

*Research Article***Experiences and opinions of mollusk fishers in the Cox's Bazar coast, Bangladesh**

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ABSTRACT

The coastal and maritime ecosystem of Bangladesh provides an array of diverse range of mollusks which support millions of fishery dependent livelihoods. Human dependency on maritime resource is increasing day by day. There are lots of livelihood options for coastal communities whereas they have given topmost priority in fishing as their principal economic activity. Fishermen community is an integral part of the coastal areas of Bangladesh which is mostly dominated by small-scale fishermen. This study was conducted along the two coastal regions of Cox's Bazar-Caufaldandi besides Moheshkhali Channel and Shahpori Island besides the Naaf River Estuary. The main objective was to indentify the challenges faced by the fishers involved in mollusk fishery. Several survey methods were adopted including questionnaire, interview and field visit. This research revealed that different environmental and socio-economic factors have had significant impact on the coastal livelihood. These impacts scored ranging from moderate (3) to very high (5) in the scale of 0-5. Mollusk fishery in Cox's Bazar region has been dominated by Rakhain community with a great influence on their livelihood. However, the tribal community of Bangladesh is still lag behind due to lack of proper facilities and opportunities. In this situation, different ecological as well as socio-economic challenges make the tribal fishers more vulnerable. Therefore, it is time to take proper initiative for the livelihood management plan and coping strategies. This kind of approach will be useful to mitigate the identified ecological and socio-economic challenges of small-scale fishermen in the Cox's Bazar region.

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1. INTRODUCTION

The small-scale fisheries supply more than half of the global marine catch (FAO, 2010) while in Bangladesh, more than ninety percent contribution comes from this sector (FAO, 2014). The marine fisheries sector of Bangladesh contributes significantly to the national food security and delineates new horizon for venturing

blue economy. The fisheries activities contribute at least 4.4% in National GDP, approximately 22% to the agricultural GDP, and less than 3% GDP comes from foreign export of fishery products (DoF, 2015; DoF, 2017). More than 11% of the total population relies on this sector for their livelihood. Despite the abundance of marine waters, only 15.41% of the country's total

fish production is contributed from the maritime sector (DoF, 2017).

The coastal resources are enriched with a wide diversity of flora, fauna along with mollusks species, but most of our marine fishery resources are still unexploited (Ahmed, 1990). The mariculture and coastal aquaculture of Bangladesh are still confined in fish and shrimp culture. Therefore, other sectors such as mollusk and crab are given less importance even though they have great culture potential and economic importance. In the coastal area of Bangladesh, suitable mollusks habitats exist as sandy and rocky ground, mangrove and coral reefs; and thus are suitable for the development of shellfish culture (Shahuddin *et al.*, 2010). There were three species of mollusks those are naturally found in our coastal water, namely green mussel (*Perna viridis*), clam (*Meretrix meretrix*) and oyster (*Crassostrea madrasensis*). These species are commercially very important in all over the world. The coastal belt of Cox's Bazar (Moheskhal and Teknaf) considered as principle coastal area which have great potential of mollusk culture. Especially, green mussel and oyster has huge abundance in Moheskhal channel and Naaf estuary (Shahuddin *et al.*, 2010). Rakhain community of Cauldandi area beside the Moheskhal channel and some fishermen in Shahpori Island adjacent to the Naaf estuary collect the green mussel and oyster for their daily consumption and economic benefit. The shells are also sold to the poultry farm which is used to prepare poultry feed (Salam *et al.*, 2006).

In recent years, the livelihoods of these green mussel and oyster collectors have been disrupted by various ecological and socio-economic challenges which have been identified through this study. Information on the livelihood of green mussel and oyster collectors were provided by Shahuddin *et al.*, 2010 which is confined mainly into their common livelihood strategy. The precise and detailed information on socio-economic and ecological hindrance of green mussel and oyster collector is scanty recently. Therefore, the present study was undertaken to make a fundamental survey on these challenges and their impact on the livelihood of green mussel and oyster collector of Cauldandi and Teknaf region of Cox's Bazar. The objective of the study was to find out the best possible strategy for sustainable livelihood management. This paper also addresses the gap in the existing management strategy by providing primary data on the experiences and opinions of mollusk fishermen regarding aquaculture development in the coastal belt of Cox's Bazar and hence provide information relevant to mollusk fishery

development, planning and sustainable use of coastal resources. The main purpose of this study was to explore the range of experiences and opinions on different perception, not to count the opinions or numbers following the Gaskell, 2000.

2. MATERIALS AND METHODS

The empirical part of this research work was obtained by qualitative data (fieldwork) and in certain cases by quantitative data. The total duration of the fieldwork was 6 months where qualitative methods were employed including observation and interviews.

Methods for data collections

Questionnaire preparation

A semi-structured questionnaire was prepared for the questionnaire survey. The prepared questionnaire was divided into five sections; as general information, ecological and environmental features, oyster and mussel fishing information, biodiversity loss and ecological challenges in green mussel and oyster fishing and socio-economic condition. Most of the questions related to ecological and socio-economic conditions were scored based on scale where 0 was the lowest score (no impact) and 5 denoted the highest score (very high impact).

Participant and direct observations

Observations had been performed by accompanying the fishers in their fishing areas, particularly to observe green mussel and oyster collection activities. This observation also accompanied the communities to investigate the catch in local markets as well as in landing sites to investigate price negotiation and for the setting of marketing channels. All these activities were performed to gain insight into their daily activities and income to ensure the validity of the collected data.

Sampling representativeness

This study aims at identifying and understanding the issues at stake in the Small-scale Fishermen and their livelihood rather than collecting quantitative study of social phenomena. A major part of empirical data was collected from interviews. Majority of interviewees were from Rakhain communities and few numbers of interviewees were from other fishers' communities engaged in oyster and green mussel collection. Interview questions were modified during the study that considered the respondents' understanding of the questions. Preference was given to interviewing in the workplaces during periods with less workload or inside

the living areas where interview was conducted according to the convenience of the fishers and their availabilities. Special caution was taken when interviewing fisherwomen, considering the prevailing norms of the society.

Method of data analysis

The information collected from the participants was kept as a note immediately. In most of the cases, recorded and hand-written data were transcribed just after returning back from the sampling site. After the transcriptions, contents were analyzed and themes were identified and classified into variables (Spencer *et al.*, 2003) such as the causes of poverty, coping strategies for further explanation by relevant theories. The factors described under the natural, ecological and socio-economic crisis experienced by the mollusk collectors for last 12 months were analyzed through one way ANOVA test using IBM SPSS Statistics 22 Version.

Limitations

Conducting the interview in rural areas of Bangladesh has several issues and limitation (Islam, 2003, 2004). Getting information from a single person might be difficult as other people interfere in the conversation which results in a group discussion. Some fishers might hope to get help and over explain the real situation of their problems. So, crosschecking of the information was done to avoid these situations.

Study area

The selected study areas of this research were near the Naaf River Estuary and Moheshkhali Channel of Cox's Bazar, Bangladesh (Figure 1). Because, a large number of tribal people live in Caulfaldandi and Shahpuri Island region. Different research areas were set to investigate the views and opinions of small-scale coastal fisheries, which varied considerably depending on circumstances and places.

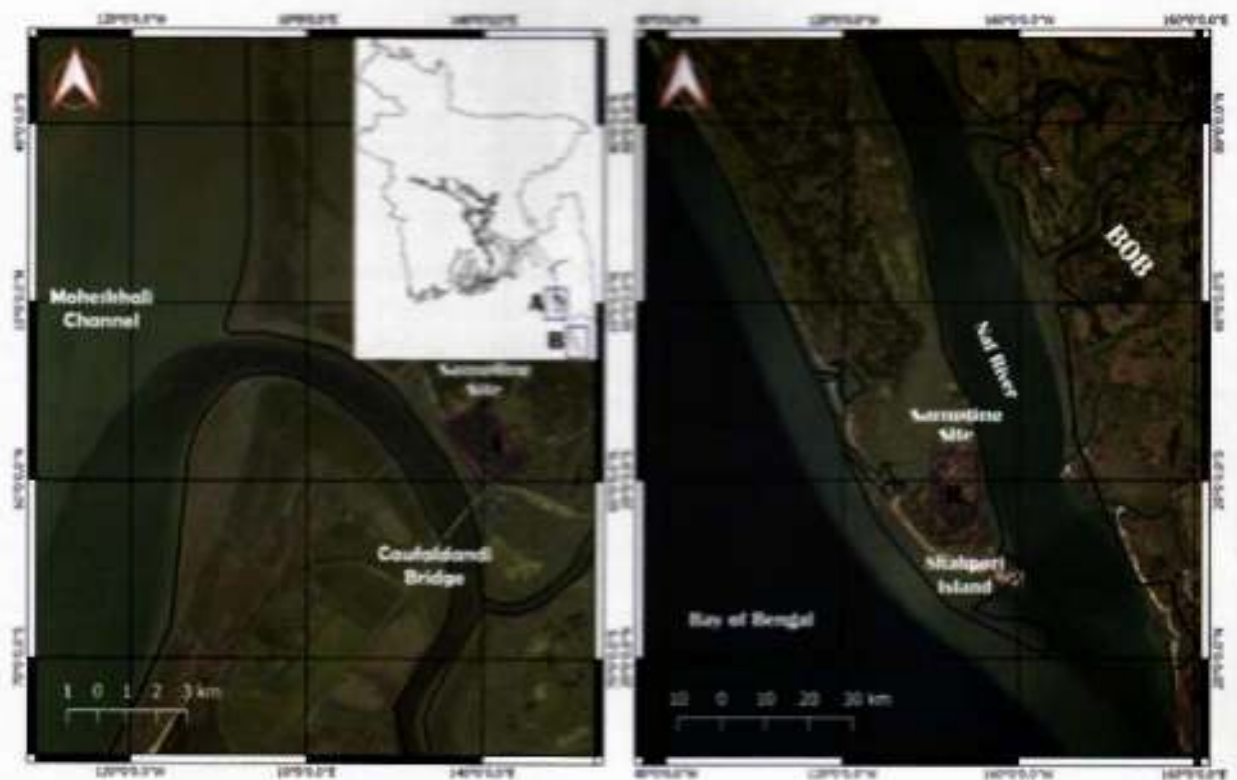


Figure 1. Survey location of survey in the Cox's Bazar region

3. RESULTS

Socio-economic characteristics of small-scale fishermen

The bio-geological system of Moheshkhali Channel and Naaf River estuary comprise a prominent ecosystem in Mollusk fishery sector. The questionnaire survey generated

100 responses. According to the interviewee, there were about 1800-2000 people in Caulfaldandi and 700-800 in Shahpuri Island involved in fishing activities. About 60-70 Rakhain fishermen from Caulfaldandi and 20-30 Rakhain fishermen from Shahpuri Island were reported to have direct involvement in Mollusk fishery. Despite

having access to the significant water resources of the channel and estuary, fishers have not improved their status owing to declining catches and the fragile state of the ecosystem. The economic condition of the entire participants of fishing communities from the research

locations were found with poor living standard. The involvement (40%) of middleaged (30-40 years) generation was significant in this sector (Fig. 2a). The household size of mollusk collectors in both areas was ranging from 5-8 persons (Fig. 2b-2c).

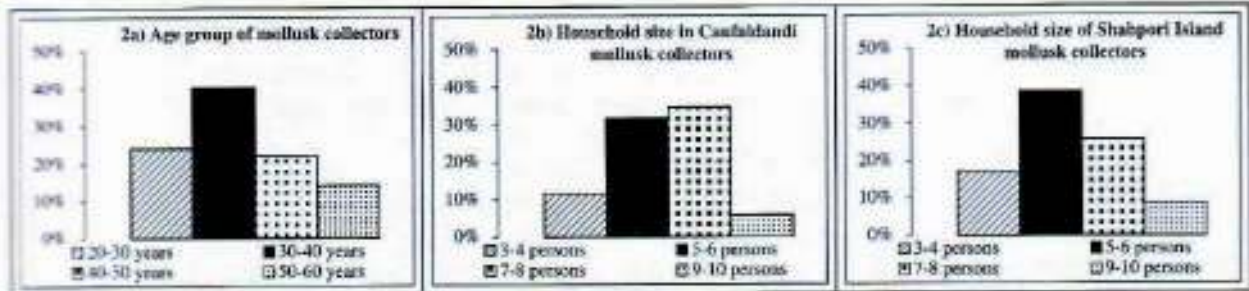


Figure 2. Demographic features of the mollusk fishers

Present study showed that 68.57% fishermen in Caufaldandi and 71.4% fishermen in Shahpori Island region were illiterate. More than fifty percent participants of Caufaldandi and 31% participants of Shahpori Island stated that proper health facilities have been provided. According to questionnaire survey, it has been showed that the lack of drinking water facility and inadequate health facilities have been considered as health risk. In case of health facility, both areas are still far behind. The scarcity of safe drinking water is a serious concerning issue in the coastal belt of Bangladesh. Tube well and pond waters are the major source of drinking water in both study regions which is

not safe for drinking due to saltwater incursion. Conflicts have been identified as a common phenomenon in the fisheries community because there is a various intensity of interaction among different uses and activities. Results of questionnaire survey showed that 69% fishermen of Caufaldandi and 76.2% fishermen of Shahpori Island assumed that strong conflict has been present among the fishermen community (Table 1). These conflicts include the distribution of fishing areas, profit gained from fishing, a coexistence of fisheries with aquaculture, middlemen conflicts, and local-tribal conflicts.

Table 1. Socio-economic features of the coastal belt of Bangladesh

Socio-economic features	Caufaldandi (%)	Shahpori Island (%)
Illiteracy	68.5	71.4
Conflicts among the fishermen	69	76.2
Health facilities provided	55.2	31

According to questionnaire survey, it has been showed that besides fishing, fishermen also engaged in some alternative occupations for their extra economic. Dominated alternative occupations have been chosen by the small-scale fishermen in the Cox's Bazar region are day labor (100%), wild-fry collection (81.86%),

fuel wood collection (80.13%), work in a salt field (70%) and agricultural field work (39.98%). Moreover, there are some other activities which are not dominant but adopted intermittently; such as boatman for transport, local business, boat making and rickshaw pulling (Figure 3).

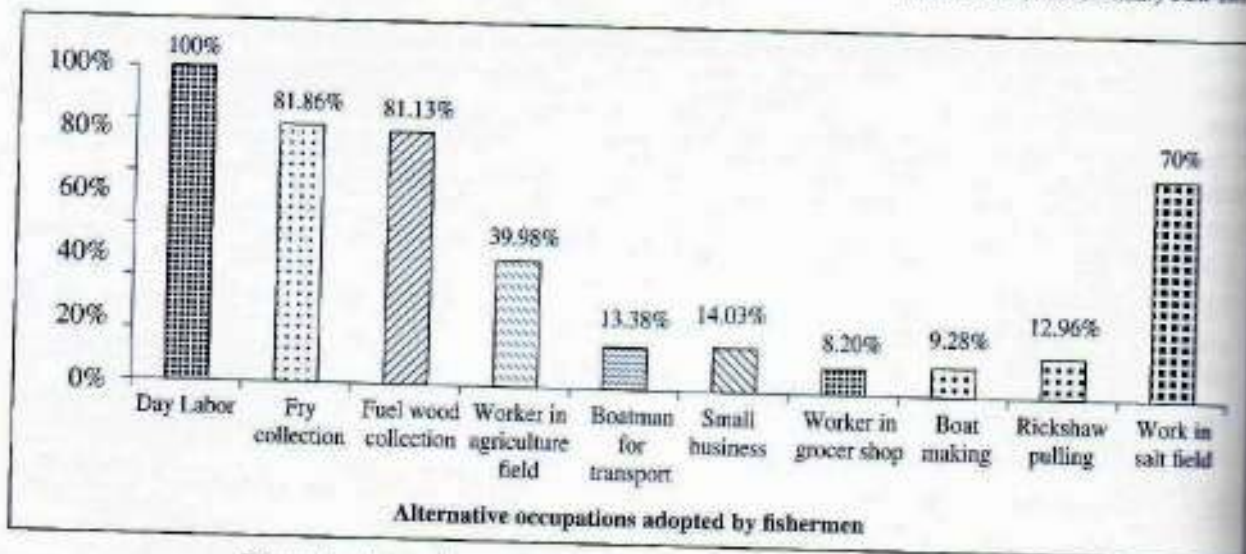


Figure 3. Alternative occupations prioritized by small-scale fishermen

There were various natural and socio-economic crisis faced by the small-scale mussel fishermen in this study which have great influence on their living status and strategy. Fishermen were mainly found vulnerable to different natural calamities (cyclone, flood and salinity intrusion) and socio-economic along with some ecological crisis including less fish catch, diseases,

accident, theft, robbery, social conflicts, dowry and child trafficking. The descriptive statistics associated within two groups of fishermen communities who faced different crisis as natural disasters (flood, drought, cyclone), depleted fish catch and diseases were common phenomenon in both study areas (Table 2).

Table 2. Crisis faced by small-scale fishermen over last 12 months

Socio-economic features	Average score		Degree of occurrence	
	Caufaldandi	Shahpori Island	Caufaldandi	Shahpori Island
Flood, excessive rain	4.52±0.82	4.62±0.50	Very highly occurred	Very highly occurred
Drought	4.45±0.74	4.48±0.51	Very highly occurred	Very highly occurred
Cyclone	4.72±0.80	4.81±0.40	Very highly occurred	Very highly occurred
Less fish catch	4.34±0.77	3.90±0.70	Very highly occurred	Highly occurred
Diseases	4.66±0.55	4.67±0.58	Very highly occurred	Very highly occurred
Theft	3.17±0.93	2.48±0.75	Highly occurred	Moderately occurred
Robbery	3.66±0.90	3.29±0.46	Highly occurred	Highly occurred
Social conflicts	2.38±0.86	2.19±0.60	Moderately occurred	Moderately occurred
Child/Women trafficking	3.52±0.63	3.10±0.54	Highly occurred	Highly occurred
Physical/Mental torture	1.90±0.90	3.05±0.74	Less occurrence	Highly occurred
Boat sunk	2.45±1.09	2.14±0.79	Moderately occurred	Moderately occurred

The crisis faced and coping strategy of fishermen group of Caufaldandi region were found significantly associated with the Shahpori Island fishers' community. The ANOVA test yielded a statistically significant difference in crisis faced ($p < 0.001$) in the study areas. The coping strategy adopted by the small-scale fishermen in both study areas were

correlated with each other. Therefore, that the observation of the research findings was the small-scale mollusk fishermen faced the same natural, ecological and man-made crisis and adopted the similar coping strategy to get rid of this to make their livelihood sustainable (Table 3).

Table 3. Coping strategies adopted by small-scale fishermen to overcome crisis situation

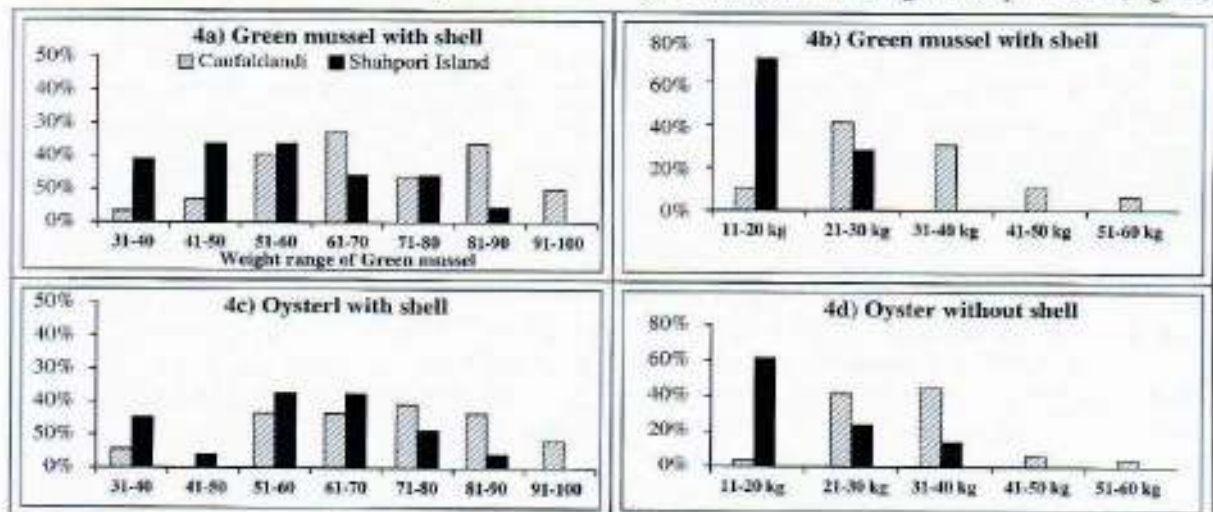
Socio-economic features	Average score		Degree of application	
	Caufaldandi	Shahpori Island	Caufaldandi	Shahpori Island
Loan from neighbor	3.48 ± 0.99	3.52 ± 0.51	Highly practiced	Highly practiced
Loan from money lender	2.21 ± 0.94	2.48 ± 0.98	Moderately practiced	Moderately practiced
Loan from NGOs	1.41 ± 0.57	2.14 ± 0.57	Less practiced	Moderately practiced
Taking less food	4.21 ± 1.05	4.33 ± 0.78	Very highly practiced	Very highly practiced
Food stuff on loan	3.45 ± 1.43	4.14 ± 0.79	Highly practiced	Very highly practiced
Livestock / poultry sold	2.69 ± 0.97	3.43 ± 0.60	Moderately practiced	Highly practiced
Excessive physical labor	4.41 ± 1.15	4.62 ± 0.59	Very highly practiced	Very highly practiced
Child labor	3.21 ± 0.94	2.71 ± 0.90	Highly practiced	Moderately practiced
Migration	1.76 ± 1.09	1.67 ± 0.91	Less practiced	Less practiced
Change of profession	1.59 ± 1.02	1.76 ± 0.83	Less practiced	Less practiced

Present status of mussel and oyster fishermen

Present study depicted that mollusk fishery has been considered as an important occupations by the small-scale fishermen specially in Rakhain fishermen. Mollusk fisheries in study regions were resulted as confined within green mussel, oyster and clam collection. These mollusks were found as principal collection species due to their availability and consumer demand. Most of the mollusk collectors (79.3%) in Caufaldandi were reported to collect green mussel, oyster and clam; and 62% of mollusk collectors in Shahpori Island collected only green mussel and oyster. However, 19% in Shahpori Island area have caught oyster only. Presences of substrate and previous experience have been applied during site selection for mollusk collection. There are some places in Moheskhali channel such as Caufaldandi, Khuruskul, Badarkhali, Sonadia, Matalbari and Ojontia where

green mussel and oyster are available. On the other hand, Naaf estuary near Shahpori Island area considered as natural habitat for oyster and mussel. Mollusk collections have been conducted throughout the year which has been abundantly found in winter and rainy season.

In Caufaldandi, the amount of green mussel caught with shell were mostly ranged from 51-90 kg whereas mussel without shell ranged from 21-40 kg. In Shahpori Island region, mollusk collectors revealed that the amounts of green mussel with shell and without shell have been ranging from 31-60 kg and 11-30 kg respectively (Fig. 4a-b). In case of oyster, the amount of oyster with shell per catch operation ranged from 51 to 90 kg and 51 to 70 kg in Caufaldandi and Shahpori Island correspondingly (Fig. 4c). Instead, mollusk collectors confessed that the amount of oyster without shell per operation reported with 21-40 kg in Caufaldandi and 11-20 kg in Shahpori Island (Fig. 4d).

**Figure 4.** Catch per operation of green mussel and oyster according to study area

When considering the price of green mussel and oyster, it showed that the price have been varied according to their size, availability and demand of buyer. In Caufaldandi, price of green mussel has been ranging from 300-500 Bangladeshi Taka (BDT) while in Shahpori Island, it fluctuated from 100-300 BDT. On the other hand, the price of oyster meat has been varied

from 700-900 BDT while it was resulted from 300-600 BDT in Shahpori Island. At present, the amount of large size green mussel and oysters were found 74%, large size ranged from little to high in number and medium size mussel and oyster ranged from very little to moderate in number (Figure 5a, 5b, 5c).

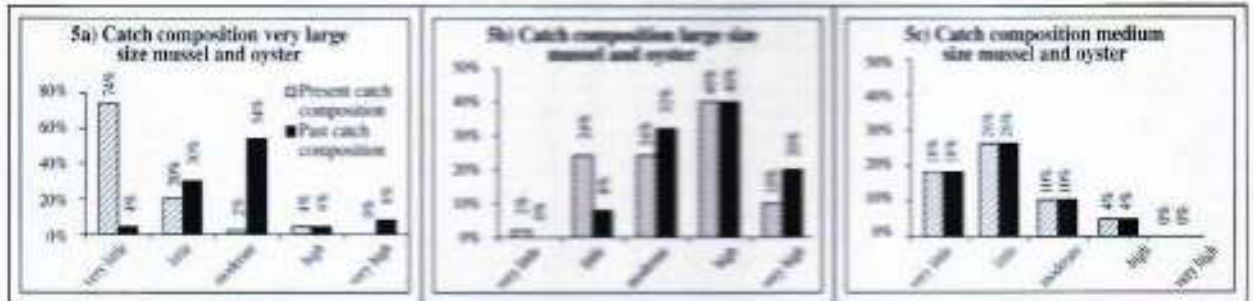


Figure 5. Present and past catch composition of green mussel and oyster

Ecological feature and challenges

According to the fishermen perception, various activities such as urbanization, human encroachment, tourism, bridge construction, and coastal pollution have caused significant ecological concern. There are also some environmental factors responsible for ecological change such as temperature increase, salinity change, change of rainfall pattern and intensity, bottom topography change and water level rise. Temperature, rainfall pattern and intensity and basin depth of Moheskhal Channel and Naaf river estuary have been observed to change moderately (Figure 6, 7), while basin size and salinity of Moheskhal channel and Naaf

river estuary have not changed that much. Approximately 58.6% fishermen of Caufaldandi and 42.9% fishermen of Shahpori Island believed that urbanization has very little impact on the Moheskhal channel (Figure 6) and Naaf River Estuary (Figure 7) ecosystem respectively. There is a bridge constructed on the Moheskhal Channel in the Caufaldandi area which has provided useful communication service to the local people whereas 56% fishermen stated that it has little impact on the Moheskhal Channel ecosystem (Figure 6). Most of the fishermen believed that overfishing and destructive fishing (>90%) have had a very high impact on the fish abundance and distribution.

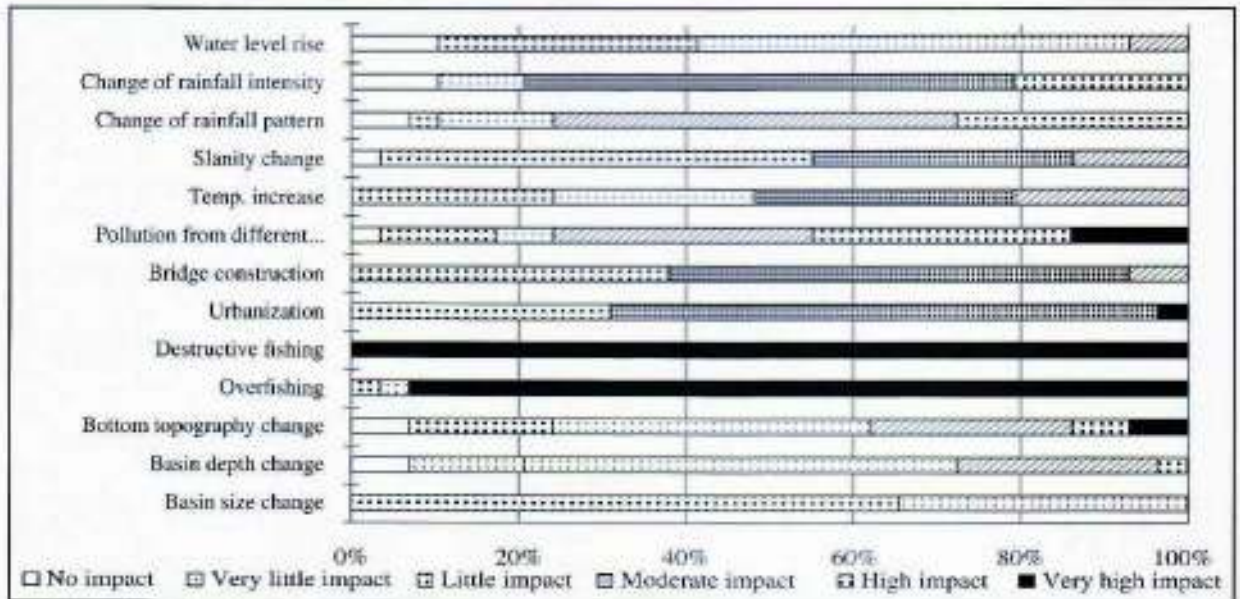


Figure 6. Ecological challenges associated with Moheskhal channel ecosystem according to fishermen perspective

A further ecological problem identified by the fishers is pollution which had a high impact (>85%) on the water quality and habitat of both Mohekhali channel and Naaf river estuary. Pollution from different sources such as oil pollution, dumping from a boat, municipal sewage, street drainage and household waste has highly

occurred in the ecosystem. Besides these factors, fishermen revealed that change of basin size, depth and topography, salinity change, change of rainfall pattern and intensity have little to moderate impact on the ecological system of both study areas (Figure 6, 7).

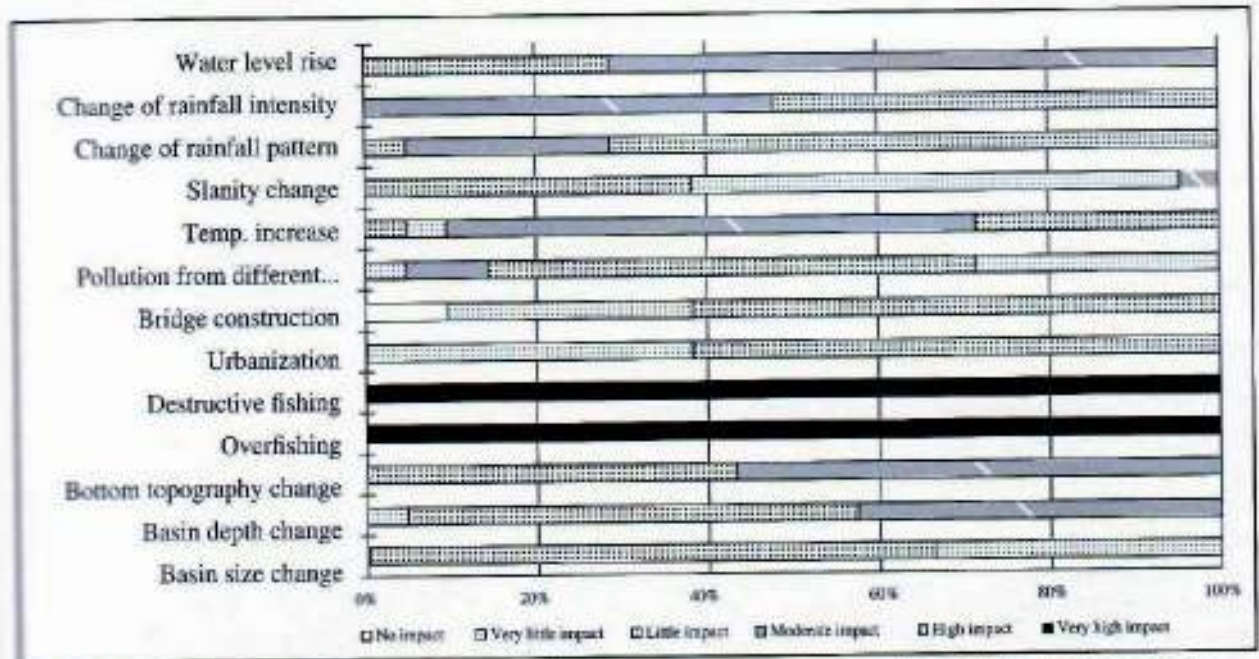


Figure 7. Ecological challenges associated with Naaf estuary ecosystem according to fishermen perspective

Biodiversity loss and ecological challenges

The perception of mollusk collectors depicts that the abundance of green mussel and oyster has highly decreased than that of 10 years ago. Overharvesting is considered as one of the main causes of stock depletion according to the mollusk collectors. The depth properties

of the basin have very little to little impact on the distribution and abundance of mollusk. Moreover, temperature change, changing of rainfall pattern and intensity and dumping from boat have had moderate to high impact on the distribution and abundance of green mussel and oyster in both studied areas (Figure 8-9).

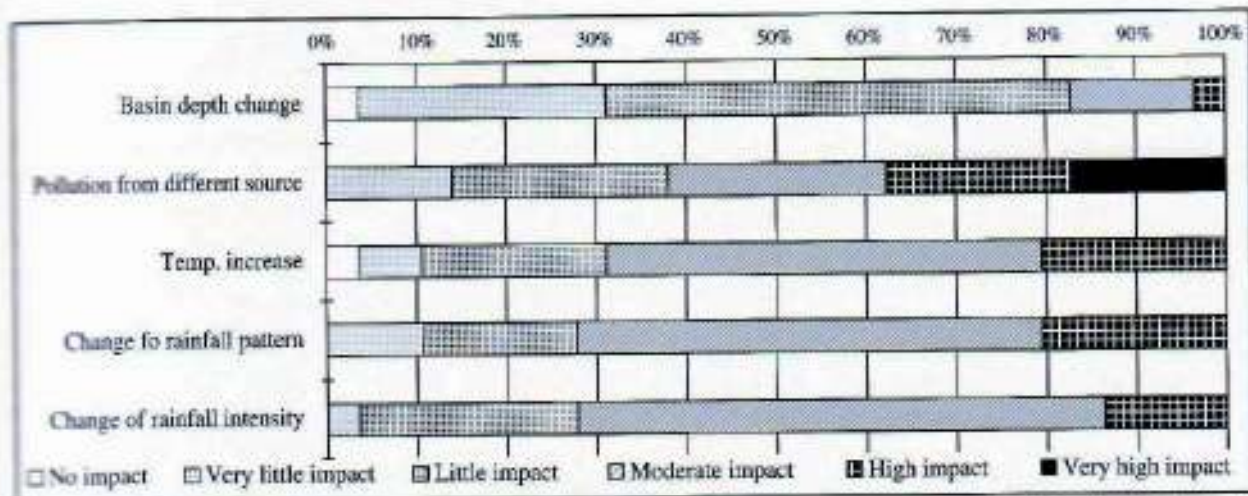


Figure 8. Impact of major ecological factors on the abundance of green mussel and oyster in Mohekhali channel

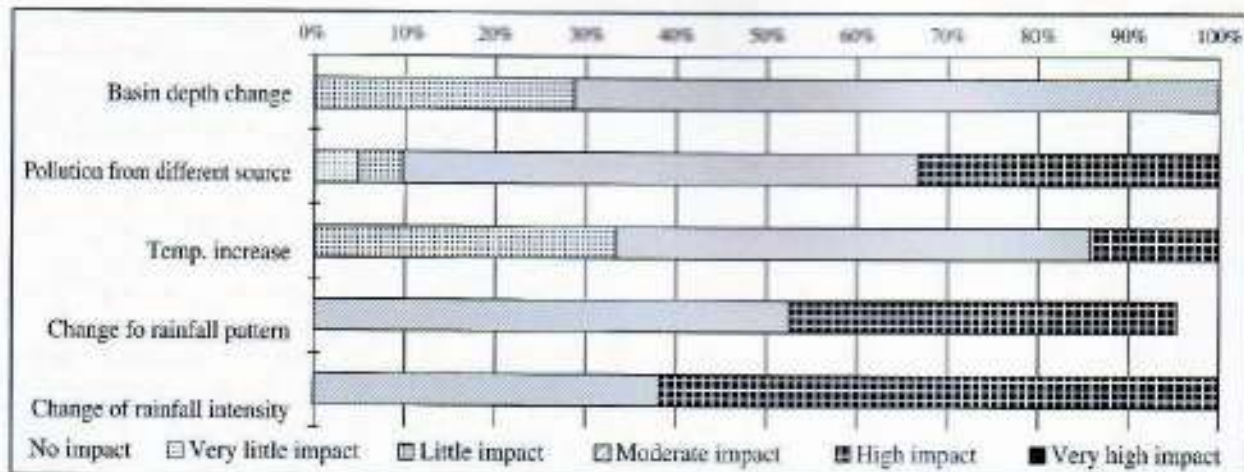


Figure 9. Impact of major ecological factors on the abundance of green mussel and oyster in Naaf river estuary

4. DISCUSSION

This study revealed that livelihoods of coastal small-scale fishermen have been greatly hindered by various ecological and socio-economic challenges. Small scale fishing is characterized as a livelihood of last resort, an occupation of landless poor and even a poverty trap due to various hindrances (Béné C. 2003, 2006; Andrew *et al.*, 2007). Generally, coastal communities of Bangladesh experience multiple risks and hazards due to the environmental settings (Torresan *et al.*, 2012), and they are also sensitive to inconsistent socio-economic condition compared to other socio-economic group (Béné *et al.*, 2009) which have been focused in this research.

Socio-economic status

Socio-economic status of small-scale fishermen in Bangladesh coastal zone is still lag behind due to poor economic condition and different natural calamities (Das *et al.*, 2015). This study revealed that the economic condition is very much disappointing, focused by their living condition which is strongly agreed with Das *et al.*, 2015. Research study showed that the economic condition of small-scale mollusk fishermen were poor and comprised with one (58%) or two (38%) income-earning member in family size of 5-7 persons. The coastal zone of Bangladesh supports 36.8 million population and 52% are poor and about 41% is below the age of 15 (Islam, 2008). The livelihoods of 20% of coastal population depend directly on coastal and maritime resources (Salam *et al.*, 2006).

Das *et al.*, (2015) revealed that 75% small-scale fishermen were illiterate in Khulna region. Present

scenario is completely different from previous situation where it was depicted that 71.12% children of coastal fishing community didn't get any education facility (Sahjahan *et al.*, 2001; DoF 2012). Instead of education, they send their children for fishing or engaging in other activities to obtain additional income due to their poor economic and living condition which is in accordance with the study of Ahmed *et al.*, 2013. Faruque (2006) found that health facility of Borobelabeel fishermen community was very poor. The study of Das *et al.*, (2015) and Mamun A.A. (2011) revealed that 70% fishermen of Khulna and 85% fishermen in Kaptai region had been affected by various water borne diseases which are in accordance with the present study. Scarcity of pure drinking water is a common phenomenon faced by the coastal people of Bangladesh (Chowdhury *et al.*, 2011). The present research also depicts the same trends of illiteracy and health facility received by the coastal fishers.

Maximum fishermen belong to poor and underprivileged class who cannot improve socio-economic condition by the fishing profession as the income is too low to support all the family members. Therefore they involved in day laboring, salt field, agriculture and fuel wood collection as their alternative occupations. It was showed that day laboring have been dominated compared to the other alternative occupations adopted by the fishermen which is different from the result showed by Das *et al.*, (2015). That study investigated only 10% fishermen of Khulna were involved in day labor as their alternative occupation. Conversely, present study revealed that fishermen of both Cauldandi and

Shahpori Island regions were found as day labor as their alternative occupation as a result of increasing working scope in construction activities. Besides day labor, large number of fishermen (70%) worked in salt field during November to April. Moreover, wild shrimp fry collection, agricultural field work and fuel wood collection have been chosen as a supplementary occupations.

There are many natural phenomenon faced by the fishing communities such as natural disaster, scarcity of food and safe drinking water, accident, theft and robbery and social conflicts. Fishermen confessed that the amount of fish caught by the them have been decreasing day by day due to overfishing, destructive fishing, pollution and other natural consequences which acted as a major threats for their livelihood. Chowdhury *et al.*, (2011) showed that the reduced fish catch has become a as major crisis for the livelihood of small-scale fishermen in the Naaf river. The problem confessed by the fishermen is still unsolved due to lack of awareness about conservation of fisheries resource and improper management strategy. Presence of conflicts among the fishermen community such as fishermen-fishermen, fishermen-creditor and fishermen- middlemen conflicts have been considered as major hindrances revealed by the present study. Due to analogous livelihood strategy, similar types of conflicts have been present in the fishing community. This result resembled with the findings of Mozumder *et al.*, (2017), Das *et al.*, (2015) and Chowdhury *et al.*, (2011).

Sahabuddin *et al.*, (2010) stated that younger fishermen were not interested in mollusk collection. But this study showed that interest of mollusk collection have been increased among the young (24%) and middle-aged fishermen (40%). High food value in tribal community, high market price, increasing demand of mollusk shell and availability in nearest coastal waters are the main catalyst which increase the young and young-adult concern in the mollusk fishery. This study also revealed that household size of mollusk collectors in both study areas ranging from 5-8 persons which is similar with Sahabuddin *et al.*, 2010. This finding indicates that population growth has been uncontrolled yet and it is impossible for one or two income-earning member to support five or six other family members.

This study showed that lending money from money lender as well as neighbor, foodstuff loan from grocery shop, taking less food, increased working hour, forced children and women outside work, poultry or livestock selling, and migration to other locality have been considered as common coping strategies prosecuted by the fishing community. According to Parvin *et al.*,

(2008) and Chowdhury *et al.*, (2011), it was showed that more or less similar coping strategy had been taken up by the coastal fishing community. These similarities revealed that coastal fishing communities experienced similar types of problems. Therefore, similar types of coping strategies have been adopted by them. Although fishermen communities of both study area have experienced different socio-economic crisis frequently, various facilities have been provided by the government to improve their living status. Small-scale fishermen of Caufaldandi and Shahpori Island have some expectations from the government by considering their present socio-economic condition such as annual allowance, creation of job facilities, health facility, rehabilitation, security and government loan facility. Those kinds of administrative facilities will be acted as catalyst for improving their livelihood standard.

Present status of mussel and oyster fishermen

The finding of this research gave an outline about the mollusk resource and fishermen around the coastal belt of Bangladesh. Among the Cox's Bazar coast Mobskhali channel and Naaf river estuary have great abundance of green mussel and oyster which have been agreed with the research findings of Sahabuddin *et al.*, 2010. Fishermen from two study areas are directly involved in mollusk collection whereas most of them are tribal Rakhain. Tribal fishermen are dominated in the mollusk fishery sector in Bangladesh due to the demand of mollusk meat in their community. The mollusk fishery generally covered by oyster, clam and green mussel collection in Cox's Bazar whereas in Khulna confined by oyster and clam collection. Present study revealed that a major portion of small-scale mollusk fishermen have been lived in Caufaldandi and Teknaf region and some lived in Khulna (Sahabuddin *et al.*, 2010). Green mussel and oyster collection has been conducted at 5-10 days interval by the small-scale mollusk fishermen in Caufaldandi while in Shahpori Island collection has been accompanied at 10-20 days interval. Present study also showed that clam collection in both study areas have been conducted by the women and children during low tide at regular interval. Traditional way has been used for mollusk collection which means there is no improved mechanism has been adopted by the mussel and oyster collection due to lack of awareness in mollusk fisheries management. According to fishermen perceptions present study indicated that 2000-3000 taka are the cost for single operation of mollusk collection for the purpose of boat fuel, oxygen cylinder and food cost.

The amount of green mussel and oyster collected by the small-scale fishermen have been varied according to season, locations and presence of substrate which is in accordance with Sahabuddin *et al.*, (2010). Perceptions of mollusk collectors indicated that mussel and oyster have been available in places where substrates are available like pillar of bridge or abandoned bridge etc. Mollusk collectors of Caufaldandi region have collected huge amount of green mussel and oyster attached with the pillar of Caufaldandi Bridge which was observed during survey.

Green mussel and oyster have been abundant during winter season. So, during winter season all the mollusk collectors are busier than other season and handsome profit have been come from mollusk meat and shell selling. The amount of green mussel and oyster with shell and without shell per operation has been varied according to location. In Caufaldandi, the amount of green mussel and oyster with and without shell were higher than the Shahpori Island. This difference occurred due to higher abundance of green mussel and oyster in Moheshkhali channel than Naaf river estuary. The similar findings were specified by Sahabuddin *et al.*, (2010) and Khan *et al.*, (2010). Green mussel and oyster collector have gained double benefit because the shell part and the muscle part have been sold separately. An interesting factor has been observed during this survey that the price of muscle part of green mussel and oyster in Caufaldandi was higher than Shahpori Island. The main reason for that difference has been found that the tribal population in Caufaldandi is much higher than Shahpori Island therefore high demand of tribal people in Caufaldandi.

Mollusk collectors confessed that catch composition of mollusk have been changed over time. The perception of fishermen is that very big size green mussel and oyster were caught regularly before 8-10 years ago. Comparing with previous catch composition, the size of collected green mussel and oyster have been turned into large medium to medium size. According to Sahabuddin *et al.*, 2010 green mussel and oyster were highly abundant in Caufaldandi, Teknaf and Khulna region but the abundance of green mussel and oyster have been decreasing day by day due to overharvesting and pollution depicted in this study.

Ecological feature and challenges

The Moheshkhali channel and Naaf estuary are characterized by an ecologically healthy, robust and rich in biodiversity which agreed with Sahabuddin *et al.* 2010 and Khan *et al.* 2010. According to fishermen and key informants,

activities such as urbanization, human encroachment, bridge construction and pollution have caused serious ecological concern. However, the past and present human activities have affected the ecosystem of both Moheshkhali channel and Naaf river estuary. Fishermen confessed that overfishing and destructive fishing activities are responsible for gradual fish stock depletion. Similar objection has also been found by Coll *et al.*, 2006 and Smith *et al.*, 2011. The fishermen believed that small-scale fishing have impact negatively when destructive gears are used or overfishing occurs which is argued with the result of Ahmed *et al.*, (2015). The study showed that 72% fishermen believed small-scale fishing was not harmful to the river ecosystem. The geomorphological variation in study areas and fishing methods practiced by the fishermen are the probable cause of this difference. The opinions of both fishing community about destructive fishing and overfishing is obviously significance because during the survey it was seen that lots of ESNB and mosquito net were set in both regions which is contradictory with the fishing laws and regulations.

A further ecological problem identified by the fishermen was coastal and marine pollutions. The crucial pollution problem is associated with oil pollution, oil dumping from boat, municipal sewage and household waste. According to the long experience of fishermen, pollution from different sources has been increased year after year which have greatly affected the biodiversity of aquatic resources. Moreover, environmental factors have had great influence on the ecosystem of Moheshkhali channel and Naaf river estuary such as increased temperature, saltwater intrusion and change of rainfall pattern and intensity have greatly observed by the fishers. The environmental factors have had great impact on the biology of aquatic resources Sahabuddin *et al.*, (2010). Considering the ecological condition of Moheshkhali channel, Caufaldandi Bridge has little to moderate impact on the Moheshkhali channel ecosystem. Bridge construction on water body causes the reduction of water area and promoted bareland formation in the upstream region. The research findings suggest that overfishing, destructive fishing; pollution and some environmental phenomenon have affected the ecosystem of Moheshkhali channel and Naaf river estuary which create great concern for the habitat and distribution of aquatic resource. The fishers and community members reported that the abundance of wildlife in Old Brahmaputra River had declined by 40% over the past decade (Ahmed *et al.*, 2015). Increasing number of mussel and oyster collectors,

competition among the collectors and lack of appropriate planning and law enforcement on mollusk catch are identified as present trends which have significant impact on mollusk fishery.

Biodiversity loss and ecological challenges

Though the previous study of Sahabuddin *et al.*, (2010) revealed that mollusk stock in coastal region of Bangladesh was virgin field in respect of exploitation, present study showed that in Moheskhali channel and Naaf river estuary the green mussel and oyster stock has not been virgin anymore due to continuous harvesting. The large size green mussel and oyster have been decreasing day by day due to overharvesting. The abundance of green mussel and oyster has been reducing due to pollution and competitor among the tribal community which also hampers the water quality and makes the habitat uncomfortable. Competition has been expanded due to the increasing demand of green mussel and oyster meat in tribal community as well as the demand of restaurant in Cox's Bazar region. Besides the meat, demand of green mussel, oyster and

clam shell has also been increased among the lime, poultry and feed industry. These consequences may be included in the list of causes responsible for decreasing the abundance of green mussel and oyster.

Sustainable management approaches are needed for the conservation of mollusk resources otherwise similar phenomenon will be occurred which was happened with Ganges river dolphin (*Platanista gangetica*). Ahmed *et al.*, (2015) stated that these dolphins have been lost because of environmental degradation and human encroachment. According to present study these environmental degradation and human extravagances have already been experienced indicating that this is the high time to take compatible management strategy for the protection of Moheskhali channel and Naaf estuary ecology. The framework of small scale fishermen community related with mollusk collection illustrate that, the socio-economic issues have some coping strategies for maintaining key ecological issues includes some preferred coping strategies as banning period, catch restriction and culture system establishment (Fig. 10).

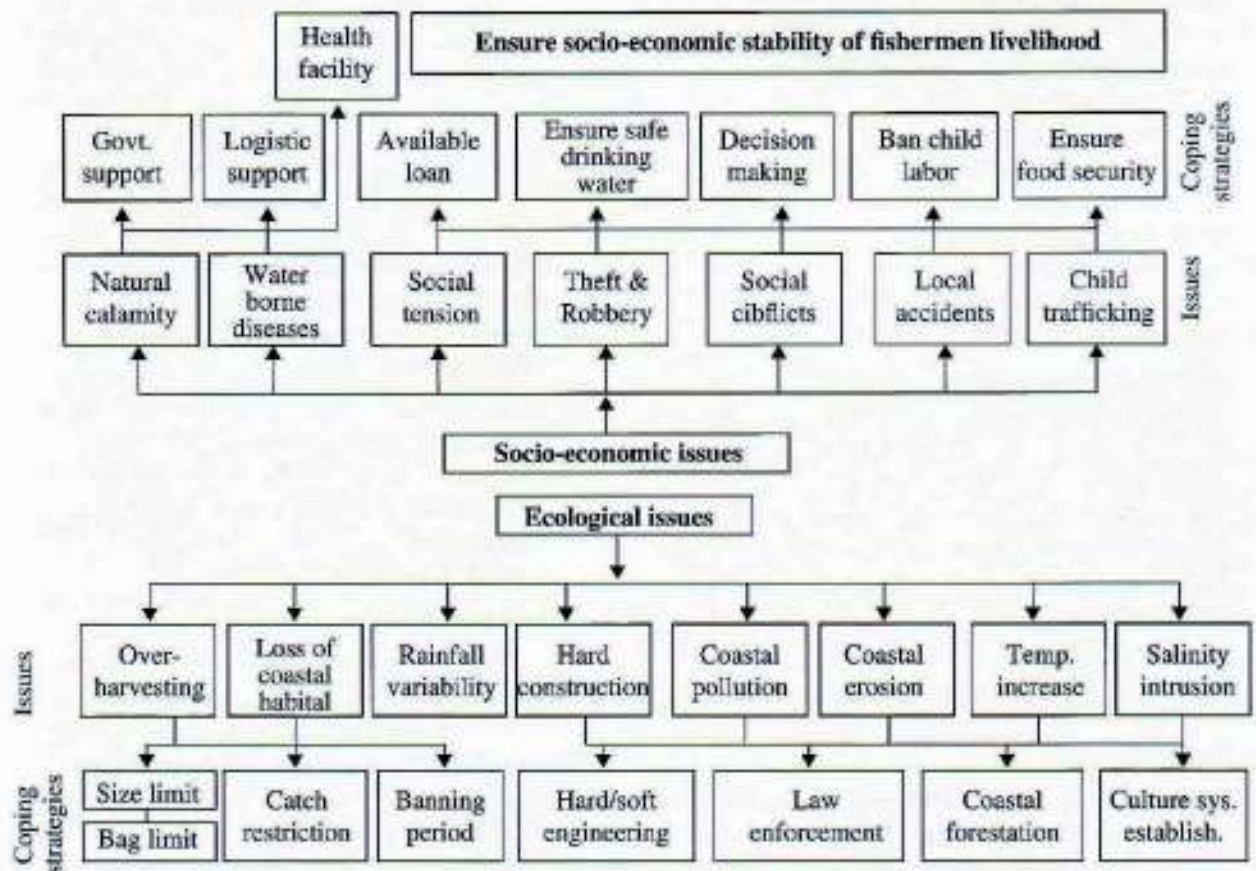


Figure 10. Framework for sustainable mollusk fisheries management

5. CONCLUSIONS

Mollusks fishers depend on small-scale fishing which varies according to their capacity to fish and collection methods. The livelihoods of mollusk collectors are vulnerable owing to declining catches resulted from overharvesting, usage of destructive fishing gears, environmental degradation, human encroachment and water pollution. This small-scale fishing activity like destructive fishing and overfishing leading to biodiversity loss and the decline of capture fisheries resource. Moreover, growing populations within fishing communities have increased fishing pressure which is threatening current income levels. Fishers are vulnerable to overexploitation of the resource resulting in the loss of social, economic and ecological benefits that can be obtained from responsible fisheries. It is a great hope for us that research on mollusk fisheries have been initiated which will possibly bring great success in this sector. The culture system of green mussel and oyster is needed to establish by considering the global demand and economic prospects which will open a new dimension for small-scale mollusk fishermen to improve their livelihood standard. All the mollusk collectors who were interviewed have emphasized that it is time to take proper initiatives for the conservation of green mussel and oyster. Policy makers should consider banning period, catch restriction and culture system establishment as conservation tools. Establishment of culture system will be a great achievement in mariculture field which will decrease the pressure on natural stock of green mussel and oyster. Different coping mechanisms are required to ensure the benefits of enhanced management that are essential to distribute equitably among fishing communities to safeguard the long-term sustainability of resources. A number of significant challenges, spanning socio-economic and ecological domains must be overcome before the anticipated benefits of the fishing community and aquatic biodiversity. The patchy distribution and labor intensive collection procedure, dependency on seasons for supply, culture of mollusks especially mussels and oysters have been considered an urgent option for the coastal aquaculture practices in Bangladesh.

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