







Literature Review

Obayed (1998) and Saha et al. (2000): focused on mud crab culture covering its breeding, marketing, grading, standardizing and exporting.

Khan and Alam (1992): addressed the distribution, culture, stock development, taxonomy, value chain, biochemical and industrial analysis on mud crab.

Mahmud and Mamun (2013): stated that mud crab creates employment opportunities for people of diversified group.

Azam et al. (1998): Mud crab supports livelihood of millions of poor crab catchers, fatteners, fishers, traders and transporters.

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Literature Review

Acharya and Kamal (1994): Mud crab oriented economic activities are currently fully dependent on wild catch mainly from the swamps of mangrove along the coastal zone of Bangladesh.

Ali et al. (2004): Bangladesh started exporting mud crabs in FY 1977-1978.

EPB (2002, 2007, 2015):

Earnings form mud crab **export** of Bangladesh:

FY 2005-2006:	less than 300 million US\$
FY 2012-2013:	1.27 billion US\$
FY 2013-2014:	1.78 billion US\$

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Literature Review

Prevailing literatures demonstrate that mud crab contributes in:

- income generation
- employment creation
- livelihood support

for the actors engaged in mud crab value chain.

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Objectives

This study will focus on **preservation** of wild mud crab oriented coastal ecosystem for livelihood support of the people engaged in the crab value chain.

Main objectives:

- To analyze the mud crab **value chain**
- To analyze the **socio-economic condition** of actors across the mud crab value chain
- To assess the **economic value** of mud crab oriented coastal mangrove ecosystem service

Mud Crab Oriented Business Activities at a Glance

Mud crab oriented economic activities are **versatile in nature**.

1. Crab **catchers collect** mud crab from mangrove and then **directly sell to the depot owner** or **through middlemen to depot owners**.
2. Collection of **immature / under-weight** mud crab by the fatteners from crab catcher and depot owner Fattening (only making the **shell hard!**)..... ultimately selling it to the depot owners.
3. **Depot owners** also sometimes work as crab fattener through nursing the juvenile crab in their **own pond**.
4. Nursing **immature / under-weight** crab – **a new window!**

Parties Involved in Mud Crab Centric Economic Activities

(First objective)

Stakeholders: Juvenile mud crab catchers, harvesters, middlemen (*araders*), nursery owners, fatteners, depot owners, exporter and the final local and foreign consumers.

Figure 1: Actors in Mud Crab Value Chain

Source: Authors' compilation based on literature review and KII

N.B.: Arrows refer to flow of mud crab; Thickness of a line refers to flow volume; Dotted lines refer to less flow; HF refers to hardening and fattening of mud crab; HF close to a stage refers to self-managed hardening and fattening center.

Dimensions of Value Chain Assessment

Comprehensive investigation on multiple dimensions of mud crab value chain.

Concepts of product, input and money flow, value addition, forward and backward linkages, involved stakeholders and related other issues will be considered.

Figure 2: Dimensions of Mud Crab Value Chain Analysis

Source: Authors' compilation based on literature review and KII

Determinants of Market Preference Outlet

What are the **determinants of market outlet choice** of the wild mud crab catchers?

Multinomial logit (MNL) model of equation 1.

$$P(\text{CHOICE}_{ij} = j) = \frac{\exp(\beta_j X_{ij})}{\sum_{j=0}^2 \exp(\beta_j X_{ij})} \dots \dots \dots (1)$$

i portrays *i*th crab catcher
j is market outlets available to the mud crabbers
j=0 for sale to depot owners
j=1 for sale to the middlemen
j=2 refers to sale for domestic consumption
P is the probability of crab marketing outlet *j* to be chosen by *i*th crab catcher
X_i is vector of explanatory variables

Here only three options are considered which might be changed based on the findings of FGDs which will be accomplished in the study area before administering the final survey.

Determinants of Market Preference Outlet

Table 1: Variables for MNL Model of Crab Catchers Marketing Outlet Preference

Explanatory Variables	Explanation / Measurement Unit
Crab catcher's age	Years
Gender	Dummy variable (1=Male, 0=Otherwise)
Education	Years of schooling
Religion	3 dummies for 4 options
Experience	No. of years engaged in crab sector
Income from crab	BDT/Month
Household (HH) size	Number of family members
HH land holding	in <i>Bigha</i>
HH crab catcher	No. of family members engaged in crab catching
Entry fee	BDT/week
Distance	Travelled distance inside the mangrove forest for crab collection (in km.)
Distance	Distance from residence to the nearest forward/backward segment (in km.)
Contractual bondage	1=Yes if bound to sell the product to the fixed buyer, 0=Otherwise
Market information	1=Access to information about current market price, 0= Otherwise
Credit from buyer	1=Yes, 0=Otherwise
NGO support	1=Have support from NGO, 0=Otherwise
Training	1=Having training on mud crab business, 0=Otherwise
Equipment dummy	Separate dummy for each of the major equipments used
Boat size	2 dummies for three types: large, medium and small
Team member	No. of members involved in mud catchers' group
Visit	Frequency of visit inside the mangrove for crab collection per month

1 refers to the nearest crab market, crab middlemen, crab village, crab nursery and crab depot from the catcher.

Determinants of Market Preference Outlet

The same model (equation 1) will be **re-run** through replacing mud crab catchers with **crab fatteners, crab nursing houses and middlemen separately**. The required **adjustments** will be made through discarding irrelevant variables and incorporation additional variables.

The variables of Table 1 are **appropriate for wild crab catchers only!**

The variable list will be **modified** while considering middlemen, fattener and nursery.

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Socio-economic Status of the Mud Crab Value Chain Actors

(Second objective)

Socio-economic status of the **Mud Crab Catchers**

Variables of Table 1
+
information on:
asset ownership, housing condition, sanitation and drinking water facilities, crab catch amount and related other variables.

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Socio-economic Status of the Mud Crab Value Chain Actors

Five important segments in mud crab value chain:

- (i) wild crab catchers
- (ii) middlemen
- (iii) fatteners
- (iv) nursery operators
- (v) depot owners

Similar exercise for middlemen, crab fatteners, crab nursing houses and depot owners separately.

Required adjustments will be made through discarding irrelevant variables, incorporation additional explanatory variables and modifying existing variables, as appropriate, in assessing the socio-economic status of the agents in the mud crab value chain.

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Socio-economic Status of the Mud Crab Value Chain Actors

Livelihood pattern of the actors of the said five segments will be assessed through applicable socio-economic variables i.e. age, gender, religion, income, educational status, housing status, sanitation facilities, access to drinking water, easy access to credit etc.

Indicators, such as gross margin analysis (Ferdoushi and Guo, 2010), revenue-cost ratio (Ferdoushi and Guo, 2010), sales value, profit sales ratio and so on will be calculated through using field level primary data.

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Socio-economic Status of the Mud Crab Value Chain Actors

Factors influencing the socio-economic status and livelihood of the actors in the mud crab value chain (equation 2).

$$Y_i = f(S_i; F_i) \dots \dots \dots (2)$$

Indicators, such as monthly income, monthly proceeds from mud crab sector, gross margin and revenue-cost ratio will be considered as separate dependent variables (Y_i) which will be regressed with respect to corresponding and appropriate explanatory variables.

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Socio-economic Status of the Mud Crab Value Chain Actors

In addition to socio-economic and demographic variables (S_i), this study will consider some mud crab related variables (F_i), such as agreement with forward and backward linkage actors, distance of marketing channel, cost, coverage of time duration in the considered segment, availability of inputs and access to output market as explanatory variables in the regression analysis.

Note that, the list of dependent and explanatory variables and corresponding units of measurement for this analysis will be finalized after administering the FGDs and pilot surveys in the study area.

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Economic Valuation of Mud Crab as a Provisioning Service of Coastal Ecosystem

(Third objective)

To assess the economic value of mud crab as a provisioning service by the coastal mangrove ecosystem.

Net Present Value (NPV) calculation:

$$NPV = \sum_{t=0}^n \frac{B_t}{[1+i]^t} - \sum_{t=0}^n \frac{C_t}{[1+i]^t} \dots \dots \dots (3)$$

B and C are the annual economic benefits and costs, over n years, at i rate of discount (Boardman et al., 2001).

Multiple discount rates will be used for economic valuation to avoid criticism.

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Economic Valuation of Mud Crab as a Provisioning Service of Coastal Ecosystem

The summation of the NPVs for the said five groups (wild crab collectors, middlemen, crab fatteners, nursery operators and depot owners) will represent the value of mud crab provisioning service provided by the coastal mangrove ecosystem.

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TE Assessment of Mud Crab Culture

To evaluate technical efficiency (TE) and to estimate production function for two segments:

(a) crab fattening and
(b) crab nursing

Considering each crab fattening house as a production center, we will use the Cobb-Douglas Stochastic Frontier Model (CDSFM) as depicted in equation 4.

$$\ln y_t = \beta_0 + \sum_{j=1}^k \beta_j \ln x_{jt} + v_t - u_t \dots \dots \dots (4)$$

The same exercise will be conducted for crab nursing house. In this case, variables will be rearranged, reorganized and discarded, as required.

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TE Assessment of Mud Crab Culture

The logic behind TE assessment:

To investigate whether the **availability** of crablet or juvenile crab affect the farm level technical efficiency or not.

List of explanatory variables for TE assessment of crab fattening farm is depicted in **Table 2**.

The list of dependent and explanatory variables and corresponding units of measurement for TE analysis **will be finalized** after administering the FGDs and pilot surveys in the study area.

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TE Assessment of Mud Crab Culture

Table 2: Variables of TE Estimation for Crab Fatteners

TE assessment of mud crab fattener (Dependent variable: Quantity of mud crab in kg)	
Input variables	Unit of measurement
Labor	Hour/day
Capital	BDT
Food of mud crab	BDT/month
Farm specific features	
Farm age	Year
Experience	Year
Family size	Number of family members
Pond size	<i>bigha</i>
Gender of HHH	Dummy variable (1=Male, 0=Otherwise)
Education	Years of schooling
Religion	3 dummies for 4 options
Training	Dummy variable (1=Yes, 0=Otherwise)
Contract	1=Yes if bound to sell the product to the fixed buyer, 0=Otherwise
Crab availability	Likert scale (1-5)
Season	Dummy
Village	2 dummies for three locations

Source: Authors' compilation based on literature review and KII

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Economic Valuation for Conservation of Mud Crab Species

Direct valuation of provisionary service through NPV

+

Contingent valuation (CVM) for conservation of the said ecosystem service

Quantify the **willingness to pay (WTP)**

Since mud crab has potentials in creating more job opportunities and boasting export earnings, a **further extension** of the ongoing wild mud crab collection **might exasperate the situation** and **ultimately might threaten the environment and ecosystem**.

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Economic Valuation for Conservation of Mud Crab Species

CVM - might help to know about **how much financial liability** may be imposed on the crab collection based livelihood dependent people.

To find out the **perception of the people** towards conserving the natural stock of mud crab, who are directly or indirectly linked with mud crab value chain.

Individual is ready to **pay some amount (how much?)** of his income to enjoy the support of the ecosystem, as proposed by quantity **A**.

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Economic Valuation for Conservation of Mud Crab Species

The respondents **will be asked to assign** a certain amount of money that they are willing to pay for the entrance in the mangrove under a **hypothetical situation** where entry is assumed as **completely restricted** for all.

In this hypothetical situation of **complete ban**, to have entrance in the mangrove **for his/her livelihood support**, **how much he/she is willing to pay** for the ecosystem service is the main query to know.

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Economic Valuation for Conservation of Mud Crab Species

Equation for CVM:

Probit model: $Z_i = \beta_i X_i + u_i$ $\begin{cases} Z_i = 1 \text{ if } X_i \geq 0 \\ Z_i = 0 \text{ if } X_i \leq 0 \end{cases}$ (5)

Linear regression model: $y_i = \beta_i X_i + \sigma \lambda_i + v_i$ (6)

List of explanatory variables for CVM analysis is depicted in the **Table 3**.

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Economic Valuation for Conservation of Mud Crab Species

Table 3: List of Variables for CVM

Variables	Explanation / Measurement Unit
Age of the actor	Years
Gender	Dummy variable (1=Male, 0=Otherwise)
Education	Years of schooling
Household size	Number of family members
Religion	3 dummies for 4 options
Experience	No. of years engaged in specific occupation
Income	BDT/Month
Knowledge	Knowledge index formed through asking related questions
Threat perception	Threat index formed through asking related questions
Benefit	Perception of benefit received from mangrove using likert scale (1-5)
Occupation	4 dummies for five types: crab collector, middlemen, crab nursery operator, crab fattener and depot owner
Crab dependency ratio	No. of HH member engaged in crab business / Total number of family members
Village	2 dummies for three villages
Main occupation	Dummy variable (1=Yes, 0=Otherwise)
Self consumption	Dummy variable (1=Yes, 0=Otherwise)
Profession nature	Dummy variable (1=Hereditary profession, 0=Otherwise)

Source: Authors' compilation based on literature review and KII

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Future Threat Assessment

CVM exercise - will help to formulate **policy recommendations** for preservation and sustainable use of wild mud crab oriented coastal ecosystem service for livelihood support of the people engaged in the mud crab value chain.

Wild mud crab **collection at mass level** is a threat to ecosystem. Review of literatures, discussion with KII and government's restrictive access policy for the mangrove signals the concern of the stakeholders regarding this threat. In the long run, it might affect the food chain of mangrove. Hence, **search for next best alternative** (for example, **hatchery technique**) is probably inevitable.

According to Williams and Primavera (2001), without development of **hatchery technique**, the expansion of mud crab culture will lead to over exploitation of the natural stock.

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Future Threat Assessment

This study will try to **understand this threat** level through asking appropriate questions regarding the **perception** of the crab catchers in a likert scale.

This study will also try to understand the threat level **indirectly** through asking **proxy questions**. For example, **change in travelled distance inside the mangrove for wild crab catch and availability of wild crab over the time period** might be considered as proxy to threat. A longer distance whistles more threat for available stock of mud crab. **Crab collection and distance ratio, crab collection and required time ratio** can also be used as proxies for understanding the threat level. The information of crab availability over the time period will be collected and the change in availability will be used as proxy to understand the threat level.

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Concluding Remarks

Finally, this study will try to link among the issues of mud crab value chain, livelihood of value chain actors, valuation of crab supply oriented ecosystem service and preservation of the ecosystem.

We believe that any policy recommendation focusing on mud crab oriented livelihood support and ecosystem preservation simultaneously, will add value to the existing literature.

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Study Area, Sampling and Data Collection

Six FGDs

- will help to finalize the list of variables and concerned unit of measurement as described in Table 1-3.

Focus on the south-west region of Bangladesh covering Sharkhira, Khulna and Bagerhat districts.

Three upazials (sub-districts) will be selected purposively from the three districts as the study sites considering easy access, availability of mud crab value chain stakeholders, time and other constraints.

A brief discloser of sampling framework is depicted in Table 4.

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Study Area, Sampling and Data Collection

Table 4: Sampling Framework

Group	Area			Total
	Shatkhira	Khulna	Bagerhat	
Wild mud crab collector	30	30	30	90
Middlemen	30	30	30	90
Juvenile mud crab nursing	30	30	30	90
Mud crab fattener	30	30	30	90
Depot owner	30	30	30	90
Total	150	150	150	450

Source: Authors' compilation

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Study Area, Sampling and Data Collection

Separate questionnaire: for each of the five groups under consideration: wild mud crab catchers, middlemen, nursery operators, fatteners and depot owners.

Pilot survey
 Necessary modifications
 Final survey
 Data entry
 Compilation, cleaning and sorting
 Econometric test i.e. multicollinearity, heteroscedasticity, omitted variable bias etc.
 Appropriate analytical tools: for addressing the stated study objectives.

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Key Personnel Related with the Research

Name and Address	Designation	Number	Role
Mohammed Zaul Haider, Ph.D Professor Economics Discipline Khulna University Khulna, Bangladesh Phone No.: +08801730004131 Email: haidermz@yahoo.com	Lead Researcher	01	Finalize the draft questionnaire
			Supervise FGDs
			Train the enumerators
			Supervise pilot survey
			Monitor and supervise final survey
			Monitor and supervise data entry and cleaning
			Data analysis
			Report writing
			Monitor and supervise the research team
			Liaison with project sponsoring organization
Fariha Farjana Lecturer Economics Discipline Khulna University Khulna, Bangladesh Phone No.: +08801955806201 Email: fariha_farjana@yahoo.com	Co-researcher	01	Financial management of the project fund
			Liaison with stakeholders
			Review the draft questionnaire
			Supervise FGDs
			Train the enumerators
			Supervise pilot survey
			Monitor and supervise final survey
			Monitor and supervise data entry and cleaning
			Data analysis
			Report writing
Monitor and coordinate the research team			
Compilation and Documentation			
Liaison with stakeholders			

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Key Personnel Related with the Research

Name and Address	Designation	Number	Role
*	Consultant - Fishery Expert	01	Review the draft questionnaire
			Supervise FGDs
			Train the enumerators
			Supervise pilot survey
			Monitor and supervise final survey
			Data analysis
			Report writing
			Liaison with stakeholders
			Draft questionnaire preparation
			Accomplish FGDs
*	Research Assistant	02	Assist the training of enumerators
			Assist pilot survey
			Monitor and supervise final survey
			Monitor and supervise data entry and cleaning
			Assist in data analysis
			Assist in report writing
			Liaison with stakeholders
			Pilot survey
			Data collection
			Cross checking
*	Enumerator	15	Data entry
			Data cleaning

*N.B.: * refers to 'will be recruited later'.*

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