Fishers’ Perception of Climate Change on Saltmarsh and Seagrass Ecosystems in the Southeastern Coast of Bangladesh

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INTRODUCTION

The earth’s environment is undergoing on notable changes. Based on past 100 year’s surface temperature data it is determined that global average surface temperature of the earth has been increased by 0.74 °C (IPCC, 2007). Bindoff et al., (2007) also enumerated that during the 20th century the global sea level rose at 1.7±0.5 mm/year, whereas since 1950, sea surface temperature averagely rose up to 0.6 °C. Likewise, other parts of the world, temperature trends of Bangladesh has also been changed (Chowdhury and Debsharma, 1992; Mia, 2003; Islam, 2009). In Bangladesh, the analysis of 85 years data (1895-1980) shows that the average temperature had been increased by 0.31°C during that period (Divya and Mehrita, 1995). Considering the changing and increasing pattern of temperature and climatic hazards during the previous decades, it is expected that temperature of Bangladesh will be increased (Karmer and Shrestha, 2000) along with the increased rate of other meteorological hazards. Climate related extreme events like, heavy rainfall, flood, cyclone, storm surges have already been increased and many coasts are experiencing erosion and ecosystem losses (Zhang et al., 2000). Due to the transitional habitat between ocean and the land, increased rate of meteorological hazards may
affect the distribution, abundance and communities of saltmarsh (Adam, 2002) along with the massive loss of seagrass beds by uprooting and clogging of plants (Short et al., 2006).

Saltmarshes (<0.5 m tall) are herbaceous or low woody vascular halophytic vegetation occur within the intertidal zone having the characteristics of withstanding harsh environment like, high salinity and extreme moisture (Adam, 2002). However, seagrasses are marine angiosperms (flowering plant), can propagate also by vegetative parts (shoots, rhizoids)(Hemminga and Duarte, 2000). These ecosystems are considered as the most productive marine ecosystems. The diversity of fisheries are quite satisfactory adjacent to saltmarsh and seagrass ecosystems in the southeastern coast of Bangladesh (Nabi et al., 2011). In a recent study, a total of 50 species of fish (39), shrimp (9) and crab (2) were identified in the area adjacent to these ecosystems in the southeastern coast of Bangladesh (Billah, 2013). Though, the coastal zone of Bangladesh is endowed with seagrass and saltmarsh ecosystems (Abu Hena and Khan, 2009), very few studies have been conducted on the ecological characteristics of saltmarsh and seagrass ecosystems (Abu Hena, 2007; Rezwan, 2008; Islam, 2012; Abu Hena, 2013).

Bangladesh is a country of around 160 million people (Rabbani, 2009) and out of them the number of people living in the 21 coastal districts are about 37 million (Hossain, 2013). Their life and livelihoods are dependent on the resources available in the coastal areas like, fishery, mangroves, seagrasses and saltmarshes. Due to geographical location, being a vulnerable country as a result of climate change and sea level rise (Rabbani, 2009) these coastal ecosystems are mostly vulnerable and the vulnerability is gradually increasing day by day. But there have been no specific study on the vulnerability of saltmarsh and seagrass ecosystems, perception of nearby community people especially the fishermen and other relevant stakeholders about the degradation of these productive ecosystem due to climate change induced effects. The goods and services derived by the fishermen from these valuable ecosystems especially in southeastern coast of Bangladesh is completely unknown, though it is essential for its conservation and management. So present study was an effort to determine the fishers’ perception of climate change on saltmarsh and seagrass ecosystems in the southeastern coast of Bangladesh.

Study Area:
Selection of sampling sites and target group for questionnaire survey:

Two study sites (Salimpur, Chittagong and Sadar Upazila of Cox’s Bazar) were selected to represent the southeastern coast of Bangladesh. These sites were selected based on the existence of saltmarsh and seagrass ecosystems. For example, Salimpur, Chittagong was selected for the presence of saltmarsh ecosystem (Abu Hena, 2010; Islam, 2012) and Cox’s Bazar for the presence of both saltmarsh and seagrass ecosystems (Abu Hena, 2007). Due to the main resource users for these ecosystems fishermen were the target group of the present study.

Profile of the study sites:

Cox’s Bazar district is 150 kilometers south of Chittagong having an area of 2491.86 km². It is located at 21°35’0” N 92°01’0” E(Figure 1). The population and household of Cox’s Bazar district are 22,8,999 and 4,15,954 (Community report, Cox’s Bazar Zila, 2012). The major rivers are Matamuhuri, Bakkhal, RejuKhal, Nafriver, and Maheshkhal Channel. The coast of Cox’s Bazar experienced several cyclones in the history. For example in the year 1991, during the devastating cyclone approximately 145,000 people and 70000 cattle were diedalong with huge crops damage (Khan and Damen, 2013).

The approximate location of the Salimpur coast, Chittagong is 22° 23.89’N and 91° 44.84’E and it is 20 km of south west of Chittagong port (Figure 1). The tidal range of this coast was about 2.43 m to 3.04 m throughout the year (Talukder, 2004). In the fishing villages of Salimpur the total number of households in north and south Salimpur were 116 and 271, respectively(Baseline survey, 2010).

Temperature:

In the analysis of last sixty years (1949-2010) data from the two stations (Cox’s Bazar and Chittagong) of Bangladesh Meteorological Department(BMD), it has been recorded that the maximum and minimum temperature were found in the month of May (39.5° C) and January (7.7° C) (Figure 2). The mean temperature of month April, May, July and August were almost same (26°C). Generally it is considered that there is relationship between sea surface temperature (SST) and intensity of tropical cyclone especially when it is over 26.5°C (Palmen, 1948; Emanuel, 1987; Michaels et al., 2005). However, study shows that increased water temperature has direct effect on the metabolism of seagrass (Short, 1998).

Rainfall:

Generally in the country southwest monsoon brings much rainfall from May to September while the northeast monsoon brings certain rain in October and November (Hossain, 2013). Trend analysis of annual maximum rainfall data of last 40 years (1970-2010) from BMD of Chittagong and Cox’s Bazar stations shows
that there was decreasing trend of rainfall in both the stations. For example in Cox’s Bazar there was a decreasing trend of 0.570 mm per year (Figure 3b) and in Chittagong it was also a decreasing trend of 0.8 mm per year (Figure 3a). In the coastal wetland rainfall plays a key role by increasing of water content of soils thus creating suitable conditions for plant physiological function (Smith and Duke, 1987; Ball, 1998). Besides, the germination and recruitment of species may govern by the changes of amount and seasonality of rainfall (Noe and Zeedler, 2001).

**Fig. 1:** Study area for assessing fishers’ perception (Salimpur, Chittaogn and Cox’s Bazar district) of southeastern coast, Bangladesh.

**Fig. 2:** Monthly average daily maximum, minimum and mean temperature (°C) during the last sixty years (1948-2007) in southeastern coast of Bangladesh (Data source: Bangladesh Meteorological Department of Chittagong and Cox’s Bazar station).
Materials and methods

Field survey:
Extensive field visits and interviewing of fisherman household heads of two sites of southeastern coast of Bangladesh were conducted using a semi-structured questionnaire. A total of 200 individuals were interviewed (100 respondents in each site) (Table 1). The samples from two sites (Salimpur, Chittagong and Cox’s Bazar) were similar with regards to age (χ² = 6.95, df = 3, p>0.05), and number of family members (χ² = 1.85, df = 3, p>0.05) but differ in demographic features like occupation (χ² = 53.06, df = 5, p<0.0001) and education (χ² = 7.96, df = 2, p<0.05) This differences reflects the diversity and livelihood standard of the samples.

Table 1: Demographic information of the samples surveyed; for Salimpur, Chittagong and Cox’s Bazar (in each site n=100).

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Salimpur</th>
<th>Cox’s Bazar</th>
<th>Education level</th>
<th>Salimpur</th>
<th>Cox’s Bazar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisherman</td>
<td>35</td>
<td>12</td>
<td>Illiterate</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>Fish labourer</td>
<td>40</td>
<td>25</td>
<td>≤ Class 5</td>
<td>65</td>
<td>50</td>
</tr>
<tr>
<td>Fish marketing</td>
<td>10</td>
<td>8</td>
<td>≤ Class 10</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Fish dryer</td>
<td>-</td>
<td>10</td>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Labourer in fish dry centre</td>
<td>-</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net swing</td>
<td>15</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td></td>
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The interviews were conducted into local language. The interviews focused mainly on the perception of fishermen on the major climatic vulnerabilities, impact of these vulnerabilities in their life and livelihoods, the major uses of saltmarsh and seagrass ecosystems on their daily life and likely impact of climate change on these ecosystems. Interviews with key informants such as school teacher, village leaders, government officer to validate the data (IIRR, 1998; Trap, 2006).

Results:

Major Climatic vulnerabilities observed by the respondents:
The increasing trends of climatic vulnerabilities especially cyclones cause loss and damage of assets of the coastal people. In regards to this, the respondents were inquired to mention the major climatic vulnerabilities that they experienced in their life. 70% respondents in both study areas opined that tropical cyclone is the most prominent vulnerability (Figure: 4) due to climate change. On the other hand, 10% fishers of Salimpur coast cited that thunder storm is the another prominent vulnerability next to tropical cyclone, whereas, only 3% respondents of Cox’s Bazar expressed their opinion regarding thunder storm as climatic vulnerability. In addition to that, in Salimpur, Chittagong, 4% respondents in regards to tidal surge and 7% respondents in regards to heavy rainfall cited as observed climatic anomaly especially in the rainy season.
Fig. 4: Major climatic vulnerabilities observed by the respondents in the study area.

Impacts of climatic vulnerabilities on the fisher’s livelihood:

The highest proportion of the respondents (over 50% in both the areas) opined that their main earning source especially daily income was severely hindered and decreased due to climate change induced hazard like cyclone followed by scarcity of food during the calamities (over 10% opined in both study areas) (Figure 5). 6% respondents of Cox’s Bazar and 3% respondents of Salimpur cited that a number of fishers migrate to nearby town and other areas of the country as a result of direct and indirect hazards of climate change prevails in the study area. 9% Respondents of Salimpur cited that impairment of boat and net was their 3rd major impact, whereas this impact was very less in Cox’s Bazar (3% opined) compared to Salimpur.

Fig. 5: Impact of climatic vulnerabilities observed by the respondents in the study area.

Causes of saltmarsh destruction:

In Cox’s Bazar (60% opined) over harvesting was the main reason for the destruction of saltmarsh ecosystem, whereas, rapid horizontal expansion of ship breaking industry was the major reason cited by the 53% respondents of Salimpur. Using the marsh beds as footpath was another reason for the destruction of saltmarsh cited by the respondents of Cox’s Bazar (about 14%) and Salimpur (8%). Moreover, there were few proportion of respondents who cited that appropriate harvesting method (the way of cutting the marsh grass which is not suitable for regeneration) was also a reason for the destruction (Figure 6).
Fig. 6: Fishers’ perception about the degradation of saltmarsh resources in the study area.

Direct use of saltmarsh grass:
In both study areas over 60% respondents cited that they were using saltmarsh grass for fodder, followed by thatching material (12% respondents opined) (Figure 7). In both study areas there were some fishermen who do not use saltmarsh grass in their everyday life and their percentage were 12% for Salimpur and 9% for Cox’s Bazar, respectively. Moreover, only 10% of the respondents use saltmarsh grass as source of fuel in both study areas.

Fig. 7: Fishers’ perception about direct use of Saltmarshes in the study area.

Direct benefit derived from saltmarsh and seagrass beds:
Crab collection from the saltmarsh and seagrass beds were much popular to the respondents of Cox’s Bazar than that of Salimpur, that percentage were 75% and 45%, respectively. Bait fishing in the marsh bed was popular to some of the respondents of Salimpur coast, although fishers’ of Cox’s Bazar usually do not practice it. In Salimpur, Chattagong around 15% of the fishers’ were engaged in shrimp fry collecting in the marsh area, whereas, in Cox’s Bazar it was only 5%. In both study areas there were some respondents who were not benefitted directly from saltmarsh and seagrass habitat and that proportions were 23% and 15% for Salimpur and Cox’s Bazar, respectively (Figure 8).
Fig. 8: Fishers’ perception regarding the uses of saltmarsh and seagrass beds.

*Indirect benefit derived from saltmarsh and seagrass beds:*

To be acquainted with the indirect benefits of saltmarsh and seagrass ecosystems almost all the respondents were confused especially of seagrass ecosystem. But while it was described regarding indirect benefits all the respondents in both study areas agreed and opined that saltmarsh and seagrass ecosystems play significant role in regards to erosion control as well as decrease the velocity of flood in the coastal areas eventually protecting the lives and livelihoods related resources especially crops and vegetables. Regarding indirect benefits of seagrass they could not mention properly may be due to lack of knowledge.

*The loss of saltmarsh and seagrass resources due to climate change:*

In Cox’s Bazar about 45% of respondents cited that these ecosystems were highly influenced by the climate change induced disasters like, cyclone, storm or high wave across the bay or river, whereas, about 15% respondents of Salimpur, Chittagong cited that climate change has high impact on this resources. On the other hand, in both the areas, 30% respondents opined that climate change plays insignificant role in regards to saltmarsh and seagrass destruction. Besides, it has also been found that some of the respondents (11% in Cox’s Bazar and 5% in Salimpur) have no idea about the climate change induced impacts on saltmarsh and seagrass ecosystems (Figure 9).

Fig. 9: Fishers’ perception regarding the impact of climate change on saltmarsh and seagrass resources.

*The previous status of saltmarsh and seagrass resources in 10-12 years ago:*

To know the previous status of saltmarsh and seagrass ecosystem in the study areas the respondents were interviewed and 78% respondents of Cox’s Bazar and 70% respondents of Salimpur, ranked it as high, i.e. there
were healthy and noticeable ecosystems in both study areas (Figure 10). But very few respondents, averagely around 5% in both study areas ranked it as small to medium in regards to ecosystem richness in the study areas and around 6% respondents in both areas have no idea about these ecosystems. The reasons might be due to lack of knowledge about this ecosystems.

**Fig. 10:** Fishers’ responses regarding the status of saltmarsh and seagrass resources 10-12 years ago.

**Discussion:**

The present study illustrates that the major climatic vulnerabilities faced by the coastal fishers’ of the southeastern coast of Bangladesh were tropical cyclone followed by tidal surge, coastal flooding, thunder storm and heavy rainfall, respectively. Fortunately, there was no massive cyclone after 1991. It is mentionable that, during 1991 drastic cyclone, not only 138,866 people were died, but also millions of people were injured along with huge loss of properties and infrastructure and socio-economic disruptions (EM-DAT, 2010). A similar observation was also mentioned by a number of authors studied in the mid and southeastern coast of Bangladesh including Miah, (2010); Chowdhury et al., (2012); Sarker and Hossain, (2012). Our findings show that thunder storm was the second major climatic hazard cited by the respondents of Salimpur, Cox’s Bazar; however, recent research stated that every one degree Celsius of warming, there will be approximately a 10 percent increase in lightning activity (thunder storm) (Science daily, July 2012).

The greatest threats that are facing mankind today is the climate change and it’s adverse effect undermine the economic development, human security, and people’s fundamental rights (Clime Aisa, 2009; UNDP, 2007). The respondents cited that due to climatic hazard the main impacts on livelihood that they are facing directly and indirectly and as a result, poverty is increasing gradually due to reduction of income source, damage of boat and net as well as food shortage. During the cyclone period fishermen who use ESBN (estuarine set beg net), cannot monitor their net placed on the bay, therefore it is sometimes washed away by the strong current of the bay.

The present study illustrates that in both study areas, 50% respondents cited that they use saltmarsh grass as fodder for their cattle. It is considered that from the ancient period saltmarshes are the place where livestock forages or source of hay (Adam, 2002). Sea grass meadows provide services which include social, cultural, and spiritual resources. Many indigenous people have close cultural and religious ceremonies. The fishermen of Cox’s Bazar glean gastropod from the saltmarsh and seagrass habitat. In Floeres, Indonesia local people glean gastropod from the seagrass meadows (Unsworth et al., 2010). In Salimpur, Chittagong fishermen did not mention about gastropod collection from the saltmarsh beds probably due to the absence of these organisms in this habitat. The respondents of Salimpur, Chittagong cited that they were practicing bait fishing in the marsh beds; whereas it was not cited by the respondents of Cox’s Bazar probably due to engaging with other alternative income generating source like, fish trading, fish laborer, tourism etc. The respondents engaged themselves in crab collection during the low tide in the marsh area.

In this study coastal fishers’ cited that saltmarsh losses were aggravated by the intervention and establishment of coastal infrastructure like, ship breaking industry, over harvesting of saltmarsh as well as mooring on the saltmarsh beds. It is noted that the world’s largest ship breaking yard lies in the Salimpur, Chittagong. The horizontal expansion of this industry is not only destroying the nearby saltmarsh bed but also

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creating severe pollution on the adjacent saltmarsh ecosystems, thus playing as key role behind saltmarsh degradation. Adam, (2002) has already described the major reasons for the destruction of saltmarsh bed. According to Adam, (2002) the reasons associated with saltmarsh destructions were grazing by livestock, land claim (i.e., coastal infrastructure like port, jetty), sea salt production, aquaculture, tidal powered mills, tidal barriers, water storage, pollution and introducing invasive species. In USA saltmarsh losses were caused by rapid urbanization, coastal construction project and possibly due to sea-level rise. It is noted in both study areas that about 34% of saltmarsh resources has declined due to anthropogenic impact.

Majority of the respondents cited that climate change has medium effect on saltmarsh and seagrass ecosystems. It is mentionable that increased rate of climate change induced hazard like, cyclone, flooding, and heavy rainfall may cause massive loss of seagrass beds by uprooting and clogging of the plants (Short et al., 2006; Chollett et al., 2007). The distribution, abundance and communities of saltmarsh may likely affected by the climate change, because there are variation of the distribution of saltmarsh species in the world which reflects the influence of climate (Adam, 1990). However Change in temperature and rainfall may change the distribution of salt-pan in saltmarshes (Bertness, 1999). The germination and recruitment of saltmarsh species may govern by the changes of amount and seasonality of rainfall (Noe and Zeedler, 2001). Changes of some environmental forcing factors like, relative sea level, sediment supply, erosion and freshwater inputs may also cause the destruction of saltmarsh (Adam, 2002).

Conclusion:

It is proven that Bangladesh is highly vulnerable and disaster prone country of the world due to its geographical location in low elevation. Being a vulnerable country coastal people especially fishermen communities are more vulnerable compared to others as they live in the mostly vulnerable area i.e. coastal areas of the country. It is determined that coastal peoples’ livelihood in Bangladesh depends on fishing and other resources of the coastal ecosystems especially mangroves, coral reef, salt marsh, seagrass etc. Salt marsh and seagrass ecosystems provide tangible and intangible benefits to nearby community people like, fish, crab, fodder, thatching materials along with reduction of erosion, flood etc. From our study findings, it is clear that, this valuable and important ecosystems are highly vulnerable as a result of climate change induced impacts like, tropical cyclone, erratic rainfall, flood, water logging, saline water intrusion etc. Apart from that, peoples’ ignorance in regards to the effects of climate change on salt marsh and seagrass ecosystems and some anthropogenic factors like over harvesting, intervention of ship breaking industry in these ecosystems are the main driving force for the degradation and destruction of these ecosystem habitat. It has also been found that this degradation is aggravating day by day due lack of any initiative for its conservation and management practices neither from the relevant govt. department nor from the any non govt. organizations and nearby other stakeholders. The fishermen who are benefitting and feel to conserve these ecosystems, are quite helpless to take initiative for the conservation, as they are backward people in the society due to their poverty. On the other hand there is no rules and regulation for its conservation and lack of research and systematic monitoring to observe the status and consequences of these ecosystems.

So in order to conserve and restore these ecosystems, an integrated long term study for monitoring the impact of climate change and sea level rise on salt marsh and seagrass ecosystems are essential; fishers’ oriented awareness programme in regards to climate change, sustainable use of these resources are needed to stop further degradation and destruction, and development of conservation management plan (CMP) and its implementation with the active participation of relevant stakeholders especially the nearby community people may be the best option for its sustainable conservation, restoration and management of these ecosystems

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