# Climate Forecast Applications In Bangladesh For Water Related Disaster Mitigation

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## Abstract

Recurring natural hazards associated with climate variability, such as severe floods and droughts, undermine development efforts of Bangladesh and aggravate poverty. It has long been recognized that if society could have advance information on climate, the adverse effects associated with it could be minimized. Prevalence of traditional forecast practices in various parts of the world reflects the demand for medium & long-range forecasts to manage uncertainties associated with climate variability. Recent advances in climate prediction has brought huge benefits to the society. There is a need for concerted efforts to address these gaps to take full advantage of climate prediction advances.

## Introduction

Bangladesh is a deltaic country located at the lower part of the basins of three large alluvial rivers, the Ganges, the Brahmaputra and the Meghna. Total catchments area of these three rivers is to the tune of 1.75 million sq. km (Catchments Map Fig. 1). Three major rivers namely, Ganges, Brahmaputra and Meghna are flowing through Bangladesh and drain into the Bay of Bengal. About 92% catchment areas of the rivers in Bangladesh (including these three major rivers) are situated outside the country.

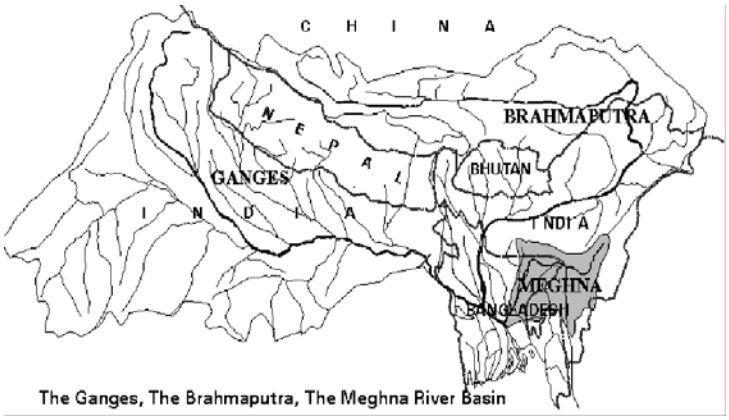


Fig. 1 The Ganges, the Brahmaputra and the Meghna River Basins

Numerous tributaries and distributaries of these river systems and extensive floodplains are the main physiographic characteristics of the floodplains . In fact about four-fifths of the country is floodplain. As a result of flat topography of the floodplain, one fifth to one-third of the country is flooded annually by overflowing rivers during monsoon when rainfall is also very high in the catchments.

Among the different types of flooding (e.g., monsoon river flood, flash flood, local rainwater flood and storm surge), monsoon river floods are the major flood type occurring regularly. Monsoon river floods are caused by simultaneous occurrence of excessive discharge in the three major rivers. The situation has been made worse as a result of retardation of outflow into the Bay of Bengal due to high sea level during monsoon. Thus the major contributor to this monsoon floods is the discharges from the Ganges and Brahmaputra & Meghna basins and concomitant sea level rise due to south westerly monsoon. It is, therefore, obvious that the forecasting of discharges of the Ganges and Brahmaputra are very crucial for the flood forecasting of Bangladesh.

**CFAB background**

One of the potential instruments to minimize the impacts of natural hazards is climate information. From 2000-2003, the US Agency for International Development's Office of Foreign Disaster Assistance (USAID/OFDA) supported the Climate Forecast Applications (CFAB) project in Bangladesh to reduce vulnerability to climate hazards in agriculture and water resources, and to mitigate the disastrous effects of floods through the generation and application of climate and flood forecast information. The project has been under implementation by the Program on Atmospheric and Oceanic Sciences (PAOS) at the University of Colorado Boulders, USA. The research works mainly forecast on increasing the lead-time of flood forecasting in Bangladesh through providing forecasts of Brahmaputra & Ganges discharge (fig 2)., and sea-level height.

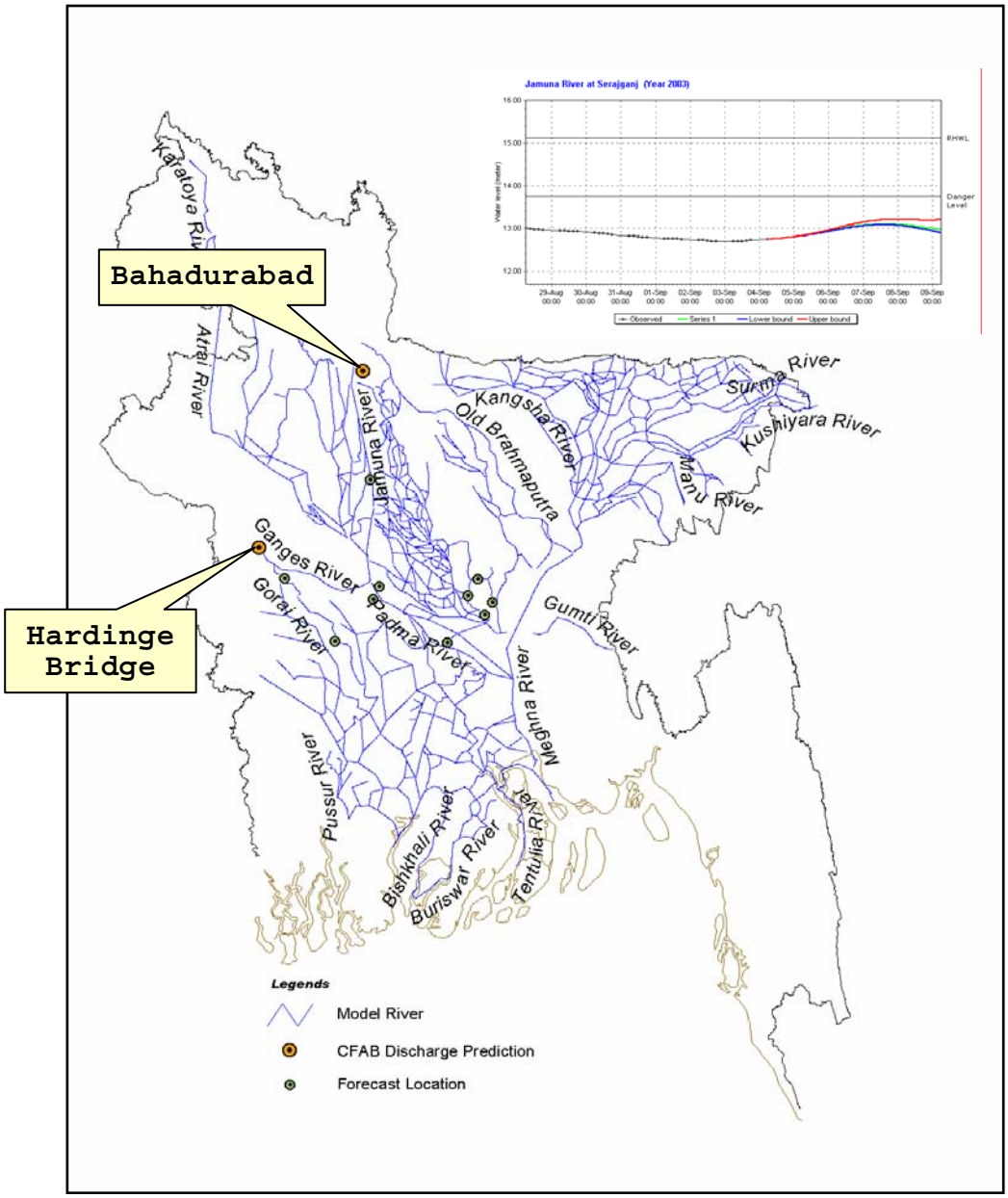



Fig 2: CFAB forecast station

**Goals and objectives of CFAB**

The main goal of the programme is to apply of climate forecasts products to mitigate adverse impact of weather and climate variability on the society and economy of Bangladesh.

Specific objectives of the programme are:

- Develop techniques and provide short, medium- and long-range forecasts of probability of rainfall, floods, storm surges and droughts
- Develop appropriate warning messages for end users.
- Agricultural Risk Management
- Disaster Risk Management

**Potential use of climate forecast products in Bangladesh**

**Flood forecasting**

The rapid development of computer simulations and models of natural phenomena (weather systems in particular), and the wide availability of satellite imagery in near-real time means that the flood events are increasingly predictable, with greater reliability over longer lead-times. CFAB has demonstrated successfully that medium-range (5 days to 2 weeks) and longer-range (monthly, seasonal) predictions of flood events could be possible with probabilistic approach based on climate forecasts.

These types of predictions could be made useful in planning agriculture or facilitating flood-preparedness measures and are as follows:

Medium range forecasts (5 days to 2 weeks):

- Taking decisions regarding early harvesting to avoid major crop damage.
- Planning of transplanting of rice crops
- Taking protection measures for saving assets and livestock
- Taking precaution for culture fisheries
- Planning flood response activities
- Taking precautionary measures to protect infrastructures (growth centres, food silos, embankments, Roads etc.)

Long range forecasts (monthly, seasonal) can help in

- Planning cropping strategy
- Planning national budget for relief, rehabilitation and reconstruction
- Planning flood and drought response activities

**Storm surge forecasting**

Most damages during a cyclone are due to the storm surges, which can inundate extensive areas. Therefore, accuracy of prediction of storm surge heights at different locations along the coast is essential for taking mitigation measures in advance. The existing cyclone forecast system can detect the cyclones, analyse their intensity, determine their position and track their motion using satellite information. But due to chaotic nature of this type of systems it has very low predictability due to its extreme sensitivity to initial conditions. Recent development of numerical ocean-atmospheric climate models have paved the way to better understanding of the motion of cyclone and prediction of storm surge height for given initial conditions. Probabilistic predictions could be made by analysing the system for a range of probable initial conditions.

Such predictions are possible in the scale of hours or a few days that has useful applications as follows:

- Disseminating warning messages regarding location and height of storm surge
- Evacuation of people from high risk areas
- Mobilisation of resources and planning relief and rehabilitation measures

**Forecasting of rainfall and droughts**

Prediction of rainfall and drought events are complex in the sense that it would require close monitoring of the soil moisture contents, groundwater tables,variation of evapotranspiration, cloudes distributed over a wide area for longer duration together with forecasting of dry spells. A combination of climate models with effective monitoring systems could provide useful information, which could be used for qualitative prediction of droughts. However, long-term (weeks and months) probabilistic forecast of precipitation based on outputs of climate forecasting models can help in anticipating drought events. This type of probabilistic drought forecasting can help as follows:

- Planning cropping strategy including irrigation plans and opting for drought tolerant crops
- Estimation of food crop production
- Planning national food import, storage and distribution programme

**Assessment of experimental CFAB forecast**

CFAB start delivery of experimental forecast during the summer monsoon 2003. The project performed experimental real-time long, medium and short-term forecasts of river discharge into Bangladesh for the summer of 2003. Short term and long-term forecast of CFAB are shown in

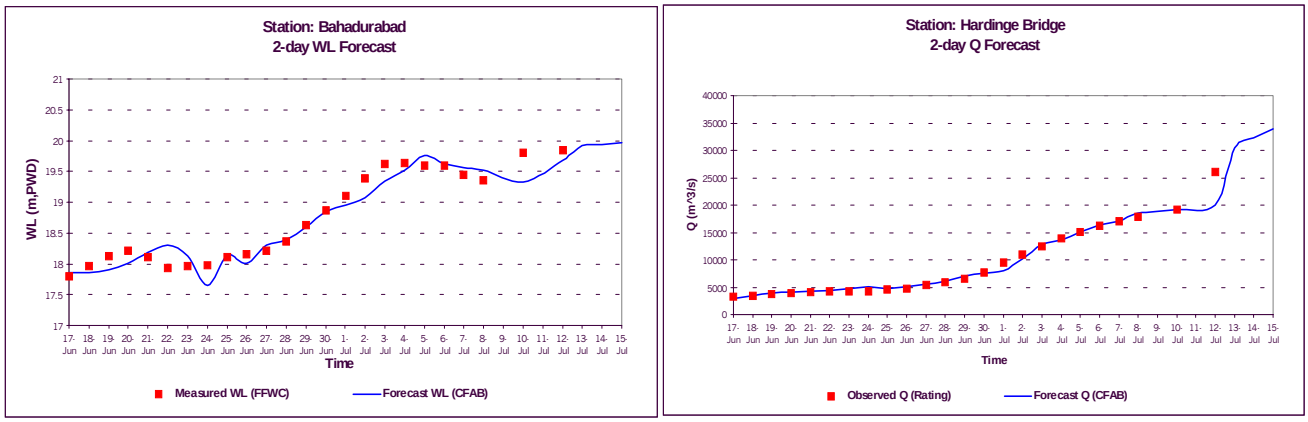



Fig 3: 2 days forecast by CFAB in HB and Bahadurabad station

the figure 3 and figure 4 for Brahmaputra at Bahadurabad and Ganges at Harding Bridge respectively. It is seen that the short term forecast are very close to observed discharge.

20-25 day forecast scheme developed a new statistical scheme for the forecasting of precipitation (and river discharge) into Bangladesh. The firm line show observed data and the doted line is forecasted (Fig 4). The figure shows that the discharge is increasing in the first half of July 03 and shortly decrease in the following half of the month. In case of the Ganges it is showing peak both in July and August 03 with a short period of decreasing trend.

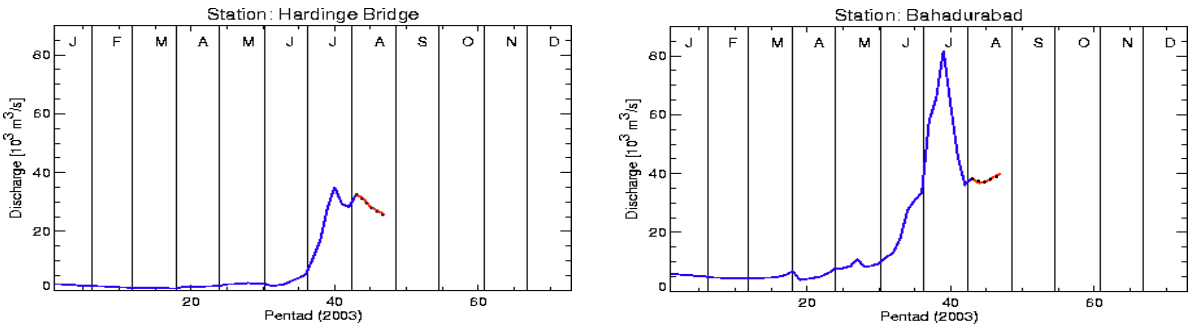
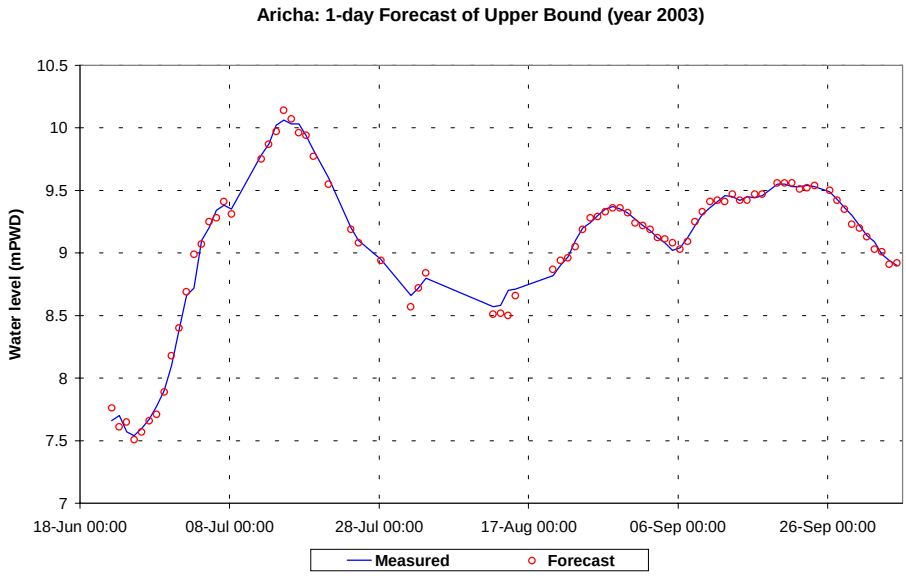



Fig 4: 20 days forecast in Ganges and Bahadurabad station.

In all selected series, the performances of forecasts deteriorates as it goes away from the time of forecast, i.e., the 1-day forecast performed better than 2-day forecast, 2-day forecast performed better than 3-day forecast and so on.

Plots showing the comparison of 1-day and 5-day forecasts at Aricha on Brahmaputra with the measured and forecasted levels have been presented below in Figure 5 and Figure 6




respectively. These results were obtained through customisation existing FF model with CFAB outputs.

Figure 5: Comparison of 1-day forecast with measurements

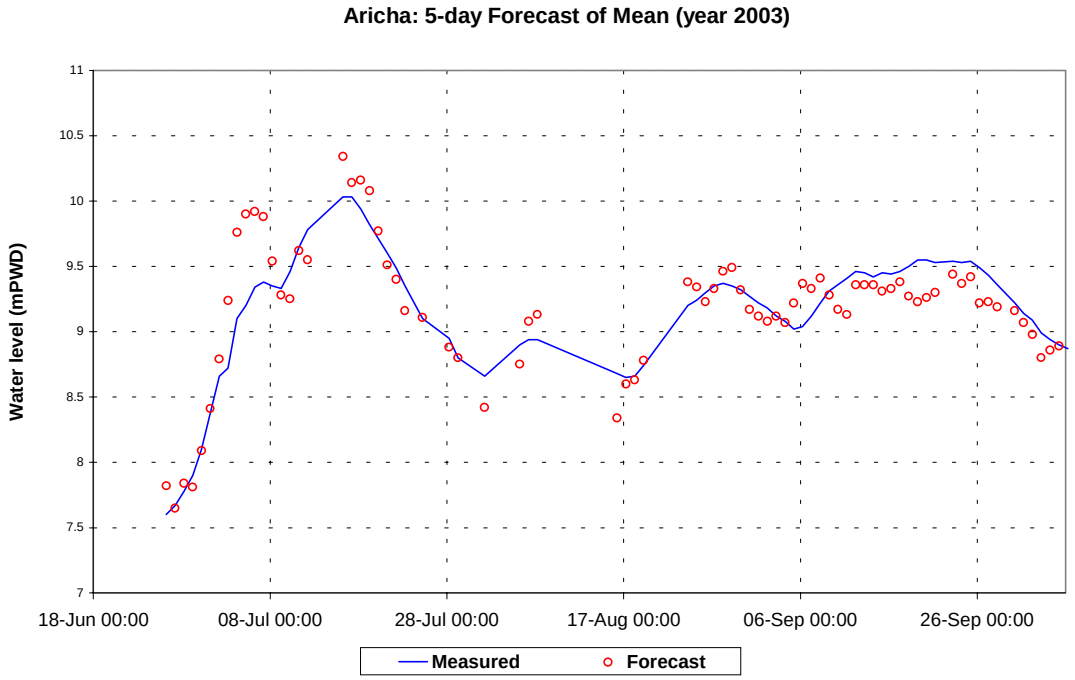



Figure 6: Comparison of 5-day forecast with measurements

## Customisation of FFWC model for using CFAB predictions

The updated FFWC model was taken for customization for real-time flood forecasting utilizing CFAB predictions. The customized FFWC model used in this project for the study of flood forecasting using CFAB predictions is hereafter called as “CFAB Flood Forecasting Study” or CFAB-FFS model

The flood forecasting modelling system uses three MIKE Zero modules viz., rainfall-runoff, hydrodynamic and flood forecasting modules. CFAB-FFS model provides water levels and discharges at model grid points and the water levels on the rivers during forecast period are flood forecast. Using Flood Watch utility programs, model forecasts were extracted to a format suitable for dissemination to partner organizations. Three sets of forecasts are being disseminated for 10 locations (figure 2)

Field discharge measurements were collected from BWDB Hydrology Division to verify the performance of 5-day CFAB discharge predictions on the Brahmaputra and Ganges rivers. However, only 4 measurements at Bahadurabad on the Brahmaputra were available in this data set to compare the forecasts against measurements. Although, these data are not sufficient to make an analysis, the 5-day forecasts (Series 1, Lower Bound and Upper Bound) were plotted against the measurement, which is presented in Figure 7. It can be seen from the plot that out of 4 cases, measured discharge stayed once within the Lower-Upper band. Except one occasion the Lower Bound performed better than other 2 series. This indicates that CFAB predictions were over simulated.

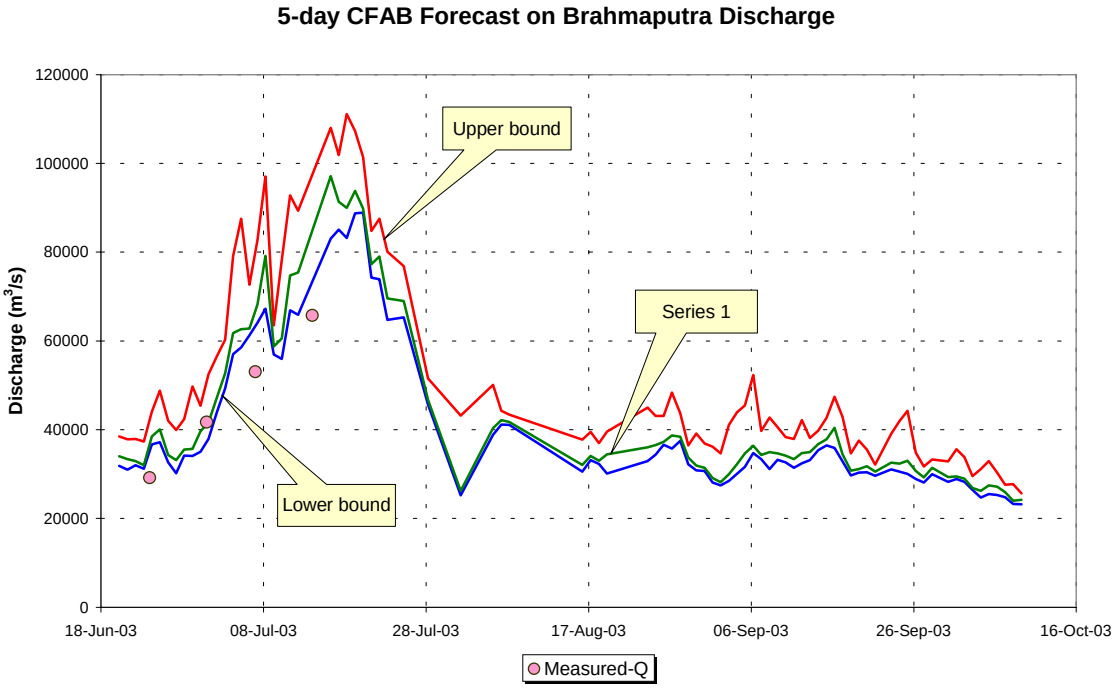



Figure 7: CFAB Prediction Vs Measured Discharge at Bahadurabad

Use of CFAB prediction data for the flood forecasting in Bangladesh has provided an excellent opportunity to assess the applicability of CFAB predictions, explore the possibility of increasing the lead-time in flood forecasting and ultimately providing early flood warnings to vulnerable communities and stakeholders. Application of CFAB data in 2003 monsoon flood forecasting showed a very encouraging results to increase the lead-time of flood forecasting in Bangladesh.

The Mean of 51 ensemble produced better forecasts during 4 and 5-day forecasts. The 1-3 day forecasts showed excellent capability both in accuracy and consistency.

**CFAB achievements**

Over the past three years of its implementation, the project has achieved the following:

- Partnership development. A strong partnership has been set up within Bangladesh to facilitate the development of flood forecasting schemes and their application. A Steering Committee, consisting of the Disaster Management Bureau – Ministry of Disaster Management and Relief (DMB-MDMR), Department of Agricultural Extension (DAE), Flood Forecasting and Warning Center (FFWC), Bangladesh Meteorological Department (BMD), Center for Environmental and Geographic Information Services for the water sector (CEGIS), Surface Water Modeling Center (SWMC) and ADPC,and CARE Bangladesh was formed. The Steering Committee meets regularly to guide project implementation.

  Internationally, in association with PAOS at the University of Colorado and the Earth and Atmospheric Sciences (EAS) at the Georgia Institute of Technology, collaboration has been developed with the European Center for Medium-range Weather Forecasts (ECMWF) for accessing its forecast products.

- Testing of long-term (1-6 months) forecast schemes. Historical data were used to initialize the long-range flood forecasting scheme. Results of the test indicated that major flood years could be predicted months before their occurrence – for example, the 1998 floods would have been forecast three months before their occurrence, giving sufficient lead time for anticipatory actions.

- Development of new medium-term (20-25 days) forecast scheme. A new statistical scheme for the prediction of rainfall (and river discharge) into Bangladesh has been developed, providing potential application for disaster management, particularly for the management of floods and drought.

- Establishment of skill of short-term (1-6 days) flood forecasts. The project has showed that short-term forecast can be extended from the current 2 days to nearly 8 days. This increase in lead time will allow emergency planning, and selective planting or harvesting to reduce potential crop losses at the beginning or end of the cropping cycle.

- Forecast application. A method to bridge the gap between producers and users of probabilistic forecasts has been developed through the generation of a User Metric that provides an aggregated risk analysis to aid a user community in making absolute decisions (for example, whether to harvest early to obtain 80% of the potential yield, or wait for two weeks for 100% yield or entirely loss the harvest).

- Delivery of experimental forecast during the summer monsoon 2003. The project performed experimental real-time long-, medium- and short-term forecasts of river discharge into Bangladesh for the summer of 2003, and the validation of which is presented in the following table:

Table 1. Experimental forecasts delivered during the summer monsoon 2003

| Type of forecast | General use | Forecast issued in May 2003 | Validation |
|---|---|---|---|
| **Long-term (1-6 months)** produced every 15th of the month for the next six months (most accurate for the ensuing 3 months) | Provides an overview of the coming season. Application includes long-term agriculture and water management planning and anticipatory actions to manage disaster risks. | More likely greater than expected water levels with some probability of dangerously above average flow for July. Most likely average to slightly below average river flow into Bangladesh for August. | Observed conditions through July showed rising trend of water levels; flood-associated damages were reported. In late July and early August, discharge into Bangladesh has decreased as forecast. |
| **Medium-term (20-25 days)** made separately for the Ganges and the Brahmaputra every 5 days. | Finer resolution compared to long-term forecast, applicable for timing of planting and harvesting, storage of water for irrigation, and logistics planning for flood management | Rising trend in water levels in the Ganges in mid-July, and in Brahmaputra in last week of July with discharge exceeding the danger levels. | Observed water levels agreed with the prediction quite well. Floods were confined to localized areas since peaks in water levels in Ganges and Brahmaputra were attained at different times in July. |
| **Short-term (1-6 days)** issued daily | Most certain forecast compared to medium- and long-term forecasts, with detailed information of river discharge into Bangladesh. Allows early decisions for flood and drought mitigation, and disaster management. | Early in the process, there were some deviations between forecasts and observed conditions particularly in the Brahmaputra basin in the first week of July, especially at extended time of the forecast period (>5 days). Mid-course correction was done and the deviations were narrowed down because of the interactive feedback mechanism established between the PAOS, University of Colorado, Boulder, USA, the Georgia Institute of Technology, USA and partner institutions in Bangladesh who provide regular feedback based on local observation. | |

Now that the institutional partnership is in place. Technology for climate and flood forecasting has been developed and experimentally tested during the summer monsoon 2003. There is a need to transfer this prediction technology to Bangladesh institutions, build the capacity of these institutions to use this prediction technology, and set up an end-to-end climate information application system where this prediction is translated and interpreted into a form (e.g. impact outlook) that is easily understood by end users such as farmers, fishermen and other communities whose livelihoods are affected by floods and drought.

**Conclusion**

The usage of increased understanding of regional climate systems for the production of local forecasts may be extremely valuable for the society and the environment in Bangladesh. In order to receive value-added benefits from the climate information, requirements of different users need to be looked into very carefully and to be met judiciously. More over, accuracy and lead- time of forecast is very important for a country like Bangladesh, which is a lower riparian country of three major river systems and drains huge run-off from a large catchments.

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