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Hydrodynamic Modelling for Identifying Flood Vulnerability Zones in Narmada Lower Sub-Basin

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Abstract: Floods can cause widespread devastation, resulting in loss of life and damages to personal property and critical public health infrastructure. River flooding is the most common type of flooding in many parts of the world. It occurs when a water body exceeds its capacity to hold water and usually happens due to prolonged heavy rainfall. Narmada river located in Gujarat state, India, being major west flowing river was inundated in august 2006. This present study aims to develop mathematical model using HEC-RAS 6.0.0 version to analyze one dimension and two-dimension unsteady flow of water in Narmada lower sub-basin. The river stretch for hydrodynamic modelling starts from Garudeshwar gauge station located 14 km downstream of sardar sarovar dam at Narmada district of Gujarat to the mouth of Narmada river in gulf of Khambhat. The simulated results in 1D modelling show that that approximately 64.38% of the total cross section, have their bank station in overtopped condition both for discharge equal or more than 31061.91 m3 /s. It has been observed that right bank of river indicating eastern side of Narmada river near Vadodara city is more prone to water spill from higher water levels in River. 2D modelling results show that highest water surface elevation was observed in low lying areas are of Kherda, Rajupura and Bhanpura located between Anand and Vadodara city are mostly inundated. Model outputs can be used as Non-structural method of flood vulnerability assessment by government agencies to reduce flood damage.

Keywords: Inundate, Flood vulnerabilty, Water surface elevation, 1D & 2D model.

I. INTRODUCTION

A flood is an overflow of water that submerges land which is typically meant to be dry. While it's going to occur along river banks, lakes and sea coasts. river flooding is that the commonest sort of flooding in many parts of the planet. It occurs when a water body exceeds its capacity to carry water and typically happens thanks to prolonged heavy rainfall. Major causes of floods in India include inadequate capacity within riverbanks to contain high flows, riverbank erosion and silting of riverbeds. Additionally, other factors are; landslides resulting in obstruction of flow and alter within the river course, retardation of flow thanks to tidal and backwater effects, poor natural drainage within the flood prone area, cyclone and associated heavy rainstorms, cloud bursts, snowmelt, glacial outbursts and dam break flow. Effective flood warning systems can help take timely action during natural calamities and may save lives. Pre-planning can significantly reduce when river flooding leads to a substantial amount of injury in nearby localities, it can be prevented if rivers are managed properly, especially in densely populated and flat areas.

II. METHODOLOGY AND DATA ANALYSIS

A. Data Analysis in 1D Modelling

One-dimensional models treat flow through both the channel and floodplain as only in the longitudinal direction. The equations for modeling one-dimensional flow are derived from the conservation of mass and conservation of momentum equations between adjacent cross-section

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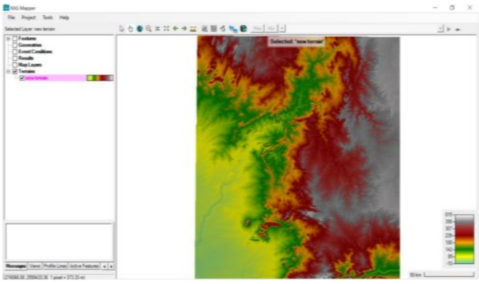

Fig. 1 New Terrain File created of study area in RAS mapper

Cross-sectional cut lines (73): Cross sections of 500m equal interval and width of 3000m was generated perpendicular to river lines (green color). Total 74 numbers of cross section cut lines covering 37.4km of river reach were delineated by edit geometry tool in RAS mapper.

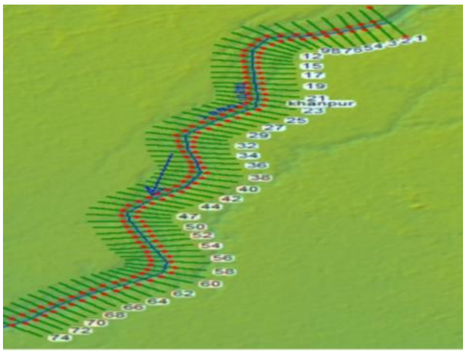

Fig. 2 Digitization of Narmada lower river reach and cross section

B. Data Analysis in 2D Modelling

In 2D model flood event of august 2006 is simulated by considering computational interval of 30 second for SRTM 30m grid under unsteady condition

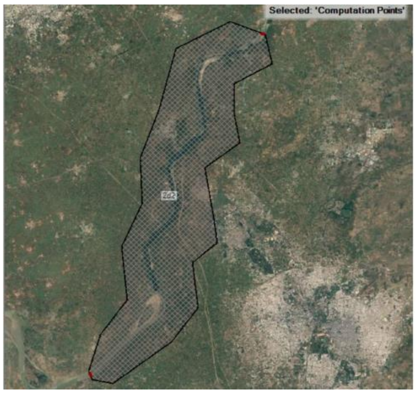

Fig. 3 2D mesh generated with geometry feature in RAS mapper

III. RESULTS AND DISCUSSION

The august 2006 flood event in Narmada lower sub-basin is simulated for the time period of 11th August 03:00hr to 13th August 24:00hr, and the model is run for total 72 h duration with peak discharge of 31061.91cumec. The flood depth, water surface elevation, velocity, arrival time, duration and flood inundation for Narmada lower sub-basin from Garudeshwar gauge station at upstream to Mujpur village at downstream were simulated. The simulated results are validated with observed water surface elevation obtained from SWDC Gandhinagar.

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One Dimensional HEC-RAS Model

The water depth data of august 2006 is used to test the consistency of the model simulation. The comparison between simulated data and observed data at Gharudeshwar gauge station is shown in Fig

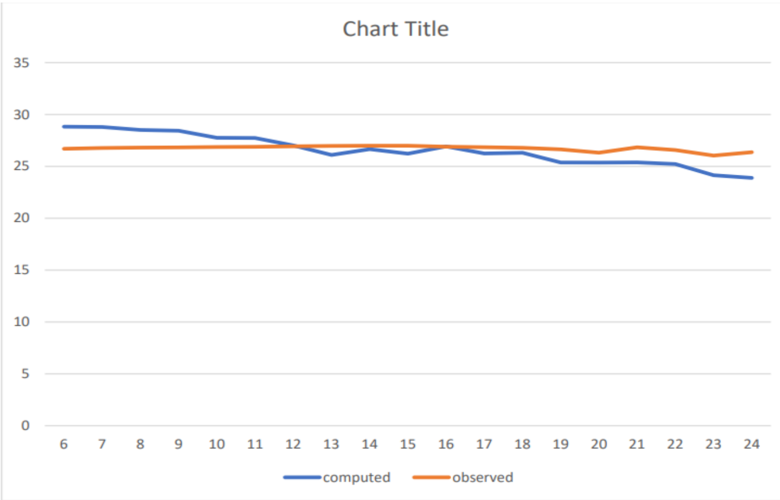

Fig. 4 Comparison of computed water surface elevation and observed water surface elevation

Two Dimensional HEC-RAS Model

Fig. 5 Velocity distribution maps of Narmada lower sub-basin, 12 August 2006, 12:00 hours

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Fig. 6 Arrival time map along Narmada river reach for Discharge of 31061.91cumec

It has been clearly observed from figure 6 that for peak discharge duration, the velocity of flow remains mostly in range of 1.6 to 2.24 m/sec for entire study area. It is observed that 2.9km of river reach starting from Aries riverfront to Hinglot stepwell located downstream of Sindhrot bridge has lower velocity ranging between 0.89m/s to 1.82m/s. Whereas maximum velocity of 5.12 m/s upstream of Sindhrot bridge connecting Asardi and Amrapura village of considerable population which is of much concern. As the study areas of the Narmada River specifically in Gujarat has comparatively flat terrain with double fanned shaped catchment area towards mouth of river, which gives rise to high intensity flash floods. It is necessary to analyze the arrival time of water level and maximum velocity of water to predict the behavior of river and to take required precaution measures.

IV. Conclusion

This study was carried out in 37.4km section of the Narmada River stretching from the Gharudeshwar gauge station to Mujpur village, was modeled using the HEC-RAS unsteady flow analysis for one dimension as well as two dimension. Flood model was calibrated and validated for the Flood 2006 event in Narmada lower sub basin. The developed 1D and 2D models proves to be relevant means to explore in advance the flood depth, velocity, water surface elevation against different terrains created from 30-m SRTM DEMs for future flood event corresponding discharge at upstream. Hydraulic modelling results showed that most parts of the right bank of Narmada lower sub-basin is more vulnerable to flooding as west side of Vadodara city is more prone to water spill from higher water levels in River as cross-section of the river is narrowed due to anthropogenic activities Based on these results, and after verifying with past flooding history, one can say that HEC-RAS can be used for flood level simulation within the river reach. The one dimension hydraulic modeling confirmed the incapacity of cross section to carry discharge more than respective carrying capacity and indicated that approximately 64.38% of cross section having both left and right bank have possibilities of water spill and inundation for discharge equal or more than 31061.91 m3 /s.

On the other hand, two dimension modelling showed that highest water surface elevation was observed in low lying areas are of Kherda, Vadodara, Rajupura near Poicha temple in Vadodara and Bhanpura located between Anand and Vadodara city near Vasad village which were mostly inundated. By using the model outputs, the government agencies can contribute to a significant reduction of flood damages.

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