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Probable Submergence Depth of Centre Zone –GIS Approach

KEYWORDS: Flood, Tapi, GIS, DEM, Centre Zone

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ABSTRACT Over years to manage watersheds has been expensive and time consuming with most of operation performed manually using paper maps. Now a day, new technologies, such as Geographical Information System and Remote Sensing are helping the researchers to create accurate floodplain maps with improved efficiency. This paper illustrates GIS applications for developing floodplain models of Centre zone of Surat City, fastest growing city of Gujarat state, India. Flood event occurred in 2006 is taken as reference to workout probable submergence depth of the study area at different discharges. Finally it summarises some of the experience and lessons learnt in applying GIS in modelling and flood mapping.

[I] INTRODUCTION

Accurate and current floodplain maps can be the most valuable tools for avoiding severe social and economic losses from floods. Accurately updated floodplain maps also improve public safety. Early identification of flood-prone properties during emergencies allows public safety organizations to establish warning and evacuation priorities. Armed with definitive information, government agencies can initiate corrective and remedial efforts before disaster strikes [1].Flood is a natural disaster in India, however human activities in many circumstances change flood behaviour. Activities in the flood plain and catchment such as land clearing for urbanisation or agriculture, construction of infrastructures such as highway and road and bridges in the flood plain may increase the magnitude of flood which increases the damage to the properties and life. The behaviour of flood due to flood mitigation project such as river widening and straightening must well be understood since this kind of work may transfer the flood problem form upstream to the downstream part of the river. The combination of GIS software and hydraulic software able to speed up the process of producing flood risk map which is suitable for a decision support system[2]

[II] STUDY AREA

Tapi basin is divided in three zones, Upper Tapi Basin (UTB), Middle Tapi Basin (MTB), and Lower Tapi Basin (LTB).The portion between Ukai Dam to Arabian Sea is known as LTB, includes Surat city and surrounded industrial and rural area. The Tapi river basin in Gujarat, encompassing an area of about 65.95 lakh hectares [3] covers parts of Surat district. The topography in LTB comprises narrow valley and gently sloping ground [4]. The LTB receive an average annual rainfall of 1376 mm, and these heavy downpours are one of the main reasons for occurrence of flood and water loggings downstream. Surat city, situated at latitude 21o 06' to 210 15' N and longitude 72 o 45' to 72 o 54' E on the bank of river Tapi having coastline of Arabian Sea is on its West. Surat had experienced so many flood events before and after construction of Ukai dam. Flood occurred in August, 2006 is described as worst flood in history of lower Tapi basin. Centre Water Commission(CWC) along with department of irrigation, local Municipal Corporation and other state government agencies have invested large amount of resources for protecting the fastest growing city of the India [5] by making structural and non-structural measures.

[III] DATA COLLECTION

For the research Geo-coded Indian Remote Sensing (IRS-1D) satellite image is used, Topo-Sheets at 1:50,000 scale collected from Survey of India, High resolution Google-earth image down loaded through internet. Physical measurements for river hydraulic parameters obtained after monsoon of 2006 and Contour maps for centre zone at 0.5m interval were collected from Surat Municipal Corporation (SMC). In order to find out discharge carrying capacity of river Tapi, detailed drawings of 309 river channel sections which were measured at a mean distance of 150 to 200 m by irrigation department were collected. The water level and river discharge data from hourly to daily scales for different stations viz., Ukai dam, Kakarpar weir, Mandavi, Ghala, Singanpur weir, Hope (Nehru) bridge were collected from Central Water Commission, State Water Data Centre (SWDC), and Irrigation Department. Maps showing centre Zone along with Town Planning Scheme numbers and area name collected from Surat Municipal Corporation.

IV METHODOLOGY

Creating DEM

DEM is a computerized representation of the earth relief. GIS and RS provide a broad range of tools for determining areas affected by floods or for forecasting areas likely to be flooded due to high river or sea water levels. For an effective management of flood water in low- flying flood prone areas, GIS and RS technology is providing to be a useful and effective instrument. Special data stored in the digital database of the GIS, such as a DEM, can be used to predict the effects of future events[6]. The extent of inundation and depth of flooding can also be forecasted.A TIN is a triangulated mesh constructed on the (x,y,z) locations of a set of data points. The TIN model allows for a dense network of points where the land surface is complex and detailed, such as river channels, and for a lower point density in flat or gently sloping areas used TINs to model storm drainage in an urban setting. [7]–[8].TIN surface found very effective for the determination of parameters for design flow calculations and performed some of the work connecting hydraulic modeling of river channels and GIS.[9]

Digital Elevation Model of Centre Zone of Surat city is generated by digitizing contours at 0.5 m interval. Following procedure is adopted.

ArcGIS software requires database in form of map, for that Toposheet at 1:50000 scale collected from Survey of India department, Ahmedabad

Scanning is a process of converting any paper-based

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material into a digital format, which is usually integrated into the GIS database[10]. The toposheets are scanned at 400 dpi resolution shown in Figure-1.

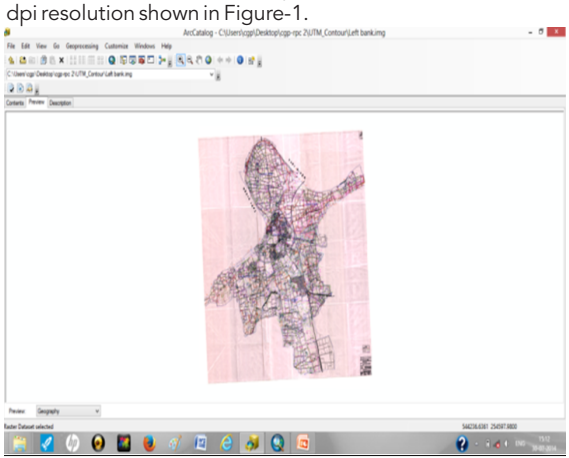


Figure-1.Scanned image of Surat City

Georeferencing is a process of assigning map coordinates to an image data .Data that are already georeferenced can be used as reference in georeferencing[11] .Georeferencing of the study area is shown in Figure-2.

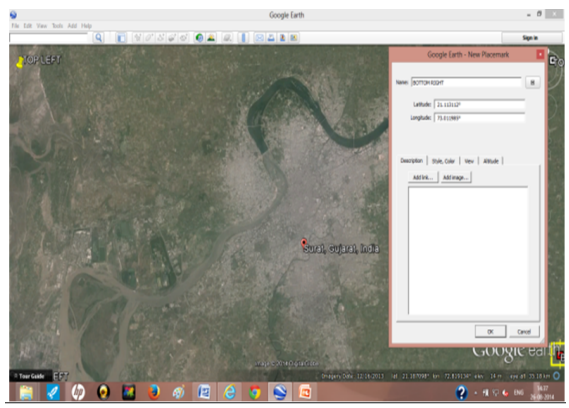


Figure-2. Georeferencing of image

Required topographical features such as contours, Gauge level and Discharge data are collected.
Then contour map is georeferanced over downloaded Google earth image and a spatial adjustment is applied for better accuracy.
Contours are digitized with help of ArcGIS software, see Figure-3

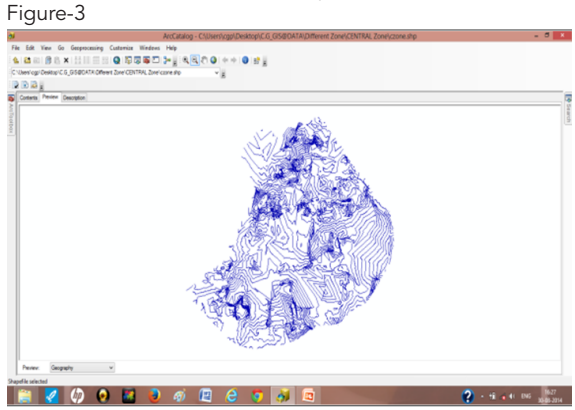


Figure-3 Digitised contour of Centre Zone

There after spatial and temporal data are interlinked using GIS software and customized Data Base Management System.

Tool 3D analyst is used to convert digitized Contours in to Triangulated Irregular Network as shown in Figure-4

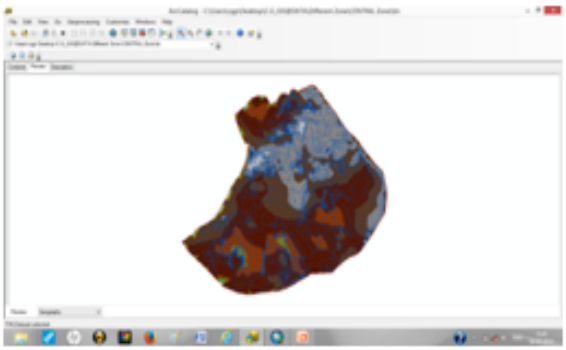


Figure-4 TIN of Centre Zone

Triangulated Irregular Network was converted in to Digital Elevation Model with the help of Interpolation Method, the DEM is shown in Figure-5

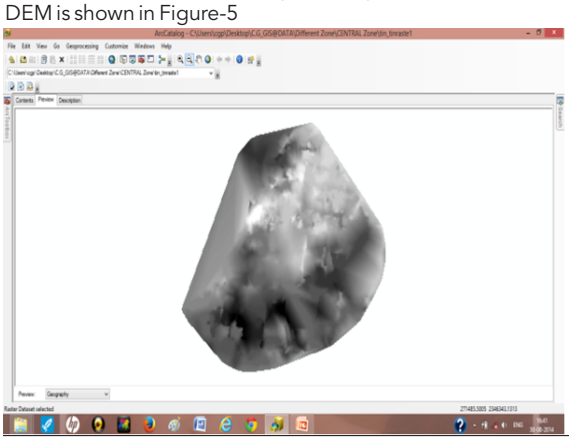


Figure-5 DEM of Centre Zone

In order to identify submerged area of different zone at various levels surface analysis in 3D analyst tool is used.
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Finding Submergence Area

For finding out submergence area of Centre Zone shape files of the zone is required. In order to find out probable submergence depth of different area falling in Centre Zone ,following procedure is done in ArcGIS software.
Arc Toolbox - Analysis tool - Extract-Clip-Area of interest/Contour. Output of the operation is shown in Figure-6

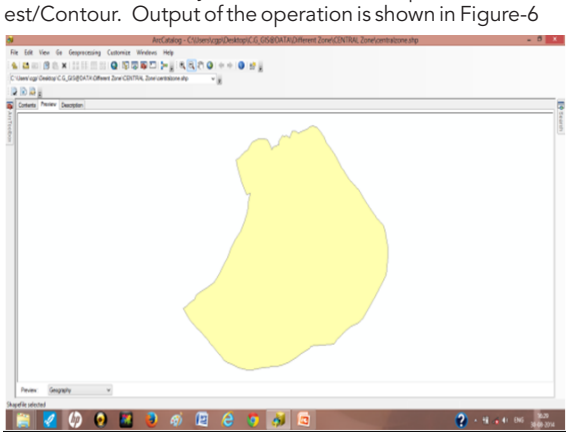


Figure-6 CLIP of Centre Zone

Arc View- Toolbars-3DAnalyst Tools-Create / Modify TIN-

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Create TIN from feature.
Arc Toolbox- 3DAnalyst Tools- Conversion- TIN to Raster. Output of the operation is shown in Figure-7

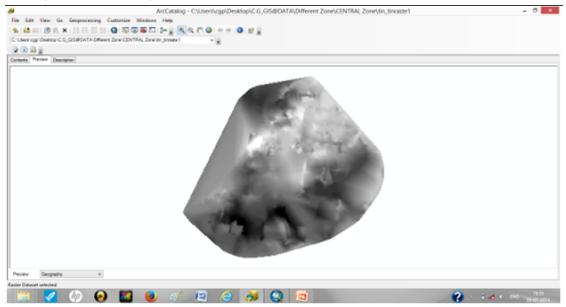


Figure-7 TIN converted in to Raster

Arc Toolbox-Spatial Analysis Tool- Hydrology – Flow Direction. Output of the operation is shown in Figure-8

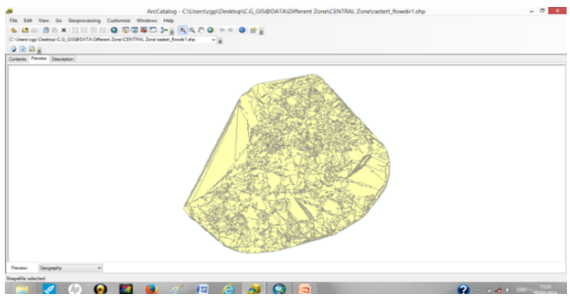


Figure-8 Flow Direction of Centre Zone

Arc Toolbox – Spatial Analysis Tool- Hydrology- Watershed. Output of the operation is shown in Figure-9

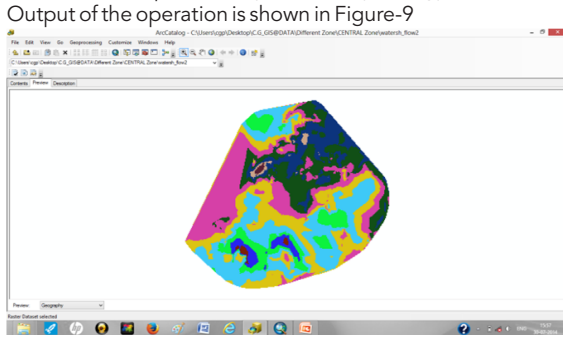


Figure-9 Centre Zone –Watershed

Arc Toolbox- Conversion Tools- From Raster choose Raster to Polygon.
Arc Toolbox- Spatial Stastic Tool – Utilities-Calculated Areas
After following all the steps in the end choose shape file of calculated area and use Query function. Through the function Query find 'GRIDCODE' and 'F_ AREA'. In 'GRIDCODE' put the figure of desired contour (e.g. 6, 7). Finally 'GRIDCODE' indicate the area of contour.

[V] RESULT AND DISCUSSION

Digital Elevation Model (DEM) of the Surat city is generated by collecting contour map of 0.5 m interval (Source SMC). Considering safe river gauge level with reference to lowest bank height near Hope Bridge and applying this limit to prepared DEM of Centre Zone , possible flood hazard map for future flood event is generated. The slope of curve represents flood hazard potential of Centre Zone of Surat city. In this curve a steep slope represent a high potential and gentle slope represent a low potential of hazards. Hence the analysis is based on reference to two water surface level 7.55 m threshold value for the bank height near Hope bridge and 12.50 m water level measured at Hope bridge in last flood event of 2006. Surat started developing its sub urban area from this Zone. The area of Nanpura, Navapura, Gopitalao, Haripura, Mahidharpura, Shahpur, Sharaget, Sagrampura, Sangadivad-Sonifalia-Wadifalia and Rampura belongs to the Central Zone. Compare to other Zones, area of this zone is flat surfaced and low lying, as results indicate that when water reach up to 6 m half of its area gets start to submerge. Nanpura is about 0.43 Km2 area will go under water when water level rise up to 10 m. Sangadivad-Sonifalia-Wadifalia is having steep slope , when water level reach up to 12 m its entire area of 1.69 Km2 would totally submerged. Sahara gate is high rise area in this zone, it will affected by flood water when its reach to 8m. Rampura is high rise area and it will go under water when water level rises from 8 m to 13 m Sagrampura is having gentle slope and will start flooded when water level varies from 6 m to 12 m. Water level of 12 m total submergence of this area would be 0.74 Km2.n this Zone. Like Sahara gate area it will get flooded when water rise from 8m to15m.The total submerged area of it would be 0 .66 Km2 if water rise up to 15 m. Details of Submergence of Centre Zone is shown in Fig. Wide graph of Submergence area versus RL in metre.

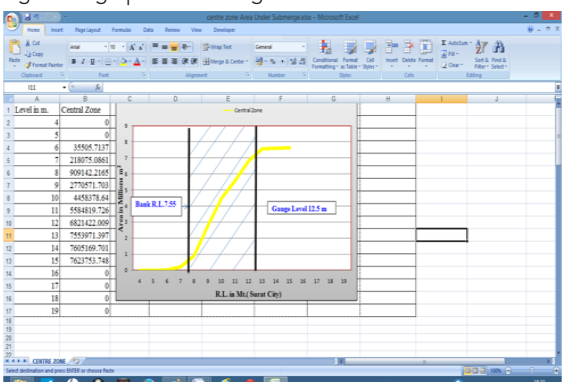


Figure-10 Graph of RL Vs Area Submergence Area – Centre Zone

[VI] CONCLUSION

Use of RS and GIS provide supplementary data in Hydrology for analysis and make easy to interpret and to understand flood phenomena and its characteristics. Digital Elevation Model (DEM) can be effectively used for simulation to get a complete model of the area. The generated DEM of Surat city has an accuracy of 0.5m in vertical and has been used for analysis of delineation of flood prone areas. In order to reduce effect of flood in centre Zone river section like LD-RD-3,L8-R8,L-11-R-11,L-13-R13 and L-16-R-16 having very low bank heights must be raised to improve water carrying capacity near Centre Zone.

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