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Flood Hazard Mapping and 1 D Hydraulic Module for Damanganga River, Valsad district, Gujarat, India

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Abstract *- This research represents the application of Arc GIS and HEC-RAS interface for 1D flood modeling of Damanganga River. Floods are among the most devastating and recurring natural hazard. It caused extensive economic losses and human lives around the word. Damanganga River in south Gujarat is prone to unexpected floods in 1994, 1997, 2001, 2003, 2004, 2006, 2013, 2016 and 2019. This paper presents a model development to determine the water level along the Damanganga River from Arabian Sea using HEC-RAS hydrodynamic model.The first phase for the modeling was done in Arc-GIS environment and function like GEO-referencing, creating Shape file, Mosaic extract by mask, etc. GIS file exported to HEC-RAS. In HEC-RAS RAS Mapper open to create terrain file and generate river center line, bank line, Flow path and cross section cut provide and save geometric data. The second phase for model execute to provide steady / unsteady flow data inserted for the result obtained to show water surface elevationfor peak discharge, need of flood gates on the storm drains are also assessed. The recommendations are done based on this study either to increase height of bank or build a retaining wall at certain section along the study reach.*

Keywords - *Damanganga River, Flood Analysis, DEM, Arc-GIS, HEC-RAS, Hydrodynamic modeling, steady / unsteady Flow*

I. INTRODUCTION

Flood is among the most devastating natural hazard in the world, claiming more lives and causing more property damage than any other natural hazard. When the depth of the flow exceeds the main channels called flood. Flood are of many types including flash flood, river flood, coastal flood, urban flood and flooding due to the opening or breaking of dam or reservoir.

Pathan and Agnihotri (2020a) simulated a 1-Dimensional flood modeling approach using HEC- RAS and ArcGIS to identify the flood extent of the lower region of the Navsari city. The integrated hydraulic and hydrologic models like HEC-RAS, SWAT model are very useful to develop the flood risk map and flood forecasting models with different return periods (Prabnakorn et al. 2019). Pathan (2019) introduced integrated use of Geographical Information System (GIS) and Hydrologic Engineering Center River Analysis System (HEC-RAS) for a one-dimensional modeling approach to determine flooding at different cross-sections on the Purna River basin. The hydraulic model HEC-RAS and Global Flood Monitoring System (GFMS) are very effective tools to delineate the extent of flooding and recognize the flood hazards zones that can be helpful to the disaster management authorities to warn the concerned communities on the flooding event (Kumar et al. 2020).

II. CASE STUDY AREA

Valsad district is situated the south part of Gujarat state, India. Valsad district lies between latitude 20.610^0 N 72.926 E^0. In Valsad district Navsari district in the North, Maharashtra and Dadra & Nagar haveli in south, Kaprada region in East, and Arabian Sea in the West. Valsad has a topographical region of about 3008 Km^2. Damanganga River start from Ambegaon in Dindoritaluka of Nashik district, Maharashtra, India. Study area map and Google map are shown in Fig 1 and Fig 2. The total length of the Damanganga River is 131.30 Km from start to end in Arabian Sea. Damanganga River basin lies between 20^0 11’ 12” to 20^0 25’ 24” North zone latitude and 72^0 49’ 20” to 73^0 04’ 12” East zone longitudes. The total catchment region of Damanganga Basin is 1813 Km^2.

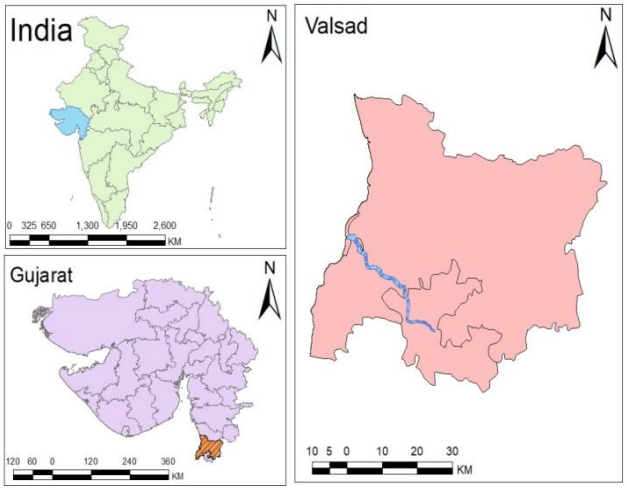


Fig 1: Location Map of Study Area

Fig 2: Google Map of Study Area (Source: Google Map)

A. *Flood frequency in Vapi, Daman & Dadra Nagar Haveli Region*

From the last 20 year data, in year 2004, 2005, 2013, 2016, 2019 major flood event have occurred which lead to damage of properties and lives in huge amount. Fig3 Shown the year-wise discharge phenomenon from Madhuban Dam.

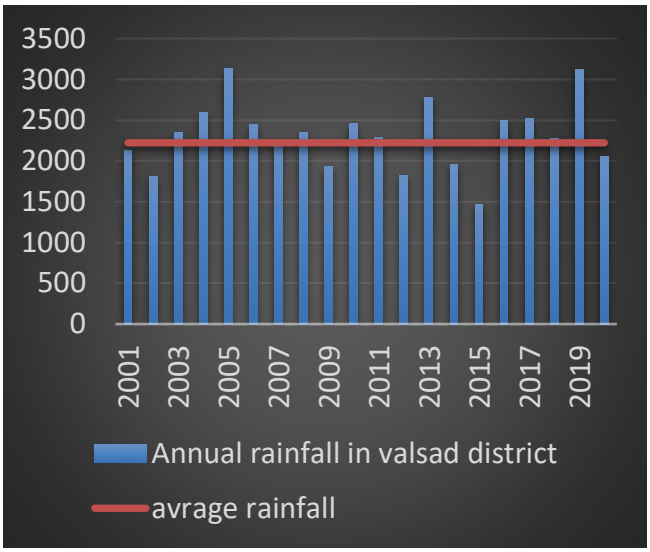


Fig 3: Annual rains in Valsad District from 2001 to 2020

III. MATERIALS AND METHODS

Hydrological data

Hydrological data recorded at the gauge station play a key role in model calibration & validation. The rainfall and runoff data are used establishing the hydrological and river behavior parameters. The hourly and daily rainfall data collected from state water data center and Madhuban dam site.

Arc-GIS software

Arc-GIS are a geographical information framework for working with maps and geographic data. It is applied for making and utilizing maps, accumulating geographic information, investigating mapped data, finding geographic data, promote maps and geographic data in the scope of uses, and managing geographic data in a database

HEC-RAS

HEC-RAS (hydrologic Engineering Center River Analysis System) is a program that representation the hydrodynamic of water moves through common stream and different channel. HEC-RAS program for modeling water moving through framework of open channel and calculating water surface profile & velocity. It is discover specific viable application in floodplain mitigation measures.

Methodology

Conceptual diagram of 1D hydrodynamic flood model Methodology is shown in Fig 4.

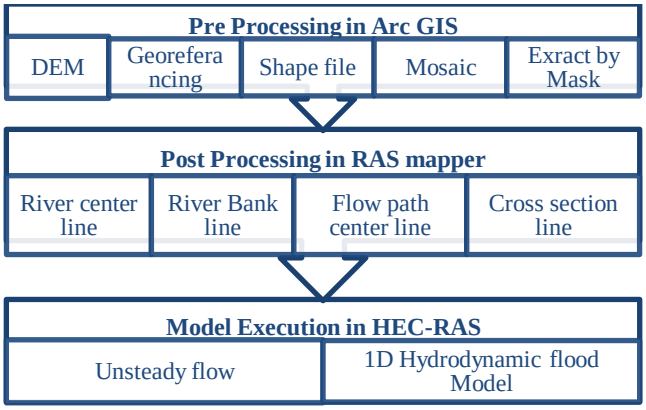
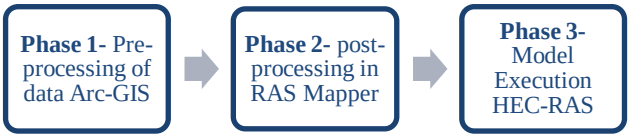


Fig 4: Conceptual Diagram of 1 D Hydrodynamic flood



Pre-processing of data Arc-GIS

A geographic information system (GIS) is an excellent tool for stacking, analyzing, and retrieving large numbers of non-spatial and geo-spatial databases including RS images. It is essential to understand representations of spatial features and various formats in which spatial databases are stored on GIS. Distance-based proximity tools in GIS are useful for ana1ysing and interpreting multiple spatial databases. It permits the formation of HEC-RAS import record, containing geometric property information from a current digital elevation model (DEM) and correlative informational collections.

DEM (digital Elevation Model): it is 3D image of the terrain surface of the planet made from a terrain surface elevation data. DEM is freely available on "bhuvan.gov.in", "USGS Earth Explorer" etc. as shown in fig 5.

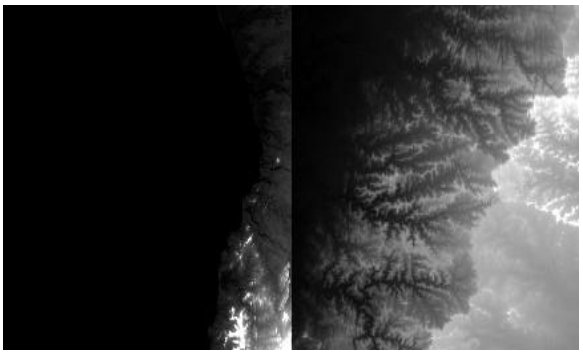


Fig 5: DEM images

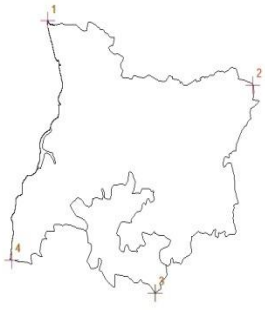


Fig 6: Georeferencing

Georeferencing: it is a technique assigning 3-dimensional directions to information that is spatial in nature. Georeferencing is shown in fig 6.

Shape file: It is a geospatial vector information position for geographic data framework programming. Shape file for Valsad area as appear in fig 7.

Mosaic: It is a process of merging two or more adjacent DEM image into one entity, so that multiple DEMs can be seen as a single DEM as shown in fig 8.

Extract by Mask: It is Arc-GIS geo-processing tool the extracts the raster corresponding to the area define by mask, which gives the result of Valsad district and DamangangaRiverwith DEM image shown in figure.

Above five steps are pre-processing steps which have been used in Arc-GIS environment with proper methodology, it is used in HEC-RAS in RAS-mapper window to create geometry for the model.

Fig 7: Shape file

Fig 8: Mosaic

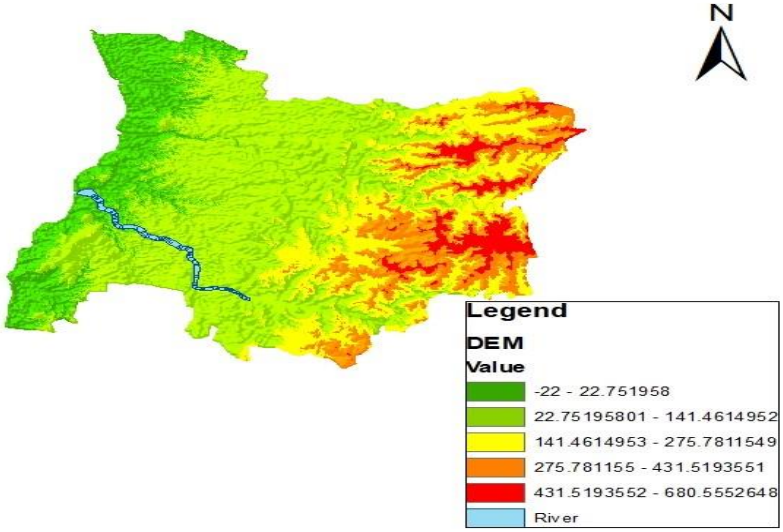


Fig 9: DEM of Research zone

Post processing RAS Mapper

In this process RAS Mapper window in HEC-RAS software to input projection file that freely available in geospatial projection coordinate ESRI website. Input GIS file through terrain data to create geometry for the flood mapping. Save the geometry as River name to provide stream center line, bank line, flow line and cross section line.

Stream center line: The River is characterized by the stream centerline.

Main Channel Bank: Main channel bank lines are Utilize to separate the primary stream line from left bank or right bank of the floodplain territories inside which the stream is contained.

Flow path center line: It is stream way to define upstream to downstream.

Cross section cutline: cross sections are located at the interval along a stream to characterize the flow carrying capability of the stream and its adjacent floodplain. The general approach to laying out cross section is to ensure that the cross sections are perpendicular to flow lines.

In the fig 10 shown that the Blue color indicate the "Stream centerline", Red color indicate the "Main channel Bank line", Yellow color indicate the "Flow path" of the Damanganga River from upstream to downstream. Final Geometry data is open in main window of HEC-RAS geometry window for model Execution.

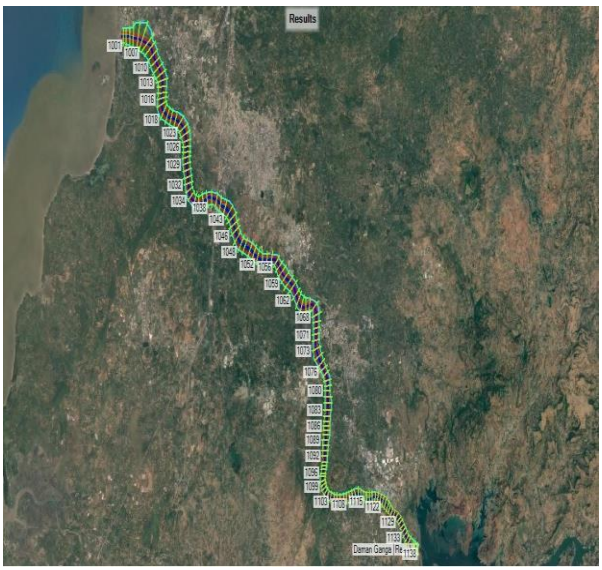


Fig 10: RAS Geometry in RAS Mapper

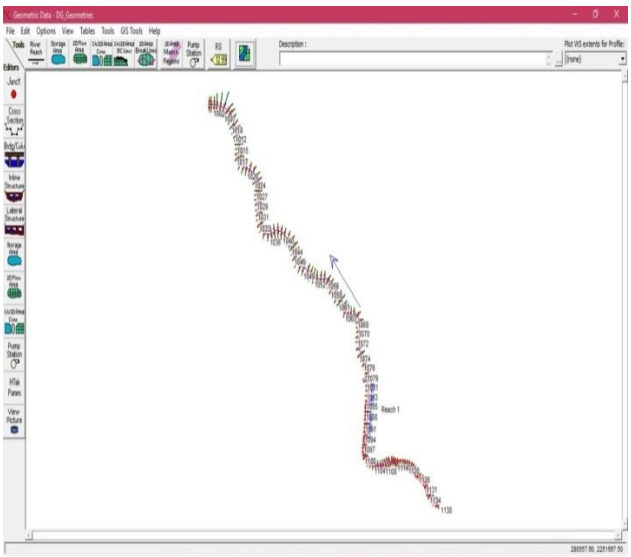


Fig 11: Geometry data in HEC-RAS

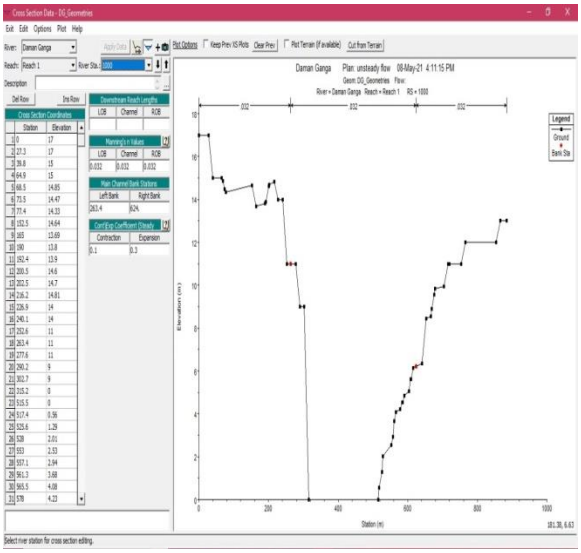


Fig 12: cross section 1 Geometric data editor window

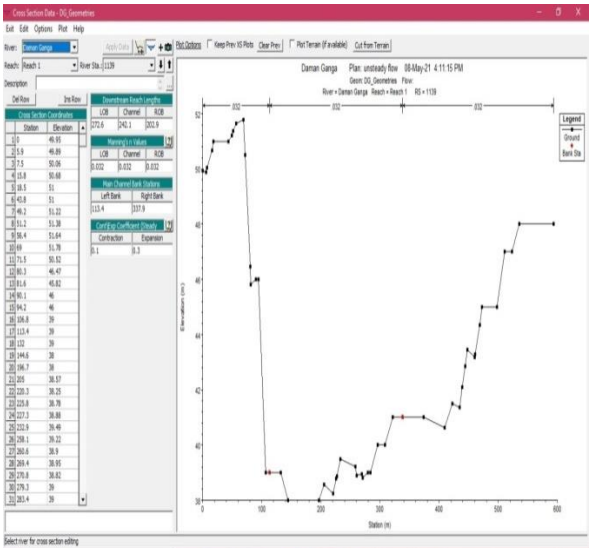


Fig 13: cross section 138 Geometric data editor window

IV. MODEL EXECUTION IN HEC-RAS

In HEC-RAS RAS Mapper through created geometry of the river is directly appearing in the geometry window shown in fig 11. Then we have add Manning's co-efficient (Roughness coefficient was obtained using the table of Chow's roughness coefficients according to bed material of river reach) for the L.B & R.B as per observed data as shown in fig 2 & 13. Then we have applied unsteady flow data for the year of 2019 and 7 day period timely data we provide. Then apply boundary condition in which for the unsteady flow we provide 'Normal Depth' as slope of a value 0.0001. Finally, run the model after applying all the data. We provided 92 cross sections for the upstream to downstream of Damanganga River.

After running the model, HEC-RAS will give the result of the unsteady flow data with water surface elevation in the figure. Figure shows that we observed that cross sections are affected by flooding where the water releases from the Madhuban Dam in 1st august 2019 to 7th august 2019. In figures shows the cross section 1003, 1082, 1088, 1104, 1134, 1137, 1138 are affected by flood as shown in fig 14 to 20.

Hear we taken cross section for the model executions for model which are in flooded during discharge. Fig 21 shows that the XYZ perspective views of the entire river which we see that that some cross sections are more affected by flooding during high discharge from dam.

V. RESULT OUTCOMES AND DISCUSSION

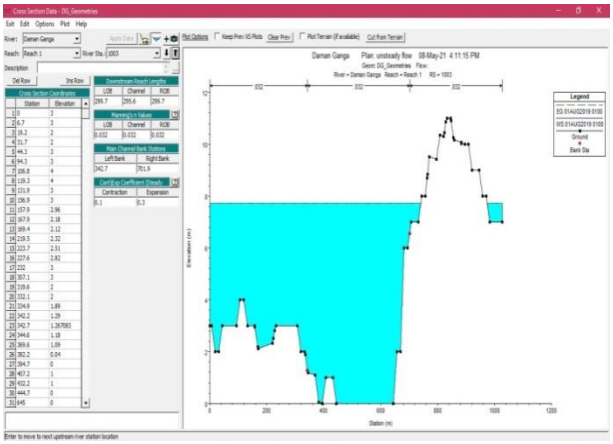


Fig 14: water surface profile c/s 1003

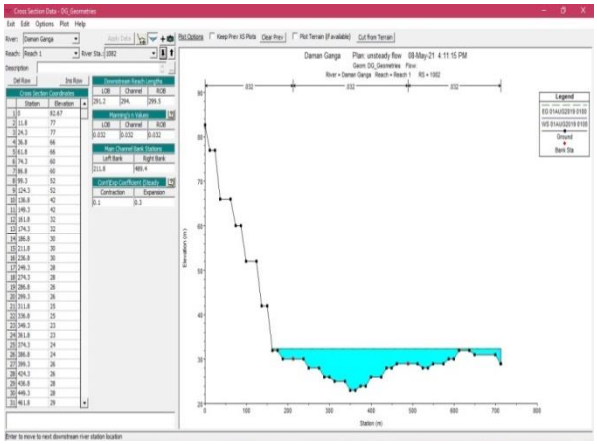


Fig 15: water surface profile c/s 1082

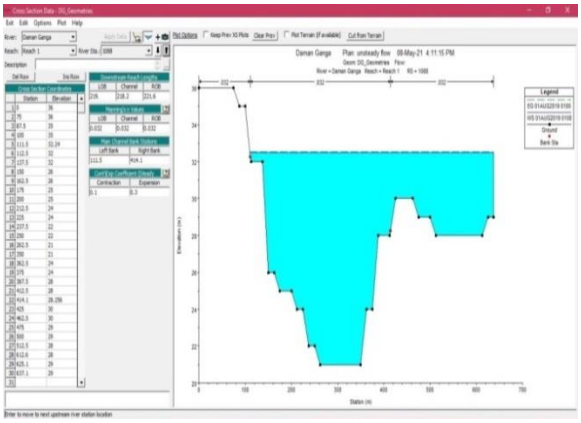


Fig 16: water surface profile c/s 1088

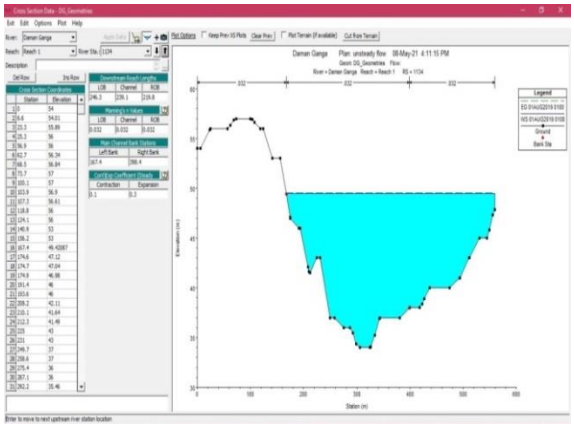


Fig 17: water surface profile c/s 1134

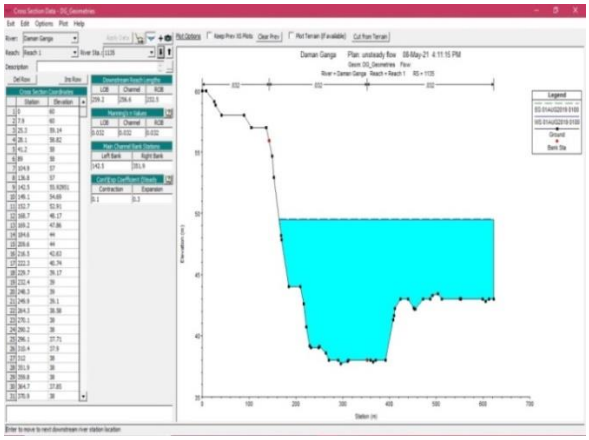


Fig 18: water surface profile c/s 1135

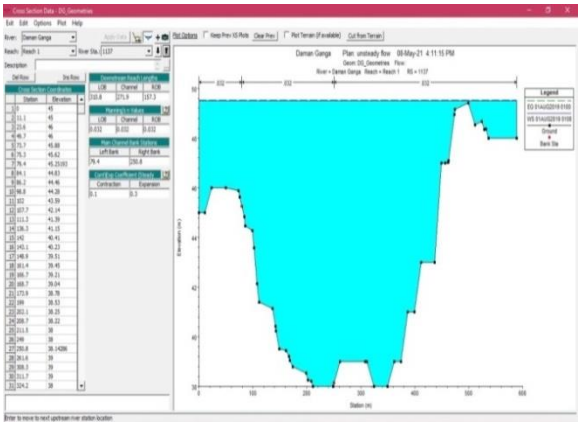


Fig 19: water surface profile c/s 1137

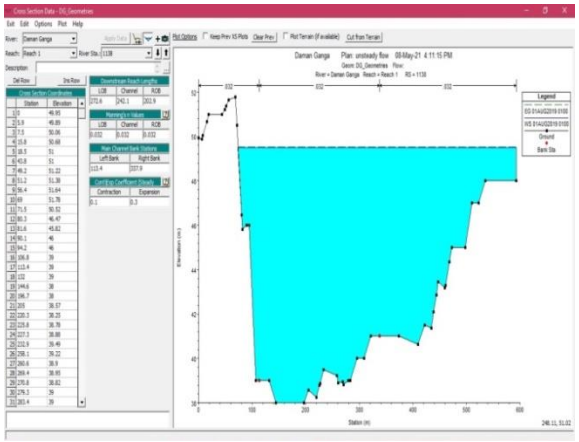


Fig 20: water surface profile c/s 1138

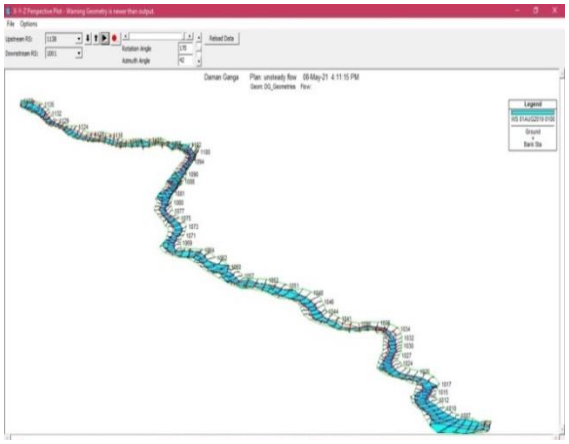


Fig 21: XYZ perspective plot

VI. CONCLUSION

In this research the combination of ArcGIS and HEC-RAS software in the estimation of flooding at different cross section which is flooded. This model used to Study of the Damanganga Riverfrom Madhuban Dam to Arabian Sea for flood event in the 2019 year. From this study I recommend that to improve the river training work and river bank protection work for Damanganga River by considering past flood. The results from the study indicate that area near Madhuban Dam as well as near Damanganga dam and Arabian Sea area which highly flooded during discharge from the dam. After model execution future work lies in construction of retaining wall where water is over topping from the bank.

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REFERENCES

[1] Azazkhan I. Pathan, P. G. Agnihotri, 2-D Unsteady Flow Modelling and Inundation Mapping for Lower Region of Purna Basin Using HEC-RAS in 2020. In Nature Environment and Pollution Technology (2020).

[2] Azazkhan I. Pathan, P. G. Agnihotri, A Combined Approach For 1-D Hydrodynamic Flood Modeling by using Arc-Gis, Hec-Georas, Hec-Ras Interface - A Case Study on Purna River of Navsari City, Gujarat in 2019. International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, 8(1)(2019).

[3] Muhammad Farooq, Muhammad Shafique, Flood hazard assessment and mapping of River Swat using HEC-RAS 2D model and high-resolution 12-m TanDEM-X DEM (WorldDEM) in natural hazard (2019).

[4] Vinay Ashok Rangari, N. V. Umamahesh, Assessment of inundation risk in urban floods using HEC RAS 2D in Modeling Earth Systems and Environment 5(2019) 1839–1851.

[5] DasallasLea , Kim Yeonsu, Case Study of HEC-RAS 1D–2D Coupling Simulation: 2002 Baeksan Flood event in Krea in water(2019).

[6] Sumit B. Patel, Darshan J. Mehta, One dimensional hydrodynamic flood modeling for ambica river, south gujarat in 2018 JETIR , 5(4) (2018).

[7] Azhar Husain, Mohammed Sharif, Simulation of Floods in Delhi Segment of River Yamuna Using HEC-RAS. American Journal of Water Resources, 6 (4)(2018) 162-168.

[8] Noor SurayaRomali, ZulkifliYusop, Application of hec-ras and arc gis for floodplain mapping in segamat town, malaysia International Journal of GEOMATE,15(47)(2018) 7 -13.

[9] Dhruvesh P Patel,Jorge A. Ramirez, Assessment of flood inundation mapping of Surat city by coupled 1D/2D hydrodynamic modeling: a case application of the new HEC-RAS 5 Nat Hazards 89(2017) 93–130.

[10] V. Moya Quirogaa, S. Kurea, K. Udoa& A. Manoa, Application of 2D numerical simulation for the analysis of the February 2014 Bolivian Amazonia flood: Application of the new HEC-RAS version 5. Ribagua, 3:1, 25-33, DOI: 10.1016/j.riba.2015.12.001.

[11] HeenaIngale, R. V. Shetkar, Flood Analysis of Wainganga River by using HEC-RAS model International Journal of Scientific Engineering and Technology., 6(7)(2017) 211-215.

[12] Rahul Agrawal, Regulwar D.G. Flood Analysis of Dhudhana River in Upper Godavari Basin Using HEC-RAS. International Journal of Engineering Research., 5(1)(2016) 188-191.

[13] Vahdettin Demir & Ozgur Kisi, Flood Hazard Mapping by Using Geographic Information System and Hydraulic Model: Mert River, Samsun, Turkey Hindawi Publishing Corporation Advances in Meteorology., (2016) Article ID 4891015.

[14] Darshan j mehta, Manthan Ramani, application of 1D HEC-RAS model in design of channels (IJIRAE)., 1(7) (2014).

[15] Dhruvesh P. Patel, Prasant K. Srivastava, Flood Hazards Mitigation Analysis Using Remote Sensing and GIS: correspondence with town planning scheme Water Resources Management.,(2013)DOI: 10.1007/s11269-013-0291-6

[16] P. V. Timbadiya, P. L. Patel, Hec-ras based hydrodynamic model in Prediction of stages of lower tapi river ISH Journal of Hydraulic Engineering (2012).

[17] P.G. Agnihotri, Patel J.N. Improving carrying capacity of river tapi (surat, india) by channel modification. International Journal of Advanced Engineering Technology E-ISSN 0976-3945.

[18] Jie Yang, Ronald D. Townsend. Applying the HEC-RAS model and GIS techniques in river network floodplain delineation. Can. J. Civ. Eng., 33(2006).

[19] M.R. Knebl, Z.-L. Yang, Regional scale flood modelling using NEXRAD rainfall, GIS, and HEC-HMS/RAS: a case study for the San Antonio River Basin Summer 2002 storm event.Journal of Environmental Management., 75 (2005) 325–336.

[20] Muhammad ShahzadKhattak, Faizan Anwar, Floodplain Mapping Using HEC-RAS and ArcGIS: A Case Study of Kabul River. Arab J SciEng 41 (2016)1375–1390. DOI 10.1007/s13369-015-1915-3.

[21] HEC-RAS river analysis system, Hydraulics reference manual, version 5.0, (2016)., U S Army corps of engineers.

[22] Vapi development plan(2016 – 2020) report.

[23] Patel CG, Gundaliya PJ Floodplain delineation using HECRAS, model—a Case Study of Surat City. Open J Mod Hydrol 6(01) (2016) 34.

[24] Remo JW, Carlson M, Pinter N Hydraulic and flood-loss modeling of levee, floodplain, and river management strategies, Middle Mississippi River, USA. Nat Hazards 61(2) (2012) 551–575.