RIVER ACTION PLAN, FLOOD MANAGEMENT & BASIN DEVELOPMENT

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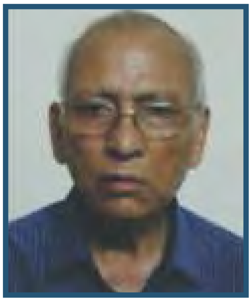

S.K.Mazumder
Former AICTE Emeritus Fellow and
Professor of Civil Engineering
Delhi Technology University (DCE)
somendrak64@gmail.com
www.profskmazumder.com

M.S.Dhillon
Chief Engineer, Flood Mgmt.
Central water Commission
cefmgmt@nic.in

Anuj Kanwal
Director, Reservoir Sedimentation
Central water Commission
kanwal.anuj@nic.in

1.0 Introduction

Water is one of the five great elements among air, water, fire, earth, and ether that make our universe (Rig Veda)

In 1947 when India woke to freedom, the country was facing stark realties of recurring famines and floods. Based on limited experience and inadequate technological strength, the country embarked on its journey into water world for the future. India has roughly four percent of the world's fresh water resources to feed its 17% world population. India receives an average precipitation of about 1170 mm which corresponds to an amount of annual volume of 4000 BCM(NCIWRD-1999). There is considerable variation in precipitation both in time and space. Nearly 75% of precipitation i.e. 3000 BCM occurs during the monsoon season confined to 2 to 3 months in a year.

River action Plan deals with the pollution of water which is imposing high cost on health, water and waste water treatment. River water is getting highly polluted due to disposal of untreated waste water from overpopulated cities, industries and encroachment of flood plains by poor people. In rural areas, there is overexploitation of ground water leading to severe health problems and rise in pumping cost. Water savings, treatment and reuse techniques continue to be on priority lists in urban cities and process industries (Kumar and Mazumder,2016).

Floods are natural phenomena. In a tropical country like India, floods are mainly due to excessive rainfall in a short period during monsoon. Out of a geographical area of 329 mha , flood prone area in India is about 40mha as estimated by Rastriya Bar Ayog (RBA,1987). Although, floods occur allover India, it is predominant in the north, east and north-east part of our country. Flood damage occurs in both rural and urban areas. While rural flooding is mainly due to spillingof river banks and breaching of flood embankments (Mazumder,2011), urban flooding occurs mainly due to inadequate drainage capacity and lack of maintenance of drains. Average annual cost of flood damages in India is about Rs.4,000 crores. India's first National Water Policy adopted in 1987 and backed by 40 years of experience, helped usin building and operation of multipurpose storage and diversion projects. They helped bringingabout food self-sufficiency andcounter the extremes of droughts and floods.

The concept of river basin development in India was first introduced by an eminent scientist-Meghnand Saha in 1938- who put forth his views that river basins, because of their intrinsic ecological integrity, were ideally suited as territorial units for undertaking comprehensive programs of socio-economic development. He made a strong plea for a systematic study of all the river basins of the country so that a scientific foundation could be laid for future integrated programs. Damodar Valley Corporation (DVC) - the first major multipurpose river basin development authority in India -was constituted in the late 1940's in the pattern of Tennesy Valley Authority (TVA) in USA in 1920's .

2.0 Water Demand for Food Production

Civilizations decay when structural interventions of policy, pricing or inputs and outputs and the unchecked misuse, is not sustainable. Using 2011 census figures, the population of India in 2025 is being projected as 1394 million when average per capita availability of water will fall to just 1,342 m3 in an average year which is quite low compared to some other countries in the world.

Table-1 Per Capita Water Availability (in m3) in Different Countries in the World as on 2011

USSR	USA	China	Australia	India
19,500	9,900	5,000	2,420	1,545

Estimated demand of water for different sectors in India from 2010 to 2050 is given in Table-2 (INAE,2008).Because of the timely irrigation development, India today is self sufficient in food, producing 250 million tons of food grains for our 1250 million people. Fig.1 (Mazumder,2002) shows the projected growth in population, food grain production and irrigated area up to 2050. Out of a total of 113 Million hectare (Mha)area underirrigation in India today, 58 Mha is by major and medium surface irrigation schemes , 15 Mha area is by surface minor irrigation schemes and 40 Mha is by minor ground water schemes (IWRS-2007). Irrigation consumption is the highest at 78% (in 2010). Fig.2 illustrates yield of cereals in India vis-a-vis other neighboring countries. To feed the growing population with the available water,productivity of irrigated land per unit area and unit water has to be improved since the irrigated area remains the same after 2001 (Fig.1).

Table-2:Water Demand for Different Uses

S.No.	Total Water Requirement for Different Uses (in BCM)			
	Uses	Year 2010	Year 2025	Year 2050
		High Demand scenario	High Demand scenario	High Demand scenario
1.	Irrigation	557	611	807
2.	Municipal	43	62	111
3.	Industries	37	67	81
4.	Power (Energy)	19	33	70
5.	Others	54	70	111
	Total	**710**	**843**	**1180**

3.0 Water Crisis Situation in India

Average annual water availability of India is 1869 billion cubic meters (BCM) from different river basins in the country [CWC (1993); Iyer,(1989)]. The utilizable water with conventional approach is 1121 BCM which comprises of 690 BCM of surface water and 431 BCM of replenishable ground water. The remaining water i.e. 748 BCM is lost to the atmosphere through evapo-transpiration from rain fed agriculture, barren lands, forests, natural vegetation, storage ponds, lakes and flood flow in to the sea.

At present, India has a meager storage capacity of 300 BCM , mostly in surface reservoirs. It is inadequate to fight drought like situations arising occasionally in different parts of the country. Loss of live storage due to silting of reservoir is estimated as 53 BCM by 2050 (CWC,1991). NASA has identified more than 30 hotspots in India where freshwater is in particular danger (IAHR- 2018).The situation is going toaggravate further due to uncontrolled pollution of both surface and ground water. Without strong action by government to preserve water, the situation is likely to worsen further

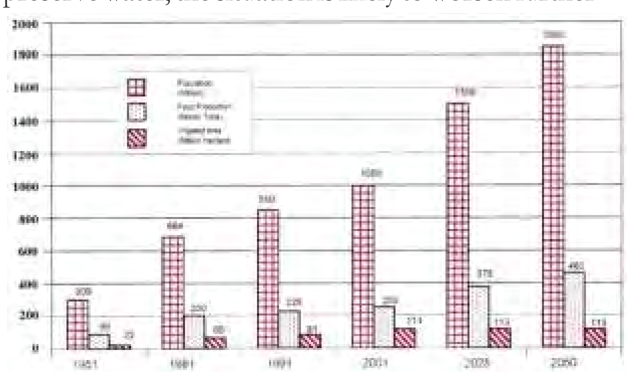

Fig.1 Growth of Population, Food Production and Irrigated Area in India (1951-2050)

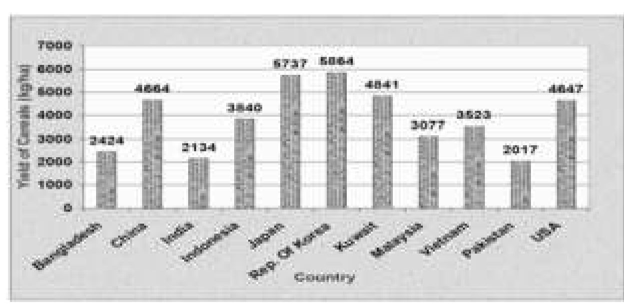

Fig.2Yield of Cereals in India and other Neighboring Countries

4.0 Need for Efficient Water Management

We must manage the available water resources in a judicious and efficient manner (CWC,2010). Currently, there is a lot of loss of water in irrigation and other sectors primarily due to heavily subsidized water supply policy and poor on-farm development (Ministry of Agriculture, 1979).The overall efficiency of irrigation projects (also called project efficiency) in Indiais too low at an average of 35% in the case of major and medium surface irrigation projects as compared to 55% in China and 70% in Japan(INCID, 1998). The average project efficiency in three major river-valley projects, determined by the first author, was found to vary from 18.6% to 38.8% (Mazumder, 1984). Most of the irrigation water was found to be lost in conveyance and field application and extremely poor management of water at the farm level [Mazumder (1986); Bharat Singh (1991)]. Zimermann (1966) examined several drawbacks of protective type extensive irrigation practice being followed in India where available water is spread over vast areas through a widely spaced unlined canal networks. Most of the water in such a system is lost in conveyance and most of the remaining water is lost because of inefficient irrigation management [IWRS(2007)]. Different steps for improving overall efficiency of irrigation have been suggested by Mazumder (2007).

5. River Action Plan

River health changed with the advent of intensive development taken up by the society. The surface waters suffered for de facto policies of exploitation, neglect and abuse - the primary drivers behind the significant environmental ruin.The extent of the damage can only be 'rehabilitated' rather than fully 'restored' to their original condition. Hence River Action Plans were initiated to patch up the damages to reflect the fact that significant ecological restoration of natural eco-systems is beyond the scope of currently proposed policies. The legal, institutional and political frameworks that have emerged over the past 20 years for rehabilitation include specific projects and initiatives which signal a shift in public policy and the start of a rejuvenation process in streams. This has been primarily for the fact that there has been very little water available to maintain in-stream flow at desired levels.

Recent advancesin River Action Plan have given a few lessons which primarily include:

a. Creating infrastructureto create a nationalgrid
b. Improvedregulation andupgradedsewagetreatment for the return flow
c. Creating Institutions and Legal Framework to sustain the change

5.1 Development, Degradation of Rivers and River Restoration

The waters of majority of Indian rivers is perennial with meaningful year-round flow. Before the modern period, the serivers and stream scontained healthy aquatic ecosystems that we rehabitats for fish, turtles, even crocodiles. They also provide dinnumerable' ecosystem services' including watering holes for terrestrial wildlife and grazing, asource of primitive irrigation, power for the occasional mill and of course my riadcultural services for local communities. Indeed, the contribution of these water bodies to the recreational and spiritual heritage of India is well known and reflected in their ritualistic roles.

Types of flora and fauna (https://www.nature.scot/habitats-and-ecosystems) in a riverine system depend on the:

- physical dimensions of the basins
- chemistry of the water and sediments of the rivers
- soils and geology of the catchment area

Conditions may range from soft, relatively acidic waters with low levels of nutrients to hard, more alkaline waters with higher nutrient concentrations. More fertile catchments and shallow basins tend to support more bio-diversity.

Unexploitedwater was considered awasted resource and asign of in efficiency and poor performance. The imperative of water resource development and increasing water supply was manifestedin Nehru's vision of independent India with large dams as temples of Modern India. Our geometric growth of population, industries and agricultural activity for expanding the yields continued for 30 years under the dam temple era. And this came to full circle after popular movements were started protesting the large dams as master piece of destruction of the environment and violations of human rights. In July 1983, the veteran social worker Muralidhar 'Baba' Amte wrote to the Prime Minister, Indira Gandhi, urging her to intervene in stopping two dams in central India that would submerge 2,00,000 acres of dense forest and displace 40,000 adivasis; although they would be paid monetary compensation, 'nothing can compensate for the wrench they would suffer in leaving their traditional cultural environment…'. The need for River Action Plans were never felt before these movements and the River Action Plan for River Ganga was first initiated by the late Prime Minister Rajiv Gandhi in 1986 to save Ganga from pollution. In practice, poor understanding of the hydrological assets by our early water and land managers and paramount economic priority on agriculture and later on Industrial production has now led to a situation to redefine the use of the riverine waters.

5.2 Environmental Impacts

Much of the bio-logical systems in many rivers in India during urban reaches have been transformed into conduits for municipal sewage or garbage dumps. Environmental conditions in low-flowing river streams tend to be particularly poor. This is compounded by the little fresh water that was available to be tapped for purposes of irrigation and urban supply. Moreover, even after domestic sewage treatment, the effluents discharged into these streams do not get diluted by a lean flow. The high concentrations of biological oxygen demand (BOD), nutrients and bacteria frequently have a more direct and severe impact on the ecosystem than in naturally perennial streams. In Gnaga Basin,for example, the population grew at exponential range as shown in Table-3.A look at the BOD in Ganga River as per Fig.3 indicate the position from 2002-2008.A range of pollutants, including non-point agricultural runoff, urban stormwater and discharge from industrial sites, treated and occasionally untreated municipal wastes, determine the river water quality. In fact, the few spotted pollution suggests that nonpoint sources from agriculture and urban runoff are the single greatest source of nutrients and other pollutants to the streams.

The major shift in river ecology is due to pollution affected vegetation cover, bank and bed stability, sediment transport and storage. The associated hazards of mosquitoes, odours and of course groundwater contamination can be substantial. The natural vegetation and fauna are often replaced by invasive species that are better adapted to contaminated, wet environments. Opportunistic flora in some areas so thrived on organic loadings, that natural flow become clogged. Perhaps of greater concern, many rivers are repositories for industrial wastes, heavy organic discharges from fish ponds with chemical residues, including heavy metals and organic chemical compounds leaving a toxic sludge at the river base.

Of course, the contamination of rivers does not stop on the surface water onlybut also led to deterioration in aquifer water quality. For instance, the Arsenic contamination in groundwater in the Ganga-Brahmaputra fluvial plains in India and Padma-Meghna fluvial plains in Bangladesh and its consequences to the human health have been reported as one of the world's biggest natural groundwater calamities to the mankind (Ghosh, et al).

With virtually no price of the Irrigation water – the quantum use of water was abused leading to the most important problem regarding river water quality andquantity or 'minimum natural flow' in the river. The minimum flow is considered by many aquatic ecologists to be based on one master variable habitat, its temperature, its ability to process nutrients, stream geomorphology and numerous other aspects of ecological functioning.

For past 60 years, the public sentiments was largely indifferent to the massive degradation of the nation's streams. One event, however, seized national attention and influenced public perceptions about the severity of the river water quality crisis was the declaration of the river as a 'living being'. Voices were echoed when one state Government in Indian state of Madhya Pardesh in May 2017 moved the proposal to give 'living being' entity status to river Narmada to control pollution, illegal mining on the river banks and to save the river from getting depleted.The Government statement read as : "Giving living entity would not only conserve the river but also save the environment. We can lodge acomplaint in the name of river Narmada against all illegalities.

Table-3 Growth of Urban Population in Different States in India in Ganga Basin

	States	No of Towns & Cities	Urban Population (1991)	Urban Population (2001)	Urban Population (2011)
1	Bihar (inc.Jharkhand)	130	6,715,096	8 ,681,800	19,691,077
2	Haryana	106	4,054,744	6,115,304	8,842,103
3	Himachal Pradesh	57	449,196	595,581	688,552
4	MadhyaPradesh (including Chhattisgarh)	394	12,152,967	15,967,145	26,006,642
5	Rajasthan	222	10,077,371	13,200,000	17,048,085
6	Uttar Pradesh	704	27,544,233	34,539,582	44,495,063
7	Uttarakhand	86		2,179,074	3,049,338
8	West Bengal	373	18,707,601	22,427,251	29,093,002
9	Delhi	1	8,471,625	12,905,780	16,368,899
	Total		**88,172,833**	**1,07,929,717**	**165,282,761**

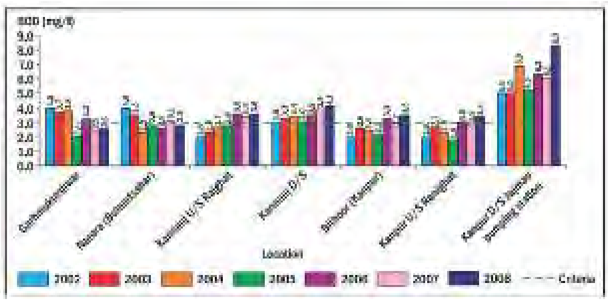

Fig.3Trend in Biochemical Oxygen Demand(BOD) in River Ganga in UP (upper Segment)

As Narmada is the biggest river in thestate, we have initiated the conservation programme from Amarkantak. After the success of this campaign we will also initiate conservation of Kshipra, Gambhir, Ken, Betwa and Kali Sindh rivers with public participation". The legal activism of the Uttrakhand High Court to declare Ganga as a living entity is under further legal scrutiny in Supreme Court in July, 2017

5.3 Towards Rehabilitation of Rivers

The combination of increasingly pernicious environmental conditions with social, economic and political influences with increased and concerned environmental awareness among the public converged to change the approach to the matter with:

- Challenges of National Level Committed Plan
- Challenges of coordinating multiple agencies
- Challenges to bring Drainage Authorities
- Challenges of Funds Arrangements
- Challenges to handle public interest advocates and NGOs.

The vacuum at the national level was filled by several impressive initiatives by regional agencies that 'thought globally and acted locally'. A critical first step in rehabilitation efforts involves creating a Masterplan that can serve as a blueprint for the myriad activities which need to be part of a restoration program. Implementation may take decades, yet slowly but surely the plan can become operational. With plans in various stages of development, the steady improvement in sewer creation and sewage treatment is bringing the river back to its original state.

Ultimately, streams cannot come back to life if they do not have a reliable flow of fresh water. Because water allocation in water-scarce regions is essentially a zero sum game, taking water for stream restoration has traditionally been perceived as taking water away from agriculture. Politically, the aquatic eco- systems cannot compete with farm requirements. However, allocation of natural flows of fresh water to nature – essentially an allocation for the restoration of the streams.

With improvements in the discharge standards, rehabilitation projects like the 'Namamage Gange' are being undertaken as baby steps. Dredging of the rivers and reduction in pollution inputs have not been sufficient to compensate for decades of accumulated stocks of pollution in the streambed sediments, and current conditions in the river bottom are still extremely toxic. In an attempt to actually rehabilitate the river, a master plan need to be developed, debated and approved for each river. The amount of effort and money that is now being dedicated to rehabilitating the nation's most toxic rivers may indicate a true turning point as to how river action plans are valued in the country.

While significant progress has been madeto improve water quality and develop rehabilitation plans for the nation's rivers, significant challenges remain. The centrally sponsored National River Conservation Plan (NRCP) started in April 1995; it covers 38 rivers in 178 towns spread over 20 States. Sewage treatment capacity of about 4,064 million litres per day (mld.) has been created and an expenditure of Rs.4,085 crore has been incurred so far under this Plan. River conservation activities such as creation of civic infrastructure for sewage management and disposal are also being implemented under other central schemes. Based on independent monitoring undertaken by reputed institutions on some of the major rivers under NRCP, the water quality in terms of BOD values has improved at most locations as compared to water quality before taking up of pollution abatement schemes. The Central Government , in February 2009, has set up the National Ganga River Basin Authority (NGRBA) as an empowered planning, financial, monitoring and coordinating authority to ensure effective abatement of pollution and conservation of the river Ganga by adopting a holistic approach with the river basin as the unit of planning. Interception and diversion of sewage and setting up of Sewage Treatment Plants have, therefore, been among the main components of pollution abatement schemes under the National River Conservation Plan (NRCP, 2011).

6.0 Flood Management

For an efficient basin development, flood management plays a crucial role in the overall development of India's economy. The main causes of floods are as under:

(i) High intensity rainfall in short duration

(ii) Poor or inadequate drainage/channel capacity

(iii) Unplanned reservoir regulation

(iv) Failure of flood management structures

The Rashtriya Barh Ayog (RBA,1987) had estimated that the, total area liable to floods in the country as 40 Mha. Subsequently, the extent of maximum area affected in a year by floods has been updated by XII Plan Working Group on Flood Management and Region Specific Issues as 49.815 Mha. The State-wise representation of Flood Prone Area is shown in Fig.4.As per database maintained by CWC, the highlights of flood damage during the period from 1953 to 2016 are given in Table-4

Table-4 Average and Maximum Flood Damages in India

SN	Item	Unit	Average Annual Damage	Maximum Damage	
				Extent	Year
1	2	3	4	5	6
1	Area affected	mha.	6.95	17.50	1978
2	Population affected	million	31.34	70.45	1978
3	Human lives lost	nos.	1626	11316	1977
4	Cattle lost	nos.	92992	618248	1979
5	Cropped area affected	mha.	3.72	12.30	2005
6	Damage to crops	Rs crore	1354.09	13816.76	2015
7	Houses damaged	nos.	13817	3507542	1978
8	Damage to houses	Rs crore	667.45	10809.795	2009
9	Damage to public utilities	Rs crore	2148.94	17509.353	2009
10	**Total Damage to crops, houses & public utilities**	**Rs crore**	**4282.16**	**33257.02**	**2009**

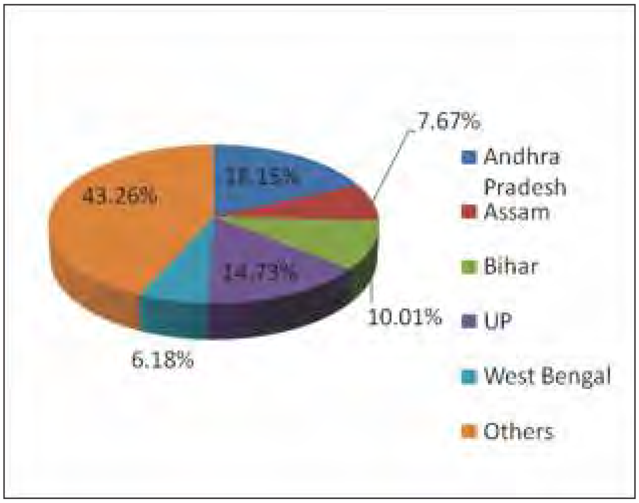

Fig.4 Showing Flood Prone Areas in India

6.1 Flood Management Measures:

As per the view expressed by the experts, floods are natural phenomena except the situations involving failure of flood control structures or faulty regulation of reservoirs; and permanent immunity against floods is not techno-economically feasible. However, impacts of floods can be mitigated to a certain degree by adopting appropriate structural and non-structural measures as listed below:

a. Structural Measures :

Some of the structural measures of flood control are:

(i) Reservoirs

(ii) Detention basins

(iii) Embankments

(iv) Channelization of rivers

(v) Channel improvement

(vi) Drainage improvement

(vii) Diversion of flood waters

(viii) Watershed Management

b. Non-Structural Measures :

Flood forecasting:

The work of flood forecasting and warning in India is entrusted with the Central Water Commission (CWC). Flood Forecasting and flood warning in India was commenced in a small way in the year 1958 with the establishment of a unit in the Central Water Commission (CWC), New Delhi, for flood forecasting for the river Yamuna at Delhi. Presently, there are 878 Hydrological and Hydro-meteorological sites being operated by CWC across the country covering 20 river basins for gauge, discharge, sediment & water quality observations.

Table-5 Structural Measures of Flood Control taken up upto XII plan in India

S.No.	Flood management measures	Extent
1.	Embankment	37072.659 km
2.	Drainage channel/channel improvement	39726.700 km
3.	Village raised/protected	7713 nos
4.	Town/Village protection works	2906 nos
5.	Raised Platforms	65os

The formulation of a forecast requires effective means of real time data communication network from the forecasting stations and the base stations. The activity of flood forecasting comprises of Level Forecasting and

Inflow Forecasting. The level forecasts help the user agencies in deciding mitigating measures like evacuation of people and shifting people and their movable property to safer locations. The Inflow Forecasting is used by various dam authorities in optimum operation of reservoirs for safe passage of flood downstream as well as to ensure adequate storage in the reservoirs for meeting demand during non-monsoon period. Presently, Flood forecasts are issued by CWC at 226 stations (166 Level Forecast Stations + 60 Inflow Forecast Stations). Annually, about 6000 flood forecasts are issued by CWC during floods with accuracy of more than 96%. During high, unprecedented and emergent situations, alerts are also issued through SMS to the concerned authorities on their mobile phones.

In order to meet the requirement of real-time data collection, automatic data transmission and flood forecast formulation, expeditious data / information dissemination, the Central Water Commission has undertaken modernization and expansion of its data collection and flood forecast network. So far, CWC has set up modern system of data collection, flood forecast formulation and its dissemination to concerned States/Agencies

Flood Plain Zoning

Flood-plain zoning is a concept central to flood plain management. This concept recognizes the basic fact that the flood plain of a river is essentially its domain and any intrusion into or developmental activity therein must recognize the river's 'right of way'. Flood-plain zoning measures aim at demarcating zones or areas likely to be affected by floods of different magnitudes or frequencies and probability levels, and specify the types of permissible developments in these zones, so that whenever floods actually occur, the damage can be minimized, if not avoided. Unfortunately, while all in principle generally endorse this approach, scant attention is given to it in actual practice, leading to increased flood damages.

Rain water Harvesting

Floods are due to high run-off from rainfall excess in the catchment area. Run-off can be substantially reduced through rain water harvesting by several means e.g. vegetation, plantations, recharging ground water, cultivated land preparation before monsoon, ponding etc. with in the respective catchment areas.

6.2 Long term Solutions for Flood Control

All most all committees, boards, task force, Commissions, Working Group of Planning Commission, National Water Policy, etc. have emphasized projects with dedicated flood storage as the long term solution to the devastating floods occurring every year. For example, the estimated flood storage requirements in Brahmaputra basin, a flood storage of the order of about 9.2 BCM is recommended bya committee under Chairmanship of Member (D&R), CWC. These flood storages will play a crucial role in attenuation of floods in the north eastern states reeling under floods every year. These storages will help in making the Brahmaputra river Navigable throughout the year. They will also help in water supply and lean flow augmentation and generation of hydro-power.It may be mentioned that although Brahmaputra basin has a hydro-power potential of 59,000 MW (40% of the total hydro-power potential of India), the hydro-power tapped so far in the north eastern states in Brahmaputra basin is about 5.000 M Wonly.

Central water Commission (CWC) has been issuing flood forecast based on conventional gauge to gauge methodology with a lead time up to one day. Under Flood Forecasting (FF) modernization programme, CWC started rainfall based real time flood forecasting using mathematical modelling technique for whole country increasing lead time up to 72 hrs since 2017 (http://120.57.32.251/index.php).CWC has utilized the latest modelling technique in generating maps for the inundation forecast. Emphasis has also been made to validate maps using satellite images to the best possible extent. Whenever forecast of river stage exceeds certain threshold levels (warning level, danger level & highest flood Level), CWC FF station-wise inundation would be portrayed. Comprehensive inundation scenarios for all the inundated districts along with road transport and railway network could thus be seen on real time basis. It will help the state government officials and various flood response agencies for emergency planning and response action in mitigating the flood damage in the basin. Moreover, this will be useful in many other aspects like land use planning, flood proofing, design of evacuation plans and flood protection measures etc. The inundation forecast could be refined as and when high resolution data sets or more advanced methodologies are available in near future.

7. Challenges and the Road Ahead for River Basin Development and Management

As mentioned earlier, river basin is considered as the basic hydrological unit for planning and development of water resources. It has a defined water boundary within which there is an inter-relationship between the surface and groundwater resources. Besides, there is cultural affinity among the people of the basin which provide sound basis for planning over all development issues.

Based on similar hydro-meteorological characteristics, CWC et. al (1959) divided the country into 26 hydro-meteorologically homogeneous sub-zones for estimation of floods of different return periods. There are 12 major river basins in India with catchment area of 20,000 km2 and above. Ganga-Brahmaputra-Meghna is the largest with catchment area of about 11.0 lakh km2.The other major river basins with catchment area more than 1.0 lakh km2 are Indus, Mahanadi, Godavari and Krishna. There are 46 medium river basins with catchment area between 2,000 and 20,000 km2. All major and medium river basins are inter-state in nature covering about 81% of the geographical area of the country. Our National Water Policy (MOWR,2002) lays down that there should be an integrated and multi disciplinary approach to the planning, formulation, clearance and implementation of projects, including catchment treatment and management, environmental and ecological aspects, rehabilitation of affected people and command area development .

The first challenge is the regulatory frame work.The only River Rehabilitation Authority existing in India – NMCG (National Mission for Clean Ganga) for instance, is an interagency body to distribute the funds to the state executing agencies and it can at best act in the advisory capacity only. It has no statutory authority derived from the Constitution of India to issue abiding directions to the state Governments.

National Water Code is an urgent need where the law related to water management need to be codified for household-needs; agriculture; industry; commerce; and public services. Legally at least, nature can be made a legitimate user of water. The water code may define the development with little regard for the carrying capacity or the hydrological integrity of the country's water resources. Water Bureaucracy also need to change with an understanding of water management in social perspective. The engineered solutions must pave way to management arena.

The second challenge of River Basin development is the arrangement of funds for the continued maintenance efforts. Many economic assessments have found the economic value of river rehabilitation or flood management is quite high, of ten out weighing the costs. However, the benefits are in the form of non revenues public good feeling is not measurable. For rivers in urban areas, some of the revenues canberaised through tourism, waterways or property taxes on areas expected to seean in creasein property value. Other economic policies to generate revenue, such as adedicated tax on water consumption or discharge need also to be explored. Like toll tax in highway sector, Govt. may consider imposing some taxfor cold drinks like Coca-cola, Limka, Fanta etc.

A healthy Rivers Action Plan for improving water management in the river include healthy Basin with reduction in nutrient inputs like water-soluble phosphate fertilizers and to check Drainage of Nutrient to remove nutrients from drains and tributaries before water is discharged into the rivers. The efforts for reducing the input of contaminants at their sources in the sub basins and intercepting nutrients as they travel through the tributaries, drains and groundwater is a challenging task.

The research and innovation program that provides sound technical information for managing the river system also need development adaptation strategies. Public opinion, both among policy-makers and the public at large need to be developed to see rivers associated with recreational culture. After living through decades of depleted conditions, our generations have grown up viewing streams as an environmental hazard, not a resource to be enjoyed.

8.0 Inter Basin Water Transfer by Linking Indian Rivers

Basins with water availability less than 1000 m3 per capita per year are designated as scarce. Although, the average figure (1540 m3 per capita as on 2011:Table-1) for India if taken as a whole, indicates that India may not be water deficit right now, but looking at the spatial distribution of water varying widely from basin to basin (IWRS, 1996), there is an utter need of water transfer from surplus to scarce basins [IWRS (1996; Mazumder (2018)]. Only way we can address the recurring problems of water shortage in scarce basins is by interlinking rivers for transfer of surplus flood water to drought prone areas. Besides hydro-power, navigation, flood control and dry weather flow augmentation, an additional area of 35 mha of land can be brought under irrigation by river linking.A perspective plan has been drawn to interlink Indian rivers by constructing 30 link canals-14 in Himalayan and 16 in Peninsular regions in India (NWDA,2005). Few Short distance river links like Ken-Betwa have been readied for implementation. Long distance links by successive transfer of water from one river to another by constructing some 30 small, medium and large reservoirs are under exploration.

9. River Basin Authorities (RBA) under Water Dispute Tribunals

As early as 1956, the Government of India had enacted the River Boards Act, recognizing the necessity of some organization for the control and regulation of interstate river basins. No River board(RB) has been created for the purpose in India under this Act. Tribunals set up under the River Water Disputes Act,1958 have created institutions similar toBasin Authorities for the Godavari, Krishna, Narmada and Cauvery basins. Inter-State river disputes have become a threat to the nation's unity and Integrity.

10.0 Conclusions

River basin development is a key to all round development of India.River Action Plan is a prolonged process that requires considerable stamina on the part of society and decision-makers. With some preliminary projects initiated, the challenges to meaningful rehabilitation of the country's rivers is still the biggest challenge.Flood control and flood management are essential to reduce flood damages, mostly in the north, east and north-east part of India. Both structural and non-structural measures are effective.Excess flood water need to be transferred from surplus to drought prone areas.With limited water availability and increasing growth of population, only way left is to properly manage water and to increase productivity of land per unit of area and unit of water.

REFERENCES

Bharat Singh (1991), “Management of Irrigation in India – A perspective” pub. in “Water Management” by Water Management Forum, The Institution of Engineers (India), kolkata

CWC(2010) “Water Use Efficiency for Irrigation Projects”`Pub. by Central Water Commission, Min. of water Res., River Dev. and Ganga Rejuvenation, Govt. of India, april,2010

CWC(1993) “Water Resources Potential In The River Basins Of India” chapter-1 : Publication by Central Water Commission, Min. of Water Resources, River Development and Ganga Rejuvenation, Govt. of India

CWC(1991), “Compendium on Silting of Reservoirs in India”Pub. by Central Water Commission, Min. of Water Resources, Govt. of India.

CWC(1979) “Flood Estimation Reports” prepared jointly by CWC, IMD, RDSO &MORTH, Govt. of India, Pub. by Hydrology Division of Central Water Commission, Sewa Bhawan, R.K.Puram, New Delhi

Ghosh, N. C. && R.D. Singh( ) “Groundwater Arsenic Contamination in India: Vulnerability and Scope for Remedy” National Institute of Hydrology, Roorkee - 247 667, Uttarakhand

IAHR(2018) “IAHR-World News Flash”, pub. by International Association of Hydraulic Research, May

INAE (2008) “Water Resources Management-Role of Water Sector in India”, Pub. By Indian National Academy of Engineers, IIT(Delhi), Feb.21-22

INCID (1998) “Sprinkler Irrigation in India” pp 1-16, pub by Indian National Commission on Irrigation and Drainage, Ministry of Water Resources, Govt. of India

IWRS (2007), “ Role of Water Resources Development & Management in Bharat Nirman”, theme paper presented on Water Resources Day observed by Indian Water Resources Society (IWRS) at ICID, New Delhi, May 9th.

IWRS (1996), Inter-basin transfer of water for national development- problems and Prospects, theme paper pub. on water resources day by IWRS, New Delhi

Iyer, S.S. (1989) “Water Resources of India – An Overview”, Journal of Indian Water Resources Society, Vol. 9, No. 2, April.

Kumar, L.V. and Mazumder,S.K.(2016) “Water Storage in Reservoirs and Aquifers- Recharging Ground Water”, Paper submitted for consideration of publication in the Annual Volume on 'Water Conservation and Management' by Civil Engg.Divn. Board of The Institution of Engineers (India).

'Mazumder, S.K. (2018) "Inter-basin Water Transfer through Link Canals-Some Problems and Solutions", Paper published (Keynote speech) in the Int. con. on Sustainable Technologies for intelligent water management (STIWM-2018), org. by Dept. of WRD&M and IWRS during 16-18 February, 2018 at IIT, Roorkee.

Mazumder, S. K. (2011) "Interlinking Indian Rivers Merits, Demerits and Difficulties in Implementation" published in the Journal of Bharati Vidyapeeth

Mazumder, S. K. (2011) "Breaching Of Flood Embankments With Particular Reference To Kosi & Farakka Barrages In India" paper published in the journal of Water Energy International by Central Board of Irrigation & Power, New Delhi, March 2011

Mazumder (2007), "Irrigation Engineering", pub. Galgotia Publications, 5, Ansari Road, Daryaganj, New-Delhi-110 002

Mazumder, S.K. (2006) "Priority of Inter - Linking Indian Rivers" Paper presented and published in the National Conference on Hydraulics and Water Resources with Special Emphasis on Inter- Linking Rivers, HYDRO-2006, org. by Indian Society for Hydraulics and Bharati Vidyapeeth, University College of Engineering, Pune, 8-9 Dec

Mazumder, S.K. (2002), Performance of surface irrigation schemes in India, keynote speech pub. in the proc. of all India seminar on water and environment-issues and challenges, org by IWRS and WRDTC , IIT (Roorkee), Oct. 2002

Mazumder, S.K. (1986) "Efficiency of Irrigation in some River Valley Projects in India" Proc. of International Seminar on Water Management in Arid and Semi-Arid Zones, held at Hissar Agricultural University, Haryana, Nov. 25-27, 1986.

Mazumder, S.K. (1984) "Efficiency of Irrigation in the Command Areas of DVC, Mayurakshi and Kangsabati projects in West Bengal", Proc. National Seminar on Water Resources Management for Rural Development, KNIT, Sultanpur, Oct. 18-19.

Ministry of Agriculture (1979) "Manual on Irrigation Water Management- pub. by the Ministry of Agriculture and Irrigation, Govt. of India

MOWR (2002)"National Water Policy" Ministry of Water Resources, Govt. of India ,Shram Shakti Bhawan, New Delhi

NCIWRD (1999), Annual Report of National Commission for Integrated Water Resources Development, Min. of Water Resources, River Development & Ganga Rejuvenation, Govt

NRCP (2011) "National River Conservation Plan" pub. by Min. of Water Resources, Govt. of India.

NWDA (2005)," Water for life", 11th National Water Convention, org. by National Water Development Agency, Govt. of India Delhi, May 11th

Planning Commission (2007),"Ground Water Management and Ownership" Report of the Expert Group on Ground Water, CGWB, New Delhi, India: Government of India

RBA (1987), "Rastrya Bar Ayog", A Govt. of India Publication

Zimmerman, Josef D. (1966) "Irrigation", John Wiley & Sons, Wiley International Edition.