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RESEARCH PAPER

# Flood control for sustainable development in upper Krishna river basin

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## ABSTRACT

Ecologically, Krishna is one of the disastrous rivers in the India, flowing fast and furious, often reaching depths of over 23 m, causing heavy soil erosion during the monsoon season. The Krishna and its river systems potentially store tremendous wealth for the region, and yet, at the same time, this very same potential turns destructive with fatal regularity in the form of floods. The upper basin of Krishna, Koyna, Warna, and Panchganga receives enormous amount of rainfall during the monsoon every year and has a very profound impact on the ultimate quantum of water resources in downstream areas causing a devastating flood. A large number of human lives and property are lost in the district in Maharashtra and the adjoining districts of upstream and downstream of the Alamatti dam in the state Karnataka. The Central Water Commission has classified river basins in this region (Sangli and part of Solapur) as Upper Krishna (NW) 15A, Upper Krishna (East Yerala) 16A, Upper Krishna East Agrani (16B), and remaining Bhima (downstream of Ujani including Man (18B)). This paper focuses on study to divert abundant water from sub-basin 15A to Sub-basin 18B by gravity (diverting water from upper river Krishna to sub-basin of Man to Jath, Atpadi, Talukas of Sangli district and Sangola taluka of Solapur district.) through tunnels. It is proposed to divert water only in flood situations, and to feed existing water resources and small storages in Man sub-basin, which will help to minimize flood hazards and loss of property. This study was carried out by field survey, remote sensing and GIS techniques. In field survey actual ground levels, high flood levels and topography were studied to locate flood tunnel inlet and outlet. Satellite imagery substantiated to calculate areas under benefits and economic aspect of the proposal.

**Key Words :** Flood tunnel, Remote sensing, GIS, Flood control, Sustainable development, Ecologically.

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Krishna flows with abundant water and flood passes through Sangli district in Maharashtra state, but at the same time the Yerala, the Agrani and the Man - tributaries of Krishna remain dry Fig. 1(a), (Fig. 5). This natural geographical and metrological inequality forces local administration to act for flood protection works on one side and scarcity relief works on other side at the same time. Every year due to heavy rainfalls in Sahyadri ranges in the months of June and July, flood situation occurs in Palus, Walva, Shirala, and Miraj talukas on the banks of Krishna. At the same time, water supply for drinking water in Jath, Kavathe, Mahankal, Atpadi, and Sangola talukas is supplemented by water tankers. This diversity is within radius of 50-100 km. Upper Krishna 15A sub-basin is having abundant water (availability 18,307 $m^3$/ha), while Yerala 16A, Agrani 16B and Man are having water availability 1,19,252 $m^3$/ha and 1,657 $m^3$/ha, respectively (Maharashtra Water and Irrigarion Commission Report (1996).

Thus, 15A is having abundant water, while other three are highly water deficit sub-basins. It could be seen that the water availability alongside of river Krishna is about 45 and 35 times that of Yerala basin and Man basin, which is hardly

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50 to 100 km away from Krishna. The above highly deficit sub-basins are having per capita water availability below 500 $m^3$. With increasing population, this per capita availability is likely to reduce further. This area is chronic drought prone and suffers heavily from frequent droughts affecting livelihood and forcing migration of human beings and cattle.

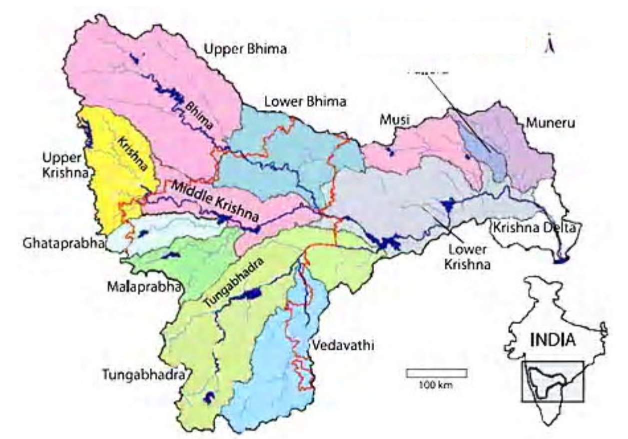
In addition, Krishna flood is one of the most devastating natural phenomena that affects and disrupts the well-being of a society, especially poor people, who are vulnerable to disaster due to limitation of their resources. The government spends huge amounts of money for temporarily relieving the pressure of scarcity. It, however, does not help in the drought prone areas from the frequent occurrence of water scarcity. It is, therefore, essential to properly review the planning of existing water resource for such highly flooded and highly deficit sub-basins in right earnest and during the flood calamity, decision-makers would get rid of facing large number of impulses.

To overcome the ill effects arising out of poor availability of water in highly deficit sub-basins and highly flooded sub-basin suggestive measures for long term measure has been the thrust in this research in conjunction with geographic information system (GIS), which has emerged as an indispensable tool in the study of floods, particularly with its capacity to provide near real-time data, enabling preparation of hazard maps of inundated areas and assessment of damages. Several studies connected with floods (areal extent, zonation, damages) have been undertaken on the basis of remote sensing techniques (Kale, 2003; Sankhua *et al.*, 2005; Jain *et al.*, 2005; Prasad *et al.*, 2006). At the present juncture, this has become an imperative necessity in the absence of any flood management measures of the river. The flood perspective and the rationale for an assessment with flood knowledge base are evaluated in terms of the relevant data. Feasible solutions are subsequently suggested, followed by a section on the adequacy of the knowledge base, based on the available information, flood analyses for reaches of the system. The paper concludes with three proposals in particular perspective of flood and recommendations pertaining to addressing the critical gaps in the flood control knowledge base of the upper Krishna basin.

**The study area:**

Three tributaries meet the Krishna near Sangli. Warna meets Krishna near Sangli at Haripur. This spot is also known as Sangameshwar. Panchganga river meets the Krishna at Narsobawadi near Sangli (Fig. A). The study area is subdivided into Upper Krishna West -15A (West-North) and Upper Krishna15B (West-South) and East -16A (Yerala) and 16B (Agrani) for easy formulation of appropriate water accounting and planning, in conformity with their respective local features. The total geographical area of this sub-basin is 15A and 15B is 116 sq. km. Upper Krishna (East) is mostly drought prone and measuring 5,284 sq. km area on the eastern side of Krishna falls.

Normally 85 per cent rainfall occurs during June to September due to south-west monsoon, 10 per cent between September and December due to north-east monsoon and 5 per cent after December. Average annual rainfall in component basins 15(A) and 15 (B) is 1584 mm and 1907 mm, respectively. Rainfall decreases from west to east in this sub-basin. The Yerala and the Agrani have 550mm and 470 mm average rainfall, respectively (Table A). The main objectives of the study are underlain by diverting water from high flood to deficit sub-basins and assessment of water and its effects on flood and deficit sub-basin.




**Krishna basin**

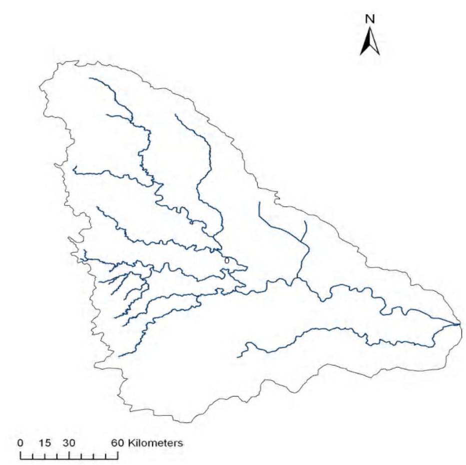



**Fig. A : Study area of Krishna basin**

## RESEARCH METHODOLOGY

The topographical maps of 1:2,50,000 scale

The Landsat TM digital satellite False Colour Composite (FCC) February, 1999.

**Table A : Details of study area (Hydrological, Meteorological, and statistical)**

| Sr. No. | Description | Upper Krishna ( North West ) | Upper Krishna ( East Yerala) | Upper Krishna ( East Agrani) | Remaining Bhima Down Stream of Ujani including Man |
|---|---|---|---|---|---|
| 1. | Classification as per Maharashtra water and irrigation commission | 15 A | 16 A | 16 B | 18 B |
| 2. | Local name | Krishna | Yerala | Agrani | Man |
| 3. | Talukas from Sangli district | Shirala ,Walawa, Miraj, Tasgaon, Khanapur | Miraj, Tasgaon, Khanapur | Miraj, Tasgaon, Khanapur, Jath, Kavathe Mahankal | Jath, Atpadi, Sangola |
| 4. | Rainfall in MM | | | | |
| | Average | 1584 | 569 | 589 | 552 |
| | Maximum | 9480 | 1206 | 1596 | 1157 |
| | Year of max. rainfall | 1961 | 1981 | 1994 | 1987 |
| 5. | Average available water in Mm3 | 9676 | 130 | 87 | 1607 |
| 6. | Available water at 75% dependability | 8539 | 14 | 11 | 1254 |
| 7. | Available water at 50% dependability | 9341 | 34 | 29 | 1729 |
| 8. | Available water per ha. for 50% | 6987 | 119 | 252 | 1657 |
| 9. | Available water per capita in $M^3$ | 2195 | 32 | 112 | 907 |
| 10. | Average G.L. for command area in m. | 525 to 600 | 600 to 700 | 625 to 850 | 600 to 750 |

The land use and soil map of the area with scale 1: 250,000.

Hydrological and hydraulic data.

- Various base maps for study area were prepared in GIS environment.
- Land sat 7 TM digital satellite data were used for formation of FCC and super imposed this image to base maps prepared.
- Slope maps were analysed and verified to identify the exact elevations, high flood levels (HFL)
- With the help of remote sensing imagery, location of inlet and outlet of flood tunnels were identified.
- All data observed and calculated were verified with ground truth and field work.
- All detailed flood studies examined the areas through which floodwater flows.

After the field wis completed the information so obtained in incorporated in the GIS analysis to analyze and compile the diverging of flood water and analysis was carried out to minimize the flood risk.

## Research And Remonstration Findings

The results of the present study as well as relevant discussion have been summarized under following heads:

**Field observations :**

**Survey for river cross sections:**

The area was surveyed thoroughly for the flow of floodwater by studying the river cross sections, ground

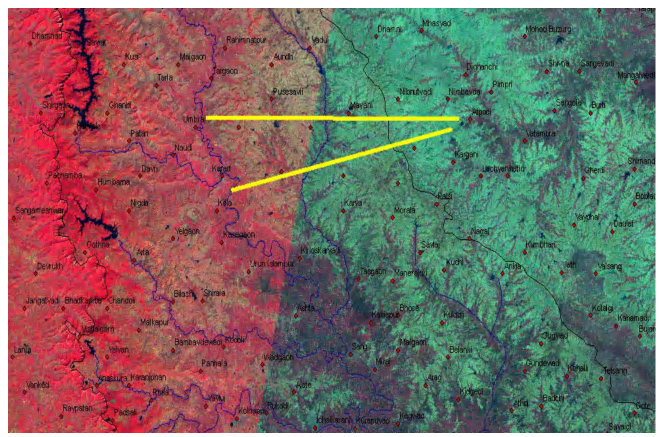


**Fig. 1: Land sat image for location of flood tunnel**

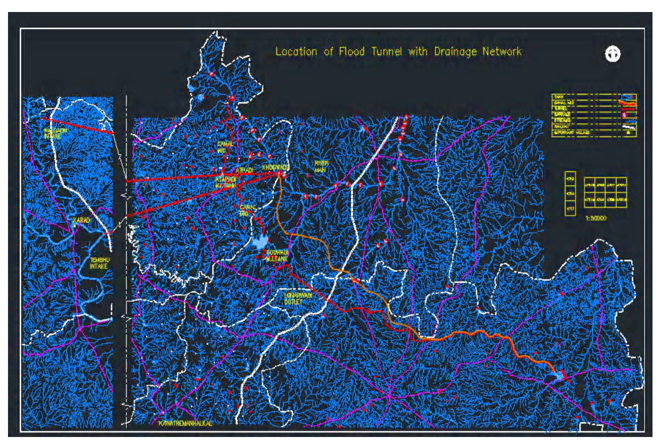



**Fig. 2: Tunnel location with drainage network**

elevations and obstructions (such as buildings, bridges, and other developments) for these areas. Accurate data on the shape of the stream and changes in the floodplain were obtained from ground surveys, topographic maps (Fig. 2). To locate the true elevations at a site, elevation reference marks or benchmarks were established that are referenced to a common vertical elevation reference or datum. Also, there were some benchmarks set by government agencies, most of them were established by private surveyors and local agencies. Local reference marks were related to a national datum but some were not. It is double checked that the datum used in the community for elevation reference marks is the same used for flood elevations. It is taken perpendicular to the flow of the stream. At each cross section, the irrigation division has accurate information on the size of the channel, the shape of the floodplain, and the changes in the elevation of the ground. Cross sections are taken across the floodplain at locations along the stream that are representative of local conditions. They are taken at each bridge or other major obstruction and at other locations, depending on how much the stream or adjacent floodplain conditions change.

**Survey for diverting water from high flood to deficit sub-basins:**

*Alternative-1 (15A,15B to 16A 16B) lifting water from elevation 555m to 530m:*

The topographical conditions shows that Agrani and most part of Man sub-basins are situated to 150m above the river Krishna. To divert water from river Krishna to these sub-basins one has to resort to LIS. Some part of Man sub-basin can be reinforced with water from abundant sub-basin 15A by gravity.To increase per hectare water availability sub-basins 16A, 16B, 18B (*i.e.* Yerala, Agrani and Man), Government of Maharashtra is implementing lift irrigation schemes (LIS) namely Tembhu, Takari and Mhaisal.

*Alternative-2(15A,15B to 18B) Gravity flow by proposed tunnel from elevation 555m to 750 – 850m:*

The altitude of river Krishna ranges from 555-530m in Sangli district while the altitude of Mahadeva Range hills is having altitude of 750-850 m, meaning that to connect these two sub-basins, one has to do it by lifting or by means of a tunnel. While connecting these sub-basins through tunnel, it crosses the sub-basin16A ( Nandani and Yerala). The clearance between top of tunnel and Nandani river at crossing is 126 m, and Yerala river is 82 m.

*Alternative- 3 (15A to 18B) gravity flow through proposed tunnels:*

In the present study, it is proposed to divert abundant water from sub-basin 15A to sub-basin 18B by gravity (diverting water from proper river Krishna to sub-basin of Man to Jath, Atpadi, Talukas of Sangli district and Sangola taluka of Solapur district through tunnels). Diverting water only in flood situations and to feed existing water resources and small storages in Man sub-basin would prove to be better.

**The proposals:**

As the water diversion by lift has not economical as compared to gravity flow. The various alternatives to connect river sub-basins were examined and the best three alternatives proposed are:

– Tunnel start point near u/s of Umbraj (Kalgaon Village $74^0$7'14''E $17^0$28'11''N) and exit point near Atpadi minor irrigation tank(MI) ($74^0$53'50"E$17^0$23'58"N) and from exit point to Dighanchi K.T. Weir on Man river of Sangli district by natural existing canal.

– Tunnel start point at Tembhu Barrage ($74^0$14'3"E$17^0$16'52"N) and exit point at Lonarwadi K.T. weir downstream of Atpadi on Man River

– Tunnel starting point at Tembhu Barrage and exit point Lonarwadi K.T.weir and lift from Lonarwadi to Atpadi MI tank.

While studying the alternatives the water availability at entry point and water requirements at the exit points are considered to design the tunnel. The river Man joins river Bhima at Sarkoli village of Pandharpur, downstream of Ujani dam. Most of the shore of river Bhima downstream of Ujani is under command of Ujani reservoir. Hence, while evaluating water requirement the water reservoirs in the command of Ujani are deleted and only drought prone uncommand area is considered. It is assumed that 80 per cent of storage capacity of minor irrigation (MI) tanks and K.T. weirs will be feed by this flood tunnel.

*Details of proposal I:*

Tunnel from Kalgoan to Atpadi (Krishna river to Man river through Atpadi MI tank):

In this proposal, the proposed tunnel start point is at Umbraj (Kalgaon village) with bed level is 587 m (at Kalgaon), and bed gradient 1:4100. The length of this tunnel works out to 82km from GIS layout. The tunnel opens near Atpadi minor irrigation Fig. 3 (a).

After tunnel the flood tunnel is divided into three branches.

*– Atpadi MI tank to Man river through Dighanchi K.T. Weir:*

After opening the tunnel at Atpadi, first flood canal *i.e.* Dighanchi branch is diverted towards Dighanchi in opposite direction of Man river and it is ended in Man at Dighanchi KT weir.This is gravity flow by natural existing channel of 17.30 km length.

*– Atpadi MI tank to Man river through Sankh Weir:*

This branch not connect to direct Man river.This helps

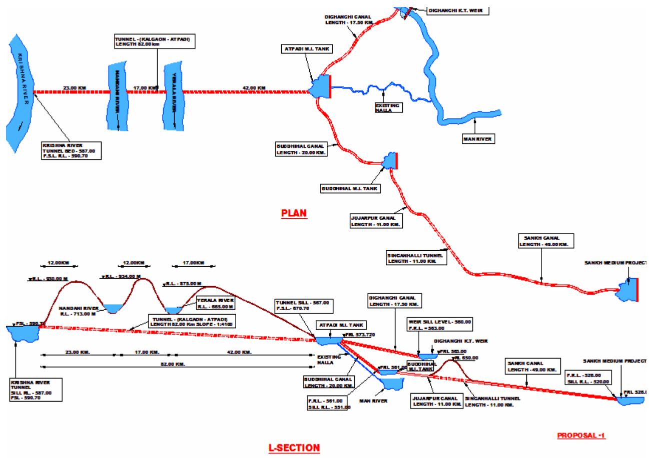



Fig. 3(a): Proposal I

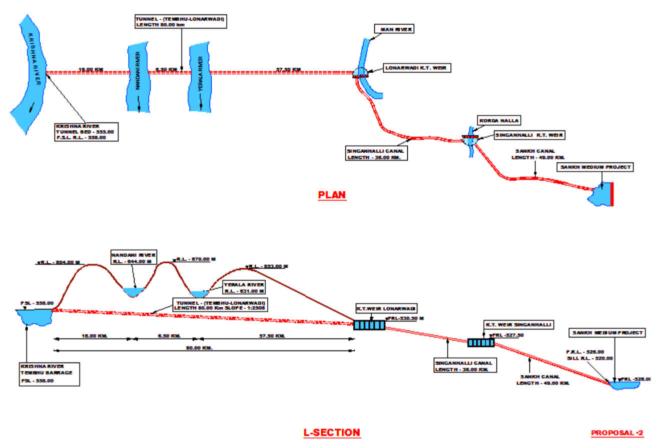



Fig. 3(b): Proposal II

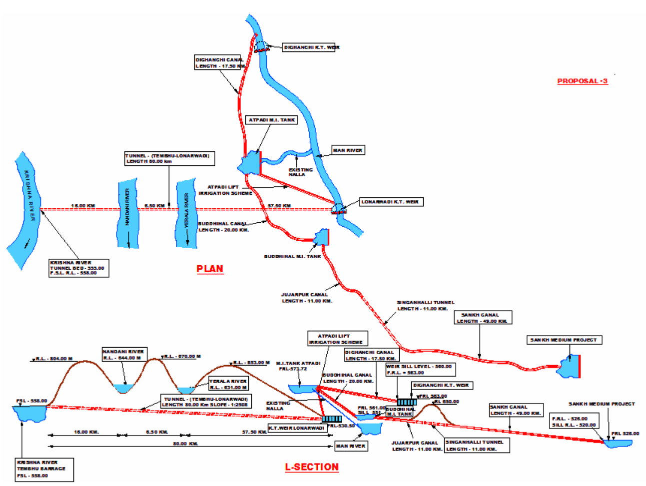



Fig. 3(c): Proposal III

to fed the water to West side of Man river.This is the second flood canal in this proposal. This branch is further divided into three parts.

– Atpadi to Buddhehal MI tank,20 km by natural existing chanel

– Buddhehal to Jujarpur 11 km by gravity flow

– Jujarpur toSankh by proposed tunnel of 11 km at Jujarpur and 42 km through open natural chanel.

*Details of proposal II:*

Tunnel form Tembhu Barrage to Lonarwadi (Krishna river to Man river directly).

In this proposal, the tunnel start point is considered at upstream of Tembhu Barrage whose F.R.L. is 558 m. The intake point of tunnel will be 500m u/s of Tembhu LIS intake point. Fig. 3(b). The tunnel bed level is proposed at 554.85 m. Considering tunnel gradient 1:2520, length works out to 80 km. The tunnel opens near Lonarwadi KT weir. The Lonarwadi KT weir is on river Man having nalla bed level of 523.10 m. (FRL. 527.60 m). From this KT weir, part of flood water will be released in to man river and remaining flood water will be diverted through flood canal towards Singanhalli and then towards Sankh medium project.

*Details of proposal III:*

Tunnel form Tembhu Barrage to Lonarwadi (Krishna river to Man river by gravity flow and Man river to Atpadi MI by Lift)

The proposal I is having intake at Kalgoan, which is at u/s of Koyana confluence, so it will have lesser water availability than the proposal II even during floods. In the proposal II, the outlet of main tunnel opens at Lonarwadi KT weir, which is located at the end of Atpadi taluka and the major scarcity command is omitted from benefits.

To overcome these limitations of the above two

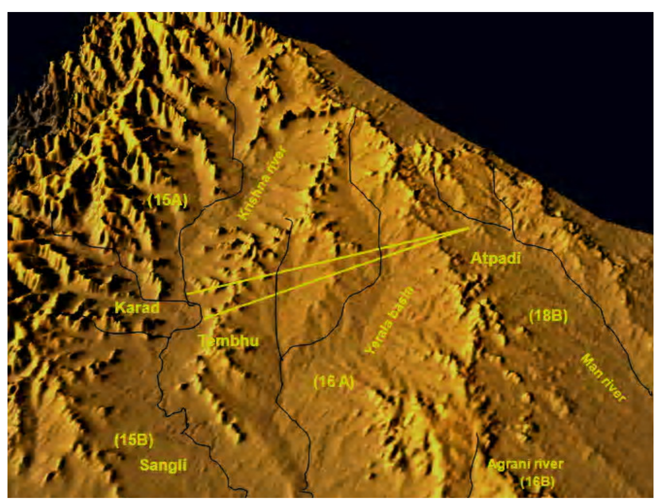



Fig. 4 : 3D-DEM

proposals, the third proposal has been studied Fig. 3 (c). This proposal is combination of the proposal I and II. The command area is as per proposal I and main tunnel alignment is as per proposal II. The main tunnel is as per proposal II *i.e.* intake at Tembhu and outlet at Lonarwadi. But the capacity of tunnel is increased to match increased command area. The command area is increased equal to proposal I by providing mini LIS from Lonarwadi to Atpadi MI tank. Then from Atpadi MI tank the two flood canals Diganchi branch and Singanhalli Sankh branch are proposed. The proposals are tabulated in the Table A.

## Conclusion:

The mute question of fundamental importance to flood-hazard in Upper Krishna basin in India is, whether the future is likely to see the situation improved, unchanged or exacerbated. It is evident from this present research that to have some possible solution to control flood through flood tunneling can continue to give a gainful solution. Traditional descriptive and classificatory studies have been replaced by more systematic and quantities studies of the floods and their impacts. Three proposals as suggested can easily divert flood water from Krishna river to Man sub-basin, which will definitely reduce flood intensity and will provide water to the drought prone area assuming that 80 per cent of storage capacity of MI tanks and K.T. weirs will be feed by this flood tunnel. Around 131.79 MCM and 102.45 MCM of flood water will be diverted from proposal I and II, respectively, while in proposal III 139.49 MCM is possible for diversion. Thus, total 380.43 MCM of flood water can be diverted from river Krishna, which can minimize flood occurrence in this sub-basin enhancing the water supply for drinking and irrigation in this highly water deficit region. The present work would definitely irks out a way that the affected community of any scale is suggested to follow in order to make it prepared for flood hazards to minimize their negative impacts and lead to quick recovery when they occur reflective of the continued trend towards a broader understanding of how collectively make use of the opportunities provided by floods and flooding, cope with risks posed by them and plan for and respond to flood events.

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