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Adaptation

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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.

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 compartmentalization 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 floodwater. 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.

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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 south-eastern 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;

Increased salinity in ground and surface water, and corresponding impacts on soil salinity and agriculture.

Increased coastal morphological dynamics (erosion and accretion).

Increased intensity of cyclones and storm surges.

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 inundated by rising seawaters. Such a speculative projection was made based on two major approximations; (a) the coastal plains are not protected and (b) the seawater front will follow the contour line. In reality, however, it is found that most of the plains in the coastal region are protected. Moreover, it is seen from the records that there is net gain of lands in coastal zone.

About 6000 km embankments have been constructed along the coastlines, banks of rivers and tidal estuaries to form polders. At present there are 108 polders and sub-polders in the greater Khulna, Barisal, Patuakhali, Noakhali and Chittagong districts in the coastal zone of Bangladesh. Several thousand drainage sluices are provided to remove accumulated rainfall run-off from the polders to the sea or adjacent rivers by gravity flow during low tide. Automatic flap gates are provided with the sluices to prevent saline water intrusion inside the polder during high tides.

Existing embankments provide protection against flooding from high tides but are not designed to prevent inundation by severe storm surges. In addition to protection of the regular inundations and saltwater intrusion, the embankments can reduce the tidal forces. This has an adverse effect on the drainage conditions (siltation due to reduced tidal volumes) and the ecosystems (water logging and stagnant waters). These negative effects have already been visible in parts of the coastal area such as Khulna, Barisal, Patuakhali and Noakhali regions.

Drainage congestion may become an even more serious threat than higher flood risks. Due to the siltation and poor maintenance of the drainage channel network in many parts of the coastal zone, drainage congestion is already a grave problem. The problem is expected to aggravate considerably.

Proper emphasis should be given to the fact that protection measures against inundation by embankments interrupt with the natural processes of land sedimentation and delta formation. This implies that subsidence and sea level rise will not be compensated by sedimentation and the risks of inundation and drainage congestion will be even greater in the future. These amplifying effects are particularly alarming and indicate that quite a different approach may be required to face the problems especially in the seaward parts of Bangladesh.

Unlike the densely populated sea-front area, the Sundarbans is not protected and is heavily influenced by tidal effects. A rise in sea level will tend to inundate the mudflats of the forest and reduce the land area of the forest.

Increased salinity in ground and surface water: impacts on soil salinity and agriculture

The effect of saline water intrusion is highly seasonal in Bangladesh. Saline intrusion reaches its minimum during the monsoon (June October) when the GBM rivers discharge about 80 percent of the annual fresh water flow. In winter months the saline front begins to penetrate inland and the extent of affected areas rise sharply from 10 percent of the country in the monsoon to over 40 percent in winter. Climate change would further increase saline intrusion. Climate change-induced extreme weather events especially low flow conditions in winter will accentuate the saline intrusion in the coastal areas.

Increased coastal morphological dynamics (erosion and accretion)

The morphological dynamism of deltaic Bangladesh is manifested in the coastal zone. The coastal areas have been experiencing natural erosion and accretion. Although current literature suggests that coastal land is in the process of slow accretion at the approximate rate of 8 km2/year during the past 210 years (Allison, 1998, Martin and Hart, 1997), much of this may be attributed to cross dams that have been built to reclaim land from the shallow continental shelves. Nevertheless, due to climate change induced alterations in thermal energy at the ocean-terrestrial interface and the expected changes in the inflow of riverine sediments, the dynamics of coastal morphology appears to be highly uncertain. Furthermore, new embankments for reclaiming additional land would affect the morphological dynamics of the coast.

Cyclones and storm surges

From time immemorial, cyclones have been striking the delta causing extensive damages to the lives and properties of millions of people in the coastal districts of Bangladesh. In 1876, about 200,000 people were reportedly killed in Barisal by a cyclone. Another cyclone that hit in 1822 killed more than 70,000 people in Barisal and 95 percent population of the Hatiya Island. Considering the much lesser population during those times, the numbers of deaths give an indication of the severity of the cyclones. A cyclone in November 1970 hit the southern districts of Bangladesh forcing a 9 m high storm surge and killing approximately 300,000 people. The cyclone of 1991 caused loss of 138,000 lives. In more recent years, however, numbers of deaths caused by the cyclones with severe intensity have declined due to the growing successful institutional arrangements for disaster management and the fact that there are now over 2000 cyclone shelters spread along the coast which are being utilized during the cyclones. The most recent one is SIDR which was one of the most severe tropical cyclones which caused the losses of trees, crops, dueling houses and deaths of more than 3447 people. Climate change is expected to increase the intensity of cyclones and the penetration of storm surges further inland, causing higher damages.

ADAPTATION

Adaptations to Drainage Congestion

Physical adaptation requires mainly two steps: (i) bringing water from the land into the main drainage system; and (ii) drainage of water to the sea. Step (i) presently is done under gravity, mostly through regulators, which open during low tides. When higher water levels impede this process, pumping remains the main option. Step (ii) requires a well-maintained drainage network, and improvement of drainage system. Increasing the drainage capacity of existing infrastructure, maintaining the out fall channels of hydraulic structures and providing new drainage structures in the locations where sedimentation process is less. Increased river/channels flow by diverting the Ganges river flow in the existing 24 big and small rivers under the proposed Ganges Barrage Project will reduce the drainage congestion and river siltation problems in the south-western region of Bangladesh. Pumped drainage seems a last, but expensive resort especially when the outside water levels become too high for drainage under gravity.

Institutional measures include guidelines to incorporate climate change in long term planning. Establishing proper O&M arrangements for the maintenance of drainage channels and infrastructure could be an effective approach. Establishment of water management associations, support of local water management including involvement of local institutions and development of appropriate

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