 2003); this compares with 3500 ha in the mid 1980s (Muir 2003a). At present, the prawn culture area has increased to an estimated 50 000 ha

(Khondaker 2007). This figure is expected to rise with the increasing expansion of prawn cultivation into new areas. Prawn farming has been expanding rapidly in recent years, an average 10–20% per annum (Williams & Khan 2001; DOF 2002a; Khondaker 2007).

Farm size

Prawn farms are typically smaller than farms in the brackishwater shrimp sector; an average 0.28 ha compares with 4.0 ha of shrimp farms (DOF 2002a; Muir 2003a). This figure compares with prawn farms more than a decade ago which was averaged 0.35 ha in Bagerhat district (Rutherford 1994). However, Ahmed (2001) reported that the average prawn farm size was 0.23 ha in the Bagerhat area, with thousands of tiny farms and only a few large units; the largest farm size was 1.01 ha and the smallest was 0.06 ha. In the Mymensingh area, the average farm size is smaller than other parts of Bangladesh, an average 0.08 ha (Ahmed, Wahab & Thilsted 2007), while the average farm size in the Noakhali region was reported at 0.17 ha (Alam & Demaine 2003).

Prawn farming practices

There are two prawn farming systems in Bangladesh: pond and *gher*. Approximately 71% of farmers are involved in *gher* systems and the remainder in pond systems (Muir 2003a). Although prawn farming practice is still traditional and extensive in nature, many farmers (20%) practice improved methods where prawns are cultivated semi-intensively. Extensive production typically use slightly modified versions of traditional methods and are called low-density (10 000–18 000 postlarvae ha^{-1} year^{-1}) and low-input system. The system relies mainly on natural productivity (e.g., phytoplankton, zooplankton and benthos) of the pond, but organic and inorganic fertilizers are occasionally used to promote the growth of natural foods. Extensive feeding practices generally use supplementary diets consisting of a mixture of locally available feed ingredients, such as rice bran, wheat bran, oil cake and fish meal. Semi-intensive operations practice intermediate levels of stocking (18 000–30 000 postlarvae ha^{-1} year^{-1}) and other inputs. Farms with semi-intensive feeding practices depend on commercially manufactured pelleted feeds.

Pond systems

In pond systems, farmers usually stock hatchery-produced postlarvae during April to May. In the Noakhali area where pond culture is now the main system, the stocking density is low at around 10 000 postlarvae ha^{-1}. In the first week of postlarvae stocking, 50 g of wheat flour is applied per 1000 fry, and the following week a double quantity is given. Different carp species are also stocked by all farmers at a stocking density ranging from 2500 to 3000 fingerlings ha^{-1} (Lecouffe 2005). Farmers apply home-made feeds with ingredients either available on their farm or bought from the local markets. Home-made feeds use a mixture of fish meal, rice bran, mustard oil cake, molasses and wheat flour. If those ingredients are not available, farmers can simply feed the prawn with boiled wheat or cooked rice (Alam & Demaine 2004). Most farmers do not apply feed on regular basis, but according to their financial ability. In the Mymensingh area, commercial fish feeds are used by most farmers to increase prawn productivity. Feeding schedules of prawns are observed for three feeding periods: (i) starter – first 4 weeks at the rate 6% of body weight, (ii) grower – second 12 weeks at the rate 4% of body weight and (iii) finisher – last 8–12 weeks at the rate 3% of body weight (Ahmed, Ahammed & Lecouffe 2007).

Prawn harvest usually starts after 6–8 months of stocking from October to December, but in perennial ponds may continue up to May–June of the following year. The average size of prawn at harvest is from 60–150 g, with the larger sizes coming from the perennial ponds. The annual yield of prawns ranges from 175 to 200 kg ha^{-1} in the Noakhali area (Lecouffe 2005), which compares an average 400 kg ha^{-1} in the Mymensingh area (Asaduzzaman *et al*. 2007).

Gher systems

In southwest Bangladesh, the cultivation of prawn in modified rice fields is locally referred to as '*gher*' (Rutherford 1994). The Bengali term '*gher*' is an enclosure made for prawn cultivation by modifying rice fields through building higher dikes around the field and excavating a canal inside the periphery to retain water during the dry season (Kendrick 1994). According to Kamp and Brand (1994), *gher* farming is a 'quiet, indigenous technological revolution', suitable for the cultivation of prawn, fish and rice. *Gher* farming can be considered as a method of integrated aquaculture–agriculture on one plot. During the rainy season the whole water body is used for the cultivation of prawn and fish. However, when the weather is dry then only the trenches are used for fish and rice is planted in the central part of the plot. The dikes can be used for growing vegetables and fruits throughout the year (Chapman & Abedin 2002). The *gher* are generally situated in low lying areas of the floodplain, which are irregular in shape and cover hundreds of hectares (New 1995). The principal water sources for *gher* are rainfall, ground water and sometimes river water through canals.

Most farmers practice integrated prawn farming in *gher* systems. The *gher* design potentially provides good opportunities for diversified production, with primary dependence on prawn, fish, rice and dike crops (Fig. 2). Prawns are produced for export markets while fish, rice and dike crops are for local markets and household consumption.

The peak season of prawn farming in *gher* is from May to January. Prawn postlarvae are stocked in May to June and harvested primarily from November to January, a culture period of around 9 months. Farmers cultivate *boro* rice in the central plateau of the *gher* during the dry season from January to April and originally avoided cultivation of monsoon season *aman* rice during June to October when the prawns are in the *gher*, because of the perceived negative effects on prawn growth (Ahmed 2001). However, evidence from other countries suggests that concurrent rice with fish and prawn is a positive practice. Nguyen (1993) stated that integrating prawn culture with rice farming is ecologically sound and a good method of diversification in Vietnam, where prawns predate upon insects and improve soil fertility. Roy, Das and Mukhopadhyay (1991) noted that in integrated prawn culture in deep water rice fields, rice production has increased due to presence of prawn. This practice is now growing in Bangladesh, partly as a result of the promotion of integrated pest management. Culture of a high value crop like prawn in rice fields almost automatically restricts the use of pesticide.

A range of carp species is cultured with the prawn, but these are harvested throughout the year. Farmers stock the Indian major carps such as, catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhina cirrhosus*), as well as exotic carps, silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*). These are generally stocked at low densities ranging from 2000 to 5000 fingerlings ha^{-1} and traditionally at least there is no particular stocking mix (Ahmed 2001).

Almost all farmers cultivate a variety of dike crops on a small-scale and this practice has been steadily increasing. During the winter season, different types of dike crops such as carrot, tomato, onion, mustard, long yard bean, spinach and pea are produced, while crops produce in the summer season include potato, ladies finger (okra), sweet gourd, cucumber and chili. A range of short-cycle fruits is also produced on dikes such as banana, papaya and guava.

Production technology in *gher* systems

Stocking of prawns

Prawn culture in *gher* systems still remains dependent on wild postlarvae (Angell 1990, 1992; Ahmed 2000; DOF 2002b). Traditionally, farmers prefer to stock wild postlarvae rather than hatchery-produced fry because, until recently, the production of the hatchery postlarvae has been limited and farmers consider them to be of lower quality. The survival of wild postlarvae is reported to be much higher than that of hatchery-produced fry. The average annual

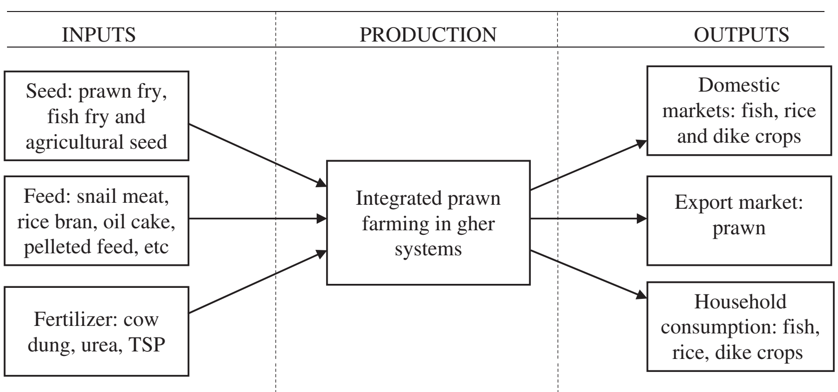

Figure 2 Freshwater prawn production in *gher* systems (adapted from Ahmed 2001).

stocking density of postlarvae is 20 680 ha $^{-1}$ (Ahmed 2001), ranging from 10 000 to 30 000 (Rosenberry 1992; Muir 2003a). Most farmers directly stock postlarvae without rearing in nursery systems. However, in recent years a few farmers have started to use *hapa* (i.e., net enclosure) or separate small ponds for nursing of postlarvae to improve survival rate. In general, farmers rear postlarvae for 4–6 weeks with a stocking rate from 50 to 100 m $^{-2}$ (Ahmed 2001). According to Singh and Vijiarungam (1992), better survival of stocks has been reported when nursing of postlarvae is done in net cages.

The livelihoods of around 400 000 people, many of them women and children, are associated with prawn postlarvae fishing in coastal Bangladesh during April to June (Ahmed, Ahammed, Rahman, Begum & Haque 2005; USAID 2006). Indiscriminate fishing of postlarvae with high levels of by-catch (i.e., non-target species caught incidentally) has an impact on biodiversity in coastal ecosystem and has provoked imposition of restrictions on postlarvae collection. In September 2000, DOF imposed ban on wild postlarvae fishing (DOF 2002b). This ban has not been strictly enforced because of the limited availability of hatchery seed. Nevertheless, the ban has been one of the factors that have stimulated the expansion of the prawn hatchery sector over the last few years. In 2000, there were only 16 hatcheries with a total production of 10 million postlarvae a year. In 2007, there exist 81 prawn hatcheries, although only 38 (47%) are operational in the sense of producing around 100 million postlarvae, 20% of total demand (Winrock International 2007). Lack of knowledge of the complex technology of prawn hatcheries, inadequate skilled manpower and insufficient supply of wild brood are important reasons for the poor results of many hatcheries.

Feeds and feeding of prawns

Supplementary feeds are used by all farmers in *gher* systems. A variety of feeds are used but the preferred feed is the freshwater snail, *Pila globosa* (Ahmed 2001). The use of snail meat as prawn feed is widespread in prawn farming areas and snail populations are reported to have declined heavily due to excessive harvesting. A wide variety of people including women and children are involved in snail harvesting during June to October. Overall, the supply of snails has generated a number of employment opportunities, in catching, processing, transporting and marketing activities.

An average 66.5 kg ha $^{-1}$ day $^{-1}$ of snail meat is applied for feeding of prawns during June to October (Ahmed 2001). In general, chopped snail meat is given twice a day in the morning and evening. If excessive snail meat floats up in the water, feed supply is reduced, and it is increased if it does not float in the water. The supply of snail is irregular and therefore farmers also use home made feed mixing by cooked rice, rice bran, oil cake and fish meal, or sometimes use industrially manufactured pelleted feed. In the early 1990s, the majority of pelleted feed was imported from Thailand and Taiwan, while most farmers currently use locally made pelleted feed for prawn farming.

Fertilization

Prawn farmers use two types of fertilizer: organic, mainly cow dung, and inorganic – urea and triple super phosphate (TSP). The purpose of using fertilizers in the *gher* is to create conditions, which help to increase the production of good quality of natural feed. Almost all farmers apply cow dung in their *gher*, which is relatively cheap and available. On the other hand, the use of inorganic fertilizer is not widespread and only a few farmers use a mixture of urea and TSP together with cow dung. On average, annual fertilization rate is 1467 kg ha $^{-1}$ of cow dung, 403 kg ha $^{-1}$ of urea and 217 kg ha $^{-1}$ of TSP at varying frequency (Ahmed 2001). Farmers also use lime in their *gher*, which is an important factor for prawn farming to maintain a healthy and productive environment to prevent disease. The average annual liming rate is 247 kg ha $^{-1}$.

Harvesting of prawns

In *gher* systems, the peak season of prawn harvesting is from November to January. Farmers harvest their prawns by using cast nets and seine nets, usually netting several times at a few weeks' intervals (Ahmed 2001). Cast nets are generally used for small *gher* and seine nets for large *gher*. A cast net can be operated by a single farmer, while a seine net is operated by a group of 3–4 commercial harvesters rather than the producers themselves.

The partial harvesting of larger prawns allows smaller prawns to grow. Harvested prawns are kept in aluminium or plastic containers. Ideally, the prawns are cleaned with tube-well water and kept in containers until they are sold to traders. Farmers grade all head-on prawns by size and weight and sell them to the prawn traders. About 50% of production is grade 20, < 10% is grade 5 and 10, although this may increase in perennial *gher* systems. The remaining is equally divided between grades 30 and 50, with anything smaller than grade 50 restocked rather than harvested (Muir 2003a). The average farm-gate price of prawns depends on grade and varies between US$ 2.6 and 6.5 kg $^{-1}$ (Table 2).

Constraints of prawn farming

Despite the great potential of freshwater prawn farming in Bangladesh, successful commercial culture faces a number of constraints including high production costs, insufficient supply of postlarvae, poor quality of feed, water pollution, disease and flood (Ahmed 2001). The expansion of prawn farming depends on availability of postlarvae. The major bottleneck for further expansion of prawn culture is the lack of adequate supply of postlarvae. Catches of wild postlarvae have declined in recent years because of over fishing, use of destructive gears, environmental degradation and pollution. Disease is a common and major problem of prawn farming in Bangladesh. A wide variety of diseases are found including shell diseases or black spot, white spot and gill disease (MacRae, Chapman, Nabi & Dhar 2002). Black spot, the most widespread disease of prawn from postlarvae to harvest size, is caused by bacteria and sometimes, later, by fungus (Cai, Wang & Yang 1997), causing mortality and also reducing the value of harvested prawns through discoloration. A number of social constraints have also been accompanied with the prawn farming sector in Bangladesh (Bundell & Maybin 1996; Ito 2004). Prawn farmers are socially, economically and educationally disadvantaged and lacking their own financial resources, are heavily indebted to traders and middlemen.

Table 2 Grade and average farm-gate prices of head-on prawns in southwest Bangladesh

Grade	No. of head-on prawns kg $^{-1}$	Average weight of a prawn (g)	Average price (US$ kg $^{-1}$)
5	5 or less	200	6.5
10	6–10	125	5.3
20	11–20	70	4.3
30	21–30	40	3.6
50	31–50	25	2.6

Table 3 Comparison of prawn yields in Bangladesh and other producing countries

Country	Prawn production (kg ha $^{-1}$ year $^{-1}$)	Reference
Bangladesh	336	Muir (2003a)
China	1,500	Weimin and Xianping (2002)
India	600–1,000	Raizada, Chadha, Javed, Ali, Singh, Kumar and Kumar (2005)
Taiwan	1,500	New (1995)
Thailand	2,338	Vicki (2007)
Vietnam	1,000–1,500	Ridmontri (2002)

Prawn productivity

The average annual yield of head-on prawns in Bangladesh was reported to be 336 kg ha $^{-1}$ (Muir 2003a). The present production levels suggest that the average productivity of prawn has increased in recent years, probably as farmers have become more confident to increase stocking densities and feeding levels. In the early 1990s, the average yield of prawn was only 168 kg ha^{-1}, which was low due to the traditional farming method and the relatively low level of inputs (Rahman 1994). However, in the late 1990s, reported yields had increased, with a typical yield of 200–250 kg ha^{-1} being obtained (Rahman 1999), while Hoq, Islam and Hossain (1996) reported that prawn production when reared together with fish, varied from 162 to 428 kg ha^{-1}. Nevertheless, most of the prawns are cultivated using extensive methods in Bangladesh and productivity is low compared with other countries (Table 3). Countries with a larger export market than Bangladesh use more intensive techniques and have significantly higher yields.

The quantity of total prawn production in Bangladesh remains rather uncertain because production statistics often do not distinguish between prawn and shrimp. In 2004–2005, total annual production of prawn and shrimp was 82 661 tons, of which only 25–30% was prawn (DOF 2006). The total production of prawn and shrimp has been increasing since 1995 though at a rather irregular pace (Table 4). The average annual growth of prawn production over the last decade (1995–2005) was 11.56%.

Environmental impacts of prawn farming

Freshwater prawn farming in Bangladesh had not been associated with any of the negative environmental consequences for which marine shrimp production has received so much criticism (Csavas 1993; Phillips, Lin & Beveridge 1993). However, in recent years there are some concerns about its long-term environmental sustainability. The development of prawn farming has brought about several environmental impacts due to *gher* construction, wild post-larvae collection and snail harvesting (Fig. 3). In southwest Bangladesh, large areas of wetland have been used for *gher* construction. The reduction in wetlands is likely to have negative impacts including reduced wetland biodiversity, loss of aquatic plants and wildlife, increased flood risks and reduced rice production (Nuruzzaman 1993; Ahmed 2003). Decreased rice production has meant decreased availability of paddy straw, used for both cooking fuel and fodder for cattle. Construction of *gher* has also resulted in a reduction of grazing land for livestock, especially cows.

Wild prawn production has significantly decreased due to uncontrolled fishing of postlarvae, which may be threat to their natural population. Large-scale collection of postlarvae is likely to affect the recruitment of other species (Ahmed 2003). A huge number of other fish fry are caught and discarded along with the prawn postlarvae due to the fine mesh nets used, which may have severe long-term impacts on coastal fish production (DOF 2002b).

Negative environmental effects also appear from over harvesting of snails for use as prawn feed. The snail population has become extinct in most parts of Bagerhat district due to excessive harvesting during the monsoon, which is the peak season of their reproduction (Ahmed, Miah & Islam 1997). Over-harvesting snails has created problems of disposal of large quantities of snail shells, which has resulted in pollution and blockage of canals and other open water bodies. The canals have suffered from abuse

Table 4 Prawn and shrimp production in Bangladesh over the years 1995–2005

Year	Production (tons)	Growth year $^{-1}$ (%)
1995–1996*	38 327	+33.02
1996–1997	44 954	+17.29
1997–1998	54 394	+20.99
1998–1999	58 317	+7.21
1999–2000	59 414	+1.88
2000–2001	59 156	− 0.43
2001–2002	58 241	− 1.55
2002–2003	64 870	+11.38
2003–2004	75 167	+15.87
2004–2005	82 661	+9.97

Source: DOF (2006), USAID (2006).
*Bangladesh fiscal year: 1 July–30 June.

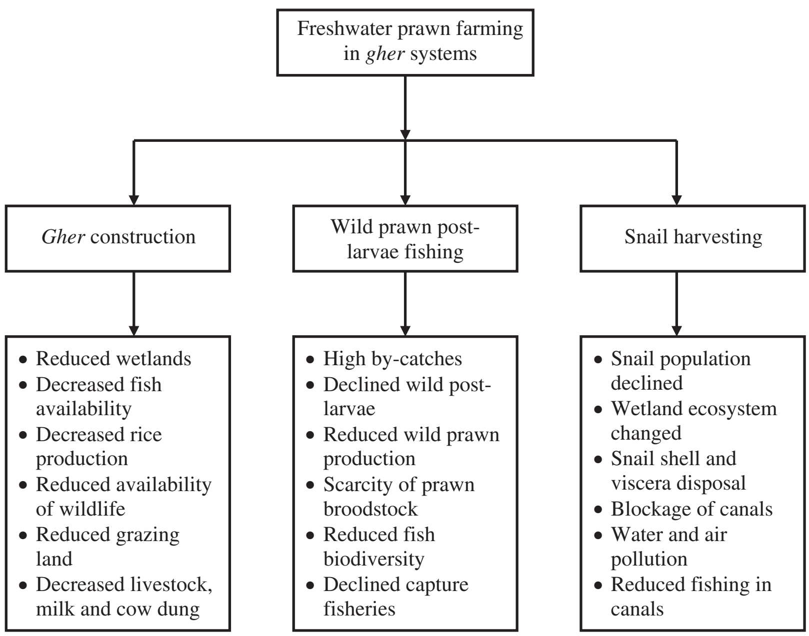

Figure 3 Environmental impacts of freshwater prawn farming in *gher* systems (adapted from Ahmed 2001).

and neglect (i.e., not used for fishing). The disposal of snail shells after the meat has been extracted poses environmental problem – the smell of rotting snails permeates the air and the open waterways have become polluted (Gain 1998; Khan 1998).

Economics of prawn farming

Production costs

In southwest Bangladesh, annual prawn production costs an average US\$1343 ha^{-1}, of which variable costs and fixed costs are US\$992 ha^{-1} (74%) and US\$351 ha^{-1} (26%) respectively (Ahmed 2001). Variable costs in prawn culture are cost of seed, feed, fertilizer, labor (family and hired), harvesting and marketing, and miscellaneous. Fixed costs include depreciation (water pump, net, feed machine, etc), land use and interest on operating capital (Shang 1990). Within variable costs, seed and feed dominate all other costs averaging 39% and 33% of total costs respectively (Ahmed 2004). Muir (2003a) reported that prawn production costs comprise 28% of seed, 21% of feed and only 4% of labor. Despite the benefits of prawn farming, the costs of inputs are high and are often beyond the financial capacity of most small and marginal farmers.

Finance of prawn farming

A quite substantial amount of money is required in prawn cultivation. Costs of prawn production have increased significantly in recent years as a result of increased price of seed, feed and wage rates of laborers. One of the main problems for small and marginal farmers is the shortage of operating capital. Inadequate and costly finance is therefore a constraint for the efficient and profitable prawn farming by resource poor farmers.

A study in southwest Bangladesh reported that 68% of farmers use their own money for prawn farming while the rest receive loan (Ahmed 2001). The average amount of credit received by a farmer is US\$228 year^{-1}. Farmers apply a wide variety of strategies to develop prawn farming. The finance comes mainly from a broad mix of personal and informal sources. Farmers primarily finance their prawn farming operations through disposing of household assets. Some have their own capital, either savings or proceeds from sales of personal assets, especially cows, gold jewellery and timbers (Kendrick 1994).

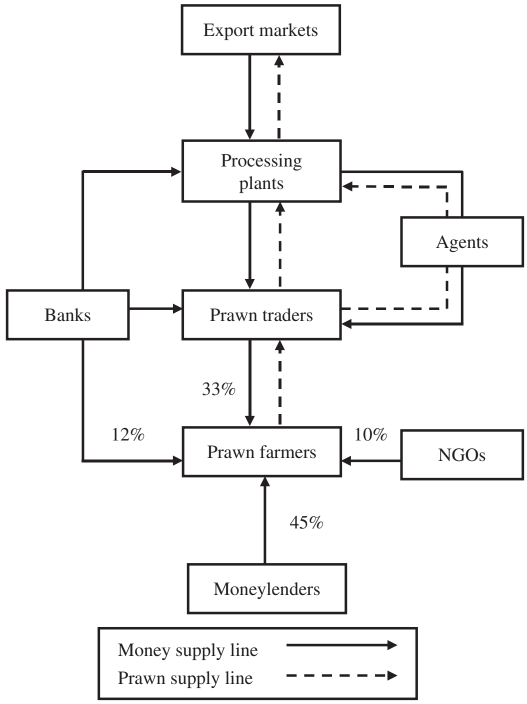

Figure 4 Credit supply chain from different sources to prawn farmers (adapted from Ahmed 2001).

Cattle are the most common assets to be sold for developing a prawn farm.

Access to credit is considered to be one of the important factors influencing prawn production. Over recent years several institutions providing credit to the prawn farmers include banks, NGOs, prawn traders and local moneylenders (Fig. 4). Local branches of national banks provide credit to the prawn farmers, collateral against land at a 15% yearly interest rate. The *Grameen* Bank, a specialized bank for micro credits that was awarded the Nobel Peace Prize for 2006, is active in several villages of prawn farming areas.

Net return

In southwest Bangladesh, the annual net return of *gher* farming is an average US\$1430 ha^{-1} (Muir 2003a). The combination of prawn, fish and rice cultivation in *gher* systems give particularly good potential returns. The annual gross revenue of prawn production average US\$1601 ha^{-1} (69%), while that of fish and rice production is US\$330 ha^{-1} (14%) and US\$389 ha^{-1} (17%) respectively (Ahmed 2001). The net return of prawn farming represents 68% of total turnover (Muir 2003b). The net return in the low input systems in Noakhali is rather lower, an average US\$650 ha^{-1} (GNAEP 2006).

Prawn marketing, processing and export

Prawn marketing

In Bangladesh, prawn production and its commercial viability depends on international markets. These markets have grown strongly in volume over the last decade. Freshwater prawn marketing is almost entirely managed, financed and controlled by a group of powerful intermediaries (Ahmed, Ahammed, *et al.* 2007). The market chain from farmers to international markets passes through a number of intermediaries: prawn traders, agents and processing plants (Fig. 4).

In southwest Bangladesh, the peak season of prawn marketing is from November to January. Farmers tend to sell their head-on prawns to traders in local markets. Farmers commonly use vans, rickshaws (i.e., pedal tricycle) or walk to transport the prawns from the *gher* to the markets. Sometimes suppliers buy prawns from the farmers at the *gher* side and carrying them to the prawn traders. Prawn traders are normally based in local markets near to prawn farming areas. Prawn traders supply prawns directly, or via agents, to the processing plants within 1–2 days of purchase, during which they are kept on ice. Consignments are sent once sufficient quantities have been obtained, an average 225 kg day^{-1} $trader^{-1}$ (Ahmed 2001). Trucks and pickups are commonly used to transport prawns to the processors. Plastic containers with polythene covers are commonly used for keeping the prawns during the transport. The flow of prawns from *gher* to the processing plants is between 24 and 48 h (Muir 2003a). Finally, processing plants export frozen headless prawns to international markets.

Apart from the generally unhygienic conditions and practices mentioned above, there are a number of constraints in prawn marketing including, poor road and transport facilities, high transport costs, inaccurate weighing, poor supply of ice, crushing prawn during storage in the depots, power cuts in processing plants, political disturbances (i.e., strikes and road blocks) and labor unrest (Muir 2003a; Ahmed, Ahammed, *et al.* 2007). In addition to these problems, farmers are in a particularly weak position (i.e., no bargaining power on price) in relation to intermediaries of prawn marketing systems. It is therefore important for Bangladesh to improve its marketing chain to cope with emerging requirements of the international market.

Processing

There are 124 prawn and shrimp processing plants in Bangladesh of which 35 are currently operational in Khulna, 38 in Chittagong and 51 have either closed down or are waiting approval of a quality inspection license (Muir 2003a). License allocation requires development of a hazard analysis and critical control point (HACCP) manual and all plants are subject to a quality control by DOF. The collective capacity of these plants is around 165 000 tons, this allows for processing of 825 tons day^{-1}.

The removal of the shell and legs during processing leads to an average 45% of decrease in weight. Process wastes are sold to local markets for human consumption. An average of 575 contract workers both men and women are employed in a typical prawn processing plant during the peak season from November to January (Ahmed 2001). Women are usually engaged in cleaning and beheading of prawns, while men work more closely with machinery, block freezing and packaging (USAID 2006). Processing plants transport their prawns to Mongla or Chittagong ports using their own refrigerated vehicles. Shipping agents load the prawns into freezer containers, which are then loaded into ships destined for international markets. A typical processing plant exports an average 4.5 tons of prawns daily during the peak season (Ahmed 2001). Processing plants export frozen headless prawns either as individually quick frozen or block frozen.

Bangladesh has been facing problems in maintaining quality standards in prawn processing. Raw material contamination may occur due to traditional practice in the production process and inadequate care during prawn marketing. In 2000, most of the Asian countries increased their prawn exports to the US market with the exception of Bangladesh. Banning of consignments occurred in 2002 following detection of nitrofurans and pathogenic bacteria in a prawn lot exported from Bangladesh (Muir 2003a). In recent years, DOF has amended the fish inspection and quality control act to incorporate HACCP principles. The sub-district and district fisheries officers have been instructed officially to enforce the inspection and quality control act under which they can visit prawn farms, hatcheries, feed industries, depots and processing plants, and take action on the defaulters. However, there have been further cases of rejection of prawn due to nitrofuran contamination in 2005–2006, raising doubts about the effectiveness of the inspection process. Following a recent European Union inspection, with the help of the Bangladesh Frozen Food Exporters Association, the DOF is establishing a laboratory capable of testing for nitrofuran metabolites in country. However, a total traceability system is also needed if this is to identify the sources of the contaminants.

Table 6 Average prices of headless prawns from processing plants to international markets

Grade	No. of prawns lb^{-1}	Average price US$ lb^{-1}	Average price US$ kg^{-1}
U-5	Less than 5	7	15.4
5/7	5–7	6.5	14.3
8/12	8–12	6	13.2
13/15	13–15	5.5	12.1
16/20	16–20	5	11.0
21/25	21–25	4.5	9.9
26/30	26–30	4	8.8
31/50	31–50	3.5	7.7

Source: DOF (2006), USAID (2006).

Export

Bangladesh was once a major exporter of prawn caught by artisanal fishers in rivers, lakes and floodplains. In the early 1990s, the vast majority (>90%) of the prawns exported from Bangladesh derived from natural resources, with an estimated 60% from the Khulna and Bagerhat areas, 35% Comilla and Noakhali areas and 5% Cox's Bazaar area (DIFTA 1993). Bangladesh was thus well placed to develop an export market for farmed output. Owing to the importance of prawn as an export product, the government had declared prawn cultivation to be of primary industry status and designed a specific support program to boost production (Datta 1995).

Prawn is a highly valued product for international markets and almost all Bangladeshi prawns are therefore exported. In 2004–2005, Bangladesh exported 46 533 tons of prawn and shrimp valued at US$380 million (Table 5), of which 25–30% may have been contributed by prawn. Of the total export in 2004–2005, 48.74% was sold to Europe, 34.78% to the United States and 11.26% to Japan (USAID 2006). Demand for prawn is increasing the US and European markets; especially Belgium, the United Kingdom, Germany, the Netherlands and Denmark hve largely accepted Bangladeshi prawn. Although the Japanese market has declined, new markets have emerged in Asia such as Hong Kong, Singapore, Malaysia and Thailand (Muir 2003a; USAID 2006).

Despite rising market demand, the prices of prawn have been declining in recent years as supply has increased. The trend in prawn prices was consistently upwards between 1970 and 1990. Thereafter, prices of prawn in the major markets largely stagnated and, since the late 1990s, have begun to decline in some markets (USAID 2006). In 2006, the average prices of Bangladeshi prawn for export markets varied from US$7.7 to 15.4 kg^{-1} depending on grade (Table 6), compared with the range of US$7.7–19.8 kg^{-1} in 1996 as quoted by Borua (1996). This suggests that the export price of prawns has declined over recent years.

Table 5 Export of prawn and shrimp over the years 1995–2005

Year	Export (tons)	Export value (million US$)
1995–1996*	25 225	279
1996–1997	25 742	281
1997–1998	18 630	246
1998–1999	20 127	242
1999–2000	28 514	322
2000–2001	29 713	349
2001–2002	30 209	252
2002–2003	36 864	297
2003–2004	42 943	362
2004–2005	46 533	380

Source: DOF (2006).
*Bangladesh fiscal year: 1 July–30 June.

Livelihoods of the poor

Freshwater prawn farming sector offers diverse livelihood opportunities for the rural poor in Bangladesh. It is estimated together with published sources and personal communications with concern departments that around 300 000 people are directly involved in prawn production, marketing and associated activities in addition to 400 000 people of prawn postlarvae fishing. A range of associated groups such as prawn farmers, wild postlarvae collectors, fry traders, snail harvesters, feed traders, prawn traders and day laborers including women and children are involved in this sector. A network for postlarvae trading has developed involving fishers, intermediaries, traders, local agents and farmers. Similar networks for feed trading and prawn marketing have established. The opportunities for day laborers to find work have increased significantly in prawn farming. Labor is required for *gher* construction, postlarvae marketing, feed trading, snail breaking, prawn harvesting and marketing. In markets, laborers perform postharvest tasks that include handling, cleaning, sorting, grading, icing and transportation of prawn. Additional employment opportunities are also generated in hatcheries, commercial feed industries, ice factories, processing plants and in the transport sector ranging from rickshaws and vans to the large vehicles which carry prawns to processing plants. Processing plants employ around 30 000 people, about 60% of whom are women (USAID 2006). Women also play a pivotal role in prawn farming. They are involved in various facets, including feeding of prawn, fertilization, *gher* supervision and management, prawn harvesting, postharvest handling and dike cropping (Ahmed 2005).

Conclusions

Freshwater prawn farming plays an important role in the economy of Bangladesh, earning valuable foreign exchange and contributing to increased food production, diversifying the economy and increased employment opportunities. In spite of several problems, the practice of prawn farming has offered an opportunity to increase incomes for farmers and associated groups. Freshwater prawn farming is particularly appropriate for small-scale units, though, to exploit markets, producer groups and marketing organizations are essential. Prawns require particular care during harvesting, processing and marketing. Poor quality prawns have been marketed in the past. This must be avoided, particularly if export potential is to be achieved and sustained. The use of suitable harvesting, handling and processing techniques are also important to ensure a quality product for export markets. It would appear that the most appropriate form of action would be to enhance quality, traceability and marketing systems.

The future for prawn farming is bright but requires dynamism to exploit fully. A range of public and private sector investments and initiatives are needed to realize the potential for growth and expanding economic output from this sector. The realization of its potential must be aided by improvements in production technology and hatchery operation. Better broodstock management is required for successful operation of prawn hatcheries. A number of low-cost locally produced ingredients feed industries would help to increase farmer's profit margins, reduce the negative environmental impacts of snail harvesting, and increase job opportunities.

Although numerous constraints can be recognized, the prospects for prawn farming are positive, and the recent record of production and export value demonstrates the emerging strength of this sector. However, a number of significant challenges particularly socioeconomic and environmental issues are vital in translating its benefits effectively to the thousands of rural poor involving in this sector.

The issues of environmental sustainability of prawn cultivation, while clearly not as negative as those of marine shrimp culture in Bangladesh, are nevertheless poorly understood. Therefore research would be required as quantitative and qualitative environmental impacts for sustainable prawn farming. In addition, research in areas such as seed and feed production may need to be given particular attention, considering existing technology, the transfer, adaptation and development of new technology.

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