What lies in store for us

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THE increase of the annual mean surface air temperature has been evidenced in Bangladesh during the period of about 50 years. The warming of the sea surface temperature (SST) and rapid rise of Sea level (4-7.8 mm/year) in the Bangladesh coast of the Bay of Bengal have also been observed. The Fourth Assessment Report of IPCC has shown that the global mean surface air temperature scenarios will attain the values between 2.4 6.4o C by 2100, where the best estimate is 40C using A1F1 (the fossil intensive storyline with rapid growth) scenario of GHG emission. This was obtained from the climate simulation using a number of Global Circulation Models (GCMs). The projection for global sea level rise was estimated as 24-67 cm by 2100 based on the same GHG emission storyline.

Note: DJF: December, January and February; MAM: March, April and May; JJA: June, July and August and SON: September, October and November

According to IPCC the global sea level of Bangladesh is expected to rise by 67 mm by 2100 in the worst case. In Bangladesh, the current net sea level rise is 4-7.8 mm/year which accounts for the combined effect of global warming and geological subsidence of the tectonic plate. Subtracting the current rate of global sea level 1.8 mm / year due to warming from the total sea level, rise it is seen the contribution from subsidence is 2.2-6 mm /year. If we take the worst case the net sea level rise due to warming as well as geological subsidence will exceed 1m in the coming 100 years in the Bangladesh coast.

With the above climate change scenarios, Bangladesh will face severe consequences to its disasters, economy and environment. Most severe impacts will be experienced in the following sectors:

Vulnerability in Fresh water resources, Floods and drought

Floods: Bangladesh is a flood-prone country. Analysis of past floods suggests that about 26 percent of the country is subject to annual flooding and an additional 42 percent is at risk of floods with varied intensity. According to government sources, the 1998 flood inundated about 100,000 km2. In contrast, the 1987 flood had inundated about 57,000 km2 and the 1988 flood inundated 89,000 km2. The 1998 flood affected 68% of the country, and seriously impacted the livelihoods of 30 million people. Overall damage was estimated at two to three billion US dollars. The 1998 floods lasted for over 10 weeks. The 2004 flood affected about 57% of Bangladesh. It has been observed that the return period of severe floods is decreasing. For an increase of monsoon rainfall of 22.5% by 2100, the runoff is expected to increase by 40-50%. This will cause the increase of flood depth and inundation areas. The sea level rise causes delaying of the discharge of flood water due to the decrease of the sea ward gradient of water.

Due to prolonged discharge of floodwaters, the rate of sedimentation will increase. As a result, both the riverbed and the bed of the adjacent floodplains will rise leading to further drainage congestion, and possibly more intense flooding in the following years. Such a cyclic course of events would intensify flood problem in the already flood-prone areas of the country. Moreover, instead of fertile silt, if infertile sand or coarse sediments are deposited with flooding, it will severely reduce productivity of the topsoil.

Droughts: The source of water resources for Bangladesh is rainfall, water flowing along the rivers from upstream and ground water. Because of high increase of temperature the evaporation rate will be higher and the soil moisture will dry up rapidly and the surface water areas will shrink. Further it has been found that the river flow of the rivers is decreasing especially in the dry season. Thus the water demand for agriculture, industries and household purposes will increase. The demand for water will further increase due to population increase and increased economic development. The flow deficiency in the Ganges over Bangladesh in the dry period has caused the flow of the southern rivers to decrease; as a results these rivers are being silted up. Because of this, this vast area is facing severe salinity problem in the soil and both in surface and ground water.

Very severe droughts hit the country in 1951, 1961, 1975, 1979, 1981, 1982, 1984, and 1989. The drought years have low rainfall and high temperature. High temperature causes evaporation, further deteriorating the water balance situation. Past droughts have typically affected about 47 percent area of the country and 53 percent of the population. A geographical distribution of drought-prone areas under climate change scenarios shows that the western parts of the country will be at greater risk of droughts, during both the Kharif (January May) and pre-Kharif (June October) seasons. It is found that, under a moderate climate change scenario, Aus production would decline by 27 percent while Wheat production would be reduced by 61 percent. Under a severe climate change scenario (with 60 percent moisture stress), yield of Boro might be reduced by 55-62 percent. Moisture stress might force farmers to reduce the area for Boro cultivation. In case of severe droughts, forced by a change of temperature by +2oC with a decrease of rainfall by 10% the runoff in the Ganges, and Brahmaputra, and Meghna rivers would be reduced by 32, 25 and 17 percent respectively. This would limit surface irrigation potential in the drought-vulnerable areas, and challenge food self-sufficiency programs of the country.

Table 1: Climate change projections for 2050 and 2100 as obtained from GCMs taking 1990 as the reference year.

Year	Parameter	DJF	MAM	JJA	SON	Annual
2050	Temp (C)					
		1.7	1.9	1.4	1.8	1.8
2100		3.6	3.5	2.6	3.1	3.3
2050	Rainfall (%)					
		10.5	15	11	7.5	10.4
2100		25	25.4	22.5	13	18.4

Adaptation

Adaptations to Reduced Fresh Water Availability: Possibilities for physical adaptations to reduced fresh water availability refer to increasing surface water availability through additional inflows from upstream, construction of reservoirs by constr5ucting Barrages on the main rivers, increasing drainage capacity of infrastructure, and increase of storage of water in the area itself. One way of storage would be through rainwater harvesting excavation of ponds etc., which could be a promising alternative.

Institutional adaptation includes reducing water demand, and participatory management of the water use. For example: groundwater extraction, which is basically uncontrolled, could be better regulated and monitored; or farmers could be trained to increase water use efficiency through farm practices. Again, market concepts could be introduced (by having consumers to pay for water use, or allowing trading of water rights) which may help ensure that water goes to the most needed applications. Another important and promising institutional mechanism to increase the flexibility to adapt to climate changes is proper participatory arrangements for operation and maintenance of water resources infrastructure.

Adaptation to Drainage Congestions: Physical adaptation to drainage congestion includes restoration of channels, flushing capacity enhancement, enhancement of drainage capacity of infrastructure in roads, controlled sedimentation and landfills, and pumped drainage. The institutional adaptation includes improved design criteria for openings in drainage blocking structures, and community involvement in the operation and maintenance of the water resources infrastructure.

Adaptations to Dynamic Morphological Changes: Physical adaptations to increased morphological dynamics (erosion & accretion) may include river training and bank protection, and dredging of navigation channels, which suffer from increased sedimentation. Institutional adaptation includes improved monitoring and forecasting of changes, relocation of victims of erosion, and navigation management and information dissemination. Monitoring and forecasting morphological changes become more and more important to prepare for anticipatory measures to protect the increasingly important infrastructure such as the Jamuna Bridge, Bhairab bridge, Meghna bridge etc. Knowledge and experience to analyze the morphological behavior of the rivers in Bangladesh are growing though still inadequate. An institutional and regulatory framework is necessary to relocate the victims in government-owned Khas lands, which may be supplemented by NGO-driven micro credit programs to facilitate income generation activities in those areas. Navigation would greatly benefit from proper and real time information about the navigability of rivers during the dry season and demarcation of navigation channels.

Adaptations to Increased Flooding: It includes full flood protection embankments, controlled flooding, elevated land as flood refuge, and increase in flood refuge areas. Full flood protection embankments are widely practiced in Bangladesh in areas, where full flood control is economically needed and justified. Although effective, their feasibility is medium because of the Operation & Maintenance requirements. Controlled flooding in combination with compartmentalisation has been practiced under the FAP Project (FAP20), and deserves more attention. In terms of feasibility, controlled flooding scores low. Landfills (elevated land) and flood refuge areas focus directly on the affected people and assets rather than on limiting or managing the excess flobdwater. In response to the need for increased dredging operations in Bangladesh, introduction of larger scale landfill or flood shelter operations could be considered. Most of the pucca schools and the elevated roadsides are considered now as flood refuge areas. These measures are quite effective and feasible. Besides, the people over the flood prone areas are advised to build houses by raising the lands or with high plinth height. This will save their houses and household properties. The tube wells for potable water are to be built by raising the base above the flood levels.

Since, water is scares in the dry season, the multi-purpose water reservoirs may be constructed in the upstream as collaborative efforts among the SAARC member states as well as in the major rivers of Bangladesh like the Ganges and Brahmaputra, which will not be used only for flood moderation but also to produce electricity, provide irrigation water in the dry season, provide channel augmentation and cultivation of fishes. Such construction is feasible and would serve as long term adaptation measures in water sector over the region.

Improved flood warning and forecasting, setting limit to developments in high-risk areas, awareness brief up and evacuation of vulnerable people and valuables are some possible institutionally adaptation measures. The flood monitoring, warning and dissemination system should be improved. The bilateral relations between Bangladesh with India and Nepal are to be made more effective for exchange of data and information on the river conditions and rainfall amounts which are valuable inputs for flood warning. Flood warning should not only predict water levels in rivers, but should also give an estimate of inundation depth and duration of floods, which is much more useful to farmers. Improved forecasts need to be combined with proper dissemination mechanisms and techniques. Improved damage assessment techniques would then support efficient and effective relief measures. Involving local community in maintaining flood protection embankments should be a priority both as physical and institutional adaptation.

The flood victims should be properly rehabilitated to begin their economic activities as soon as the flood recedes. The agricultural adaptation is highly important for the food security. Sufficient seed beds are to be prepared in the highlands to meet up the emergency need, such as post-flood rehabilitation. After the flood is receded, the transplantation is to be performed as quickly as possible to replenish the loss. The damage to agricultural crop can be minimized by introducing flood resistant cultivars. The changing land use pattern may help overcome the crop loss. The farmers now grow winter rice more extensively using irrigation as the winter rice have lower risk compared to Aman rice. Again, the winter rice is engendered by more frequent severe flash floods in the eastern and north eastern zones of Bangladesh in the month of May. The winter rice may be saved from the flash floods by shifting the transplanting dates to middle of January from the middle of February. In that case, the rice would be harvested before the flash floods.

Vulnerability in coastal zone and coastal resources: The landmass of Bangladesh is connected to the Indian Ocean through a 710 km long coastline. The coastal region is marked by a vast network of river systems, and ever dynamic estuaries, interaction of huge quantities of fresh water that are discharged by the river systems with saline water and a saline waterfront penetrating inland from the sea. In addition to the coastal plains, there are a number of small islands that are subject to strong wind and tidal interactions throughout the year, and are inhabited by a large number of people. The coastal areas of Bangladesh are highly prone to cyclone-induced storm surges.

In the western coastal areas of Bangladesh, the Sundarbans, a large patch of naturally occurring mangrove forest is located. The Sundarbans stretches further west into the southeastern part of the state of West Bengal in India. It occupies a total area of about one million hectares, about 62 percent of which is situated within Bangladesh.

The central region of the coastline is situated between the eastern and western coastal areas. Most of the combined flow of the GBM system is discharged through this low-lying area. The lower Meghna River is highly influenced by tidal interactions and consequential backwater effect. Heavy sediment inputs from the rivers result in a morphologically dynamic coastal zone. Cyclones and storm surges bring about the most catastrophic damages to the area.

The 1991 census recorded the size of the population of the coastal districts as approximately 24 million. The population density of the coastal districts is 959 inh/km2. compared to the national average of 861 inh/km2

Coastal resources highly vulnerable to climate change, include land and water resources, as well as the mangroves forests. More specifically there would be:

Changes in water levels and induced inundation and water logging: Any rise in the sea level will propagate upstream into the river system. In Bangladesh, this backwater effect will be more pronounced because of the morphologically dynamic rivers, which will adapt their bed levels in a relatively short time period. This whole process will lead to decreased river gradients, increased flood risks and increased drainage congestion.

Since most of coastal plains are within 3 to 5 meters from the mean sea level, it was previously thought that a significant part of the coastal areas (as high as 18 percent of the country) would be completely

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