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Issues and Constraints (Climate change) of Water Resource Management in Tungabhadra River Basin in India

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Abstract

This paper discusses the issues and constraints associated with the water resource management in the Tungabhadra River basin in India. It is a sub basin of River Krishna and confluence of two major Rivers Bhadra and Tunga. Tungabhadra is a non perennial River and flows from high altitude from 3000 ft to low altitude. Originate in the state of Karnataka and moves towards the state of Andhra Pradesh and also known as the interstate River. This study is limited to the state of Karnataka and identified several water management issues in the basin. The issues such as interdispute, un authorized irrigation, crop violation, head reach and tail enders problems at the agriculture level. And also, drinking and industrial water requirements at commercial levels leads violate the decisions at the official levels. In addition emerging climate change issues (mainly evaporation losses) and requirement of environmental needs to conserve the fragile ecosystems are observed and are authorities are failing to consider under management concern. This study followed different Integrated Approach (IA) method to assess at the different levels in the basin. Several grassroot implementation approaches has been recorded and also identified the traditional management techniques and tried to link with existing systems of management.

Keywords*:* Water, issues, management, climate change, integration.

Introduction

The impact of changes in climatic patterns is predicted to be highly significant at all the levels, viz., local, regional and global, particularly on the water resources such as, increased evaporation, a result of higher temperatures, combined with regional changes in precipitation characteristics (such as total amount, variability, frequency and intensity of extreme events), soil moisture and water supplies for the irrigation etc. On the other hand, increased monsoonal precipitation does not necessarily lead to higher agricultural production. Increase in run-off may have positive results for hydropower or drinking water supply, but in numerous drainage systems, particularly altered systems, it may lead to water logging, salinity and sedimentation. In view of its complexity, it may said that managing water resources holistically imply redirecting human activities in ways that satisfy both human and ecosystem needs. IWRM, from the very beginning, attempted to bring in these needed fundamental changes in terms of values, beliefs, perceptions and political positions, not only the institutions involved in water management and in the way they deal with stakeholders, but also the stakeholders themselves. It is also natural that progress in this area is difficult and slow as the operational aspects are complex, yet it is generally accepted that to manage water resources.

IWRM has attracted lots of attention in recent years. The concept of IWRM is put forward by the GWP[1] and has received widespread support precisely because, it's addressing the interconnections between water, development and sustainability. Therefore, integration needs to be interpreted broadly. This should be done without compromising the critical marginal users such as small scale food gardens[2]. The user principle has been well articulated but goes against the grain of equity particularly when large paying users should have more say when decisions are made. The quality of the environment needs proper care of soil, water and air. In semi-arid area's water comprises an important commodity connected with developing the human society[3]. The present paper looks at proper solutions to comply with water needs in the Tungabhadra (TB) River basin, which is a sub basin of the river Krishna in Southern India. The average amount of annual rainfall in the basin is 800 mm (2,000-3,000 mm at the point of origin and 500-600 mm at the river end point) and most of the area is under dry condition with a poor availability of fresh water. This study focused on the various issues of water resources management like climate change, socioeconomic and political issues affecting the water needs and also impacted by cropping pattern changes, rapid urban growth, industrial development and land use changes.

Study Area: The Tungabhadra (TB) River basin is one of the major sub-basin of the Krishna river basin in peninsular India and stretches over an area of about 47,827 Sq. Km (1.45 percent of the Indian total geographical area) in the states of Karnataka (81.1 percent of the basin) and Andhra Pradesh (18.89 percent of the basin) figure 1. The total population of the TB basin is about 88.53 lakh with population density of 302 persons per Sq. Km Average literacy rate is about 64 per cent in the basin. The total forest area of the basin is about 4.48 lakh Ha in which 60 per cent of the area is situated in the upper part of the basin (Western Ghat) while the rest is spread both in middle and lower parts of the basin. This study limits upto the border of Karnataka only.

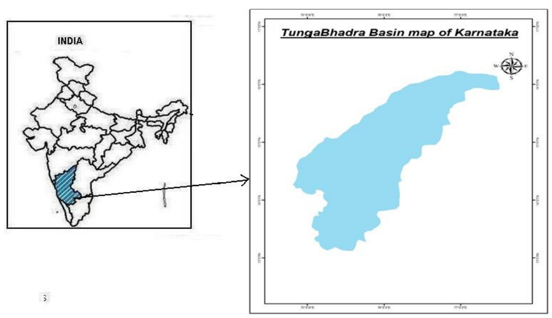


Figure-1
Location of the study area, Tungabhadra River Basin, South India

Reseach Methodology

Adopted an Integrated Assessment (IA) approach method to identify the issues and constraints associated with water management in River basin to develop management strategies. IA approach provides a research framework to integrate water and climate change scenarios with current socioeconomic conditions and sustainability. Developing an integrated approach includes, surveys, consultations with policy makers, subject experts, Geographical Information Systems (GIS), remote sensing and also employees multi-criteria decision making, besides cross checking with the other studies conducted in different parts of the globe using IA approach.

Results and Discussion

The Present Scenario of TB Basin: Tungabhadra River is a confluent of two major Rivers Tunga and Bhadra. These Rivers originate at high altitude of Gangamula in Western ghat and flows towards a semi arid area of Karnataka (major) and Andhra Pradhesh. The River Tunga flows up to 147 km from the origin to the confluence point and then joins with the Bhadra River, and form Tungabhadra River. It flows up to 278 km to join the Krishna River in Andhra Pradhesh. The basin has three major reservoirs, such as Bhadra, Tunga and Tungabhadra, with a maximum capacity of 75 TMC, 12 TMC and 132 TMC respectively. The Tungabhadra reservoir is constructed across the River Tungabhadra in the year 1953 and irrigation is started in the year 1954. This reservoir supplies water to an area 3.62 lakh Ha in Karnataka.

Water Availability (Surface and Ground water) in TB Basin: The Tungabhadra River basin receives heavy rainfall in the western ghats and less rainfall in the semi arid area. There are 4,438 irrigation tanks are located in the basin with a storing capacity of 14.38 TMC ft per annum and irrigating an area of about 63,143 Ha. The basin has storage of 364.88 TMC of surface water and 796.6 TMC of ground water per annum.

Urbanization and Water Demands: Urbanization is a process by which a drainage district undergoes two major changes, viz., 1. Increase of population density and 2. Increase of impervious area. Such as residential, commercial and industrial along with other infrastructure developments which takes place in watersheds inflict sometimes irreversible damages to natural flow regimes and the quality of water available. These changes are having implications during supply of water for domestic use, disposal of waste, seweraging, risk of floods and associated disease outbreaks and on the environment[4]. In the event of fully urbanized scenario, provision of safe water for drinking and domestic purposes, disposal of water and smooth draining out of excess water during heavy rainfall events become the major concerns for authorities[4]. The urban population shows a more increasing trend in comparison to rural population also indicating that there is more influx into the urban towns, adding more pressures on the infrastructure. Particularly between 1991 and 2001, there has been an increase of 36 per cent.

Population Growth Leading to Increasing Pressures: Population growth increases economic activity and improved standards of living lead to increased competition and conflicts over the limited freshwater resource. Water withdrawals have increased more than twice as fast as population growth that experience medium to high water stress; pollution is further enhancing water scarcity by reducing water usability downstream. A combination of social inequity and economic marginalisation forces people living in extreme poverty condition to overexploit soil and forestry resources, with damaging impacts on water resources. The present population in the basin is 0.88 million (Census of India, 2011), showing an increase of 15 per cent in the last decade, from 2001 to 2011. Urban areas are floating with migrating population.

Drinking Water Scenario in TB Basin: Water is the prime need for human survival and also for industrial development. Both ground water and surface water meet the drinking water requirements for various towns and villages across the basin. The total drinking water consumption (allocated) from surface water sources is 4.49 TMC ft per annum while the rest is from ground water. The water allocation made on the basis of the population and per capita requirements (ranges from 70 to 135 lpcd across the towns) see table 1.

Groundwater mainly supplies to villages located in the TB basin through mini water supply schemes, piped water supplies and other schemes. There is consistency in the supply of groundwater in the lower part of the basin compared to upper part because the lower part is contaminated with fluoride, salinity and alkalinity issues. Many villages are not accessing groundwater for drinking, instead they are using surface water from the canals. Sometimes, they store canal water for future access (especially for summer) because canals will be closed during summer season.

Water Demands from Industrial Sector in TB Basin: The industrial sector is one of the major stakeholder of water consumption in the basin. There are many large-scale and small-scale industries are located in the basin see table 2. Iron and Steel Paper and Pulp, Chemical and Sugars are the major types of industries in the basin.

There are 19 major industries across the basin and consume 6.1 TMC ft of water per annum and they release 80 percent as effluent. All these industries are located on the bank of River Bhadra and Tungabhadra. A few industries have come up in recent years and the demand on the water sector is quite increasing. The table 3 below shows the water allocated by different project for the industrial sector.

Table–1
Surface water consumption in TMC ft in Tunghabra River basin

Sector	Tunga	Bhadra	Tungabhadra	Total
Drinking Water Consumption in TMC ft	0.45	1.46	2.58	4.49

Source: Karnataka Planning Commission Report, Tungabhadra Project (TBP), Bhadra Reservoir Project (BRP)

Table–2
Number of large scale industries in and around Tungabhadra River basin

Implemented	Under Implementation	Dropped	Total	Type of Industries
27	50	7	84	Iron and Steel, Paper and Pulp, Chemicals, Sugar and Energy

Source: Department of Industries and Commerce, H.O Bangalore.

Table–3
Industrial water consumption from different projects in Tungabhadra River basin in TMC ft

Sectors/Projects	Tunga	Bhadra	Tungabhadra	Total
Industrial Consumption in TMC ft	-	1.54	4.56	6.1

Source: TBP, BRP & Upper Tunga Project (UTP)

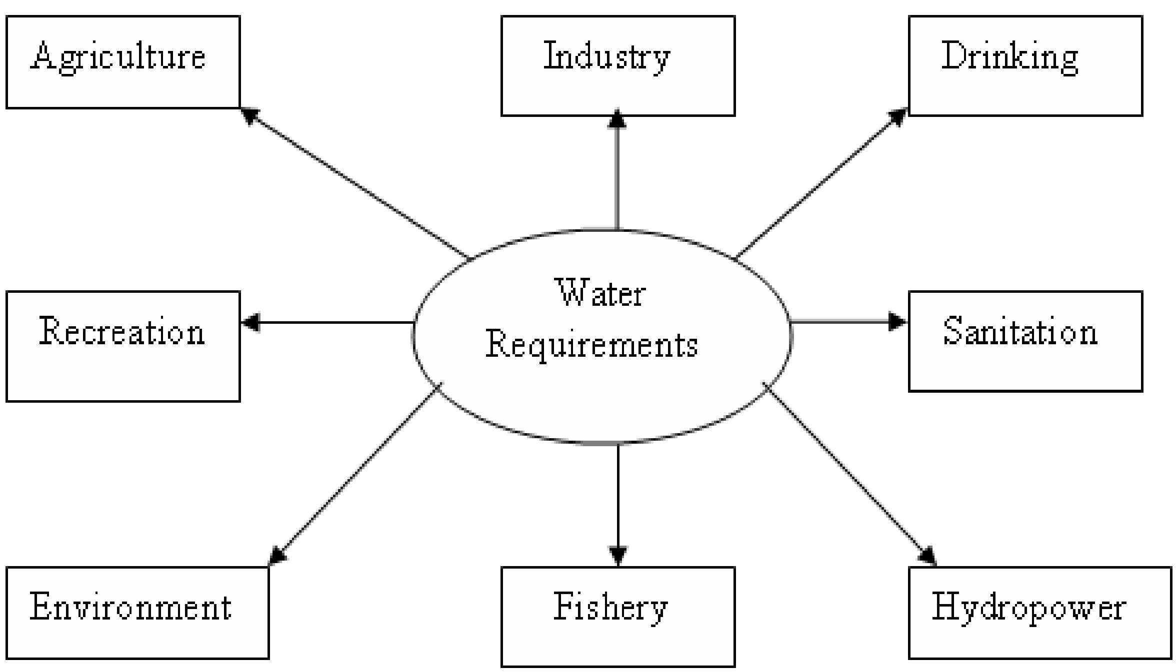


Figure-2
Water requirements by different sectors in Tungabhadra basin

Actions for Industrial Pollution Monitoring: There are three major schemes which are monitoring the release of waste in the TB basin, they are.

State and Central Pollution Control Boards and Industries: Pollution Control Board is responsible for monitoring and evaluating the water quality in the basin for which a series of processes are following. GEMS and MINARS programme under the Ministry of Environment and Forests at the Central Government level has taken up the programme across various river basins. Central Pollution Control Board (CPCB) identifies the points to be sampled regularly for analysis. Some of them have been pointed out by the State Board for testing water quality and this applies all along the river by many regional departments.

Global Environmental Monitoring System (GEMS) Programme: Was started in 1980. The Board is collecting and analyzing samples from surface and ground water under GEMS water quality monitoring programme. It has a few points in the Tungabhadra basin for analysis purpose regularly.

Monitoring of National Aquatic Resources Programme (MINARS) was started in the year 1989. The Central Pollution Control Board has sponsored the Board to monitor the quality of water of the rivers and lakes under the Monitoring of Indian Aquatic Resources.

Water and Agricultural Sector in TB basin: Agricultural potential in the Tungabhadra basin is quite huge. Approximately 80 percent of the poor live in rural areas of the basin and are dependent on agriculture for their livelihoods. Further, agriculture is the most important sector of the economy and employment in the region.

Land Use Cover and Land Use Change in TB basin: Observation and analysis of statistical data over a period and intensive field observation and discussions have brought out that land use change in the basin over a period is changed. Forest area in the basin has increased from 13.4 per cent to 15.8 percent (according to forest department) due to implementation in the forest programmes such as afforestation, social forestry and other forest programmes. Land available for non cultivation is decreased from 11.2 per cent to 10.2 per cent because of land acquisition for other built up areas such as residential, commercial and road network etc., Other uncultivable land excluding fallow land have also came down drastically to 8.6 per cent from 13.2 per cent due to decrease in grazing land and cultivable waste. Fallow land is slowly increasing from 10.3 per cent to 11.0 per cent but current fallows has decreased drastically due to insufficient supply of water through canals (tail end problems), lack of rainfall and increasing poverty of in farmers see table 5. Cropping intensity is increased (10 percent) over a period due to increase in unauthorized irrigation by converting hilly areas into irrigable land.

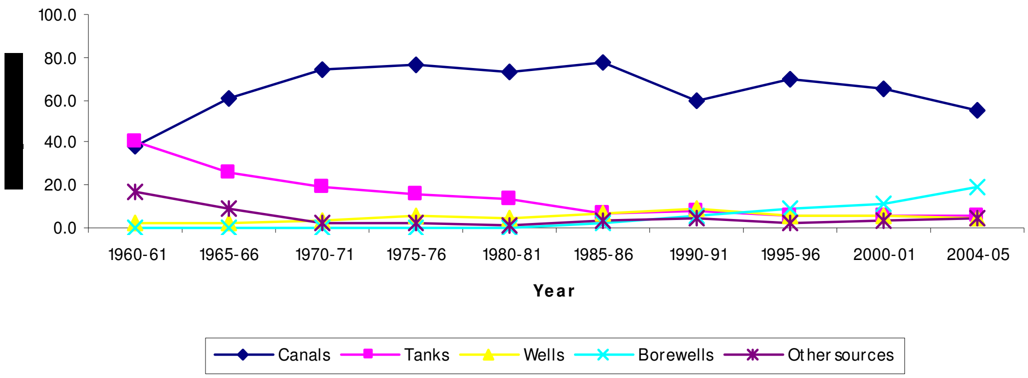
Table–4
Key issues/Impacts and reasons – An overview

Key issues	Impacts	Reasons
-Industrial pollution -Change in water quality -Impact on soil quality -Sewage pollution from towns -Agricultural residues	-Increasing demand on water -Impacts on health have been witnessed along some industries -Instances of aqua life which has been affected -Soil contamination	-Increasing competing users -Poor implementation of standards -Political interventions -Blame game due to lack of common platform

Table–5
Land use changes in theTungabhadra Basin in Percent

Year	Forest area	Land Not Available for Cultivation	Other Uncultivable land excluding fallow land	Fallow Land	Net area sown	Area sown more than once	Total Cropped area
1960-61	13.49	11.19	13.19	10.32	58.05	1.66	63.75
1965-66	9.71	10.79	22.43	5.69	61.29	1.53	62.82
1970-71	11.87	6.75	10.58	7.94	59.06	6.06	62.21
1975-76	12.10	8.83	11.98	9.23	57.58	5.34	62.91
1980-81	14.20	8.77	9.39	12.31	52.52	5.56	59.86
1985-86	15.05	9.79	10.65	10.10	60.16	10.15	70.31
1990-91	14.71	9.41	7.30	8.35	54.39	14.70	71.00
1995-96	15.03	9.51	8.31	9.77	57.59	11.38	87.96
2000-01	14.80	9.57	7.54	9.31	58.25	11.70	69.95
2004-05	15.83	10.24	8.59	11.03	61.27	13.07	73.74

Source: District at Glance, MES Bangalore



Figure–3
Net area irrigated in percentage from 1960 to 2005

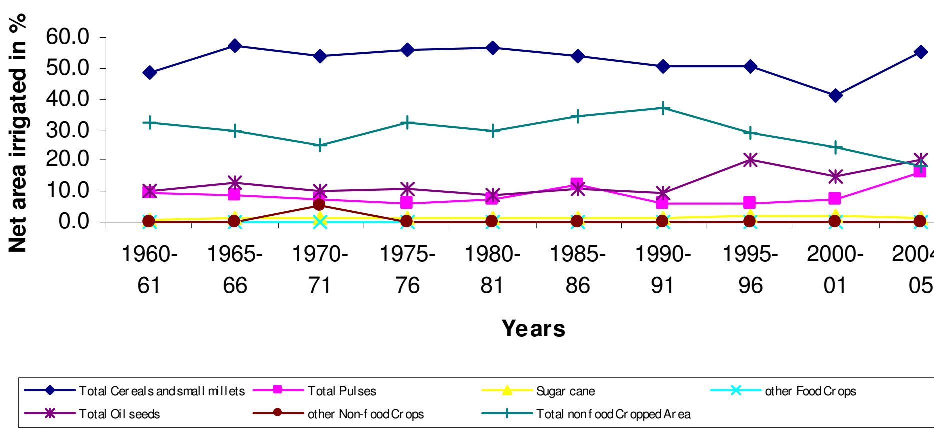


Figure-4
Area under different crops in percentage from 1960 to 2005

Variations in Cropping Pattern: Net area irrigated in the Tungababhadra basin by different sources such as canal, tanks, open wells, bore wells and other sources is accounted and analysed over a period. It is observed that canal irrigation is increased upto 15 per cent because of development of irrigation sector construction of new reservoirs and medium irrigation projects in the basin across the main river and also in the tributaries of the same. Tanks irrigation has come down from 40 percent to 6 percent due to encroachment through irrigation, built up areas, silt accumulation and severe breaches of tank bed. Bore well irrigation is extended up to 20 percent due to the application of easy technology/methods in the extraction of groundwater, insufficient rainfall and increase in the livelihoods of farmers by farming throughout the year. Other sources of irrigation noticed as decreasing from 17 to 4 percent due to huge cost involvement in cultivation see figure 3.

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The area under different crops such as cereals, millets, oil seeds and other non food crops in dry, wet and irrigation areas has been taken into consideration to understand the consumption of water by different crops and requirement of water for existing crops. Most of the area, 55.5 percent (in 2005) is used for cultivating cereal and minor millets and it is increasing gradually (7 percent) over a period because of the requirement of food crops and introduction of paddy as well. The area of the pulses has increased from 9.3 percent to 16.3 percent due to easy access to market, increasing income level in households. Non food crops such as sunflower, groundnut, cotton and other oil seeds are also increased up to 10 percent but cotton production and the area have decreased a lot because of the pest affection, decrease in yield and change in climate. The traditional cropping system is disappearing in non food crops with the introduction of high yielding varieties see figure 4.

Area under different crops in percentage from 1960 to 2005: Landholding size is declining from big to small or marginal because of fragmentation in family and selling of land for different personal purposes. Marginal land holders are increased from 31.8 per cent to 40.0 per cent, but small and medium landholders decreased by 4 per cent. Big and medium land holders have decreased by 5 and 3 per cent respectively. Water management is better among the big landholders rather than small landholders.

Irrigation and Water: It is observed that the usage of water for water guzzler crops like sugarcane and paddy over a time has increased and also the extent of water usage for semi-arid crops see table 6. The total water consumption has shown an increasing trend over the years (except in 2004-05) for both types of crops. Furthermore, agriculture is the major sector of the economy[5], rainfed agriculture is highly dependent on the quantity and temporal distribution of rainfall. As a general rule, an absolute minimum of 300-400 mm of precipitation is required per year to make rainfed arable farming. The risk of crop failure is minimized and farmers can hope for higher and more reliable agricultural production and better levels of income[5]. The table 6 below shows water consumption over a period by different crops.

Table–6
Crop-wise water consumption in Tungabhadra River ba

Year	Water Use in TMC ft for Agriculture		
	Paddy + Sugarcane	Dry Crops	Total
1960-61	91.9	211.1	303.0
1965-66	110.4	202.9	313.3
1970-71	155.3	190.3	345.6
1975-76	145.3	199.4	344.7
1980-81	171.1	181.4	352.5
1985-86	166.2	210.0	376.2
1990-91	202.1	216.9	419.0
1995-96	240.6	269.2	509.8
2000-01	270.2	194.4	464.6
2004-05	259.7	254.7	514.3

Source: Data compiled from District at a Glance and are analyzed

In general, in India, the canal system is geared to a specified crop pattern (i.e distribution of irrigable area under seasonal, two seasonal, perennial as well as heavy water using crops like paddy, sugarcane, banana etc.) for both Kahrif and Rabi crops as such. Water in the Tungabhadra River basin through canal run water for about 10 months in a year because limitations in availability and design pattern. As per the record paddy is designed for 18.7 percent but currently practicing 60 per cent in the basin (Irrigation Department, TBP) because head reach farmers are violating cropping pattern towards paddy because it is easier to grow. Irrigated dry is designed for 70.33 per cent but it had been reduced to 30 percent in the year 2006 due to insufficient water supplied to tail end and irregular rainfall.

Violation of Cropping Pattern: The extent of violation of cropping pattern was 58.35 percent in the Tungabhadra project and 39.30 percent in Bhadra. The percentage of semi-dry crop varies with 19.20 percent in Bhadra project and 33.41 percent in the Tungabhadra command area. Violation of second crop during Rabi is severe in the Tungabhadra as well as in Bhadra. Most of the farmers (70 percent) violate the cropping pattern by cultivating paddy.

Unauthorized Irrigation: The irrigable area lying within the gross command area was not envisaged in the Tungabhadra project. A principle called localization was adopted in the project where only certain pockets within the command area were selected for irrigation leaving several patches unirrigated. The purpose was to extend the gross command area to cover more villages. However, it was very difficult to restrict irrigation to the localized pockets only and the farmers were drawing water to the remaining patches of land also. This was one of the main reasons for unauthorized irrigation in the Tungabhadra basin.

In south India the present system of distribution of water makes it possible for a user to take water to his fields till satisfaction but which may not have any relation to the crop water requirement at different stages. All these suggest to extension of 20.6 percent of unauthorized area in the command area in the basin. Farmers convert their hilly and dry land/unused area into the command area to access water from the canal at the head and mid reach of the canal. The farmers at the tail end will suffer a lot due to poor accessing of water for their crops and it is seen in the Rabi season.

Impacts of Climatic Change: Temperature: Temperature is one of the major factors of the climate, it alters the climate by variability and also changes the rainfall pattern. There are 10 temperature monitoring stations in the Tungabhadra river basin, viz Chickmagalur, Shimoga, Davanagere, Dharwar (for Haveri), Koppal, Bellary, Raichur, Cuddhappa, Kurnool and Ananthpur. The below figure 5 shows the temperature variation in Krishna basin[6]. The 0.6^0 C rise in average temperature and it leads to major evaporation losses in the basin.

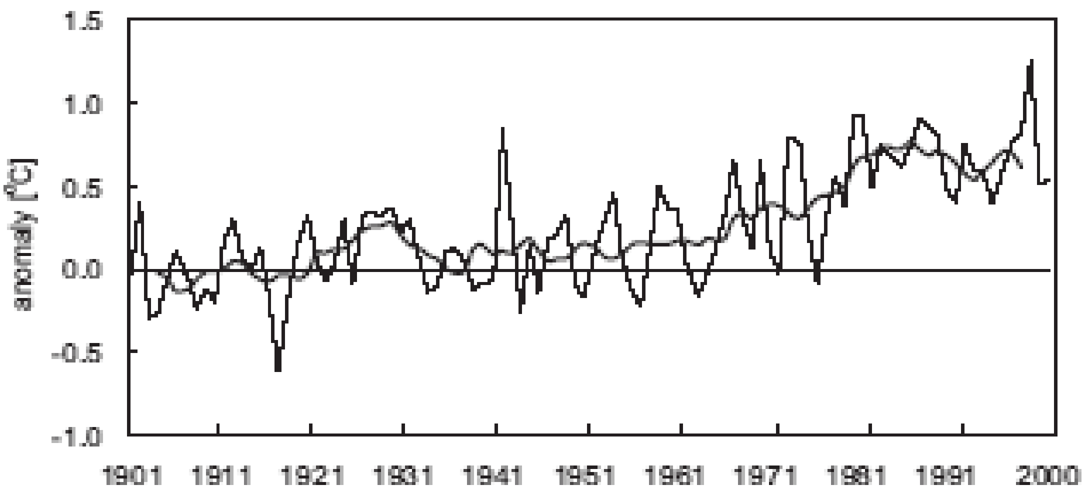
Rainfall: The analysis of rainfall series of the basin in selected seven districts reveal highest rainfall maximum of 3000 mm was recorded in Shimoga and Chikkamagalur districts (upper part of the basin) because these districts belongs to western ghats. The average rainfall of about 1000 mm recorded at Davangere, Haveri and Koppal districts because they come under semi arid regions. In 1980 highest rainfall recorded in the basin see figure 6.

Evapotranspiration: Evapotranspriation is one the major issue in the Tungabhadra project. Water evaporates up to 18 TMC (in the year 2006) per year due to high temperature and low humidity (climate change). The figure 7 shows the variations in the evaporation losses over a time. The evaporation depends on the changes in the climatic system. Evaporation recorded highest during high temperature and it is observed in the Tungabhadra reservoir as case

Table – 7
Notified cropped area and unauthorized irrigation in 1996-97 in Ha

Name of the Project	Crop Area Notified for Irrigation	Unauthorized irrigation	Percentage
Tunga Anicut and Bhadra Project	208,074	6,559	3.15
Tungabhadra	351,337	61,384	17.46
Total	559,411	67,943	20.61

Source: TBP, BRP and UTP



Figure–5
Temperature variations in Krishna basin[6]

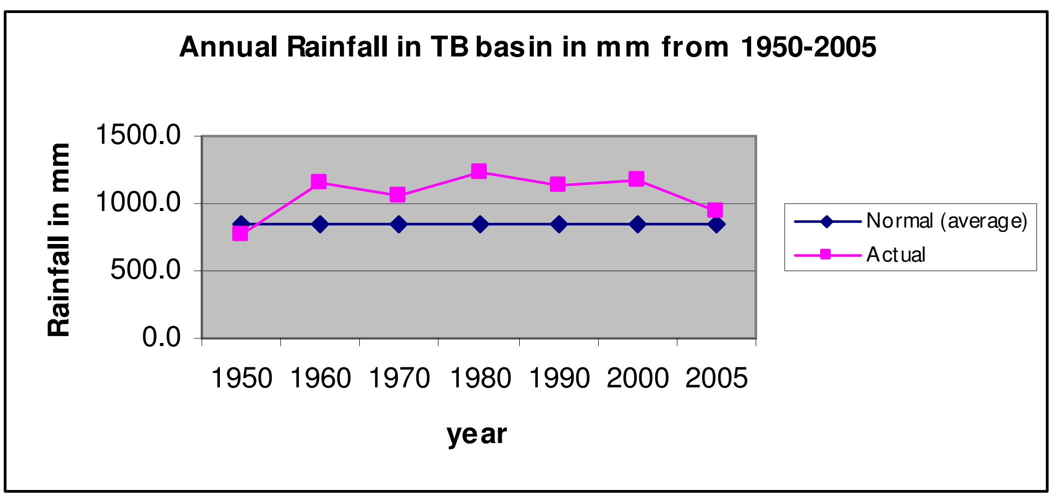
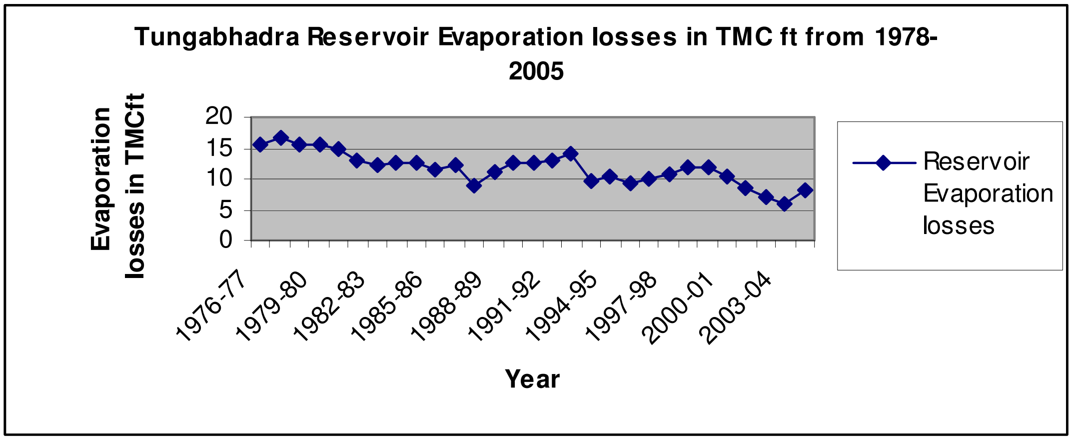


Figure-6
Rainfall in the TB Basin in mm from 1950 to 2005



Figure–7
Evaporation Losses in TB Reservoir

Major Issues and Constraints in TB basin: Water demands from different sectors have significantly changed over a time in the Tungabhadra basin. Agriculture has been the major consumer and intra-sectoral within the basin. In the process, crucial sectors like environment and fisheries are not given adequate importance. Conflicts within and across sectors are common apart from interstate disputes, due to the transboundary nature of the River. Total water allocation can be measured as, 94.3 percent for agriculture, 1.96 percent for drinking water and 3.72 percent for industrial usage.

Although allocation for drinking water is given first priority, water availability is still a issue. Further pollution enhances water scarcity. Designed cropping pattern has been specified for semi arid crops but water intensive crops (paddy and sugarcane) dominate in the basin. A combination of social inequity and economic marginalisation have forced people living in extreme poverty to overexploit soil and forestry resources, with damaging impacts on water resources. Scope for political interventions aids in favoring the economically ignoring the poor. Violation of rules is prominent and it id it difficult to manage.

There is a competition between agricultural sector and other sectors such as drinking, industry and environment. Increasing population, industrial activities and environmental requirements has been exerting pressure on irrigation allocation in developed countries[7]. Economical output by the agriculture sector is lesser than the other sectors but livelihood dependency is high. Agricultural sector plays a major role in human utilization of water and IWRM is likely to have a significant impact on water sector while implementing. Water Management in supplies (i.e water availability in space and time), demands (i.e., increasing efficiency of water use), balancing competing demands (improvement in upper reach and lower reach) and sustainable development in agro-ecosystem and natural ecosystem.

Water management in the agricultural sector includes advanced crop varieties, substitution in cropping pattern (water guzzling crops to dry crops), and maintaining soil quality through organic farming, controlling weeds and pests by biological methods. The only way to ensure local food security and water security to meet the basic needs for drinking and cooking is by undertaking rainwater harvesting and groundwater recharge on a large scale through the participation of the community, including especially the women and the landless people[7].

IWRM benefits the agricultural sector effectively and equitable manner. It develops sustainable practices, reduces conflicts among upper reach and lower reach and even transboundary issues. 10 percent improvement in the efficiency of water use would be equivalent to adding 14 million hectares of gross irrigated area[7]

Participatory irrigation management, biotechnology, irrigation water standards and capacity building, evaluation of externalities, management tools and water users associations at regional level are requirements of IWRM within an agricultural sector. Property rights, institution and public policy may be required for sustainable irrigation management. We have not taken significant steps so far for improving water use-efficiency through modernization or renovation of existing systems[7]. Participatory irrigation Management (PIM) is designed to improve water-use efficiency. In India, 7 percent of the irrigated area has been transferred to Water Users Associations (WUAs) as against 45 per cent in Indonesia, 66 per cent in Philippines and 22 per cent in Thailand[7].

India is an agriculture-intensive country[8], a technology like remote sensing can provide timely and reliable information on agriculture with respect to potentials and limitations of the soil, spatial extension of crops grown and pre-harvesting yield of major crops, which is a pre-requisite for optimal land use planning and formulating policies on food security[9].

Water usage across the basin is diversified. Various institutions exist in managing the resources across these sectors and sharing mechanisms are evolved. However, participation is again limited to certain combinations of institutions and stakeholders. Although, participatory methods and participatory consensus-based approaches have emerged as an important tool to simplify complex and multiple institutional arrangements, certain class and group of people dominate during negotiations.

Water demand is also increasing from the religious institution in the basin on the River banks. Sri Sharada temple at Sringeri is drawing water from the River Tunga. They are drawing on an average of one lakh liters per day in a peak season. It attracts people from all over the India and even from outside the country also. Demand on water in the seasons like festival and holidays will be more compared to other seasons. Sri Annapoorneshwari Temple on river Bhadra draws 25,000-30,000 liters per day for drinking cooking and bathing for pilgrims. Hampi is also one of the major pilgrim institutions on the River Tungabhadra. Many more small temples are located all along the River Tungabhadra.

IWRM requires developing platforms where different stakeholders often with apparently conflicting requirements, work together for sustainability, reforms at the institutional and legislative frameworks at all stages in the water planning and management cycle. Although its a gradual process, it has to be in a step-by step process with a combination of focusing on immediate changes and others requiring planning and capacity building. To that extent, several attempts have been made for managing limited water resources in the basin.

Water conflicts arise due to scarcity of water resulting from faulty water management practices. Water conflict is a manifestation of the lack of norms to build consensus for sustained use of water as a common property resource. Water is often used as a measure of control thus power relations in a society make it difficult to resolve conflicts. Competition to access water has resulted in controversies. The challenge has been to make rational use through sharing and better management of water[10]. It is important to understand that various types and situations in which conflicts have emerged and also the traditional and modern knowledge systems in valuing trade-offs. As per the present governance system, the Parliament is equipped with a provision to do so and could enable the centre to make meaningful interventions in conflict resolution. The need for institutional arrangements like water courts to help resolve local water conflicts are required while role models of institutional systems can be identified and lessons could be learnt.

Ecosystems can benefit through an integrated approach in water management by supporting environmental needs and voice in the water allocation debate. The ecosystem approach provides a new framework for IWRM which focus on water management. It provides an alternative to sub-sector competition perspective, with more emphasis on maintaining the underlying ecosystem as a factor that involves stakeholders in developing and joint action.

An ecosystem approach to water management focuses on several field level interventions: protecting upper catchments (e.g., reforestation, soil erosion control etc.,), pollution control (e.g., point source reduction, non-point source incentives, groundwater protection etc.,) and environmental flows (e.g., through reducing abstractions, special releases by reservoirs, river restoration etc.).

Climate change influences water scarcity across the basin for both drinking and irrigation. Water scarcity is occurred mainly during summer i.e. from February to May. Western Ghat area faces less scarcity compared to semi arid region. According to Agriculture pattern and drinking water status, there is a lot of scarcity in the basin. Over-exploitation of ground water has lead to ground water quality degradation in the TB basin. The study carried out by the Department of Mines and Geology says that ground water levels have depleted in the taluks, which fall under TB basin.

Conclusion

Integrated water resources management is a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental and climate change. Lack of cross-sectoral linkages lead to uncoordinated water resource development and management, resulting in conflict, waste and unsustainable systems. Lack of coordination between different line department in managing the water resources in the TB basin is seen and it should be coordinated in proper direction. Currently, there are 15 departments involved in managing the water resources in the basin. The need of common vision and plan in perspective of IWRM as water management is purely managed based on administrative boundaries. There is no common data or information regarding the basin as a whole and the respective departments function within their administrative boundaries.

The challenge has been made to rational use through sharing the water. An effective plan is required to envisage the transformation in the management of water. Although mentioned in water policy to reflect the principles of sustainable management through integrated water resources management. It is essential to put policy into practice. In addition adapting relevant principles of IWRM into a water sector to achieve sustainable development and attain political support as and when required.

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