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Flood Inundation Modelling using HEC-RAS 2D for Brahmani and Baitarni Basin, Odisha, India

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Abstract—*All flood disasters cause huge damage if not properly controlled. Flood is an unusually high stage in a river, normally the level at which the river overflows its banks and inundates the adjoining area. The 2011 Odisha floods, driven by unprecedented monsoon rain in the Jenapur, Jajpur, Bhadrak, Balasore, Kendrapada region of Odisha and affected the Brahmani-Baitarni river basin. Only a few models are available to simulate flood inundation in a river basin for real flood events considering all the spatial heterogeneity of physical characteristics of topography such as HEC-RAS 2D. When water begins to overflow, it becomes a 2D phenomenon and the use of 2D is more suitable and positively applied for flood inundation. The discharge is used as upstream boundary condition of the main river channel and then a 2D modelling is performed. Due to acceptance of HEC-RAS, this new 2D abilities are a great revolution for future flood studies. The present study aims to analyze the flood inundation using the 2D capabilities of the new HEC-RAS. The simulated flood extent displays decent performance when associating to the flood extent observed the satellite images.*

1. INTRODUCTION

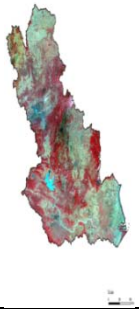
There are many factors that contribute to the floods. The heavy intense rainfall is always one of the main factors that contribute to the floods. However, human activities in many circumstances change flood behaviour. Flood disasters are among the world's most frequent and damaging types of disaster. Flood inundation indicates the geographical areas which could be covered by a flood. Flood maps are primarily used for Flood Risk Management Strategy (prevention, mitigation) Land-use planning, land management, Emergency planning, Public Awareness should cover the populated areas of thecountry.

The flood occurrence was replicated by using the new HEC-RAS-v5 model established by the USACE. HEC-RAS is a community territory model established by the US Army Corp of Engineers. River Analysis System (HEC-RAS) is software that allows you to accomplish one-dimensional steady and unsteady flow river hydraulics designs. HEC-RAS-v5 can be used moreover as a fully 2D model or as a hybrid 1D2D model when the main rivers are modelled as 1D and the floodplains are modelled as 2D. The current study used a full 2D model because the over- flow locations were unidentified. Future exploration may use the present results in order to perform a 1D2D model seeing the well-defined overflow sites.

2. STUDY AREA

Brahmani and Baitarni Basin, Odisha, Indiais used for this study.Rainfall varies both spatially and temporally in the Brahmani-Baitarani basin. The basin is also rich in forest which covers 34.36% of the total area. The forest class includes evergreen, deciduous and scrub forest. With 4.62% built up land, the basin has 2.95% area covered by rivers, streams, and reservoirs.The main soil types found in Brahmani and Baitarni basin are red and yellow soil, red sandy and loamy soils, mixed red and black soils and coastal alluvium.

River system of Brahmani and Baitarni basin

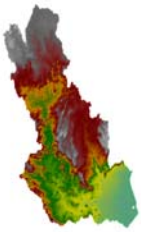


Satellite image of Brahmani and Baitarni basin

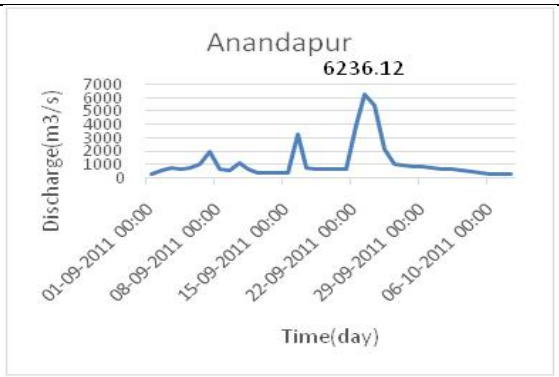
3. DATA REQUIRED

Two types of boundary conditions, two hydrograph boundary condition at Anandapur and Altuma (Brahmani and Baitarani basin), water level of Anandapur and Altuma , one normal depth at downstream side of junction. The normal depth boundary(s=0.000241) condition was located not only at the downstream extreme of (Brahmani and Baitarani basin) but also at the borders of the model .

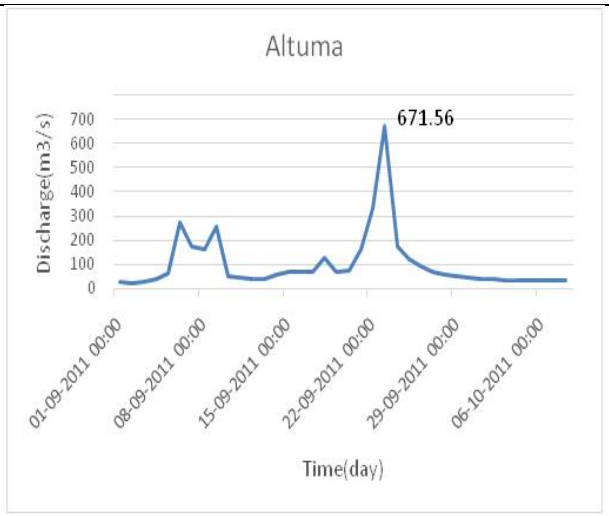
SRTM 30Brahmani and Baitarani basin



Terrain model of Brahmani and Baitarani basin

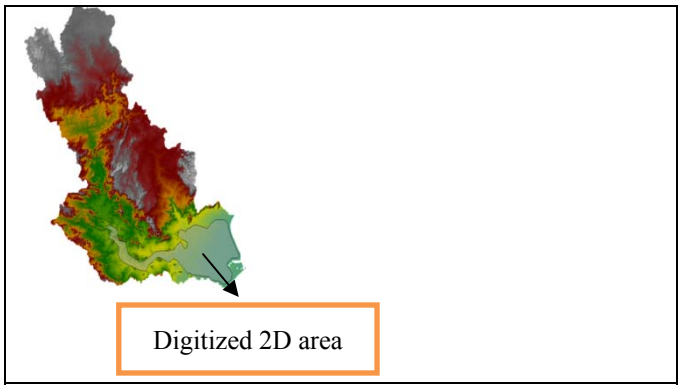


Discharge at Anandapur from 1st September to 8th october2011



Discharge at Altuma from 1st September to 8th october2011

HEC-RAS layers stream centerline, flow path center lines, main channel banks, and cross-section cut Lines are generated using Digital Terrain Model (DTM) of the river in HEC-RAS. RAS layers are used to extract additional geometric data for import in HEC-RAS. Terrain is created by giving DEM as input in tiff/adf file format. 2d Flow area is the area within which flood is likely to be happen, 2d flow area is created by digitizing using 2D flow area tool in geometric editor.



2D Digitized area of Brahmani and Baitarani basin

4. METHODOLOGY

The flood occurrence was pretending during the new HEC-RAS-v5 model established by the USACE. The new HEC-RAS-v5 resolves either the full 2D Saint Venant equations or the 2D diffusive wave equations.

4.1 Mathematical Modelling

The formula for computational step was fixed according to the courant friedriches lewy condition.

$$Cr = C\,\frac{\Delta t}{\Delta x} = \frac{\sqrt{g\,h}\;\Delta t}{\Delta x} \leq 1$$

Where,

Cr is the courant number

g is the gravitational acceleration (m/sec^2)

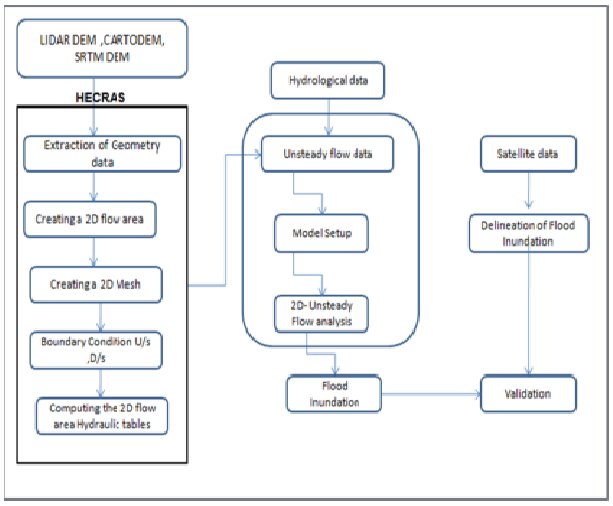
c is celerity (m/sec),

h is the flow depth (m),

Δx is the grid cell size (m),

Δt is time step. (s)

The geometry pre-processor, unsteady flow simulation, post processor and flood mapping programs were taken into consideration for simulation. The simulation Starting date was taken as 01/09/2011 1200hrs and ending date was 01/10/2011 2400 hrs as flood event occurred in between the aforesaid dates. All the above parameter will be able to find in the figure below.

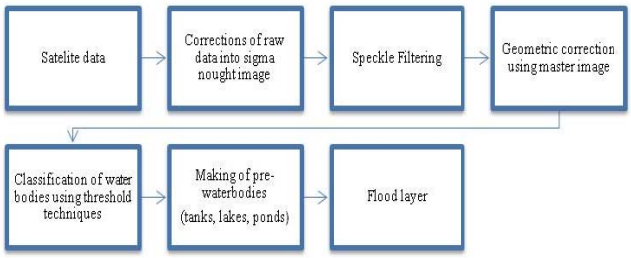


Flow chart of HEC-RAS 2D Modelling

4.2 Extraction of Flood Layer using satellite data

After the flood watch, the affected regions as reported are identified and all the available satellites covering the affected area are earmarked and coverage charts are prepared. Presently microwave date is being used. The advantage of microwave data over the optical data is its ability to penetrate cloud cover and data acquisition during day and light. Water surfaces are generally smooth at radar wavelengths and can be regarded as specular reflectors which yield small backscatter. Hence, water is regarded as low intensity areas whereas the

Surrounding terrain corresponds to brighter intensities.



5. RESULT

This version of HEC-RAS uses double-precision floating point numbers for elevations when storing data to internal memory. However, when the data is written to results file HEC-RAS version stores the results with a precision of six digits (five numbers and a decimal point). The simulations results had a precision of 1mm. The performance of the modelled simulation was validated by remotely sense Radarsat satellite image captured at the time of flood event on 10^{th}, 12^{th}, 14^{th}, 19^{th}September 2011 for 24hrs.

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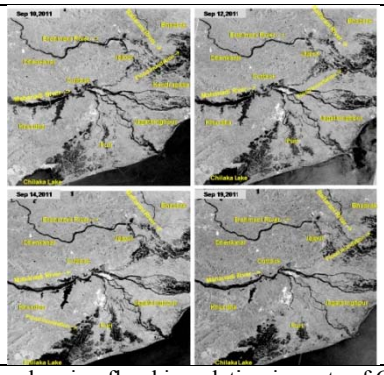


Satellite images showing flood inundation in parts of Orissa

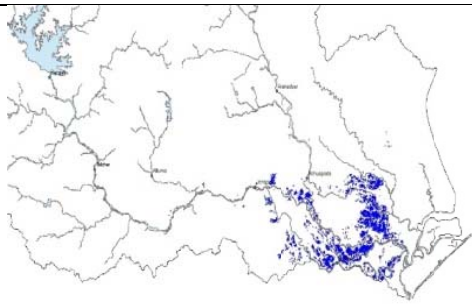
In figure displays the inundation registered by satellite image on 10^{th}, 12^{th}, 14^{th}, 19^{th}, September 2011 24 hrs and flood simulated by the HEC-RAS. The model offers decent arrangement with the observed flood.

5.1 Satellite data observation

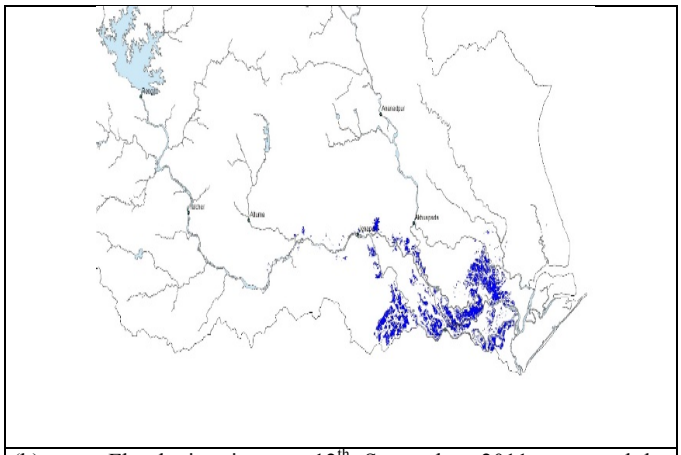
Floods were mapped in the state of Orissa 2 times during 12 times during September and once during October. During 2011 flood season maximum inundation of about 1,52,488 ha was observed on 12^{th} September, 2011.Kendrapada and Bhadrak were worst affected by flooding during September 2011. Flood inundation situation in part of Orissa state during 5^{th}, 8^{th}, 10^{th}, 12^{th}, 14^{th}, 17^{th}, 19^{th}, 26^{th}, 29^{th} September to 1^{st} October 2011.

5.2 Flood inundation images which is extracted by HEC-RAS 2D

In images a,b,c,d shows the flood occurrences during the period of 10^{th}, 12^{th}, 14^{th}, 19^{th} September 2011 for 24 hrs.

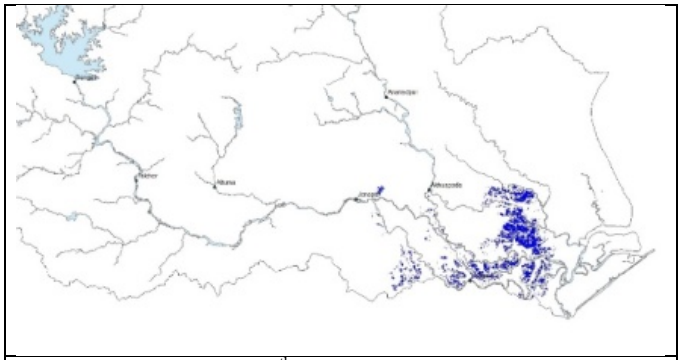


(a) Flood situation on 10^{th} September 2011 extracted by HEC-RAS 2D

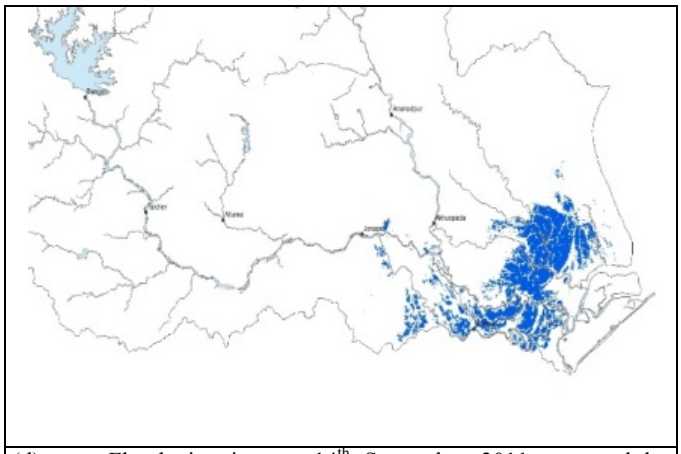


(b) Flood situation on 12th September 2011 extracted by HEC-RAS 2D

However, when the data is written to results file HEC-RAS version stores the results with a precision of six digits (five numbers and a decimal point). The simulations results had a precision of 1mm.



(c) Flood situation on 14th September 2011 extracted by HEC-RAS 2D



(d) Flood situation on 14th September 2011 extracted by HEC-RAS 2D

6. CONCLUSION

The simulation shows good performance when comapring the simulation results with flood extent registered by satellite images. The study displays that at the downstream area of the basin of Brahmani and Baitarni basin is the most perilous one; it has superior flood amount, it has deeper flood depth and longer flood duration. The study displays that the new HEC-RAS version 5 is a significant tool for studying and understanding flood events. Upcoming application of the new HEC_RAS may help to examine likely flood management strategies.

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