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Tapi River Flood Risk Map for Surat by Using Gis

KEYWORDS Flood assessment, Flood risk map, Flood hazard map, Cartosat-1 image, Geographical Information System.

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ABSTRACT *During the flood 2006caused damages on flood embankment and retaining wall at many places. The flood also resulted in total losses of Indian Rupees 21000 Crores in the year 2006. This flood event of 2006 signified concern on flood protection and control as such frequent event causes extensive damage to public property, infrastructure, agriculture, trade, industries, wages etc. along with loss to private properties and business establishments in general. Keeping in view the serious concern, it feels the research in that direction for minimization of Tapi river flood impacts –Surat (Gujarat) is of vital importance. Tapi River flood risk map prepared for whole Surat city which indicates high, moderate and low flood water risk level with respect to area by using GIS.*

FLOOD SITUATION IN SURAT CITY

Tapi River covers approximately 515041 cm (79%) of Maharashtra state, 9804 km (15%) of Madhya Pradesh and 3837 km (5%) of Gujarat State, The basin finds its outlet in the Arabian Sea and is bounded on three sides by ranges of hills. The Tapi River and its tributaries flow over the plains of Vidharbha,Khandesh and later to Gujarat, and can be divided in to three Zones, Viz. Upper Tapi basin Middle Tapi Basin and Lower Tapi Basin The portion in between Ukai Dam to the Arabian Sea is considered as Lower Tapi Basin mainly occupying the Surat and Hazira twin cities along with tens of small towns and village by the river. The Surat and Hazira twin cities are almost 90 km downstream of Ukai dam and are affected by the recurrence of floods at regular intervals. Five main and several minor creeks pass through the city and meet river Mindholain south of Surat. Surat is city located on the western part of India in the state of Gujarat.

Tapi river is known for occurrence of large floods due to influence of depressions originating from Bay of Bengal and travelling from East to West along the river course causing rains first in upper catchments and then in the lower catchments resulting in aggravation in magnitude of flood along its course. The city of It is located barely 20 km upstream of the confluence of Tapi with the Arabian Sea. The river flows through a large meander just upstream of Surat. The city of Surat is located at the downstream end of a large meander in the riverand on concave side of the river course. The city of Surat is second largest city of Gujarat along with population more than 2.80 million soles. Tapi river floods in yr. 1998 and 2006 have created havoc on Surat city lives and properly recently in the memory of people. The maximum observed flood for a few years would certainly lead to formulation of proper guidelines for operation of Ukai dam spillway gates by using RS and GIS on Cartosat-1 image for Surat city.

In recent times, several Indian cities such as Surat, Mumbai, Chennai, Kolkata, Bangalore etc. have witnessed unprecedented incidences of flooding due to various causes. Faulty urban planning and failure of drainage system are considered as main reasons behind flooding and surface inundation in urban areas in developing countries. The capacity of storm sewers can be overtaxed occasionally and water rises in man holes as well as inundating the urban areas. Thus, monitoring sewer flow for large cities and prevention of damages has always been a concern. A well designed sewer system can reduce the probabilities adequate drainage of storm sewer flow.

It is estimated that a single flood event In the lower Tapi basin, a river stretch between the Ukai dam and Arabian sea, during 7-14 August-2006 resulted in 300 people being killed and approxRs. 21,000 crore (US $ 4.5 billion) of property damage-human life came to a stand-still for almost two weeks in Surat and Hazira twin cities, as well as tens of rural villages along the lower Tapi basin. The Tapi River in Surat recorded the highest water levels of the last 35 years. Therefore, it is of prime importance to minimize the property damage, reduce infrastructure disturbances, and identify zones and buildings having greater flood hazard and flood risk.

DATA USED IN RESEARCH STUDY

River Tapi flows through the city and meets the Arabian Sea at about 16 km from Surat. Surat is 90 km in downstream of Ukai Dam over river Tapi. Five main and several minor creeks pass through the city and meet river Mindhola in south of Surat. Study area of Surat city for DEM generation of Cartosat –1 data, image of Fore and Aft a scene of town mentioned in Table.1.

TABLE – 1
INFORMATION OF FORE AND AFT SCENES

Sr. No.	Fore Image	Aft Image
1	Satellite ID=Cartosat-I	Sat. ID=Cartosat-I
2	Date of Pass: 20th March 2012	Date of Pass: 20th March 2012
3	Sensor= PAN_AFT	Sensor = PAN_FORE
4	Path = 0511	Path = 0511
5	Row = 0299	Row = 0299
6	Resolution Along = 2.5 m	Resolution Along 2.5 m
7	Resolution Across = 2.5 m	Resolution Across = 2.5 m
8	No. of Scans = 12000	No. of Scans = 12000
9	No. of Pixels = 12000	No. of Pixels = 12000

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PAN-A/F (2.5m high resolution) Cartosat-1 image data collected from NRSC, Hyderabad in stereo pair path 93, raw 57, SOI Map sheet 46c15 and 16, UTM map projection,WGS84 datum, product no 4.2 ortho kit in GEOTIFF file format. For DEM generation of Cartosat –1 data, data of Surat city collected. Fore and Aft scenes of town, dated 12th January 2012 were used.

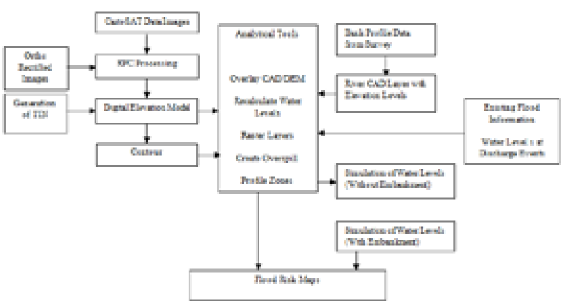
RESEARCH OBJECTIVES

- Preparation of flood risk and flood hazard map for whole Surat city by using Cartosat data image and software (MicroDEMfor Image Processing and DEM processing/Eshayal Smart for GIS Map Window 4.5 for Stereo Data Processing and Watershed Delineation).
- Recommend optimal solutions to minimize the Tapi River flood impacts- Surat (Gujarat).

FLOOD RISK ASSESSMENT

The Flood risk assessment study was carried out to understand the impact due to two types of floods. Flood due to Tapi River (releases from Ukaireservoir) discharges ranging from 11,326 to 33,980 cumec (0.4 to 1.2 million cusec). The outputs of the study are presented in the Figures. The second type of flood is caused by the two streams passing through the city. These floods (also called Khadi floods) are more frequent but cause comparatively less damage.

Methodology shown below in form of flow chart for flood risk map assessment.



METHODOLOGICAL FRAMEWORK

The concepts of hazard, vulnerability and risk have been extensively used in various disciplines with a different meaning, impeding cross-disciplinary cooperation for facing hazardous events. The methodology aims to assist water managers and stakeholders in devising rational flood protecting strategies.

In addition to economic and social damage, floods can have severe consequences, where cultural sites of significant archeological value are inundated or where protected wetland areas are destroyed. Regarding floods in Europe, two trends point to an increased flood risk and to greater economic damage from floods. First, the scale and frequency of floods are likely to increase in the future as a result of climate change, inappropriate river management and infrastructure development in flood risk areas. Second, an increase in vulnerability has been noted due to the number of people and economic assets located in flood risk zones. Therefore, the coming decades are likely to see a higher flood risk in Europe and greater economic damage.

On 18th of January 2006 the European Commission proposed a Directive on the assessment and management of floods (COM, 2006). Its aim is to manage and ultimately to reduce the risks that floods pose to human health, environment, infrastructure and property. Under the proposed Directive, the Member States are obliged to deliver the following for river basins and sub-basins:

- Preliminary flood risk assessment
- Flood risk maps
- Flood risk management plans

The provision of structural flood can have a major impact on the environment and there has been an expression of concern by many members of the public for the degradation of river corridors. Therefore, it is becoming common practice for central and local government to subject flood management plans to public discussion (COM, 2006).

It is obvious from the above that concepts such as hazard, risk and vulnerability are the most commonly used terms to describe the potential threats that natural disasters pose to human life, the environment and the infrastructure. Additionally, these terms are used to question the capacity of various structural and non-structural measures, which are applied for protection from these threats. In the absence of regulatory establishment of a common accepted terminology platform, the confusion on the context of these terms grows. Furthermore quantification of the terms is not an easy task. It is possible that some parameters affecting the above concepts are beyond quantification and also that these parameters vary in space and time (Brauch, 2005; Thywissen 2006). To clarify these concepts and to highlight a methodology for the assessment of flood hazard and flood risk.

Without Embankment

Though the Surat Municipal Corporation constructed series of the embankment on the river banks the feasibility of its success was not tested. The present exercise also documented two scenarios (a) without embankment and (b) with Embankment along with various discharge scenarios from Ukai. The peak discharge of 7 cusec water from the reservoir was tabulated with water levels at various locations along the river. The bank overflow data was supplied along with the height of bank, flow in the river, depth of existing water and spill point. These data resulted in the calculation of spill over areas at different levels at the designated points.

With Embankment

During period 2006-2012, the Surat Municipal Corporation has strengthened the embankments by constructing protection walls. Since the varied length and structures are available along the river bank there is likely chance of having different impact on the spillover scenario. Three scenarios with Water discharge between (a) 1.2-2.5 cusecs (Low) (b) 3.2-5.0 cusecs (Medium) and (c) 5.5-7.0> (High). The river bank profile data from the survey was overlaid on the embankment levels and water levels assumed at various sections with the river. Data was simulated for 10 section points divided into the sections in river. The Table.2 shows estimated flood levels at locations from Digital Elevation Model (DEM) was estimated after simulation of the flood levels using the overlay analysis techniques in GIS shown below.

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TABLE – 2
ESTIMATED FLOOD LEVELS AT LOCATIONS IN STUDY AREA

ID	River Section	WL_NORMAL	Water Levels at Discharge (including Bank Height)*			
			FE_2_5	FE 3_2	FE5	FE_7
1	NH 8 Bridge	6.00	8.50	9.20	11.00	13.00
2	Railway Bridge	6.00	8.50	9.20	11.00	13.00
3	Kosad Bridge	7.00	9.50	10.20	12.00	14.00
4	Wier	4.00	6.50	7.20	9.00	11.00
5	Nehru Bridge	4.00	6.50	7.20	9.00	11.00
7	Low Level	3.00	5.50	6.20	8.00	10.00
8	Sardar Bridge	3.00	5.50	6.20	8.00	10.00
9	ONGC Bridge	4.00	6.50	7.20	9.00	11.00
10	Hazira Point	5.00	7.50	8.20	10.00	12.00

*Data Estimated from the Digital Elevation Model Image and Discharge Simulation Results, FE=Flood Discharge Elevation

The above results are being validated with the actual case data of the water levels in the last floods and probability if such occurrences cannot be ruled out. The result of embankment also reduces the extent of the spread from 80 sq.km of the areas with SMC limit to about 40-54 Sq.km in the simulated data sets. The zone flooding data shows lesser damage in Katargam area due to construction of the embankment.

However, the impact of the embankment would be lesser in the South and South west part of the city due to poorly conceived length of the protection structures. The high density of the development on the Western part of Surat and development along Hazira restricts the movement of the flood water there by resultant spread in upstream.

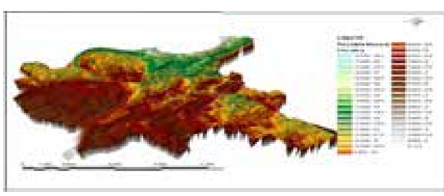

FIG.1 TIN (DEM) OF SURAT CITY.

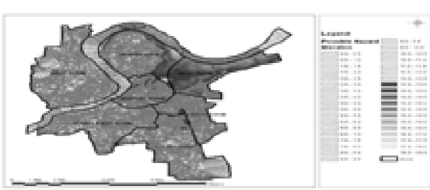

FIG.2 FLOOD HAZARD MAP OF SURAT CITY (FLOOD 2006)

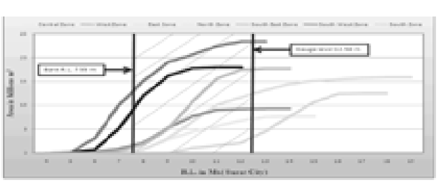

FIG.3DIFFERENT ZONES OF SURAT CITY SUBMERGED IN WATER

VALIDATION OF MODEL

Data based on the contour levels supplied by SMC, a digital elevation model (DEM) for the west zone Flood hazard mapping using remote sensing was developed. After combining the DEM with river bank levels, a flood risk map for various water-level scenarios at 0.5 m intervals was prepared. The sample flood mapping potential areas for the west zone have been demarcated. The possible areas under each water level height are depicted with different colors in the flood hazard map. After generating the flood risk map, the water levels of the 2006 flood were compared with Hope (Nehru) Bridge. It was found that Hope Bridge has a bank level of 4.1 m; therefore there will be about 3–4 m water over the right-bank area. Hence, the major parts of the Adajan area will be submerged. The Rander area will also be submerged by 1–2 m depth of water, as was experienced during the August 2006 flood. This shows the accuracy of our hydraulic and GIS model for flood mapping.

RESULTS

By using GIS and RS on NRSC Surat city image, flood risk and flood hazard map prepared which shows risk level of submergence areas at Surat city under different flood events. The results of analysis have shown Table.3 in form of high, moderate and low flood risk level in ft.

Table – 3
WATER LEVELS IN FT (SIMULATED OVER THE BANKS OF TAPI: SURAT)

ID	FE_1_3	FE_EM2_5	OVER-SPILL	BANK_HT	PROP_BLD_P	RISK_LVL
1	2.500	0.000	5.500	2.500	-3.000	LOW
2	2.000	-0.500	4.500	1.500	-3.000	LOW
3	2.244	-0.256	4.988	1.988	-3.000	LOW
4	2.122	-0.378	4.744	1.744	-3.000	LOW
5	1.876	-0.624	4.252	1.252	-3.000	LOW
6	1.430	-1.070	3.360	0.360	-3.000	LOW
7	1.870	-0.630	4.240	1.240	-3.000	LOW
8	2.034	-0.466	4.568	1.568	-3.000	LOW
9	2.320	-0.180	5.140	2.140	-3.000	LOW
10	7.540	5.040	15.580	12.580	-3.000	HIGH
11	4.320	1.820	9.140	6.140	-3.000	MOD
12	7.540	5.040	15.580	12.580	-3.000	HIGH
13	7.540	5.040	15.580	12.580	-3.000	HIGH
14	7.540	5.040	15.580	12.580	-3.000	HIGH
15	4.320	1.820	9.140	6.140	-3.000	MOD
16	7.540	5.040	15.580	12.580	-3.000	HIGH

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Table - 4
CALCULATED PROBABLE SUBMERGED AREA IN DIFFERENT ZONE

R.L. in m.	Central Zone Area in m3	West Zone	East Zone	North Zone	South Zone	South West Zone	South Zone
4.	0	16459.8931	0	0	0	0	0
5.	0	82685.7784	0	0	125204.4521	144157.84	0
6.	35505.7137	3148877.841	0	0	309496.1909	733934.2222	10170.2584
7.	218075.0861	10087669.98	0	23947.3616	932935.9305	5177583.488	340280.2013
8.	909142.2165	15174263.9	4975.9088	724519.5648	2179847.015	12081565.46	1829098.736
9.	2770571.703	19010774.62	69214.0399	3012504.379	5216316.875	16197165.4	4961610.873
10.	4458378.64	20579900.4	1045504.081	6518841.898	7630186.822	17815792.9	10546086.5
11.	5584819.726	22467947.47	1570872.928	10057721.87	9038917.745	17972520.79	15533632.09
12.	6821422.009	23309406.67	2139519.887	11644490.98	9281470.812	17979211.44	17351842.98
13.	7553971.397	23343323.55	4557964.053	13145141.06	9323525.22	0	17658427.94
14.	7605169.701	0	7620681.004	14424795.18	9327802.941	0	17686694.4
15.	7623753.748	0	10665881.83	15114343.94	0	0	0
16.	0	0	12370449.75	15403339.84	0	0	0
17.	0	0	12474629.8	15751534.07	0	0	0
18.	0	0	12475711.15	15871592.54	0	0	0
19.	0	0	0	15886591.83	0	0	0

CONCLUSION

Conclusions on finding of these studies presented in below in form of recommendations are made for protection from possible flooding of Surat city, other urban development's along banks and the Hazira industrial area.Proposed embankments and retaining walls suggestedshown below Fig. 4.to minimize Tapi River flood impacts for Surat City.

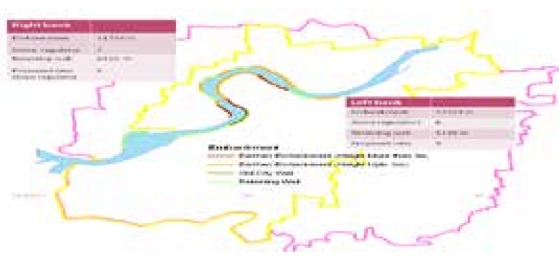

FIG. 4 EMBANKMENTS AND RETAINING WALLS

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