Impacts of Climate Change on Coastal and Marine Fisheries Resources in Bangladesh*

Bangladesh has an area of 147 570 sq. km and a population of 156 million. It is bordered by India and Myanmar, with the Bay of Bengal and the North Indian Ocean to the south and the Himalayas to the north.

Climatically, Bangladesh is one of the world's most vulnerable countries (Table 1). Frequent natural disasters such as cyclones cause loss of life and damage to infrastructure, economic assets, and livelihoods. Much of the country is routinely inundated during the summer monsoon. High population density and poverty aggravate the vulnerability. The population of Bangladesh may swell to over 200 million by 2050 (WB and BCAS 1998).

* *M. G. Hussain, Director General, Bangladesh Fisheries Research Institute (BFRI), Mymensingh. M. Enamul Hoq, Project Director, Support to Sustainable Development of BOBLME Project, BFRI, Mymensingh.*

Climate change is a long-term phenomenon. Scenarios for 2030 and 2050 for Bangladesh have been developed under the United States Country Study Program, also by the World Bank (Table 2).

According to IPCC (2001), the following changes related to the Bay of Bengal have been observed in Bangladesh in the form of climate trends, variability and extreme events:

- Average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during the 14 -year period from 1985 to 1998.
- The annual mean rainfall has been increasing and decadal rain anomalies have exceeded the long-term average since 1960s.
- Serious and recurring floods have taken place during 2002, 2003 and 2004. Cyclones originating from the Bay of Bengal have been noted to decrease since 1970 but the intensity has increased.
- Frequency of monsoon depressions and cyclone formation in the Bay of Bengal has increased.
- Salt water from the Bay of Bengal is reported to have penetrated 100 km or more inland along tributary channels during the dry season.

The coastal and marine environment of Bangladesh

The Bay of Bengal, the marine area of Bangladesh, is characterized by a semi-enclosed tropical basin. The coastline of the country comprises about 710 km extending from the tip of Teknaf in the south-east to the south-west coast of Satkhira (Fig.1). As a result, an area more than 166 000 km^2 along a 710 km coastline comes under the economic jurisdiction of Bangladesh for

exploration, exploitation, conservation and management of its marine resources.

Climate vulnerability

El Niño and La Nina

Some studies report that the *El Niño* Southern Oscillation events influenced the record-breaking floods of 1987, 1988 and 1998 (Chowdhury, 1998).

The rapid transformation of *La Nina* from the *El Niño* phase of early 1998 is said to have influenced high rates of precipitation over the entire GBM catchment basin. As a result, a prolonged dry season was followed by the wettest monsoon – eventually leading to the deluge of the century. Global events can therefore have ominous local weather effects.

Flooding

Analysis of past floods suggests that, about 26 percent of Bangladesh is subject to annual flooding. An additional 42 percent is at risk of flood with varied intensity (Ahmed and Mirza, 2000). A 10 percent increase in monsoon precipitation in Bangladesh could increase runoff depth by 18 to 22 percent, resulting in a seven fold increase in the probability of an extremely wet year (Qureshi and Hobbie, 1994).

Cyclones and storm surges

A tropical cyclone hits Bangladesh, on an average, every three years. These storms generally form in the months just before and after the monsoon and intensify as they move north over the warm waters of the Bay of Bengal. Storm surges are higher in Bangladesh than in neighboring countries because the Bay of Bengal narrows towards the north, where Bangladesh is located. In recent years, general cyclonic activity in the Bay of Bengal has become more frequent, making the seas rougher and making life difficult for fishermen and making small craft difficult to use.

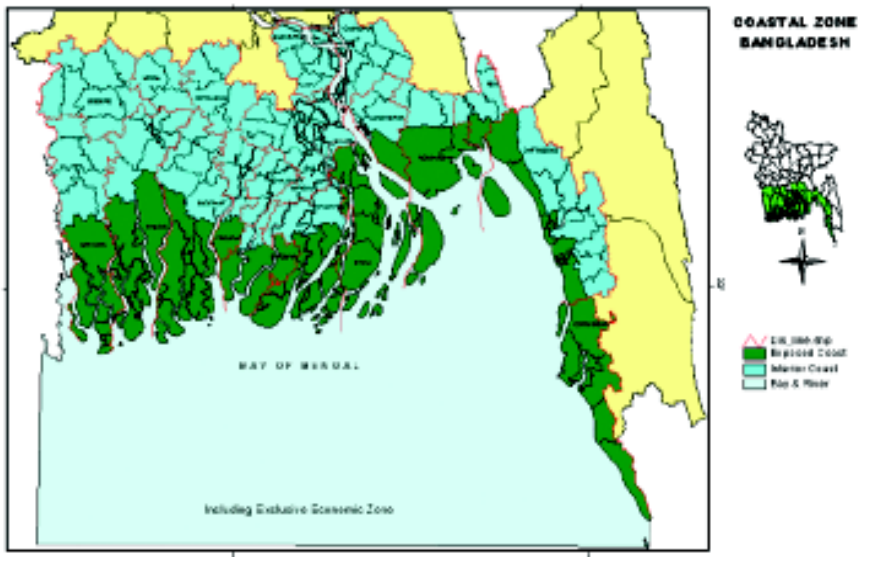

Figure 1. Coastal zone of Bangladesh

Table 1. Major climate-vulnerable countries (Deaths/100 000 people exposed to floods or cyclones)

Floods			Tropical cyclones		
1	Venezuela	4.9	1	Bangladesh	32.1
2	Afghanistan	4.3	2	India	20.2
3	Pakistan	2.2	3	Philippines	8.3
4	China	1.4	4	Honduras	7.3
5	India	1.2	5	Vietnam	5.5
6	Bangladesh	1.1	6	China	2.8

Source: UNDP (2004)

Table 2. Climate change scenarios for Bangladesh in 2030 and 2050

Year	SLR (cm)	Temperature increase (^{0}C)	Precipitation fluctuation compared to 1990 (%)	Changes in evaporation
2030	30	+0.7 in monsoon +1.3 in winter	-3 in winter +11 in monsoon	+0.9 in winter +15.8 in monsoon
2050	50	+1.1 in monsoon +1.8 in winter	-37 in winter +28 in monsoon	0 in winter 16.7 in monsoon

Source: UNFCCC (2002)

Sea level rise in Bangladesh

Another critical variable that determines the vulnerability of Bangladesh to climate change impact is the magnitude of sea level rise.

Impact on fisheries and aquaculture

Sea level rise and consequent changes to the river estuary can trigger changes in fish habitat and breeding ground. Penaeid prawns breed and develop in brackish water, where salt water and fresh water mixes. Sea level rise would turn this interface backward, changing the natural habitat of the prawn population. There are some 60 shrimp hatcheries and 120 shrimp processing plants in the coastal zone of Bangladesh. The hatcheries are located along the sea beach at Cox's Bazar. Favourable environmental condition and brood stock availability are the main reasons to set up hatcheries in that area. Some hatcheries have also started trial and experimental production in Chittagong and Satkhira coast. These districts are located in coastal zones vulnerable to sea level rise – making the shrimp hatcheries and shrimp fields vulnerable as well.

Sea level rise helps shrimp farming in one way – by introducing salinity in the coastal area. But flooding caused by sea level rise can inundate shrimp ponds and destroy this prospective foreign exchange earner. It can also affect the dry fish industry.

Table 4. Marine fish production (MT) in Bangladesh

Year	Industrial	Artisanal	Total
1997-1998	15 273 (5.60)	257 545 (94.40)	272 818
1998-1999	15 818 (5.11)	293 979 (94.89)	309 797
1999-2000	16 304 (4.88)	317 495 (95.12)	333 799
2000-2001	23 901 (6.30)	344 596 (93.70)	379 497
2001-2002	25 165 (6.06)	390 255 (93.94)	415 420
2002-2003	27 954 (6.47)	403 954 (93.53)	431 908
2003-2004	32 606 (7.16)	422 601 (92.84)	455 207
2004-2005	34 114 (7.18)	440 483 (92.81)	474 597
2005-2006	34 084 (7.10)	445 726 (92.90)	479 810
2006-2007	35 391 (7.26)	452 047 (92.74)	487 438
Average	26 061 (6.30)	376 868 (93.70)	404 029

** The figures in parenthesis indicate percent of total*

Climate change and the Sundarbans ecosystem

On the basis of different vulnerability indicators for accelerated sea level rise, the Woods Hole Oceanographic

Institute (WHOI), 1986 produced a list of 27 low-lying countries. The list was headed by Bangladesh. The Bay of Bengal acts as a funnel for storm events, creating severe storm surges. These can raise sea level above tidal height and devastate a low-lying coast like that of Bangladesh.

The Sundarbans can be wiped out by a 1- metre rise in sea level (World Bank, 2000). Loss of the Sundarbans would be catastrophic – a loss of heritage, of biodiversity, of fisheries resources, of life and livelihoods and of a very high productive ecosystem.

Sea level rise can decrease availability of light for corals and thereby their growth. It can destroy St. Martin's island, the only highly productive coral island of Bangladesh.

Climate change impacts on marine fisheries resources

Alteration of marine ecosystems due to climate change has both direct and indirect effects on fish – their reproduction, migration and survival.

Hilsa (*Tenualosa ilisha*) is the national fish of Bangladesh. It accounts for 13-14 percent (valued at around Tk 6 000 million, 1.3 % of GDP) of the total fish production of Bangladesh. During the last two decades hilsa production from inland waters declined about 20 percent, whereas marine water yield increased threefold. Major hilsa catch has gradually shifted from inland to marine waters.

Recent studies reveal that the availability of hilsa is gradually declining in the Padma and Meghna river catchment areas. Result: hilsa production in the rivers has been going down, while that in marine waters has been going up. Similar conditions might occur for other marine fish/shrimp species, but no study has yet been carried out in Bangladesh.

Combating climate changes

In 2005, the Government of Bangladesh launched its National Adaptation Programme of Action (NAPA), in partnership with other stakeholders. It identified adaptation needs to combat the effects of climate change. The Climate Change Cell in the Department of Environment supports the mainstreaming of climate change into national development planning.

Adaptation measures in fisheries as prioritized in Bangladesh NAPA

- Promoting adaptation to coastal fisheries through culture of salt tolerant fish, especially in coastal areas of Bangladesh.
- Adaptation to fisheries in areas prone to enhanced flooding in North East and Central Region through adaptive and diversified fish culture practices.
- Reduction of climate change hazards through coastal forestation with community focus.

Adaptation options for climate changes

Adaptation seeks to reduce the adverse effects of sea level rise on living organisms, including human and the environment. The ability to adapt and cope is a function of wealth/income, technology, scientific and technical knowledge and skills, information, infrastructure, policy and management institutions and equity.

Sea level rise adaptation can be addressed by changes in policies that lessen pressure on resources, improve management of environmental risks, and enhance adaptive capacity. As most of the populations of the coastal communities of Bangladesh are fishermen and farmers, the adaptation options should focus on these two sectors. If we can implement various adaptation options for coastal fisheries, as shown in the following Causal Loop Diagram (CLD) (see Fig. 2 on page 38), we find that five loops may reinforce to increase the fisheries production. Foreign exchange earned by coastal fisheries could be re-invested to develop the sector.

Coastal communities should be prepared to combat climate change through disaster preparedness activities. A disaster calendar should be prepared for the communities, so that they can safely practise fish farming. Example: most cyclones in the coastal zone occur in October and May. Coastal district Noakhali as well as Khulna, Satkhira and Patuakhali districts should be covered by the proposed calendar. Fishermen should avoid these districts for fishing and fish farming during specified periods.

Weather forecasts on Bangladesh radio and television are usually delivered in an academic or literary style, not suitable for coastal farmers and fishermen. Target

groups should be able to understand and react to forecasts. Local radio stations should broadcast special programmes on issues relating to sea level rise.

Research should be conducted to identify salinity-tolerant species in coastal fisheries. Species selection should be made for low, moderate and high saline environment. After selecting different species for different zones or saline environments, fishermen should be trained in breeding and seed production techniques including cultivation and harvesting of the species.

Future climate change strategy and action plan

The Government of Bangladesh is committed to strengthen the country's resilience to climate change, reduce risks posed to national development; and development of the country along a low-carbon growth path. The Bangladesh Climate Change Strategy and Action Plan (BCCSAP) is a 10-year programme (2009-2018) to build the capacity and resilience of the country to meet the challenge of climate change (see box on page 39). It has been developed through a participatory process involving various ministries and agencies, research organizations and the business community.

Role of Bangladesh Fisheries Research Institute

The Bangladesh Fisheries Research Institute (BFRI) is at the primary stage of a climate change study. BFRI has a long-term study programme on hilsa fishery in Bangladesh. Recently, a programme was initiated on the impact of climate change on the maturity and spawning of hilsa in relation to habitat degradation. Another technical support programme is going on – to identify and analyze sound fisheries and aquaculture risk adaptation options in drought-prone areas of North West and coastal areas of South West Bangladesh.

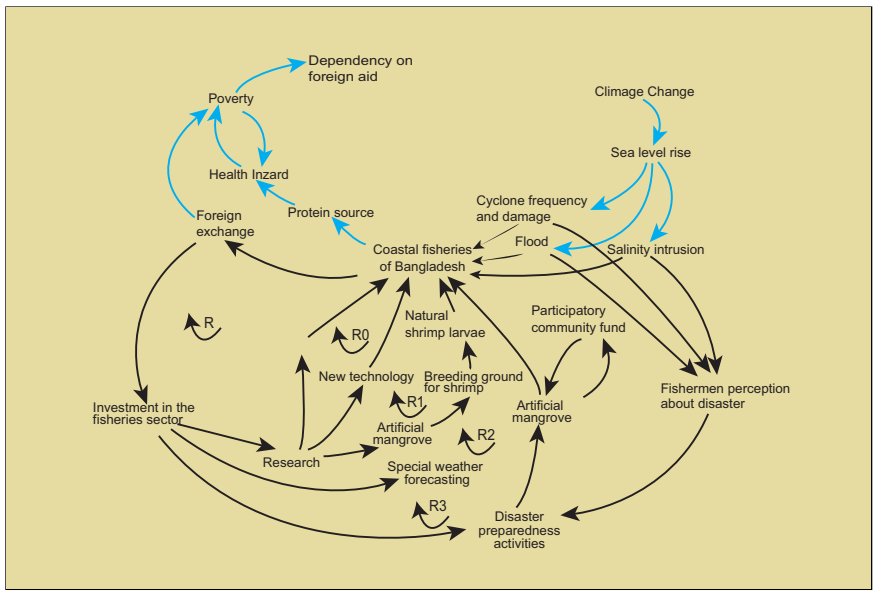

Figure 2. Causal Loop Diagram for adaptation options of coastal fisheries with sea level rise (Sarwar, 2005).

BFRI should in future heighten its focus on climate change impact on fisheries; it should in particular strengthen research as well as survey and monitoring capacity in marine fisheries – which is presently weak because of absence of infrastructure (vessel) and technical manpower. The Department of Fisheries is trying to obtain a research vessel for BFRI through the OIC-supported Marine Capacity Building Project.

Conclusions

Climate change impact in Bangladesh is high, though the country's greenhouse gas emissions are low. The government needs to pay keen attention to issues related to climate change impact, organize research, develop salinity-tolerant species in both agriculture and fisheries, and develop a strategy to combat impact. Adaptation costs should be recovered from coastal resources using economic instruments.

Research is also needed to preserve the country's biodiversity. Technical and financial assistance from the international community is essential.

The main climate change impacts on the marine environment are rise in sea water temperature, salinity and sea level, drop in sea surface pH, and changes in upwelling and water mass movement, and the behaviour of *El Niño* and *La Nina*,

Climate change would affect the distribution and abundance of marine fish species. Many fish species have a narrow range of optimum temperatures related both to their basic metabolism and the availability of food organisms. Depending on the species, the area it occupies may expand, shrink or be relocated. No specific research has yet been conducted in these issues in Bangladesh and countries. A coordinated long-term research project on the impact of climate change on marine resources in the Asia-Pacific region is an urgent need.

BCCSAP of Bangladesh concerning fisheries and biodiversity

Programme and time-frame	Justification	Specific actions
The development of adaptation strategies in the fisheries sector (mid to long-term)	Climate change is likely to adversely affect freshwater and marine fisheries resources in Bangladesh. For example: the spawning of freshwater and marine species may be affected. Water temperatures in fresh, brackish and marine waters may go up. Saline waters may extend further inland in the south of the country. This will alter existing aquatic ecosystems and production of fish. There may be turbulent weather along the coast for longer periods, impacting on the livelihoods of fishermen. These potential impacts must be identified and researched and management strategies developed, tested and made ready, in anticipation of climate-related changes.	• Assess potential threats to fish spawning and growth of fish in the freshwater fisheries sector and develop adaptive measures, including fish farming and river-based cage aquaculture, etc. • Assess potential threats to fish spawning and growth of fish in the coastal zone and brackish water and develop appropriate adaptive measures and mariculture practices. • Assess potential impacts on the shrimp sector and develop appropriate adaptive measures and cultural practices. • Assess potential threats to the marine fish sector and develop adaptive measures to protect these resources
Monitoring of ecosystem and biodiversity changes and their impacts (mid to long-term)	One of the objectives of the UNFCCC is to urgently reduce green house gas emissions, so that ecosystems and their flora and fauna have time to adjust to climate change. Salinity levels are also likely to increase significantly in the coastal belt. Mangrove ecosystems, which are already under serious stress for anthropogenic reasons will suffer heavily due to further increases in salinity. These could alter the entire ecosystem of the Sundarbans and cause the extinction of some valuable fish/shrimp and other aquatic species. In view of these expected changes, a systematic monitoring mechanism should be put in place to assess the impact of climate change on ecosystems and bio-diversity. A participatory impact monitoring mechanism involving communities and experts will be designed. Pertinent physical, chemical and biological data will be collected. Changes that take place in livelihood patterns due to ecological and biodiversity changes will be assessed and policy recommendations and appropriate actions suggested.	• Set up a well-designed monitoring system to evaluate changes in ecosystem and biodiversity, covering all important and sensitive ecosystems. • Develop participatory monitoring systems by involving trained people such as school teachers, communities and academic researchers. • Report changes in ecosystems and biodiversity and assess the implications, including those for the livelihoods of local people, and recommend adaptation measures.

Source: MOEF (2008)

Further reading:

Ahmed, A U and M M Q Mirza, 2000. Review of Causes and Dimensions of Floods with Particular Reference to Flood '98: 'National Perspectives'. In: Q K Ahmad, A K A Chowdhury, S H Imam & M Sarker (eds.) Perspectives on Flood, 1998. The University Press Limited, Dhaka. 142p.

Chowdhury, A, 1998. Disasters: Issues and Responses, In: Gain, P (ed.), Bangladesh Environment: Facing 21st Century, SEHD, Dhaka, Bangladesh.

IPCC, 2001. Climate Change 2001: Impacts, Adaptation and Vulnerability, Cambridge University Press, UK.

Qureshi, A and D Hobbie (eds.), 1994. Climate Change in Asia: Thematic Overview. Asian Development Bank, Manila. 351p.

Sarwar, M G Mahabub, 2005. Impacts of sea level rise on the coastal zone of Bangladesh. Thesis, Lund University. International Masters Programme in Environmental Science. Lund University, Sweden. 45p.

UNDP, 2004. A Global Report: Reducing Disaster Risk: A Challenge for Development. http://www.undp.org/bcpr.

WHOI (Woods Hole Oceanographic Institute), 1986. http://www.whoi.com.

World Bank, 2000. Bangladesh. Climate Change & Sustainable Development. Report No. 21104 BD, Dhaka.

World Bank and BCAS, 1998. Bangladesh 2020: A Long-run Perspective Study. The World Bank & Bangladesh Centre for Advanced Studies (BCAS). The University Press Limited, Dhaka, Bangladesh.