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Urban Flood Scaling Using Hydrologic and Hydraulic Models with Inception for Early Warning

Romeji Ngangbam, Amaljit Bharali, and Sonamani Kangjam

Abstract*—Urban floods are generally characterized by surge in runoff volumes resulting in high flow peaks and water depths incurring huge socio- economic losses. Hydrologic and hydraulic simulation tools integrated with ground survey inputs can be effectively used to simulate the movement of flood waters in intricate urban environments. Integration of hydrological–hydraulic flood models supported by geospatial tools and hydro-meteorological analysis is one effective measure to comprehend urban flooding. Numerical Weather Prediction (NWP) models as WRF aided aided by Nowcasting DWR observations is one resourceful tool for urban flash flood forecasting. The NWP forecasted precipitation data is conglomerated to a distributed hydrological model to derive flood hydrographs. The theme of the study is to establish flood runoff thresholds in one of the most flood-prone urban region of India – Guwahati city, by simulating the spatial flooding extents, developing flood runoff thresholds and to scale the flood events. Database build up for actual flooding events, ground reconciliation using ETS-RTK survey, setting up of Base Flood Elevation (BFE) points for hydraulic model integration was done. The resulting hybrid DEM (1m resolution) was adopted for building the spatially-distributed hydrological model in HEC-HMS. Model runs were carried out to derive flood runoff hydrographs and peak discharges using time series NWP–WRF and AWS data. Drainage active areas, building footprints and blockages in storm drains were laid over the high resolution 1m bathymetric grid in hydraulic MIKE FLOOD model. Flood inundation simulation using runoff hydrographs were carried out under source/sink pairs. Schematization of the simulated flood inundation layers using threshold scales of flood discharges was used to develop a scaling of the urban flooding in Guwahati, with early warning inception.

***Index Terms*—Urban, flood, hydrological–hydraulic, integration, hydrographs, schematization, scaling.**

I. INTRODUCTION AND REVIEW OF STUDIES

Urban flash floods are generally characterized by surge in runoff volumes and flow velocities, resulting in high flow peaks and water depths resulting in public woes and incur huge socio-economic losses. Urbanization alters a watershed's response to precipitation. The most common effects are reduced infiltration and decreased travel time, which significantly increase peak discharges and runoff [1]. Hydrologic and hydraulic simulation tools integrated with ground survey inputs using GIS schematization provide a viable solution to understand the movement of flood waters in intricate urban environments. The most common effects of urbanization in hydrological context are reduced infiltration and decreased travel time, which significantly increase peak discharges and runoff [2]. Amongst the urban conglomerates in the north-east region of India, Guwahati city, which serves as the gateway to most of the other states in the region, perpetually suffer from urban flash flooding every year. Flood events, notably in 2012, 2014 and 2017 have witnessed huge socio-economic losses. The spatial parity of the flood events with the geomorphologic aspects in a basin to assessed the potential or highly-flood prone zones has degrees of uncertainty which depend on the typical basin and hydrodynamic characteristics [3].

The theme of the study is to establish flood runoff thresholds in the intricate urban catchment, simulate the spatial spread of floodwater using adaptive hydraulic flood propagation models, and develop flood runoff thresholds using modelled flood hydrographs of actual flood events along with simulated flood inundation layers. The next target is to formulate a block for an operational flood forecasting mechanism with ample lead time to assist administrators in flood disaster preparedness using a coupling of hydro-meteorological modelling aided by real-time Doppler Weather Radar (DWR) observations. The application of the USACE Hydrologic Engineering Centre (HEC) models for urban hydrologic analysis [4] has initiated to the development of urban flood models. Water Management Model of United States Environmental Protection Agency (EPA-SWMM) and traditional flood simulation model (FLDSIM) developed by National Institute for Land and Infrastructure Management (NILIM), Japan comprising of (i) MESHSIM to simulate the 2D overland flow using mesh-network and (ii) RIVSIM to simulate the 1D flow through river-network have been used to as an integrated modelling approach to predict flooding on urban basin [5]. Studies have been done on developing an urban flood inundation model by coupling a one-dimensional (1D) model with a two-dimensional (2D) model to overcome the drawbacks of each individual modelling approach, with an additional module to simulate the rainfall-runoff process in urban areas [6]. 2D modelling of floodplain dynamics and rainfall–runoff processes involving urbanized areas are generally hampered by the strong geometrical variability of the urban network cell, inducing an important hydraulic variability. The shallow-water model equations with porosity can be effectively used to account for the reduction in storage and in the exchange sections due to presence of buildings and other structures on the urban floodplains. The introduction of the porosity in the shallow-water equations modifies the expressions for the

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fluxes and source terms [7].

II. STUDY AREA

Guwahati urbane has drastically undergone incipient flooding and inundation pattern in the last decade. The rapidly developing metropolitan environment has indiscriminately changed the large vacant lands, natural drainage controls, etc. Some of the roads have the road side drains and some have inadequate gradient and storm discharge conveyance. The city is located in a valley belt surrounded and interspersed by hillocks and thus experiences recurrent flood inundation and severe water logging during flashy and high intensity storm events and particularly during the rainy season, it has become a public grievance.

Guwahati, the capital of Assam state, is one of the rapidly growing metropolitan cities in the north-eastern region of India. It serves as the gateway to the north-east of India and ranks 44 among the 5230 urban centers of India. Guwahati urbane is bounded by latitude 26º 05' N to 26º 10' N and 91º 30' E to 91º 50' E longitudes (Fig. 1). Guwahati Metropolitan region covers an area of 261.77 sq. km (as per Master Plan) with a population density of the order of 3750 persons/sq km. Of late the city is facing anthropogenic stress due to rapid rise in population and urbanization. Guwahati urban is a crescent shaped basin, surrounded and interspersed by lofty hills (Fig. 1), which are outliers of Meghalaya Plateau, and this variant topography acts as a sink basin for storm water [8]. Some of the prominent hills in Guwahati urban are: Nabagraha-Sunsali hill series situated in extreme north eastern corner, Japorigog hill situated in the extreme east, Sonaighuli-Jutikuchi situated in the south, Jatiya -Kahilipara- Odalbakra in the south and southwestern side, Kamakshya hill situated in west central, Fatasil hill situated in south-west, Jalukbari hill in the extreme south western corner of the city, Khanapara hill situated in the extreme south eastern corner of the city, etc. The major natural drainage system of the city is the river Brahmaputra which flows along the northern boundary with an average width of about 1.5km. The other streams forming the natural drainage system are the Bharalu, Digaru, Amchang, Mora Bharalu, Borapani, Khanajan and Bondajan.

III. DATABASE

To establish efficient flood forecasting exercise in urban catchments, the following database have been reconciled and used in the study:

A. Historical Flood Database and Records

These are extremely important sources of information about where these phenomena have occurred in the past, and what their extent was. With today’s increased mobility, however, people are not always sources of information that can allow us to identify catastrophes from long ago.

B. Meteorological and Hydrological Data

This information allows us to evaluate with a fairly high degree of accuracy where floods have taken place and what their extent was. For regions situated far from rivers, they only allow us to estimate what sort of rainfall caused the phenomenon to take place (duration, intensity).

(a) Rainfall data (hourly, daily) for last 25 years, and predicted NWP rainfall values

(b) Discharge and water level data of rivers and major drainage channels/storm sewers

(c) Sewer and drainage network of urban sphere

(d) Cross-section and Longitudinal profiles of rivers and major drainage / sewer channels

C. Spatial and Ancillary Data

(a) Digital Elevation Model (DEM) in fine resolution, and satellite imagery

(b) Design Flood

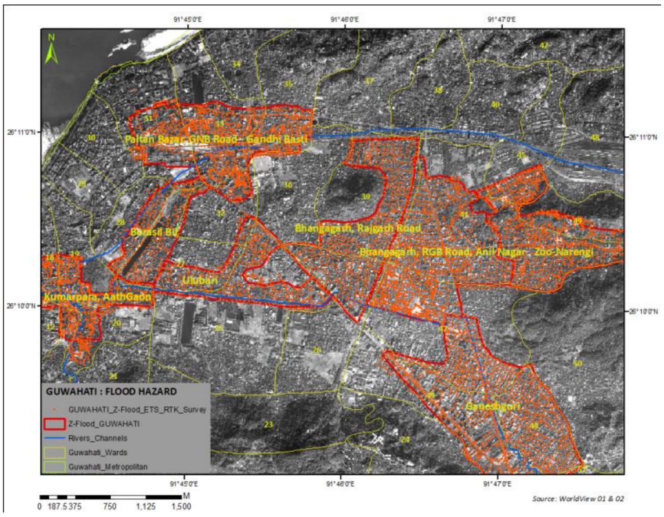
(c) Land Use Land Cover

(d) Soil Map

(e) Urban city map layout, Building Footprints, etc

D. Hybrid Digital Elevation Model

For intricate urban watersheds, refined DEM/DTMs are essential. As the main constraint is in getting a sub-metre contour topographic map or fine resolution DEM, a hybrid DEM is developed by using Z-flood points obtained from RTK/ETS ground survey and integrated with the DEM/DTM derived from photogrammetric processing of CARTOSAT-1 stereo satellite data. The hybrid DEM is the fundamental topographic data used for development of the urban catchment hydrological model component and the hydraulic flood simulation platforms.



Source: WorldView 01 & 02

Fig. 1. Study area: Guwahati metropolitan and wards – Highlighted zones (in red) are core study zones).

IV. OBJECTIVES OF THE STUDY

The theme of the study is to establish flood runoff thresholds in the intricate urban catchment, simulate the spatial spread of floodwater using adaptive hydraulic flood propagation models, and develop flood runoff thresholds using modelled flood hydrographs of actual flood events along with simulated flood inundation layers. The next target is to probe for an operational flood forecasting mechanism with ample lead time to assist administrators in flood disaster preparedness using a coupling of hydro-meteorological modelling aided by real-time radar (as Doppler Weather Radar) observations. The overall objective of this study is to demonstrate the potential benefits of high-resolution weather radar data in quantitative precipitation nowcasting, high resolution NWP precipitation forecast, physically-based distributed hydrological modelling, and hydraulic flood inundation modelling for urban runoff estimation with spatial extent and author flash flood forecasting. The results of the study will support the Guwahati metropolitan administration in coping up with urban flood disaster preparedness and management by providing quantitative rainfall/ flood advisory with maximum possible lead time for viable flood disaster risk reduction. An outline of the study is listed below:

- Enhancement of robust numerical weather prediction models as WRF, in fine 1km grid aided with multisource data analyses from Doppler Weather Radar observations for real-time urban flood forecasting.
- Ensemble Hydrological and Hydraulic Flood Inundation modelling for detail analysis of flood hydrographs and spatial extent of flooding in complex urbane environment.
- Develop flood thresholds based on runoff hydrographs and rainfall intensities (from recorded flood and storm events) and test for flood flow forecasting in Guwahati urbane.

V. METHODOLOGY AND APPLICATION

Studies have been done on developing an urban flood inundation model by coupling a one-dimensional (1D) model with a two-dimensional (2D) model to overcome the drawbacks of each individual modelling approach, with an additional module to simulate the rainfall-runoff process in urban areas [9]. In the present study, a quasi-distributed hydrological model in HEC-HMS platform using ground-based Automated Weather Station (AWS) precipitation data, Doppler Weather Radar (DWR) and WRF predicted data is used to obtain the flood runoff and hydrographs for Guwhati urban catchment on a 1 to 3-hourly scale. The flow process followed in the study is shown in Fig.2.

A. Hydro-Meteorological Data Analysis

The rainfall data analysis showed that there are storms and surges in the annual intensity-duration-frequency (IDF) trend in the last 10 years as shown in Fig. 3. Monthly total rainfall peaks ranged between 80 mm upto 400 mm in the last 10 years. The recent flood event between 25 to 26 June, 2014 in Guwahati recorded an accumulated rainfall in the scale of 87-146 mm in 3 hours (source: AWS). These rainfall storm events have induced flood inundation and water logging in parcels of Guwahati metropolitan. The analysis of the monthly rainfall data showed that the average annual rainfall is about 2355 mm and out of this about 22% of the annual precipitation occurs in April & May and about 65% of the precipitation occurs in the period of June, July, August and September. However, it can be introspected that the rainfall intensity has a bearing with the induced surface overland flow and drainage discharge capacities (over that it was already conveying prior to the storm event).

B. NWP–WRF and Nowcasting Using Doppler Weather Radar (DWR) Observations

Coupled Hydro-meteorological models are used to forecast floods; accurate estimation of rainfall prediction in quantity over refined grids plays a crucial role in the hydrological rainfall-runoff model process. Numerical Weather Prediction (NWP) uses "models" of the atmosphere and computational techniques to forecast weather conditions in both space and time domains. Many weather forecasting organizations have developed their own models. During the last decade or so, the most effective technique used to predict the weather condition for forecasting, is the high resolution Weather Research and Forecasting (WRF) model, because of its highly developed physics schemes and oriented time integration method to give improved output at shorter durations [10]. It features multiple dynamical cores, a three-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. In the present study the basic inputs for the WRF model run are the initial conditions of the atmosphere (as terrestrial data, radiance, cloud motion vector, etc) and the boundary condition of the domain. These inputs are globally generated and they may not represent the local mesoscale conditions fully for a particular region which may result in inaccurate model outputs.

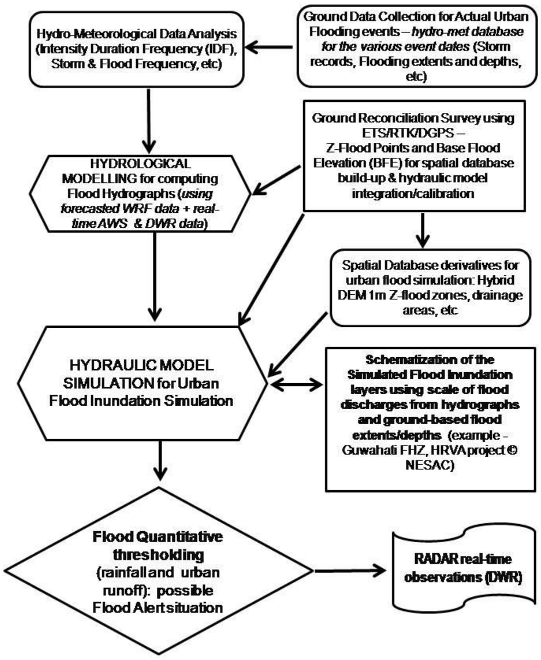


Fig. 2. Workflow adopted in the study.

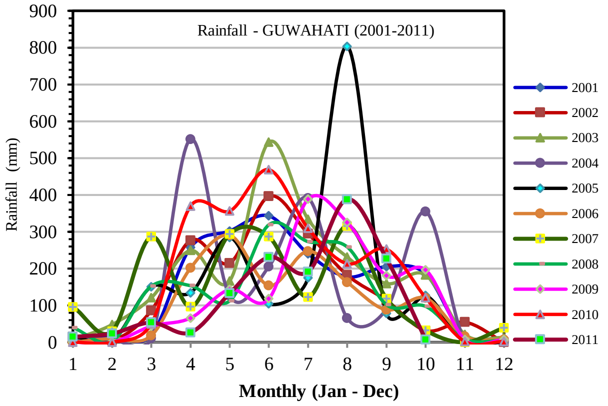


Fig. 3. Rainfall pattern in Guwahati during 2001-2011 (source: IMD – RMC, Guwahati)

Thereby a data assimilation scheme is done in parallel using ground Automated Weather Station (AWS) data and Kalpana-1 satellite-based Cloud Motion Vector (CMV) observations to improve the accuracy of the forecasted precipitation data in 1-to 3-hourly time scales with lead time of 48 to 72 hours (Fig. 4a).

A combination of high-resolution weather radar precipitation estimates, physically-based distributed hydrological modelling, and quantitative precipitation in 3-hourly nowcasting may be taken as one effective standard procedure to address urban flood hydrological disaster.

TABLE I: BOUNDARY DOMAIN USED IN THE WRF MODEL

Central Lat Lon	21°N 88°E
Number of grids	180 ×180 , 184 × 184
Horizontal resolution	3 km, 1 km
Vertical levels	36
Time step	120 sec
Projection	Mercator

Nowcasting systems as RADAR is used to provide quantitative precipitation forecasts that are a great potential for flood warning and short-term forecasting in urban catchments related with extreme storm events [11]. The basic parameters available from Doppler Weather Radars are Reflectivity (Z), radial velocity (V) and spectral width (ω). Based on standard algorithms and assumptions, various products of practical utility for issuing forecasts and warnings are generated from these base parameters. Six main products namely Plan Position Indicator PPI(Z), PPI(V), Max(Z), Volume Velocity Processing (VVP2), Surface Rainfall Intensity (SRI) and Precipitation Accumulation (PAC). In this pilot project study, we have mostly used PAC (Precipitation Accumulation) which is available in the Indian Meteorological Department (IMD) website at 0830 hrs IST daily which gives accumulated rain for last 24 hours and Surface Rainfall Intensity (SRI) uploaded at every 10 minute. For the study, DWR data from Agartala and Mohanbari stations (proximate stations to the study area) were being used for the flood forecasting exercise. A typical DWR data as observed at Agartala station is shown in Fig. 4b. A combination of high-resolution weather radar precipitation estimates, physically-based distributed hydrological modelling, and quantitative precipitation in 3-hourly nowcasting may be taken as one effective standard procedure to address urban flood hydrological disaster.

C. Hydrological Modelling

A quasi-distributed hydrological model was developed in HEC-HMS environment [12] for Guwahati urban catchment and model runs were carried out for the particular event dates when actual flood inundation has taken place in parts and parcels of Guwahati city. Rainfall-Runoff modelling is focused on quantifying the runoff occurrence, without necessarily looking into the processes of runoff generation. Runoff at the spatial and temporal scale for a basin is generally obtained by direct in-situ discharge measurements or indirect techniques involving 'lumped' or 'distributed' hydrologic models. In this model the urban catchment is divided into elements (by a grid) and precipitation, infiltration, evaporation and other catchment processes are modelled and overland flow, soil moisture is computed at element level. Assessing with ground information, the magnitude and scale of storms were modelled in the urban catchment of Guwahati on the hybrid DEM to derive flow hydrographs at drainage reaches, junctions and outlets for selected storm event dates which have actually triggered flash floods.

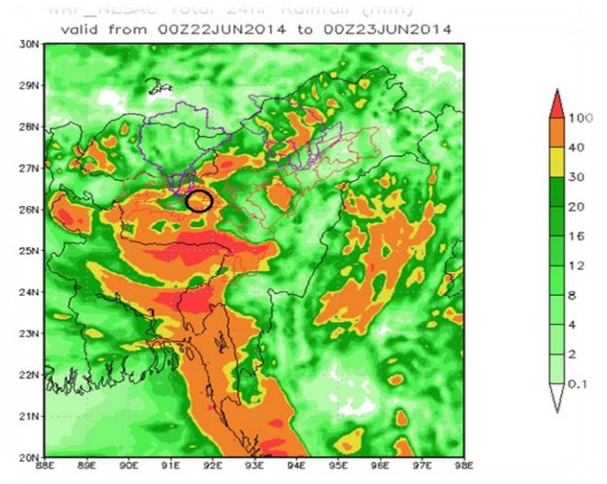


Fig. 4a. WRF forecasted precipitation data (3km grid)

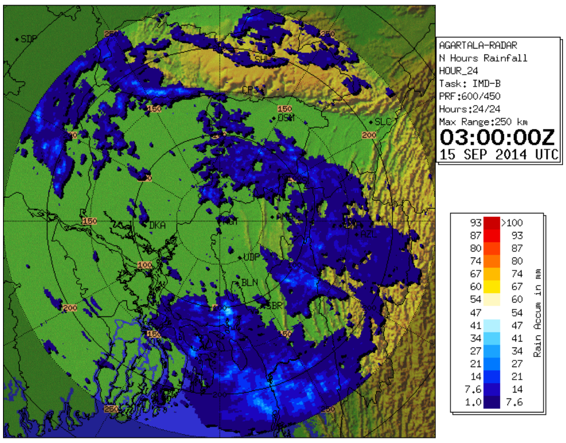


Fig. 4b. DWR observation – Precipitation accumulation
(source: www.imd.gov.in/section/dwr/dynamic/dwr.htm)

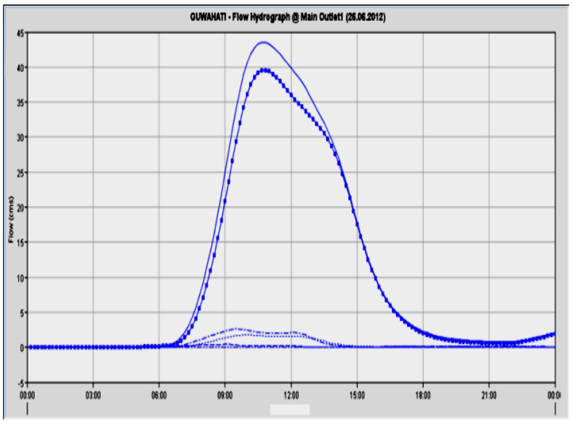


Fig. 5a. Flow hydrograph of flood event 25-26 June, 2012

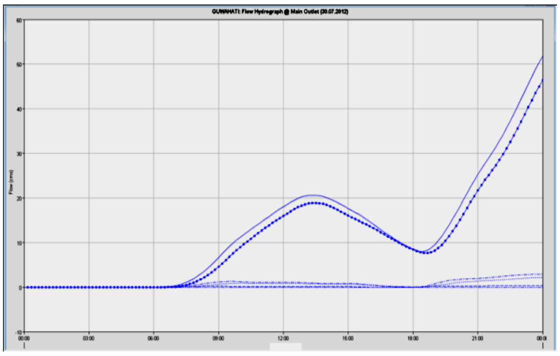


Fig. 5b. Flow hydrograph of flood event 21-22 Sept, 2014

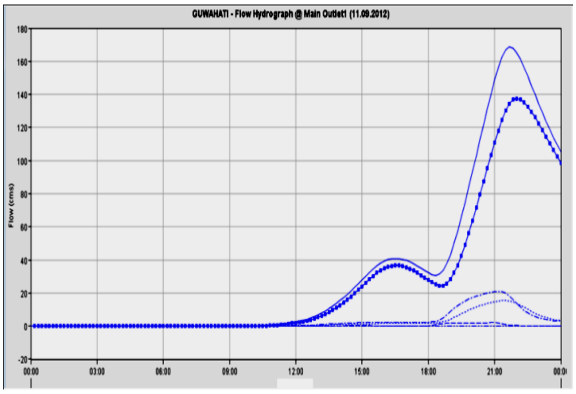


Fig. 5c. Flow hydrograph of flood event 13-14 June, 2017

$$\frac{\partial Q}{\partial x}+b\frac{\partial y}{\partial t}=0 \tag{1}$$

$$\frac{\partial Q}{\partial t}+\frac{\partial\left(\alpha\dfrac{Q^2}{A}\right)}{\partial x}+gA\frac{\partial y}{\partial x}=0 \tag{2}$$

where, Q is the runoff or flood discharge in a channel of width b for a wetted cross-sectional A. At a time step t, the depth of flow is taken as y for reach x in the channel or drain. The energy correction factor or Corriolis coefficient is taken as α for the particular flow conditions.

A looped network was created for the complex urban drainage and sewer system. The 6-point Abbott–Ionescu finite difference scheme is implemented in the MIKE FLOOD program in coupling the MIKE-11 and MIKE-21 modules. Drainage less than 1m in top width was neglected in the model setup to make the model less complicated and to avoid the numerical instability. A complete dry simulation was initially performed with only precipitation data on both wet and dry grids and few pairs of source and sinks with constant discharge. Detailed simulations on Ganeshguri and Zoo road area were carried out with hydrographs obtained from HEC-HMS model run as upstream boundary condition in the Bharalu river, which is the major cause of flash flood in Guwahati. The bathymetry for two dimensional modelling was modified with buildings layer digitized from CARTOSAT imageries which were then given specific heights to create a practical situation. Major and minor roads were also identified and suitably modified from field information. Finally, the drainage systems were overlain and modified in the bathymetry grid as per the drainage composition. The hybrid DEM used in the process helped to replicate the urban topography of Guwahati. It was observed that most parcels of the highly vulnerable and flood-prone areas such as Anil Nagar, Nabin Nagar, Ganeshguri Chariali, etc, were inundated in the most of the MIKE FLOOD simulations. But few prcels reported flooded during heavy rains, were found to be as a result of flashy runoff from the surrounding hills accompanied by drainage overflow. This showed that local conditions such as drainage blockage were mainly responsible for the flooding in these areas.

D. Hydraulic Flood Inundation Simulation

The hydraulic model setup was done as preparing the drainage system in MIKE-11 and MIKE-21 conjunctively [13]. The hydraulic geometry and boundaries of the active channels and drains were incorporated in MIKE 11 and the topographic (bathymetry) grid file of the overland surface in the urban area was composed in MIKE-21 [14]. An issue with the 1D-2D coupled models is the accuracy and resolution of the 2D surface model (bathymetry grid as shown in Fig. 6) which is highly dependent on the input topographic data resolution (density and elevation, shapes of buildings, etc) to represent the urban structure grid influencing the flood flows on account of buildings and roads. A grid size for urban 2D surface model of 1m to 5m has been recommended [11]. In this context, a bathymetry grid file of 1m spatial resolution has been prepared to take care of the surface and overland flow. The hydraulic flood simulation was mainly taken up after the flood event to check the extent of flooding induced by the rainfall for such a short period. Before starting a detailed MIKE FLOOD simulation a general study was done to check the effect of very high rainfall as such of 26 June 2014 in Guwahati urban, i.e. which areas affected by runoff from surrounding hills were identified and GIS grid layers created from the field information. Finally the drainage systems were overlaid and modified in DEM as per the drainage criteria The generated flood hydrographs (Figs. 5a, 5b and 5c) for some of the selected flood events are used as the boundary input conditions for the hydraulic flood inundation simulation. It may be noted that spatial resolution of rainfall data used in the hydrological model was assumed in the range of 0.5 km effective radius.

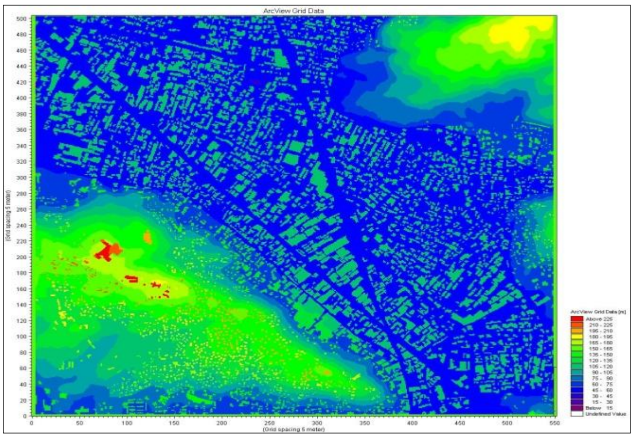


Fig. 6. Topographic (bathymetry) grid developed for the hydraulic flood simulation (a portion of the study area)

For focussing to the most flood-prone areas, segments of Guwahati catchment comprising of the major flood prone zones was selectively built as the bathymetry input file in MIKE-21 in different phases of the simulation. Thereby the modified shallow water St. Venant's equations used in the hydraulic flood simulation [11] is given in "(1)" and "(2)".

TABLE II: Flood Hazard Zone (FHZ) Scaling of Guwahati Urbane (Based on Flood Discharge)

Sl. No	Category of FHZ	Range of Peak Flood Discharge (Q_p)
1	Very High	$Q_p > 120 \text{ m}^3/\text{s}$
2	High	$80 \text{ m}^3/\text{s} < Q_p < 120 \text{ m}^3/\text{s}$
3	Moderate	$40 \text{ m}^3/\text{s} < Q_p < 80 \text{ m}^3/\text{s}$
4	Low	$Q_p < 40 \text{ m}^3/\text{s}$

VI. Results and Discussions

Guwahati metropolitan region has a major land cover of interspersed hillocks and elevated areas, more than 70% It has been found that parcels of Rajgarh, Anil Nagar, Nabin Nagar localities and its bye-lanes suffer from perpetual flooding and may be classed as high to very high flood prone zones. It was found that floods have occurred with daily total rainfall peaks ranging between 80 mm to 400 mm (analysis of storm records 2000 - 2014). For instance, extreme storm events were recorded in and around 5th June, 26th June, 30th July and 11th Sept in 2012 which have caused flooding in Guwahati metropolitan (*source*: AWS_ISRO1107 Christian Basti stn. & AWS_ISRO1101 Khanapara stn.). Flood hydrograph analysis of the recent storm events in 2017 also revealed that peak flows as high as 120 m^3/s have been generated in short durations of 3 to 6 hours, exceeding the discharge capacities of major drainage channels as Bharalu, Bahini, Amchang Nallas, etc in Guwahati urban catchment. Drainage nodes and congestion points were identified and statured based on classed as high to very high flood prone zones. It was found that floods have occurred with daily total rainfall peaks ranging between 80 mm to 400 mm (analysis of storm records 2000 - 2014). For instance, extreme storm events were recorded in and around 5th June, 26th June, 30th July and 11th Sept in 2012 which have caused flooding in Guwahati metropolitan (*source*: AWS_ISRO1107 Christian Basti stn. & AWS_ISRO1101 Khanapara stn.). Flood hydrograph analysis of the recent storm events in 2017 also revealed that peak flows as high as 120 m^3/s have been generated in short durations of 3 to 6 hours, exceeding the discharge capacities of major drainage channels as Bharalu, Bahini, Amchang Nallas, etc in Guwahati urban catchment. Drainage nodes and congestion points were identified and statured based on the drainage gradient and confluences. These nodes/points were used as junctions in during the hydraulic model simulation in MIKE FLOOD environment. The simulated flood inundation layers results for various magnitudes of flood runoff were compared for each particular storm events and it was found that the rainfall intensities did not influence the spatial location of the flooded areas in Guwahati urban catchment. The most flood prone zones were more or less affected in any flood event. The magnitude and time of flood inundation were also analyzed in the MIKE VIEW & Animator platforms. Further, specific simulation for the urban flood events of 26 June 2014, in Guwahati have been carried out to comparatively assess the magnitude and scale of the flooding that were reported from ground (Figs. 7 and 8).

From the above steps, the computed flood runoff peak values and runoff hydrographs was correlated with the magnitude and spatial extent of flooding in the urban catchment. GIS spatial analysis and post processing as overlay, union, intersection areas, etc were carried out on the (i) Simulated flood inundation layers (based on different flood discharge values), (ii) Base Flood Elevation layer established by ground Z-flood points, and (iii) ground database of actual flooding recorded in Guwahati urbane. Simulated flood inundation layers of flood-prone zones of Guwahati were schematized covering major and minor infrastructures such as roads, residential areas, commercial areas, mixed urban areas, etc, to build flood hazard zonation (FHZ) layers at periodic scales (Fig. 9). These layers were used to scale the flooding thresholds and develop a flood forecasting scale (Table II) and criterion in urban environments integrated with nowcasting ground-based RADAR (DWR) observations in corroboration of the quantitative precipitation estimates (QPE), surface rainfall intensity, etc, as shown in Table II.

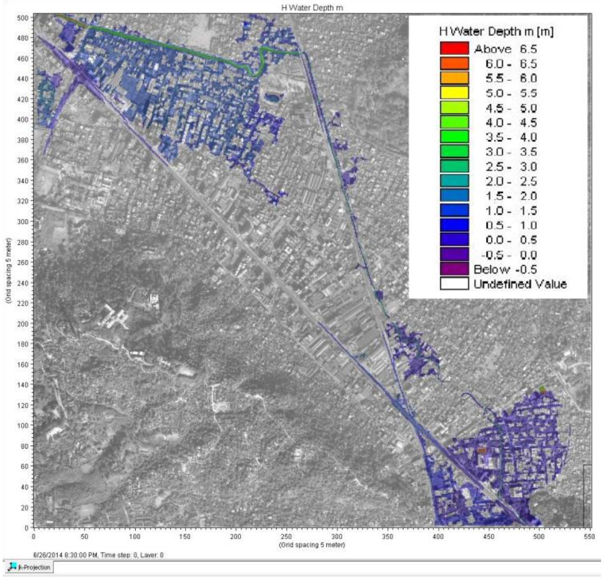


Fig. 7. Flood inundation simulation for the flood event 26−27 June 2014, in a parcel of Guwahati (Ganeshguri – Zoo road).

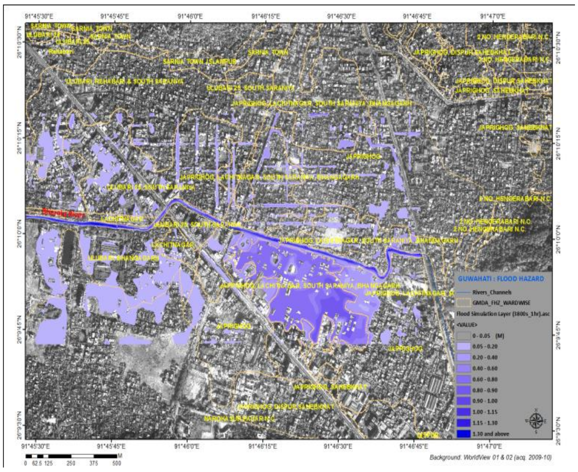


Fig. 8. Flood inundation simulation for the flood event 26−27 June 2014, in a parcel of Guwahati (Lachitnagar area).

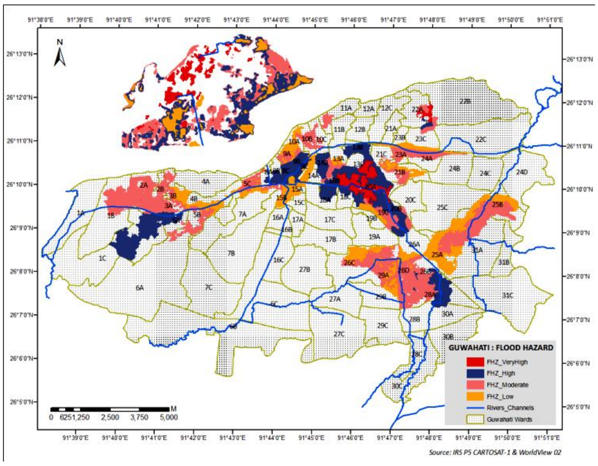


Fig. 9. Flood hazard zone (FHZ) scaling of Guwahati urbane (spatial scale).

VII. CONCLUSIONS

Due to the complexity of conditions affecting urban flash floods, availability of timely and accurate hydro-meteorological data especially rainfall intensity in proximate stations is a primary requirement to develop a robust flood early warning system for urban catchments. Flood hydrograph analysis of the recent storm events reveal that peak flows as high as 120 m^3/s have been generated in short durations of 3 to 6 hours of rainfall, exceeding the discharge capacities of major drainage channels as Bharalu, Bahini, Amchang Nallas, etc. This has inflicted drainage deficiencies which may have been designed for storms of much lesser magnitude. It was also found that floods have occurred with daily total rainfall peaks ranging between 80 mm to 320 mm (analysis of storm records 2001 - 2017). Specific flood zones were selected and simulations carried out with building footprints, minor drainages/sewers, etc imposed on the bathymetry. It was found that the computed flood runoff peak values and runoff hydrographs was following with the magnitude and spatial extent of flooding in Guwahati urban catchment. For setting up of urban flood early warning system data availability at four AWS stations were inadequate to resolve distributed rainfall intensities which normally is a phenomenon in Guwhati urban. Numerical weather prediction models such as WRF at times do not coherently capture the localized rainfall and orographic effects. It was found that WRF model assimilation using AMSU radiance data significantly increases the accuracy of the forecasted precipitation data. Continuous monitoring of DWRs along with precipitation estimates, hydrological flood runoff computations, and flood hydrograph analyses with the scales, should serve as a platform for a viable flood forecasting systems in urban catchments. Validation of the flood hazard layers cannot be fully correlated due to unavailability of detailed ground flood inundation data. Some data obtained from sources as GMC, WRD, etc were used for validation of the spatial extents of the final flood inundation layers. Prediction of urban flash floods faces limitations depending on various factors such as accuracy of forecasted rainfall data and spatiotemporal resolution, urban grid resolution, surface parameters, etc. A hydrological model used for urban flood modelling and prediction is inevitably an abstraction of reality. The use of a model is necessary since the use of hydrological measurements can be very limited and insufficient. The design of a framework for urban flood modelling and forecasting block will need the coercion of meticulous weather observations and analysis in short time periods, to be followed by a scaled and consistent hydrologic – hydraulic model.

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