CHAPTER 7

PROBABLE SOLUTIONS FOR MINIMIZATION OF IMPACTS OF TAPI RIVER FLOOD

7 PROBABLE SOLUTIONS FOR MINIMIZATION OF IMPACTS OF TAPI RIVER FLOOD

In this chapter optimal solutions for minimization of Tapi river flood impacts-Surat (Gujarat) discussed and listed in detail. Solutions to reduce Tapi river flood impacts, best solutions, feasibility of best solutions, optimal solutions, reasons for optimal solutions, limitations of proposed model covered in this chapter. Among them, importance of major control point Ukai Dam outflow release decision described below.

7.1 Solutions to Minimize Tapi River Flood Impacts

Few solutions to minimize Tapi River flood impacts to save Surat City from flood impacts are listed below.

7.1.1 ARIMA 1 – D Mathematical Model

Tapi River flood water surface profile predicted by using ARIMA model. This model give flood water depth information at various locations across Surat City. Moreover, it also helpful for different flood frequency operation conditions.

7.1.2 Graphical Techniques

1. **Propose new rain gauge stations**

   Catchment area from Gidhare rain gauge station to Ukai is 7500 km^2. Contribution of this area is 38 % of total inflow. The estimation of runoff due to rainfall in the catchment between Sarangkheda to Ukai will further improve, if two new propose wireless stations will open.

   The proposed stations are:

   (a) Sagbara (Existing Raingauge of Indian Meteorological Department) - For transmitting rainfall data.

   (b) Navapur (River Rangawali) - For transmitting Rainfall/Gauge/Discharge data.

2. **Flood Routing Studies**

   Alternate flood routing studies done by consideration different flood scenario shows that cumulative outflow must be total 4 lac Cusecs from Ukai dam at single time one lac release.

3. Probability Study for Flood Forecasting

The peak flood data used 73 years (from 1939-2012) for this research study. Probability of Peak flood determined by using statistical analysis method i.e. Hazen's method, weibulls method and California method.

7.1.3 Revised Rule Level for Ukai Dam Reservoir Gate Operation

7.1.3.1 Importance of Release Decision

Outflow means the quantity of water or specifically the discharge which has been released by the gate operation procedure of any dam while in the non-gated dam or dam without spillway, this becomes the quantity of water which is going to be spilled either in much less volume of water or much more volume of water. This outflow becomes the value of inflow or directly varies with inflow when the higher flooding conditions have been observed. According to experienced engineers, this, outflow, is the actual value either to be released from the dam to avoid to avoid dam break phenomenon, and also the quantity of water which is to be released for achieving the different advantageous functioning, like hydropower generation.

There are so many research papers in which the outflow forecasting is given utmost importance, but left described within a paragraph as mostly as mostly outflow quantity is fixed according to downstream channel capacity. But, the timely forecasting of outflow gives the assurance of not being affected by the recurring disaster of India, namely flooding conditions. That means, we can mitigate and manage the flood phenomenon, if timely inflow forecasting as well as timely outflow forecasting is achieved.

There are so many factors which bound the limitations of dam outflow release volume, like, as said before the downstream channel capacity, the purpose to be served by the multipurpose reservoir, the real-time quantity of water available in reservoir, as well as the quantity of water to be available after the regular interval of time, stage-discharge release decision system, spillway gate capacity, maintenance and operation of spillway gates, type of condition of soil and soil profile in the downstream side, type of channel (i.e. unlined and lined channel), type of spillway provided either within the dam or away from dam, etc.

It has been observed that during the flood situation and conditions. The limitation of outflow release volume has been either achieved from the past outflow release data as well as limitation of downstream channel conditions as well as characteristics. But, now- a-days, as water and land, we know, have become precious natural source and that's why not to be waste, the operation of dam release decision and dam release action can save good quantity of water which can be utilized for satisfying the purpose for which the dam is to be made or has been made. The development of methods to define reservoir operation rules has been the focus of research for many years.

7.1.3.2 Suggested Revised Operation Policy

It is a general policy to assume impingement of the design flood at the FRL, and the dam reservoir system is designed for this condition. The Ukai dam has also been designed for such a situation. The PMF with a peak value of 46,270 Cumecs (21.16 lac Cusecs) from the dam spillway, and attainment of a maximum water level of 106.99 m (351.0 ft) in the reservoir. The capacity of the Tapi River downstream of Ukai dam been adequate to pass this flood, without causing any serious inundation, the flood control operation of this dam would have been a simple affair.

7.1.3.3 Application of Optimization Techniques

Application of optimization techniques to reservoir operation has become a major focus of water resources planning and management. Traditionally, reservoir operation is based on heuristic procedures, embracing rule curves and, to a certain extent, subjective judgments by the operator, and optimization techniques are expected to provide balanced solution between often conflicting objectives. The research proposes an avenue for changing traditional reservoir operation into optimized strategies, taking advantage of the rapid development in computational techniques.

7.1.4 Forecast Base Reservoir Operation (FBRO) for Real Time

FBRO prepared for real time reservoir operation with help of Microsoft excel program. By giving Ukai Dam reservoir water level as an input, reservoir gate release as an output instructions are obtained for different flood conditions. Suggested operation schedule for real time listed for conditions: N, N1, N2, N3, N4 and N5.

7.1.4.1 Tapi River Carrying Capacity (Year 2006)

Unfortunately, the safe carrying capacity of the river, particularly near the city of Surat is grossly inadequate to pass the floods of such high order. The effort is to restrict the downstream flow to around 19,822 Cumecs (7 lac Cusecs), at least for the size of floods already experienced by the dam. Full advantage of the flood forecasting facility available for the Ukai reservoir is taken to permit possible pre-depletion of the reservoir. Temporary filling of the reservoir above the rule level is also allowed when the forecast indicates recession in the flood discharge. This creates room for storing more flood waters, and permits further moderation of the flood peak. As the safety of the dam is of paramount importance, the reservoir level under no circumstances shall be allowed to go above the MWL of 106.99 m (351.00 ft).Normal, high alert and emergency situations have been defined and detailed operational procedures under each of these situations described in this research study. Reasonably accurate forecasts of inflows into the Ukai reservoir, and the stipulated information about the rainfall in the Upper Tapi catchment are assumed to be available during the period of flood.

7.1.4.2 Tapi River Risk Map for Surat City

Probable submerged area calculated for different zone of Surat City by using suggested flood risk map. Flood risks define in form of high, moderate and low risk for whole Surat city.

7.1.5 Silting Control in Reservoirs

In order to increase the life of a reservoir it is necessary to control the deposition of sediment. Various measures are undertaken in order to archive this aim. The various methods which are adopted can be divided into two parts: (1) Pre-constructing measures (2) Post-construction measures. These measures are discussed below:

7.1.5.1 Pre-Constructing Measure

They are those measures which are adopted before and during the execution of the project. They are innumerate below:

- **Selection of Dam Site**: The silting depends upon the amount of erosion from the catchment. If the catchment is less erodible, the silting will be less. Hence, the silting can be reduced by choosing the reservoir site in such a way as to exclude the runoff from the easily erodible catchment.
- **Construction of the dam in stage**: The design capacity plays an important role in the silting of a reservoir. When the storage capacity is much less than the average annual runoff entering the reservoir, a large amount of water will release from the reservoir, thereby, reducing the silting rate compared to what it would have been if the entire water would have been stored.

Therefore, the life of a reservoir can be prolonged by constructing the dam in stages. In other words, first of all, the dam should be built lower, and raised subsequently when some of its capacity gets silted up.

- **Construction of check dam:** The sediment inflow can be controlled by building check dams across the river streams contributing major sediment load. These are smaller dams and trap large amounts of coarser sediments. They are quite expensive.
- **Vegetation Screen**: This is base on the principle that vegetations trap large amount of sediment. The vegetation growth is, therefore, promoted at the entrance of the reservoir as well as in the catchment. These vegetative covers, through which flood waters have to pass entering the reservoirs, are known as vegetation screeds, and provide a cheap and a good method of silt control.
- **Construction of under-sluices in the dam:** The dam is provided with openings in its base, so as to remove the more silted water on the downstream side. The sediment concentration will be more at some levels than at others. Therefore, sluices are located at the levels of higher sediment concentration. The method in itself is not sufficient because the water digs out a channel behind the sluice for movement and levels most of the sediment undisturbed. Therefore, this is simultaneously supplemented with mechanical loosening of the neighboring sediment in order to increase its effectiveness. But to provide large sluices near the bottom of the Dam is again a structural problem. The use of this method is, therefore, limited.

7.1.5.2 Post-Construction Measures

These measures are suggested to undertake during the operation of the project. They are given below:

(1) **Removal of post Flood Water:** The sediment content increases just after the floods; therefore, attempts are generally made not to collect this water. Hence, the efforts should be made to remove the water entering the reservoir at this time.

(2) **Mechanical Slurring of the sediment:** The deposited sediment is scoured and disturbed by mechanical means, so as to keep it in a moving state, and thus, help in pushing it towards the sluices.

(3) **The Project authorities are advised:** To take suitable measures for better performance of the Ukai reservoir as per IS 12182-87 and IS 6518-1992.

7.1.6 Developing a Flood Plain Management Program

A local community faces a persistent flood problem and potential threat by engineering studies, if no record of floods. The solution in either case is found in the following sequence of steps for formulating an action by developing a flood plain management program.

- Recognition of the flood hazard by the community, its officials and its citizens.
- Implement and maintain an appropriate flood forecasting and warning system.
- Develop a detailed operating schedule for flood fighting and emergency measures.
- Outline a program for immediate adjustments in structures and occupancy in flood hazard areas.
- Implement flood plain regulations, using (a) immediate, short-range, stop-gap measures and (b) long-range measures based upon comprehensive planning.
- Plan of the optimum utilization of the flood plain, and implement the plans with (a) technical studies, (b) socioeconomic studies, and (c) Legal-institutional-management studies.
- Construct engineering works for the control of flood waters that are a part of the comprehensive plan for flood plain utilization and are economically feasible.
- Operate and maintain the entire flood plain management program.

Fig.No.7.1 shows typical River cross section and Flow chart shows flood plain management program.

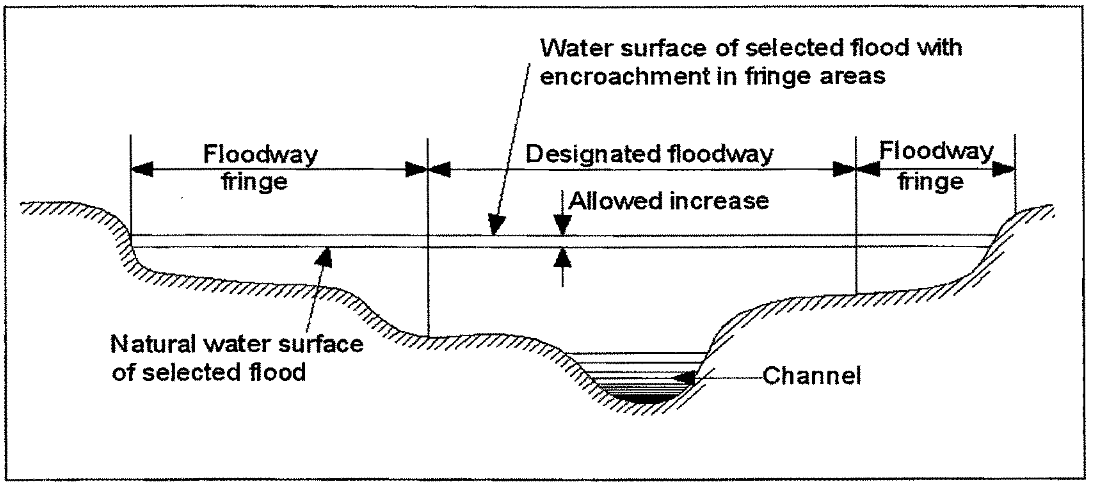

Fig.7.1 Typical River Cross Section

Flow Chart for Flood Plain Management

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Develop operating schedule for flood fighting measures

↓

Make immediate adjustments in structures and occupancy

↓

Formulate, implement flood plain regulations

↓

Plan for optimum future use of the flood plain

↓

Complete necessary construction programs which accompany long-range plans

↓

Operate, maintain, up-date the action program for flood plain management

7.1.7 Hydrographic Survey of Tapi River Reach from Kathor to Hazira

In order to assess any siltation in the reach upstream of Singanpur due to construction of weir as well as siltation in the reach from Hazira to Nehru to Nehru Bridge due to sediment brought in by tidal flows the hydrographic surveys along fixed cross sections may be carried out at the interval of 5 years regularly. Below shown idea for diversion of flood found not feasible because it would take symphonic action to lift water, otherwise we have to provide Small River of minimum width 100 to 150 meter this will require large land acquire. Above idea is away from Surat about 30 to 40 km away. It is just to divert Tapi flood in to Mindhola River showing diversion of Tapi River in Plate.No.7.1.

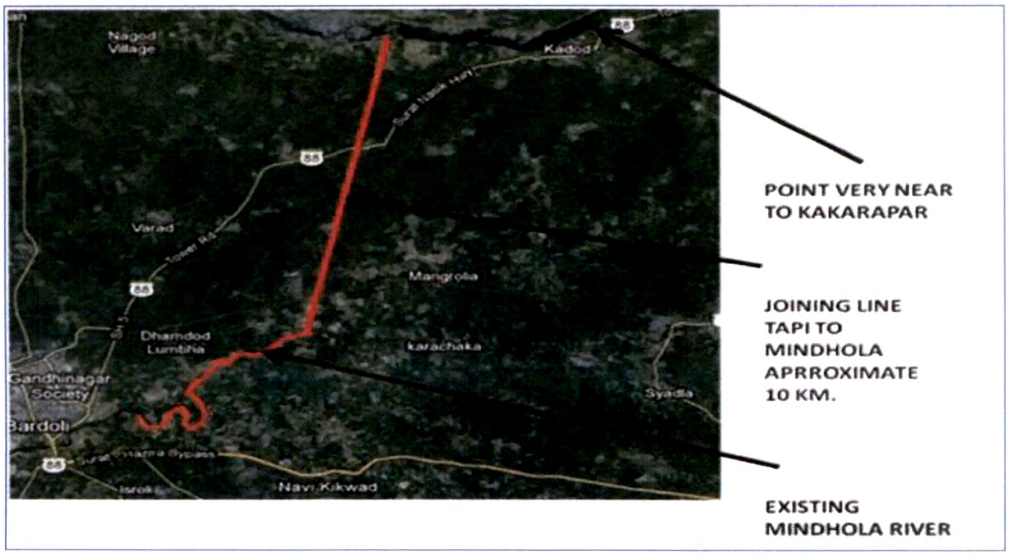

Plate.7.1 Google Image Showing Diversion of Tapi River

The below Plate No.7.2 shows removing suggestion for obstruction removing Kadiya bet, Mora bet and Hazira Mangroves forest. If red circle island can remove, then Surat have large opening for flood discharge easily. Plate.No.7.3 shows possible diversion of Tapi River to near creeks i.e. Kim creek, Sena creek and Tena creek.

Plate.7.2 Large opening for Tapi River

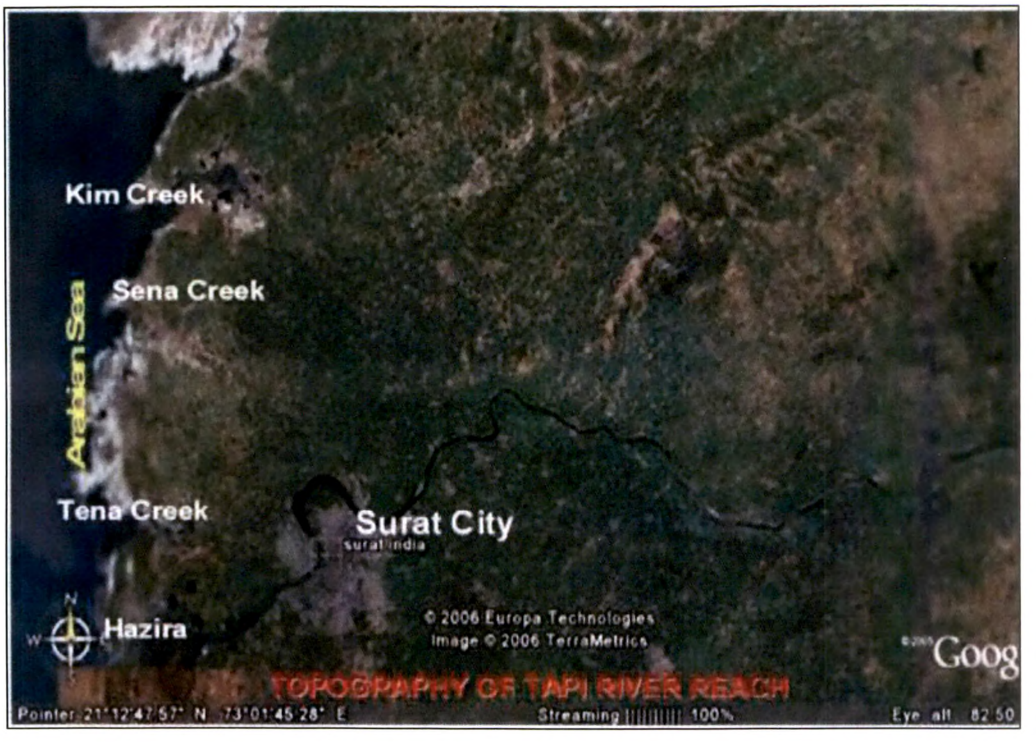

Plate.7.3 Diversion of Tapi River since to near Creeks

7.1.8 Flood Forecasting and Warning System

Below Fig.No.7.2 shows information for advance flood forecasting and warning system for Surat City.

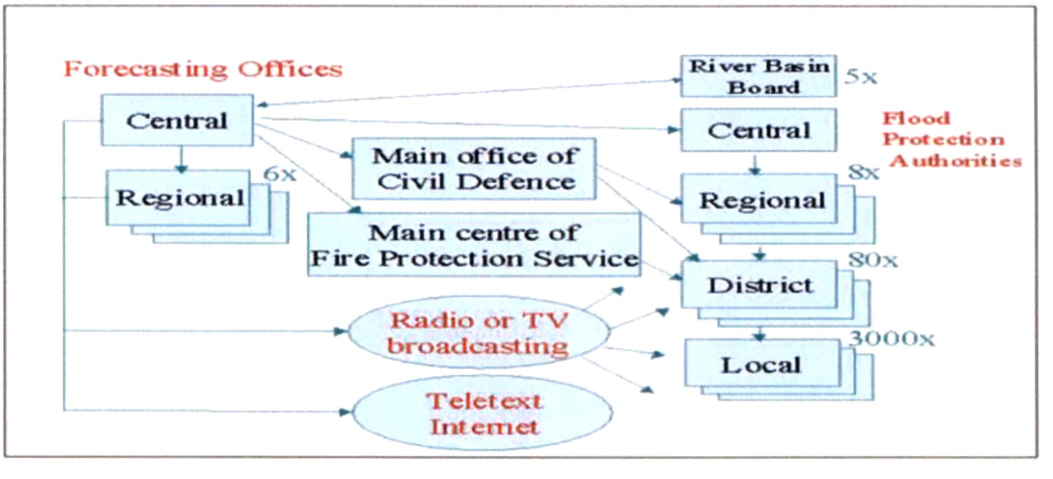

Fig.7.2 Proposed Flood forecasting and warning System

7.1.9 Propose Structural Measure

Below Fig.No.7.3 shows structural measures in form of comparison dike v/s polder. Reduction of the peak flood water level and retention volume emptying achieved with help of below shown structural measure. Fig.No.7.4 shows rubber dam operating system of type A and B for flood control.

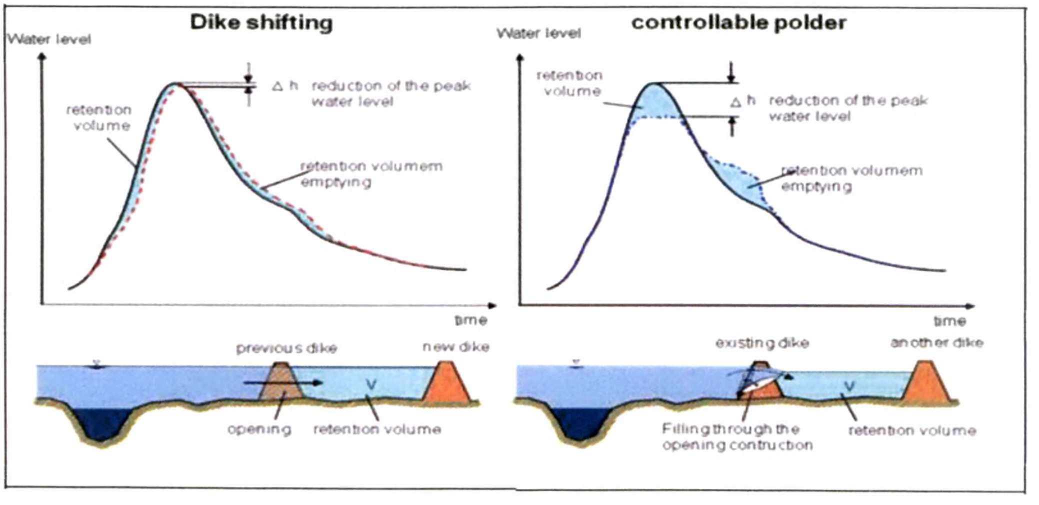

Fig.7.3 Structural Measures: Dike v/s. Polder

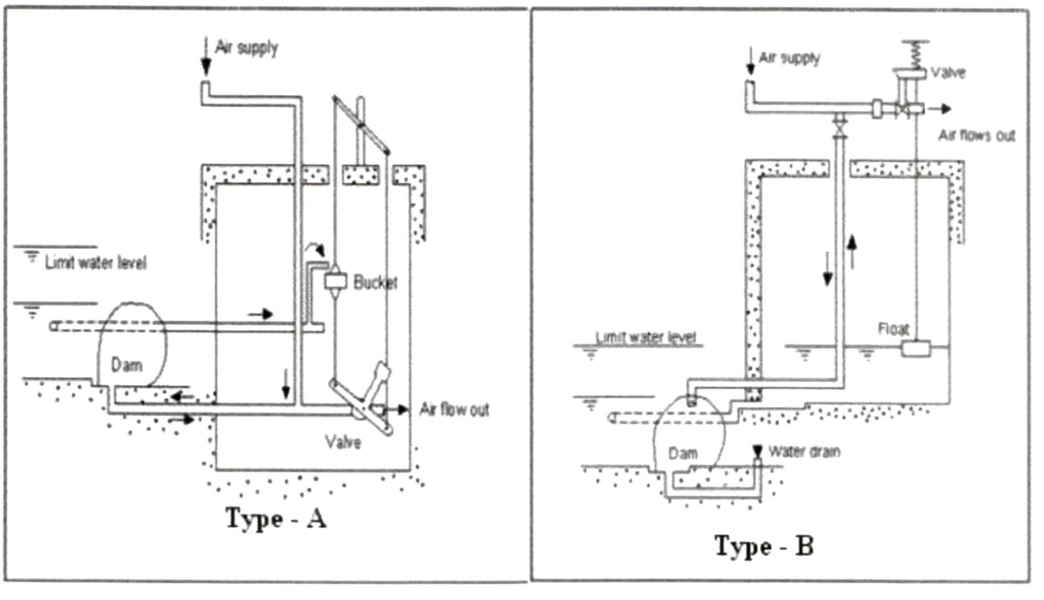

Fig.7.4 Rubber Dam operating System of Type A and B

7.1.10 Approaches for Flood Protection Measure (FPM): Non-structural

- Early warning
- Flood forecasts
- Analysis of flood areas
- Institutional
- Strengthening
- Disaster plan
- Preparedness plan
- Relocation plan

7.1.11 Par – Tapi – Narmada Link

The 7 proposed reservoirs provide a total of 1350 mm^3 of water. The link canal can be considered in two parts namely Par-Tapi and-Narmada. The Par-Tapi portion of the link is 210 km long which includes 5.5 km tunnels, 33.267 km of feeders and the capacity of the canal varies from 44 Cumecs to 91 Cumecs. The link starts with a tunnel connecting Mohankaavchali reservoir to Paikhed weir. The open channel link starts from Paikhed weir and drops into Ukai reservoir. The Tapi-Narmada portion of the link starts from Ukai reservoir crosses Narmada River and it terminates at the Miyagam branch canal of Narmada Main Canal. This part of the link is 190 km long with a capacity varying from 71 to 45 cumecs.

The diverted water will be used to irrigate a total of 1.69 lac ha annually comprising of 0.52 lac ha enroute new command and 1.17 lac ha in the Narmada command, consisting of Miyagam branch of the Narmada Main Canal.

Power houses are proposed at the foot of the dam at Jheri, Paikhed, Chasmandva and Chikkar dams. In case of the Dabdar and Kelwan reservoirs, power houses are proposed in the feeder canals along the falls. The estimated annual energy to be generated from these power houses is of the order of 93 Mkwh.

Seven proposed reservoirs in this link would submerge an area 7,559 ha out of which 3,572 ha is forest land. Apart from this, around 14,832 people and 9,029 liver stocks would also be affected by the submergence. Provisions have been made in the report to resettle and rehabilitate the affected persons by providing them a practical and attractive package. Provision has also been made for compensatory a forestation.

7.1.12 Public Awareness

For public awareness against flood forecasting, one LED light indicator at few important locations within Surat City to show Ukai Dam reservoir level as shown in below plate.

Image.7.1 LED Light Indicator Ukai Reservoir Level

7.2 Best Solutions

1. ARIMA 1 – D mathematical model
2. Graphical techniques
3. Rule level for monthly base withdrawal for revised reservoir operation
4. Forecast base reservoir operation for real time
5. Tapi river carrying capacity and flood risk map for Surat City

7.3 Feasibility of Best Solutions

7.3.1 Feasibility of ARIMA 1 – D Model

ARIMA 1 – D mathematical model is feasible for whole Tapi River flood water surface profile. This 1-D mathematical model is capable for numerical simulation of unsteady water and sediment movement in multiply connected network of mobile bed channels. This model is capable of handling unsteady water and sediment flows in multiply connected channels highly non uniform sediment and grain sorting and armoring process. The model can simulate processes such as; sediment sorting, bed armoring, flow dependent friction factor and alternate drying and flooding of perched channels. The flow over the weir can also be handled.

7.3.2 Feasibility of graphical Techniques

Graphical techniques capable to determined possible new rain gauge station for flood forecasting. Moreover, peak flood probability analysis and flood routing studies handled with help of this techniques.

7.3.3 Feasibility of rule level for Monthly base Withdrawal for Reservoir Operation

Reservoir operation is a complex problem that involves many decision variables, multiple objectives as well as considerable risk and uncertainty. In addition, the conflicting objectives lead to significant challenges for operators when making operational decisions. Traditionally, reservoir operation is based on heuristic procedures, embracing rule curve and subjective judgments by the operator. This provides general operation strategies for reservoir releases according to the current reservoir level, hydrological conditions, water demands and the time of the year. Established rule curves, however, do not allow a fine-tuning (and hence optimization) of the operations in response to changes in the prevailing conditions. Therefore, it would be valuable to establish an analytic and more systematic approach to reservoir operation, based not only on traditional probabilistic/stochastic analysis, but also on the information and prediction of extreme hydrologic events and advanced computational technology in order to increase the reservoir's efficiency for balancing the demands from the different users.

7.3.4 Feasibility of forecast Base Reservoir Operation for Real Time

This program capacity to handle real time reservoir operation for normal and emergency flood situations.

7.3.5 Feasibility of Tapi River Carrying Capacity and Flood Risk Map for Surat City

By using River cross section Tapi River carrying capacity determine for respective flood years for possible flood disposal. By using image flood risk map for Surat City prepared which define submergence area zone wise for different flood scenario.

7.3.6 Feasibility of Par – Tapi – Narmada Link

NWDA earlier prepared the Feasibility Report of Par – Tapi – Narmada Link and circulated among all concerned on 14.08.1995. The report envisaged transfer of surplus of water flowing rivers between Par and Tapi and surplus water of Tapi at Ukai to deficit area in North Gujarat. However letter when water balance study of Tapi at Ukai was done, it was found that there is no surplus in Tapi River at Ukai. As such was done, it was found the earlier proposed link has been dropped and revised feasibility report has been prepared. Thus the present proposal of the Par-Tapi-Narmada link envisages transfer of surplus water from west following river between Par and Tapi to water deficit areas in North Gujarat. The scheme is located mainly in southern Gujarat but it also covers part of the areas of Maharashtra, North of Mumbai on the western Ghats of India. The link project consists of 7 proposed reservoirs on the rivers between Par and Tapi and a 395 km long link canal (including 33 km length of the feeders) connecting these reservoirs to carry water to their target command areas north of Narmada. It will also irrigate small enrooted areas. The target areas are part of the command of the Narmada canal system. By taking over part of Narmada command, the water saved in Narmada canal can be used to extend the irrigation further north in the drought prone areas of Gujarat. The project details are shown in the attached Index map.

Considering the possible full development of irrigation and the projected in basin domestic and industrial requirements up to 2025 AD, a total surplus of 1834 Mm^3 would be available in these basins. However, considering the topographical constraints of storage sites, only a part of the surplus is proposed for diversion. For this purpose, 7 storage sites have been considered and simulation studies carried out considering monthly inflows and monthly demands, Yield capacity curves were drawn for each of the reservoirs and optimum capacities were decided from these curves. The catchment area, water availability, storage capacity and dependable yield etc. for these reservoirs.

The irrigation benefits from the project have been worked out considering the project area with irrigation and without irrigation. The net annual benefit for irrigation has been estimated to be Rs. 53.50 lacs per hundred ha. Thus the total benefit for irrigating 1.69 lac ha works out to Rs. 56,301 lac per year. The annual benefits from power generation are estimated to be Rs. 5,523 lacs. The overall cost of the link Rs. 6,016 crores (At price level 2004-05). The benefit cost ratio of the project has been found out to be 1.08. The internal rate of return for the project has been computed as 8.82%.

7.4 Optimal Solutions

1. ARIMA 1 – D mathematical model
2. Graphical techniques
3. Rule level for monthly base withdrawal for revised reservoir operation
4. Forecast base reservoir operation for real time
5. Tapi river carrying capacity and flood risk map for Surat City

7.5 Reasons for Optimal Solutions

For above mentioned optimal solution to minimize Tapi River flood impact – Surat City, Simple desk studies require. Data can be collected from various Government offices, scrutinize, and interpret according to point of interest. Optimal solutions in form of few modifications in existing condition, disaster flood situations impacts minimized without more expenditure.

7.6 Limitations

7.6.1 Limitation of ARIMA 1 – D Mathematical Model

- Channel network pattern assumed (i.e. total no. of channels, and their inter-connections) must remain same during a particular simulation.
- Cross sections are assumed to rise or fall without changing its shape.
- Continuous lateral flows not considered However, in additions due to rainfall could be represented by channel joining at regular interval.
- Other restrictions associated with sediment routing processes (i.e. those required for sorting, armoring sediment discharge, friction prediction etc).
- Model is validated up to August – 2006.

7.6.2 Limitation of Graphical Technique

With the help of Graphical techniques Tapi river capacity predicted for the year 2008, but river capacity change every year due to siltation problem and change in morphological condition in catchment.

7.6.3 Limitation of FBRO

If any downstream change in hydrological condition evolved then, this MS excel program should be revised.

7.6.4 Limitation of Rule level for Monthly base withdrawal

Only 34 years (1973 to 2008) data used to find reservoir operation for monthly based withdrawal rule level, as Ukai dam constructed in the year 1973. Hydraulic cycle occurred at every 100 years so, perfect prediction is not possible due to less year's data consideration.

7.6.5 Limitations of Flood Risk Map

The main limitation is the assumption of straight-line cross-sections. This model requires cross-sections to be defined such that they are perpendicular to the flow lines in both the floodways and main channel. As a result, land surveys of river cross-sections take the perpendicularity requirement into account.