FLOOD HAZARD MAPPING OF DHAKA-NARAYANGANJ-DEMRA (DND) PROJECT USING GEO-INFORMATICS TOOLS

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ABSTRACT

Dhaka-Narayanganj-Demra (DND) Project is one of about 700 water sector projects built by Bangladesh Water Development Board (BWDB) in Bangladesh. It was a successful project from all considerations. But during 1998 flood, there was overtopping and breaching of embankment. At that time BWDB was able to stop much inundation by doing emergency work. Still many people are building their houses and factories in low-lying area. The study area is nearer to central Dhaka city. So urbanization is increasing rapidly. Again, due to global warming, intensity and magnitude of different disasters are increasing. That is why this project is chosen as study area to examine the inundation depth in overtopping occurrence and that result is used to prepare an informative Flood Hazard Map.

A flood hazard map of DND Project was developed using the 1988 flood data. The inundation simulation was conducted using ArcGIS and HEC-RAS considering water level of 6.93 m at Shitalakhya river and that of 7.23 m at Buriganga river. The analysis shows that about 21 % of the total study area has been inundated by less than 1 m depth which is 45 % of the total inundated area. 15 % of the total study area has been inundated by 1 m to less than 2 m depth which is 32 % of the total inundated area. So in total 36 % of the total study area has been inundated by less than 2 m depth which is 77 % of the total inundated area. The maximum inundation depth has been found 6.67 m. This affected about 47 % of land of the study area and about 250,000 people. But the residents are not aware of it. The results obtained in this study would provide essential information for flood plain management aimed at containing flood damages in future. The way of dissemination of FHM has been done to raise public awareness.

Keywords: Flood Hazard Map, Inundation Simulation, DND

INTRODUCTION

Bangladesh is one of the most disaster prone countries in the world. It is a low-lying deltaic country, which is situated in South Asia, is formed by the Ganges, the Brahmaputra and the Meghna rivers. The study area is Dhaka-Narayanganj-Demra (DND) Project. The area is about 56.79 sq. km and about 800,000 people are living here. During 1998 flood, there was overtopping and breaching of embankment. At that time BWDB was able to stop much inundation by doing emergency work. Still many people are building their houses and factories in low lying area. The housing companies have acquired cheap land in flood plains and developed residential colonies there, which are very vulnerable to flooding. Due to global warming, intensity and magnitude of different disasters are increasing. Hence, there is a need to have a decision support system for the planners and developers.

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The important reasons of selecting the area are: 1.The area is very important as it is very near to the central Dhaka city; 2.Urbanization is progressing rapidly in this area with the increasing population; 3. Vulnerability of the residents is also increasing rapidly; and 4. Availability of Data.

The goal of this thesis is to examine the inundation depth when overtopping occurs and to prepare an informative Flood Hazard Map and the way to disseminate the information to increase awareness of residence.

Geographic Information System (GIS) provides state of the art methods for the analysis and presentation of spatial and temporal data and information which are easily visualized by the administrators and planners. The flow and transport phenomena of the river can be easily modeled using hydrodynamic models.

Fig. 1 Location of Study area with respect to Greater Dhaka city

DATA

In this analysis two types of data have been used. They are Hydrological data and Topographic data. Hydrological data includes discharge and water levels of Shitalakhya and Buriganga River. Topographic data includes Digital Elevation Model (DEM), Satellite image and Land use map of the study area. The used stage hydrograph of 1998 flood have been shown in Fig. 2 and 3.

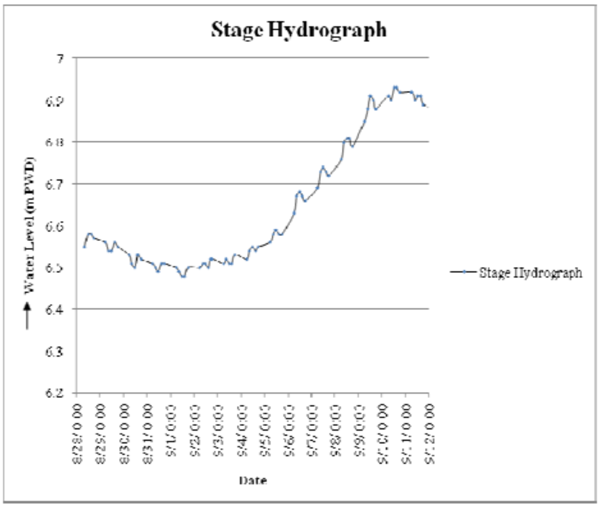

Fig. 2 Stage hydrograph at Demra of Shitalakhya river during 1998 flood

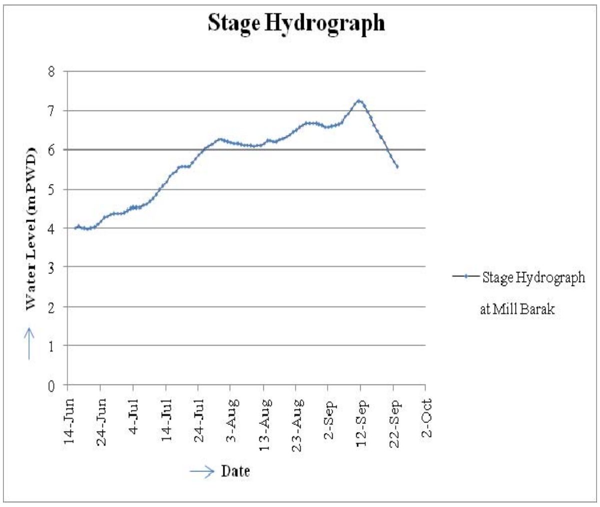

Fig. 3 Stage hydrograph at Mill Barak of Buriganga river during 1998 flood

METHODOLOGY

Geo-informatics provides various tools for the analysis and visualization of spatial and temporal data. In this study, ArcGIS 9.1 (ESRI, 1999) and HEC-RAS 3.1.3 (Hydrologic Engineering Center, 2002) have been used. HEC-RAS have been used in this study to acquire cross-sections from DEM, to interpolate flood water levels between sections, to compute flood depth from DEM and the preparation of hazard maps.

HEC-RAS is one-dimensional hydrodynamic model capable of performing water surface profile calculation for steady and unsteady flow in natural or constructed channels. The water surface profiles for unsteady flow are computed by solving the continuity and momentum equations which are expressed mathematically in the form of partial differential equations. Within HEC-RAS, these equations are solved using four-point implicit finite difference scheme also known as box scheme. In this study, HEC-RAS is used to compute unsteady and steady flow water level along the channel reach for 1998 flood, which is required to prepare a flood hazard map.

The methodology as shown in flow chart of Fig. 4 can be summarized as following steps: 1. Preparation of Digital Elevation Model (DEM); 2.Delineation of watershed and drainage network; 3.Applying of Boundary conditions and cross-section data; 4.Estimation of spatial and temporal variation of stream flows for different flood events using hydrodynamic model (HEC-RAS); 5.Preparation of flood hazard map for severe flood events using GIS; and 6.Find out the way to disseminate flood hazard map to increase awareness.

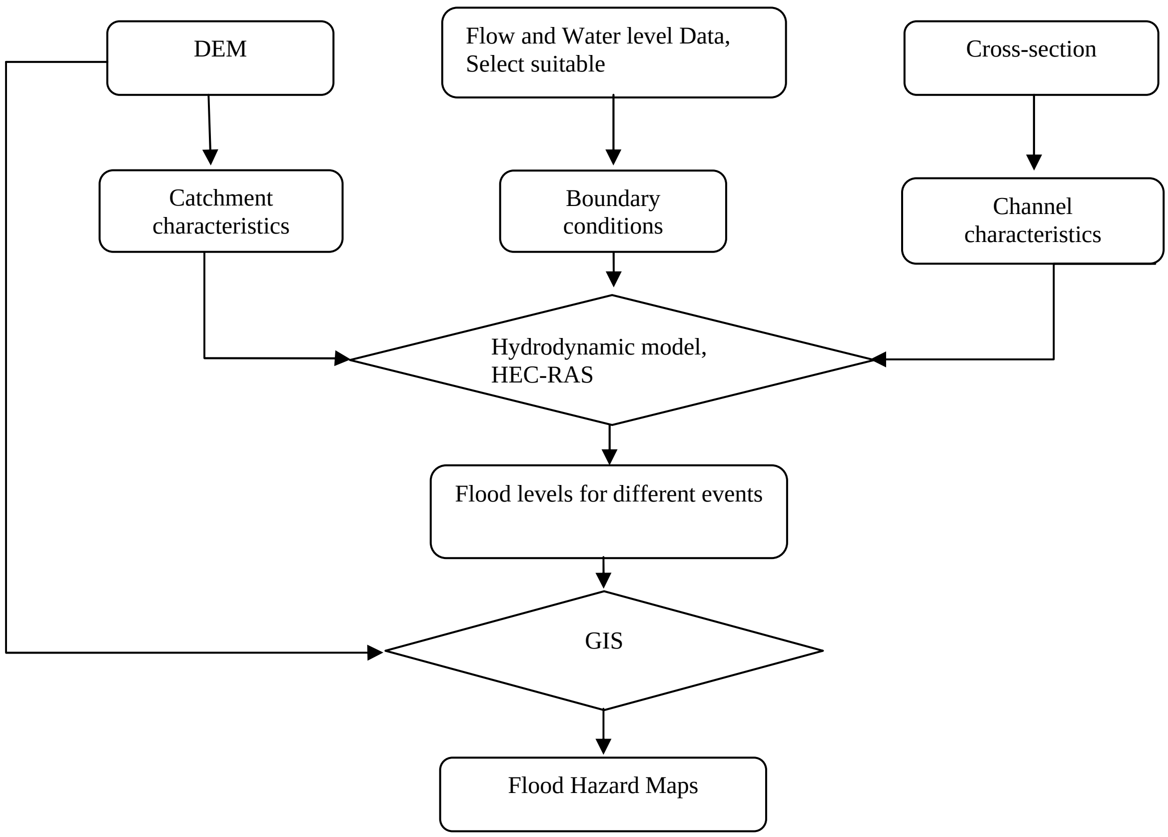

Fig. 4 Flow chart of Methodology

DEM data file for this study has been collected from the HydroSHEDS (Hydrological data and maps based on Shuttle Elevation Derivatives at multiple Scales). For this study, DEM of the study area has been extracted from these DEM data which is shown in Fig. 5. And the data have been checked with some actual ground elevation data near the study area.

Satellite image was collected from Google Earth which is not Geo-referenced. So the image has been Geo-referenced according to the geographic co-ordinate system. DEM is also in geographical coordinate system: GCS_WGS_1984. Then the DEM and Geo-referenced image have been projected into coordinate System: WGS_1984_UTM_Zone_45N from the geographical coordinate system.

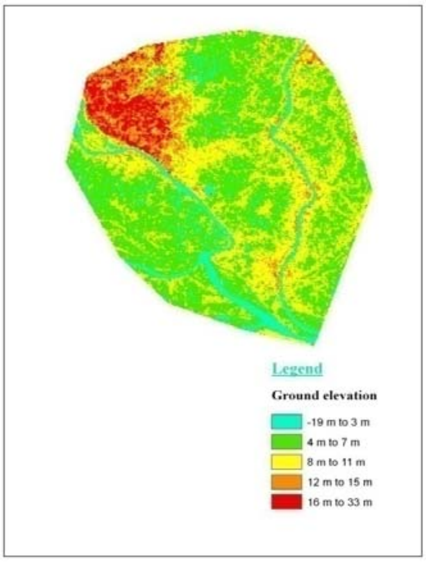

Fig. 5 Extracted DEM of the study area

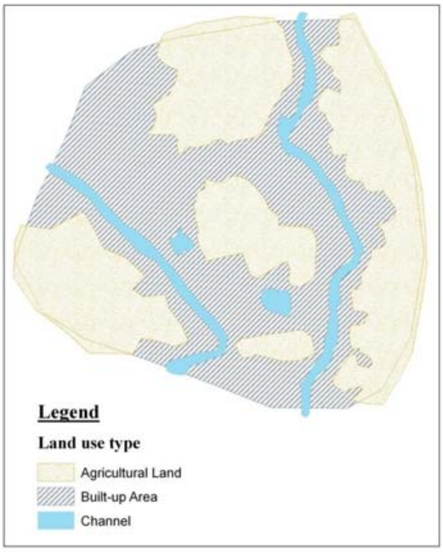

Fig. 6 Created Land Use map of the study

It is observed that for analysis of large area, downloaded land use map can be used. In case of small area we need detailed land use map. So a detailed land use map has been created with the help of ArcGIS. Created land use map is shown in Fig. 6.

Different Manning's n value has been assigned for different land use type which is shown in Table 1 (Chow, V. T., Maidment, D. R., and Mays, L. W. 1988).

Table 1 Assigned Manning's n Value for Different Land Use Type

Land Use Type	Manning's n Value
Built-up Area	0.08
Channel	0.04
Agricultural Land	0.035

SIMULATION RESULTS AND OBSERVATIONS

The simulation has been done for three cases. Firstly unsteady flow analysis has been done with discharge data of 1988 and 2005 flood events. Secondly steady flow analysis has been done with water level data of 1998 flood event. Finally unsteady flow analysis has been done with water level data of 1998 flood event. Second and third analyses give same result which has been used for flood hazard map.

The analysis shows that about 47 % of the total study area has been inundated. 21 % of the total study area has been inundated with less than 1 m depth which corresponds to 45 % of the total inundated area. 15 % of the total study area has been inundated with 1 m to less than 2 m depth which accounts for 32 % of the total inundated area. So in total 36 % of the total study area has been inundated with less than 2 m depth which accounts for 77 % of the total inundated area. The maximum inundation depth has been found 6.67 m. The detailed result is shown in Table 2.

Table 2 Result of Steady and unsteady flow analysis with water level data

Level of inundation depth	Inundated area (km^2)	Inundated area (% of total inundated area)	Inundated area (% of total study area)
Less than 1 m	12.75	45	21.19
1 m to less than 2 m	9.03	32	15.01
2 m to less than 3 m	4.50	16	7.48
3 m to less than 4 m	1.29	5	2.15
4 m to 6.67 m	0.82	3	1.36

The inundation depth obtained in all simulations at different location has been found reliable because it matches with the field condition. The study area is surrounded by two rivers –Shitalakhya and Buriganga. During flood time the water level in the both rivers are almost the same. For that reason, simulation with one of these rivers or both rivers gives same inundation depth. It is observed that at the boundary of two rivers inundation was all most same.

It is observed that inundation depth is almost same for all simulations. But inundation depth is little more for 1998 flood event. So the results obtained in case of steady and unsteady flow analyses with water level data of 1998 flood event have been used for flood hazard map.

FLOOD HAZARD MAPPING

Flood hazard map have been prepared on the basis of inundation map for unsteady flow analysis with water level data of 1998 flood event. This flood hazard map has been prepared following the Flood Hazard Mapping Manual. This manual was prepared by Flood Control Division, River Bureau, Ministry of Land, Infrastructure and Transport (MLIT), Japan. To prepare a good flood hazard map, town watching and discussion with residents are essential. But that can not be done because study area is far away from here. So location of flood evacuation centers, disaster prevention organizations, flood fighting depots, flood warning speakers and sirens could not be set exactly in the flood hazard map. The final hazard map is shown in Fig. 7.

After preparation of Flood Hazard Map, it is difficult to make it useful. That is why dissemination of flood hazard map is an important task especially in developing countries like Bangladesh. If the distribution can be done properly, it will be helpful to increase awareness. Dissemination should be promoted within all divisions of municipality.

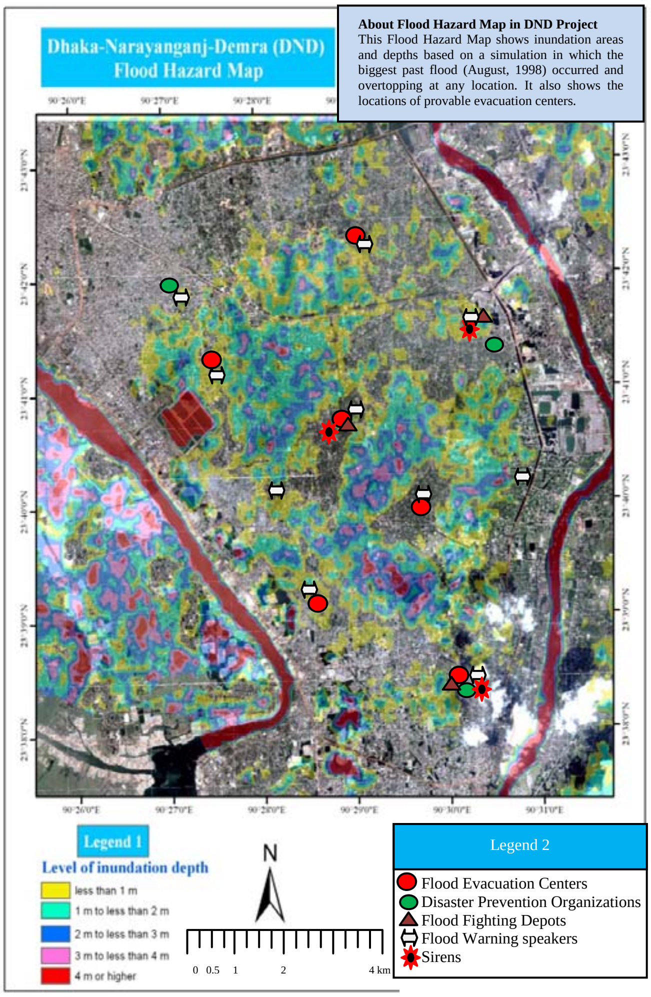

Fig. 7 Dhaka-Narayanganj-Demra Flood Hazard Map

CONCLUSION

Total inundated area is about 28 km^2 which is about 47 % of total study area and the affected people are about 250,000. Inundation depth ranges from 1 to 3 meter is about 87 % of total inundated area. The north-western part and area nearer to embankment are mostly unaffected. The area which is a little bit away from embankment is mostly vulnerable because many people constructed their houses at lower elevation. The central part has high inundation depth.

RECOMMENDATIONS

The major focus of this study was to assess the vulnerability of the people in this area regarding high flood in Bangladesh. From the results of this study, it appears that if breaching of embankment or high flood occurs, serious damage will be occurred. So, necessary steps should be taken by the government to improve this condition.

Major recommendations for improvement of the project are summarized below:

1. The software HEC-RAS has been used for hydrologic simulation. It allows performing one-dimensional steady flow and unsteady flow calculations. Two-dimensional modeling software can be used for future studies to compare results obtained here.
2. A more detailed Flood Hazard Map can be prepared by conducting town watching and interview with residents and local leaders in the future.
3. For simulation, only river flow is considered. Rainfall, evaporation, percolation can be included for further studies to get better result.
4. After preparing a detailed Flood Hazard Map, it should be distributed to the people in some meeting with the residents. It will be helpful to increase awareness about the flood.
5. During the preparation of Flood hazard map, participation of residents and local leaders is essential to make it useful and to increase awareness and responsibility.

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