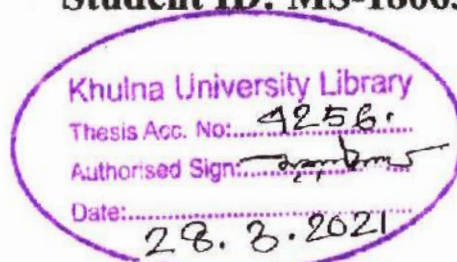


**Present status of mud crab collection, culture and marketing in
Bagerhat and Khulna districts**

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September, 2019

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Khulna districts**

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Declaration

Present status of mud crab collection, culture and marketing in Bagerhat and Khulna districts

The result presented in the thesis with the above mentioned title are entire of the candidate's own investigations and no part of the results has been accepted for any degree nor it is being concurrently submitted for any degree.

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Dedicated To
My Beloved Parents
& Elder Brother



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Abstract

Crab cultivation has been treated as one of the dependable sources of livelihood for many years. A majority number of families in that area have chosen crab cultivation as their exclusive source of income. The present study was aimed to examine the economics of collecting, culture and marketing of live mud crab at Dacope upazila under Khulna district and Rampal upazila under Bagerhat district of southwest region of Bangladesh. A total of 30 crab farmers were randomly selected from this two upazila and 30 were crab collectors. The study determined costs, returns and profitability of mud crab production in respect of crab collection and culture. However, for the male crab, 5 grades namely extra-extra-large (XXL), extra-large (XL), large (L), Medium (M) and small (SM) were observed, whereas 4 grades were observed for female crab namely F1, F2, F3 and KS3 both in descending order of live gross weight. The average size of crab farm was about 1 acre. The demand of live crab was higher in winter season (November-March) when the production and catch were relatively higher. The results from profitability analysis revealed that total cost and gross return of crab collecting in one season (Sept-Feb) were about Taka 353280 and Tk. 474000 respectively whereas in one culture period (Nov-Feb) of fattening, per acre total cost and gross return were Tk. 835692 and Tk. 1020000 respectively in Bagerhat and Tk. 838373 and Tk. 930000 respectively in Khulna. Net returns of crab collecting and crab fattening were Tk. 120720 per season and 184308 per acre in Bagerhat and 91627 per acre in Khulna respectively. In this study, it was also tried to explore the challenges that collectors and cultivators faced in mud crab production and the challenges conceded by the producers and middlemen in the marketing of mud crab. Considering the total export earnings from mud crabs, this sector shows future potential and for achieving this, development and support should come from government and different non-government organizations to improve the sustainability of this sector in Bangladesh.

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Chapter 1

Introduction

Introduction

1.1 General Introduction

Bangladesh has a coastline of 710 km with 6.18.780 ha of mangrove tidal flats and 80,000 ha of associated areas suitable for coastal aquaculture (Chakraborty et al. 2018). Mud crab (*Scylla serrata*, Forskal, 1755) is one of the most important coastal aquatic crustacean species among 12 marine/brackish water species in Bangladesh. The mud crab plays an important role in the national economy by earning from export (Joarder 2014). Bangladesh is one of the richest regions and leading fish producing country of Indo-pak-Bangladesh subcontinent in respect of fisheries potential. This sector is contributing significantly in food security through providing safe and quality animal protein. The fisheries sector contributes 3.61% to GDP and 24.41% to agricultural GDP. Fish supplements to about 60% of our daily animal protein intake. This sector also has high potential for the perspective of economic development of the country. Bangladesh earns a considerable amount of foreign currencies by exporting fish, shrimps and other fisheries products (DoF, 2017-18). Mud crab is very known and economic potential animal in coastal area of Bangladesh. Mud crab is acting as valuable member among exported fish and fisheries product from Bangladesh. It is considered as one of the luxury seafood items. Mud crab fishing has been practiced for many years in coastal region, particularly in Khulna, Bagherhat and Satkhira based primarily on capture and fattening of juvenile crabs from the wild. Export of mud crab started in 1977- '78 and became a stable business in 1982 and ranked third among frozen foods exported from Bangladesh (Ali *et al.*, 2004). The export of live mud crabs from Bangladesh has increased many folds in the last decade (Zafar *et al.*, 2004). It offers excellent food for estuarine crocodiles, sharks, estuarine groupers turtles and grey headed fishing Eagles (Lee, 1992).

There is a highly demand for mud crabs and this has led to over-exploitation in many areas (Molla, et al. 2009). The mud crab, *Scylla serrata* is widely distributed in the Pacific and Indian oceans. Crab culture and fattening are however, still in the experimental stage in South Asia (Salam et al. 2003). Mud crab of genus *Scylla*, also known as green crab or mangrove crab constitute an important secondary crop in the traditional shrimp or fish culture systems in the Asian countries including Bangladesh. The importance of live mud crab as an export commodity has opened up great opportunities for crab farming. Considering the increasing

demand of mud crab in the local and international markets, it has been gaining popularity among the coastal communities in greater Khulna and Chittagong regions (Azam et al. 1998). The annual production of crab is estimated to be more than 10,000 tons (Zafar and Siddique 2000). During winter (November to January), the largest number of crabs are harvested from the mangrove areas and the tidal rivers. During rainy season (June to August), shrimp ghers are the main sources of mud crab. The maximum number is catch occurs during spring tide and neap tide locally known as gown (Uddin, 2002). Apart from collecting from the wild, mud crab fattening in earthen ponds started during 1993 in coastal area of Bangladesh (Chakaria Sundarban, Rampal, Munshiganj and Paikgacha areas). Considering the increasing demand of mud crab in the local and international markets, it has been gaining popularity among the coastal communities in greater Khulna and Bagerhat regions (Azam et al., 1998). Crab fattening is widely practiced in Thailand, Taiwan, Malaysia, Singapore, India, Indonesia and Bangladesh. In Bangladesh, coastal farmers have been practicing mud crab fattening mainly in encircled earthen ponds. In earthen ponds, some crabs manage to escape and cannot be caught in time due to burrowing inside the mud. High mortality and poor survival are the main constraints of crab fattening in existing systems. The introduction of mud crab fattening in cages is new in our country though it has been practiced in the Philippines, Indonesia, Malaysia and other South-east Asian countries. In the Philippines, only documented studies on fattening crabs were in bamboo and net cages (Du, et al., 2000). Pens and floating cages made of bamboo, polyethylene netting and galvanized wire netting are used in coastal waters, shallow lagoons and ponds for mud crab fattening (Cholik and Hanafi (1992). In Myanmar, the traditional mud crab fattening practice is done in ponds, bamboo enclosure and cage in river and canal system (Le et al., 2006). Primavera., (1995) reported mud crab fattening practice in cage in Vietnam. In Malaysia, floating cages ($6m^3$ with a depth of 1m) are used to fatten mud crab (He et al., 1999). Export of mud crab started in 1977-78 and became a stable business in 1982 and ranked third among frozen foods that were exported for earning foreign currency from Bangladesh (SEAFDEC, 1998; and Ali et. al., 2004). The export of live mud crabs from Bangladesh has increased many folds in the last decade (from US\$ 31,000 in 1989-90 to US\$ 57,92,000 in 1995-96 and sharply decreased from US\$ 55,35,000 in 1996-97 to US\$ 2,83,000 in 1999-2000 (BEPB, 2004). The trading pattern of mud crab involves a series of intermediaries like the harvesters, supplier, exporter and the consumer. Final price of the product depends on the marketing network. The greater the number of the intermediaries, the higher the price of the crab (Ladra and Lin, 1991). The market chain of the mud crab begins in the poorer households

in the village. The most marginalized segment of coastal population especially lands less people, widow, orphan and children earn their livings for several months by collecting crabs from the wild and selling these to the local aratdar (who purchase crabs from the local collectors). In many cases, aratdar pays advance money to the collectors. This situation drew the attention of scientific communities and it was deemed necessary to find out the answers to some of the questions: who are actually involved in crab related activities and why, what is their socio-economic condition, what is the existing marketing channel, how and at what rate the values are being added in every stage of crab marketing, what are the problems in crab exporting and what should be done to improve the crab fishery. It is very much needed to improve Culture techniques of mud crab to get higher production in Bangladesh.

1.2 Species information

Mud crab, genus *Scylla* is a commercially important portunid crab and it is traditionally exploited by artisanal fishermen and provides a basic source of income for coastal fishing communities throughout the Indo-pacific region (Islam *et al.*, 2010). Productions of mud crab through aquaculture in some country are becoming important as an export commodity. Mud crab has become one of the important export commodities that's leads to many big opportunities in crabs farming (Begum *et al.*, 2009).

Four species of the genus *Scylla* are revised *Scylla serrata*, *S. paramamosain*, *S. olivacea* and *S. tranquebarica*, of which *S. olivacea* is one of the economically important species due to their large size and better nutritive value that inhabit a wide range of inshore and continental shelf area including coastal area mangrove area and in sea of intertidal zone to at least 50 m depth. In Bangladesh, mud crab is widely distributed in the tidal rivers of Cox's bazar, Chittagong, Barisal, Patuakhali, Sathkhira and Khulna up to 40-50 backwaters and around the offshore islands particularly Moheshkhali, Kutubdia and Sandwip (Khan and Alam, 1991). It is also available in the coastal shrimp ponds. Crabs are highly abundant in the Khulna and Chokaria Sundarban Mangrove forest (Khan and Alam 1991).

“Mangrove crab” locally called as “Habbakankra” or “kankra”. It occurs abundantly in the tied fed rivers, estuaries and mangrove swamps and the entire low saline coastal waters of Bangladesh (Shafi and Quddus, 1982; Bhuiyan and das, 1976; Mohmood, 1977; Islam 1977).

Bangladesh (Shafi and Quddus, 1982; Bhuiyan and das, 1976; Mohmood, 1977; Islam 1977). Bangladesh earns considerable amount of foreign exchange through exporting the crabs in live condition (Azamet *al.*, 1998

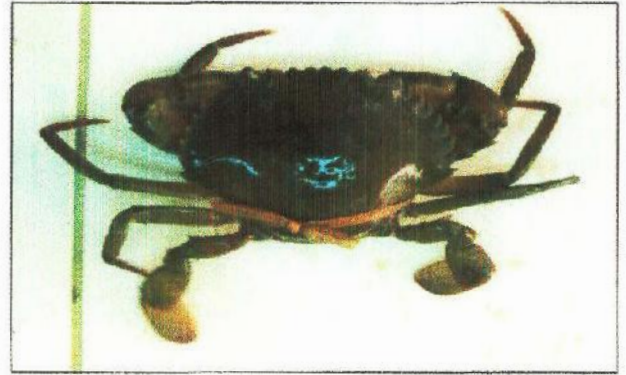


Fig a: Image of Male (left side) and Female (right side) mud crab

1.3 Life cycle

Scylla Olivacea is a species with a biphasic life cycle. It is fast growing (up to 160 mm CW in the first 15 months (Hill, 1975) and can reach to 280 mm CW and 2-3 kg; (Heasman, 1980) within a life span 3-4 years. Throughout its life, *S. olivacea* undergoes several ontogenetic shifts, expressing different behaviors and occupying different habitats at each stage. The larvae are (presumably) released offshore, and undergo five larval stages before returning to coastal areas. The larvae metamorphose into the megalopa stage in these coastal areas and subsequently settle and transform into the first juvenile stage in supposedly inshore areas. Early juvenile mud crabs inhabit sheltered mangrove areas, and they expand their habitat to larger subtidal and intertidal areas in or adjacent to mangrove habitat when growing into an adult crabs. Courtship and mating occur in estuaries. After mating, the male resides in inshore waters, whereas the female sets out to spawn at sea ('spawning migration'). Mature *S. olivacea* migrate offshore 9 up to 50 km to spawn. The differences in habitat use are mainly driven by life-stage-dependent tolerances as well as intraspecific competition (cannibalism) (Hilke Alberts-Hubatsch 2015). Typically associated with mangroves in estuaries and sheltered coastal habitats, they are found in soft muddy bottoms where they dig deep burrows. Crabs instars undergo several molts before attaining full maturity. As the male crab

mature, the claws enlarge and the testes become massive, filling the cavity under the carapace. Mature females have wide and dark abdomens and dark orange ovaries that fill the cavity under the carapace.

1.4 Ecology

S. olivacea inhabits muddy, bottoms, mangrove marshes and river mouths in estuarine environment (Motoh, 1979). *S. olivacea* are common in the mud flats of the littoral, parts of the sub-littoral and the intertidal zones of the Bay of Bengal. It is widely distributed over a wide range of salinity from 2 ppt to oceanic waters, from the coast to interior brackish waters. They are essentially euryhaline but die beyond 70 ppt. Crab live in mud burrows, which occur densely in intertidal mangrove swamps, a little above the low tide mark. The burrows are also in the embankment of shrimp culture ponds. Crabs take shelter in burrows during the day when tide is low. During high tide at night they swim in search of food (Khan & Alam, 1991).

They migrate from high salinity to estuarine or brackish water bodies during their post larvae or juvenile stages (Srinivasagamet al., 2000). Tagging and telemetric and ultrasonic transmitter studies and laboratory experiments have clearly demonstrated the anadromous behavior of mud crab in relation to habitat selection (Webley et al., 2009). Its burrows characteristics shape and form permeate the mangrove floor which helps to aerate the substratum and provide refuge for many other animal including mudskippers, frogs, and sea slugs (Azam et al., 1998). The mud crab is an omnivorous opportunistic feeder feed on slow moving and sessile benthic invertebrates and prefers small crabs (mainly gassed), bivalves and detritus (Macintosh et al., 2002; Hillet al., 1976; Prosad et al., 1985; Christopher 1991). Mud crabs are nocturnal animal, remaining buried during the day and emerging at sunset (Christopher, 1991).

1.5 Food value

Mud crab is one of the most popular and luxury food items in many parts of the world (Pripanapong and Tongdee, 1998). In Bangladesh, its excellent and distinctive flavor makes it one of the most delicious and costly food item. The mud crab meat provides an excellent source of nutrition because of its high protein content. Mud crab meat contains high protein value 20% (Warner, 1977; Wanget al., 1995). The other part of the body is also important for



1.6 Economic importance

Mud crab is regarded as the most valuable crab species in Bangladesh and considered a profitable business due to its emerging contribution to export earnings. Among the exportable fish and fishery products of Bangladesh, crab is the third largest single fishery product after hilsha and frozen shrimp. Mud crab is one of the most important foreign exchange earner commodities. Continued increased in export of live mud crab plays an important role in the economy of Bangladesh (Azam *et al.*, 1998). According to forest department, there are about 3000MT crab and shrimp harvested from Sundarbans – “the crab mining zone” and about half of the production coming from crab only. Ahmed (1991) estimated the annual landings of mud crab from different coastal area of Bangladesh in 1990 were 2151 tons. Chantarasasri (1994) reported the yearly production and maximum Sustainable Yield of mud crab from the Sundarbans reserved forest area at 375 MT and 150MT respectively. Over the last 10 years crabs export has grown from 336.0 MT with export value of \$ 0.86 million in 2001- 2002 to 12000 MT live crab earning of \$ 18.59 million in 2010-2011 financial year (Rahman *et al.*, 2012 and Matshya Sankholan 2014). According to the department of fisheries (Daily protidin dated 1 July 2015) annual crab production from Bangladesh is about 10000 tons which market price is about 350 crores. However, major production comes from Khulna, Sathkhira and Bagerhat region which earning about TK. 200 crore/year. At present crab is exporting to China, Taiwan, Singapore, Malaysia, Thailand, Japan, Hong-Kong, USA and in many countries of Europe. There are more than 100 thousand men and women are directly engaged for their livelihood in crab business from Khulna sathkhira region (Daily protidin 1 July 2015).

1.7 Importance of the study

Considering the increasing demand of mud crab in the local and international markets, it has been gaining popularity among the coastal communities in greater Khulna region (Azam *et al.*, 1998). The entry of new fishers in crab harvesting from coastal waters has increased manifolds. As a result, the natural populations of mud crab are declining throughout the south-east Asia due to over-exploitation, loss of mangrove habitat, water pollution coastal environment degradation. In addition, catching of small crabs due to high demand of recent crab fattening resulting contribution of small increased to higher in catch that greatly hampered in biological reproduction as most of the individuals caught before maturity. The exact figure is not investigated yet, from the farmer's point of view the availability of the species have decreased. Less than 80% populations are being caught before getting the size of first maturity

(Islam *et al.*, 2012). In last few natural disasters (like Aila, Sidre) have changed lot in coastal habitat and livelihood pattern of the marginal people. Still many areas associate of sundarban area under flooded which is not possible to undertake in aquaculture except natural fishing which also increasing threats to the natural mud crab population. So, a comprehensive management activity is urgent need for the mud crab fishery to sustain the harvesting the animal from natural population and the secure of livelihood of the coastal marginal people who have rare alternative livelihood option. So, to set fruitful management strategies, it is essential to know the present condition of the population.

1.8 Objectives of the study

Broad/General objective:

Through this study a total scenario of mangrove associated mud crab sector will be depicted. Major information on mud crab collection, associated problems faced by fisher folk and the prospect of future collection will be discussed. Detail information on mud crab culture and its economics will be brought in to discussion. Finally, the marketing channel of mud crab from collectors to exporters will be analyzed to outline the existing bottlenecks in the existing marketing systems. Besides, socio-economic information of the stakeholders will also try to be discussed.

Specific objective:

- To know the present situation, future prospects and existing challenges of mud crab sector in Bangladesh.

Chapter 2

Literature Review

Literature Review

Several studies on present trends of mud crab collection, culture and marketing have been conducted by many researchers in various part of the world, especially in those countries, where aquaculture is practiced in large scale. Some studies that are conducted on related topic are mentioned below-

Islam *et. al.*, (2009) studied on “Socio-economic status of crab collectors and fatteners in the southwest region of Bangladesh” and described the socio-economic conditions of mud crab (*Scylla serrata*) collectors and fatteners in Khulna and Satkhira districts.

Islam *et. al.*, (2017) studied on “Challenges in mud crab production and marketing: A study on Khulna and Satkhira District” and described the challenges of mud crab production and marketing in Bangladesh faced by the farmers in the field level.

Ross *et. al.*, (2012) studied on “ Crab culture potential in southwestern Bangladesh: alternative to shrimp culture for climate change adaption” and evaluated coastal land based criteria for mud carb farming based on water quality, water availability, salinity, risks of flooding, soil types, topography, land use/land cover; infrastructure, inputs, seed sources, market and support services.

Mirera D.O. and Mtile A., (2009) studied on “A preliminary study on the response of mangrove mud crab (*Scylla serrata*) to different feed types under drivein cage culture system” and described the growth rate, moulting and mortality of crabs fed using locally available feeds.

Alam *et. al.*, (2009) studied on “ Comparative study of mud crab (*Scylla serrata*) fattening practices between two different systems in Bangladesh” and compared the survival, production and economics of mud crab fattening in cage with fattening in encircled earthen brackish water pond and finally showed that mud crab fattening using bamboo cage might be better than encircled earthen area with fencing in Bangladesh

Jayamanne *et al.*, (1991) reported that the maximum size of *S. serrata* ranged from 190 mm to 280 mm ICW Exploited population size was > 130 mm. In the present study 96% of exploited male 99% of exploited female population was lower than 110 mm ICW. Approximately 50%

of harvested female crabs were within 70-80 mm size class while 18.476% males were within 70-80 mm size class.

Islam S., and Kurokura H., (2013) worked on gonad development and size at maturity of the male mud crab *Scylla paramamosain* (Forsk., 1775) in a tropical mangrove swamp. The gonad development was classified into three stages: a) Immature b) Maturing c) Mature. 72% was under gonad development stage I, where only 12% was mature stage. The 50% maturation of male *S. paramamosain* were 109 mm internal carapace width.

Ikhwanuddin et al., (2012) stated that the carapace width range of berried crabs sampled was from 9.64 to 13.32 cm, while the body weight ranges from 75 to 235 g. The mean number of eggs produced by females in different size ranged from 105443.333 ± 35448.075 per egg batch. Mean egg size during embryonic development at stage I was 0.307 ± 0.037 while 0.386 ± 0.039 and 0.396 ± 0.033 for stage II and stage III, respectively. Study showed that there was significant ($p < 0.05$) relationship between the number of eggs, body weight and carapace width.

Safaie M. et al., (2012) showed that the annual sex ratio is not M: F = 1:1 with 51.9% female. All the five stages of ovarian development of *P. segnis* were observed throughout the year and spawn all the year round with a spawning peak in midwinter to early of spring season. The fecundity of ovigerous crabs ranged from 521027 to 6656599 eggs with average fecundity of 2397967 eggs and the minimum carapace width (CW) of female crabs that reach sexual maturity was 92-138 mm.

Islam et al., (2010), worked on the ovarian development of mud crab, *Scylla paramamosain*. Ovarian development was classified into five stages: proliferation (stage I), previtellogenesis (stage II), primary vitellogenesis (stage III), secondary vitellogenesis (stage IV), tertiary vitellogenesis (stage V)

Jirapunpipat (2008) worked on population structure and size at maturity of the orange mud crab *S. olivacea* in Klong Ngao Mangrove Swamp, Thailand. The male and female sex ratio was 1.3: 1 and the male was larger than the female. The 50% maturation of female crabs were 9.55 cm carapace width, as estimated from a logistic model.

King et al., (2007) stated that the morphometric relationship between length-weight can be used to assess the well-being individuals and to determine possible differences between serrate unit stocks of the same species.



Satapathy *et al.*, (2007) reported the GSI of *S. serrata* varied between 1.5 and 6.3 and higher GSI was reported from the month of September-November, which almost match with the present observation. Higher GSI of *S. serrata* during the month of August – November and low female sex ratio during this month indicated the possible migration of *S. serrata* female for spawning in the sea during the months of august –November.

Soundarapandian and Tamizhazhagan (2006) worked on the fecundity and eggs color of *S. serrata* and found that the fecundity of the species ranging from 9,00,000 to 10,00,000. The color of the eggs is initially yellow and it was gradually transformed into orange, brown and black colors.

Oriola *et al.*, (2005) calculated the length weight characteristics of crabs and the maximum carapace length was 6.0 cm (4.38 ± 0.04) in *cardiosoma armatum* and 7.0 cm in (5.17 ± 0.04) in *Callinectes pallidus*. All body proportion and counts except the right chelae diameter were significantly different ($p \leq 0.05$) in these two species.

Fielder and Allan (2004) reported that ovigerous females of *S. paramamosain* and *S. olivacea* occur between January and October, peaking in the warm (May –July) and rainy (June –July) seasons, but we found no berried females of *S. serrata*. The female biased sex ratio of *S. paramamosain* and *S. serrata* and the larger body size of females during the period from autumn (November) to early spring (April), suggest that gravid females may have migrated offshore before the spawning season. The mean body size of the females and males of *S. paramamosain* and *S. serrata* tended to increase and the mating activity was high May and October, showing the molting and growth season.

Emmerson *et al.*, (1994) worked on gonadosomatic index of the male and female crabs who's studied according to size and weight of the crab. The GSI of the male crab (0.48) was increased from immature crabs to mature crabs (0.79). The size of the animals was ranging between 8.0- 8.5 cm carapace width to 15.1- 14.5cm carapace width.

Brown *et al.*, (1993) found that in *Scylla sp.* male and female growth rates differ, after puberty, female generally grows slowly than males because females allocate more resources for gonadal development and parental care and egg are attached to the abdomen until hatching which prolong the inter molt period.

Chapter 3

Materials & Methods

Methodology

Materials and methods are a very important concept in research on the basis of which study is conducted. It is the blueprint of collection, measurement and analysis of data. Materials and methods depend on the types of study and data collected from that study in terms of time and resource constraints.

3.1 Study Area and Experimental Design

The present study was carried out in the Dacop upazilla of Khulna District and Rampal upazilla of Bagerhat district. Three major stakeholders of crab sector i.e. crab collectors, crab farmers and traders were introduced for information collection under this study.

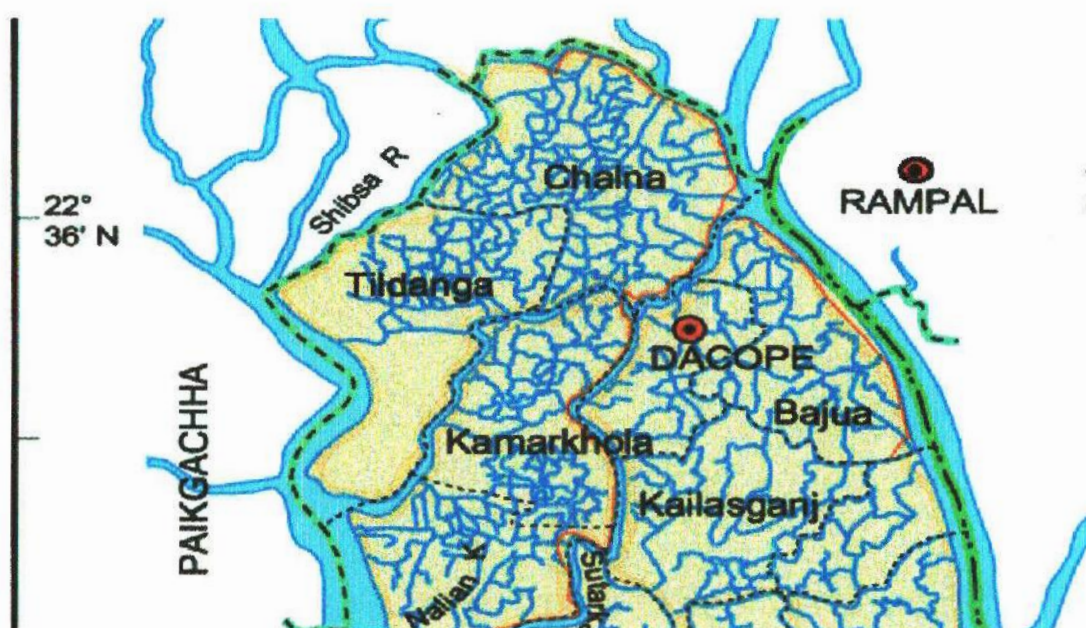


Fig-1: Study area of the thesis work

3.2 Experimental procedure

Detail survey on mud crab sector of Bangladesh emphasizing the information on wild catch procedures, CPUE, culture management systems, marketing channels, associated problems, challenges and future potentiality was gathered by using a self-structured questionnaire. Data was collected from February 2019 to June 2019. Besides primary data, secondary data was also

gathered from literature review and from different government and non-government organizations working with crab sectors of Bangladesh. Two questionnaires were used to collect data one from crab collector another from crab farmer. Respondents were asked to collect the primary data. 30 respondents from each area were selected to conduct the survey. Some of the open-ended questions were asked to know their strengths, weaknesses, recommendations, marketing strategies, and policy barriers.

3.3 Data analysis

The processed data was transferred to a master sheet from which classified tables will be prepared revealing the findings of the Questionnaire of the study. Preliminary data sheets were compared with computer spread sheets to ensure the accuracy of the data. After data entry, “Microsoft Excel” and IBM SPSS 20.0 computer packages were used to perform descriptive statistical analysis of data. Frequencies and percentages of different variables are displayed in the tabular form. Graphical presentation like bar graph and pie chart are displayed to better describe the scenario of mud crab aquaculture in Bagerhat and Khulna districts.

Chapter 4

Results & Discussions

Result and discussion

4.1 Present status of crab Collection

The mud crab fishery is absolutely based on wild catch mainly from the swamps of the Sundarbans and vast areas of the traditional shrimp *ghers* along the coastal region of Bangladesh. The actual culture technique of mud crab has not yet been developed in Bangladesh. In the present study, it was observed that 55 percent of the crab collectors collected crabs from the Sundarbans mangrove forest, whereas 35 percent and 10 percent collected crabs from *ghers* and rivers/canals, respectively. Seventy-five (75) percent of crab collectors used *cuchia* as bait. Collectors were found to collect crabs for 12-15 days in 1 trip. It was also observed that the season during September to February is profitable for crab collectors. Around 10-12 trips were occurred by the crab collectors in one season (Sep-Feb). On the other hand, juvenile crabs were collected from Sundarbans and adjacent rivers for hardening and fattening and the rejected crabs were transferred for trading into the crab depots.

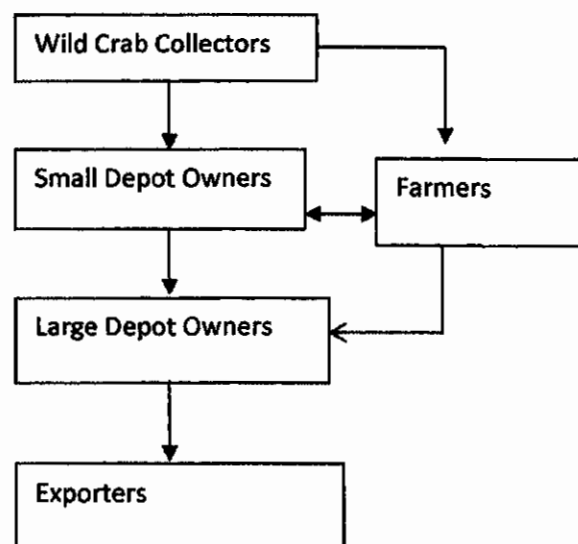


Fig 2: Crab supply chain

Table 1: Costs of collecting and marketing of crab (cost/trip (12-15day)/collector)

Particular	Unit	No./ Quantity	Price/unit (Tk.)	Cost (Tk.) /Trip	Total cost per season (Sept-Feb) in Tk.
A. Variable cost				28340	
a. Labor used	person	2	300	14400	
a. Food provided (2 persons)			90	4320	
b. Baits (Cuchia)	Kg	20	30	600	
c. Synthetic rope (tape) used for binding crab legs	Kg	10	140	1400	28340*24= 340080
d. Tax				3000	
e. Transportation cost				3000	
f. Mortality loss	Kg	7	160	1120	
g. Miscellaneous				500	
B. Fixed cost				1100	
a. Depreciation cost of boat				1050	1100*12= 13200
b. Miscellaneous				50	
Total cost (A+B)				29440	3353280

Table 2: Grading of male and female live crabs

Grade	Female	Grade	Male
Grade	Weight	Grade	Weight
FF1	>180g	XXL	>500g
F2	>150g	X	>400g
F3	>120g	L	>300g
KS3	>120	M	>250g
		SM	>200g

Table 3: Grading of male and female live crabs in International Market

Grade	Female	Grade	Male
Grade	Weight	Grade	Weight
FF1	>200g	XXL	>500g
F2	>180g	XL	>400g
F3	>150g	L	>300g
KS3	>120	M	>250g
		SM	>200g

4.2 Present scenario of Crab culture

Different people in different family conditions were involved in crab culture sector. In Bagerhat among 30 samples 23 were involved in agriculture and 7 were involved in Business where the monthly expenditure of 33% farmers were (4000-5000) Taka, 60% (5000-10000) Taka and 7% were above 10000 Taka. In Khulna among 30 samples 26 were involved in agriculture and 4 were involved in Business where the monthly expenditure of 50% farmers were (4000-5000) Taka and 50% are (5000-10000) Taka.

Table 4: Income and expenditure distribution of crab farmers

Variable	Categories	Address		Total
		Bagerhat	Khulna	
Source of income	Agriculture	23 (76.7%)	26 (36.7%)	49
	Business	7 (23.3%)	4 (13.3%)	11
Monthly family expenditure	4000-5000 Taka	10 (33.3%)	15 (50.0%)	25
	5000-10000 Taka	18 (60%)	15 (50.0%)	33
	Above 10000 Taka	2 (6.7%)	0 (0%)	2
Total		30	30	60

Small ponds are used in coastal areas for crab fattening in Bangladesh. These ponds are fenced by bamboo ticks locally known as "Pata" to prevent escaping of crab. Fattening usually requires

2-4 weeks to complete. Within this time, premature crabs are well fed to develop their body fully. In the study area, most of the ponds used bamboo fences of 1 to 2 meters in height. The pond depth varied from 0.25 - 1.50 meter and water ranged between 0.50 - 0.75 meter. Most of the ponds were rectangular having a common inlet and outlet made of PVC pipes. The peak season for fattening was winter (November-February). The stocking density varied from 2000 kg of crab let/acre and fed at 10 percent of body weight once in a day during evening hours. The farmers used trash fishes, snail meat, eel, cuchia, offal of chicken and cattle meat as feed of crabs. The period of fattening and hardening varied from 10 to 25 days depending on the stage of gonad and/or Hepatopancreas development, shell development and price of fattened crabs in the depots.

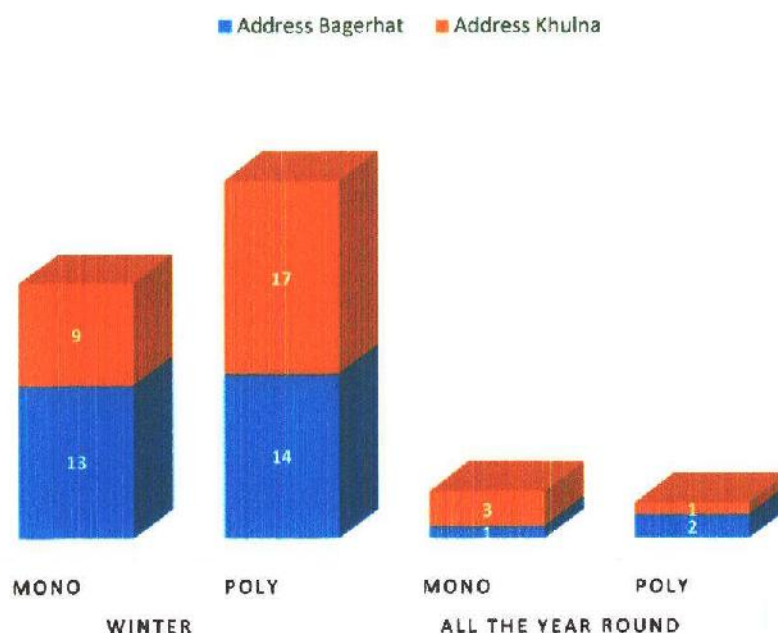


Fig-3: Crab culture system practice in Bagerhat and Khulna

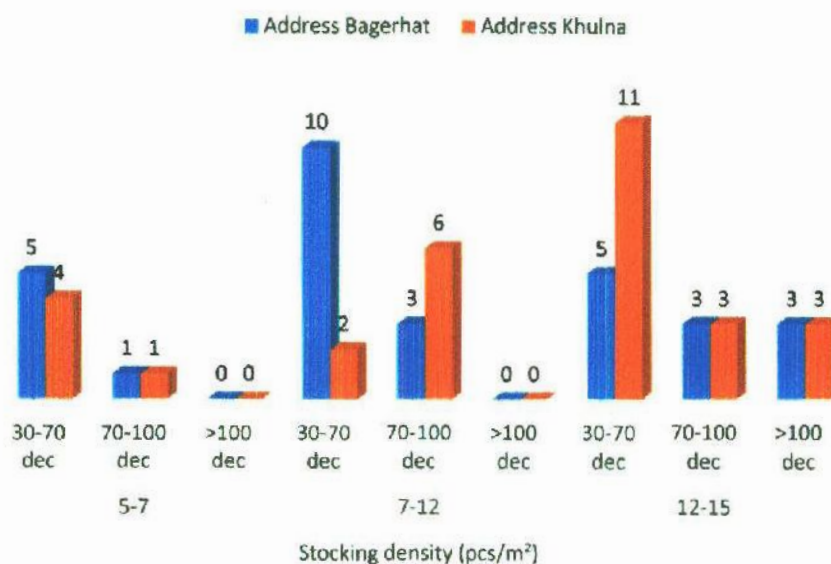


Fig-4: Stocking density of crab culture system

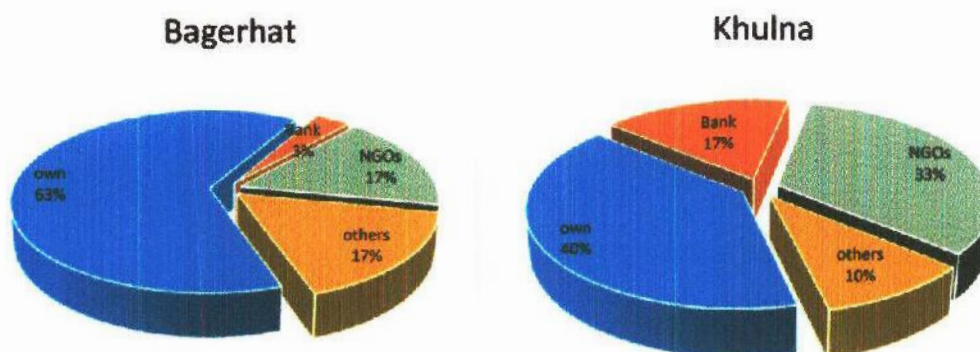


Fig 5: Different financial source of crab farmer

In Bagerhat, among 30 samples 17% took loan from NGOs, 3% from Bank, 17% from others and 65% had his own finance and in Khulna among 30 samples 33% took loan from NGOs, 17% from Bank, 10% from others and 40% had his own finance. In the lean season when people find no way to earn then they took loan from the local aratdar in a condition that they would sell their entire catch to that aratdar, at a pre-fixed price. Through such conditional trading local collectors never got the actual price of their catch. In spite of its increasing demand and great export potential no marketing system has yet been established in Bangladesh.

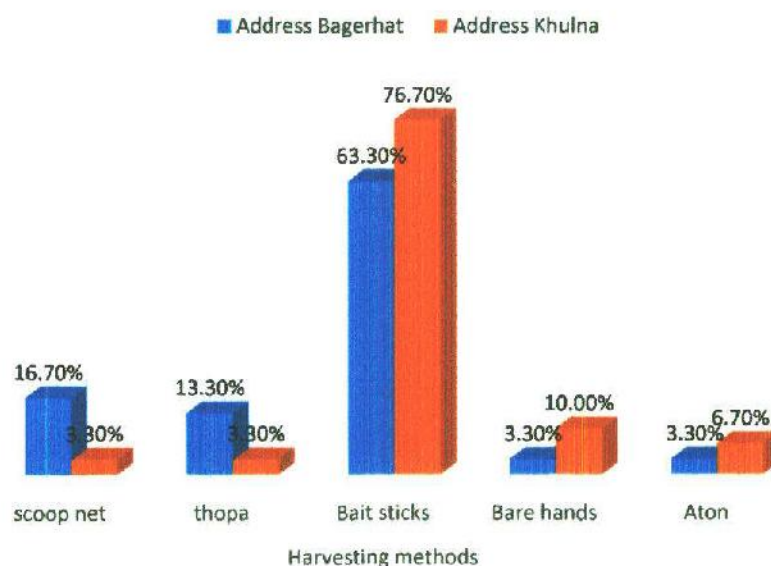


Fig 6: Different harvesting methods of crab culture

4.3 Crab marketing channels

The trading pattern of the mud crab involves a series of intermediates between the catcher/farmers and the consumers. The farmers and collectors usually market their catch 2-3 days after catch. During this time the crabs are kept in their homes or boats, either in water or in cages. The marketing channel of the mud crab business was found to be consisted with the harvesters, forias (middlemen), depot owner's suppliers, agents and exporters. The trading pattern involved a series of intermediaries from harvesters to consumers. In general, it was found to be similar in two districts. In the whole region, two major types of marketing channels (Figures7) were observed.

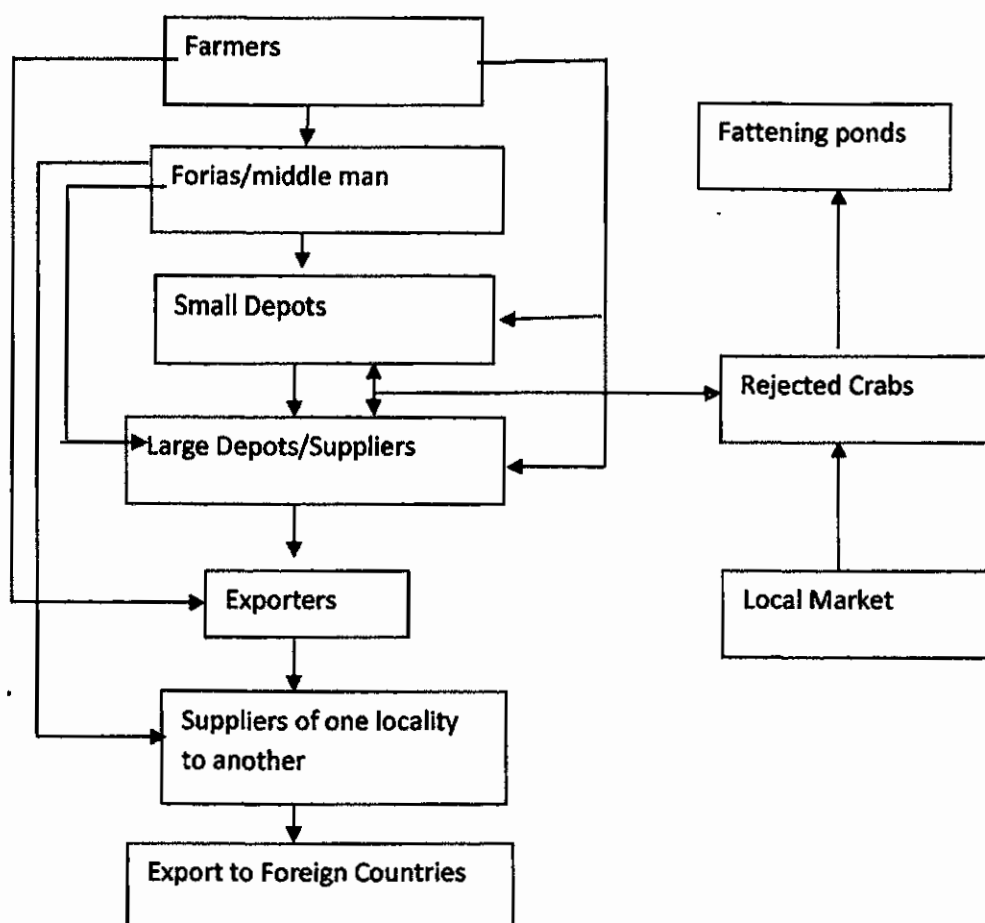


Fig-7: Marketing channel

Table-5: Marketing and Transportation system of crab culture

Variable	Categories	Bagerhat	Khulna
Marketing system	Local foria	1 (3.3%)	5 (16.7%)
	Depo	29 (96.7%)	25 (83.3%)
	Box	5 (16.70%)	9 (30.00%)
Transfer system	Baskets	20 (66.7%)	21 (70.0%)
	Container	5 (16.7%)	0 (0.0%)
Destruction rate in percentage	0%-5%	22 (73.30%)	30 (100.0%)
	5%-10%	8 (26.70%)	0 (0.00%)

4.4 Mud crab transportation

Harvested mud crabs from various wild sources were transported to Dhaka by various means. Depending on the sources of harvest, harvested crabs were reached Dhaka within 7 hours to 7 days.

4.4.1 Transport to local depots

Harvested mud crabs were transported to the depots by small wooden boats and sometimes by mechanized trawlers, from gher carried in bamboo baskets, plastic pots and to local depots by bi-cycle or Van. It took 2-3 hours to reach at local depots by the forias and middle men. Fishers kept the harvested crab's moist spraying river water over them.

4.4.2 Transport to Dhaka

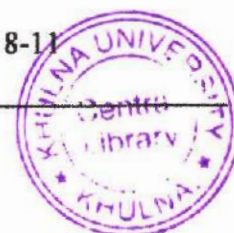
All products (crabs) were transported to Dhaka through associations. Plastic baskets of different sizes were used to transport from local depots to Dhaka. The baskets were long necked in shape and covered with sackcloth or gunny bags. A layer of wet betel-nut leaf was placed at the bottom of the baskets to keep low temperature and to prevent dehydration. Crabs of different grades were placed together in the same baskets. Each basket contained about 30-100 kg crabs. Baskets full of crabs were transported to Dhaka by bus and mini-truck (Pick up) at night hours depending on the quantity and availability of suitable vehicles (Table 6).

Table 6: Timing and mode of transportation for mud crab from SW region to Dhaka

Locality	Mode of transportation	Time required (hours)
Khulna	Bus, Pick-up	6-9
Bagerhat	Bus, Pick-up	8-11

4.4.3 International transportation

Immediately after reaching in Dhaka at early morning hours, crabs were again graded following international grades and packed in small bamboo baskets. Each basket contained 15 kg of crabs. The baskets were stacked one over another. Plastic baskets were used to airfreight the crabs from Shahjalal International Airport, Dhaka. The mortality rate varied from season to season which was low in winter and high during summer. Mortality in transportation affected the production of mud crabs. The transportation mortality rate was 5-9 % in Philippines (Ladra.



F.D. and C. J. Lin. 1991). Higher mortality occurred due to stress during the long transportation (Liong, P.C. 1992). In SW region of Bangladesh, the transportation mortality was 4-6 % but during packing and handling mortality was high (9-14%). Necessary care should be taken during packaging and handling. Practically the price of crab was entirely dependent on the demand in foreign market. If foreign demand went high and the availability of crab went low, then the price of mud crab increased significantly. The price of different grades varied in different seasons (Kamal, D. 2002).

4.5 Costs involved in crab fattening and hardening

Variable costs for crab fattening and hardening included crablet, pond preparation/raising dyke, zeolite, feed cost, human labour, mortality loss, lime, transport, alum etc. and fixed costs included cost for land use, depreciation cost, interest on operating capital etc.

Table-7: Costs of crab fattening and hardening at Rampal

Particular	Unit	Quantity	Price/unit (Tk.)	Cost (Tk.)
A. Variable cost				
Crablet /soft-shell crab	kg	2000	300	600000
Pond preparation/Raising dyke		1		1500
Human labor	person	3	400	1200
Lime (1time/2 month)	kg	20	13	260
Alum	kg	1	32	32
Zeolite	kg	10	15	150
Feed cost (10 percent of body weight in a week)	kg	3200	30	96000
Mortality loss	kg	300	300	90000
Transport				1000
Miscellaneous				1000
Total Variable Cost (TVC)				791142
B. Fixed cost				
Land use cost				25000
Depreciation cost				5000

Interest on operating capital	12550
Miscellaneous	2000
Total fixed costs (TFC)	44550
Total cost (A+B)	835692

Table- 8: Costs of crab fattening and hardening at Dacope

Particular	Unit	Quantity	Price/unit (Tk.)	Cost (Tk.)
A. Variable cost				
Crab let/soft-shell crab	kg	1800	300	540000
Pond preparation/Raising dyke				2300
Human labor	person	3	300	900
Lime (1time/2 month)	kg	25	15	375
Feed cost (10 percent of body weight in a week)	kg	3000	30	90000
Mortality loss	kg	250	300	75000
Transport				1000
Miscellaneous				1500
Total Variable Cost (TVC)				805373
B. Fixed cost				
Land use cost				26000
Depreciation cost				5000
Miscellaneous				2000
Total fixed costs (TFC)				33000
Total cost (A+B)				838373

4.5 Profitability of crab farming

To determine the returns from crab collection a comparative economic analysis was made for one season (September-February) where 12-15 trips were made. A brief account shows below how the individual cost and return was computed in the present study. Gross return, the money value of total output, consisted of the values of live crabs. It may be noted here that on an average, price of live crab received by the collectors were found to be Tk. 800, 700, 600, 500, 120, 500, 200 and 150 per kilogram of crab in Dacope and Rampal for grade XXL, XL, L, M, SM, F1, F2 and F3 respectively. The estimated average gross return was found to be Tk. 474000 per season. The average gross margin of crab collection was found to be Tk. 133920. The estimated average net return was found to be Tk. 120720.

Table 9: Gross return of crab collector (return/trip (12-15day)/collector)

Sl. No.	Item	Per trip (12-15 days) in Tk.	Per season (Sept-Feb) in Tk.
A	Gross return	39500	474000
B	Variable costs	28340	340080
C	Gross margin (A-B)	11160	133920
D	Total fixed costs	1100	13200
E	Total cost (B+D)	29440	353280
F	Net return (A-E)	10060	120720

In case of fattening and hardening, In Bagerhat, the average selling price was calculated at Tk. 600. The estimated average gross return was found to be Tk. 1020000 for producing total 1700 kg crabs per acre per culture season. The average gross margin of crab farming was found to be Tk. 228858. The estimated average net return was found to be Tk. 184308 which indicates that crab production is a profitable business for the crab farmers. The findings were supported by the previous studies. Therefore, it can be concluded that the crab production is profitable for farmers.

Table 10: Gross margin and net return for crab farming at Rampal

Sl. No.	Item	Crab farming amount (Tk./acre)
A	Gross return	1020000
B	Variable costs	791142
C	Gross margin (A-B)	228858
D	Total fixed costs	44,550
E	Total cost (B+D)	835692
F	Net return (A-E)	184308

In case of fattening and hardening, In Khulna, the average selling price was calculated at Tk. 600. The estimated average gross return was found to be Tk. 930000 for producing total 1550 kg crabs per acre per culture season. The average gross margin of crab farming was found to be Tk. 124627. The estimated average net return was found to be Tk. 91627 which indicates that crab production is a profitable business for the crab farmers.

Table 11: Gross margin and net return for crab farming at Dacope

Sl. No.	Item	Crab farming amount (Tk./acre)
A	Gross return	930000
B	Variable costs	805373
C	Gross margin (A-B)	124627
D	Total fixed costs	33000
E	Total cost (B+D)	838373
F	Net return (A-E)	91627

4.6 Discussion

Present status of mud crab collection

The present study focuses on the present situation of mud crab collection, culture, marketing and related aspects of coastal area of Bay of Bengal. Juvenile *S. serrata* are most common in intertidal habitats, whether on mudflats or in mangroves (Hill BJ, 1975), moving into deeper habitats as they grow (Hill et al., 1982). Larger male *S. serrata* are commonly found in mangrove channels or in association with burrows located in mangrove forests, on mudflats, or in the banks of channels, as well as on neighboring reef flats (Perrine D 1978). Most households on mangrove area harvest crabs from nearby mangrove forests. The goal of this effort is to inform development of management strategies that will ensure continued availability of mangrove crabs, yet are simple for local resource managers to implement and evaluate. The highest volume of mud crab population was collected from mangroves and tidal rivers from November to January while shrimp farm was the main source of crabs during rainy season from June to August. The catch was high during spring and neap tide (Islam S, 2013). Medium and large crab of more than 14 cm carapace width and weighing more than 400 g were collected exclusively for export, which is agreed by (Raj, M. M. 1992). The female crabs with mature ovaries was particularly expensive in the market of Bangladesh, which is agreed by (Ladra et al. 1991). The catch statistics indicate that fishing pressure of coastal area was increased rapidly. The total catch statistics of mud crabs in the surveyed coastal area indicated that percentage of mud crabs was sharply decreased within four years which are very similar to the study of Chakraborty (Chakraborty BK 2009).

Mud crab was facing as higher risk of extinction day-by-day. A planned and systematic study was applied to determine the present status of biodiversity in the coastal area with a view to undertake appropriate measures to conserve and manage the mud crab resource. To overcome the basic requirement of mud crab fry in the aquaculture mud crab field, hatchery should be established in the coastal region of Bangladesh. But until to establish the hatchery, eco-friendly catch system of mud crab and juvenile mud crab culture should be applied in the coastal area. These trends among coastal area that mangrove crabs are becoming increasingly scarce have raised concerns regarding the sustainability of current harvest levels and determination of mangrove crabs as a viable and valuable resource (Hauff et al., 2006).

Economic performance of mud crab culture

In south-west part of Bangladesh most of the mud crabs' depots are located nearby the river for easy landing of harvested crabs. The farm size varied between 0.2 acre to 2 acres and the stocking density was 1500-2000 Kg/acre. The average size of mud crab fattening ponds in Thailand was around 270 m² and the stocking density is 2-4 individuals/m² (Hanvivatanaki, P. 1990). In Taiwan, the stocking density was 2-4 individuals/m² (Sivasubramaniam, K. and C. Angel. 1992). In Myanmar, crabs were fed with chopped trash fish, ascetes and agricultural-by products (Win, T. 2000). The grades of the mud crabs depended on the sex, size, body-weight and gonadal maturation. The grading system was almost similar in all districts of the SW region. The female crabs with mature ovaries was particularly expensive in the Philippines (Ladra. F.D. and C. J. Lin. 1991). The peak harvesting season of mud crab in Bangladesh was from mid to late monsoon (June-August) (Ahmed, M. K., 1992). Fattening of crab is profitable because of the fast turnover, low operating cost, high survival rate and good market demand for the end products (Liong 1992). After 4-6 months, the crabs achieved an average weight of 300-450g and fed with trash fish and molluscs. (Thach, 2004). (Escritor, 1972) concluded that cannibalism and the burrowing habitat of *S. serrata* should be controlled to minimize losses and to make the crab culture profitable. Survival in pond culture is generally lower as a result of cannibalism and escape (Liong 1992).

The comparative benefit-cost analysis In Bagerhat, the estimated average gross return was found to be Tk. 1020000 for producing total 1700 kg crabs per acre per culture season. The average gross margin of crab farming was found to be Tk. 228858. The estimated average net return was found to be Tk. 184308 and in case of fattening and hardening, In Khulna, average gross return was found to be Tk. 930000 for producing total 1550 kg crabs per acre per culture season. The average gross margin of crab farming was found to be Tk. 124627. The estimated average net return was found to be Tk. 91627. The present economic analysis revealed that crab production is a profitable business for the crab farmers.

The total mud crab's production was higher in Bagherhat districts than Khulna districts. The reason behind for such higher production was the close proximity to the Sundarhan mangrove swamps and numerous criss-crossed rivers and canals with the mud crab supply from numerous shrimp ghers in this district.

Marketing behavior of mud crab in southwest region

The marketing channels were mostly uniform in all districts of the SW region. Sometimes, the exporters employ agents to purchase crabs directly from the crab catchers or middlemen. As a result, conflicts arose sometimes between the depot owners, suppliers and exporters. Two types of markets existed for crab in Bangladesh: (a) local markets in the vicinity of fishing villages and (b) consumer markets away from the fishing areas (Ladra, F.D. and C. J. Lin. 1991). The non-Muslims and the tribal people were the major consumers of crab. Direct sell by fishermen in the local markets or in the consumer markets was the general mode of marketing. Previously, there were no middlemen in this trade. Female crab fetched a better price than males. The development of an export market was a recent phenomenon in Bangladesh (Ahmed, M. K., 1992). The meat of mud crab was very delicious and contained high nutritive value (Radhakrishnan, C.K. 1985). So, it had high market value in developed countries. But after 1995-96 mud crab export decreased because the availability was reduced (DoF, 2008).

Policy barriers and problems associate with crab business: The survey showed that the Ministry of Forest and Environment, Ministry of Commerce and Ministry of Fisheries were directly involved in monitoring, assisting and transferring technology of crab business. Department of Forest was responsible to give the license for harvesting hard shell crabs whereas Department of Fisheries (DoF) was responsible to give permission for installing soft shell crab farm (DoF 2017) and issued the health certificate for export. Results showed that the Export Promotion Bureau was responsible to give permission to open L/C for export. About 70% of the respondents reported that the factors like bad communication between collection points and the depots, insufficient market information, weak registration process of the government, inadequate marketing facilities, lack of credit, influence of middleman, grading fraudulence, inadequate space, high mortality rate due to mishandling and poor transport system, inconsistency and the low survival rates of the larvae accelerate the growth of the crab industry (Joarder, 2014).

4.7 Challenges and Recommendations

- ❖ The present study demonstrated that both the crab collection and farming were profitable business. However, there are some concerns prevail in this sector.
- ❖ Crab production and marketing has been operating in ancient method which is the main impediment in the development of this sector. To have well developed crab sector it is better to set up a national plan and implement that plan in each and every sector in Bangladesh.
- ❖ Since the farmers are following the ancient method of production system so the rate of production has not been satisfactory at all. So, there should have some training facilities for the farmers from government to introduce them with modern production system.
- ❖ Natural calamity like flood, erosion etc. sometimes create threats to the farmers so steps should be taken to save the farmers from those kinds of natural calamity and compensation should be given if necessary.
- ❖ Virus and the related diseases are sometimes regarded as the main cause of loss to the farmers. Little consciousness can erase the possibility of those hazards in many forth. Only training, publicity and awareness creating programs can solve these kinds of problems.
- ❖ The relationships among the crab farmers associations were not cooperative. So, the middlemen somehow got the chance to abuse the ill motive. Therefore, crab farmers relationship can be strengthened by building crab farmer's cooperative society.
- ❖ The harvesting of mud crab completely depends on the natural sources in Bangladesh. Over exploiting is the main concern for the sustainability of this sector.
- ❖ Besides this, there are no standard culture techniques for mud crab. Although the mud crab business had developed since mid-80's, the livelihood of the crab fishermen remained unchanged.
- ❖ The crab collectors and the fatteners suggested that the government should pay some attention to this sector to prevent over exploitation of the species and to prevent environmental degradation affecting their habitat.
- ❖ There is a growing interest among farmers for crab fattening. The main factor behind this interest is the increasing demand for crab in the international market.
- ❖ After the outbreak of shrimp and prawn diseases, many farmers diverted from shrimp farming to crab fattening. According to their responses, they can get higher profit within a shorter time and with lower investment required compared to shrimp.

- ❖ Different Government and non-government sector should play a significant role for providing different training programmes for the farmers and establishing model farms for disseminating modern aquaculture techniques.
- ❖ Various non-government organizations in the southwest of Bangladesh (e.g. Caritas, Shushilan) should encourage the crab fatteners and working with the fishers on sustainable farming practices and for adopting new technology through different development programs.
- ❖ Quality seeds are required to expand crab farming among the crab cultivators in these area.
- ❖ By creating a learning environment with comprehensive training facilities among all level of crab farmers are essential.
- ❖ Technological support system should be developed for crab production and marketing.
- ❖ Entrepreneurial support should be enhanced to make this sector more lucrative for both local and global markets.

Chapter 5

Conclusion



Conclusion

A considerable scope apparently exists in the study area for the expansion of mud crab business in the country. The study reveals that the mud crab business is highly profitable. One way to bring more profit is by reducing operating costs as much as possible. This can be achieved through scientific, biological and technological mechanisms, such as reducing mortality loss, transportation cost, labor cost and other operational costs. The government and NGOs should come forward to launch a proactive campaign that would create a local market for mud crab. An export market cannot sustain on its own for longer term unless supported by a strong local market. Mass awareness campaign is necessary to educate people that the custom of eating crab has no religious or scientific basis.

Chapter 6

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Chapter 7

Annex

Appendix

A Questionnaire

on

Present scenario of Mud Crab aquaculture in Khulna and Bagerhat districts

Questionnaire no:

Date:

About the Respondent

Name of the Respondent:

Age: a) 21 – 30 b) 31 – 40 c) 41- 50 d) above 50

Sex: a) Male b) Female

Religion: a) Muslim b) Hinduism c) Others

Source of income: a) Farmer b) Service Holder c) Labor d) Others

Address:

Vill: Thana. District.....

Number of Family members:

Monthly family expenditure: a) below 5000 b) 5000 – 10000 c) 10000 – 15000 d) above 15000

Number of family member related with crab culture:

About culture system

Culture system: 1) mono 2) poly

Culture type 1) pond 2) cage 3) others

Location: 1) Bagerhat 2) Khulna

Area/size (in decimal) : 1) <30 2) 30-70 3) 70-100 4) >100

Season: 1) summer 2) winter 3) rainy 4) all the year round

Stock.den: 1) 5-7 2) 7-12 3) 12-15 4) 15-20 5) above 20

Source of fry: 1) collector 2) Hatchery 3) Depo

No of production cycle per year: 1) one-time 2) two times

Source of finance: 1) self 2) loan:

Source of Loan: 1) Bank 2) NGOs 3) others

Feeding management:

Food & feed type	Price/kg	Feeding time	Feeding rate	Feeding frequency	Quantity

Disease management

Name of disease:

Symptoms:

Cause of disease:

Prevention:

Growth performance:

Harvesting:

Size during harvest: Male..... Female.....

Harvesting time: 1) Early morning 2) Afternoon 3) Anytime

Harvesting methods: 1) Scoop net 2) Thopa 3) Baitsticks 4) Bare hands 5) Aton

Marketing System

1) Local foria 2) Depo 3) others

Transport system

1) Box 2) baskets 3) Container:

Vehicles: 1) Pickup van 2) Microbus 3) Container bus 4) Others

Destruction rate during transportation: 1) 0%-5% 2) 5%-10% 3) Above 10%

Cost-benefit analysis

Total variable cost:

Total fixed cost:

Others costs:

Gross return:

Net return:

Challenges in production of crabs:

A Questionnaire

on

Present scenario of Mud Crab collector in Khulna and Bagerhat districts

Questionnaire no:

Date:

About the Respondent

Name of the Respondent:

Age: a) 21 – 30 b) 31 – 40 c) 41- 50 d) above 50

Sex: a) Male b) Female

Religion: a) Muslim b) Hinduism c) Others

Source of income: a) Farmer b) Service Holder c) Labor d) Others

Address:

Vill: Thana. District.....

Number of Family members:

Monthly family expenditure: a) below 5000 b) 5000 – 10000 c) 10000 – 15000 d) above 15000

Number of family member related with crab culture

The location where crab collected

1. Inside sundarban () 2. Outside of sundarban () 3. Small river ()

Collecting gear

1. Don () 2. Thopa () 3. Aton ()

Collecting vessel

1. Boat () 2. Troular ()

No. of month in year crab collected

Collecting crab inside sundarban no. of days stayed.....

Collecting crab inside sundarban which collecting gear and vessel used.....
.....

