IMPORTANCE OF DISTRIBUTED HYDROLOGICAL MODEL FOR FLOOD MANAGEMENT IN BANGLADESH

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1. INTRODUCTION:

This study aims to demonstrate the need of a distributed hydrological model for the flood risk management in Bangladesh. The Ganges-Brahmaputra-Meghna (GBM) River basin is highly heterogeneous in geography and climate settings with a majority of the basin located outside of Bangladesh, which is situated at the river mouth. Bangladesh is a disaster prone country to natural hazards and experiences frequent floods causing large inundated area as in 1988 and 1998 (Fig. 1.A). Among those floods, the 1998 flood was the most devastating to the country, lasted for 63 days and affected 53 districts out of 64 (Fig. 1.B). To make the matter worse, the hydro-meteorological data required for national water management are not available from the upstream areas. In this study, although the study is still on-going, the preliminary results demonstrate the use of distributed hydrologic model to solve above challenges.

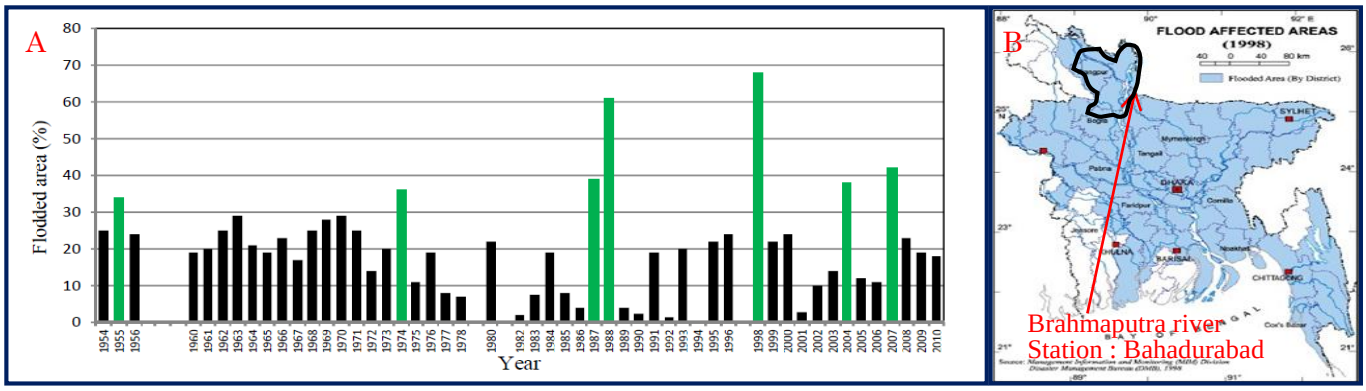

Fig. 1 Annual flood affected area of Bangladesh (FFWC, 2012); A) and Flood affected area in 1998 by District with 4 districts selected for this study shown in black; B)

1.1. Difficulties of flood risk management in Bangladesh

Currently, the major challenges of the effective flood risk management in Bangladesh are:

- No information about 97% water inflow from India and China.
- No flood control of Transboundary Rivers with more inflow during rainy season.
- Flat topography increases time of flood inundation.
- Storm surges such as Aila, Sidr etc. from the coast.
- Localized heavy rainfall (recorded highest on June 27, 2012, 463 mm/day)
- Poor risk management due to rapid increase of urban population and economic activity.

A distributed Hydrological Model can overcome the problem of limited data and provide us with the information of how much water is entering from the upstream area and of what the extent of flood inundated area.

1.2. Necessity of Distributed Hydrological Model (DHM)

A Distributed Hydrological Model (DHM) as against lumped model is required for the effective flood risk management in Bangladesh due to the following:

- Hydrological simulations in basins of upstream countries is necessary as
  - ✧ No data are exchanged or expected with upper basin nations.
  - ✧ Upstream basins are huge with multi-heterogeneity in geographical and climatic conditions.
- Hydrological simulations of localized rainfall are also necessary as heavy rainfall are intensifying.
- The stream network of the basins is very dense and complicated.

For the GBM river basin study, we selected a DHM model called BTOP, which is a block-wise TOPMODEL developed and described by Takeuchi et al. (2008), for the hydrological simulations and advisory of the national flood management .

1.3. Objective of the case study

The main objective of this study is to show how BTOP model is applied for the GBM basin hydrological simulations. The GBM basin hydrological simulations will be used for flood risk assessment in Bangladesh starting from an exposure assessment.

Keywords: Flood Risk Management, BTOP Model, FID Model, calibration
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2. CASE STUDY DESCRIPTION:

2.1. Target area

In this study, four districts with 20,000 sq. km. of area (Lalmonirhat, Kurigram, Gaibandha and Rangpur) of northern region of Bangladesh have been selected for flood risk assessment (Fig 1.B). The area is located along the bank of Brahmaputra River downstream of the Bahadurabad gauging station. Due to its geographical location and flat topography, the area is very much prone to flood.

2.2. Data

Hydro-meteorological information of precipitation and discharge are not available in the upstream area. Therefore, the daily WFD precipitation and temperature data was used for the BTOP simulation (Weedon et al., 2011). The potential Evapotranspiration estimated by the Shuttleworth-Wallace model using climate forcing data CRU TS3.1 (CRU, 2008) and a monthly normalized difference vegetation index (Tucker et al., 1994). The BTOP model was constructed on 20 km grid resolution using the HydroSHEDS (Lehner et al., 2008). Even though Bangladesh has many water level stations, the river discharge information is available only at the Bahadurabad gauging station.

2.3. Methodology

The flood risk assessment methodology consists of the following steps. In the first step, the daily river discharge is simulated with the BTOP model using globally available data. Using this simulated BTOP discharge, present and future inundation area to be estimated with the use of GIS-based Flood Inundation Depth (FID) model developed by Kwak et. al. (2012). Next, flood risk assessment of the target area is performed and quantified in terms of affected people. Finally, the effects of some structural adaptations will be assessed and recommended. The focus of this study is only the first step of the proposed methodology.

3. RESULTS AND DISCUSSIONS:

The goal of the BTOP calibration is to match the flood peal discharges during the wet season, especially 1988 flood. The BTOP simulated river discharge was calibrated to the measured and rating curve calculated river discharge (IWM, 2006) at the Bahadurabad station located on the Brahmaputra River (Fig. 2). Although parameter calibration for huge GBM basin is difficult, it seems the simulated and observed discharge are in good agreement and the statistical indices used to evaluate the hydrograph simulation are close to the best fit of 1: Nash-Shuffle Coefficient = 0.79 and the Coefficient of Determination = 0.62.

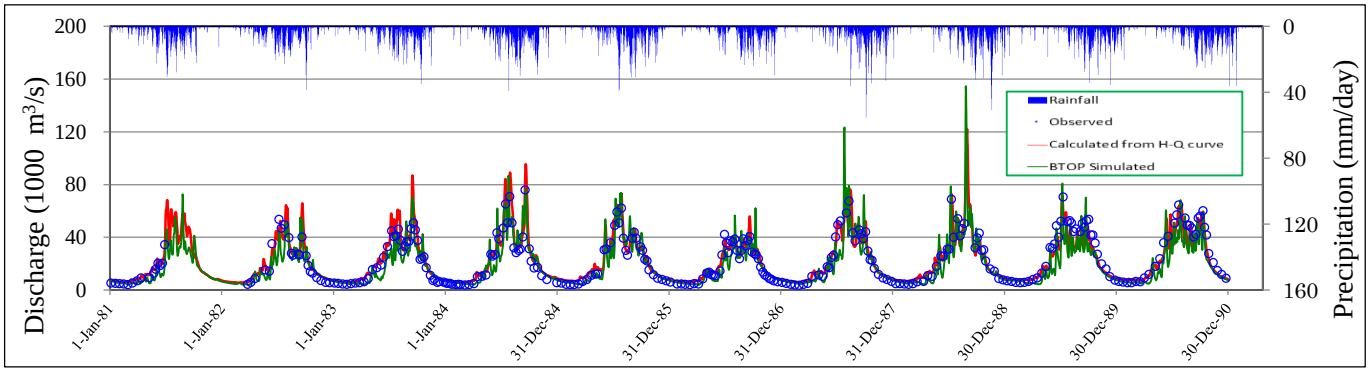

Fig. 2 Observed, calculated and BTOP simulated discharge of Brahmaputra River at Bahadurabad station.

4. CONCLUSION:

Without considering the simulation of the GBM basin with DHM, Bangladesh could not be able to manage flood in the future. The results of this study will have a great impact in flood management specially reducing flood damages in Bangladesh. Structural adaptations as well as early warning systems regarding flood disaster management in most affected areas can be improved based on the result of this study.

RERERENCES

Flood Forecasting and Warning Center (FFWC), Bangladesh Water Development Board, Bangladesh. Annual Flood Report of Bangladesh, 2012; www.ffwc.gov.bd.

IWM, Updating and Validation of North Weat Region Model (NWRM) Rep., 2006, Institute of Water Modelling, Bangladesh.

Kwak Y, Takeuchi K., Fukami K., Magome J. A new approach to flood risk assessment in Asia-Pacific region based on MRI-AGCM outputs. Hydrological Research Letters, 2012, Vol.6, pp.70-75.

Lehner, B., Verdin, K., and Jarvis, A.: New global hydrography derived from spaceborne elevation data. Eos, Transactions, AGU, 89(10): 93-94, 2008, http://hydrosheds.cr.usgs.gov

Takeuchi K, Hapuarachchi P, Zhou M, Ishidaira H., Magome J. A BTOP model to extend TOPMODEL for distributed hydrological simulation for large river basins, 2008.

Tucker, C. J., J. E. Pinzon, and Brown, M. E.: Global Inventory Modeling and Mapping Studies, NA94apr15b.n11-VIg, 2.0, Global Land Cover Facility, University of Maryland, College Park, 1994.

University of East Anglia Climatic Research Unit (CRU). [Phil Jones, Ian Harris]: CRU Time Series (TS) high resolution gridded datasets, NCAS British Atmospheric Data Centre, 2008.

Weedon, G. P., S. Gomes, P. Viterbo, J. Shuttleworth, E. Blyth, H. Osterle, J. C. Adam, N. Bellouin, O. Boucher, and M. Best, Creation of the WATCH Forcing Data and its use to assess global and regional reference crop evaporation over land during the twentieth century, J. Hydrometeorol, 2011, 12, 823–848.