EMERGING CHALLENGE ON SUSTAINABLE WATER MANAGEMENT IN INDIA

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ABSTRACT

Climate change is a reality and its impact are being felt all over India. The most impact of it will be on water resource. It will aggravate flood, cyclone and draught with devastation effect on human life. "Water is life" as defined in Veda; the oldest holy book of ancient India. Its importance and proper use were understood, researched and implemented in urban and rural areas in a most efficiently developed townships and agricultural fields in India more than 5000 years ago. India now have 18% of world population, 4% of renewable water resources and only 2.4% of land area of the world. Also, water availability in India widely varies with region and time, making the water management a most challenging issue. Major need of water in India is for irrigation, Industries, thermal power, drinking and domestic purpose besides renewable use in Hydroelectric Power Plants including secondary benefits for navigation and recreation facilities. This paper will focus on most challenging issues on water management in surface and ground water where its aggravation on scarcity and flood devastation will impact on human life, identify their short term and long-term solution based on research and planning by various organisation and individuals.

1. HISTORY OF WATER MANAGEMENT IN INDIA

Water is essential for survival of human race. The United Nation defines water security as "The capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability." It encompasses security for adequate supply and quality of drinking water and of all household requirements of water, security to health, security of food grain production, security from spread of water borne diseases, security from natural disasters like floods and contribution towards energy security and quality of life with water as a resource of power. The discovery of ancient farming village Mehergarh in Baluchistan, now in Pakistan, is an example of scientific farming with irrigation and food storage technology in ancient India in 7000 BCE. The discovery of Harappa Mahenjodaro and other urban ruins and rural development in Indian subcontinent, the example of finest form of ancient civilization in 3300 to 2000 BCE is a glowing example of most scientific water use and conservation by planned water supply, sanitation, drainage, storm water management, water treatment system, irrigation, transportation for internal and international trade.

The gradual decline of Indus Valley civilization and its extinction between 2000 BCE and 1500 BCE is a most mysterious part of Indian History. The location where the Indus valley civilisation once flourished is a desert today. Perhaps they could not work out right water security system with forward planning in the climate change cycle. However, during Vedic period 2000 to 1000 BCE, highly developed civilizations continued to exist in other parts of India. Water usage in scientific ways also evolved. The Veda mentions only well-style irrigation, where kupa and avata (wells). This water was, diverted into channels to fields for irrigation. Later during Puranic period, in the 4th-century BCE Indian scholar Pāṇini, mentions tapping several rivers for irrigation. Buddhist texts from the 3rd century BCE also mention irrigation of crops. Texts from the Maurya Empire era (3rd century BCE) mention that the state raised revenue from charging farmers for irrigation services from rivers. In Tamil Nadu, the Grand Anicut (canal) across the Kaveri River was implemented in the 3rd century CE, and the basic design is still used today. The industrial, scientific and economic revolution in the recent past, particularly after India got its Independence in 1947, the standard of human life has risen to a phenomenal level i in India. From repeated famine during pre-independence period to food surplus situation in three decades of post-independence era with adding about 4000 Dams and reservoirs, now totalling over 5000 numbers from sixties to nineties with flood control, irrigation, water supply and hydropower benefits, agricultural revolution with research work and modern farming technology had created food and water security. Mining and Industrial revolution with steel, metals, coal and consumer's durables, machine and tools, increase of health services with increase in average life span are only a few examples which have put India to one of the fastest growing developing country. But with the population growth, India could not keep the pace to evolve adequate technique and systems for water management to get water security

in ascending order. Again, history is trying to repeat itself with water shortage and threat to water security, challenging our existence. In today's context, it requires planning, efficient management, storage, conservation and distribution of water of suitable quality and quantity even in worst scenario with the aid of modern technology. Water security encompasses food, health, energy and all aspects of life for sustainable development. Present initiative on clean India, water, education, health, clean electricity for all is a right approach to sustainable development.

2. EMERGING CHALLENGES

Today with 1.3 billion population is facing multi-fold challenges. India's all-round development, the average life span of population is increased rapidly and substantially. The basic infrastructure for sustained development are Road and Railway communication, housing and land development, water supply, agriculture and irrigation, Health and education, Electricity and fuel, protection from flood and drought. For a developing country like India, none of these factors can be termed as secondary or less priority. The urban development in India has a phenomenon growth with all the modern facilities in last three decades. However, the rural development, after irrigation and agriculture revolution, has seen a sharp rate of decline in all fronts when compared to urban development. As a result, there is mass migration of population from rural to urban in search of a better life. This trend has completely put an off balance on scientific development. Threat to health as a result of water pollution of water resources and our failure to provide right quality of drinking water to urban and rural population is a matter of urgent concern. Adding to it, the climate change factor has created another dimension of challenge, threatening the aggravation of drought and flood, shortage of water and food. Thus, future of India mostly depends on Water Security which in turn assures Life Security. The water security is like a life insurance. Whatever water we save from our use, it will protect us from future known and unknown risk and hazards. However, to achieve water security it is not like a simple financial solution. It needs elaborate planning and ground work for implementation. Some of the measures are enumerated as below:

2.1 Water Storage

(i) Multipurpose Storage Dams and Reservoirs with distribution system

(ii) Ground Water control and recharge from reservoirs and canals

2.2 Flood Protection

(i) Flood control Dams and Reservoir, embankment protection

(ii) Catchment Area Development and anti-erosion measures

2.3 Water Conservation and reuse

(i) Sprinklers & drip irrigation, rain water harvesting,

(ii) Domestic and Commercial use; Raw and Waste water treatment plant

(iii) Raw and waste water treatment plant

(iv) Water pollution treatment and revival of Rivers and Water Bodies

3. PRESENT STATUS AND TREND OF WATER STORAGE

Table 1

Geographical Area	329 M ha
Flood Prone Area	40 M ha
Ultimate Irrigation Potential	140 M ha
Total Cultivable Land Area	184 M ha
Net Irrigated Area	50 M ha
Natural runoff (Surface & Ground)	1869 cubic km
Estimated Utilisable Surface Water Potential	690 cubic km *
Ground Water Resource	361 cubic km
Net Utilisable Ground Water Resource for Irrigation	325 cubic km

* Assessment is based on Projects where Preliminary Feasibility Report is prepared and feasibility is established. Further feasibility studies in other project locations are continuing.

Water storage in India today is highly inadequate considering emerging challenge on climate change when drought and flood will aggravate and for both we need storage for flood protection and Irrigation and water supply. Once a reservoir built for storage to combat the flood and drought the hydropower generation is a by-product of the same facility. Excess and controlled water release from reservoir during flood and drought will pass through the turbine to generate electricity. The Water Resources of India, assessed by National Institute of Hydrology is enumerated below:

In India, per capita water in cubic meter as on 2015 is as follows:

Table 2

Total effective Storage	175 cubic km
Population	1282 M
Per capita effective storage	136 cum
Minimum sustainable water storage per capita	300 cum **
Projected Population by 2030 in India	1528 M
To ensure per capita 300 Cum, the storage utilisation needed	458 cubic km< 690

** The present effective storage capacity of India is 175 Cubic Km is highly inadequate and minimum storage per capita of 300 cum is a rough estimate as indicated by various publications and papers.

The net irrigated area is only 50 million Ha as against total irrigable potential of 140 Million Ha. Which indicates that only 36% of agricultural land is covered by Irrigation and rest 64% depends on monsoon. In view of Climate Change there is an urgent need for increasing the storage capacity to at least 458 Cubic Km from present level of 175 Cubic Km in accelerated mode. The present status of surface water storage in India shows a negative trend for storage per capita. Figure.1 shows five yearly per capita effective storage. Till 1985-1990 the per capita storage is in ascending order and peaked at 172 cum per capita thereafter the curve declined steadily and in 2015 it stands at 136 cum per capita. Figure. 2 shows five yearly numbers of storage dams constructed in India. It peaked in 1975-80 to 1980-85 with 729 and 717 respectively thereafter the trend is declined. In 1985-90, the water resources projects commissioned on that five-year block stood as 503 nos. In 2010-15 five-year block only 19 nos. projects were commissioned. Due to stringent and often unfair restriction on environmental issues and agitation by local population with misguided information the projects are being stalled. A glaring example is in Arunachal Pradesh, where more than 35 major water resources are stalled even after Detailed Project Reports are prepared and allotted to private developers and PSU. It must be understood that there no alternative than that of water resources projects for survival of a nation. India has enough water potential and the 90% of water resources projects are environment friendly with multiple benefit such as Irrigation, water supply, flood control and hydropower. India can ill afford to starve the agricultural fields, remain in lowest range of per capita power consumption and per capita water storage, knowing fully well the impending danger of climate change.

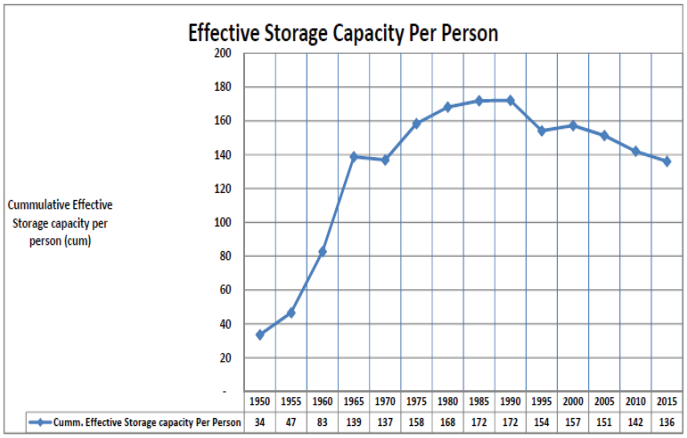


Figure 1 : Five yearly per capita storage of water in India

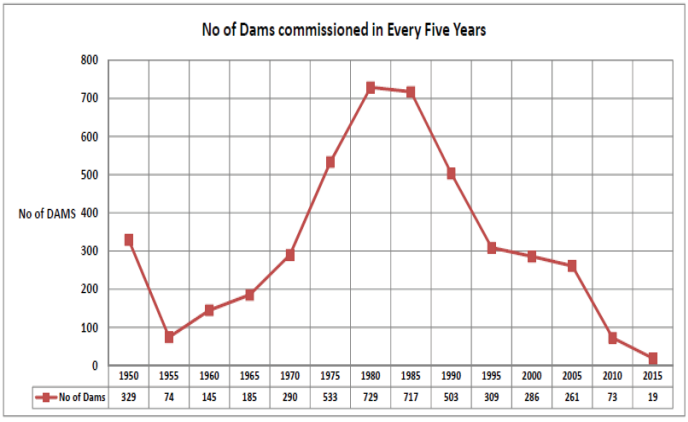


Figure 2 : Five yearly development of Dams and Reservoirs in India

4. BENEFITS OF WATER RESOURCES PROJECTS

4.1 A water resources projects have multiple direct benefits

(i) Irrigation

(ii) Flood Control

(iii) Power

(iv) Navigation, if the reservoir is long

4.2 Other Benefits

(i) Tourism and recreation

(ii) Infrastructure development outside project for construction benefitted to local population

(iii) Infrastructure inside project developed for construction utilised for other institution

(iv) Medical facility of project rendered to local population

(v) Employment generation and on job training to local population, training during construction

(vi) Business generation for local population with increased potential of small, medium and large Industrial development

(vii) Increase of standard of living to local population by statutory social benefit rendered from project like education, water supply, sanitation, health service etc.

(viii) Fishery development

5. FLOOD DAMAGE MITIGATION

As per National Disaster Management Authority the annual average loss, based on 1996 to 2005 data is Rs. 4745 Cr. and annual average human lives loss is 1600. Such losses are too high to be ignored. With climate change knocking at the door, the losses of property and lives will aggravate alarmingly. A short term and long-time strategy is the need of the day.

An extract of report on study of Brahmaputra basin by N.N. Bhattacharyya and A.K.Bora, which analysed the recurring devastating flood in Assam and Bangladesh is reproduced below:

Floods in the Brahmaputra basin of India are characterized by their extremely large magnitude, high frequency, and extensive devastation. The mean annual flood discharge of the river at Pandu is 47,608 m^3/s with a recurrence interval of 2.56 years.

Consequently, there have been regular flood onslaughts, adversely affecting the agrarian economy of the Brahmaputra valley.

The 2004 floods, over 25% of the population of Bangladesh or 36 million people, was affected by the floods; 800 lives were lost; 952,000 houses were destroyed and 1.4 million were badly damaged; 24,000 educational institutions were affected including the destruction of 1200 primary schools, 2 million governments and private tube wells were affected, over 3 million latrines were damaged or washed away, this increases the risks of waterborne diseases including diarrhoea and cholera. Also, 1.1 M ha of rice crop was submerged and lost before it could be harvested, with 7% of the yearly aus (early season) rice crop lost; 270,000 ha of grazing land was affected, 5600 livestock perished together with 25,400 poultry and 63 MT of lost fish production. Bangladesh topography does not have and feasibility of major water storage reservoir for flood control.

There are only a few minor diversion dams constructed in Northeast region of India purely for Hydro Power Generation without any significant storage in a few minor tributaries which have no flood control or flood modulation capacity.

For the sake of information, we can compare the history of development on Yellow River in China which was known as "China's Sorrow". In 1931 flood 1 million lives were lost during devastating flood. However, the magnitude of flood and discharge are much smaller than that of Brahmaputra. To mitigate such loses, since 1960 to 2016 as many as 16 Dams were constructed which controlled the flood, provided more irrigable land and generated Hydro Electric Power. As on 1999 Yellow River served 140 million people and Irrigated 74,000 Sq Km. of Agricultural land.

Table 3 : A general comparison of Yellow River and Brahmaputra is listed below

	YELLOW RIVER	BRAHMAPUTRA
Total watershed area	752,546 Sq. Km	712,035 Sq. km
Average discharge	2,110 Cumecs	19,800 cum
Flood discharge	25,000 Cumecs	100,000 cum
Storage Dams	16 nos	Nil
Surface Irrigation	74,000 Sq.Km	Nil

6. HYDRO POWER AND RIVER LINKING PROJECT BENEFITS

(i) Renewable, Cheap Power, minimum O&M cost

(ii) Minimum pollution and emission, environment friendly.

(iii) Fluctuation, Peak power management and Grid Stabilization unique capability

(iv) Long life of 40 to 60 years and life can be further extended economically by renovation and up gradation.

(v) Huge potential untapped. Universally preferred source of generation

(vi) One Scheme has three major multiple benefits, Irrigation, flood control & power

(vii) Only long-term benefits due to long gestation period. Small Hydro has short gestation period and can serve short term benefit.

In India, commercial generation of Hydro Power started in 1897 at Sidrapong Hydro Electric power station at Darjeeling, West Bengal, developed and operated by Darjeeling Municipality to supply power to Governor House and Govt. establishment.

After Independence, major Multipurpose Projects were planned and implemented like Bhakra and DVC for Irrigation, Flood Control and Electricity generation. In fact Electricity was a secondary product to first two major benefits. Many more projects came up in five year plans and till 1980 Hydro Power contributed 40.6% to total installed capacity of 26,680 MW. Balance was Thermal Projects. This was a very healthy mix in India with 60% to 40% load factor. Therefore, base load was shared by Thermal Power with 80% assured plant load factor sharing only 20% of low fluctuating load. While Hydropower shared 40% of fast fluctuating and peak load which thermal power cannot absorb.

However, this healthy trend was seriously disrupted due to focus of short term rapid demand of power and growth of coal based Thermal generation offsetting the healthy power mix.

Table 4 : Installed capacity by source in India

Source	Installed capacity
Coal	203,954.50 MW (56.1%)
Large Hydro	45,399.22 MW (12.5%)
Small Hydro	4,610.81 MW (1.3%)
Wind Power	36,930.32 MW (10.2%)
Solar Power	31,101.71 MW (8.6%)
Biomass	9,271.30 MW (2.6%)
Nuclear	6,780.00 MW (1.9%)
Gas	24,937.22 MW (6.9%)
Diesel	509.71 MW (0.1%)
Total	363,484.79 MW

Table 5 : Energy generation in as on 30.11.19

Source	% of generation
Fossil Fuel	79.8%
Renewable	17.3%
Nuclear	2.9%

The grid failure in the world affecting largest area and population in July 2012 happened in India when half of India remained blacked out for 3 days and nights is still fresh in the memory. Besides stabilizing the grid against grid failure, it is only Hydro Power which can black start instantly and supply adequate power to thermal units for start-up. This is another reason as why blackout period continued for three days.

After cloudburst and devastating flood in Uttarakhand in June 2013, a PIL was filed in Supreme Court and by August 2013, 24 Hydro Project under Construction was stalled by the order of Supreme Court. A news item of International Commission of Large Dams (ICOLD) during same period published a report that Tehri Dam saved the Holy Cities of Hardwar and Rishikesh. The incoming peak flood of 7000 cum was stored in Tehri reservoir and a regulated flow of only 500 cum was discharged through the spillway, thus saving thickly populated areas of downstream. This report was given least priority in the media.

Another reason of diminishing storage capacity and fewer development of Multipurpose Projects is that in seventies onwards several PSU were formed like NHPC, SJVN, NEEPCO etc. to exclusively develop Hydro Power on the basis of power demand and their commercial viability. These Organizations neither have any direction nor authority to develop Multi-Purpose Projects. As a result, potential benefits of entire downstream population were denied. The stalling of

Subansiri Lower Hydro Electric Project (2000MW) for 8 years by agitators on environment issue is a glaring example. A Report of Ministry of Development of North Eastern Region, as on January 2010, total Capacity of 48,167 MW for 86 projects, allotted to organizations of Centre, State and Private sectors have not yet seen the light of the day for too many wrangling processes in local issues. Status remain same as on 2020

For last 46 year we have not moved much on the Interlinking of river (ILR), a scheme drawn out and proposed by the eminent Engineer and Minister of Irrigation & Power Dr, K.L. Rao in 1972. The Figure. 3 shows the schematic plan of interlinking of Rivers (ILR) in India. The Project had following direct benefits as updated in 2003-04 by National Council of Applied Economic Research:

Table 6

Irrigation 30 million Ha @ Rs. 17,482/ha	=Rs. 52,444 Cr/ year
Power (net) 24,800 MW @ Rs. 1.67/KWH	=Rs.9072 Cr/year
Water Supply 12bcm @2paise /litre	=Rs. 24,000 Cr/year
Flood damage saving Rs. 27,000Cr/10 years	=Rs. 2700 Cr/year
Total Benefits per annum	=Rs. 88,216 Cr (20 % of Capital Cost)

Present net irrigated land is 50 million Ha adding 30 million Ha will boost by 60%. Hydro Power present installed capacity is 44765 MW, addition of 24,800 MW will enhance by 55.40%. Flood damage annual cost presently is Rs.4745 Cr. By saving of Rs.2400 Cr. per year will save the damage by 50.60%. There is no restriction of taking up these projects except a long-term planning and development. This scheme will store water during flood season only accruing benefit on flood control of both the countries. Bangladesh and India can share benefit of Flood Control, Hydro Power and Irrigation 14 Nos. River linking in Himalayan region and 15 nos. in peninsular region is proposed. Multipurpose benefits from flood control, irrigation, water supply and hydropower benefits were planned.

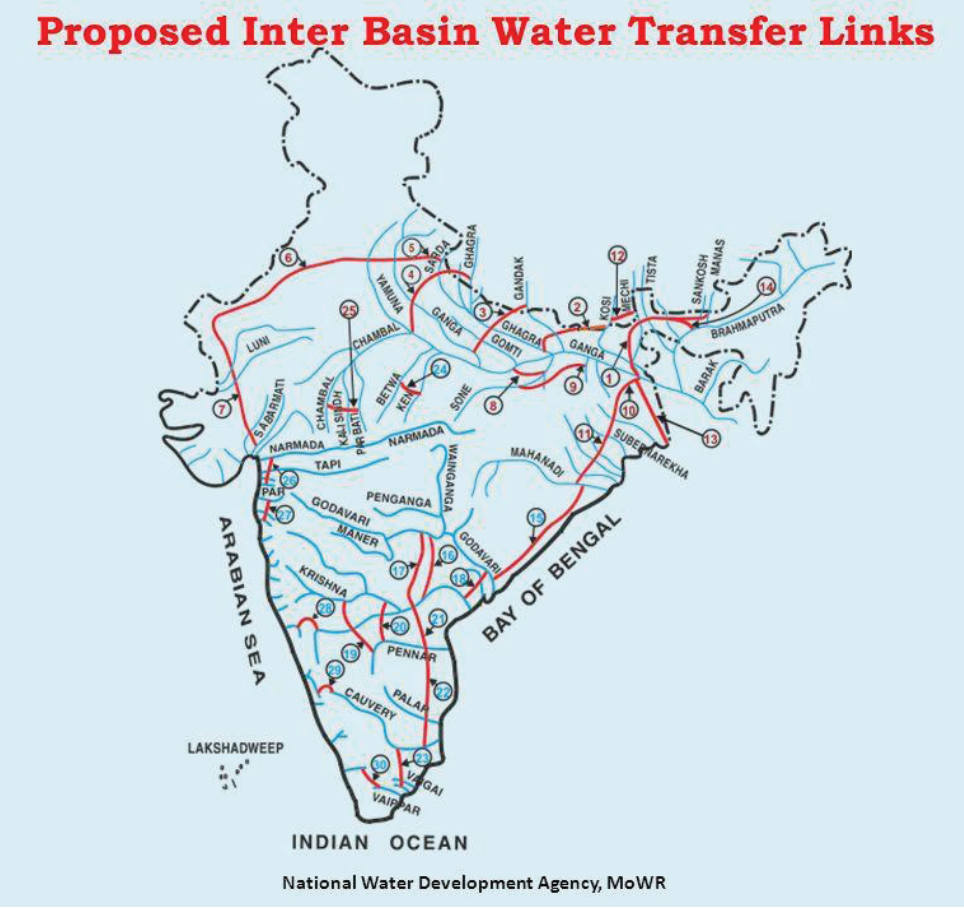


Figure 3 : Interlinking of Rivers (ILR) in India

7. GROUND WATER VIS-À-VIS SURFACE WATER MANAGEMENT

The Ground water utilization and management is one of the most important and yet neglected part in overall water management. Overuse and underuse in different areas needs to be evaluated and action plan to be chalked out to have a sustainable a long-term strategy for this rich resource.

Table 6 : The Surface and Ground water availability in India are assessed as below:

Annual Water availability	1869 Billion cum
Useable water assessed as on 2015	1123 Billion cum
Surface Water	690 Billion cum
Ground Water	433 Billion cum
Natural discharge of Ground water	32 Billion cum

The Ground water is also a renewable asset but its judicious extraction and use is an imperative necessity. In India 68% of Ground Water is recharged by Annual precipitation and 32% is recharged from Canal seepage, Irrigation field, Tanks, Ponds and Reservoirs. If monsoon fails, recharge from all source are also equally impacted.

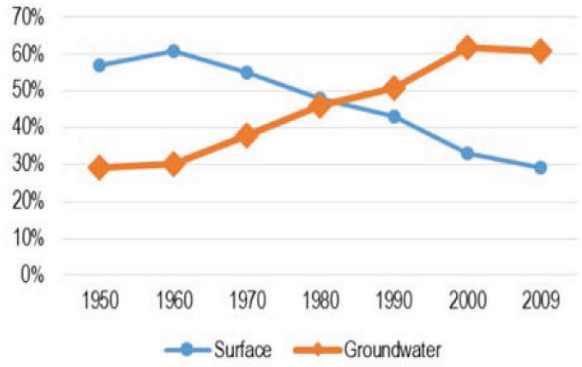
Table 7 : As per estimate, assuming 68% to 50% is threshold limit of Ground water use which is expected to be recharged naturally from rain, actual extraction of State wise Ground Water is given in % use of availability as assessed in 2011 will show wide and alarming variations as below:

Danger level of extraction >70%		**Threshold level >50%<70%**		**Safe level <50%**	
Punjab	172	Gujarat	67	Kerala	47
Delhi	137	MP	57	Bihar	44
Rajasthan	137	Uttarakhand	57	West Bengal	40
Haryana	133	Telangana	55	Andhra	37
Puducherry	90	Maharashtra	53	Chhattisgarh	35
Tamil Nadu	77			Jharkhand	32
UP	74			Odisha	28
HP	71			Sikkim	25
				Others	<10

Over extraction of Ground Water will lower ground water table, contaminate ground water with chemical used as pesticides and fertilizers. The demand of surface water irrigation will increase. In successive years the situation will be aggravated in dangerous level on water quality and quantity from well in rural population and on agricultural products.

89% of Ground Water extracted are used in Irrigation, 9% are for domestic consumption and 2% for industrial use. 50% of urban and 85% of rural domestic use are from Ground water.

61.6% of Irrigation water in India are used from Ground water and 24.5% are from canals and rest 3.9% from other sources, such as local ponds, direct streams etc. While earlier to 1980 the dependence on canal water was higher, the situation is reversed after green revolution, subsidised or free tariff of electricity for tube wells, subsides tariff for purchase of Tube wells by farmer, high demand of use of water with drastic reduction on development of reservoirs by construction of Dams and Barrages. Following figures will show the reversal and trend of uses of Surface and Ground water and Canal water use vis a vis Ground Water in India for irrigation.



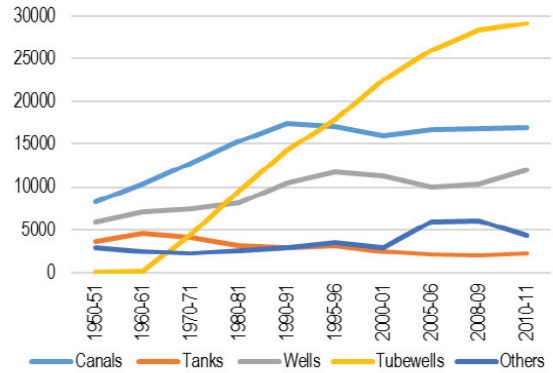


Figure 4 in left shows increase in ground water utilization for irrigation

Figure 5 in right shows tube well increasingly being the main source of irrigation

In addition, the yield of Agricultural products in MT per cum of water used for irrigation, particularly on Rice, Wheat and Cotton are very low as compared China and USA as shown in following table.

Table 7 : Cubic meter of water use in irrigation for per MT of agricultural production

	BRAZIL	INDIA	USA	CHINA
RICE	3,082	2,800	1,321	1,275
SUGARCANE	115	159	117	103
WHEAT	1,616	1,654	690	849
COTTON	2,777	8,264	1,419	2,535

With above data and figures it revels immediate attention to-

(i) Scientific assessment of soil, need of fertilizers, efficient irrigation to minimize water loss, use of more drip irrigation.

(ii) Increase of surface water use and reduction of indiscriminate ground ware use.

(iii) Climate change threat factors with periodical aggravation of flood and draught must be realistically assessed and incorporated in overall water resources planning

8. WATER POLLUTION, REVIVAL OF RIVERS & WATER BODIES AND WATER FOR ALL

The water pollution in urban area is growing steadily due to lack of Industrial waste and sewage water treatment and management. In rural areas the unchecked ground water extraction and untreated surface water is aggravating unchecked.

Present initiative of giving more emphasis of water pollution control projects to be accelerated.

9. CONCLUSION & RECOMMENDATION

Water and its judicious use by human is directly linked with food production from Irrigation and agriculture, hydropower production, flood control, navigation, tourism etc. With emerging challenge of climate change and population growth, there is no alternative in India than to develop all feasible storage reservoirs to harness entire water flowing from Himalayas and running down to sea unused. Many developed countries have already harnessed all feasible water resources and are in the process of water conservation by increasing efficiency of water use. Countries. India have already started and have to continue in a war footing on following.

(i) Development of multipurpose project mega projects including implementation of ILR to be declared National project and planned for accelerated development.

(ii) Improve Agriculture system scientifically, reduce wastage of water with high yield

(iii) Develop water treatment plants in urban and rural area to reuse and reduce pollution

(iv) Surface and ground water be declared national wealth with Central Subject

(v) Present trend of quality of life improvement to be accelerated.