
VALUE-CHAIN ANALYSIS OF FRESHWATER APPLE SNAIL (*Pila globosa*) USED FOR ON-FARM FEEDS IN THE FRESHWATER PRAWN FARMING SECTOR IN BANGLADESH

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Abstract

Growth of the freshwater prawn (*Macrobrachium rosenbergii*) sector in Bangladesh since 1970s has been supported by natural availability of freshwater apple snail (*Pila globosa*), used for on-farm prawn feeds. The present study identified the current configuration of the value-chain benefits and constraints of freshwater apple snail in south-western Bangladesh in August 2011, based upon Rapid Market Appraisal (RMA) approach. The site of snail collection was Chanda Beel in Gopalganj district, while trading, processing and final consumption was represented by Rayer Mahal Bazar in Khulna district. There were seven different nodes recognized throughout the value chain. Snail marketing was identified as a seasonal business and took place during June to November each year. Between 1995 and 2011 the price of whole snail, meat and shell has increased by 800%, 325% and 315%, respectively. The abundance of snail had been reduced and its demand has increased due to the expansion of the prawn farming industry. Prawn farmers preferred snail meat due to its low cost (US\$ 0.21 kg⁻¹) as a source of protein compared to commercial prawn feed (US\$ 0.41 kg⁻¹). Snail harvesting and processing were considered as additional livelihood options for the poor, where 60% of the labour involved in snail harvesting were women, and 95% the de-shelling workforce. Induced breeding in captivity and sustainable management in nature as well as development of commercial production of apple snails might reduce the pressure on ecosystems and positively contributed to the continued expansion of freshwater prawn farming in Bangladesh.

Keywords: Bangladesh, Prawn Farming, Snail, Value Chain

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Introduction

There are about 450 species of snails in Bangladesh (Gain, 1998), of which freshwater apple snail, *Pila globosa* (Swainson) is one of the most abundant and commercially valued molluscs. It is widely distributed in all types of temporary and permanent water bodies, such as ponds, canals, ditches, *beels* (a large surface static water body that accumulates surface runoff water through internal drainage channel), *haors* (a wetland ecosystem which physically is a bowl or saucer shaped shallow depression, also known as a *back swamp*), and *baors* (closed water body equivalent to an ox-bow lake, up to several hundred hectares) (Nath *et al.*, 2008). Snail plays an important role in the ecosystem in maintaining healthy aquatic environments by acting as a biofilter, a pre-requisite for conserving biodiversity (Jahan *et al.*, 2001). According to a study of the *P. globosa* in Chanda Beel, Bangladesh, the snail flesh contain 85.5±0.02%

moisture, 2.599±0.02% ash, 8.272±0.05% protein, 0.725±0.03% fat, 2.902±0.03% carbohydrate and 0.0256±0.01% crude fibres, with each g of shell containing 3.04 mg calcium, 1.33 mg phosphorus, 1.00 mg iron, 0.43 mg sodium, and 0.32 mg potassium (Baby *et al.*, 2010). The energy content of snail is between 4.745 and 5.594 Kcal g⁻¹ dry weight and also enriched with an essential amino acid index (EAAI) of 0.84, is a useful alternative source of protein (Sing, 1991; Bombeo-Tuburan *et al.*, 1995). It can easily be cultured in fertilised fish ponds and rice fields (Xoing *et al.*, 1987).

Snails are not consumed by humans within the Muslim community of Bangladesh. Saha (1998), however, identified 29 groups of tribal people that consume snail flesh. Snail meat is instead more extensively used in freshwater prawn (*Macrobrachium rosenbergii*) farming in the south-western part of the country (Baby *et al.*,

2010), which (prawn) is one of the major exports earning sectors in Bangladesh (DoF, 2011). The average application of snail meat to prawn ponds is 66.5 kg ha⁻¹day⁻¹ during June to October (Ahmed *et al.*, 2008). Snail meat is also utilized as supplementary feed in indigenous catfish (*Clarius batrachus*) farms and domestic ducks throughout most of the year (Banglapedia, 2006). Snail shell is used to produce lime and animal feed additive due to its rich CaCO₃ content (Nath *et al.*, 2008).

However, recently, as a result of excessive fishing pressure and lack of regulations, drastic reductions of wild snail populations have occurred in Bangladesh (Nath *et al.*, 2008). Regulating the collection of snails is difficult as it is an essential livelihood for the poor (Jahan *et al.*, 2001). After collection, snails are distributed to prawn farmers in the south-western regions through a line of middlemen. Although Ahmed (2001) described the value chain of snails from Chanda Beel of Gopalganj to Bagerhat district in 1999 and Nath *et al.* (2008) within Khulna in 2006, the chain between Chanda Beel and Khulna district has, to date, remained unreported.

The aim of this study was to obtain a more detailed understanding of the actors, activities, inputs, costs, opportunities and constraints related to the flow of snails throughout the value chain, starting with harvesters and ending with the targeted buyers and/or consumers. The outcomes will provide increased understanding of the designing, implementation, evaluation, and scaling the relevant enterprises. It will also provide an up-to-date description of the snail value chain to aid researchers and policy makers in improving future regulations within this sector.

Materials and Methods

Study locations were identified through a preliminary interview of 10 DoF (Department of Fisheries) personnel in Khulna and fieldwork was conducted in August 2011. The site of snail collection was Chanda Beel in Gopalganj district, where a major portion of all snails originate from. Trading and processing is represented by Rayer Mahal Bazar in Khulna district and the final utilization is also representative of practices in Khulna where a high density of prawn farms are

located (Fig. 1). Data was collected using a Rapid Market Appraisal (RMA) approach, as described by Holtzman (2002). This method relies on a combination of secondary data, a review of trends and primary data collected by interviews. After identifying chain actors, respondents were opportunistically approached for each market stage. Data for the specific inventories were collected directly from the stakeholders by personal interview (total 35 interviews, 5 for each chain actors) and focus group discussion (total 3 FGD for harvesters, small retailers and farmers), using a questionnaire. Secondary information was collected from published reports.

Results and Discussion

Actors and stages of the snail marketing chain

A cradle-to-farm gate approach ensured the inclusion of all lifecycle stages, from snail capture in wetlands to application in prawn farms. Seven different chain actors were identified, namely harvester, trader-1, trader-2, commission agent, small retailer, prawn farmer, and supplier of shell to lime and/or animal feed factory. The stages of the snail marketing chain are shown in Fig. 2.

Snail harvesting from wetland

Chanda Beel is the most important wetland of the Madhumati river floodplain ecosystem in the south central Bangladesh (Baby *et al.*, 2010). It is also one of the largest freshwater wetlands in the country, covering an area of 10,870 ha (Khan, 1998). Seven species of snails are found in Chanda Beel, amongst them *P. globosa* is of greatest commercial importance (Khan *et al.*, 2005). Snail collection first started in 1992 in this area and is seasonally restricted to six months of the year, from *Jaishtha* (May-June) to *Kartik* (October-November) (Ahmed, 2001). The peak season for snail collection lasts for three months, from *Ashar* (June-July) to *Vadro* (Aug-Sep). *Ashar* is the rainy season when snails are commonly found in high abundances in natural wetlands. In the winter season, harvesters are unable to collect snails as they dig down in the mud and demand for snail meat declines.

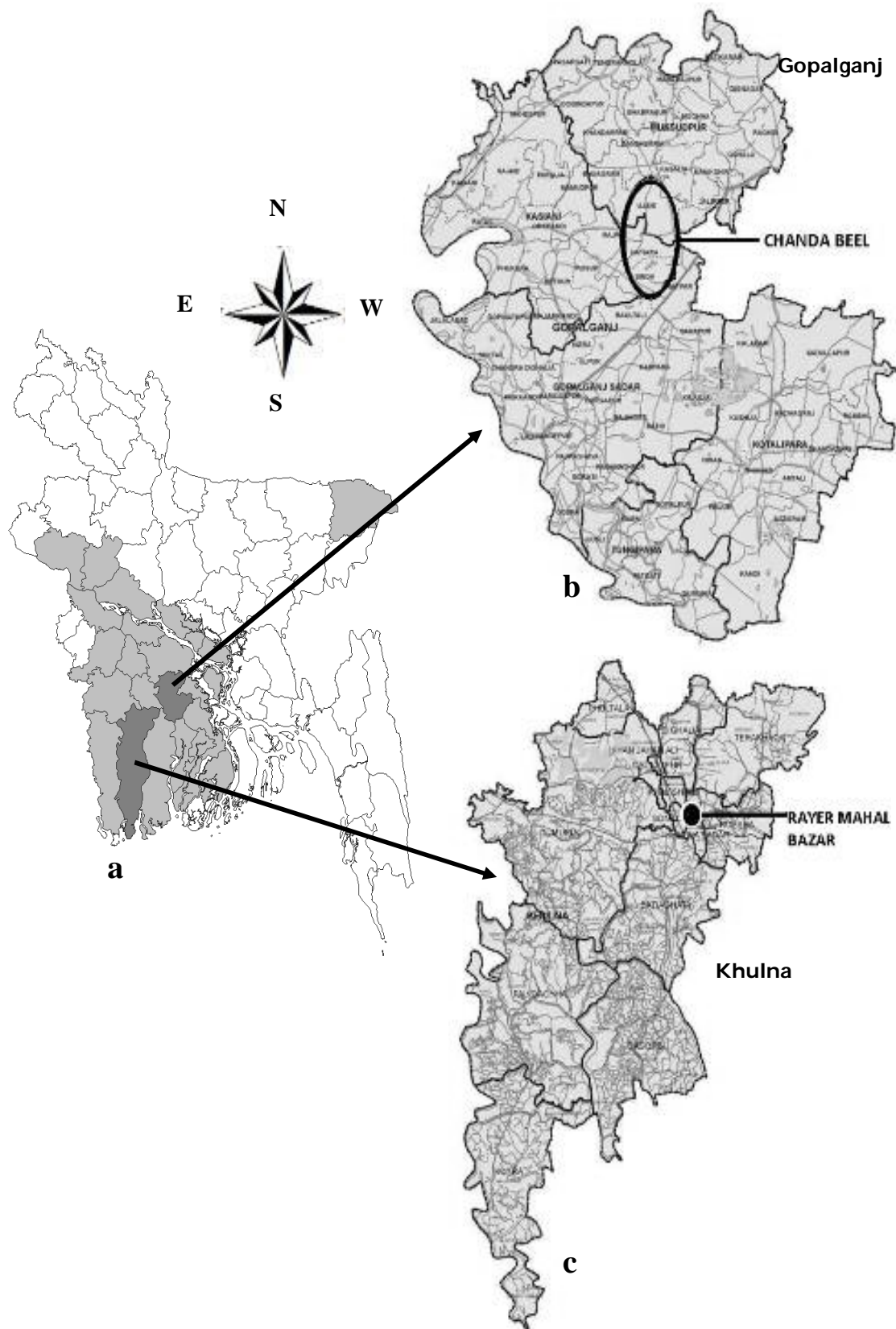


Fig. 1. a) The shadow areas show the major snail harvesting locations in Bangladesh, b) Gopalganj district showing Chanda Beel, c) Khulna district showing Rayer Mahal Bazar.

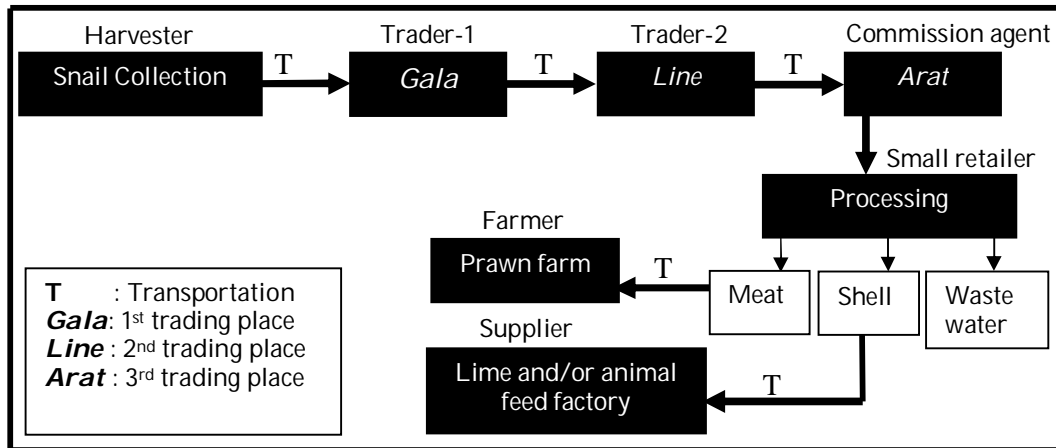


Fig. 2. Flow chart of snail marketing chain from Chanda Beel of Gopalganj to Khulna district

Transportation to 1st trading place (Gala)

At the day of capture, harvesters go 5 km to the floating market place in the *beel* area (locally called as "Gala") to sell the recently collected snails. The same boat as used for harvesting is used to transport the snails from the site of collection to the *Gala*.

1st trading place (Gala)

There are between 150 and 200 boats selling snails in each *Gala* every day in season. Traders (here referred as trader-1) come here to buy the captured snails from the *Khetoyas*.

Transportation to 2nd trading place (Line)

Trader-1 then transports the snails to another market, about 20 km away, (locally called "Line") using a motor boat. Each boat can carry about 500 kg snails and travels two hours to get from *Gala* to *Line*.

2nd trading place (Line)

In *Line*, other traders (here referred as trader-2) buy snail from trader-1. He packs the snails into jute bags, each containing 55 kg of snails. The activities run at the afternoon to the evening.

Transportation to 3rd trading place (Arat)

After packaging the snails, trader-2 transports them 120 km overnight by truck to the market (Locally called *Arat*) at Rayer Mahal Bazar (studied location), one of the most important snail markets in Khulna. Different types of trucks of different carrying capacity are used for this transport.

3rd trading place (Arat)

The *Arat* is the third trading place for snails. It opens at four in the morning and goes on for only two hours. At the *Arat* there are several commission agents. The commission agents are the middlemen between seller (trader-2) and

buyer (small retailer and/or farmer). They take the risks of selling the snails, collecting the money, and forwarding the payments to the trader-2. The commission for this is US\$ 0.27 bag⁻¹ of snail (1 bag contain 55 kg snail) for which they sometimes take the risk of accepting credit. Processing or de-shelling by the small retailers

Processing locations are near to the *Arat*. In Bengali the small retailers are called "*Khuchra-Pyker*" in the snail market. They buy the snails from trader-2 at wholesale price after which they de-shell and sell the snail meat to prawn farmers at retail price. Small groups consist of 5-7 people and large groups of 20-30, most of which are women. The women members also have household duties on the side and therefore only break snail's part of the day, with the occasional help of their men. The children also help when not in school.

One large group buy 30-35 bags day⁻¹ during peak season on the credit given by the commission agent. An efficient member can break up to 11 kg of snails per hr. Two handmade small devices (locally called *Futoni* and *Kholani*) made of wood and iron pin are used for this purpose. Large farm owners buy the snail directly from the *Arat* in bulk amount and transport it to their farms for processing at farm-gate. Small farmers may instead group and buy snails together, after which they transport them to their farms using different hired vehicles. At the farm, they pay local snail breaking groups US\$ 0.41 bag⁻¹ of snail for de-shelling.

Selling of snail meat and shell

De-shelling of one kg snail yields 0.51 kg meat, 0.33 kg shell, and 0.16 kg waste water. Meat is subsequently spread into the prawn farms on the day of de-shelling. The shells on the other hand are stored before they are supplied to a lime and/or an animal feed factory.

Amount of snail harvested in different years

The study revealed that amount of available snails has decreased by 50% between 1995 and 2011 in the Chanda Beel (Fig. 3). Overharvesting is believed to be the reason for the rapid disappearance of *P. globosa* from the wetland ecosystem of Chanda Beel (Baby *et al.*, 2010).

Chowdhury (1999) reported a total catch of 365, 849 mt *P. globosa* in Bangladesh in 1999. However, Sultana *et al.* (2002) identified a 48% reduction in snail catches in between 1997 to 2000 in Goakhola-Hatiara Beel of Narail district, whereas Nath *et al.* (2008) showed a 90% reduction in the abundance of snail in the Khulna district between 1997 and 2006.

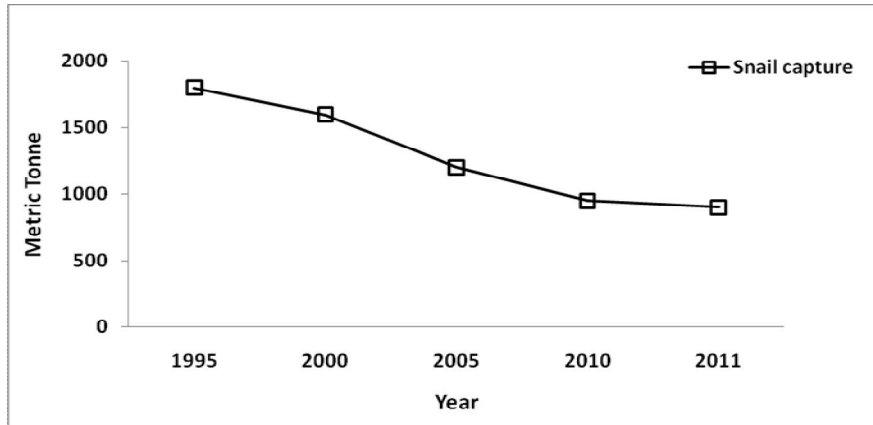


Fig. 3. Amount of *P. globosa* capture in Chanda Beel in different years

Seasonality, supply and demand of snail

Demand, availability and price of snails remain high from mid-June to mid-October. Between June and August, the rainy season offers a suitable breeding environment for the snails (Andrews, 1964) and abundances increase. Prawn farmers also utilize more snail meat during this period as the prawns are of 4-5 months age (stocked in April) and need quick growth before harvest.

In the Chanda Beel, the flood water starts to ebb at the end of October and at the end of December the entire area becomes dry with exception for some deep pockets. During this period, the snails aestivate in the sediments as their habitat dries up (Andrews, 1964). Similarly does the demand of snail meat decreased during this period of year as it is the beginning of the prawn harvest. The price of snails varies over the year depending upon supply and demand (Table 1).

Price trend of snail meat and shell

The price of snail meat and shells were recorded to have increased by 800%, 325% and 315% in 2011 compared with 1995 (Increased rate are

based on BDT (to understand the actual growth rate) and figure is based on US\$. Exchange rate of one US\$ to BDT varied in different years which were 40 in 1995; 50 in 2000; 60 in 2005; 70 in 2010; and 74 in 2011 (gocurrency.com, 2011) (Fig. 4 and Fig. 5). The reason for this rapid increase is due to a decreasing supply alongside an increasing demand for snail meat. Availability of snail is decreasing in an alarming rate in different water bodies, whereas prawn farms have been reached to 50,000 ha (DoF, 2010), compared with only 3,500 ha in the mid 1980s (Muir, 2003).

During the early 90s, snail shells were of little demand and were mainly dumped in nearby canals after removing the meat. However, in the mid-90s, the demand for snail shells increased as a result of lime production and in 2000 it started being used as a cheap calcium source (US\$ 0.01 kg⁻¹) in animal feed factories. The price has therefore steadily been increasing and today shell suppliers even give advance payments to the shell breaking groups to ensure smooth supply.

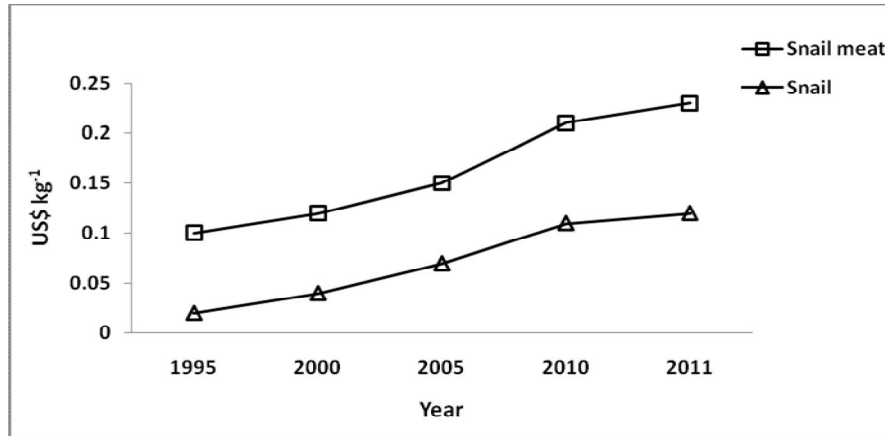


Fig. 4. Price of snail meat and snail in different years at farm level

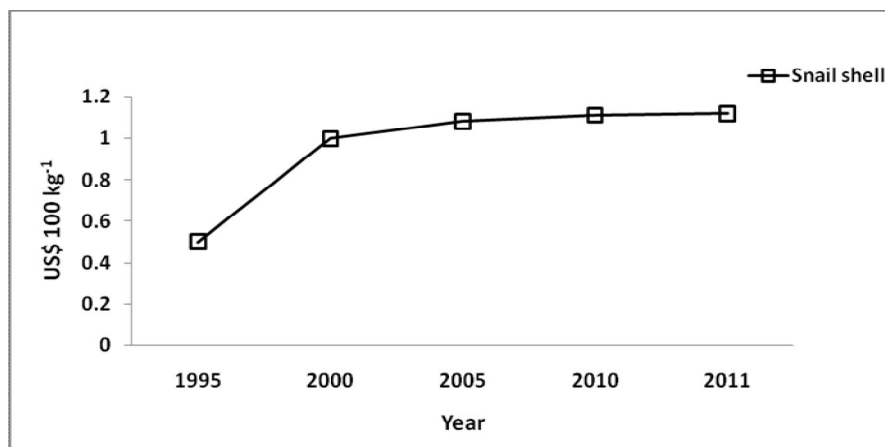


Fig. 5. Price of snail shell in different years (Source: Survey outcomes)

Snail price at different stages of the production chain

At each stage of the market chain, the cost of the snails increases, often with some form of value addition (Table 2). For example, trader-1 pays to the harvester US\$ 0.04 kg⁻¹ snail, while trader-2, in turn, pays US\$ 0.06 kg⁻¹ snail and sells the snails for US\$ 0.10 to the retailer. After breaking the snails the retailers charges US\$ 0.11 for 0.51 kg of meat and US\$ 0.003 for 0.33 kg of shells.

Income of different actors of snail marketing chain

Snail harvesting has become an important additional income for the poor people of Chanda Beel without permanent positions. The additional income is of importance for these casual labourers, despite that they make US\$ 0.03 less

per hour compared to their normal labour wage (Labour wage US\$ 2.03 day⁻¹ for 10 hours of work in Gopalganj in 2011), as they invest little physical effort and is early in the morning before other duties. Moreover, the harvesting of snails is physically very easy and only requires a boat (common for monsoon transportation) and bamboo handled scoop net. Additional earning is offered to other actors in the snail marketing chain, including traders, transporters and day labourers (Table 2 and Fig. 6). Trader-1 and trader-2 have a brokerage rate of 26.59% and 18.45%, respectively, in proportion to their investment. The small retailers, in turn, need to invest US\$ 0.003 in labour wage to break the snails.

Table 1. Seasonality of snail marketing

| Bengali month and season | English month | Demand | Supply | Price (US\$ per 55 kg snail) at Arat | Remarks |
|--|---------------|-------------|-------------|--------------------------------------|--|
| <i>Jaishtha</i> (Summer) | May-June | Few | Very few | 4.73 | Supply depends on rain Demand so-so to feed overwintered big size stocked prawns Current year's stocked prawns (stocked in April) are not too big to take snail meat |
| <i>Ashar</i> (Rainy) | June-July | Few | High | 3.78-4.00 | Due to few demand and high supply price goes down |
| <i>Shraban</i> (Rainy) | July-Aug | High | Remain same | 4.73-5.41 | Due to high demand price goes up |
| <i>Vadro</i> (Autumn) | Aug-Sep | Increase | Remain same | 5.41-5.68 | Increased demand led to high price |
| <i>Asshin</i> (Autumn) | Sep-Oct | Remain same | Remain same | 5.41-5.68 | Price remained same |
| <i>Kartik</i> (Late autumn) | Oct-Nov | Decrease | Decrease | 5.41 | Prawn harvesting season |
| <i>Agrahaon</i> (Late autumn) | Nov-Dec | Few | Very few | 4.73 | Prawn harvesting season |
| <i>Poush & Magh</i> (Winter); <i>Falgun & Chaitra</i> (Spring) | Dec-April | No | No | - | It is not the prawn culture season Snails are not captured in winter |
| <i>Baishakh</i> (Summer) | April-May | No | No | - | Prawn post larvae stocking season |

Note: 1 US\$ = 74 BDT (in 2011)

However, like harvesters the retailers also consider the business as an additional income besides other duties. Retailers also receive credits from the commission agents, which allows them to avoid initial invest. For the prawn farmers, one kg of snail cost US\$ 0.19 less compared to commercial pellet feeds.

Table 2. Pricing of one bag (55 kg) snail (provides 28 kg meat and 18 kg shell) at different stages of the marketing chain

| Stage of chain | Place | Purpose | Cost (US\$) | Final price (US\$) |
|----------------------------|---------------------|---|-----------------------|--------------------|
| Snail harvester | Wetland | Capture of snail (Physical labour) (PL): | 2.68 ^a | |
| | | Total cost | 2.68 | |
| Trader-1 | <i>Gala</i> | Sell to Trader-1 | - | 2.23 |
| | <i>Gala</i> | Buy snail | 2.23 | |
| | <i>Gala to Line</i> | Transportation (T) | 0.37 | |
| | <i>Line</i> | Miscellaneous | 0.07 | |
| Trader-2 | <i>Line</i> | Total cost | 2.67 | |
| | <i>Line</i> | Sell to Trader-2 | - | 3.38 |
| | <i>Line</i> | Buy snail | 3.38 | |
| | <i>Line</i> | One jute made bag to pack 55 kg snail with labour cost | 0.34 | |
| | <i>Line to Arat</i> | T: Gopalganj-Khulna | 0.34 | |
| | <i>Arat</i> | Labour cost to off-load bag from truck | 0.068 | |
| | <i>Arat</i> | Commission to the Agent | 0.27 | |
| | <i>Arat</i> | Tax to the snail market | 0.014 | |
| Small retailer (processor) | <i>Arat</i> | Total cost | 4.412 | |
| | <i>Arat</i> | Sell to small retailer | - | 5.41 |
| | <i>Arat</i> | Buy snail | 5.41 | |
| | Beside Arat | Processing | PL: 1.01 ^b | |
| Farmer | Beside Arat | Total cost | 6.42 | |
| | Beside Arat | Sell to factory (18 kg snail shell obtained from 55 kg snail) | - | 0.20 (18 kg shell) |
| | Beside Arat | Sell to farmer (28 kg snail meat obtained from 55 kg snail) | - | 6.05 (28 kg meat) |
| Farmer | Beside Arat | Buy snail meat (28 kg meat) | 6.05 | |
| | <i>Arat to farm</i> | T (28 kg meat) ^c | 0.39 | |
| | <i>Arat to farm</i> | Total cost | 6.44 | |
| | Farm | Feed to prawn | - | 6.44 (28 kg meat) |

Note: 1 US\$ = 74 BDT (in 2011)

^a Calculation was done in context of labour wage (US\$0.203 hr⁻¹) at Gopalganj in 2011 and to capture 55 kg snail a harvester takes 13.2 hours

^b Calculation was done in relation to labour wage (US\$0.203 hr⁻¹) at Khulna in 2011 and to break 55 kg snail a person takes 5 hours

^c Transportation cost varies depends upon distance of farm from Arat and types of vehicle used.

Gender involvement at different stages of snail marketing channel

The contributions from women have been found dominant among harvesters (60%) and small retailers (95%), with no women working as traders or commission agents (Fig. 7). Women

also represented a negligible percentage (0.50% only) of the farm owners. Children (below age 15) were also found amongst the harvesters and snail breaking (small retailer) groups at 15% and 25%, respectively.

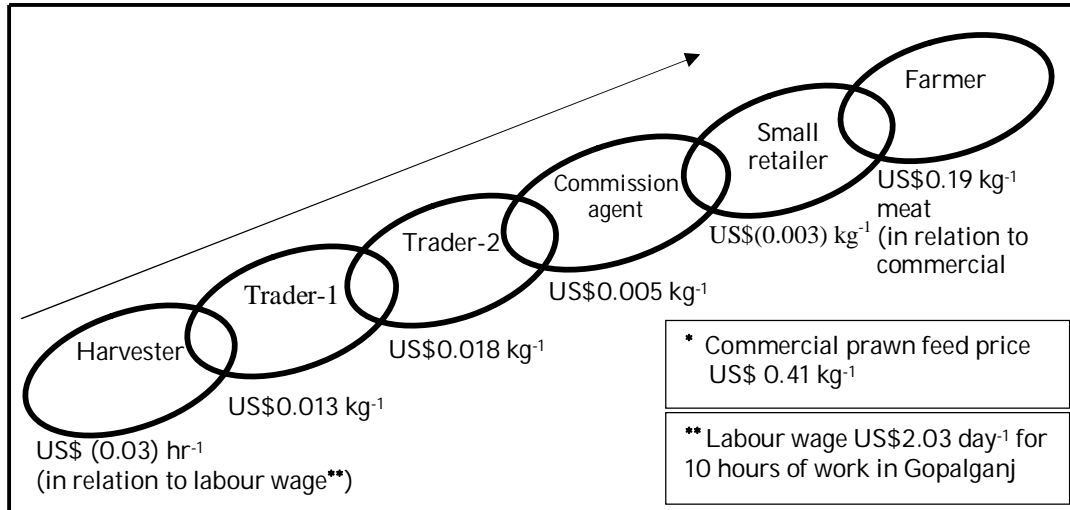


Fig. 6. Profit margins of the chain actors of snail marketing channel

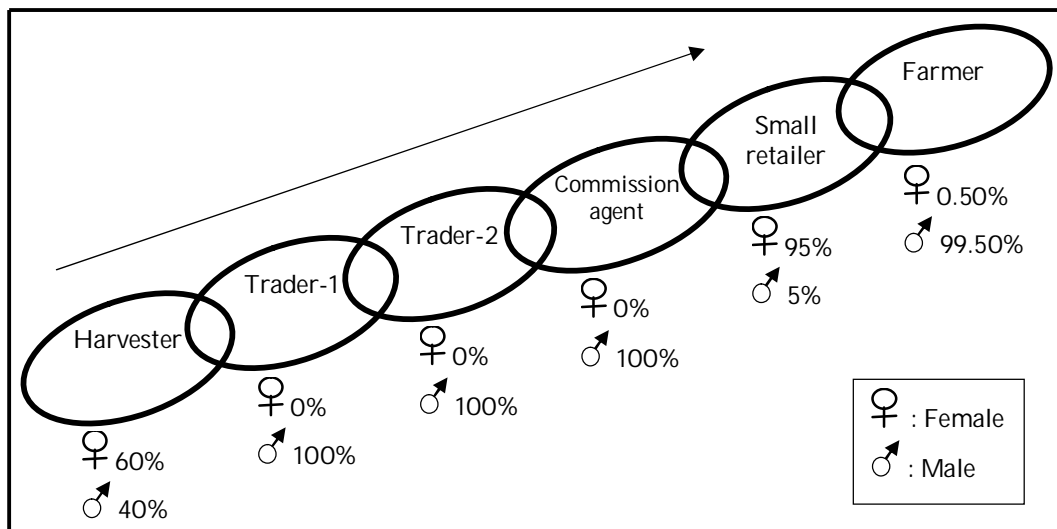


Fig. 7. Amount of *P. globosa* capture in Chanda Beel in different years

Conclusion

The snail sector has an important contribution to the national prawn farming sector. It also provides a source of income for all the men and women involved in the marketing chain, from harvesters to farmers. Concerns have, however, recently be raised about the long term sustainability of this sector at the current rate of exploitation lack of planning and improper management has led to decreases in wild stocks at an alarming rate. Due to the snail's ecological importance in limiting the overgrowth of aquatic

environments, as well as its economic significance in generating livelihood options for the poor and providing low cost protein source in aquaculture, the government needs to impose policy options to protect snail habitats and populations.

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References

- Ahmed, N. 2001. Socio-economic aspects of freshwater prawn culture development in Bangladesh. PhD dissertation. Institute of Aquaculture, University of Stirling, Scotland, UK.
- Ahmed, N., Demaine, H. and Muir, J.F. 2008. Freshwater prawn farming in Bangladesh: history, present status and future prospects. *Aqua. Res.* 39: 806-819.
- Andrews, E.B. 1964. The functional anatomy and histology of the reproductive system of some pilid gastropod mollusks. pp. 121-139. *In: Proc. The Malacological Society of London.*
- Baby, R.L., Hasan, I., Kabir, K.A. and Naser, M.N. 2010. Nutrient analysis of some commercially important molluscs of Bangladesh. *J. Sci. Res.* 2 (2): 390-396.
- Banglapedia, 2006. National encyclopedia of Bangladesh. Retrieved September 23, 2011 from http://www.banglapedia.org/httpdocs/HT/S_0437.HTM.
- Bombeo-Tuburan, I., Fukumoto, S. and Rodriguez, K.M. 1995. Use of the golden apple snail, cassava, and maize as feeds for the tiger shrimp, *Penaeus monodon* in ponds. *Aquaculture.* 131 (1-2): 91-100.
- Chowdhury, M.H. 1999. Study on thana level snail trading system. A study report of GOLDA project of CARE Bangladesh. Funded by the Department for International Development (DFID), UK.
- DoF. 2010. National Fish Week Compilation. Department of Fisheries (DoF), Ministry of Fisheries & Livestock, Dhaka, Bangladesh. 120 p.
- DoF. 2011. National Fish Week Compilation. Department of Fisheries (DoF), Ministry of Fisheries & Livestock, Dhaka, Bangladesh. 136 p.
- Gain, P. 1998. Chanda beel: shrimps attacks snails and environment. pp. 17-20. *In: P. Gain (ed.), Earth Touch. The Society for Environment and Human Development (SEHD), Dhaka, Bangladesh.*
- Gocurrency.com. 2011. Currency Converter And Exchange Rates. Retrieved September 24, 2011 from <http://www.gocurrency.com/v2/historic-exchange-rates.php>.
- Holtzman, J.S. 2002. Rapid appraisals of commodity subsectors. *In: Giovannucci D. (ed.), A guide to developing agricultural markets and agro enterprises. World Bank: Washington DC. USA.*
- Jahan, M.S., Akter, M.S., Sarker, M.M., Rahman, M.R. and Pramanik, M.N. 2001. Growth ecology of *Pila globosa* (Swainson) (Gastropoda: Pilidae) in simulated habitat. *Pakistan J. Biol. Sci.* 4 (5): 581-584.
- Khan, M.A. 1998. Chanda beel: wildlife and biodiversity in peril. pp. 17-20. *In: Gain P. (ed.), Earth Touch. The Society for Environment and Human Development (SEHD), Dhaka, Bangladesh.*
- Khan, M.S.I., Hussain, B.B. and Chakraborty, T.R. 2005. Snails in the Chanda beel area. IUCN Bangladesh Country Office, Dhaka, Bangladesh. 38 p.
- Muir, J.F. 2003. The future for fisheries: economic performance. Fisheries Sector Review and Future Development Study. Commissioned with the association of the World Bank, DANIDA, USAID, FAO, DFID with the cooperation of the Bangladesh Ministry of Fisheries and Livestock and the Department of Fisheries, Dhaka. 172 p.
- Nath, R.D., Rahi, M.L., Hossain, G.S. and Huq, K.A. 2008. Bangladesh status of fresh water snail in Khulna district. *Bangladesh Res. Pub. J.* 1 (4): 337-347.
- Saha, B.K. 1998. Ecology and bio-economics of the freshwater edible snails of Bangladesh. PhD dissertation. Rajshahi University, Bangladesh. 162 p.
- Sing, R. 1991. Seasonal variation in calorific values of *Pila globosa* and *Bellaniya bengalensis*. *J. Ecobiol.* 3 (2): 98-101.
- Sultana, P., Thompson, P.M. and Ahmed, M. 2002. Women-led fisheries management - a case study from Bangladesh. ICLARM-The World Fish Center, Malaysia and Bangladesh. pp. 89-96.
- Xoing, W.W., Tian, Y.G., Zhang, Z.G., Vue, C.J., Ying, J.G., Ji, L.P. and Wen, Z.W. 1987. Tolerance of *Azolla caroliniana* and its application. Fisheries Research, International Rice Research Institute, Philippines.