PREPARATION OF FLOOD REDUCTION PLAN FOR SURAT CITY AND SURROUNDING REGION (INDIA)

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Abstract: - Floods affect Suart city situated on river Tapi in India many times, which creates damage to the people and properties. In this paper the study of floods at Surat city in general and the study of flood occurred at Surat during 2006 in particular has been made. Certain preventive and curative measures are suggested for reducing the effects of flood in the study area. Flood reduction plan for the study area has been also prepared and presented in this paper.

Key Words: -Surat, River Tapi, Flood, Submergence, Flood Level, Desilting, Diversion, Protection Wall, Flood Reduction Plan

1 Introduction

Surat city is situated at the delta region of river Tapi (India). The river Tapi is originating from a mountain Satpuda and flowing through three states Maharastra, Madhya Pradesh and Gujarat. The river Tapi is merging to the Arabian Sea at about 15 kms away from Surat city. The map of Tapi river basin is shown in Figure 1. Ukai dam controls the flow of water and water level in the river Tapi, which is 100 kms away from Surat city. The dam is constructed at Ukai, Tal: Songadh, Dist: Surat. It is constructed for irrigation purpose mainly and also served the purpose of flood control, generation of hydropower and supply of industrial and drinking water. The average rainfall in the catchment area is about 785 mm and average yearly run off is 17,226 MCM. The salient features of Ukai Reservoir are shown in Table 1. Total seventeen rain gauge stations are available at different places and twenty two wireless stations are linked with the dam site, which gives the information about rainfall to the Central Water Commission. The Indian Meteorology department predicts the probability of rainfall in the catchment area during next 24 to 48 hours and same information is transferred to Central Water Commission and media.

Flood occurs at Surat city frequently due to sudden release of water from Ukai dam in river Tapi. At the time of floods in river Tapi, Surat city and surrounding region are most affected. History of floods at Surat city, details of floods and remedial measures for prevention / minimization of the effect of floods at Surat city are discussed in the subsequent topics. A flood reduction plan is also prepared and presented.

Table 1 : Salient Features of Ukai Reservoir

Sr. No.	Item	Description
1	Location	Songadh, (District Surat)
2	River	Tapi
3	Catchment Area	62 225 sq km
4	Design Flood Discharge	49 490 cumecs (1.75 million cusecs)
5	Year Of Completion	1972
6	Gross Storage Capacity	8.511 BCM
7	Live Storage Capacity	7.092 BCM
8	FRL	105.22 m (345 ft)
9	HFL	107 mt (351 ft.)
10	MDDL	82.3 m (270 ft)
11	Riverbed level	47.87 m (157.05 ft)
12	Installed Power Generation Capacity	305 MW (4 X 75 MW + 2 X 2.5 MW – this was added at a latter date)
13	Hydraulic Head	34-57 m
14	Maximum Discharge	213 cumecs (7522 cusecs)

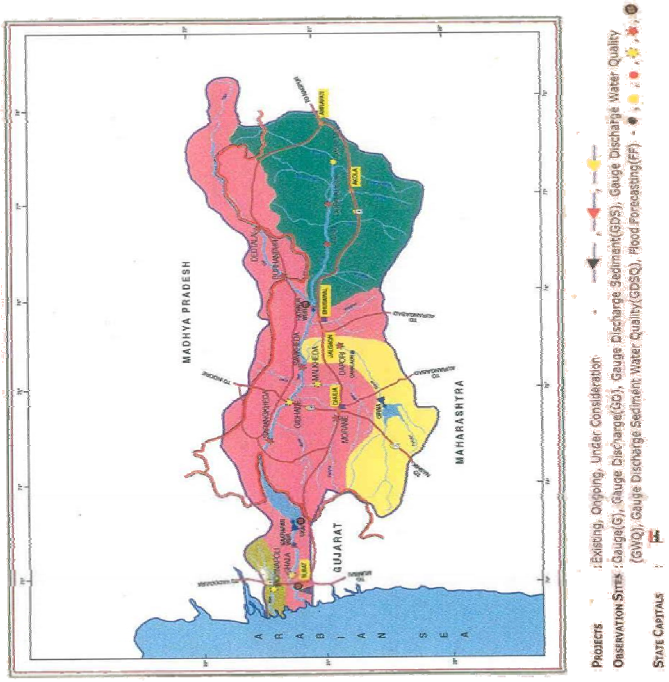

Fig. 1 Map of Tapi River Basin

2 Floods At Surat City

The Surat city has faced many floods since 1883. The history of the floods is given in Table 2.

Table 2 : Flood History at Surat

Sr. No.	Flood Event	Discha-rge (Lac Cusecs)	Water Level at Hop Bridge (m)	Period
1	1883	10.05	11.05	July
2	1884	8.46	10.05	September
3	1894	8.01	10.33	July
4	1942	8.60	10.56	August
5	1944	11.84	11.32	August
6	1945	10.24	11.09	August
7	1949	8.42	10.49	September
8	1959	12.94	11.55	September
9	1968	15.5	12.08	August
10	1994	5.25	10.10	Aug.-Sep.
11	1998	7.0	11.40	September
12	2006	9.09	12.40	August

2.1 Scenario of Flood During August 2006

The flood occurred in the year 2006 was devastating. The level of water started rising in the river Tapi from 1st August 2006 and started spreading in the nearby area of city. By 5th to 9th August 2006, almost 90% area of the city was flooded and the depth of flood water observed in the different areas was varying according to the topography of the City. The map of Surat city (Figure 4) is showing the variation in the depth of submergence in different colours. The information and warning about flood must be reached to the people timely so that the people can take their own measures of safety and precautions. Figure 2 shows the status of warning in Surat during flood 2006. From the figure, it is evident that about 43% of people did not receive any warning from the Surat Municipal Corporation (SMC) or any other state agency. They learnt about the approaching flood only when they saw the water rising. This proportion was highest (64%) in areas like citylight, umra and piplod, all of which are considered Surat's posh or upcoming localities. Only around 7% of respondents said that they had received some warning from the administration through vans or Short Service Messages (SMS) on mobile phones. As many as 30.7% of respondents said that they first learnt about the flood through the media. Friends, relatives and neighbours were of big help in warning people. A significant share making up for 20% of respondents said that they got information about the flood either through their friends, relatives or neighbours. The authenticity of message received other than local authority and the media is to be checked. It may cause unnecessary fear and disorder among the community. It is necessary to develop control techniques for flood as well as better warning system if flood occurs. Photographs of a rescue work, flooded river Tapi and area of city are shown in Figures 5 to 7.

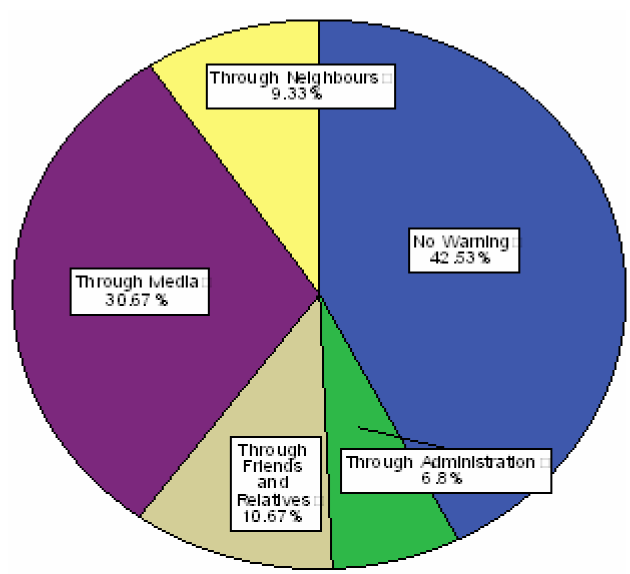

Fig. 2 Pie Chart Showing Status of Warning (Source: [2])

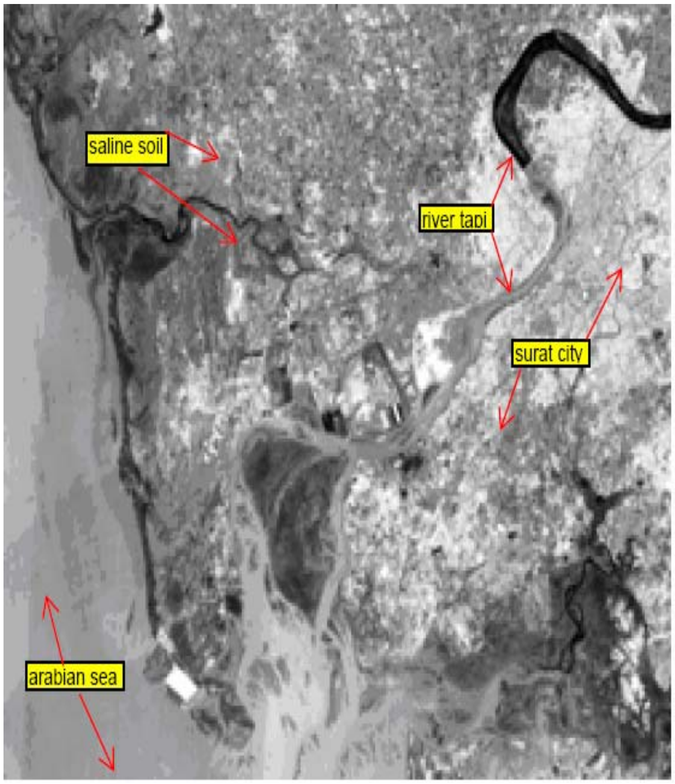

Fig. 3 Satellite Image of Surat City (Source: NRSA)

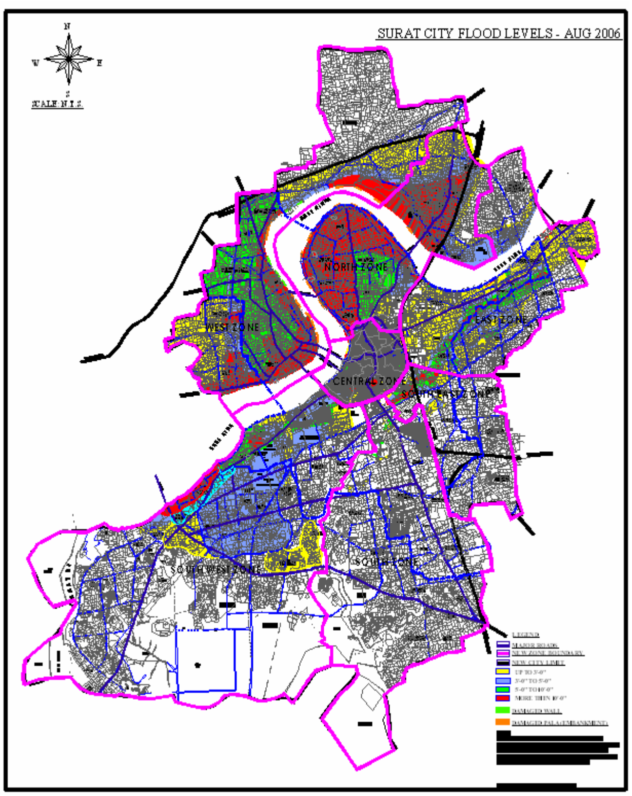

Fig. 4 Map Indicating Flood Depth at Surat City (Source: S.M.C.)

Fig. 5 A Rescue Work

Fig. 6 Flooded Area of Surat City

Fig. 7 Overflowing Bridges during Flood

2.1.1 Various Data Pertaining To The Flood-2006 (Source: S.M.C. Office)

The inflow and outflow of water and water levels at Ukai dam are given in Table 3 during 01/08/2006 to 20/08/2006. The water levels at weir cum causeway and Hop-Bridge at Surat city are also given in the table for the same time and date. The measurements were taken at 12:00 pm on respective dates.

Table 3 : Data of Flood 2006

Date	Level at Ukai (Ft.)	Inflow at Ukai (Cusec.)	Discharge from Ukai (Cusec.)	Water Level at Weir cum Causeway (m)	Water Level at Hop-Bridge (m)
	Danger level 345ft.			Danger level 6 m	Danger level 9.5 m
01/08/06	331.54	62903	1200	6.71	2.30
02/08/06	333.09	75263	1200	6.88	2.36
03/08/06	334.44	73715	23784	7.20	1.90
04/08/06	335.06	73413	23680	7.02	2.20
05/08/06	335.42	150047	125464	6.97	0.90
06/08/06	337.12	503027	352056	9.70	6.9
07/08/06	342.98	1166390	829829	-	11.90
08/08/06	345.65	922629	908994	-	12.40
09/08/06	346.02	719575	650417	-	12.20
10/08/06	345.17	363632	544795	-	11.25
11/08/06	344.45	234355	299785	-	8.90
12/08/06	344.78	209250	300775	-	6.50
13/08/06	342.03	141817	297203	10.50	7.90
14/08/06	338.50	134318	312168	10.57	8.00
15/08/06	336.14	122704	147916	9.50	6.92
16/08/06	335.32	102292	102292	8.98	5.20
17/08/06	335.16	89335	100891	8.00	3.00
18/08/06	334.23	100868	200232	8.75	3.00
19/08/06	332.37	132824	194527	9.30	5.70
20/08/06	331.00	51619	34824	9.30	5.50

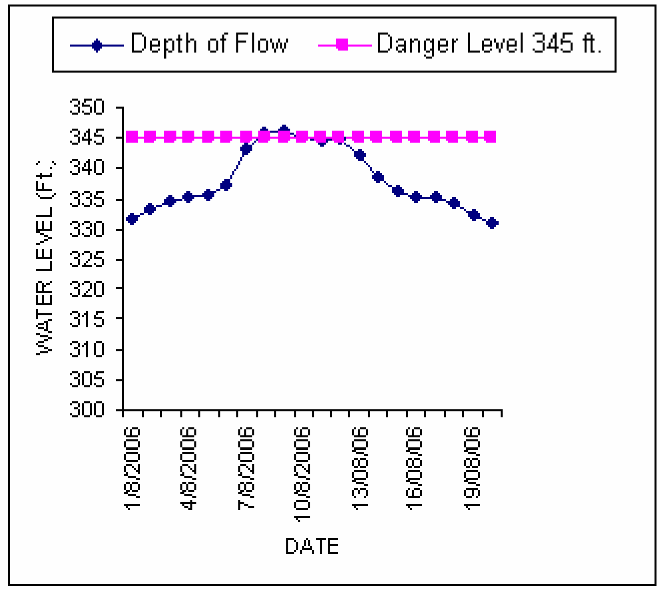

Fig. 8 Water Level at Ukai Reservoir

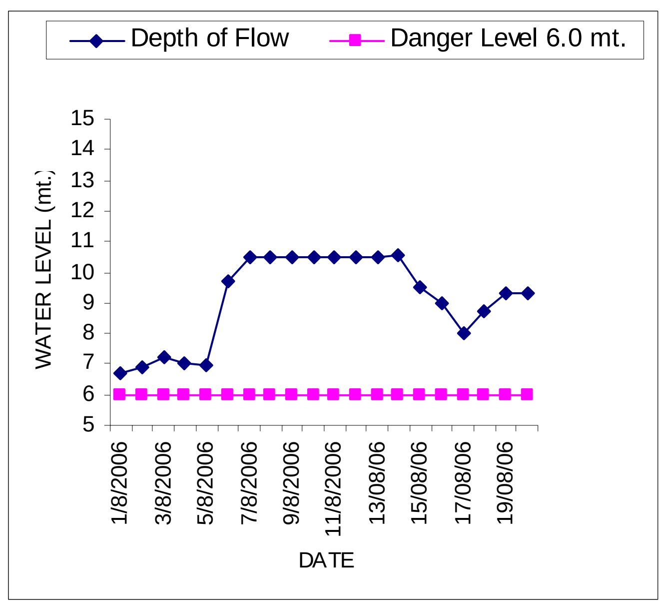

Fig. 9 Water Level at Weir cum Causeway, Surat

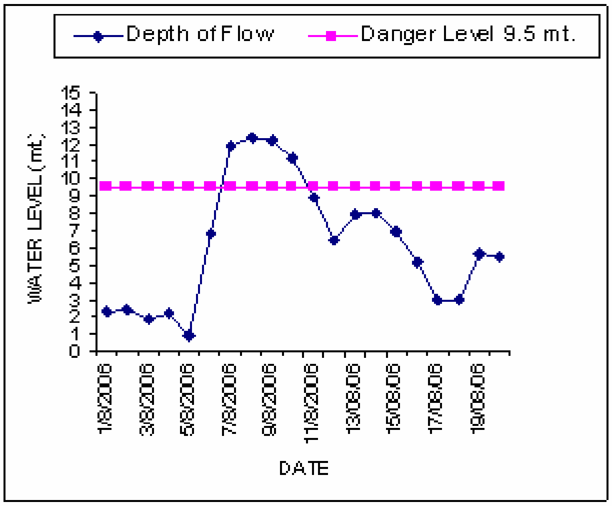

Fig. 10 Water Level at Hop Bridge, Surat

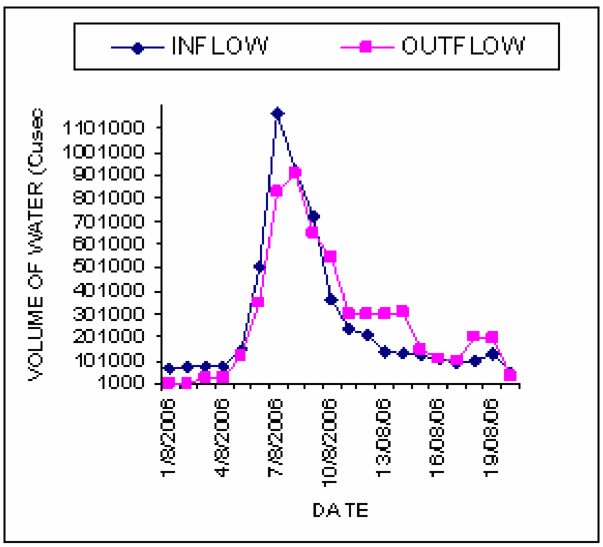

Fig. 11 Inflow/Outflow at Ukai Reservoir

3 Preventive Remedial Measures

The general remedial measures include preventive as well as curative steps for the control of flood at Surat. Some preventive measures are indicated below.

3.1. Reservoir operation policy

Full reservoir level at dam is 345 ft., but the water can be stored up to 351 ft. In critical condition water can be stored up to 348.5 ft. safely according to a study report.

3.2 Warning system from upstream

It is necessary to place advanced and computerized rain gauge stations in the catchment area and must be linked with dam site and flood forecasting cell.

3.3 Release of water from the dam

The release of water from the dam must be in accordance with the water level in the reservoir without affecting the main purpose of irrigation. Superintendent Engineer may be empowered for the same. The information regarding release of water from dam in critical condition must be given to down stream area effectively and timely.

4 Flood Reduction Plan

A flood reduction plan has been prepared which mainly include the curative measures. The details are described below.

4.1 Desilting from Reservoir

Due to silting in the reservoir the dead storage capacity of dam has been reduced. The average rate of silting is 1 ft. per year. It is difficult to completely remove mud and silt from the reservoir, however silt removal devices can be installed to minimize the silting effects.

4.2 Increasing the carrying capacity of river Tapi

The effective waterway of river Tapi has been reduced over years due to silting. The dredging of river in certain reaches and other suitable measures can be implemented to increase the carrying capacity of the river.

4.3 Storm Water Drainage Line Parallel to river

Construction of storm water drainage line parallel to river Tapi may be implemented on both the banks and necessary floodgates must be placed.

4.4 Construction of flood protection wall

It is necessary to provide flood protection wall on both the banks of river Tapi to protect the residential areas. The existing flood protection wall may not be sufficient in respect of length and height as well as it is in a damaged condition.

4.5 Recharge of groundwater

It is necessary to construct widely spread groundwater recharge wells after proper planning and design in the flood affected area, which can absorb some portion of the flood water. The recharged water will also be useful for increasing the groundwater storage, improving the quality of groundwater and control of sea water intrusion.

4.6 Spreading of flood water on saline Soil

It is also proposed to divert the floodwater to the existing saline soil areas outside the city. Such a diversion is possible by construction of suitable diversion channels. The diverted water will serve the purpose of reclamation of saline soil through leaching.

4.7 Hi-tech disaster management

This can be done by as under

- A preparation of counter map for the area from ukai to Sultanabad including Surat city using GPS technique.
- A preparation of map showing markings of H.F.L as well as their reference (latitude & longitude). This must be co related with discharge and water level at dam.
- Reference map (co-ordinate) of place should be with rescue and relief team, so that if flood occurs, relief work can be done effectively and efficiently by boat, helicopter etc.
- Flood hazard map should be prepared using GIS technique.

4.8 Diversion of Flood Water to Other Rivers

If the flow in the main channel is to be reduced, a branch channel is some times, taken off from the main channel, thus diverting a part of main river water into this branch channel. Under certain critical stages, this method proves to be very effective to relieve the flood strain, and at the same time it assures greater safety to dikes and other flood control structures. It is advisable that the diversion of flow be controlled by providing a regulator, so as to avoid the deterioration of the river in future.

The flow of river Tapi during flood can be diverted to other river through interlinking canals, so that the excess water during flood can be managed efficiently. There are five possibility of diverting the flood water from river Tapi.

- In Purna river near Navsari.
- In Mindhola river near Sachin.
- In Kim river near Kosamba.
- In Sena creek near Dandi, Olpad
- In Tena creek near KRIBHCO.

The existing capacities of above rivers / creeks and possible enhancement in their capacities are shown in Table 4. The canals connecting river Tapi with river Purna, Mindhola, Kim as well as Tena and Sena creeks are shown in Figure 12. The alignment of connecting canals are kept parallel to existing highways. In the figure the faint yellow lines indicate the existing highways. The details of reduced levels, latitude and longitude of junction points of connecting canals with river Tapi are shown in Tables 5 and 6.

Table 4 : Capacities of Rivers / Creeks

Sr. No	Name of Channel	Existing Carrying Capacity (Cumecs)	Carrying Capacity after Enhancement (Cumecs)
1	Purna	8500	11500
2	Mindhola	1300	2050
3	Kim	750	1250
4	Tena creek	250	750
5	Sena creek	100	850
Total additional capacity of all the creeks after enhancement			5500

Table 5 : Interlinking Canals

Interlinking Canal	Proposed to be connected with	Length of Canal (m)	Junction
AB	Tena	11390	A
			B
CD	Kim	10010	C
			D
EF	Mindhola	17450	E
			F
GH	Purna	27380	G
			H
IJ	Sena	20372	I
			J

Table 6 : Details of Interlinking Canals

Junction	Latitude	Longitude	RL (m)
A	N 21° 08' 48.35"	E 72° 44' 27.86"	6
B	N 21° 13' 21.75"	E 72° 40' 12.02"	3
C	N 21° 18' 56.72"	E 72° 58' 26.51"	18
D	N 21° 24' 15.54"	E 72° 58' 02.41"	15
E	N 21° 13' 8.06"	E 73° 13' 30.76"	39
F	N 21° 06' 29.37"	E 73° 06' 22.47"	29
G	N 21° 15' 10.61"	E 73° 17' 23.14"	44
H	N 21° 02' 37.88"	E 73° 13' 06.25"	29
I	N 21° 13' 51.93"	E 72° 47' 29.30"	10
J	N 21° 20' 40.30"	E 72° 39' 36.96"	4

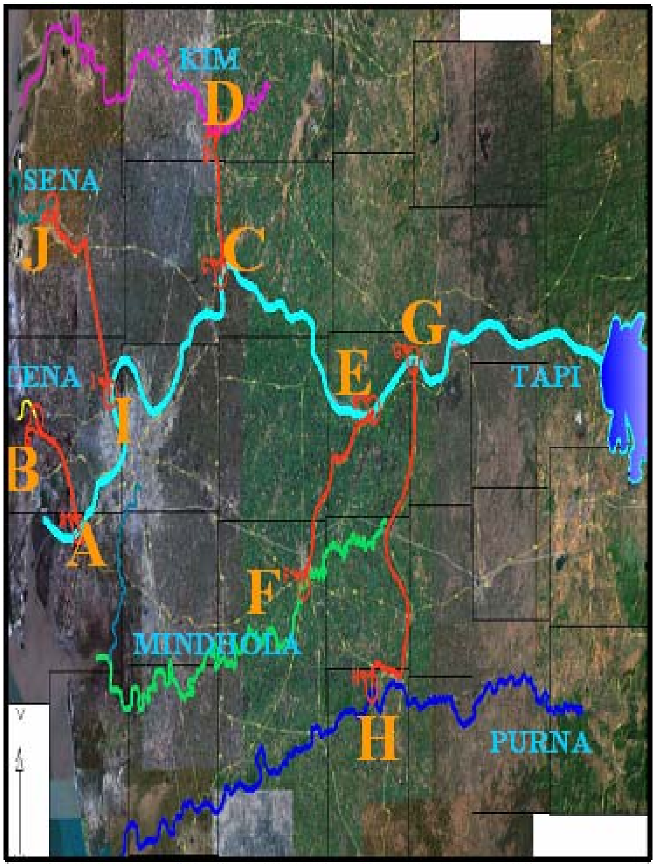

Fig. 12 Map indicating Possible Interlinking

4.8.1 Design of interlinking canals

Design of proposed interlinking canals are done using Kenedy's theory. The discharge through the canals are also verified by Maning's equation.

Design steps using Kennedy's theory

1. Assume a trial depth D of water in the canal.
2. Find the velocity of flow in the canal by Kennedy's Equation:
   $$V = 0.55\, mD^{0.64}$$
3. Find area of cross section of canal by continuity Equation $A = Q / V$
4. Find width of water in the canal assuming side slope 2:1, $A = BD + D^2/2$
5. Find Perimeter: $P = B + D\sqrt{5}$
6. Find hydraulic mean depth: $R = A/P$
7. Find velocity of flow by Maning's equation
   $$V = C\sqrt{RS}$$
   Where,
   $$C = \frac{23 + \frac{1}{N} + \frac{0.00155}{S}}{1 + (23 + \frac{0.00155}{S})\frac{N}{\sqrt{R}}}$$
   S = Bed slope of canal
   N = Rougosity coefficient
8. Velocity found in steps (7) and (2) must be equal. Ratio of Velocity in step (7) and (2) must be 1 then the assumed D is satisfactory
9. Calculation of discharge by Manning's equation
   $$Q = A \times \frac{1}{n} \times R^{2/3} \times S^{1/2}$$

Sample Calculations

<u>Calculated values of B and D for Proposed Channel AB</u>

<u>The data</u>

Discharge Q = 500 m^3/ sec
Rugosity Coefficient N = 0.0225
Critical Velocity Ratio m = 1
Bed Slope of Channel S = 0.000263

<u>Computation using Kennedy's theory</u>

1. Assume a trial depth D equal to 8.55 m.
2. $V = 0.55\, mD^{0.64}$
   $= 0.55 \times 1 \times 8.55^{0.64} = 2.17$ m/sec
3. A = Q / V = 500/ 2.17
   = 230.22 m^2
4. $A = BD + D^2/2$
   $230.22 = B (8.55) + (8.55)^2/ 2$
   From which B = 22.65 m
5. Perimeter
   $P = B + D\sqrt{5}$
   $= 22.65 + 8.55\sqrt{5}$
   = 41.77 m
6. Hydraulic mean depth
   R = A/P
   = 230.22 /41.77
   = 5.51 m
7. $V = C\sqrt{RS}$
   S = 0.000263
   $$C = \frac{23 + \frac{1}{0.0225} + \frac{0.00155}{0.000263}}{1 + \left(23 + \frac{0.0015}{0.000263} \times 1000\right)\frac{0.0225}{\sqrt{5.51}}}$$
   = 57.43

Therefore $V = 57.43\sqrt{\frac{5.51 \times 0.263}{1000}}$

= 2.19 m/s

8. Ratio of velocity found in steps (7) and (2)
= 2.19/2.17
= 1.006

Hence, the assumed D is satisfactory.

Computation using Manning's equation

1. Area $A = BD + D^2/2$
$= (22.65 \times 8.55) + 8.55^2/2$
$= 230.22 m^2$

2. Perimeter $P = B + D\sqrt{5}$
$= 22.65 + 8.55\sqrt{5}$
= 41.77 m

3. Hydraulic mean depth R = A/P
= 230.22 /41.77
= 5.51 m

4. Discharge $Q = A \times \frac{1}{n} \times R^{2/3} \times S^{1/2}$

$= 230.22 \times \frac{1}{0.0225} \times (5.51)^{2/3} \times (0.000263)^{1/2}$

$= 511.91\ m^3/ sec$

Table 7 : Computed values of B and D for Proposed Channel AB Using Kennedy's Theory

Sr. No.	Discharge Q (m^3/ sec)	S Bed Slope	B (width in m)	D (depth in m)	Discharge Q by Manning's theory
1	250	1 in 3800	15.94	6.85	248.23
2	500	1 in 3800	22.65	8.55	511.91

Table 8 : Calculated values of B and D for Proposed Channel CD Using Kennedy's Theory

Sr. No.	Discharge Q (m^3/ sec)	S Bed Slope	B (width in m)	D (depth in m)	Discharge Q by Manning's theory
1	250	1 in 3335	13.26	7.22	251.45
2	500	1 in 3335	17.91	9.5	510.22

Table 9 : Calculated values of B and D for Proposed Channel EF Using Kennedy's Theory

Sr. No.	Discharge Q (m^3/ sec.)	S Bed Slope	B (width in m)	D (depth in m)	Discharge Q by Manning's theory
1	250	1 in 1745	4.36	10.5	251.23
2	500	1 in 1745	5.87	13.55	509.38
3	750	1 in 1745	7.27	15.6	777.26

Table 10 : Calculated values of B and D for Proposed Channel GH Using Kennedy's Theory

Sr. No.	Discharge Q (m^3/ sec)	S Bed Slope	B (width in m)	D (depth in m)	Discharge Q by Manning's theory
1	1000	1 in 1624	8.4	17.25	1025.12
2	2000	1 in 1624	12.45	21.75	2130.26
3	3000	1 in 1624	13.83	25.65	3166.77

Table 11 : Calculated values of B and D for Proposed Channel IJ Using Kennedy's Theory

Sr. No.	Discharge Q (m^3/ sec.)	S Bed Slope	B (width in m)	D (depth in m)	Discharge Q by Manning's theory
1	250	1 in 3400	13.78	7.3	251.78
2	500	1 in 3400	17.9	9.5	505.09
3	750	1 in 3400	21.67	10.9	768.65

4.9 Construction of Flood Detention Reservoir

It is proposed to construction the Flood Detention reservoirs from Hazira to Hasonth interconnecting Tena creek, Sena creek and Kim river having suitable length, width and depth. About 80 villages are declared as a no source village and such villages are allotted the land for creation of pond for storing the water. Such water will be retained up to December. Such ponds in different villages can be interlinked with detention reservoir.

Mindhola river can be channelized near its mouth which will become perennial estuary and on both the bank of river, detention ponds can be constructed with balloon gates. The details are shown in Figures 13 to 15.

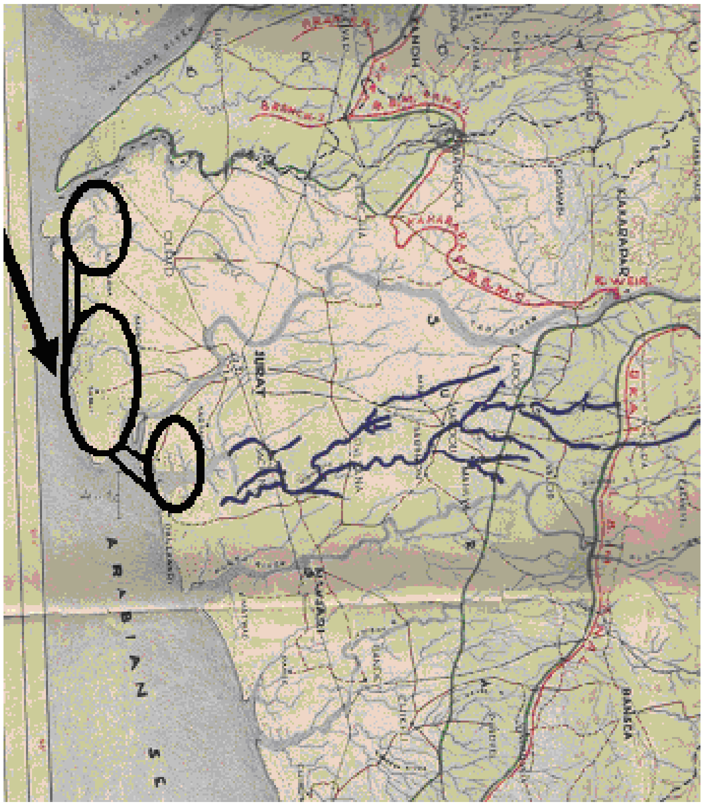

Fig. 13 Proposed Flood Detention Reservoir at Hazira to Hansot with Balloon Dam

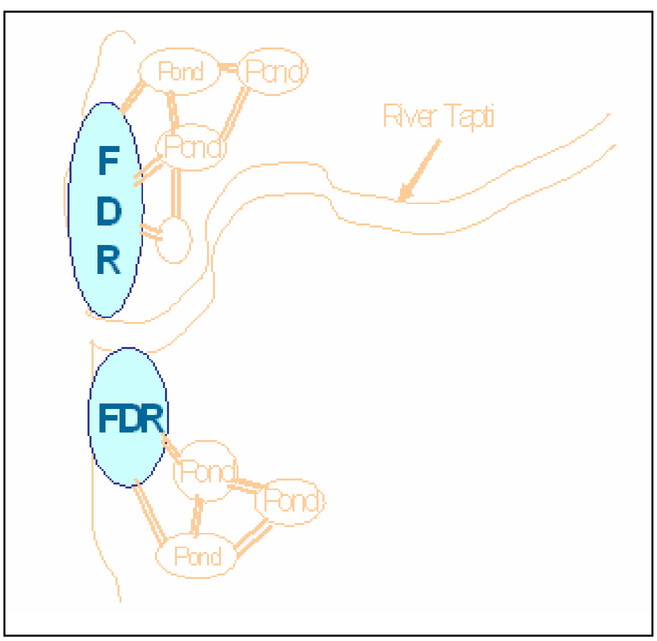

Fig. 14 Linking of Village Ponds (reserved) for no source villages

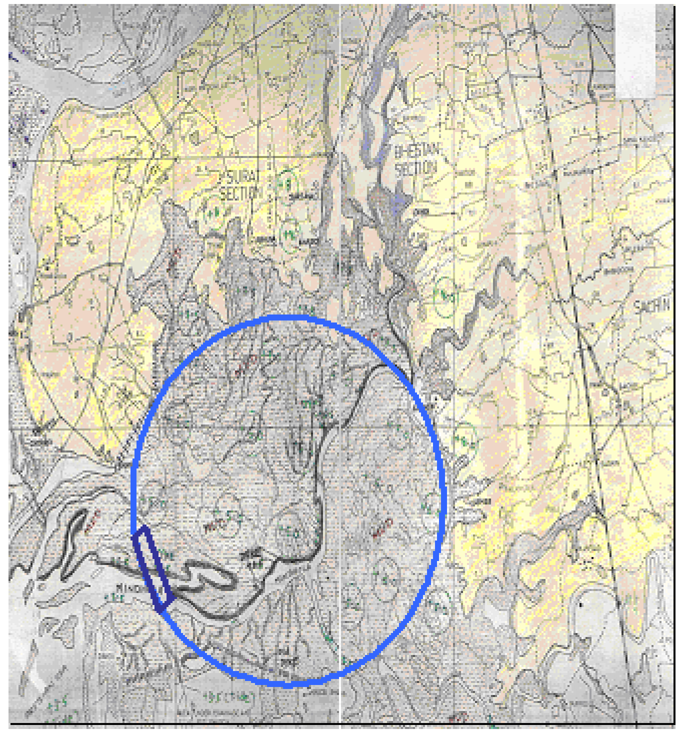

Fig. 15 Flood Detention Reservoir at Mindhola River

5 Conclusion

Surat city (India) situated at the tail end of river Tapi is subjected to moderate to heavy floods frequently due to heavy rainfall in the catchment area. Study of floods at Surat city has been made in this paper. To minimize the effect of flood at Surat city, certain preventative measures have been suggested. A flood reduction plan has been prepared and discussed in this paper which mainly includes curative measures. The aspects of diversion of flood water to other rivers and construction of flood detention ponds are discussed in details.

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