

The Journal of Governance

Volume 14

January 2017

SPECIAL ISSUE ON WATER MANAGEMENT



**IC Centre for Governance
NEW DELHI**

The Journal of Governance
IC Centre for Governance
3, Palam Marg, 3rd Floor, Vasant Vihar, New Delhi-110057

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The IC Centre for Governance has been set up in with the objective of collective thinking and acting on important issues of governance. It believes that public governance is too serious a matter to be left entirely to the state and that the involvement of the Civil Society is not only desirable but also essential. The Centre seeks to strengthen the capacity of Civil Society and government for ensuring good governance.

EDITORIAL

Management of water resources strongly influences domains that are critical for overall human development, including health, agriculture, environment, energy, spatial planning, regional development and poverty alleviation. Ambitious goals of doubling the income of farmers in next five years, eradicating open defecation by building more toilets, scientific management of municipal solid waste, wastewater and industrial pollution management for cleaner waterbodies, and building of smart cities, has set the bar for water management very high. Growing complexity of water management in India due to limiting natural resources, demographic changes and potential climate change pose increasingly complex challenges to overall sustainable development in the country.

Widespread water shortages and deteriorating water quality in many parts of the country are already impacting food productivity, health and well-being. Many water bodies, including ground water aquifers, suffer severe water quality impairments affecting drinking water vulnerability. Due to unregulated withdrawals, groundwater levels are depleting. Deterioration of surface and groundwater quality due to river pollution, over exploitation, excessive use of fertilizers, pesticides etc. has exposed drinking water sources to the risk of arsenic, fluoride and other contamination due to anthropogenic activities. Large and medium cities often get deluged by contaminated drainage waters even with rainfall of little intensity.

Many river basins in India experience seasonal water scarcity on a regular basis, while other basins are closing, that is, in the case of surface water, allocation equals or exceeds the available water; in case of groundwater, extraction exceeds natural recharge. At the same time, India is changing through rapid urbanisation and industrialisation, giving rise to new priorities and demands for water use, and a changing economic and political perspective to agricultural water use. This makes the allocation of water in space, in time, and over different sectors and social groups increasingly intricate and interlinked.

The impending climate change brings a new level of complexity and challenges leading to changes in demand due to increasing temperature, changes in precipitation pattern, decrease in the number of rainy days,

increased intensity of rainfall and increased frequency of water related extremes. These changes are likely to manifest in the water sector in a variety of ways.

Agriculture sector is the dominant freshwater user. In order to protect agriculture against climatic uncertainties, governments have long focused on expansion of large-scale irrigation. Although these large systems have helped maintain self-sufficiency in food production, they are also stuck in vicious cycle of neglect, deferred maintenance and rehabilitation and their performance has been suboptimal. Groundwater, which has contributed significantly to increase in the gross irrigated area in the country is also experiencing fast decline with many states experiencing lower productivity of water and a decrease in irrigation intensity. At the same time during the past few years, there has been significant slowing down of investment in irrigation and drainage sector. Improving the efficiency of water use in agricultural has the potential to address the water scarcity situation. Transformation of irrigation to become a responsive and reliable service component of the agricultural production enterprise is long awaited.

The vision for water is planned to be realised through developing full irrigation potential in the country; utilizing the created irrigation potential; improving the irrigation efficiency; harnessing the ground water potential at a sustainable pace; undertaking extension, renovation and modernization; recycling and reuse of urban and rural waste water for irrigation development; and increasing water storage capacity, through developing new infrastructure and revival of traditional water harvesting structures, rejuvenating the natural water bodies and creating farm ponds. At the same time erratic and uneven availability of water in different parts of the country requires augmentation of utilizable water by transferring freshwater from surplus areas to deficit areas through planned inter basin transfer of water.

Growing financial crunch, failure of dispute resolution mechanisms, stalled infrastructure development, inadequate institutional reforms, lack of stakeholders' participation, absence of monitoring and evaluation mechanisms of the progress, absence of regulation, shortage of skilled multi-disciplinary professionals and non-availability of authenticated information for scientific debate on crucial issues are recognized as some of the ills constraining the water sector.

Besides the narrowing supply and demand gap, the present situation is often attributed to far from satisfactory governance of water. With increasing scarcity of resources, imperative for sustainable development

as set out in SDGs¹, and the political will to make agriculture as an “engine of sustainable and inclusive economic growth, inflation management and rural development”² it is imperative that water governance is given a closer and critical look compared to what has been the case so far. The past performance of the water sector, emerging future water scenario with its challenges and the ambitious sustainable development goals that the country has set for itself, call for improved water governance.

The water governance and management scenario in India is undergoing structural changes for more than two decades. Reforms in the water sector began in 1990s but these efforts have been made in bits and pieces and have brought few positive results to different degrees in different states. A systematic evaluation of these reforms is called for.

The set of articles presented in this volume take a close look at the present status of the constitutional gaps in river basin planning and management; development requirements to ensure energy security; perspective on the imperatives of sanctifying nation’s water bodies; increasing flood management drinking water and wastewater management needs; rainwater harvesting; groundwater assessment, development, management and rejuvenation of depleted aquifer traditional water bodies governance and regulation.

Though water resources management is inherently a localised phenomenon, global ideas, best practices and concerns are increasingly entering Indian water policy and politics, and appropriated and embedded in domestic discourse and practice in a variety of (transformed) ways. Global discourse on the integrated water resources management, public private participation in financing water projects, the need for ‘integration’ of uses and users and notions of environmental flow are finding their way in, resonating with, or being opposed by different actors in the Indian water economy and polity. The present discourse on water governance is led by OECD in collaboration with a number of UN and other International organizations active in water issues who have developed a framework for water governance which consists of following water governance principles³: demarcated roles and responsibilities; managing water at appropriate level; policy coherence; capacities and competencies; data and information as a public good; mobilisation of financial resources; sound regulatory framework; transparency and accountability;

¹ UN Sustainable Development Agenda 2030

² “Doubling the Farm Income by 2022” as enshrined in the Union Budget 2016-17,

³ OECD (2015), *OECD Principles on Water Governance*, OECD Studies on Water, OECD Publishing;

greater stakeholders engagement; mechanism for equitable trade-offs, and monitoring and evaluation.

The articles in the issue have been written by renowned experts engaged in water resources development, groundwater management, public private participation in the water sector, hydropower, drinking and wastewater management, flood and environmental management, research and development inputs and farmers participation in the management. Articles by civil society experts bring out their experiences and perspectives. The articles identify good practices to assist different levels of governments and other stakeholders in engaging effective, fair and sustainable water policies. They establish that good governance can shape policies into concrete deliverables through bold actions through partnership between science, polity and society and harnessing the power of the people. With a view to improve water governance, various gaps that exist in water governance in the country such as: policy gaps, institutional gaps, financial gaps, information gaps, accountability gaps and capacity gaps that impact the water governance have been identified.

As per the Indian constitution, water falls within the State List and provisions under Article 262 address disputes relating to water - adjudication relating to waters of inter-state rivers. Water (Prevention and Control of Pollution) Act 1974, Environmental Protection Act 1986 and many other such acts set the legal framework for water resources development guided through a National Water Policy. Some of these and others are being addressed through National Framework Law is being evolved as an umbrella statement of general principles governing the exercise of legislative and/or executive (or devolved) powers by the Centre, the States and the local governing bodies. This needs to be expedited.

Meeting current and future water challenges requires robust public policies. There are a certain policy gaps such as those addressing water rights, waste water management principles, water reuse and recycling, priorities and objectives of environmental flows and data sharing. Although National Water Policy envisages adoption of principles of integrated water resources management (IWRM) they could be practiced only in part⁴. Informed participation of the civil society in policy formulation, planning and management faces hindrance due to lack of availability of authenticated information in the public domain. Flow of information even among government agencies at state and central level is sometimes very slow despite initiatives such as WARIS due to its limited

⁴ Mohile, AD (2003): 'Integration in bits and parts: IWRM in India', WAPCOs, New Delhi

success. Water data needs to be treated as a public good.

Fragmented institutions dealing with water at the Centre and at State Government levels need a fresh look with a view to establish proper coordination mechanisms. These institutions need to be restructured and made multi-disciplinary. Most of the Irrigation Departments dealing with water resources in the states continue to remain construction oriented and have failed to realign themselves to the changing realities and requirements. The roles and responsibilities of institutions engaged in water quality monitoring are vague and not well defined. Complexities of water management require cooperation, collaboration and convergence among institutions at various levels. Formal and informal platforms need to be made operational with well-defined goals, targets and milestones.

Decentralised management of water through devolution of powers to *panchayats*, involvement of water users associations in irrigation management and participatory ground water management suffer from lack of capacity. At times, the engineers dominating irrigation/water resources departments lack capability to adapt to and use new technologies, social engineering perspectives and conflict management skills. Capabilities in climate change predictions and assessment of its impacts on water management, drought prediction and early warning, water quality modelling, use of tools for future water scenario generation are confined to academic and research institutions and lack application at operational level.

Distributed community based interventions such as recharging of groundwater through small water harvesting structures and strengthening the livelihood base of the most vulnerable through watershed management interventions, provide the true example of integrated development of water resources. Institutional mechanisms to enhance capacities among civil society actors and bring greater water awareness to all stakeholders need to be set up with the support of civil society.

There is need to mobilize effective action and advocacy on financing and implementation to increase access to safe drinking water and adequate sanitation for all, and to improve the sustainable development and management of water resources.

We are hopeful that this volume will help provide direction and give impetus to the ongoing process of reforms to further improve the water governance in the country.

Amarjit Singh, Avinash C Tyagi & H K Varma

Rajendra Singh

The Indigenous Systems of Water Management in India

Introduction

In Indian tradition, the knowledge was transmitted through practical work under the direction of respected elders and gurus. Thus the people engaged in practical work were really the pupils of the indigenous knowledge system. The poor pupils, the prosperous pupils, and the State joined hands for the conservation of water and the preservation of knowledge. The prosperous pupils provided help to the poorest who were working for water conservation, and the State provided only the land. It was a pupil-driven decentralized water management, which is another name for indigenous water management.

This functional management of water had wisdom of every drop of rain. This indigenous knowledge system respected the agro-ecological zone diversity, and had developed a specific science, a relevant engineering and a technology appropriate to each and every part of the country. The traditional knowledge and practices of every area imbibed an understanding of ecological balances and technologies to harness natural resources in a sustainable and eco-friendly manner, though these had never been documented.

The ancient indigenous engineering was not much documented in the modern sense, because the technical aspects were transmitted through practice and words of mouth, and gradually perfected by tradition. But in some cases the legal and administration aspects were written, for example in Kautilya's Arthashastra (Treatise of Administration written by Kautilya, advisor and minister of the first Indian emperor Chandragupta Maurya, 321-297 BC). One chapter of the Arthashastra

gives a testimony of very comprehensive and detailed administrative rules, covering the whole range of legal and economic implications of a decentralized community - driven water management, facilitated by the State.

The ruler had to provide land, roads, trees and equipment to those who participated to the construction of water - works. The methods of ownership and maintenance of new, ancient and repaired structures were described in details. All users of irrigation facilities had to pay a tax, even when they had their own waterworks. But exemption of tax was granted for a number of years to those who build new structures. However, these administrative rules were only safeguards and practical provisions for the economic consequences of the implementation of waterworks. The real motivation came from another side. The participation to construction of community ponds, tanks and waterworks was a matter of pride and of religious devotion.

The lowest rainfall in India is in the arid districts of Jaisalmer and Badmer. There the people have a Tanka in every house for drinking and domestic use. They also have a pond (Talab) for common use and drinking water for animals. They also use Kuinya, for harvesting drinking water present in the form of sand moisture in the sub-surface, where the aquifer is brackish and separated from the layers above it by a layer of gypsum.

On the other hand, in Bihar, the problem is not lack of water but excessive water. Every year, devastating floods spread havoc in the state. The ancient indigenous knowledge had developed a method which puts to use the excess water, called 'Ahar-Pyne', which is in fact a 'flood water harvesting system'. The excess water from the Ganges was driven by channels called 'pyne' deep inside the land, up to 30 to 40 km. to fill tanks called 'ahar'. This ensured a long-lasting retention of water throughout the year, and a better distribution of silt.

The local indigenous knowledge in India has always developed practical ways for Society to live in a sustainable manner with Nature, in full respect with the diversity of agro-ecological climatic zones, even those that seems the most difficult and inhospitable.

Loss of tradition, and its consequences

The conservation of forest, water bodies and other natural resources in an extremely healthy state over the past thousands of years even under difficult climate and geographic conditions and with a growing population and demand, was essentially due to an extremely eco-friendly cultural traditions (dharma/parampara) of 'live within what Nature sustainability release, don't be greedy'.

For centuries, the line of thinking that soil, water, forest, wildlife and the whole environment are the common asset of the local people bestowed by the almighty to be managed as a 'trust', was the commonly accepted worldview. This age-old balance has been disturbed at an accelerating pace in the last 200 years, and every revolution and counter-revolution has indeed increased the depth of the fall: the industrial revolution, the education revolution, the agricultural 'green' revolution, the 'development' revolution, and now the 'privatization' and 'information technology' revolutions.

The European colonizers brought the idea that Nature was to be 'exploited', which undermined the feeling of responsibility towards nature. The modern State (colonial or independent) dispossessed the rural communities of their rights and responsibilities, and rivers, either legally (tree felling licenses, water rights) or illegally (corruption). The education revolution convinced the people that traditions and oral knowledge were at the root cause of poverty. Under the 'development' and socialist 'welfare' concept in the post-independence period, State promoted the illusion that everything has to be taken care of only by an all-powerful government. Now that the reality of State incompetence has become clear, the capitalistic empires, multi-national corporations (MNCs) and high-technologies (IT, GMO etc.) are called upon to rescue the situation, which is most likely to result in further and deeper degradation.

To make things even more difficult, the language itself has become corrupted. For example, the official jargon for the undisciplined water extraction technology is 'ground-water development'. And, when educated engineers seem to re-discover the ancient tradition of responsible management of common resources, unfortunately

they create abstractions and awkward technologies, like ‘artificial groundwater recharge’, ignoring the proved local traditions like Johads. Even when they begin to understand a traditional technology like the Tanka, they feel compelled to ‘improve’ it, like using cement instead of lime, or reinforced cement concrete (RCC) slabs instead of brick domes, thus degrading the tradition and its relevance, to the level of their limited understanding. The natural methods are not only forgotten, their vestiges are dug deeper into the ground day by day. To sum-up, the difficulties that we are facing can be categorized as such:

- Paradigm change: Exploitation and disintegration has taken the place of ‘feeling together’ and integration.
- State takeover of community functions: The State has dispossessed the communities of their traditional rights and responsibilities.
- Syndrome of dependence: Wherever the State succeeded (even partially or for a short period) in implementing modern amenities like water supply, sewage or power, the communities have lost their initiative.
- Neglect of traditional systems: Due to implementation or expectation of modern facilities, the traditional systems have been neglected.
- Disintegration of community institutions: The modern education and hollow dreams of modernity have disintegrated the community institutions.
- Inability to cope with increasing human and livestock population: The general degradation of natural and social conditions has led to the inability of communities to face the problems created by a growing demand.

As a result, the rural communities have lost their food and livelihood security, their living conditions have become more difficult, resulting in forced migration to big cities in search of survival in indecent and exploitative conditions.

Re-awaking the indigenous knowledge

Traditional Water harvesting system in India

There are various types of methods of Water Harvesting in India. The main common features of all systems are:

- Use of local resources and technology
- Community based operation
- Community driven de-centralized water management
- Sustainable conservation and use of natural resources

Revival of systems using indigenous knowledge

- Interventions understanding traditional systems and use of indigenous knowledge
- Mobilization of community around land, water and forest
- Participation in rejuvenating old structures and construction of new structures.
- Creation of new village level and river basin institutions.

The Case Studies presented in the following sections briefly illustrate what it takes to organize community participation in reviving the ancient wisdom and the challenges such an attempt faces.

Case Study: Reviving Tradition of Johads

On the night of 2 October 1985, when I got down at the last stop of the bus at Bheekampura with four of my friends, we only had a single agenda, which was ‘to fight injustice against the people’. And we only knew one way to do it, by spreading literacy in the villages. So we promptly started a literacy drive.

But the people suffered from a severe scarcity of water. The region that once sustained the eco-system of the ‘Aravalli’ had become barren. It was difficult to find young people in the villages as all of them had fled in search of employment. Women trudged long distances to fetch a mere pot full of water. Crops failed regularly, lack of vegetation led to soil degradation; monsoon runoff washed away the topsoil. I remember there was not a single blade of grass in the region and we often stumbled on the carcass of cattle. Barely 3 per cent of cultivable area was irrigated. Life was difficult and hardship endless.

One day, Mangu Patel, the wise old man of this village told me, ‘we do not want your literacy, we want Water’. But where was the Water? I did not know anything about Water. Mangu explained to me about the rich tradition existing in this region of building ‘Johads’, which were a prime example of the ingenuity of inexpensive simple traditional technology that was quite remarkable in terms of recharging groundwater in the region.

Demand driven solutions

‘Johads’ are simple mud and concave shaped barriers built across the slope to arrest the rainwater runoff with a high embankment on three sides while the fourth side is left open for the water to enter. The height of the embankment is such that the capacity of the ‘Johad’ is more than the volume of runoff coming from the catchment based on a rough estimation of maximum possible runoff that could come into it. Therefore the height varies from one ‘Johad’ to another, depending on the site, water flow and pressure etc. In some cases to ease the water pressure a masonry structure called ‘Afra’ is also made for the outlet of excess water. The water storage area varies from 2 hectares to a maximum of 100 hectares.

Water collected in a ‘Johad’ during monsoon penetrates into the sub-soil. This recharges the groundwater and improves the soil moisture in vast areas, mostly downstream. The groundwater can be drawn from traditional open wells, built and maintained by the villagers themselves without any input from outside. The percolation process takes some time, depending on the soil, depth of water etc. during this temporary period (sometimes several months). The water in the Johad is directly used for irrigation, for drinking by animals, and for other domestic purposes.

Also, during the dry season when the water gradually recedes in the Johad, the land inside the Johad itself becomes available for cultivation. This land receives periodically good silt and moisture, and that allows growing crops without any irrigation. So the Johad does not take away valuable arable land from cultivation. The distinctiveness of this structure is that it is based on simple and cheap technology with locally available resources, mostly labour and

soil, and sometimes when necessary, stones, sand and lime, all locally available. All the estimations are based on the villagers experience and intuition, without any physical measurements.

When I went to Bheekampura in 1985, this unique traditional water management system was still alive but only in the collective memory of the people who had remained alienated from the global environment. On the advice by Mangu Patel, we became a catalyst to building 'Johads' the local authorities were dead against us as we bypassed all bureaucratic channels and dealt with the people directly to fulfill their requirements in the manner they decided. The first 'Johad' took three years to build, in the fourth year we built 50 'Johads', in the fifth we built almost 100 in 2001 we built around 1,000 water structures and in total by the end of 2015, we have built nearly 9,000 water harvesting structures in more than 1,000 villages.

No Engineer was called for consultation; we were guided entirely by the traditional wisdom of the people who have maintained the ecological balance for generations. These water structures were built with the active participation of the community from identification of the site to the designing of the structure, its construction and by voluntary contribution towards cost of its construction and latter in its maintenance, which ensured that all the structures were need based.

When we started working in 1996, our area was classified by the government as 'dark zone', it means with severe water shortage and the water level had receded to difficult depths. The same area after 10 years was classified as 'white zone', which means underground water level are satisfactory and it does not need attention from the government. As a result, water became abundant. More water meant better crops, better conditions of soil, time for the girls to go to schools, and rich community life. It helped forestation in the area and development of wildlife.

Prosperity returned back to the region, agriculture became productive and due to availability of fodder cattle rearing started, resulting in increased production of milk. Higher water levels also meant less money on the diesel for pump set.

Small inputs, Great Return

In 1985 only 20 per cent of the agricultural land was cultivated, now it is 100 per cent, and villages started selling surplus grains in market for the first time. Studies have shown that an investment of Rs 100 per capita on a “Johad” raises the economic production in the village by as much as Rs 400 per capita per annum.

As villagers mobilized themselves to improve their quality of life by contributing in building “Johads”, this participation of the people promoted the community to become self-reliant optimizing social cohesion and emotive bonding in the community. Since people realized that members were responsible not only for individual but also for collective action, they became more aware of their rights taking on an activist stance to stop employment of children in the carpet industry and fought a legal battle up to the Supreme Court of India to stop indiscriminate mining on Forest Land.

An enlightened and active community also enforced self-discipline for the common good of the village. They strictly enforced their own rules to stop deforestation, hunting wildlife and consumption of liquor. The development of community participation through the “gram sabha” or village assembly, gave each and everyone an opportunity to freely discuss, decide and implement a common decision taken for the general benefit. This process also made them reflect on other problems of the community and help each other in solving them. While the community became active in social and economic change, the crime rate dropped in the villages as economic conditions improved of the entire region.

This momentum in the community caused by the construction of “Johads”, has encouraged the villagers to go further looking for innovative methods of social change. Now the greatest challenge before them is to sustain those traditional values that started this movement in the face of the transformation of the community due to progress and prosperity.

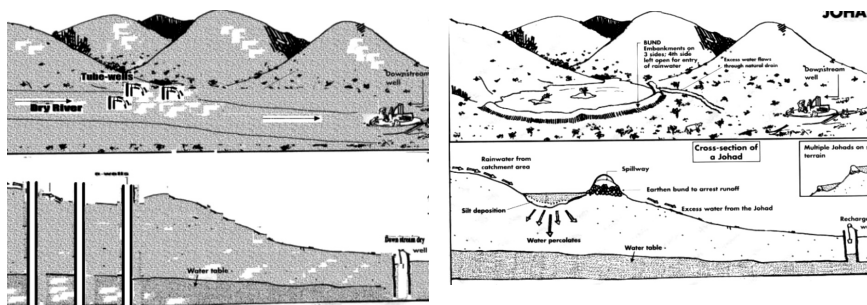
Case Study: Rejuvenating Arvari River

The Arvari River Basin in Alwar district of Rajasthan has 46 micro watersheds. There are broadly two major streams starting

from the top of the basin and joining at the dam called Sainthal Sagar. Tarun Bharat Sangh (TBS) continuous work of constructing water harvesting structures in the catchment area along with other watershed management activities resulted in rise in groundwater table in the basin and increase in the longevity of flow in the Arvari River. Holistic view in management of natural resources by undertaking land, water, and vegetation related activities was the objective of TBS. It is a perfect example of Community leadership in action in protecting a resource.

Rebirth of Aravari River

Since 1940s the Aravari River had been degraded to a mere monsoon drain, witnessing only brief and strong flows of muddy water. TBS has helped people to build more than 9,000 Johads, Check Dams, and Anicuts for Harvesting the Rain Water.



Excess withdrawal of Ground water

Increased Groundwater Recharge
Less Groundwater extraction

In 1996 we were amazed to find Aravari River flowing even at the peak of summer. We had been building these structures over the years without realizing that we were in fact recharging the river through percolation underground. Now the water is clear and shows gently throughout the year. Since then four more rivers, Sarsa, Ruparel, Bhagani and Jahajwali have become perennial.

When there was plenty of water in Aravari, there was natural growth of fish, which went on multiplying. Seeing that the government wanted to get hold of fish and brought in a contractor. The people resisted and the Government had to cancel the contract. It is not

that the local people wanted control over the fish. Far from it, they are all vegetarians and do not eat fish, but they realized that today, it was fish tomorrow it would be water.

The government through the contractor was intruding into community's domain, its right over the use of water. Water as a resource was developed by them and they wanted to have full control over it. If they had allowed that intrusion to succeed, the leadership would have failed the community to protect its right over water. But since they resisted and won, one can see the shift in the centre of power as far as control over use of Arvari water is concerned.

Then there was fear that intrusion having taken place once could take place again. Besides, there were differences over sharing of Arvari waters within the community. This led to the formation of Arvari Sansad (Parliament) representing 72 villages and it has framed 11 rules for use of Arvari water. This Parliament meets 2 times a year.

The Arvari Parliament

The concept of river basin approach was applied to Arvari River using community centric water management approach. On December 28, 1998 a River Parliament of 70 villages with the membership of 205 was formed in the catchment area of Arvari River.

Why should people come together to form a parliament around natural resources is a big question? It would have been impossible to think of river parliament without the TBS intervention in formation of new institutions, such as, Village Water Council and Women Self Help Groups (SHG), and construction of different kinds of water harnessing structures directly benefiting the population. Rise in groundwater level and increase in area under cultivation and irrigation tempted people to listen to the TBS idea of formation of the River Parliament. The community efforts in water resources are mostly in the form of harnessing of rainwater by creation of different types of surface structures. Community participation is ensured while construction of the structures right from the beginning and therefore people show interest in Arvari Parliament.

Organization of the Parliament

As the existing formal state structure i.e. the different department of government, namely Forest, Irrigation, Groundwater and Revenue department have almost failed to check the deteriorating condition of natural resources, TBS tried to educate people on the NRM issues by forming a Village Water Council (VWC) in each village. The objective of this village institution was mainly to protect, conserve and manage the natural resources in a sustainable way by community participation. After long years of hard work these councils made a dent in natural resource management by forming certain informal rules, acceptable to all the village members.

Water and vegetation are common pool resource and do not belong to only a single village as was contemplated while planning Arvari River Parliament so it was decided to form a River Basin Parliament comprising of several micro watersheds. It was planned that each VWC will be represented by nominating two or three members in the Parliament. A working group of 20 members including few co-opted members from outside basin to guide the proceedings and activities of Arvari Parliament was also proposed. It was planned to have at least two meetings of full house and more than twice of the Management Committee or Working Group as and when needed.

The Parliament meets twice a year at the interval of six months. The Arvari Parliament met 14 times since its formation. The awareness built by various discussion, group meetings, training's, exposure trips etc. also contributed in mobilizing and sensitizing community to form a group to address inter and intra village land, water and vegetation related issues and to resolve conflicts if any. Also events, such as conflict between state and community in reaping benefits of water stored and conflicting claims over ownership and control over surface water harnessed through various structures triggered the idea of coming together and protecting the interest of community¹.

¹Water harnessing structures called Jabbar Sagar dam in Hamirpur village was constructed by Tarun Bharat Sangh. The State Government tried to claim ownership and control over water by floating tender for fishery activities in 1996. One morning a contractor came to collect fish from the dam. The village community was taken by surprise as they were under the impression that water belongs to them. The community fought with the State and finally won their claim over water and fish resources.

The main goal of this Parliament was to create a larger vision or perspective i.e. thinking beyond a village, in management of common pool resources. The basin level institution created by TBS is expected to perform several roles such as:

1. To conserve water resources and emphasize on demand side management
2. To ensure community control and management over water resources
3. Equitable distribution of resources
4. Provide equal access to all sections of the society
5. Ensure sustainable use of water resource to protect interest of future generation
6. To resolve conflict if any around water resources and
7. To organize and empower people through natural resources management.

Arvari Parliament has provided people a platform to address their needs, prioritize them and design use patterns, which can maintain health of the resources. It has also provided opportunity for young local leaders to come up and safeguard the interest of the community. The discussion in meetings of Arvari Parliament is quite open providing equal opportunity both for men and women to express their views. It was the part of the scheme to ensure equal participation of women on all its activities and see that they too are empowered in the process. In the organization structure it was planned to have both men and women representatives. Presently women are actively participating in all activities.

Being a very young organization and first of its kind it will take some time to understand and act about its roles and responsibilities. Different stakeholders are taking lot of time to understand the concept of river parliament and get in practice. As it requires change in perception from individual, private, narrow profit maximization approach to a broad, village and basin level community approach to water resource management. People gradually understand the benefits of coming together and managing natural resources. So far they were

having all the freedom to use land, water and forest resources to meet not only domestic requirements but derive livelihood at the cost of complete degradation or deterioration of the natural resource. The social sanctions approved by the parliament are adhered by most of the villagers. It has made lot of a significant dent on their behaviour pattern towards natural resource management.

Despite all these benefits there are objectives that are yet partially attended to. It is not that people do not want to address those issues but the process of evolution in any institution takes lot of time and energy to arrive at major issues of equity and access in use of natural resources. There were traditional norms for sharing of water from a well in case of joint ownership. These are still in practice. The major problem attaining the objectives of equity and access is the multiple and undefined nature of property regimes. The ownership and control rights are loosely defined, rarely understood and practiced in a proper perspective. In case of water, surface and groundwater is governed by different laws related to private property, state property, and community property.

Groundwater is completely privately controlled and managed. On the other hand surface water harnessed by construction of structures both by state and community are legally owned by state. Also the water laws are directly in favour of the state government and people are mostly unaware of these laws. Groundwater is treated as private property and therefore used in a fashion to maximize individual profits at the cost of over exploitation of the resource to the extent that has negative environmental impact. However in case of forest resources ownership rights are clear and therefore, better managed by community as compared to water resources.

In the first meeting of parliament certain guidelines were drawn to regulate the behaviour of people, foresee future problems in management of NRM, resolving conflicts if any related to access and use of resources, provide guidelines for conservation, protection and management of resources, and treat water and forest as a community resource rather than private property. The specific informal rules formulated are as follows:

1. Ban on sale of fish produced in water stored by anicuts or Johad to contractor
2. Ban on use of pumps to lift water from anicuts
3. Not to sale land for mining or quarrying or industrial activity.
4. Encouraging people to grow water saving crops
5. Restrict use of chemical fertilizers
6. Limiting production of cotton and sugarcane crops only for self-consumption
7. Construction of anicut, Johad, mairbandi to check free flow of rainwater
8. Construction of mairbandi to check degradation of farmlands
9. The issues related to land, water, and vegetation to be dealt by combined effort of village community by ensuring maximum participation of households in a village.

These informal rules are discussed in each parliament meeting to highlight practical problems in their implementation and suggest new guidelines if needed. Suggestions if any are also debated and discussed to see that the members agree to implement in their respective villages. In the parliament meeting members report their efforts in implementing the objectives of the parliament and seek guidance for resolving conflicts if any. Most of the conflicts pertaining to access control and management of resources are resolved in the meetings of Village Water Council.

Impact of Arvari Parliament

There are direct and indirect impact of Arvari Parliament. These can be categorized into three broad aspects namely, Physical, Economic, and Social. In category of Physical impact, it is mostly the protection of water resources, increase in area under cultivation, improvement in the quality of land and forest resources and most important of all is physical community control over land, water, and forest resources. Economic impact is largely manifested in change in livelihood

pattern because of improved access to water resources in general and groundwater specifically. Increase in water availability has led to several commercial activities such as production of tomato and other vegetables, increase in employment and trade activities. Because of increase in agricultural production of both commercial and other nature, marketing activities came up in a big way, exporting produce from river basin to metropolitan cities, establishment of commercial states and elimination of activities of middle men and other businessmen dealing with the produce, transport activity, emergence of service such as agro service centers, commercial shops, dhabas, tea stalls etc. This has also led to diversification in livelihood activities. Several livelihood alternative came up which has engaged large number of population and stop their migration outside in search of jobs.

The social impacts, is quite significant as the Arvari Parliament empowered people to fight for their claims over resources, question state bureaucracy of their programmes and plans, and better implementation of programmes at ground level. Further it also helped in drawing plans for future use of natural resources. It is particularly the women who had no chance to put forward their views and opinion in any of the policy matter or activities in a village got platform to represent their case. Now they are participating in all the activities organized at village or basin level. It is also important to note that the Self- Help Groups formed by women are all active and doing well compared to the failure of groups formed by men. Women SHG's have changed status of women in the household activities and decision making.

Challenges faced by the Arvari River Parliament

There is a lack of clarity regarding the Ownership and Responsibility for Water Harvesting Structures and resulting Water Resources. The Arvari Parliament attempts to retrieve and revive the ancient tradition of Community responsibility towards Common Resources, in a difficult legal and administrative environment, with its impractical and counterproductive provisions. These provisions lets the so-called "owner" of a plot of land to do virtually anything with the

soil and water, for example emptying the whole aquifer or polluting the soil forever, putting a lot of obstruction in the way of any constructive initiative for community-based management of the common resources. One of these obstructions is the Irrigation and Drainage Act, 1954, which does not recognize the indigenous water management system.

In all this, workers of TBS functioned as facilitators with Gram Sabhas and their leaders. But all this is possible when every member of Village Community has a feeling of Ownership. This feeling of ownership is very important and is a product of one's contribution, participation and sharing.

The restoration of the river Arvari to life is also the story of various watersheds linked to each other. It is a logical conclusion of decades of water conservation work by the people, and a practical and efficient step towards retrieving the link between the people and their river in a meaningful and useful manner. The Arvari river is the lifeline of prosperity for 72 villages situated along its bank, and the Arvari River Parliament acknowledges this fact and just draws the logical conclusion. This river has to be taken care of, in a civilized, concerted and responsible manner.

The Way Forward

Use of Indigenous Knowledge and capacities

TBS has been able to create awareness in the community for which a strategy has been developed to involve the community both physically, emotionally and financially.

Awareness in the Community

- Awareness of various aspects of water management
- Respect for cultural, traditions and historical practices
- Will to work together for community's common interest

Working Strategy

- Constitution of Village Councils with monthly meetings of all grown ups

- Maximum possible use of traditional technology with advice from engineers where needed
- All decisions including technical (sitting, materials, design etc) by Gram Sabha
- All decisions are taken by consensus, and not majority
- Role of women in helping reach consensus
- Minimum of 30 per cent of total cost contribution is by the community rest from support agencies through TBS.

Operation and Maintenance

- Total responsibility assumed by the community

Water abstraction and Use Management

- River Parliament (Arvari Sansad) with all 72 villages of Arvari Basin represented
- Responsible for planning and enforcing sustainable use of water, particularly in agriculture

Reviving the Indigenous Knowledge: Tarun Jal Vidyapeeth

TBS runs a 9-month training for its own volunteers for many years, TBS started a Professional School of Water, Tarun Jal Vidyapeeth in 2005. The Vidyapeeth offers different courses open to all and specifically designed to fulfill the needs of young village boys and girls. The course design process itself involves the active participation of the students, to ensure a “need-based” course and their full commitment and responsibility for the revival of the indigenous knowledge system of water management.

Tushaar Shah

Sustainable Groundwater Governance: *India's Challenge and Response*

Abstract: Since independence, India has emerged as the world's largest groundwater economy, with annual groundwater use increasing from less than 50 BCM in the 1950s to over 230 BCM today. While this groundwater boom has been the bedrock of India's agricultural growth, it has also created formidable challenges in groundwater governance. Meeting the challenge of water security in the face of hydro-climatic change requires a paradigm shift in our official thinking about groundwater governance. Although the Central Ground Water Board is the custodian of the nation's groundwater resource, in reality, multiple agencies in public and private sectors have emerged as major players in India's groundwater economy. This paper reviews international experience in groundwater governance and argues for greater synergy and coordination among various stakeholders group to improve productivity, equity and ecological sustainability of India's groundwater economy.

Global Groundwater Revolution

Rapid growth in groundwater use is a central aspect of the world's water story, especially since 1950. Shallow wells and muscle-driven lifting devices have been in vogue in many parts of the world for the millennia. In British India (which included today's India, Pakistan and Bangladesh), wells accounted for over 30 percent of irrigated land even in 1903 when only 14 percent of cropped area was irrigated¹. With the rise of the tube well and pump technology, groundwater use soared to previously unthinkable levels after 1950. In Spain, groundwater use increased from 2 km³/year to 6 km³ during 1960-

¹http://dsal.uchicago.edu/statistics/1894_excel

²<http://water.usgs.gov/pubs/circ/2004/circ1268/>

2000 before it stabilized (Martinez Cortina and Hernandez-Mora 2003). In the US, groundwater share in irrigation has increased, from 23 percent in 1950 to 42 percent in 2000². In the Indian sub-continent, groundwater use soared from around 10-20 km³ before 1950 to 240-260 km³ today. Data on groundwater use are scarce; however, Fig. 1 attempts to back cast the probable trajectories of growth in groundwater use in selected countries. While in the US, Spain, Mexico, and North-African countries like Morocco and Tunisia total groundwater use peaked during 1980's or thereabouts, in South Asia and North China plains, the upward trend begun during the 1970s, which is still continuing. A third wave of growth in groundwater use is likely in the making in many regions of Africa and in some south and south-east Asian countries such as Vietnam and Sri Lanka.

Clearly, until 50 years ago, groundwater's role in agriculture was insignificant in much of today's developing world. But today, the situation is vastly different. FAO data show that over 1/3rd of the world's irrigated area of 303 m ha is served by groundwater (Table 1). In FAO data sets, groundwater irrigated areas are seriously underestimated and surface irrigated areas, seriously over-estimated in regions like South Asia as well as China (Shah 2009). As more research results become available, it is getting clear that in much of Africa

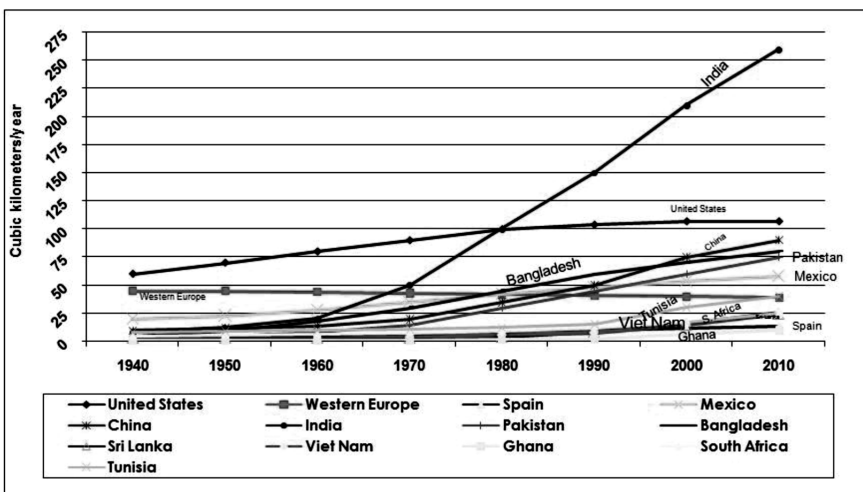


Fig.1 Growth in groundwater use in selected countries (author's estimate)

Table 1 - Part of total area equipped for irrigation by groundwater

Sl.No.	Continent Regions	Area equipped for irrigation from all sources	Area equipped with groundwater	Region's % share in groundwater irrigated area
		(1 000ha)	(1 000 ha)	(%)
	World	300,895	112,936	100
1	Africa	13,576	2,506	2.2
2	Americas	48904	21,548	19.1
3	Asia	211,796	80,582	71.4
4	Europe	22,652	7,350	6.5
5	Oceania	3,967	950	0.8

(Source: Siebert et al , 2010)

too, informal groundwater irrigation in the private sector is booming while many public irrigation systems are stagnant (Giordano 2006). In actual terms, then groundwater is likely even more important in global agriculture today than FAO numbers suggest.

Indian Irrigation at Crossroads

South Asia's irrigation economy is at cross-roads; and irrigation policies of South Asian governments, especially India and Pakistan, in a state of flux. The region's agrarian stagnation during the 1990's and thereafter has been blamed on slowdown in public investment in agriculture, mostly irrigation. However, scores of evaluations of large canal irrigation projects have found them under-performing when compared with their planning goals and targets. Over a century ago, in the preface to the second edition of his book "Irrigation Works of India" (which then included India, Pakistan and Bangladesh), Burton Buckley (1905, preface) wrote eloquently about the 'benefits which [the great irrigation works of India] confer on the people of India [which] cannot but tend to display the true beneficence of British rule in the great continent...'. Burton Buckley was able to boast that during the 7 year period between the first and second editions of his book, the 'area watered by irrigation works controlled by the Government of India increased by fifty percent' (ibid). Some hundred years later, the scenario is markedly different. Between 1990 and

2004, Government of India and various states invested US \$ 28.9 billion (at US \$=INR 45) in building new and rehabilitating old public irrigation systems under Accelerated Irrigation Benefits Program. However, benefits from government irrigation systems have declined, as the area served by public irrigation projects was reduced by over 3 million ha (Shah, 2009). “No acceleration, little irrigation, minuscule benefit” quipped a Delhi-based think-tank (SANDRP, 2006). The same situation afflicts Pakistan Punjab and Sind.

For centuries until 40 years ago, the irrigation initiative in South Asia rested first with farming communities and later with an autocratic state. The rise, since 1970, of an atomistic mode of irrigation, teeming with millions of tiny pump irrigation economies untrammelled by the state and its regulatory apparatus, is the distinctive feature that sets irrigation in South Asia (and North China) apart from its own past and from the rest of the irrigating world.

Since the onset of the 1970’s, however, South Asian agriculture has been experiencing a massive transformation with millions of privately owned wells and tube wells, which have emerged as the mainstay of small-holder agriculture. Fig. 2 shows the irrigation wells, and each black dot on this map represents 5000 irrigation wells energized by either diesel or electric pump sets. Intensive groundwater irrigation is not unique to the region; but its drivers are. The geography of global groundwater use in agriculture can be usefully divided into four socio-ecologies with distinct characteristics: (1) small-holder intensive farming systems, which emerged in South Asia and North China after 1970; (2) arid agrarian systems of western Asia and North Africa; (3) industrial agriculture systems of the U.S. West, Spain, Mexico, and Australia; and (4) groundwater-supported extensive pastoralism in Africa and Latin America. The drivers and the dynamics of groundwater use in each of these socio-ecologies are materially different; as a result, each will chart a different trajectory. This makes reflective cross-learning a profitable enterprise—and copybook transplantation of lessons counterproductive.

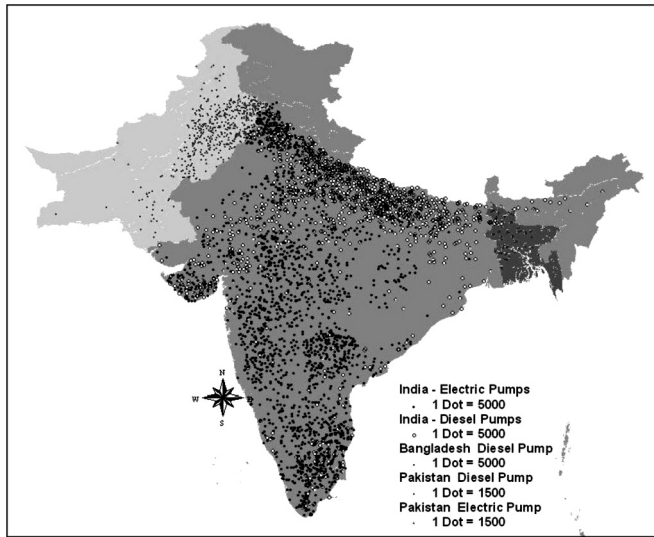


Fig. 2 - Distribution of electric and diesel pump sets in South Asia

Intensive groundwater irrigation around the world is a reflection of water scarcity; however, in South Asia, it is more a response to land scarcity. As population pressure on farmland has grown, smallholders locked into South Asia's unviable agriculture have been drawn to pumps, wells, and flexible pipes—water extraction mechanisms (WEMs)—for their land-augmenting and labor-absorbing power. WEMs enable multiple cropping and increased food and income per m^2 of farmland, they permit intensive use of underemployed family labor and scavenged water, and they afford farmers a level of control—the ability to mobilize and apply small quantities of water with high frequency on demand, year-round—that flow irrigation cannot. Strong direct links between groundwater irrigation and agrarian poverty are the hallmark of the water-scavenging irrigation economy that has come to dominate South Asian agriculture. In its early stages, pump irrigation created value by enhancing land-use intensity, but now, it is creating livelihoods by supporting value-added intensive diversification of agriculture even outside the command areas of large canal systems.

Pump Irrigation is Crowding out Gravity Flow Irrigation

The booming groundwater economy has been eroding the canal and

tank irrigation capital South Asia inherited and exposing its internal contradictions. Globally, surface irrigation thrives when the irrigation system (including its management regime) serves a small number of large customers (fewness, as in Australia); ensures homogeneous cropping, planting, and irrigation schedules on the entire command (homogeneity, as in rice irrigation systems); commands the power to enforce operational discipline on users (authority, as in the Gezira scheme in Sudan in its early years); and holds irrigators captive to an “irrigation culture” and creates an “irrigation community” (captive, as in traditional hill irrigation systems in Nepal). Many other irrigating regions of the world meet one or more of these preconditions; so did India in both the colonial and pre-colonial eras. Post-Independence South Asia increasingly meets none. As a result, despite sustained investments, surface irrigation is losing out to pump irrigation, in both relative and absolute terms.

Flow irrigation as a technology is in decline in South Asia, and irrigation management transfer to farmers’ organizations and participatory irrigation management of canal and tank systems are proving feeble responses. Therefore, it is unlikely that institutional reforms of the participatory management genre will arrest or reverse the atrophy in public and community managed flow irrigation systems. Future relevance of tanks and canal systems perhaps lies in reinventing them from a technology to deliver gravity-flow irrigation to one that can increase the supply of scavengeable ground and surface water close to farming communities.

But for the groundwater revolution, which has acted as something of a safety valve, South Asia would have arguably experienced far greater social and political instability in the countryside than it has so far. Whereas public irrigation systems could reach out to less than a 10th of the region’s smallholders, small pumps and tube wells democratized irrigation in South Asia pretty much like personal computers that have democratized computing worldwide. Thanks to its myriad and widespread benefits, the pump irrigation revolution, aided by irrigation service markets, has alleviated more poverty than most government programs.

New Water Governance Challenges

Against those livelihoods benefits, the pump irrigation revolution has produced four profound impacts on a sub continental scale. First is *environmental*: in vast and growing areas, unmanaged groundwater development is putting aquifers at risk of depletion and/or quality deterioration, with collateral damage in the form of dried-up wetlands and reduced lean-season flows downstream. Second is *institutional*: it has left the sub continental water economy more informal than it was in the 1950s, implying that a larger proportion of water diversion, use, and users in agriculture are outside the regulatory ambit of the state than was the case 50 years ago. Third is *hydronomic*: it is leaving river basins reconfigured such that public investments in surface water infrastructure begin depreciating in value even as projects are being planned and constructed. The last impact is *fiscal*: electricity subsidies began as the central cause of the pump irrigation boom during the 1970s but have now ended up throughout western and peninsular India.

So far, water governance structures and processes have little impact on mitigating, managing or coping with challenges posed by uncontrolled expansion in groundwater use. Rural communities have responded and adapted to aquifer development in myriad different ways that fall into four broad patterns with variegated socio-ecological and equity impacts: (i) In *heavily recharged alluvial aquifers* with no quality concerns, users fail to form an aquifer community and are unable to organize to produce a meaningful response, (ii) In *poorly recharged alluvial aquifers*, where users can maintain well yields by progressively deepening their wells, the resource-rich collude to monopolize access to groundwater, exclude the poor, and mobilize into powerful pressure groups to secure favorable policies through mass-based political action as evident in persistence of energy subsidies in western India, (iii) In *seemingly robust aquifers susceptible to rapid water quality deterioration upon development, as in coastal aquifer systems*, fatalism sets in early and users fail to organize for collective self-restraint and instead destroy the aquifer and move on to other livelihoods, (iv) In *hard-rock (and some confined) aquifers*, which confront their users with physical water scarcity on a daily basis, interdependence among

users can lead to destructive *rivalrous gaming* within close-knit aquifer communities, but it is also here that there are maximum prospects for *cooperative gaming*, as the experience in India over the past decade shows. With effective catalysis, users of such aquifers cooperate and mobilize to secure accelerated natural and induced recharge, evolve *some* demand management regime, and take their pump irrigation closer to sustainability.

Technology of Groundwater Governance

The technology of groundwater governance arising from the experience of industrialized countries includes five instruments: Economic incentives, Tradable property rights, Legal and administrative regulation, Participatory aquifer management, and Supply augmentation.

Economic Incentives

Using a price or a Pigovian tax is generally considered superior method of influencing human behavior than using coercion or invoking eminent domain. In China, pricing has been important in managing urban groundwater demand. Pricing works best when it is easy to measure and monitor groundwater that is where abstractors are few in number and large in volume. Where groundwater abstractors are small, numerous and poor, groundwater pricing becomes difficult to administer without awkward use of force. Jordan had to create a water police to install meters on deep tube wells and enforce pricing. As a result, while the principle of “scarcity pricing” is widely accepted, its actual practice has proved difficult in the developing world.

Tradable property rights

In the New World countries like US and Australia, secure property rights were essential to encourage settlers to make private investment in land and water development during 18th and 19th centuries. Groundwater governance in these countries is based on the premise that users *can* evolve regimes for self-governance of water resource with the state providing an overarching regulatory and facilitative framework. The institution of tradable property rights in water is

the basis for such self-governance. The experience from the US has given birth to a growing industry of tradable water rights that presents itself as a one-stop solution of problems of groundwater mal-governance. The ultimate result of creating tradable rights in groundwater, however, is by no means clear in the US or elsewhere. The impact of introducing tradable water rights in Chile has been vigorously lauded as well as roundly criticized. As with pricing, with tradable property rights, too, there is no gainsaying the principle that these can result in superior allocation of scarce groundwater. The real problem is the transaction cost of enforcement which rise in geometric progression with the number of users. Because transaction costs matter, groundwater institutions in the US and Australia carefully exempt numerous *de minimis* users to reduce transaction cost of institutional management of groundwater to manageable levels. However, if India or China were to exempt *de minimis* users that are exempted say in Kansas, Nebraska, and Australia, more than 95 percent of groundwater users would fall through the sieve.

Legal and Administrative Regulation

Governments in many countries, notably Oman, Iran, Saudi Arabia, Israel and countries in South Asia have often use laws and administrative regulation to control agricultural groundwater draft. These have worked where the state is strong - even authoritarian - and the number of groundwater users is small, as in Oman. However, almost everywhere else, administrative regulation of agricultural groundwater use has been generally poor because of lack of three essentials: popular support, political will and enforcement capacity.

Participatory aquifer management

Mexico and Spain have adapted the U.S. experience of tradable water rights and groundwater districts to promote groundwater management through farmers' organizations. Spain's 1985 water act made basin level groundwater federations responsible for resource planning and management. Similarly, Mexico's 1992 Law of the Nation's Water created Aquifer management councils, known as COTAS, for groundwater management. While the idea has great merit, the implementation of this mandate has proved difficult both

in Spain and Mexico. Mexican COTAS have played a useful role in information generation and farmers' education, but their effectiveness in managing groundwater overdraft has been poor.

Supply augmentation

Instead of demand-management, developing alternative water sources has been one of the most effective and time tested approaches for easing agricultural pressure on stressed aquifers. In the Western U.S., imported surface water supplied in lieu of groundwater pumping has been a central feature of groundwater governance for decades. The Central Arizona approach is one example; but there are many other federally supported projects that import surface water to ease pressure on and/or recharge groundwater aquifers. Spain's much-proposed water transfer project from Ebro River, China's south-to-north water transfer project and India's proposed project to link Himalayan Rivers with peninsular rivers are all inspired in part by groundwater depletion and stress. The fact that the supply side initiative is used more widely signifies the huge implementation difficulties in direct demand side groundwater management in developing countries.

The above review of experiences from around the world suggests that groundwater governance is still work in process; nowhere do we find a regime that has succeeded, in unequivocal terms, in taming the anarchy endemic to groundwater irrigation. This applies even where groundwater users number just a few tens of thousands. Trying these instruments in South Asia with more than 20 million tiny, scattered groundwater users presents a logistical challenge on a colossal scale.

Governing Groundwater in Small-Holder Intensive Agricultural Systems

Can a groundwater cess or a system of groundwater entitlements or a powerful groundwater law restore order in South Asia's irrigation economy? In theory, yes. The problem is how to make any or all of these actually work on the ground, given the atomistic nature of the Asia's irrigation economy. In Mexico, Spain, and even the United States, according to their own researchers, practice has defeated the

precept, even though their groundwater economies are much smaller and simpler than South Asia's and China's. Consider the organization of groundwater economies of the six countries listed in Table 2, with India on one extreme and the United States on the other. Indian farmers withdraw around 230 billion m³ of groundwater annually, more than twice as much as the U.S. users do. But India has nearly 100 times more independent diverters of groundwater. In addition more than half of all Indians—compared with less than 2 percent of Americans—will proactively oppose or frustrate any groundwater governance regime that hits their livelihoods. We know that transaction costs of groundwater regulation are determined less by the volume of groundwater used but more by the number of independent users involved in groundwater irrigation.

Table 2 Organization of groundwater irrigation economies of selected countries, c. 2000

Country	Annual groundwater use (km ³)	Agricultural groundwater structures (million)	Average extraction/structure (m ³ /year)	Population dependent on groundwater irrigation (percentage)	Average annual farm income per farmworker (US\$)
India	210	17.5	12,000	55–60	~350
Pakistan	55	0.9	60,000	60–65	~400
China	105	4.5	23,000	22–25	~458
Iran	29	0.5	58,000	12–18	~2,200
Mexico	29	0.07	414,285	5–6	3,758
United States	100	0.2	500,000	<1–2	67,800

Sources: www.agnet.org/library/stats/2003/24.html

The Murray Darling basin in Australia is widely acclaimed worldwide as a water governance exemplar. Yet, governing groundwater has challenged Australian water managers; and the Australian Groundwater School at Adelaide says, “Groundwater will be the enduring gauge of this generation’s intelligence in water and land management.” Many South Asian water country policy makers are hopelessly attracted to the Murray-Darling model but overlook the differences between the Australian and South Asian groundwater economies. Just 5.5 percent of Australia’s irrigated area depends on groundwater compared with more than 60 percent in India and 90 percent in Bangladesh. The 285

to 300 km³ of groundwater that South Asia withdraws every year to water crops is 50 times what Australia uses. But most importantly, South Asia has 20 million groundwater diverters—5,000 times more people to whom groundwater governance must speak.

China is discovering the implementation challenge of demand management in a vast and atomistic groundwater economy. Just issuing water withdrawal permits to some 7.5 million tube well owners is a logistical nightmare, let alone monitoring their withdrawals. Not surprisingly, Wang et al. (2007), who recently surveyed 448 villages and 126 townships from 60 counties in Inner Mongolia, Hebei, Henan, Liaoning, Shaanxi, and Shanxi, found that

“inside China’s villages few regulations have had any effect ... despite the nearly universal regulation that requires the use of a permit for drilling a well, less than 10% of the well owners surveyed obtained one before drilling. Only 5% of villages surveyed believed their drilling decisions needed to consider spacing decisions ... Even more telling was that water extraction was not charged in any village; there were no physical limits put on well owners. In fact, it is safe to say that in most villages in China, groundwater resources are almost completely unregulated.”

Constructs like integrated water resources management, which is held out as a new “philosophy of water governance,” in reality do nothing more than recycle the instruments tried by the industrialized world. The problem with IWRM-as-applied is twofold. First, it seeks to transform, in one fell swoop, predominantly informal irrigation economies into highly formalized ones, even though global experience suggests that this is a long process in which the overall economic growth of a country plays a central role. Second, by hard-selling a formulaic approach, it discourages homegrown approaches to groundwater governance with a better contextual fit. In governing its irrigation economy, South Asian policymakers would be better off working on a repertoire of indirect interventions that operate through the environment of conduct rather than through individual conduct. The operational water governance pentagram in South Asia—which can make a difference to the region’s irrigation anarchy on a here-and-now basis—suggests five arenas of action: the energy-irrigation nexus; conjunctive use of rain, surface water, waste water and groundwater; mass-based groundwater recharge;

supporting water transport and distribution by pipes instead of channels and helping communities, in the short run, cope with negative externalities rather than trying unrealistically to eliminate those externalities altogether.

The biggest barrier to effective governance of agricultural water in South Asia is institutional lock-in: the region's irrigation thinking and planning are stuck. Since colonial times, irrigation policy has been dominated by “command” and “duty” thinking in a civil engineering mode, and groundwater, soil, and water conservation were secondary considerations. Today, South Asia's irrigation economy is vastly different in its structure and organization from what the British left behind, yet mainstream irrigation policy is still steeped in the colonial mode. South Asian smallholders have now figured out to mobilize, store, scavenge, and apply water largely outside the purview of the mainstream irrigation thinking and practice. The region's irrigation planners and managers need to come to terms with the new reality, especially as hydro-climate change threatens to make irrigation management even more challenging than now.

Indian Experiments in Groundwater Governance

On demand-side groundwater management, India's track record is rather indifferent. The standard bureaucratic response has been to make laws with provisions to regulate new tube wells and the pumping of groundwater. But their enforcement has been abysmal; the sheer numbers of small-scale groundwater users makes even their identification a major logistical exercise, leave alone their constant monitoring and regulation. Limited administrative and enforcement capacity is an issue; but even more important has been the reluctance of the government machinery, and actually its sympathy for farmers. India's Central Groundwater Board categorizes areas (blocks of around 100 villages) according to the state of their groundwater development from white (under-developed) to dark, critical and over-exploited blocks where known groundwater resource has been fully or over-developed. In theory, new tube wells are banned in the latter areas; yet, come an election, the ban is relaxed. Most collateral damage associated with groundwater over-development—declining low flows,

drying up of wet lands, increasing energy costs, mobilization of harmful salts such as fluoride, etc—are evident on large and growing tracts of India.

NGOs have tried some interesting experiments at demand management. The most notable and widely publicized is Andhra Pradesh Farmer Management of Groundwater Program implemented over a dozen years with support from FAO. A recent World Bank report has held out the project as an exemplar in need of upscaling and replication. Basically, the project involved farmer communities in a program of groundwater education and monitoring using simple devices and methodologies. Groundwater data are publicly displayed in real time on Village Panchayat notice boards and farmers are engaged in discussion on how best to arrange their cropping pattern decisions based on available groundwater. The project managers claim enhanced groundwater-literacy and more enlightened decision making, resulting in reduction in groundwater withdrawals in some 700 villages. The project has now run out of funding support and more recent studies have shown that now that the funding and constant propping-up by NGO's have stopped, none of the rules of groundwater management introduced by APFMGS have survived (Verma et al. 2012).

Despite its early demise, the APFMGS experiment has left behind an ideological legacy that is turning into orthodoxy. A prominent and expensive government initiative on demand side management is Participatory Aquifer Mapping for which the 12th Five Year Plan provided a substantial sum (GoI, 12th Five Year Plan http://planningcommission.gov.in/plans/planrel/12thplan/pdf/12fyp_vol1.pdf). The original idea, derived from APFMGS -- that if farmers were engaged in systematic exploration of aquifer characteristics and processes, they would graduate to participatory aquifer management—was at the heart of this program. Giving it a good try would have required, at the minimum, a structured process of involving in the mapping exercise. However, this program has essentially reduced to a sophisticated, high-tech hydro-geological mapping of aquifers focusing exclusively on the supply side of the - equation, wholly ignoring the demand-side.

NGO's have done some more meaningful extensions of the APFMGS ideology. Kutch-based NGO Arid Communities and Technologies (ACT) has trained a small army of barefoot hydrogeologists who work with communities in sustainable development and management of aquifers. An Australian-funded research program in north Gujarat and Southern Rajasthan trained a group of local young volunteers as Bhujal Jankars (Groundwater Knowledge-ables). Gujarat's Water Supply and Sanitation Organization (WASMO) has evolved a local protocol for demand-side participatory groundwater management in Kheralu block of North Gujarat but scaling this out is a major challenge. As innovative experiments, these are all interesting. But incorporating these as components of a national participatory groundwater management program—as a new US \$ 1 billion World Bank-Government of India program intends to do is fraught with risks.

On a macro-scale, a more potent demand-management intervention has been Gujarat's Jyotigram scheme. Based on the premise that providing subsidized farm power supply in unlimited quantities is a sure formula for groundwater over-exploitation, Gujarat rewired its rural electric grid, put 1.2 million irrigation tubewells on separated feeders and imposed a daily ration of 8 hours of farm power supply alternated weekly between night and day. Accompanied by improved network management, quality of power supply and vigorous vigilance drive to curb power theft, Jyotigram has proved by far the most successful instrument of demand-side management of groundwater (Shah and Verma 2008).

Especially in India, farmers, NGOs and governments have been far more enthusiastic to augmenting the supply of groundwater resources rather than containing its demand and overdraft. This is understandable for several reasons: first, Indian agriculture has come to rely mostly on dynamic, shallow-circulating groundwater unlike agriculture in say the Middle-Eastern countries like Saudi Arabia where the bulk of the groundwater withdrawn by farmers is fossil groundwater. Second, India's high labor availability increases the feasibility of farm and community level rainwater harvesting and management options that would be unattractive to farmers in a

country like Australia. Third, the annual groundwater draft in India is just around 5 percent of the country's rainfall while the natural recharge is 7-10 percent; if farmers can help nature improve its natural groundwater recharge performance, they can make a huge difference to the groundwater balance. Of course, these gross numbers conceal wide regional variations; parts of India in the west and south that get less rainfall withdraw far more groundwater than eastern parts that get most of the rainfall and use little groundwater. Yet, even dry areas of the country get every once in a while massive rainfall events that provide opportunity to recover a part of the accumulated groundwater deficit. Finally, and most importantly, nearly 2/3rd of India is underlain by hard rock formations which have little storage and low transmissivity. Hydro-geologists consider these poor in potential; but farmer communities that try harvesting rainwater and recharge aquifers in many hard rock areas find visible change in water levels in their wells and are able to augment their groundwater supply in times of need. These do not happen in rich alluvial aquifer areas which have massive aquifer storage (as in Punjab, Haryana, western Rajasthan and North Gujarat). Community level groundwater recharge efforts have no visible impacts; and high transmissivity ensures that communities that recharge are able to retrieve very little of the water they put into their aquifers.

There is a controversy raging among hydro-geologists about whether this run-away rainwater harvesting is creating much new water and value mostly because the Saurashtra and Kutch hardrock aquifers in Gujarat have very limited storage. However, farmers in these drought-prone region swear by check-dams; and over 20 years after the movement began, constructing new check dams has still not gone out of fashion. Other evidence suggest these are helping. Since 2000, when Government of India announced a target of 4% annual growth in agriculture while national achievement has barely crossed 2%/year, Gujarat has posted agricultural growth rate of a miraculous 9.6% during 2000-2008 (Shah et al. 2009). This was made possible, among other things, by a 30% increase in groundwater irrigated area. Despite this increased groundwater use in agriculture, Gujarat seems to be the only state in India where the groundwater regime is improving.

In 2000, large areas were experiencing declining groundwater levels during May-December period when they should be rising. But in 2008, areas showing decline were much smaller. A succession of good monsoons helped; but what thousands of community level recharge structures seem to do is to enhance the drought-resilience that a good rainfall season imparts to the agricultural economy of a region.

Needed: Bold New Thinking

Reorienting South Asia’s water strategy to meet the challenge of water security under hydro-climatic change demands a paradigm change in official thinking about water management. Although the groundwater agencies of the government are the custodians of our groundwater resource, in reality, multiple agencies in public and private sectors have become major players in India’s groundwater economy. As climate change transforms groundwater into a more critical, yet threatened, resource, there is dire need to coordinate mechanisms to bring these agencies under an umbrella framework to synergize their roles and actions. Even as governments evolve groundwater regulations and their enforcement mechanisms, more practical strategies for groundwater governance need to be evolved in five spheres as outlined in Fig. 3 (Shah 2009). Synergizing the working of agencies in these spheres offers the best chance to bring a modicum of order and method to the region’s water-scavenging irrigation economy.

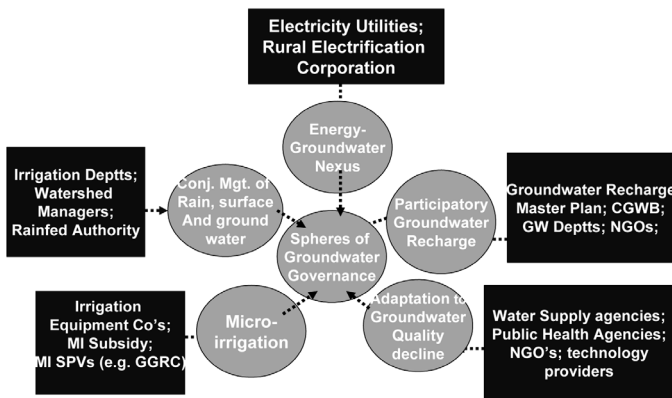


Fig. 3 - India's Groundwater Governance Pentagram

As of now, managing the energy-irrigation nexus with sensitivity and intelligence is the region's principal tool for groundwater demand management. Gujarat's experiment with 'smart rationing' of farm power supply to control groundwater draft as well as power subsidies has shown promising results (Shah 2009); but other ideas need to be tried. In the climate change context, promoting micro-irrigation on a large scale is important for the maximization of water productivity as well as energy-efficiency in groundwater irrigation.

In hard rock regions of India, Pakistan and northern and eastern Sri Lanka, mass-based decentralized groundwater recharge offers a major short-run supply-side opportunity. Public agencies are likely to attract maximum farmer participation in any programme that augments on-demand water availability around farming areas. Experience also shows that engaging in groundwater recharge is often the first step for communities to evolve norms for local, community-based demand management.

In alluvial aquifer areas, conjunctive management of rain, surface water and groundwater is the big hitherto underexploited opportunity for supply-side management. Massive investments being planned for rehabilitating, modernizing, and extending gravity-flow irrigation from large and small reservoirs need a major rethink in India and Pakistan. In view of the threat of climate change, the region needs to rethink its storage technology itself. Over the past 40 years, South Asia's landmass has been turned into a huge underground reservoir, more productive, efficient, and valuable to farmers than surface reservoirs. For millennia, it could capture and store little rainwater because, in its pre-development phase, it had little unused storage. The pump irrigation revolution has created some 300 km³ of new, more efficient storage on the subcontinent. Like surface reservoirs, aquifer storage is good in some places and not so good in others. To the farmer, this reservoir is more valuable than surface reservoirs because he has direct access to it and can obtain water on-demand. Therefore, he is far more likely to collaborate in managing this reservoir if it responds to his recharge pull (Shah 2009).

In mainstream irrigation thinking, groundwater recharge is viewed as a byproduct of flow irrigation, but in today's India, this equation

needs to be stood on its head. Increasingly, the country's 250-odd km³ of surface storage makes economic sense only for sustaining on-demand groundwater irrigation in extended command areas. A cubic meter of recharged well water, available on-demand, is valued many times more than a cubic meter of water in surface storage. Farmers' new-found interest in local water bodies throughout semi-arid peninsular India reflects the value of groundwater recharge (Fig. 4). This is evident in south Indian tank communities that are converting irrigation tanks into percolation tanks, and in Saurashtra and Kachchh, where a new norm intended to maximize groundwater recharge forbids irrigation from small surface reservoirs so that recharge gets maximized.

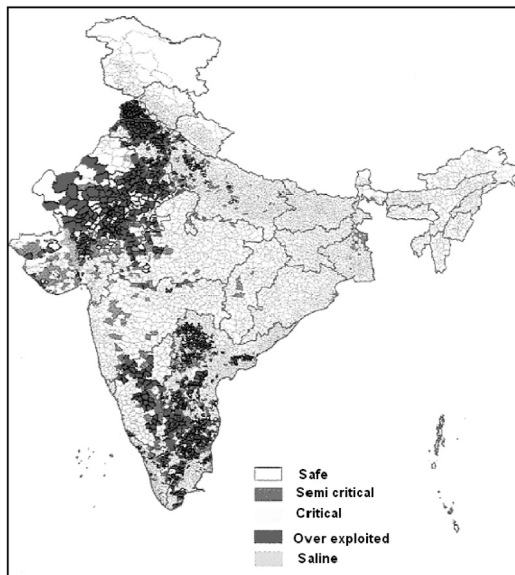


Fig. 4 - Groundwater stressed areas of India

In areas with massive evaporation losses from reservoirs and canals but high rates of infiltration and percolation, the big hope for surface irrigation systems—small and large—may be to reinvent them to enhance and stabilize groundwater aquifers that offer water supply close to points of use, permitting frequent and flexible just-in-time irrigation of diverse crops. Many canal irrigation systems have already created value by supporting well irrigation by default through farmers investing in tube wells in command areas. But canal systems need

to be redesigned to maximize recharge over a larger area than the command. While farmers are doing their bit, the management of the system itself tends to be totally antithetical to optimal system-wide conjunctive use (Shah 1993, 176–201). Surface system management is clearly in dire need of reinvention.

Surface systems in water-stressed regions of western India need to be remodeled to mimic the on-demand nature of groundwater irrigation. In Rajasthan's Indira Gandhi Canal, the government is subsidizing farmers to make farm ponds, to be filled by the canal once a month and then used to supply water on-demand. Gujarat is following suit through a new programme of supporting farmers in command areas to build on-farm storage from which they can irrigate on-demand. Integrating large canal irrigation projects in the groundwater irrigation economy may support the case for rethinking their modernization in ways previously unimagined. Replacing canal-based distribution systems below branch canals with buried pipelines may be a more efficient way of using surface storage than flow irrigation.

There is a new groundswell of enthusiasm for pipes rather than open channels to transport water throughout South Asia. The use of pipes for water transport for irrigation is also valued for at least two other benefits: first, saving scarce farmland otherwise used for watercourses and field channels, and second, micro-irrigation. Land acquisition had emerged as a huge challenge for public infrastructure projects throughout land-starved South Asia. In the *Sardar Sarovar* Project on river Narmada, in Gujarat, the major reason water-user associations refused to build water distribution systems was land scarcity. In an agrarian economy with already high population pressure on farmland, flexible pipes for water distribution make more sense than surface channels, and buried pipes are even better. Pipes also support micro-irrigation technologies. This is what explains a boom in the use of plastics in many parts of Indian agriculture. And if China's experience is any guide, this boom will continue to generate water as well as energy savings.

By far the most critical response to hydro-climatic change in India's water sector is the need for synergetic action between all players for a nation-wide groundwater recharge programme. Evolving a

groundwater recharge strategy appropriate to India needs to begin with an appreciation of the variety of actors that can contribute through different kinds of recharge structures (as suggested in table 3). Public agencies with strong science and engineering capabilities need to play a major role in constructing and managing large recharge structures. However, in India, an intelligent strategy can also involve millions of farmers and householders—and thousands of their communities—each of whom can contribute small volumes to recharge dynamic groundwater. When we approach the problem thus, new strategic avenues present themselves. India’s water policy has so far tended to focus on what governments and government agencies can do. Now, it needs to target networks of players, each with distinct capabilities and limitations. If groundwater recharge is to be a major response to hydro-climatic change, the country needs to evolve and work with an integrated groundwater recharge strategy with role and space for various players to contribute.

Table 3 - Outline of an Alternative Aquifer Management Strategy for India

Key actors	Arid alluvial aquifer areas	Hard rock aquifer areas	Roles that need to be played by CGWB, Recharge SPV, other public agencies
Farmers		Dug wells, farm ponds, roof-water harvesting; other private recharge structures	Vigorous IEC ^a campaign to promote recharge to dynamic waters through dug wells & farm ponds
			Technical support in constructing recharge pits, silt-load reduction, periodic desiltation of wells
			Financial incentives and support to recharging farmers
NGOs, local communities	Percolation ponds, check dams, sub-surface dykes; stop dams and delayed-action dams on streams		Technical and financial support to local communities, NGOs for construction and maintenance
			Supportive policy environment and incentive structures
			Support for building local institutions for groundwater recharge

Key actors	Arid alluvial aquifer areas	Hard rock aquifer areas	Roles that need to be played by CGWB, Recharge SPV, other public agencies
Canal system managers	Conjunctive management of surface and groundwater		Operate surface systems for extensive recharge
			Where appropriate, retrofit irrigation systems for piped conveyance and pressurized irrigation
			Where appropriate, retrofit irrigation systems for use of surplus floodwaters to maximize recharge
			Where appropriate link canals through buried pipelines to dug wells/recharge tube wells for year-round recharge
Groundwater recharge SPV	Recharge canals to capture flood flows for recharge (e.g., Ghed canal in Saurashtra) or transport surplus flood waters for recharge in groundwater-stressed areas (e.g., Sujalam Sufalam in North Gujarat)		Create a Special Purpose Vehicle to execute, operate and maintain large-scale recharge structures
			Build and operate large-scale recharge structures in upstream areas of confined aquifers. e.g. at the base of Aravalli's in North Gujarat
	Large recharge structures in recharge zones of confined aquifers		Build and operate large earthen recharge canals along the coasts

*Information, Education, Communication campaign

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S.P. Sinha Ray & L. Elango

Deterioration of Groundwater Quality *Implications and Management*

Abstract: Groundwater is a major source of providing water which is intensively exploited for domestic, industrial and agricultural purposes in many places of the world. In India, groundwater is getting contaminated due to geogenic and anthropogenic sources. There are increasingly widespread indicators of degradation in the quality and quantity of groundwater, caused by over abstraction and inadequate pollution control. Hence, the present study was carried out to assess the geogenic and anthropogenic contaminations in groundwater and its impacts to the inhabitants and the environment. This paper is based on the review of the contaminations due to fluoride, arsenic, iron, nitrate, uranium, etc., in the groundwater system of India. This paper aims to raise the awareness among stakeholders and policymakers, to highlight the groundwater quality issues, to provide an outline for the systematic consideration of the groundwater management, and to formulate approaches for more sustainable management of groundwater resources in developing countries.

Introduction

A major attraction of using groundwater for drinking purposes is that it usually requires little or no treatment, but this is no longer the case. The quality of groundwater is deteriorating rapidly due to geogenic and anthropogenic activities which are excessive exploitation, disposal of waste and spillage of chemicals, removal of vegetation, etc.). Active research is carried out across the globe in determining the groundwater quality of various regions since several decades where high concentration of various ions such as fluoride, arsenic, iron, nitrate, etc., in groundwater has been reported

(Brindha and Elango 2011; Custodio 2016). The problem of the high fluoride in groundwater has been reported by several researchers in India, China, Japan, Sri Lanka, Iran, Pakistan, Turkey, Southern Algeria, Mexico, Korea, Italy, Brazil, Malawi, North Jordan, Ethiopia, Canada, Norway, Ghana, Kenya, South Carolina, Wisconsin and Ohio (Brindha and Elango, 2011). The well known areas subjected to excess arsenic concentrations in groundwater are Bangladesh, India (West Bengal), Argentina (Pampas), Australia, USA, Brazil, Russia and China (Margat and van der Gun, 2012). Very high concentrations of nitrate ($>100\text{mg/L}$) in groundwater was reported in India (Zhao, 2015), and concentrations of nitrate above 50 mg/L to 100 mg/L were reported in several others countries like Australia, Argentina, South Africa, China, Mexico, Iran, USA (Zhao, 2015). Iron contamination in groundwater has become one of the most discussed issues nowadays. The high concentration of Iron is observed in several countries by many researchers in India, Bangladesh, Australia, New Zealand, China, Russia, Iran, Kazaksthan, South Africa, Brazil, USA, Canada and Sweden (Rajmohan and Elango, 2005; Lepokurova et al., 2014). Nitrate is one of the major threat to the groundwater system in India. High concentrations of nitrate in groundwater found in several regions has been reported by many researchers (Brindha et al., 2012; Verma et al., 2014). Mitigation methods has become indispensable to avoid further contamination of groundwater and also to improve the groundwater quality which requires knowledge about the causes and effects of deterioration of groundwater quality.

Various Groundwater Quality Issues in India

Geogenic sources

The high concentration of fluoride, arsenic and iron in the groundwater is due to the impact of geology and geochemical processes in an area. Fluoride in groundwater above 1.5 mg/L will be considered as not suitable for drinking purposes as recommended by (BIS & WHO). Fluoride concentration above permissible limits has been reported in 14 Indian states including, Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Telegana, Uttar Pradesh

and West Bengal. Groundwater with high fluoride concentration in different states were studied by several researchers, at Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Telangana, West Bengal.

The high concentrations of arsenic in drinking-water has emerged as a major issue. With newer-affected sites discovered during the last decade, a significant change has been observed in the arsenic contamination, especially in West Bengal and Bihar. The WHO limit for arsenic content in drinking water is 10 ppb. However, the maximum permissible limit of arsenic in drinking water is 50 ppb (if alternative source is not available) according to BIS. High levels of arsenic in groundwater above permissible limit was found in the alluvial plains of Ganges covering six districts of West Bengal. Some other Indian states which are affected by arsenic in groundwater are namely Bihar, Chattishgarh, Jharkhand and Uttar Pradesh.

High concentration of iron in ground water has been observed in more than 1.1 lakh habitations in India. The permissible limit for iron in groundwater is 0.3 mg/L as per WHO guidelines. The highest value (52 mg/L) has been found in Lakmipur, Assam. Deterioration of groundwater quality by iron has been reported in Assam, Chhattisgarh, Karnataka, Orissa and West Bengal. Localized pockets are observed in states of Bihar, Uttar Pradesh, Punjab, Rajasthan, Maharashtra, Madhya Pradesh, Jharkhand, Tamil Nadu and Kerala. The geogenic contamination of groundwater due to iron in Assam was studied by several researchers, Chhattisgarh, Karnataka, Orissa and West Bengal.

The chronic exposure of uranium radionuclides in groundwater is a potential health risk factor in India. The permissible limit of uranium in groundwater is 0.03 mg/L as per WHO guidelines. The high concentration of uranium in groundwater occurs in Andhra Pradesh, Jharkhand, Orissa, Meghalaya, Rajasthan, Telangana and Punjab.

Anthropogenic sources

Industrial discharges, urban activities, agriculture fertilizers and disposal of sewage wastes are affecting the groundwater quality adversely. Leakage of spills from oil tanks, release of chemical

effluents from dyeing industries, fertilizers and pesticides applying to agricultural land, leakage in septic tanks and from waste disposal sites tend to accumulate and migrate to the groundwater table leading to contamination of the groundwater system. Such contaminations can render groundwater unsuitable for potable use.

Agriculture

Intensive use of chemical fertilizers and pesticides in the agricultural land results in the leaching of the residual nitrate causing high concentration of nitrate in groundwater. Nitrate can cause the health problems in infants and animals, as well as the eutrophication of water bodies. Groundwater with nitrate concentration of above 13 mg/L is considered to be contaminated by anthropogenic activities. However, the maximum acceptable limit of nitrate concentration in potable water is 45 mg/L (BIS) and 50 mg/L (WHO). In India, nitrate concentration above permissible level of 45 mg/L has been reported in 14 states, Andhra Pradesh, Bihar, Haryana, Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Telengana, West Bengal and Uttar Pradesh.

Industries

Due to rapid industrialization growth, major cities of India generates large quantity of industrial effluents which is dumped in to the nearby water bodies. The shallow aquifer of Ludhiana city has been polluted by the stream effluents from 1300 Industries around the city. The chemical effluents from tanneries in Vellore district of Tamil Nadu were released into Palar river that contaminates the groundwater of the region. The disposal of untreated effluents from various industrial units in Baddi-Barotiwala Industrial belt of District Solan, Himachal Pradesh results in the contamination of groundwater by heavy metals. The extensive industrial activities in the region of Pydibhimavaram Industrial Area, Andhra Pradesh, India resulted in the contamination of aquifer due to chloride, sulfate, nitrite and trace elements of Fe, Ni, Cd and Pb from the industrial effluents. The industrialized area where petrochemical storage tanks are located in Chennai, Tamil Nadu, was affected by PAHs pollution from early 90's. In addition, a recent survey undertaken by Centre for Science

and Environment, eight places in Gujarat, Andhra Pradesh and Haryana has been reported with traces of heavy metals such as lead, cadmium, zinc and mercury.

Aquifer Contamination Relation Dynamics

Geochemical analysis is the major approach for defining ionic concentrations in groundwater. The nature of groundwater is very complex and it becomes challenging for interpretation. Consequently, the origin and chemical composition of groundwater can vary considerably. Hence, it is necessary to thoroughly examine the spatial and temporal groundwater chemistry in an aquifer to interpret the sources and processes of groundwater contamination.

Spatial variation in Groundwater quality

Spatial variation of hydrochemical constituents of groundwater acts as tool to interpret the hydrogeological condition of the aquifer. The predictable changes in quantity and quality of dissolved constituents in groundwater during the transit of areas of recharge and discharge is useful to analyze the physical and hydrogeological properties of groundwater system. Variations in different geologic formation can cause the changes in groundwater chemistry. Mineral composition of rocks, weathering pattern, soil type, flow pattern, flow pattern, vegetation cover, and climate change are the major phenomena to determine the groundwater chemistry. Significant difference in geochemistry of groundwater is observed at varying depths also accounts for spatial variation.

Temporal variations in Groundwater quality

Temporal variations of aqueous chemical constituents within hydrogeologic environments provide a valuable insight into the natural physio-chemical processes, which govern groundwater chemistry. Temporal variation is an approach to examine the variation of ionic concentration with elapsed time at each well. The temporal variations in chemical concentration of groundwater is attributed due to: rapid groundwater movement after recharge in shallow aquifer system, natural or artificial fluctuations of the zone of saturation into and

out of weathering profiles and mixing of groundwater of differing chemistries in highly pumped aquifers.

Impact on Public Health

The most widespread groundwater contamination in India is Fluoride. The next important contamination is Arsenic. Both Inland brackish water and coastal saline water under marine and estuarine contribute to Salinity hazards. Iron and Manganese in ground water are also widely distributed in India. Uranium, Radon and Strontium contamination from geogenic source, reported from limited areal extent in parts of the country. Chromium pollution in ground water is due to anthropogenic activities, specially in leather industrial areas. Selenium contamination is localised in Punjab and Himachal Pradesh has also been reported. Nitrate contamination, resulting from biologic nitrification process mainly due to agricultural activities has caused point-source pollution in various parts of the country. Uptake of excess level of the above contaminants in the human health through drinking water and through food chain can be described as under.

Arsenic

Significant research on health effects of chronic arsenic toxicity in human has been carried out in India during the last thirty years. The symptoms of such toxicity are dependent on the magnitude of the dose and duration of its exposure. Pigmentation and Keratosis are the specific skin lesions characteristic of chronic arsenic toxicity. 'Raindrop' pattern of pigmentation normally marked in the non-exposed part of the body, such as trunk, buttocks and thighs. Arsenical hyperkeratosis appears predominantly on palms and the plantar aspect of the feet. It has been observed that the men had two to three times the prevalence of Keratosis and pigmentation compared to those for women apparently ingesting the same dose of arsenic from drinking water.

The evidence of carcinogenicity in humans from exposure to arsenic has also been detected. Other diseases from arsenic toxicity may be respiratory distress due to irritation of mucous membranes, resulting into laryngitis, bronchitis, myocardial depolarization and cardiac arrhythmias that may lead to heart failure, gastrointestinal effects

like burning lips, painful swallowing, thirst, nausea and abdominal colic. Anaemia and leucopenia are also common. Arsenic exposure during pregnancy can adversely affect several reproductive end points including spontaneous abortion, preterm birth, still births, neonatal and prenatal mortality have also been documented. Chronic exposure to arsenic may also cause skin cancer, urinary bladder cancer and lung cancer in addition to Gangrene, Pedal Oedema (non-pitting) etc. Guha Mazumder et al (2015) has indicated from studies of impact of dietary arsenic intake in human body can provide a potential pathway of arsenic exposure even where arsenic intake through water was reduced to 50µg/l in arsenic endemic region in West Bengal.

Fluoride

Excessive intake of fluoride (more than 1.5 mg/l) may result in slow, progressive crippling scourage known as Fluorosis. However, low level fluoride is required by human system in preventing Dental Carries. (Sinha Ray, 2015). Normal level fluoride in water, urine and blood is upto 1 mg/l, 0.1 mg/l and 0.02 mg/l respectively.

Fluorosis occurs in three forms: dental, skeletal and non-skeletal Fluorosis (Figure:2). Dental Fluorosis becomes visible from discoloration of permanent teeth aligned horizontally and/or discoloration in spots away from gums, mostly in children. The dental Fluorosis is the loss of luster and shine or dental enamel, discoloration starting from white, yellow, brown to black. Skeletal Fluorosis is due to excessive quantity of fluoride deposited in the skeleton, being more in cancellous bones compared to cortical bones. In skeletal Fluorosis, generalized bone and joint pain occur in mild cases which are followed by stiffness of joints with restricted movement of spine and joints. Finally flexion deformity develops in spine and joints. Crippling deformity includes Kyphosis, Scoliosis flexion deformity of knee joints, Paraplegia and Quadriplegia. Skeletal flurosis affects both children and adults. Non-skeletal Fluorosis includes ill effects of skeletal muscle, Erythrocytes, Gastro-Intestinal System, ligaments or combination of all. Compared to female patients male patients are highly affected by non-skeletal Fluorosis due to calcium deficiency in Red Blood Cell as also due to strenuous work.

Iron

High iron (more than 0.3 mg/ltr) makes the taste of the water astringent. It may appear brownish due to precipitation of ferric hydroxide and may stain utensils, laundry and equipment. As per EPA, although iron in drinking water is safe to ingest, the iron sediments may contain trace impurities or harbor bacteria that can be harmful. Excess iron stored in Spleen, Liver, Bone marrow can cause Haemochromatosis. Chronically consuming excess amounts of iron causes iron overload. Iron overloading may lead to haemochromatosis, a severe disease that can damage the body's organs. If it is not treated, it can lead to heart disease, liver problems and diabetes.

Manganese, Uranium, Radon, Strontium, Chromium and Selenium

Manganese is easily concentrated in the brain, especially in the basal ganglia which can cause irreversible neurological syndrome similar to Parkinson's disease. Water containing low amounts of Uranium is usually safe to drink. Intake of a large amount of Uranium might damage the kidneys. Long term chronic intakes of uranium isotopes in food, water or air can be carcinogenic. Prescribed limit by WHO is 15 µg/l. Prescribed radioactivity exposure limit is 1 mSv/year. A study conducted in U.S.A. estimates 12% lung cancer deaths (Grans, 1985) are linked to radon (radon-222 and its shortlived decay products). Strontium is non-toxic and a daily intake of 0.8-5 mg is harmless, if it contains non-radioactive strontium. The risk involves from intake of radioactive strontium is mainly carcinogenic and mutagenic mechanism, possibly increasing infant mortality. The toxicity and carcinogenic properties of Chromium (III) in the cell can lead to DNA damage. The acute toxicity of Chromium (VI), due to its strong oxidation properties can reach the blood system and damage kidneys, liver and blood cells through oxidation reactions. Selenium exposure in humans takes place either through food or water with symptoms like loss of finger, toe nails and hair and progressive deterioration of health. It can also cause nausea, headache, tooth decay, staining of teeth and nails with brittleness and longitudinal streaks.

Nitrate and Salinity

Ingestion of Nitrate can cause met-hemoglobinemia in infants under six month of age. Bacterial reduction from nitrate to nitrite in the intestinal tract is responsible for this disease. Severe met-hemoglobinemia may result brain damage and death. Intake of high level of nitrate for a longer period is linked to gastric problems due to the formation of nitrosamines in adult human. In India, it has been estimated that about 2 million hectares of land are now affected by brackish to saline water. Generally such brackish water occurs within 100 m depth. Salinity does not cause serious health effects as compared to geogenic contaminants.

Mitigation Measures

Potential mitigation techniques are vital for improving the quality of contaminated water. The mitigation methods vary depending on the origin, type and nature of contamination. Avoiding the potential zones of contamination is the best way, but water scarcity and limited options of alternate source prevents us, and therefore better technological and economical mitigation strategies should be adopted.

Critical concerns

The primary task of providing contaminant free safe water needs to address the following critical concerns:

- Water quality monitoring and Health Risk Assessment.
- Identification of contaminated as well as safe sources.
- Provision of alternate sources of safe drinking water.
- Establishing a transparent system of information sharing by all stakeholders.
- Long-term change in Agriculture and Irrigation practice, restricting the use of ground water in critical areas.

Technology options

Based on the experience in India and neighbouring countries, the

following are major technological options for providing safe water in groundwater contaminated areas:

- Tapping ground water from alternate pollution (Arsenic, Fluoride, Chromium, Nitrate etc.) free aquifers at a deeper levels and scaling-off the polluted aquifer on the top.
- Large scale surface water based piped water supply for the communities by drawing water from the rivers and treating them for pathogenic microbes.
- Conservation and quality upgradation of traditional surface water sources like ponds, dug wells etc.
- Removal of pollutants from ground water by In-situ and Ex-situ Treatment techniques.
- These technologies can be used both large, medium and short scale water supply projects. Domestic filters for households uses can also be developed based on such appropriate technologies.

Policies and Strategies for Ground Water Quality Management

Effective policies for ground water protection must consider the institutional and cultural environment in the country, the interrelationship of quantity and quality of ground water, financial viability of any proposed measures for protection and acceptability of the measures to society. It is essential that effective policy development includes the public, government agencies and other stakeholders potentially affected.

International practices

The European Union (EU) water policy for ground water protection has been based on six basic principles: a high level of protection, application of the precautionary principle, the prevention of pollution, the rectification of pollution at source, adoption of the polluter pays principle and the integration of environmental protection in to other policies such as agriculture, transport and energy. The policy also included water pricing and ensuring that the

citizen is more involved in decision making. It also emphasized that “The Polluter Pays” principle will be incorporated through the use of appropriate economic instruments.

Indian perspective

Safe drinking water is a constitutionally guaranteed right in India. According to the Constitution of India water supply is a State subject and the Union Government is only responsible for setting standards. State Governments have established departments for supply of domestic water in urban and rural areas who are also to look after the quality of the water supplied. The National Water Policy (2002) of India also states “Both surface and ground water should be regularly monitored for quality. A phased programme should be undertaken for improvements in the water quality.” It is estimated that around 37.7 million Indians are affected by water-borne diseases annually, resulted economic burden being \$600 million a year.

The over-dependency on ground water has caused 66 million people in 22 States at risk due to excessive fluoride and around 10 million people at risk due to arsenic in 6 States. There are also problem due to excessive salinity, specially in coastal areas, iron, manganese, nitrates and other contaminants. The major ground water contaminants that affect human health are fluoride, arsenic, nitrate and faecal coliforms. Most of the ground water coliforms and related pathogens accounts for a number of waterborne disease like diarrhea, gastro-enteritis, jaundice, hepatitis, cholera, typhoid, polio etc.

Chakraborti et al (2011) examining India’s ground water quality management suggested a variety of policy options like artificial ground water recharge, increasing ground water efficiency, improving crop productivity, agricultural diversification and reducing uncontrolled ground water withdrawal promoted by highly subsidized agricultural electricity, educating and mobilizing communities by creating awareness of challenges and empowering the communities for ground water quality protection.

Groundwater quality data assimilation

The primary step towards ensuring ground water protection is to

generate reliable and accurate information about the water quality. While CPCB and State PCB laboratories has set standards for surface water effluent quality, the Bureau of Indian Standards (BIS) has been responsible for developing drinking water quality standards for India. The Central Ground Water Board (CGWB) along with the State Ground Water agencies are primarily responsible for monitoring ground water quality. Other institutions like National Environmental Engineering and Research Institute (NEERI), the National Institute of Hydrology, the All India Institute of Hygiene and Public Health, various Universities etc undertake regular water quality research. All State Public Health Engineering Departments have established water quality testing laboratories in State, district and zonal levels. The huge Data on ground water quality being collected by different agencies, need to be collated and data Banks need to be established, both Centrally and State wise.

Institutional issues for policy development

A groundwater quality protection policy framing requires primarily creation of a Policy Task Force involving Key Institutions of Environment, Health, Agriculture, Industry, Water Resources and Local Government with the setting up of a Lead Agency to co-ordinate the Policy and strategy for groundwater protection and management. Effective institutional frameworks and clarity and accountability of responsibilities facilitate achieving objectives of ground water protection.

Capacity – building

To support an intersectoral approach, inter-disciplinary training is required to ensure the necessary competence and skills to resolve ground water issues. It is necessary to treat the catchment as an integrated unit for both planning and management purposes. Community based water quality monitoring approach may yield better results. Education of local people in both aspects of hygiene and availability of resources quality-wise will help in improving public health.

Legislative framework

The Easement Act, 1882 provides every land owner with the right

to collect and dispose, within his own limits, all water under the land and on the surface (Suhag, 2016). This gives landowners significant power over ground water, and excludes landless ground water users from its purview.

As water falls under the State List of the Constitution, State Legislative Assemblies can make laws on the subject. The Central Government through publication of Model Bills (2011) provide guidelines based on which the States can choose to enact their laws. Under Article-21 of the constitution, the Supreme Court and various High Courts of the Country have delivered verdicts on concerns such as access to drinking water and on the right to safe drinking water as a fundamental right.

Abstraction rates of water may have a fundamental influence on water quality. Its control requires a sound legal basis and good enforcement. There is a realization worldwide that individual rights need to be sub-ordinate to protection of quantity and quality of groundwater and 'rights' may be substituted by 'permissions'.

Groundwater quality monitoring

Four major objectives of monitoring ground water quality such as determination of background ground water quality, determination of permit compliance, detection of groundwater contamination and characterization of the effectiveness of corrective action. They also found that ground water quality Variables may sometimes exhibit seasonality and predictability cyclic behavior and are frequently non-normally distributed. It was also found that significant variability occurs in vertical concentration gradients, horizontal concentration gradients, time or volume of pumping, sample collection procedures and data management procedures and suggested skewness test for evaluating the normally assumption in ground water quality data.

Tools for groundwater quality protection

Some specific tools and incentives may be employed to maximize the impact on groundwater protection policies and regulation which include establishing integrated pollution control measures, use of prohibition and the use of codes of practice. The use of incentives

is often as effective as the use of prohibition or controls. Legislation developed for general environmental protection and pollution control can be employed to deal with the activities which affect the quality of ground water. Important tools can be used to protect ground water are Wellhead protection plans, Vulnerability assessment, Codes of practice, economic instrument, education, community awareness and involvement and land use planning.

Aquifer mapping and aquifer modeling

Scientists are increasingly taking the help of mathematical simulation techniques in different types of ground water development schemes based on evaluation of hydrogeological mapping and information collected thereon. Applying a model is an exercise in thinking about the way a system works without any deteterious effect. Aquifer mapping should be suitably designated to collect accurate and precise informations about hydrological and hydrogeological components pertaining to concerned aquifer system to be modeled. Nevertheless, aquifer modeling is going to be the emerging tool in ground water protection in near future.

Land use planning and management

Land use planning and pollution of ground water are interrelated. Land uses and economic activities, partially in drinking water catchments, need to be under government regulatory control. Most planning controls to protect ground water quality are implemented by local Governments but should be incorporated into national planning policies and regional planning regulations. Controls on land zoning and sub-division imposed by State Governments can be very effective tools for protecting groundwater. Practices that cause groundwater pollution may be changed by providing incentives. Tax incentives to use less susceptible to leaching or degradation of soil by a specific type of fertilizer or pesticide can be an effective tool. Price mechanism can also be used to restrict the amount of contamination that reaches groundwater Stringent application of “Polluter Pays” principle may reduce the contamination effect.

Water resource management

Water Resource Management that can have an impact on ground

water quality is artificial recharge to ground water system using potable water. Artificial recharge helps in diluting some pollutants in the aquifer. Maintaining an effective water balance by controlling discharge-recharge relationship can also enhance the sustainability of ground water development schemes. Rain Water Harvesting practices can be an important means to sustain large scale ground water withdrawal resulting quality hazards, specially in small watersheds and mini-water supply schemes. Since the practice is proving to be quite effective, it is necessary to have such wise water management and a national approach should be developed to ensure that artificial recharge and rainwater harvesting schemes form the integral part of the overall ground water quality protection strategies.

Consultation and participation

Understanding the needs of the community is a pre-requisite and part of the process of establishing a dialogue from which a mutual trust can be developed for achieving common goals and plans. Continuous information gathering and educating the stakeholders on knowledge, attitudes and practices are important for ensuring accuracy of assessments, monitoring of progress and change and establishing trust among Stakeholders. Transparency of information dissemination is extremely important and requires development plans. This process can ensure ownership of the process by all involved. Community participation is an ongoing process of information gathering dialogue and negotiation.

Mass awareness and social empowerment

IEC material should be suitably tailored to create sufficient awareness among the rural and urban communities about early precautionary signals related to the diseases like arsenocosis, fluorosisetc based on the sound water quality monitoring.

Issue of social convergence

Different agencies including the Government of India are propagating decentralized water quality testing along with other agencies. There is a need to address the issues of monitoring and intervention jointly, involving NGOs, Government agencies and other Stakeholders.

Community awareness needs to be built up in the context of such social convergence by upgrading the existing laboratories managed by both Government agencies and NGOs so that capacity in terms of monitoring, analysis of microbial parameters data management, at the local level can be enhanced. There is a need for addressing bacteriological and chemical contamination in totality.

Nutrition Management

The nutrients and the sources often recommended for Nutritional Interventions for fluoride and arsenic are calcium (milk, dahi, green leafy vegetables, sesame (Til) seeds, cheese/paneer, drumstick, arbi, etc) iron (beet root, apple, raw or green banana), Vitamin C (amla, guava, lemon, oranges, tomato, spouted cereals and pulses), Vitamin E (vegetable oil, nuts, whole gram cereals, dried beans, etc), Antioxidants (papaya, carrot, pumpkin, mango, spinach(palak) and other leafy vegetable, garlic, onion, chilli, pepper, cabbage, cauliflower, radish, leechi, watermelon, soyabean, mushrooms, ginger, sweet corn etc). For arsenic patients, selenium rich food like meat etc have also been found useful.

Conclusion

Toxicity in ground water has already posed considerable problems in India. Protecting ground water from toxic contaminants, geogenic and anthropogenic, needs effective management. Ground water system, very complex in nature, the chemistry of toxic chemical, constituents in ground water, source of contaminated chemical constituents and the efficacy of different component of ground water quality protection have not yet been completely understood. Because of uncertainty in planning for ground water protection, it is imperative that ground water quality plans be continuously reviewed and reassessed. Effective steps need to be taken commensurate with availability of the technology options.

Acknowledgment

We would like to Thank Mr. M.Thirumurugan, Research Scholar, Department of Geology, Anna University, Chennai for his assistance in the preparation of this chapter.

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Sunita Narain

Temples of Modern India

Introduction

Every country has to mind its water business. But for a country like India, where it rains for roughly 100 hours of the year, the management of water becomes even more critical. It literally determines if the country remains poor or becomes rich; diseased or healthy. In other words, water is the determinant of its future.

What is clear is that the issue of water is not about scarcity but about its careful use and about its equitable and distributed access. Water is the starting point for the removal of poverty in the country. It becomes the basis of food and livelihood security. Water management strategies will need to be carefully designed so that they lead to distributed wealth generation. This will require reworking the paradigm of water management, so that it is designed to harvest, augment and use local water resources so that it leads to local and distributed wealth generation. It is also clear that local and distributed water infrastructure, will require new forms of institutional management as water bureaucracies will find it difficult to manage such vast and disparate systems. It is here that India's learning from its traditional community based water management systems will be critical.

Over the past some years, there has been recognition of the need to invest in local and distributed water systems. But as the drought in Maharashtra revealed the programmes for building, restoring and rejuvenating ponds, tanks and other water structures remain deeply flawed.

The largest investment in water management is through Mahatma Gandhi National Rural Employment Guarantee programme

(MGNREGA)¹. Under this programme, over 5.5 million water conservation structures have been created in the past 8 years. But the fact is that thousands of these valuable assets remain incomplete or simply abandoned. The programme, built on the right to employment, does not emphasise the need for completion of the developmental work. In this way, drought relief is not used to become a permanent relief against drought and water insecurity grows.

Groundwater crisis

This adds to the crisis of groundwater availability, as recharge is limited but withdrawal is unabated. Call it is one of the unknown Indian ironies. Over many years, the Indian state, through its public irrigation agencies, has systematically taken over the management of surface water systems. It has taken over the job of building irrigation systems - dams, reservoirs and canals - then maintaining these and supplying water. This has meant that over the years it has taken over water resources from the hands of village communities. The irony is that even as the state has vested this power in itself, people have taken water under their control. Groundwater - a resource under the land of individuals and under their control - irrigates the bulk of lands in the country.

This irrigation infrastructure, comprising of some 20 million wells and dug wells, shallow and deep tube wells has been created by individual farmers² - both rich and poor - using funds available from moneylenders or the meagre institutional finance provided by state credit agencies. It can be well argued that this lack of institutional support for infrastructure and the dependence on private finance is one key cause of farmer indebtedness and poverty in large parts of the country.

The intense use of this resource has meant that groundwater levels across the country are falling sharply. Technology is allowing for deeper and deeper penetration and extraction. The electricity subsidy

¹R. Mahapatra, M. Suchitra, Moyna, Down To Earth Vol 20 Issue 14 Dec 15, 2011 “A million opportunities lost

²Ministry of Water Resources, 4th Minor Irrigation Census <http://micensus.gov.in/Findings.html>

- providing cheap energy for pumping - worsens the situation, with estimations that farmers end up using almost double the water for each unit of crop when they have access to cheap or free power as compared to pump-sets using paid diesel.

We can try and regulate this use with legislation. But clearly regulating the use of 19 million users will be difficult, if not impossible. What we have to recognise is that groundwater is a replenishable asset and what is needed is to recharge wells, so that annual extraction is limited to what is sustainable. In other words, we work groundwater like a bank. Live off the interest—what is recharged—and not the capital.

This is where the irony doubles. Even as groundwater has overtaken surface water systems, other irrigation systems - tanks, ponds and all other community-based and decentralised water harvesting systems—have simultaneously declined. But the fact is that these systems played a critical role in the recharge of groundwater as they stored rainwater, which then recharged underground aquifers. These were the ‘distributed’ sponges without which ‘distributed’ water management would not be possible. Therefore, we are extracting more and more, recharging less and less.

The tragedy is that when we lost respect for traditional systems, which were designed to ensure that rainwater was stored in millions of disaggregated, diverse structures, we lost our water future. Clearly, we must understand the politics of technology to understand the economics that will matter.

Climate Change challenge

This community based decentralized water management becomes even more critical in the age of increased weather risk because of climate change and increased variability of rainfall. Just think. Every year like clockwork India is caught between the specter of months of crippling water shortages and drought and then months of devastating floods. In 2016, there was no respite from this annual cycle. But there was something new and strange afoot. Each year, the floods are growing in intensity. Each year, the rain events get more variable and more extreme. Each year the economic damages

because of floods and rain increases and again, development gains are lost in one season of flood.

Scientists now say conclusively that there is a difference between weather and its natural variability and climate change a pattern brought about by human emissions that is heating up the atmosphere faster than normal. Scientists who study the monsoons tell us that they are beginning to make that distinction between ‘normal’ monsoon and what is now showing up in abnormal extreme rain events. This remember when the monsoons are that extremely capricious and confounding natural event, hard to predict and even harder to pin down. Even then scientists can find the change.

All this is further complicated by the fact that multiple factors affect weather and another set of multiple factors affects its severity and impact. In other words, the causes of devastation following extreme events - like droughts or floods - are often complicated and involve mismanagement of resources and poor planning.

For instance, we know floods - currently ravaging parts of Assam and Bihar - are caused by unusually high rainfall. But it is also clear we have destroyed drainage in floodplains through utter mismanagement. We build embankments believing we can control the river only to find the protection broken. Worse, we build habitations in floodplains. Similarly, urban India is mindless about drainage – storm water drains are either clogged, full of garbage, sewage or just do not exist. Our lakes and ponds have been eaten away by real estate – land is what the city values, not water. In all this what happens when extreme rainfall events happen – the city drowns.

This makes for a double-whammy: on the one hand, we are mismanaging our water resources, intensifying floods and droughts. On the other hand, climate change is beginning to make the country even more vulnerable because of increased frequency of extreme weather events.

The disaster that shook the mighty Himalaya in 2013 was a deadly combination of these two factors. Himalaya are the world’s youngest mountain range, prone to landslide and flash floods. But what we do not easily comprehend is that two factors have made the already

vulnerable region more hazardous. One, climate change-related extreme weather events. Two, mismanagement of development intervention in the past decade or so. This Himalayan region has seen unchecked construction activity, illegal and legal mining, unscientific road building and, of course, hydropower projects built bumper to bumper.

Traditional systems: the way ahead

The way ahead is to respect the vulnerability of the region. It cannot be anybody's contention that the Himalayan region must not see development. The question to consider is how it should develop: by building roads and hydropower projects or local economies based on tourism, which do not work against nature. It is also a fact that changing monsoon pattern will require us to optimise use of every drop and not allow rain to become devastating flood. Only then will the Himalayan tragedy not be repeated.

Therefore, Indians know that the monsoon is the real finance minister of India. Clearly the opportunity is to make sure that every drop of this rain is harvested and used in the prolonged dry season. But this rain will make in more ferocious events, which also means that we must engineer to capture it across the country. We must plan for drainage so that when rain comes it can be channelized and optimized. Holding and channelizing rain must become the nation's mission. It is our only way to the future.

This does mean that every water body, every channel and every catchment of rain has to be safeguarded. These are the temples of modern India. Built to worship rain.

Civil Society in the Water Sector

Introduction

Most often water governance debates are centred on either institutional reforms within the State or the scope and constraints of implementing market solutions. Considering the nature of the water development issues which touches all sections of the society, all spheres of development and stakeholders that are often unrepresented, there is need to examine the role civil society organizations can play in improving water governance. This article is a quick analysis of the civil society's contributions in water sector through certain case studies in order to understand what gaps do exist in making optimal use of the civil society in water development and management and by no means is claimed to be the chronicle of involvement of civil society in the water sector in India.

According to the Johns Hopkins University's Centre for Civil Society Studies¹ which quantifies the contributions of civil society, 75 percent of civil society actors spend their time delivering social services, education, health and more to vulnerable populations. This is a sector that shows its greatest impact in communities. The engagement of civil society and other stakeholders in the run up to adoption of Agenda 2030 for Sustainable Development by the UN General Assembly in September 2015 served to greatly enrich the debates and build global awareness.

It is fully recognized that Sustainable Development Goals (SDGs)²,

¹ Lester M. Salamon, S. Wojciech Sokolowski, Megan A. Haddock, and Helen S. Tice, (2012) "The State of Global Civil Society and Volunteering: Latest findings from the implementation of the UN Non-profit Handbook. Working Paper No. 49, Baltimore, Johns Hopkins Centre for Civil Society Studies

² United Nations, 2015, "Transforming our world: the 2030 Agenda for Sustainable Development", Resolution A/RES/70/1 adopted by General Assembly on 25 September 2015.

which aim at tackling the world's biggest problems, starting from eradicating poverty to reducing inequality, require development to be more inclusive by ensuring greater involvement of all stakeholders including CSOs which work outside the spheres of State and business. CSOs can play a vital role in the implementation of the Agenda 2030 by stimulating and supporting governments to create opportunities for dialogue with all stakeholders. SDG 17, related to the 'Means of Implementation' therefore has identified a target to "Encourage and promote effective public, public-private and civil society partnerships".

Civil society in water sector in India

The phrase 'civil society' in India³, which gained general currency since the beginning of the 1990s, collectively defines individual and organisational initiatives for public good. It is also known as the social sector, the non-profit sector or the "third" sector. In India the term covers: (i) Community-Based Organisations (CBOs), (ii) Mass Organisations, (iii) Religious Organisations, (iv) Voluntary Development Organisations (VDOs), (v) Social Movements, (vi) Corporate Philanthropy, (vii) Consumer Groups, (viii) Cultural Associations, (ix) Professional Associations, (x) Economic Associations.

Since the 1980s, civil society groups have come to be more popularly known as NGOs and they have become more focussed in their actions. In the water sector and perhaps in other sectors as well, the voluntary movement can be broadly categorized into three major groups: development NGOs, advocacy NGOs and the activists.

The traditional development NGOs work in a village or a group of villages and demonstrate various means of water conservation practices etc. These NGOs engage themselves in a variety of rural development and social issues and their entry point may or may not be water. Although there are thousands of such organizations active at the village level, the two important names that come to the mind are the Tarun Bharat Sangh and the Ralegaon Siddhi experiment

³Tandon, R. (2002a), *Voluntary Action, Civil Society and the State*, New Delhi: Mosaic Books

that have resulted in rural transformation through better watershed development. The experiences of Tarun Bharat Sangh are presented elsewhere in this volume.

The second group of NGOs are those who lobby with the government or with industry or petition the courts for improvement in the sector based on research in a particular issue. A well-known example of an NGO of this type in the environment field who are active in water sector is the Centre for Science and Environment (CSE). For example, CSE picked up samples of well water and then submitted the results of the chemical analysis to a court because the organization had not been able to get the factory to change its polluting practices in any other way.

The third group can be said to include community of volunteers who see themselves as advocates of certain cause also called activists. Of course, all NGOs undertake a certain amount of activism to get their points across – they petition the bureaucrats, they alert the media whenever they find something wrong and so on. But this third group of NGOs see activism as their primary means of reaching their goals, because they do not believe they can get the authorities to move in any other way.

Perhaps the most-known example of an NGO in this category in the water sector is the Narmada Bachao Andolan (NBA), an organization that opposed the construction of a series of large dams in the Narmada river valley of central India. They oppose the dam construction ostensibly for the reason that it entails displacement of people upstream of the dam. The members of this NBA adopted confrontational approach on the construction of Sardar Sarovar Project in Gujarat delaying the entire development process. They ended up creating a make belief atmosphere that all large dams worsen water scarcity for the majority of the people in the long run rather than solve the scarcity problem. The conduct of NBA has resulted in creating a trust gap between the government and NGOs in water sector in India.

There is a strong view in the development sector that some of the NGOs belonging to this activist category fail to take a holistic development approach and focus on narrow perspective and take a

piece-meal approach focussing on a limited aspect of development. So much so that often they allow themselves to be a prey to an unscientific approach. For example, the debate on environmental flows in India is presently mired in emotional rhetoric and is largely devoid of scientific reasoning.

Realising the need for bridging some of these gaps between development facts and fictions, Ministry of Water Resources had encouraged setting up of a few civil society organizations in water sector such as: Indian Network on Participatory Irrigation Management (INPIM), Indian Water Partnership (IWP) and the Indian Water Resources Society (IWRS).

Indian Water Resources Society (IWRS) was founded in 1980 with main objective of advancement of knowledge in technical and policy aspects of water resources development and management. IWRS, acting as a think-tank was intended to serve as a platform for free and frank discussions amongst those concerned with water related issues and facilitate co-operation among the civil society with the Government agencies instead of confrontation. Concerned with the rise in the misinformation campaign unleashed by misplaced activism, IWRS has been advocating for open and informed debate based on the scientific facts rather than relying on unintended myths. They have intended to be a source of scientific information on seemingly complex issues. IWRS advocates for peoples' informed participation for which they initiated celebration of the Water Resources Day since 1988, which was subsequently adopted by UN as World Water Day, observed on 22nd March every year. Unfortunately IWRS has failed to live up to its mission of providing a multi-stakeholders' platform and organize open debates. One of the major cause for the failure of IWRS lies in its management structure as it has been headed and managed by the same people who are in-charge of the sector in the government.

Established in 2001, IWP is a non-profit organization that promotes IWRM. Largely supported by Global Water Partnership, IWP networks with other NGOs active in water sector in the country by hand-holding them and also to make them allies in advocacy, influence state policies and reinforce knowledge sharing, communications, and capacity building at the grass root level.

Civil Society organizations in water sector at international level

Civil society movement within the water sector at international level came to the forefront with the setting up of a network of institutions from around the world as Global Water Partnership (GWP) in 1996 to foster integrated water resource management (IWRM), an approach that has its origins in the guiding principles for action in the Dublin Statement issued at the International Conference on Water and the Environment (ICWE) in January 1992. GWP network is open to all organisations involved in water resources management: government institutions, professional associations, research institutions, non- governmental organisations, and the private sector. It has helped establish Country Water Partnerships as well as some Regional and Area level partnerships.

In the same year World Water Council was formed as an international multi-stakeholder platform to promote awareness, build political commitment and trigger action on critical water issues at all levels, to facilitate the efficient conservation, protection, development, planning, management and use of water in all its dimensions on an environmentally sustainable basis for the benefit of all life on earth. The World Water Forums organized every three years is the flagship activity of the Council. Indian linkages with these international civil society movements has been weak at almost all levels: the government, the institutional, civil society or at the individual level.

Examples of Successful Civil Society Interventions in India

In a large developing country like India, despite best efforts by the government numerous gaps in the development process do remain – sometimes intentional, sometimes due to lack of funds and sometimes due to lack of awareness. NGOs play an important role in filling these gaps. In the last 20 years or so, a very large number of NGOs in India have been active in the development process especially in the area of environmental safeguards.

In the context of water sector the focus has specially been on ensuring access to and control of people (including the most marginalized sections) over water, Here normative issues of social

justice, equity, participation, sustainability etc becomes important along with ensuring accountability of State in its functioning in the water sector. Empowering the NGOs and engaging them constructively for the overall benefit of the society is marred by controversies with questions of accountability, legitimacy and most importantly transparency.

It is important as well necessary to understand the developmental role played by the Civil society organizations especially their role in governance including the scope and constraints of NGOs as civil society actors in governance as well as to learn from success stories of working with government as service providers and indirectly influencing public policies including learning from the past experience the scope and constraints of influencing public polices through confrontational politics to bring in structural changes.

Before involving NGOs in government lead development activities, it is important to understand why do NGOs work with the government and what is the motive and the logic behind such collaboration. An understanding of the core values that define the work of NGOs and how these values are different from those in the spheres of government is crucial. The strategies of such organizations could be manifold ranging from collaboration to working as development appendages of the government along with occasional confrontations on specific issues. At the same time it is also important to be aware of the external factors like donor funding that influence policy and the responses from civil society. At the same time it is important to evolve parameters of 'success' such as equity, gender relations, and efficiency of delivery and how NGO strategies do strengthen peoples' abilities to access and manage water better. Care needs to be taken to avoid a situation where NGOs are getting so close to the government that their credentials for independence and autonomy are lost or weakened as a result.

Five case studies that have been recognized as successful civil society interventions and have earned international recognition from UN-Water during the last five years have been presented in appendix to this article, as follows:

Case I¹ : Community mobilization and safe water access – One Drop, Project India

IEC Minutes Item 1: Case II² : IWMI-Tata Water Policy Program, India

IEC Minutes Item 1: Case III³: *Bhagirath Krishhak Abhiyan*, Water Conservation for Food Security

Case IV⁴: Farmer Participatory Capacity-Building Programme for Drip Irrigation Management

Case V⁵: Protection of Bangalore Lakes for Posterity – Environmental Support Group.

The case studies cover local to national level interventions in various sub sectors in the water sector. These interventions cover the entire spectrum of interventions such as bridging the gap between Science and Policy, local sustainable solution in WASH, encouraging water harvesting, capacity building in use of new technology; and seeking legal intervention to assert societal right above the private and individual profiteering. More than organizational interventions, these initiatives raise fundamental questions on the current water development paradigm. Most of the case studies are social actions in response to the context – most are in a spatial context, which have relevance beyond the geographical area they were implemented.

So far, most of these interventions have worked at a micro-level: in a village, in a watershed or a small basin. Without sustained support and participation of the larger communities it is difficult to upscale these initiatives. It is important to recognize that successful intervention from NGO requires a dedicated leadership and the support of its stakeholders – users, local water management authority, community-

¹Winner, 'Water for Life', UN-Water Best Practices Award, 2015, <http://www.un.org/waterforlifedecade/winners2015.shtml>

²Winner, 'Water for Life', UN-Water Best Practices Award, 2014, <http://www.un.org/waterforlifedecade/winners2014.shtml>

³Finalist, 'Water for Life', UN-Water Best Practices Award, 2012, <http://www.un.org/waterforlifedecade/winners2012.shtml>

⁴Finalist, 'Water for Life', UN-Water Best Practices Award, 2013, <http://www.un.org/waterforlifedecade/winners2013.shtml>

⁵Finalist, 'Water for Life', UN-Water Best Practices Award, 2012, <http://www.un.org/waterforlifedecade/winners2012.shtml>

based organisations (CBOs), volunteers, etc.; and sustained financial mechanism and hydrologically sound activities – to operate and sustain itself. However the causes of successes and failures have not been adequately identified, fully examined or adequately documented. The possibilities of upscaling such community based initiatives – either as larger projects or through greater number of such projects – have not been adequately explored. There is a strong case for intervention in upscaling such NGO initiatives by making suitable policy interventions, providing adequate legal framework, establishing support mechanism or undertaking capacity development to ensure that they are economically feasible and environmentally sustainable.

Conclusions

The guiding principles of responsive governance are accountability, transparency and participation and the key attribute and criteria of its success is the process. Responsive governance for development, particularly in water sector, requires empowered government-citizen relationship where accountability of the officials is towards citizens and stakeholders. Unfortunately, there is no formal platform or mechanism for developing such a relationship with stakeholders in the water sector. There is need to develop a relationship of mutual respect shifted even more toward one of cooperation, complement, and mutual empowerment.

Water sector governance will be served positively if the influence, effectiveness and pit falls of the activities (related to public advocacy) of voluntary organizations and social movements at different levels in the country are acknowledged and analysed. It is important to accept the gaps that might be existing in the delivery of water related services and identifying the character of the space for civil society action to bridge that gap. In order to unleash the vast potential coiled up in the civil society organizations engaged in water related activities, the government needs to undertake the following steps to get their positive and constructive support:

- a. Create enabling environment for capacity development of the grass root level NGOs through a consortium of knowledge base professional NGOs;

- b. Support professional civil society organizations such as India Water Partnership to be able to provide multi-disciplinary perspectives and create an independent evaluation mechanism;
- c. Analyse and understand the reasons and obstacles in scaling up the successful NGO initiatives;
- d. Recognize that such reasons may vary from region to region and the culture of cooperatives and the past history of success (or failure) and accordingly adapt.

The government should consider supporting NGOs financially, consider their policy proposals seriously, and on occasion even enact these into laws.

Appendix

CASE I: Community mobilization and safe water access – One Drop, Project India, (Winner, ‘Water for Life’, UN-Water Best Practices Award, 2015)

Background

One Drop uses water to drive change with a unique approach that empowers people to improve their living conditions. Called the “ABCs of Sustainability”, it is based on 3 complementary components designed to establish a solid foundation on which communities can build and flourish: Access to Water and Sanitation (“A”); Behaviour Change through Social Arts (“B”); Capital/ microloans (“C”) for economic development. Project India is rooted in the “A” and “B” components. It is implemented in Odisha, which is among the seven poorest Indian states. Carried out over four years (2011- 2014), it implements sustainable solutions to the problem of poverty through a WASH program designed and implemented by Gram Vikas whereby a 100% coverage method ensures access to a toilet, a bathing room and water availability 24/7.

The project

The purpose of the project is to facilitate and accelerate participation and thus the implementation of Gram Vikas’ program in 100 villages by developing artistic activities firmly rooted in local culture to raise collective awareness, educate and mobilize the populations around WASH issues. ONE DROP draws inspiration from circus creativity to develop professional artistic activities in order to inspire people and enable the process of social change. Using a community approach, the project directly benefits more than 58,000 people of both genders, all ages and castes.

Results achieved

Globally, the behaviour change activities helped to raise communities’ awareness and understanding of the impacts of poor hygiene. The

activities generate a sense of empowerment for villagers who feel they are no longer beneficiaries but real participants in the project. The artistic workshops successfully contribute to “transform” villages from reluctant to engage in the WASH program to understanding its value and potential, helping to reach the 100% consensus for Gram Vikas WASH program. Indeed, 74% of the target population have reached consensus and are now engaged in the program, with 16% of villages already fully covered. Following the workshops, an improvement of the sanitation and hygiene behaviours could be witnessed in several villages where, for instance, women were no longer using the local stream to bathe and toilet use had increased. As reported by the villagers themselves, the practice of open defecation has reduced and children have demonstrated better hygiene practices.

The entertaining nature of the artistic activities ensures the participation of all categories of people, effectively breaking the caste, class and gender divide. Finally, conflicts over water have decreased in some villages, demonstrating how social arts can generate engagement and alleviate social disparities.

**CASE II: IWMI-Tata Water Policy Program, India,
(Winner, ‘Water for Life’, UN-Water Best Practices Award,
2014)**

Background

The IWMI-Tata Water Policy Program (ITP) was initiated in 2001 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo, and Sir Ratan Tata Trust (SRTT), Mumbai. Its mandate is to undertake policy research in the domain of water-environment-agriculture-livelihoods. Besides several other relevant research themes, one of the cornerstones of ITP’s research has been on the Energy-Irrigation Nexus. ITP was not only the first to highlight the criticality of this nexus but has been at the forefront of developing ideas for co-management of energy and groundwater, both key facets of agricultural livelihoods in India.

The core concept behind ITP was that while there is a lot of

potentially useful scientific research being conducted in India, it often does not reach the policy makers – who are willing and keen to learn from science – because neither the research objectives nor the research design are formulated with them in mind. Thus, ITP tried to fill the gap between research and policy action by simultaneously engaging with scientists and policy makers, by asking the right questions, and often by turning problems on their head to strive towards practical, action-able policy recommendations based on sound scientific principles. Towards this, ITP partnered with a large number of stakeholders and involved them in the process of research. ITP is also an example of an international scientific institute working – not as a grantee but as an equal partner – with an Indian donor to set the agenda for discussion, debate and policy action around India’s water-environment-energy-agriculture-livelihoods future.

Challenges

The challenges of the energy-irrigation nexus continue to be important in the Indian context, with different regions and states facing different challenges and trying out different solutions. While states like Gujarat and Punjab opted for feeder separation to improve rural power quality, West Bengal and Madhya Pradesh have resorted to giving temporary power connections to farmers during peak irrigation period and trying to create an alternative regime of metered farm power supply.

In eastern and tribal central India, where groundwater is relatively abundant but villages often lack electricity supply, farmers are forced to depend on diesel to run their irrigation pumps. This creates a paradoxical situation where in regions with rapidly depleting groundwater, farmers get free or highly subsidized power supply (therefore they face no economic scarcity), while in regions with abundant groundwater resources farmers tend to economize on irrigation due to expensive diesel. As a result of this and other food policies, water scarce India ends up exporting ‘virtual water’ (embedded in agricultural commodities) to water abundant India. ITP researchers have argued that before India spends US\$ 120 billion to physically transport water to water scarce regions, India’s food

policies must sync with water (and land) endowments to correct the perverse direction of virtual water trade.

Actions

Considering these recommendations from the scientific community, in 2005-2006, the Government of Gujarat launched the Jyotigram Yojana (JGY) programme and spent Rs. 11.7 billion (US\$ 250 million) to completely re-wire the state by separating agricultural feeders from domestic and industrial ones. This was done in conjunction with broader structural and organizational reforms in the Gujarat Electricity Board. The agricultural feeders were now offered 8-hours of uninterrupted, high quality power supply as per a pre-announced bi-weekly roster while the domestic and industrial feeders were offered 24*7 power supply at commercial and near-commercial tariffs. Several studies on the impact of JGY, including the ones carried out by ITP found substantial benefits of JGY in terms of improvements in quality of rural life as well as impact on the farm economy. The Government of India has now accepted Gujarat's Jyotigram initiative as a flagship scheme for its 12th five-year plan for the power sector.

By providing regular and reliable full-voltage power, JGY made it possible for farmers to keep to their irrigation schedules, conserve water, save on pump maintenance costs, use labour more efficiently and expand their irrigated agriculture rapidly. While the gross domestic product from agriculture grew at just under three per cent per annum for India as a whole, Gujarat recorded nearly ten per cent growth in the seven years from the project's inception in 2003 - the highest in India. While other factors have also contributed to this growth, JGY is definitely one of the key drivers of agrarian growth in Gujarat.

Lessons learnt

This practice has shown that practical solutions are sometimes better than optimal ones. JGY kept all parties happy and delivered spectacular results both for farming and water conservation. Pricing might have been a more straightforward solution, but it was

unpalatable to farmer groups. Partnerships and relationship building are critical in research for sustainable development. The initiative has shown that research uptake works best when it responds to issues already high on the political agenda.

CASE III: Bhagirath Krishhak Abhiyan, Water Conservation for Food Security, (Finalist, 'Water for Life', UN-Water Best Practices Award, 2012)

Background

Though India has only 40% cultivable area under irrigation but because of dependency on groundwater for irrigation a substantial geographical area has become either grey or dark. Over exploitation of ground has led to loss in productivity and production and in certain cases the complete crop failure. This has resulted into many thousand farmer suicide in India. Similarly Dewas district of Malwa plateau of Madhya Pradesh province also is facing acute water scarcity problems. It has an annual average precipitation of between 900 mm (40 rainy days) which is less than national average. Cropping intensity is only 120% with limited livelihood options and distress migration in the region whose main sufferers are poorest of the poor specially the women. The production and productivity has been going down in the region.

The project

Conscious of the problems of farmers in the region, the district administration led by Mr. Umakant Umrao, who was posted as District Administrator of Dewas in February 2006 stressed on the harvesting of rain water as possibly the only solution to overcome water woes of the district. The administration emphasized on the construction of cost effective and locally managed rainwater harvesting structures.

Aware of the problems often associated with building, maintaining and managing community water harvesting structures and frequent conflicts over distribution of available water in these structures, the

proposed approach emphasized construction of decentralized rain water harvesting structures on the lands of individual farmers with an idea to promote conjunctive use of available water for sustainable and zero risk growth. It was argued that such an approach while helping avoid the problems associated with community water harvesting structures would give the owner farmers complete control over the available water and lead to a more efficient use of the available water.

In India the land holding per family is very less and so is the surplus money to invest. In this situation translating the concept in to realistic application posed a great challenge for the administration. One, the farmers have always strongly resisted giving away even a small part of their cultivable land for non-cultivation purposes. Two, the administration did not want to use the instrument of giving subsidy to the farmers to either encourage them to invest in water harvesting or to partly meet the upfront cost of construction or as a compensation for the loss in production that the farmers would suffer on account of a part of cultivable land going out of production.

Carefully treading the process of implementation, rather than launching the approach in a big-bang way, the program started in the year 2006 with the district administration approaching initially the relatively bigger farmers (with more than 4 hectares of agricultural land) and in persuading them to change the usage of 1/10th to 1/15th part of their land for water conservation cum harvesting structure which could store runoff water during the monsoons (rainy season) and thereby assure the availability of required water for irrigating during the dry Rabi (Second crop) season. The farmers could also use part of the stored/conserved water for providing lifesaving irrigation to even Kharif (Rainy season) crops during the occasional long gaps that may come across between two rainy days during monsoon season as well.

Results achieved

There are now more than six thousand ponds in Dewas district alone, and the number is ever increasing. The impact can be calculated from the fact that total of all irrigation efforts by the Government

/Individual since independence brought an additional 3% growth in 50 years with assured irrigation whereas this movement increased such percentage by 12% in 5 years. The effort has won 5 National Awards for augmenting ground and surface water.

Agricultural intensity and productivity has increased many times. Entire mandi (Market of Agriculture produce) system has been relocated to facilitate the marketing of produce. Agriculture has diversified and farming systems have improved and farmers have shifted from Soybeans based mono crop to kharif (First crop), rabi (Second crop), and zaid (Third crop), to multi cropping. There is a reduced requirement of fertiliser per unit of agricultural land. Water user efficiency in pond irrigation is more by 30% compared to other types of irrigation.

In some cases entire villages have been covered with pond irrigation. The economy has transformed with huge increase in agricultural productivity, multiple livelihood options, and increase in agricultural productivity and number of employment days. For example village Dhaturia in Tonk Khurd has 120 households and 154 ponds.

Multiple livelihoods including dairy and fisheries have evolved and the employment days and minimum wages have gone up for the individuals. It has been noted that quality cattle breed has been introduced and milk productivity has increased up to 34% within a short period. Increased availability of vegetables, fish, milk and increased production of food grains has resulted in perceptible change in nutritional levels. Improved biomass has bettered the quality of livelihood for farming families. The women who earlier suffered from the drudgery of fetching water could now actually contribute to the family's growth. The enrolment ratio in schools has been much better. More over pucca houses have replaced the old kutchha structures.

**CASE IV: Farmer Participatory Capacity-Building Programme for Drip Irrigation Management (TND RIP)
(Finalist, 'Water for Life', UN-Water Best Practices Award, 2013)**

Background

In Tamil Nadu State, India, only about 8% of the drip irrigation farmers used the drip irrigation system effectively. Hence, to enhance the full potential of drip irrigation, a drip irrigation capacity building initiative titled TND RIP was undertaken in Tamil Nadu, India, during the period 2009-2012. A consortium involving different stakeholders (scientists, officials, drip suppliers, NGOs and leading farmers) was formed in project implementation. A cluster approach was used in selecting the villages and farmers for the capacity building program. Hands-on training in the farmers' fields was provided to all the farmers, including women, by the team of trainers. Regular feedback was obtained from the farmers about the program.

The project

The main objective of the program is to impart knowledge through capacity building to ensure the sustainability of drip irrigation practices amongst farmers. More specifically, to:

- Impart training to farmers at the village level on drip layout, water budgeting, drip fertigation and drip maintenance;
- Develop capacities in component technologies like vermi-composting and mulching;
- Establish a network between drip farmers, research institutes, government departments, private firms and marketing agencies for upscaling adoption of drip irrigation; and
- Upscale drip irrigation to other regions.

Results achieved

The program covered 1,000 farmers from across 100 villages during the period 2009-2012. The program has also created better awareness and adoption among the drip farmers in other areas. Thus, coverage of the program in creating awareness involved about 10,000 farmers in a three-year period. An Impact Assessment Study of the TND RIP program was carried out in February, 2012, to understand the impact of adoption of all the core drip maintenance practices in 11 crops cultivated by the adopters. The yield increases and water savings were

significant, ranging from 17 to 36%. Also, it created awareness of drip irrigation amongst the community, and this created the demand for its extension in other regions of the state. Also, farmers who were not adopting drip started investing in drip irrigation after seeing the success of the training program.

CASE V: Protection of Bangalore Lakes for Posterity – Environmental Support Group, (Finalist, ‘Water for Life’, UN-Water Best Practices Award, 2012)

Background

Bangalore, the capital of the Indian state of Karnataka, currently draws about 1400 million liters per day (MLD) of water from River Cauvery that flows 100 km away and which meets just over half the city’s needs. The rest of the city’s water needs are drawn from fast depleting groundwater resources the quality of which is also deteriorating. Increasing dependence on the river will not work as there is a cap on withdrawal from this highly contested river as it flows through many states where there are ever increasing demands from industrial, agricultural and urban sectors. There is serious concern that such high water stresses could easily escalate into community discord and possibly affect inter-state relations as well.

Historically, communities across South India developed a network of small and large lakes interlinked to form a larger watershed to provide critical water security in a semi-arid region otherwise dependent only on seasonal rivers. This helped recharge groundwater, provide surface water for a second crop in the non-rainy season, improved local climatic conditions and provided for the emergence of biodiversity rich wetland ecosystems.

The current metropolitan area of Bangalore (approx. 1400 sq. km.) had over 600 such lakes till about two decades ago and these provided water for drinking, irrigation, horticulture, and industrial activity. In addition, they served as important wetland habitats, especially to migratory waterfowl. Urbanisation has caused serious damage to these lakes systems in recent decades and contributed to deterioration

and dislocation of lake communities that protected and maintained these commons. Today, these lakes are sites of serious contamination and encroachment, and less than 450 lakes survive in various stages of deterioration. This has had a debilitating impact on groundwater levels.

There were serious efforts by the Government during the late 1980s to save Bangalore's lakes as a step towards utilising the waters to augment the city's ever growing water demands, and also as a measure of conserving them as commons and biodiversity hotspots. Subsequent decades failed to build on this work and soon corrupt forces encroached lakes for real estate, gross administrative neglect contaminated them, resulting in the prevailing dismal state of affairs. The challenge now is to alleviate this situation and rehabilitate lakes and their interconnecting canals with community-government-corporate action under the supervision of the judiciary.

The project

When the Environment Support Group (ESG) began addressing this situation about a decade ago, most saw this as a futile and dangerous struggle against well organised corrupt forces. Yet ESG persisted, organised local communities, and ran a series of campaigns for conservation of lake systems. These were backed by multiple workshops to build awareness about the criticality of protecting these waterbodies for the benefit of present and future generations. The basic intention was to ensure that lakes remained as commons, and that they were functional ecosystems that provided a variety of livelihood, cultural and social services. Law and policy was evolving to support such an understanding of lakes as commons, though the schemes and programmes of government agencies had lagged behind. As privatisation of lakes gained ground, the approach was largely accepted by middle class Bangalore as a progressive one.

The theme of reclaiming the commons evolved as an idea in peoples' minds, and they began to see that privatisation of lakes would result in the exclusion of their access to them. Soon what were small numbers of supportive people grew into large networks, resulting in significantly large protests in 2007 and 2008 against

Lake Privatisation. The positive outcome of this was also that local communities began to step forward to secure their lakes which were being encroached and polluted.

ESG then moved the Karnataka High Court in a Public Interest Litigation (Writ Petition 817/2008) which resulted in two major reliefs: a status quo was ordered on the ongoing privatisation of lakes and a Committee involving nine agencies of the Government officiated by a sitting Judge of the Court was constituted to develop a comprehensive plan and strategy to protect and conserve Bangalore's lakes for posterity.

The Court appointed Committee commenced its work in December 2010. A series of meetings were held to hear the submissions of various parties. All agency heads were required to participate in every meeting along with their supportive technical staff. As key petitioner and initiator of the idea, ESG was asked to assist the Committee in formulating the report. This was achieved by February 2011 and every public agency of the Committee arraigned for the tasks subscribed to the proposal. Under the direction of the Court on 3 March 2011, this document has become binding on the Government.

Results achieved

When the 450 lakes that remain now are completely rehabilitated along with their interlinking canal networks, a massive absorption of rain water into groundwater aquifers due to percolation from within the lake systems is anticipated. For urban communities this will be a significant boon: wells and tube-wells will find water levels rising, water quantities and quality will improve, and there would be decreasing energy demands in drawing water out. For peri-urban and rural communities, mostly based on subsistence farming, which supply vegetables and other farm produce to the city, this means safer water, better crop growth and thus improvement in yields. Fishing communities will prosper, once more, thus providing for a better family life that has suffered over the past decade substantially. Similar would be the prospect for cattle grazing communities; access to safe water would also mean better milk yields.

The environmental relief that clean and well conserved lakes provide

is unmeasurable. Mid-winter Waterfowl Census over the past two decades have revealed that there is a significant decline in the carrying capacity of lakes in supporting the variety and numbers of local and migratory waterfowl due to pollution and loss of lakes, especially over the past two decades. The present plan is absolutely designed to ensure that the ongoing rehabilitation of lakes is to promote them as wetland habitats, thus improving their capacities to support waterfowl and a variety of other flora and fauna.

With ongoing efforts, urban residents will significantly gain access to sylvan open spaces, providing a variety of environmental and public health benefits. Overall, this effort will have significant positive gains in a highly water-stressed city. The urban poor will benefit the most, as none of these possibilities exist for them in the current scenario.

D T V Raghuramaswamy

Sustainable Water Management in India *Financing Aspects*

Abstract: For nearly seven decades, Government of India and many states governments have invested heavily in irrigation sector. It is estimated that about INR 4820 billion has been spent to create an irrigation potential of 42 million hectares through major and medium irrigation¹. And nearly one and half times of that amount is required to develop the remaining potential during the next quarter century. Such a scale of investment is not possible to be catered based on conventional investment and implementation modalities alone, but would need active participation and collaboration of various stakeholders, including users, private sectors and financial institutions.

Academic literature presents limited evidence of engaging with private sector as most initiatives are for improving efficiency and service improvements. Direct capital investment and maintaining an asset for a long period of time would need to be supported with appropriate revenue mechanisms. Involvement of other stakeholders, notably the private sector, does not have a long precedence in irrigation and drainage sector world over, and particularly in India. Past experiences and learnings indicate that there is a lack of robust revenue model, and conducive framework to enable better participation. All the revenue models envisage collecting monies from user charges. Given the nature of holdings, societal structures and political & institutional set ups, ability to pay higher user charges is limited in India. As an illustration, a viability (financial) analysis has been undertaken to estimate the extent of user fees required to fully

¹Irrigation projects are classified based on culturable command area (CCA) as – Major having CCA more than 10000 hectare (ha), Medium having CCA between 2000 ha to 10000 ha and Minor having CCA less than 2000 ha

pay for an irrigation project. Also an assessment is done to see if any ancillary revenues would help in alleviating the user charges needed. Suggestions for developing an equitable water pricing mechanism, from various studies are consolidated and presented.

Introduction

It is anticipated that with increasing population, India would need about 380 million tonnes of food production from the current levels of approximately 260 million tonnes. Meeting this demand would imply a significant increase in availability of land under cultivation, productivity and water. Irrigated agriculture plays an important role in increasing yields as compared to rainfed agriculture – producing 40% of food supply from 20% of the irrigated land. Improving rainfed production with improvements in soil moisture conservation, rainwater harvesting and applications of limited water at key growth stages through supplemental irrigation can also play a big role in sustainable food production. Thus, expansion of irrigation wherever feasible, modernization of existing irrigation systems along with other supply and demand side management options for optimal utilisation of limited land and water resources is the need of the hour. Irrigation also provide a defence against droughts, which are predicted to occur more frequently. In India more than INR 4820 billion have already been spent over the last 65 years or so far for creation of irrigation potential of about 42 million hectare (mha) through major and medium irrigation. It is estimated that another INR 7200 billion would be needed at present day costs to create remaining potential. Under a business as usual approach, this may take another 20-25 years to create the balance irrigation potential. In India provision of formal irrigation water supply services is mainly with the government agencies, which often fail to provide either reliable and timely services in equitable manner to many stakeholders (especially the poor) or services provided is of poor quality.

Water charges and cost recovery of investments on Irrigation and Drainage (I&D) works has been a debatable issue for many decades. The inability of I&D projects to generate adequate revenues has always been a question mark on project's viability, especially when it

comes to low charges that are being charged for irrigation water and due to a small percentage of farmers who actually pay the charges. In some of the projects, expense accumulation rates are almost zero, even when water charges are well below the cost of project operation and maintenance (O&M) expenditure. This creates serious concerns both for irrigation project proponents and, in the long run, for users and other stakeholders. This essentially requires Governments to fund projects out of budget and general tax revenues.

Water fees are collected from users primarily for two main reasons - first to recoup invested amounts (either capital expenditure or the O&M costs or both), and second to encourage users to use water efficiently (appropriate quantum per unit of output or produce) to generate greater net economic returns per unit of water. In order to ensure overall development and flow of funds, economic principles dictate that the cost and pricing waters should match with each other.

Economists and planners usually recommend that subsidies incurred in different sectors of the economy should be explicit. Subsidies for irrigation water or power are both direct and indirect and are sometimes disguised in budget allocations. This exerts undue pressure on the government on account of uneconomic water rates and cheap power, especially if compounded with concessional credit for irrigation works. In India, during the last decade, there has been a little progress in appropriation of the volumetric pricing of water through participatory irrigation management. A few states/ projects have adopted volumetric pricing to a limited scale. However there is need to encourage this as with volumetric water pricing, amounts to be paid depend on the quantum of water conveyed and consumed. Financial principles dictate that price ought to be set equivalent to the cost of providing water, and it requires precise estimation of water through meters. The upside of this valuing technique is that it urges users to measure and consume exactly as much as they need. However, there are multiple challenges in implementing such a system ranging from willingness and ability to pay, reasonableness of investments and recurrent expenses and equity in provision of water.

I&D Sector Financing, Water Pricing and Allocation

Financing of I&D Sector Projects

Asian countries have invested billions of dollars of non-renewable resources on development of water system potential, which they have been receiving in the form of domestic and international aid in the past four decades. While basic infrastructure has been created, still a large extent needs to be accomplished to become more efficient/productive that needs further capital investments.

Financing of irrigation and drainage projects is conventionally undertaken through budgetary resources, and with assistance of multilateral and bilateral funding sources. Over the years, various national Five Year Plans and state budgets allocated monies for development of this sector. However, as the magnitude is huge, coupled with a need for improving the sector performance, external borrowings were sought to be utilized. Multilateral agencies such as the World Bank, Asian Development Bank and bilateral agencies such as JICA², GiZ³ participated in Indian I&D sector. These agencies typically provide sovereign guaranteed long term loans (say for 20 – 30 years) at low rates that are used for a specific project or a group of projects. This assistance, in some instances, is provided along with technical grants that could be used for capacity building of implementing agencies and to prepare project documents (detailed project reports, environmental and social safeguards compliance, setting up of project monitoring units etc.). However, accessing such loans is through national level agreements, in which states have limited say. Some loan conditions may have provisions for policy and institutional improvements that state governments need to adhere to. Usually national budget support and monies from external borrowings cover a part or full capital expenditure, while operations and maintenance (O&M) is sought to be managed by state or implementing agency. As O&M expenses are also of huge magnitude, there has been a continued stress on finances of these agencies.

²Japan International Cooperation Agency

³Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German aid agency)

Since both domestic and international resources are becoming increasingly difficult to obtain due to limited availability and competing needs, more attention is also being paid not only to the generation of financial resources to meet the operation and maintenance expenses of existing projects, but also to the recovery of capital invested in the past to fund new projects. There is likewise acknowledgment among national governments and benefactor organizations that past investments in water system improvement have not been paying profits owing regularly to problematic and inefficient use of existing water systems. Continued financial support to this sector is sought to be augmented by two other sources – collecting user charges from those who consume water, and soliciting private sector participation in a few projects. Revenue collection from user charges depends on number of users brought into this ambit and rates that are proposed to be charged. Given the holdings size in India, as conventionally water has been provided free / accessed free of cost, there is a challenge to get these farmers to adopt system of user charges.

Public Private Partnerships Experience

Government departments and other project proponents have been exploring public private partnerships (PPPs) as a means to improve efficiency in general, but also raise finances in particular in infrastructure sectors. PPP frameworks in irrigation sector are quite nascent and have not really taken off similar to the trend witnessed in transport sector. In this format, it is anticipated that private sector puts in varied amounts in capital expenditure, O&M expenses and manage the project, and recoup its investment through a variety of means including user charges, grants/ payments from government, utilizing ancillary facilities such as land, putting project resources to other uses etc. National Water Policies also consider PPP as one of options for raising finances for I&D projects. Internationally, PPPs are used in service oriented frameworks for improving efficiency and occasional infusion of investments. International experience indicates that PPP is successful if public sector substantially contributes to the capital costs and private parties are made responsible to undertake O&M activities. But, in India since there are a large number of small and marginal farmers with low land holdings (0.5 ha to-2 ha)

and income levels, governments will have to step in with payment guarantees and setting out suitable revenue risk sharing mechanism to encourage PPPs. Despite provision in National Water Policy and number of enabling initiatives undertaken by the government, unlike other sectors, there is practically no evidence of PPP involvement in case of irrigation projects in India in present times as private party perceives lack of crucial conducive framework and a robust revenue model to make investment decisions. Numerous challenges faced by water resources sector in India further complicate the situation. Within Indian context an integrated build, operate & transfer (BOT) concession model does not seem feasible instead the setting seems to be operating the projects on a service contract basis.

Water Pricing and Allocation

Recovery of monies, either partially or fully, for expenditure incurred by government has been a topic of debate and contention for a while. Irrigation user charges in Indian context would need to address issues that spread across demographic, regional, social and economic realms. Various countries have practiced different mechanisms of charging and collecting irrigation charges. The irrigation charges used in a given country might include one or more of the following:

1. Demand charges based on volume; quantum of water has also been converted to time - minutes of supply from streams (as from a supply) as in Peru or Israel's closed pipe frameworks in which a low price is charged for basic quantum of supply and a higher cost for extra water.
2. Water rate per hectare based on the kind and degree of crop irrigated, the period of the year, and other parameters. In many countries, water rates are higher when there are capacity works than from direct drawl from streams. Besides, the rates for lift water system are generally higher than for gravity-type water system ventures.
3. Extra land tax in light of expanded increased advantage from giving water irrigation systems.
4. Betterment levy on the increase in land value accruing from the provision of irrigation.

5. Irrigation cess, being the annual charges per acre/ha of the irrigable area, whether water was actually taken for irrigation or not.
6. Maintenance cess being the annual cost of maintenance and operation.

In India, all open water system frameworks are controlled by Government and there is no immediate direct equation between user charges and investments made/ being made. The water rates vary from state to state, often decided by political exigencies. It is increasingly acknowledged that water rates that are being charged are sponsored and are significantly less than even the recurring O&M costs (CWC, 2004). The most widespread practice in India with respect to charging of irrigation water is based on area. The considerations forming the basis for water charges include - source (surface water, groundwater), supply type (gravity, lift), season (rainy, winter and summer), type of crop (food grain, cash crops), duration of crop growing season (seasonal, two seasonal, and perennials), method of irrigation (drip, sprinkler), land classification (like wet and dry lands), and scale of the project (major, medium, and minor).

The National Water Policy of India (as set out in 2002 and reiterated in 2012) emphasizes that allocation of irrigation water should be done with due regard to equity, social justice and that the supply of water should be made on volumetric basis. Now many States have adopted Participatory Irrigation Management (PIM) approach, where irrigation water is supplied to the Water User Associations (WUAs). Irrigation commission (1972) recommended that the water rates should be 5% - 12% of the total value of farms produce, lower for food crops and higher for cash crops. Vaidyanathan Committee (1992) recommended a two-part tariff comprising a fixed charge applicable to entire command area as a membership charge, a variable charge based on area irrigated to recover annual operation and maintenance (O & M) cost, and 1% interest on the capital cost. Full cost recuperation was recommended to be a definitive objective. Some of the suggestions have been executed by a few State Governments. The volumetric pricing of water system is one among others that has been implemented to a limited extent in a few projects.

In India, support to water sector comprises subsidizing energy that farmers use to pump groundwater. Institutional, political and organizational structures have been so developed that within a broad-based democracy, politicians risk losing voting support if they introduce policies that significantly alters prevailing systems. With subsidies being used as incentives, indirect result is of indiscriminate over-pumping of groundwater, putting undue strain on aquifers and creating issues for downstream users.

Assessing exact quantum of water that is being supplied and consumed is critical for adopting volumetric pricing strategies. While this is apparent in the developed world, where there are large farm sizes and modernized water system frameworks, it is much harder in developing nations. Farm sizes can be as little as a fourth of a hectare, water system is frequently decentralized, and water reaches cultivator fields by means of gravity through little, sporadic trench. Unlike in developed nations, such infrastructures are seldom constructed and end-users are not accustomed to paying for resources.

Water rates of minor water system activities ought to be to such an extent that they can completely cover O&M charges. One of the approaches to reduce user charges is to minimize capital cost based on efficient construction and its consequent operations and maintenance.

Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Water Resources, Planning, Management and Evaluation Sectional Committee had been approved by the River Valley Division Council. The guidelines for fixing irrigation water rates, laid down in this Indian Standard are based on the recommendations of the following commissions and the National Water Policy, 1987:

- a. Maharashtra State Irrigation Commission 1962,
- b. Irrigation Commission 1972,
- c. National Commission on Agriculture 1976,
- d. 10th Finance Commission 1994, and
- e. Vaidyanathan Committee Report 1992.

Guidelines to frame uniform water rates in the country need to account for cropping pattern, geographical, seasonal and systemic differences. Some of the features of water pricing practices prevailing in India include the following:

1. In some states water rates on lift irrigation schemes are lower than corresponding rates for flow irrigation schemes. However, in some states it is the reverse. For example in Gujarat water rates for lift irrigation schemes on canals are half and on rivers one-third of the flow irrigation rates. In Maharashtra water rates on private lift irrigation schemes on storage reservoirs or between a dam and pick up weir are half of the water rates for flow irrigation. UP is a similar example.
2. In Haryana, if water from any state irrigation work is lifted by any cultivator at his cost, he is charged half of the flow irrigation rates. No water cess or irrigation cess is levied.
3. In Kerala the water rates on lift irrigation schemes are 50 per cent more than flow irrigation schemes. Similarly in Goa, Daman and Diu water rates on lift irrigation schemes are higher compared to gravity flow schemes.
4. Maharashtra has levied additional rates on irrigated areas in the past. These are state government charges (1989) for (i) local cess on water rates at Rs 0.20/ha, (ii) additional charge known as education cess which varies from Rs 40/ha for groundnut to Rs 190/ha for sugar cane, (iii) employment guarantee cess at Rs 25/ha on all irrigated agricultural land.

Financial Analysis for Development of Irrigation Project

Need for user charges emanate from the fact that there is a continuous decline of share of financial resources earmarked for I&D sector. India set its first priority to irrigation since 1st Five Year Plan after independence in 1947 due to growing concerns on food stress and started planned development with the provision of about INR 3760 million, which was around 22.54% of all sectors. There has been a massive increase in plan expenditure on irrigation and flood control over the next 65 years and provision for irrigation and

drainage sector rose to about INR 2117 billion during the eleventh five year plan (2007-12), amounting to a total expenditure of around INR4820 billion upto end of eleventh plan (March 2012). However, there was a gradual shift in the emphasis to other dominant sectors and by the end of tenth five year plan share of irrigation and flood control reduced to 6.28%. During twelfth five plan (2012-17) an outlay of INR4220 billion⁴ has been made for irrigation and flood control sector, which is almost double of expenditure made during eleventh plan period.

In fact, one of the key reform areas that the Government had prioritised in its budget 2016-17, was the agriculture and farming sector. The Government is looking to double farmer income by 2022 and recognises that interventions in the farming sector need to be reoriented to optimally utilise water resources with improved service delivery. A dedicated irrigation fund of Rs. 200 million has been announced in the budget to bring about 2.85 million hectares under irrigation and for sustainable groundwater management. It is increasingly being thought that Government sector alone may not be able to fill in these gaps related to financial and operation and management resources. With increasing strain on public finances, user charges could alleviate a certain portion of investments required.

To assess the extent of user charges that are required to be paid for an investment decision, financials of a typical irrigation project are considered, on a standardize basis. The data from Nira-Deoghar, a project in Maharashtra is taken as an illustration, based on scoping study on PPPs in the irrigation sector in India conducted by ADB (2012)⁵.

Project Description

Nira Deoghar irrigation project is spread across three districts of Maharashtra- Pune, Satara and Sangali; located about 90 km south

⁴Source: Twelfth Five Year Plan (2012–2017) - Faster, More Inclusive and Sustainable Growth, Planning Commission, Government of India

⁵Harish Kumar Varma, DTV Raghu Rama Swamy and Amarjit S. Dhingra, Exploring Public Private Partnership in the Irrigation Sector in India, Asian Development Bank 2012

of Pune near Deoghar village. This project on Nira River consists of 59 meters high and 2320 meters long dam with total capacity of 337 million cubic meters. This project was approved in 1984 with an estimated cost of INR 615 million, which escalated to INR 9100 million by 2000-01. 95% of construction has been completed since many years.

The Maharashtra Krishna Valley Development Corporation (MKVDC) invited Expression of Interest from the private parties to complete the project on Build Operate Transfer (BOT) basis. After designated lease period, developer/ consortium was expected to hand over the project back to the water resources department. MKVDC proposed that bidders could recover the money invested by various modes i.e. levy of water charges used for irrigation and domestic purposes, fisheries development, tourism development associated with the project. Developer/ consortium could also raise money through contract farming through land owners in the command area as per Government provisions.

The project is an ongoing one which envisages construction of an earthen dam, a masonry gated spillway, right & left bank lined canals and canals for lift irrigation. The project is expected to provide annual irrigation to an area of 43,050 hectares (CCA). The salient features of the project components are given in Table 1 below.

Table 1: Salient features of Nira Deoghar irrigation project, Maharashtra

Item	Particulars
Earthen dam	Length: 2330 m; maximum height: 58.525 m; length of masonry gated spillway: 70 m; two sides concrete non-overflow portions: 60 m
Canals	Left bank canal: 21 km; right bank canal: 208 km; CCA: 22410 ha
Lift irrigation canals	Length: 135 km; CCA: 20640 ha.

Capital Cost of the Project

The cost estimates for the analysis are based on a study conducted by Maharashtra Krishna Valley Development Corporation (MKVDC). The project cost was last reviewed in 2007-2008. Total project cost including financing charges and interest during construction has

been worked out as Rs. 19395.7 million. Based on this estimation, the project cost and viability is analyzed with the key assumptions provided in Table 2.

Table 2 – Key Assumptions of Financial Assessment

Parameter	Assumption	Description
Construction period	7 years	The time period is based on the identification and quantification of major activities, assuming mechanized construction and two-shift operation.
Time horizon for assessment	55 Years	The project is expected to provide benefits for around 100 years, but since the initial years would have major impact on the financials, 55 years have been considered for analysis.
Inflation rate	5%	The assumption is based on the average inflation rate for last few years and the estimated future inflation rate for next few years.
Pre-operative expenses	0.5% of Capital Cost	Includes cost of obtaining necessary clearances, land related costs, audit and account charges etc.
Contingencies	3% of Capital Cost	As the detailed estimations have been done for the project cost, only 3% of the capital cost is taken as technical contingency.
Receipts and recoveries	13 million	The revenues would come from recovery on account of resale or transfer of temporary building and re-sale of special tools & plants. The total estimated value is expected to be INR 13 Million.

Project Financing

The project is estimated to be financed with debt to equity ratio of 70:30 by the private developer as worked out in Table 3. No grant has been assumed for the project.

Table 3: Proportion of Debt and Equity for the Project

Parameters	Value in INR Million
Total Project Cost	19395.7
Debt (@ 70% of the project cost)	1,3577.0
Equity (@ 30% of the project cost)	5818.7

Considering the project life of 100 years and high level of capital

investment requirement, it is assumed that the loan tenure would be 30 years, at an interest rate of 12%.

O&M Expenses

Annual O&M cost for the project has been worked out with the following norms: (i) 1% of the capital cost for dam and canals with 3% annual escalation, (ii) Rs. 1000 per ha for CAD works, (iii) 0.1% of capital cost for activities like technical tests, research, training, surveys & improvements etc., and (iv) 20% of the total O&M costs towards direction and administration costs. The summary of the annual O&M costs is provided in the Table 4.

Table 4 - O&M Costs for the Project

S. No.	Components	Cost (INR Million)
1	O&M costs for CAD	43.1
2	Maintenance of dam, canals and LIS	134.8
3	Research, training, surveys & improvements etc.	14.9
4	Direction and administration	48.2
Total O&M Costs in year 1 of operation		240.9

Revenues

Possible revenue streams of the project and rates adopted in the analysis are as follows:

- i) Water Rates/ User Charges: Rs. 1100⁶ per ha. The collection efficiency is assumed at 40% in the initial year gradually increasing to 75% in the fifth year of operation and constant thereafter. The escalation in the user charges is assumed 10% every 3 years.
- ii) Revenues from fishing related activities: Rs. 8682 per ha for the total expected area for fishing as 792.5 ha. It is assumed that 50% of this revenue would be shared with the private developer.

⁶It is weighted average of the User Charges set by the concerned government agency for different crops for this particular project. The User Charges vary considerably across states.

- iii) Revenues from sale of surplus water for drinking use: About 3.03 MCM of drinking water is expected to be available to the private developer for sale. The sale rate of the drinking water is considered to be INR 6.6/cum⁷.
- iv) Revenues from tourism related activities: Revenues are assumed from sale of boating rights and entry tickets from visitors.

The summary of the estimated annual revenues in the initial years of operation are provided in Table 5.

Table 5 - Summary of estimated annual Revenues in the initial years of the project

(Amount in INR million)

Operation Years	Year 8	Year 9	Year 10	Year 11
User Charges/ Water Rates	18.9	23.7	31.3	36.5
Revenues from Fisheries	3.40	3.50	3.60	3.80
Sale of surplus available water	20.0	20.9	21.9	22.9
Tourism	39.5	40.7	41.9	43.2
Total Revenue –Operations	81.9	88.8	98.7	106.3

Viability Assessment

The viability of the project is assessed in terms of the IRR and NPV. The estimated values of the same are provided in the Table 6.

Table 6 - Project IRR and NPV

Years	Project NPV (INR Billion)	Project IRR
20	(10.3)	Negative IRR
25	(10.3)	Negative IRR
30	(10.4)	Negative IRR
40	(10.4)	Negative IRR
50	(10.4)	Negative IRR
55	(10.4)	Negative IRR

As shown in the table, the project does not appear to be financially viable as the expectation of the private developer in terms of the IRR would be around 15%. Also, the estimations of the yearly cash-flows indicate that the revenues are not sufficient to repay the interest payments and debt repayments. The equity infusion is required in

⁷The sale rate of surplus water varies across states. The rate assumed is in line with the estimation made by a government agency for a major irrigation project.

many intermediate years. Further, the equity IRR for the project is even lower than the project IRR provided above.

At this stage of analysis, revenue source for the project is from user charges. Essentially it implies that for recouping the investments, current levels of user charges are very low. In order to get an acceptable IRR, user charges have to be increased multifold almost to the level of Rs. 150000 per hectare, which is unrealistic.

Some of the commercial activities that could be included in the project to render the project financially viable, are as follows:

- Providing land for commercial development
- Building toll roads along the canal
- Allowing tourism related activities (like Water Park) near the irrigation area.

However, these facilities are very project specific and does not provide a universal model for reducing the user charges.

It can be concluded from the analysis of the project, that the user rates fixed by government agencies are not sufficient even to cover the O&M expenses of the project. Revenues from related activities like sale of water, fish farming, tourism etc. are required to cover O&M expenses and generate profits in the operational years. However, the profits are not sufficient to repay the interest and loan principal payments in many years.

International experience indicates that irrigation projects can be successful if public sector substantially contributes to the capital costs and private parties are made responsible to undertake O&M activities. But, in India since there are a large number of small and marginal farmers with low land holdings (0.5 ha to-2 ha) and income levels, governments will have to step in with payment guarantees and setting out suitable revenue risk sharing mechanism to encourage farmers to contribute their share of user charges, and to consider different modes of implementation such as with private sector participation.

Conclusions and Way Forward

Financing for sustainable water management has been a complex issue with no immediate solution being apparent. Given the scale

and nature of investments, role of public sector will continue for foreseeable future, albeit with certain improvements in institutional, governance and implementation capacity. There were anecdotal statements made that a few states would need to spend budgetary amounts (as expended at current levels) for another decade or so to finish ongoing projects. On top of this, fresh investments would be required. As availability of long term external borrowing is becoming competitive, government agencies are looking for other options for bridging the gap with PPP projects and levying user charges. Given the sheer economics of a typical project, there has not been a visible success in PPP model. User charges are very low to even cover O&M expenses fully. Adding other sources of revenue is very context specific and cannot be seen as a scalable option. Agencies are now reconfiguring PPP models to reflect service obligations, with most of capital and O&M expenditure being borne by government. User pay principle has been a point of contention due to holdings pattern, social practices and ability to pay. While a number of experts have suggested that this needs to be adopted, in practice only a few states took initial steps towards the same.

It is imperative for Government to be involved in user charges pricing due to the following reasons:

1. For the free market to decide completely the improvement and allotment of surface water system there would need to be an arrangement of unadulterated private property rights, which is not the case at present. The presence of such a framework is dependent upon specific necessities, for example, such as certainty (the property rights being well defined in terms of quantity, quality, location, and time of use), transferability (easy and low-cost transference of water rights through purchase and sale), externality (spillover effects on other people's property from water use would be absent or insignificant), and competition (the existence of competitive forces at both the demand and supply sides of the market), being met.
2. The second essential purpose behind the contribution of the legislature in the improvement and administration of

irrigation projects is the critical economies of scale which can be picked up in the capacity, movement, and dispersion of substantial amounts of irrigation water. Government administration may in this way diminish instability coming about because of supply which is exceedingly factor in time, space, and quality. These arrangements generally include benefits that are non-rival in utilization and hence it might be said exhibit of public good or collective good character.

3. The third reason incorporates the need to viably manage externalities, especially those influencing nature which emerge from the improvement and administration of water resources.
4. The fourth reason would incorporate the achievement of certain social destinations, for example, wage redistribution, nourishment independence, and practical irrigation production.

The political will for developing an equitable water pricing system seem to be lacking, although almost all official committee reports have recommended promotion of such practices. Over the period, various public functionaries and policy makers have provided suggestions for improvements in pricing framework. Some of the suggestions include:

1. Water rates should be such as to convey the scarcity value of the resource to the users and to foster the motivation for economy in water use. They should be adequate to cover the maintenance and operation charges and a part of the fixed costs. Efforts should be made to reach this ideal over a period while ensuring the assured and timely supplies of irrigation water. Water rates for surface water and ground water should be rationalized with clue regard to the interests of small and marginal farmers?
2. The currently adopted flat-rate payment system for irrigation is considered poor in promoting efficient use of water and as such they need to be replaced by volumetric pricing in order to encourage efficiency in water use at the farm level and to

recover the full costs of irrigation development. These rates could vary across different projects in relation to the degree of certainty with which water is delivered to farmers. Metering for measurement of quantum is suggested as a corollary.

3. Improvement of water markets where water rights could be purchased and sold, and different strategies for overseeing interest and supply of water.
4. Adoption of use pay principles. Attain an equitable position that provides for a commensurate price that meets costs incurred. Different accounting and assessment principles were suggested – aggregate basis or average costs etc.
5. Review and design subsidies to water system that are region specific and based on cropping patterns and yields.
6. Separate the operation and maintenance part of the irrigation projects from the fiscal budget of the government and require the irrigation agencies to earn their operation and Maintenance budget from the sale of irrigation services. Develop appropriate institutional structures to ensure the same.
7. To make a meaningful impact on water rate changes, users ought to be consulted while framing guidelines and in the institutional system being formulated.

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Water Supply and Sewerage Systems in India

Introduction

Water is fundamental to life, livelihood, food security and sustainable development. It is a prime resource for economic development. The spent/return waters are an equally important resource requiring sound management to reduce water shortages and stress on fresh water sources. Urbanisation brings economic development, and along with it a greater demand for water. Proper management of water supply and sewerage/sewage is a pre-requisite for sustainable development. The rapid urbanisation happening in the country calls for scientific water management based on economic principles.

India has more than 18 % of the world's population, but only 4% of world's renewable water resources. As per the Report of the National Commission for Integrated Water Resources Development set up by Ministry of Water Resources (presently the Ministry of Water Resources, River Development and Ganga Rejuvenation (MOWR, RD and GR), the total available water resources in the country are 1123 Billion Cubic Metre (BCM) comprising of 690 BCM surface water and 433 BCM ground water . The total water requirement for all sectors is estimated as 784-843 BCM by 2025, which is expected to go further up to 973-1180 BCM by 2050. The water requirements for various sectors in 2025 and 2050 are given in Table 1. As per the National Water Policy (2012), the top priority in water allocation has been given to drinking water requirements followed by other usages.

Table 1 - Water Requirements for Various Sectors in 2025 and 2050**(Low Demand to High Demand scenarios)**

Year	Water Demand in Km ³ (or BCM)	
	2025	2050
Domestic	55-62	90-111
Irrigation	561-611	628-807
Industry	67	81
Power	31-33	63-70
Others	70	111
Total	784-843	973-1180

Source: Report of the NCIWRD, MoWR (1999)

Steep rise in demand for water due to population growth, urbanization and changing lifestyle pose serious challenges to water security. Further, the lack of adequate sewage treatment and mismanagement of treated wastewater are polluting and undercutting water sources. In both rural and urban areas, untreated sewage and faecal matter cause insanitary conditions. The impacts of poor sanitation on human health are significant. Diarrhoea accounts for almost one-fifth of all deaths (or nearly 535,000 annually) among Indian children who are under 5 years and 88% of diarrhoeal disease is attributed to unsafe water supply, inadequate sanitation and hygiene. The World Bank's Water and Sanitation Programme (WSP) estimated the losses in GDP due to lack of Sanitation in India as about 6%. Therefore, providing sound water supply and sewerage services to households will improve the quality of life, especially the poor and the disadvantaged, thereby reducing the loss of lives and losses to economy. The social and environmental benefits thereof are immense.

Urban and Rural Scenario in Water Supply and Sewerage

As per the 2011 Census, the distribution of rural – urban population is in ratio of 68.84%:31.16%. The level of urbanization increased from 27.81% in 2001 Census to 31.16% in 2011 whereas, the proportion of rural population declined from 72.19% to 68.84% during the same period.

Census brought out that the number of urban centres in the Country

had increased to 7,935 in 2011 as compared to 4,161 in 2001, whereas, the number of rural units or villages has increased marginally to 6,40,867 from 6,38,588 during the same period. There are 53 City agglomerations in India which have a population of more than 1 million, with 6 city agglomerations having a population of 10 million or more- they are like mini-countries. Urbanization is expected to be more than 50% by 2050 (Fig. 1). Economy wise, the urban areas of the Country contribute to 60% of Country's total Gross Domestic Product (GDP). The phenomenon of sub-urbanisation of rural hinterland is also happening driven by tourism, adventure and recreation.

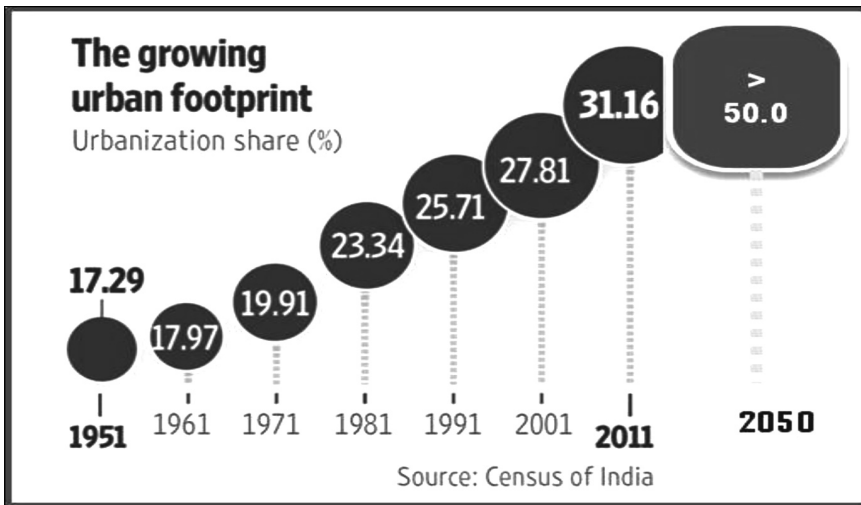


Fig.1 The growing urban footprint (Source: Census of India)

Status of Water Supply and Sewage Treatment in the Country

Water supply and sewerage and sewage treatment in the Indian Constitution come under State List. Since these services are non-exclusive, non-rivalled and essential, the responsibility for providing the services is in the public domain. The activity being local in nature, it is entrusted with the Local Bodies. The Local Body undertakes the task of water supply and sewerage and sewage treatment service delivery, with its own staff, equipment and funds. In a few cases, part of the said work is contracted out to private enterprises.

Modern Infrastructure facilities for water supply and sewerage/sanitation need to be provided for the new and expanding habitations in both rural and urban areas. These are provided by Government owned utilities but with such unprecedented growth, they are unable to meet the requirements due to various compelling circumstances. Issues and constraints that are encountered by the urban local bodies are compounded due to various reasons (dealt in later sections).

Reach of Water Supply, Toilet and Sewerage Services

According to the Water Supply service provisions recorded in the Census 2011 household data, 43.5% of households (HHs) (i.e., 70.6% HHs in urban and 30.8 % HHs in rural) have access to piped water sources whereas 53.0% HHs (i.e., 26.9 % HHs in urban and 65.2 % HHs in rural) depend upon non-piped improved sources such as well, hand pump, tube well/bore well while the remaining 3.50% of households (HHs) (i.e., 2.5% HHs in urban and 4.00 % HHs in rural) depend upon unimproved sources such as spring, river/canal, tank/pond/lake and other sources (Table 2 and Fig. 2).

In urban areas, though water supply access of 95% has already been achieved, large inequities exist in the quality and quantity of water supplied. Further, poor availability of water (i.e., 0.5 – 5 hrs. per day) and inefficiency in the delivery of water supply (i.e., unaccounted for water (UFW) up to 50%) are the major short comings in urban water supply. The service connections need to be further increased to be universally available at the yard level with treated and piped water supply in adequate quantity, quality and continuity in duration. The pricing of water supply has to be on economic principles distinct from the existing policy of low-tariff or no-tariff.

Table 2 – Main Source of Drinking Water Supply

House list Item	Number of Households		
	Total	Rural	Urban
Households by main source of drinking water			
Tap water	43.50	30.80	70.60
Well Hand pump Tubewell/ Borehole	53.00	65.20	26.90
Spring, River, Canal, Tank, Pond, Lake, other	3.50	4.00	2.50
Total	100.00	100.00	100.00

Source: Census of India 2011, Houses, Household Amenities and Assets: Main source of drinking Water Supply, Office of the Registrar General and Census Commissioner, India.

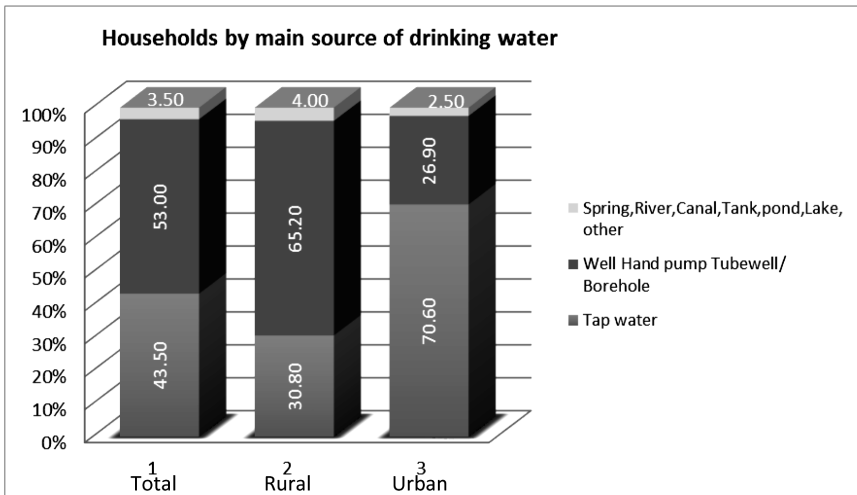


Fig. 2 – Main Source of Drinking Water Supply

As far as toilet facilities are concerned, the Census 2011 household data records that 44.0 % of households (HHs) (i.e., 79 % HHs in urban and 27.6 % HHs in rural) have a sanitary toilet whereas 2.9% HHs (i.e., 2.4 % HHs in urban and 3.10 % HHs in rural) have insanitary latrines. The remaining 53.10 % of households (HHs) (i.e., 18.6% HHs in urban and 69.30% HHs in rural) do not have toilets. This situation is the root of insanitation and spread of disease in habitations (Table 3 and Fig. 3). The Swachh Bharat Mission (SBM)¹ targeting the provision of toilet access to all and eliminate open defecation by 2nd October 2019 is meant to remove this sanitation gap. The next step is to scientifically manage the faecal sludge. Under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT)¹, cities are mandated to achieve 100% treatment either by

¹Swachh Bharat Mission (SBM), is being implemented by the Ministry of Urban Development (M/o UD) and by the Ministry of Drinking Water and Sanitation (M/o DWS) for urban and rural areas respectively. The Mission objectives are (i) Elimination of open defecation, (ii) Eradication of Manual Scavenging, (iii) Modern and Scientific Municipal Solid Waste Management, (iv) To effect behavioural change regarding healthy sanitation practices, (v) Generate awareness about sanitation and its linkage with public health, (vi) Capacity Augmentation for ULB's, and (vii) To create an enabling environment for private sector participation in Capex (capital expenditure) and Opex (operation and maintenance).

sewage treatment or septage treatment by 2020.

Table 2 – Households by Type of Latrine Facility

House list Item	Number of households		
	Total	Rural	Urban
Sanitary Latrine	44.00	27.60	79.00
Insanitary Latrine	2.90	3.10	2.40
No Latrine	53.10	69.30	18.60
Total	100.00	100.00	100.00

Source: Census of India 2011, Office of the Registrar General and Census Commissioner, India.

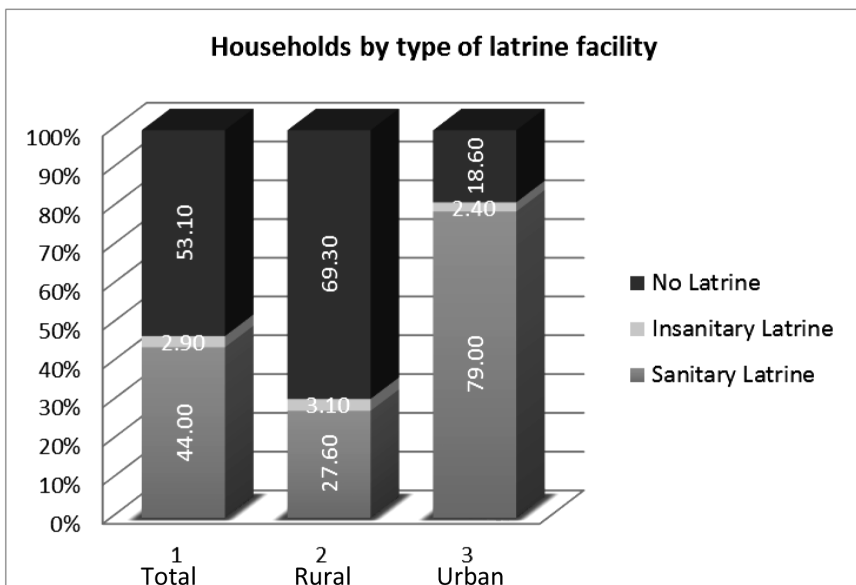


Fig. 3 – Households by Type of Latrine Facility

Sewage Treatment Systems

Sewerage System is virtually non-existent in rural areas while in urban areas it serves only 32.7% households. Septic tanks are the most used systems – 38.2% urban HHs and 14.7% rural HHs are connected to septic systems. The septic tanks however lack proper septage evacuation and treatment systems and a major cause for polluting

water sources, insanitary environment and spread of diseases.

The sewerage system itself suffers from inadequate end of pipe treatment systems. The assessment made by CPCB in the year 2015 mentions that out of 61,948 MLD generated in urban areas, treatment capacity is available for 23,277 MLD, which is only 37.6% of generation. Many of the Sewage Treatment Plants (STPs) are underperforming due to various reasons. Further, operation and maintenance of the urban sewerage systems are not up to the mark resulting in frequent clogging, back flowing of sewage, short-circuiting to storm water drains, water courses and bodies etc. Sewerage and Sewage treatment has not received the priority it deserves from the administration. The plants are often under-funded, under staffed and allowed to decay without timely R and R. The technical skills for O and M are not available with ULBs. CPCB is issuing directions to local bodies for 100% treatment of sewage and also moving towards rigorous treated effluent norms and monitoring. Nowadays, there is a shift to extended O and M contracts along with construction of STPs and model of annuity based contracting for STPs, which may be slightly costlier but have built-in assurance for quality of construction and O and M. The flagship programme of Namami Gange- National Mission of Clean Ganga (NMCG) has adopted the annuity model for proposed STPs along the Ganga. Once, it is proven under NMCG, it is expected to become the norm all over the country.

Constraints in Providing Water Supply and Sewerage System

There are several issues and constraints in providing adequate water supply and sewerage system (Table 3). These vary with respect to place and time, the predominant being the lack of financial and technical capacity in the local bodies in charge of providing the water supply and sanitation services. The other issues are the lack of proper land-use planning, lack of sustainable tariff and functional autonomy thereof, unregulated urbanisation and inefficient service delivery.

Table 3 - Issues in water supply and sanitation and remedial measures to be taken

Issues	Remedial Measures being adopted
Water Supply	
i. Sustainability and Equity	i. A new legal and institutional framework for water based on broader consensus among the States.
ii. Demand and Supply Management	ii. Focus on Demand Management,
iii. Financing and institutional issues	iii. Reducing Intra-City Inequity
iv. Tariff and OandM	iv. Quality of Water Supplied
	v. Protection of Water Bodies
	vi. Planning on a Regional Scale
	vii. Plan to supply water at affordable costs to all
Sanitation (Sewage)	
i. Expansion of Sewerage and Sanitation Facilities	i. Reduce intra-city inequity in sanitation
ii. Financing	ii. New approaches to drinking water and sanitation.
iii. Creating awareness on sanitation	iii. All water supply projects to integrate sewage systems
iv. Preparation and execution of sanitation plans for growing population	iv. Decentralize and Reduce costs on sewage systems
v. O & M of the Sanitation Facilities	v. Reinvent sewage management and treatment systems for sustainability
	vi. Reuse and recycle treated wastewater

Source: 11th FYP and 12th FYP

These problems and issues in water supply and sewage/sanitation are being addressed through various initiatives taken by Government of India from time to time, in partnership with States and local bodies. The initiatives address the hard components (infrastructure) as well as the soft components (capacity building- governance, technical and financial). The 12th FYP document recommended the following for the planned development of cities/ ULBs, among other sectors such as - Sewerage and sanitation plan; Water supply plan; Infrastructure

plan; Environment conservation plan; Plan for peri-urban area/ region. With these inputs in regional planning, the efficiency in delivering basic services as water supply and sewerage / sanitation will be enhanced.

The structural reforms in urban governance include creating dedicated urban administration civil service cadres, technical capacity building, bench marking of service levels, tariff policy, policies for the recycling and reuse of wastewater in industries and power plants, incentivising implementation of reforms (viz. 100 % metering, recovery of user charges, use of ICTs, recycling of treated wastewater, implementing e-governance, conducting water audits etc.) for the centrally sponsored water supply and sewerage projects.

Technical and capacity building support to States and Local bodies includes issuing advisories and guidelines (on the tariff structures, service levels, manuals, and guidance's) for the water supply and sewerage projects, decentralized treatment systems, funding for capacity building, IEC activities. Some of the policy initiatives taken/ advisories issued are discussed in the subsequent sections of the paper.

Current Priority Areas in Water Supply and Sanitation

Since there is a vast gap between the urban and rural areas with respect to the water supply and sanitation, the targets and the time frame fixed for achieving the targets for these areas also varies largely. However, India is signatory to the UN Sustainable Development Goals (SDGs- target 6 water supply and sanitation) which is to achieve universal and equitable access to safe and affordable drinking water, sanitation and hygiene for all and end open defecation by 2030, thus bringing harmony in the basic services in urban and rural fronts. With regard to SDGs, India has set itself earlier timelines for the SDGs. Under the Swachh Bharat Mission, it is targeted to achieve the sanitation targets by 2019 in both urban rural areas while for the waters supply, under AMRUT, at least 72% urban population is targeted to achieve SDGs by 2020- for rural areas the timelines are somewhat extended. However, by 2030, India should be able to fulfil the SDGs comprehensively across both rural and urban areas.

Current Focus in Water Supply and Sanitation

Currently under urban water supply, the Government focuses on providing 100% coverage of treated, metered piped water supply at the rate of 135 LPCD to all the households in all the 500 cities/towns with a population of above 1 Lakh by 2020 under AMRUT Programme. In rural water supply, the current priority is to provide safe drinking water supply at the rate of 55 LPCD by 2017 with piped water supply to at least 50 % of rural household of the Country. The focus is also on shifting to surface water sources from the ground water sources due to quality and quantity issues.

For sanitation, the current focus is on providing 100 % toilets by 2019 under SBM in both rural and urban areas. Further, it is to extend either sewerage network services or septage management for 100 % collection and treatment of sewage/septage in all the 500 cities/towns with a population of above 1 Lakh by 2020 under AMRUT Programme, covering about 72% of urban population. In the rural areas, the current focus is to achieve Wastewater treatment at least in Nirmal Gram Puraskar (NGP) Villages.

Fund Requirement Assessment and Fund Tapping

An estimate of the funds required for basic urban infrastructure over a 20 year period of 2010-2030, at 2009-10 prices, was made by the High Powered Expert Committee (HPEC) during 2011. The Committee estimated that Rs.5.63 lakh crore will be required for creation of services of water supply and sewerage. Moreover, the requirement for Operation and Maintenance (O & M) was separately estimated to be Rs. 7.83 lakh crore. These funds have to come primarily from the States and Urban Local bodies being State subject matter. This funding requirement can be assumed to be spread uniformly over the years. Up to 2020, it can safely be assumed that the investment required will be 40% of HPEC reported figures up to 2030. Hence 40% of Rs.5.63 lakh crore is Rs.2.25 lakh crore. Out of this, the AMRUT programme having priority for water supply and sewerage/sanitation has a corpus of Rs.1.00 lakh crore (Centre + States); the Smart Cities programme has a corpus of Rs.0.50 lakh crore (Centre); The SBM urban has fund of Rs.4,800 crore (Centre-toilets only). In

addition, Centre is also granting funds for sanitation from the Swachh Bharat Kosh - mainly donations by corporates and individuals. With new guidelines for CSR funding of infrastructure, the Corporates are directly supporting States and Cities with CSR funds.

Hence, only part of capital cost of the water supply and sanitation projects will be provided by Government of India through its various current programmes/schemes/missions; some of the ongoing programmes/schemes/missions. The total mission outlays/central allocations are described in the subsequent sections of the paper.

The rest of the funds for these projects have to be generated by own funds of the concerned State/UT/ULB and also through private participation, external funding and any other sources. However, the O & M costs have to be met by levying and collecting sustainable user charges, implementing various reforms recommended by the Government of India from time to time. These are recurring expenditure and hence, no central contribution is made on the same. In this context, the financial devolutions of the 14th Finance Commission to the States out of the divisible pool of central taxes has been enhanced from earlier 32% to 42%. The total devolution to the States in 2015-16 was Rs 5.26 lakh crore, as against Rs 3.48 lakh crore in 2014-15, representing an increase of Rs 1.78 lakh crore. The total devolution to States during the five year period up to 2019-20 will be Rs 39.48 lakh crore. This extra devolution gives enough financial leeway to States in implementing the water supply and sanitation infrastructure. In a nut shell, it can be safely stated that States should not have any financial constraint in funding water supply and sanitation projects. But financial diligence may be exercised in not squandering these funds on O & M instead of user charges.

Steps Taken to Achieve 100% Water Supply and Sanitation

National Water Policy (2012) stresses on evolving a National Framework Law for water supply for ensuring access to a minimum quantity of potable water for all citizens and enhancing water available for use by increasing the water use efficiency and by implementation of other reforms. Further, it specifies that the Recycle and reuse of

water should be the general norm and also emphasises on the fair pricing of water/treated wastewater.

Service Level Benchmarks (SLBs) for water supply and sewerage (Table 4) are directed towards universal coverage of water supply and sewerage services, resource conservation, sustainable O & M and customer satisfaction. The SLBs provide the planning philosophy of water supply and sewerage infrastructure and the O & M thereof on sustainable basis. This benchmarking will enable improved delivery of services.

Table 4 - Service Level Benchmarks

Water Supply			Sewerage	
	Indicator	Bench mark	Indicator	Bench mark
1	Coverage of Water Supply connections	100%	Coverage of Toilets	100%
2	Per Capita Supply of Water	135 lpcd	Coverage of Sewerage Network	100%
3	Extent of Non-revenue Water	20%	Collection efficiency of Sewerage Network	100%
4	Extent of Metering	100%	Adequacy of Sewage Treatment Capacity	100%
5	Continuity of Water supplied	24 Hours	Quality of Sewage Treatment	100%
6	Efficiency in redressal of customer complaints	80% (in 24 hr cycle)	Efficiency in redressal of customer complaints	80% (in 24 hr cycle)
7	Quality of Water Supplied	100%	Extent of Reuse and Recycling of Sewage	20%
8	Cost Recovery	100%	Extent of cost recovery in waste water management	100%
9	Efficiency in Collection of Water Charges	90%	Efficiency in Collection of Sewage Water Charges	90%

Central Programmes Covering Water Supply and Sanitation

Government of India has launched/implementing number of programmes to achieve 100% water supply and sanitation coverage. Brief information on these programmes is given below.

1. Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

- Date of Launch - 25th June, 2015
 - Coverage – 500 Cities with population of 1 lakh and above
 - Total outlay - Rs. 50,000 crore by Centre + States Rs.50,000 crore
 - Mission Period - five years from FY2015-16 to FY2019-20
 - The Mission will be operated as a Centrally Sponsored Scheme
2. Smart Cities Mission
- Date of Launch - 25th June, 2015
 - Coverage – 100 Cities
 - Total outlay - Rs. 500 crore per city by Centre
 - Mission Period - five years from FY2015-16 to FY2019-20
3. Swachh Bharat Mission (Gramin)
- Date of Launch – 2nd Oct., 2014
 - Mission Period - five years from 2nd Oct., 2014 to 2nd Oct., 2019
 - Total outlay - Rs. 1,34,000 crore (Centre + States)
 - Toilets, Solid and Liquid waste management are eligible components
4. Swachh Bharat Mission (Urban)
- Date of Launch – 2nd Oct., 2014
 - Mission Period - five years from 2nd Oct., 2014 to 2nd Oct., 2019
 - Total outlay - Rs. 63,000 crore
 - Toilets and Solid waste management are eligible components
5. National Rural Drinking Water Programme (NRDWP)
- Objective is to provide water supply in the rural areas of the Country

- Plan Outlay for 2016-17 – Rs. 5,000 Crore
- 6 Digital India Programme
- Date of Launch – 1st July, 2015
 - One of the goal is to implement e-governance in the Municipalities of the Countries

Central Publications for Capacity Building in Water Supply and Sanitation

1. Manual on Sewerage and Sewage Treatment Systems
 - Year of Publication – 2013
 - provides detailed guidelines / methodology for planning, designing, executing and operation and maintenance of sewage management schemes
2. Manual on Water Supply and Treatment Systems(CPHEEO-1999)
 - Year of Publication – 1999
 - provides detailed guidelines / methodology for planning, designing, executing and operation and maintenance of water supply schemes
3. Service Level Benchmark
 - As per the SLBs published under National Urban Sanitation Programme (NUSP), 20 % reuse and recycling of treated wastewater is mandated for all Central Govt. sponsored sewerage projects.
4. Advisory on Tariff Structure for Urban Water supply and sewerage services
 - Year of Publication – July, 2013
 - Specifies tariffs for water supply (metered, unmetered and non-domestic connections) and sewerage (metered and unmetered connections)
5. Various other advisories in regard to water supply and sewerage system issued from time to time
6. National Power Tariff Policy

- Ministry of power has amended the National Tariff Policy for Electricity on 28th January, 2016 wherein, a provision has been made for the thermal plants located within 50 km of sewage treatment facilities need to use treated sewage water.

Institutional Strengthening and Capacity Building

The 74th constitutional amendment act (CAA) envisaged creation of vibrant urban local bodies which would be empowered with funds, functions and functionaries. The intent of the 74th CAA can be realized only through the implementation of various governance, institutional, financial and administrative reforms which will pave the way for enhancing service delivery and effective local governance. The various programmes/schemes/missions launched by the Government in the past have been directed towards the hard infrastructure, while improvements in the soft components have been given less or no priority.

The High Powered Expert Committee (HPEC) Report on the Urban Infrastructure and Services (2011) brought out the lack of the capacity in Urban Local Bodies. The requirements for Capacity Building in terms of Demand – Supply gap is high not only on account of the number of people to be trained but also in terms of the competencies of the personnel required if the intended governance and service delivery standards are to be achieved.

Based on the analysis of the experience of implementing various reforms as well as infrastructure programmes, some of the key areas where capacity gaps have been identified include Urban Management and Administration, Financial Management, Accounting and Revenue Mobilisation, Service Level Benchmarking, Development and Implementation of PPP Projects, use of Information Technology, Project Management, Public Health Engineering, Operation and Maintenance, Project Implementation, Management and Monitoring, Contract Management. Short term re-training of lower level municipal staff and concepts such as “just in time” training and capacity building delivery needs to be emphasized.

In the recent years, emphasis is being given in building the soft

infrastructure of the ULBs. Building personnel as well as institutional capacities is imperative to the successful management of the complexities of urban development. Some of the initiatives taken by the Government of India for building the capacity of ULBs are listed below:

- Public Health Engineering Training Programme
- Ministry of Urban Development's Manuals on Water Supply And Sewerage Systems
- Training of Elected Representatives
- Training through Regional Centres for Urban and Environmental Studies
- Training through National Institute of Urban Affairs
- Research and Capacity Building in Urban and Regional Planning scheme

In addition to the above, presently the Ministry of Urban Development (MoUD) is supporting States and ULBs in capacity building activities through the Capacity Building for Urban Development (CBUD) Project.

Further, under AMRUT, capacity building is one of the admissible components and 10% of the annual budgetary allocation under the Mission has been allocated towards Administrative and Office Expenses, which will be utilised for capacity building programmes and hiring of professionals and support teams. Further, as per the guidelines of AMRUT, it has been mandated for all the 500 AMRUT cities/towns to submit their annual capacity building plan in their SAAP report to the Ministry for receiving the funds.

Discussion and Way Forward

In urban water supply sector, the goal of the Government is to achieve 24 X 7 treated water supply at the rate of 135 LPCD to all the households in the urban areas of the Country. Whereas, in the rural water supply the goal is to provide 70 LPCD tapped water supply to at least 90 % of the households in the rural areas of the Country.

In urban sewerage sector, the goal is to achieve 100% collection and treatment of sewage in all the urban areas of the Country with 100

% recycling of treated water. In the rural sanitation sector, the goal is to achieve 100% treatment of sewage generated in all the rural areas of the Country with recycling of treated water for agriculture and groundwater recharge and pollution control.

The ways and means to achieve these goals in water supply and sanitation are so crucial in improving the human development indices but are not easy. The commitment of Government to sanitation will be a turning point. The results thereof have to show up in the qualitative recovery of water resources. The sector planning has shifted from administration-centric to the social and economic angles with people-centric, integrated and sustainable methods.

The fund availability for the huge investments required in water supply and sanitation is expected to be sufficient even though PPP investments have not grown in the sector. But the Annuity based models of infrastructure development are expected to provide impetus to private fund inflows.

The administration has shifted from area based development model to access and coverage mode of service delivery ensuring social development, as the economic costs of lack of water supply and sanitation are now well understood.

The soft components of infrastructure development are receiving greater attention. The globalisation has brought in societal changes, where improved services are demanded with willingness to pay so essential for sustainability of services.

With the building up of the aforementioned support mechanisms to water supply and sanitation sector from every corner, it is expected to provide its rightful infrastructural platform for the social and economic development of the country in the years ahead and be able to support the rapid urbanization and transformation of India.

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Vinod Tare

Managing and Sanctifying Our Water Bodies

Introduction

Increasing use of fossil fuels and minerals has propelled global economic growth in the industrial age. But ever-increasing industrial production often implies the release of harmful wastes into the environment. Moreover, increase of such industrial production fuels the demand for other natural resources such as land, water and biotic resources as well as the release of even more pollutants from their consumption. Taken together, these factors cause major environmental disturbances, and their cumulative impacts can devastate the very ecosystems on which the life of a nation is crucially dependent. Primary among such vulnerable ecosystems in India are its water bodies. And India, like many other developing countries of the world, is saddled with the unenviable task of saving its rapidly degrading water bodies for the country's long term productivity without compromising her immediate growth prospects.

The key to understanding the benefits and harms that we are exposed to in a changing production-consumption environment is the ecosystem concept. An ecosystem is a part of the biosphere comprising a dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting with each other as a functional unit. And ecosystems provide various services that are beneficial to people. These include *provisioning services* or *products* (such as water, food, fibre and energy), *regulating services* (such as regulation of floods, droughts, land degradation, diseases and micro-climate, groundwater recharge, water purification, silt dispersal, and prevention of salt water intrusion), *supporting services* (such as soil formation, nutrient cycling and distribution, and biodiversity maintenance), and *cultural services* (such as spiritual, aesthetic and

recreational services). These services contribute to human well-being that in many ways include basic material for a good life, freedom and choice, health, good social relations, and security [UN Water, 2013; Smith and Barchiesi, 2009; MEA, 2005].

In India, humans have been an integral part of ecosystems for millennia, but in modern times – in particular, in the past several decades– many of its diverse ecosystems have been exploited so rapidly that they have degraded *en masse*. Not only that, some of them have become extinct altogether while others have become gravely threatened. And, hence, the vital life-supporting services provided by these ecosystems are enormously reduced even as our material consumption has increased many-fold. Our water bodies are no exception to this phenomenon, and it is imperative that institutional measures are urgently initiated to save and revive our remaining water bodies in order to secure our future. Otherwise, the vital services that they provide us with can become so scarce that no amount of industrial products could conceivably compensate for them.

Main Threats to Water Bodies in India

India's water bodies – surface water bodies (rivers, lakes, ponds, marshlands, estuaries, etc.) and aquifers– have provided a secure basis to our civilizational achievements all through history. But they have been seriously impacted in the modern age by inappropriate domestic, industrial, agricultural and socio-cultural activities. The basic problems are all too well-known but need to be reiterated here for the importance they deserve. A key problem behind the degradation of our water bodies is the gross over-extraction of water from them, thereby shrinking or decimating these ecosystems. Another widespread problem that has extensively degraded our aquatic ecosystems is the despoiling of their water quality by indiscriminate pollutant and waste discharges into them.

Both the above factors are widely known in India. However, less often emphasized is a third major factor that severely affects our water bodies (as well as other ecosystems) is that of encroachment (apart from the direct structural interventions made in them like dams, barrages, bridge piers and embankments). The problem of

land encroachment is often overlooked, but its importance cannot be overstated. Increasing human activity in areas that intrinsically belong to surface water bodies (that is including their riparian areas and floodplains) is a major cause for their degradation. This problem can be easily grasped from a broader perspective, namely, that as compared to the rest of the world, India is not as critically deficient in water as it is in terms of land. For, as is often noted by government agencies, India possesses about 4% of the world's water resources but only 2.4% of the world's geographical area to support 17% of the world's population [MOA, undated; MoWR, 2008]. Obviously, therefore, India's land constraint is much more critical than that of water in global terms. Hence human demands on land can be expected to be much more critical in India than that of water. Moreover land, unlike water, is not a renewable resource. Hence over-exploitation of land will have much longer-term repercussions on aquatic ecosystems.

India's land constraints also affect our water bodies in other ways than by direct land encroachment. Thus, increasing conversion of forested areas and grazing pastures to agricultural land and similar conversion of fallow land to built-up areas adversely affects the hydrological regime and perhaps even the rainfall regime in a basin [IITC, 2015a]. Besides they reduce the ecosystems' capacities for primary production and regulation of floods, droughts, water purification, etc. Thus short-sighted land use changes in our river basins inexorably contribute to the deteriorating state of our water bodies.

There are, of course, additional anthropogenic factors that adversely affect our water bodies, such as over-exploitation of biotic resources, silt and energy from them, and the introduction of exotic aquatic species. Such factors, too, have significantly contributed to the overall deterioration of our water bodies.

Assessing and Quantifying Sources of Pollution

Various types of anthropogenic wastes are generated in India as shown in Figure 1 [IITC, 2015b]. Two broad types of wastes, whose improper disposal adversely impact water quality of our water bodies are, 1) solid wastes and 2) liquid wastes. Solid waste can be broadly

classified as, 1) non-hazardous and 2) hazardous. Non-hazardous solid waste is generated mostly from domestic, commercial and agricultural sources. Industrial activity may result in the generation of both non-hazardous and hazardous solid waste.

Liquid waste is produced when pollutants are intentionally dissolved or suspended in water for transport away from their point of generation. Such point sources of liquid waste generation are attributable to domestic, commercial and industrial activities. All towns and villages of the country are thus point sources for liquid waste generation. In addition, industries are also major point sources of liquid waste.

Liquid waste is also generated from non-point (i.e., distributed) sources. The accumulation of garbage and the widespread practice of open defecation by humans and cattle results in the general accumulation of filth and pathogens in our basins. This is entrained in the surface runoff during rainy season and becomes a source for non-point pollution in our water bodies. The agricultural sector is also a major source for non-point pollution in many places. Chemical fertilizers and pesticides applied on agricultural fields are easily leached into irrigation return flows or storm runoffs.

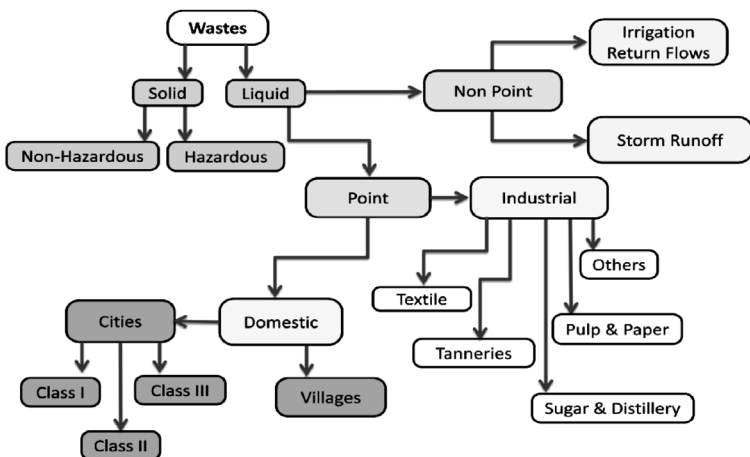


Figure 1: Various Types of Waste Generated

While there is some estimate of liquid wastes generated and discharged into water bodies from some point sources, such as from major cities and industrial units, there is little information on such wastes generated from small towns and villages. And, information on liquid wastes from distributed sources is virtually non-existent. Thus no meaningful quantification is possible on the actual ingress of pollutants into our water bodies. However, pollutant ingress into water bodies can be broadly identified as occurring in three ways, viz.: 1) by direct discharge of pollutants into water bodies, 2) discharge of polluted surface runoff into them, and 3) seepage of polluted subsurface flows into them.

Direct discharge of pollutants occurs due to: (i) discharge of liquid wastes generated from point sources into water bodies, (ii) dumping of municipal and industrial solid waste, devotional offerings, animal carcasses, un-burned/partially burned human bodies, etc. into them, and iii) non-ritual/non-spiritual bathing with the intention of cleaning body dirt, direct defecation, washing of clothes, washing of vehicles, washing/wallowing of animals, etc.

The origin of polluted non-point surface discharge into water bodies are twofold: (i) surface runoff containing leached fertilizers and pesticides applied on agricultural fields, and (ii) surface runoff containing entrained solid waste, i.e., garbage, industrial waste, human and animal faeces, etc.

Some portion of the liquid waste generated from both point and non-point sources, described above, infiltrates into the subsurface and pollutes the groundwater. This results in alteration of geochemical processes of the subsurface waters, leading to mobilization of otherwise immobile minerals (e.g. iron, manganese, arsenic, etc.), endangering human and animals through usage of such waters. Seepage of polluted ground water also results in pollution of water bodies.

Monitoring the State of Water Bodies

Presently there is very little actual monitoring of water bodies in India. For groundwater aquifers even the scales and extents are often unknown, though detailed mapping has been started by the

government. On the other hand, mapping of major wetlands in India has been carried out from satellite images since the last decade [e.g. SAC, 2011; CIFRI, undated], but other meaningful information about the geology, hydrology, water quality or biodiversity are scanty. Even where some monitoring studies have been conducted by academia or other institutions, the works remain largely dispersed and ignored, since there is no single agency or institutional mechanism to collate, process and synthesize the information. For a very few select water bodies, such as the major rivers of India, some monitoring work is carried out by government agencies like CPCB and CWC, but here too the available information is often inadequate for a comprehensive assessment of the specific river's status. It is instructive in this context to broadly review the available information about India's most important river, National River Ganga.

Hydrological Status of Ganga

The most significant cause for the Ganga river's degradation is considered by some experts to be due to the large number of barrages and dams in the river network and the concomitant over-extraction of water, with about 60% of the flow being abstracted for irrigation alone [see e.g. Wong *et al.*, 2007]. But quantitative hydrological information about Ganga, being classified by the government, is unavailable to public scrutiny. Some data were nonetheless made available to the IIT Consortium for hydrological modelling studies to prepare the Ganga River Basin Management Plan–2015. As discussed in a GRBMP report [IITC, 2015a], however, the data are quite inadequate to make reliable estimates of hydrological parameters or to accurately predict future hydrological events in the basin. And the actual estimates of water resource potentials by government agencies were found to be equally unreliable. The obvious need is to carry out systematic hydrological monitoring on a continuous basis and make the information widely available for independent review.

Water Quality Status of Ganga

Some water quality data at selected stations on River Ganga are available, and they indicate varying, but often poor, water quality status. For instance, the water quality data of Ganga river indicates

that at Dev Prayag (confluence of rivers Bhagirathi and Alaknanda) and further downstream, the faecal coliform numbers in Ganga River are, on an average, 100 times more than the levels acceptable for bathing as shown in Figure 2 [IITC, 2015b]. Downstream of large cities like Kanpur, the faecal coliform numbers are 1000 times or more than the acceptable levels. In some locations of the Ganga river system the organic loading, as indicated by the Biochemical Oxygen Demand (BOD), is also high (which adversely impacts river ecosystem), vide Figure 3 [IITC, 2015b]. Some data are also available on concentrations of nutrients like nitrogen and phosphorus, and of some inorganic salts, but data regarding loading of pesticides and heavy metals into the Ganga river system is scanty [IITC, 2015b]. Water quality monitoring need to be more judicious than at present.

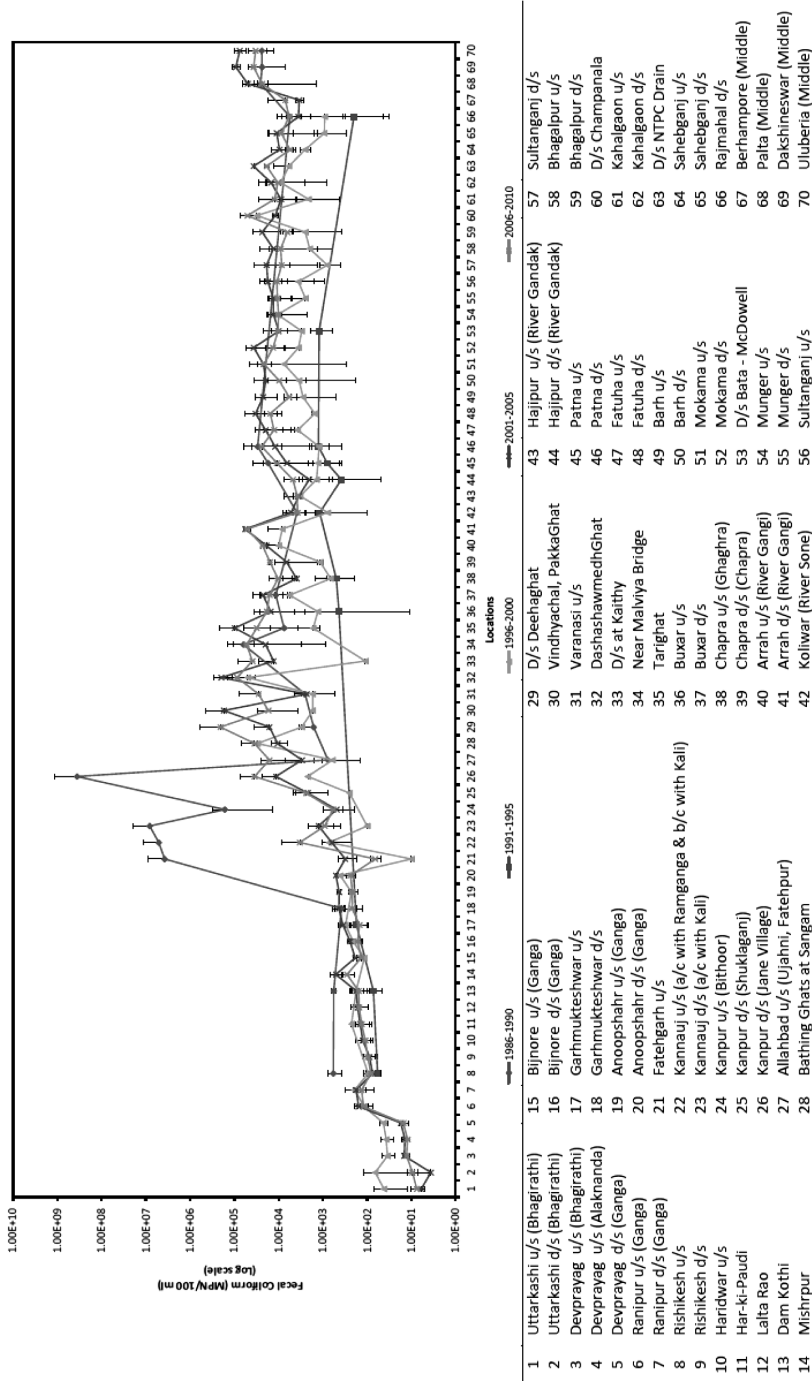


Figure 2: Variation in 5-year average Fecal Coliform at Various Locations along the Ganga River [IITC, 2015b]

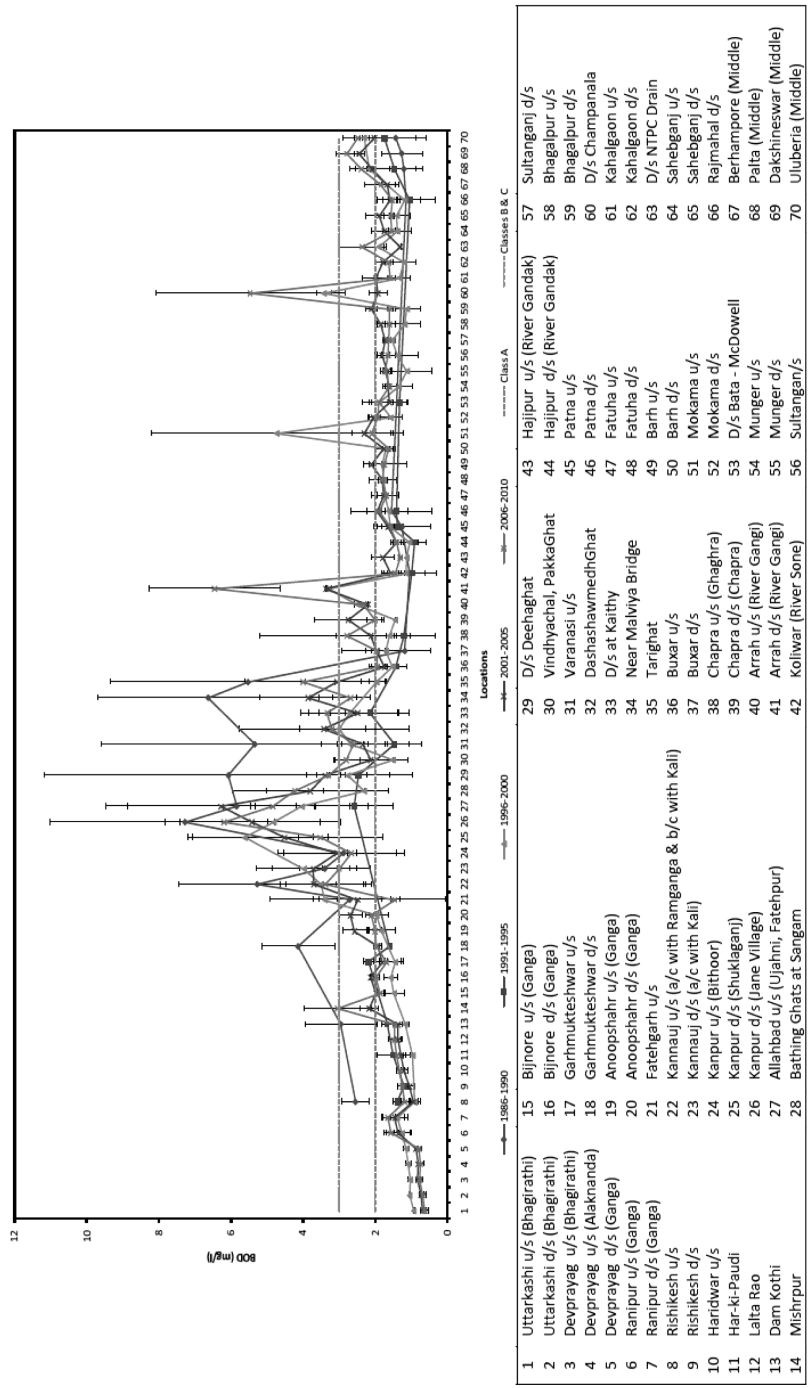


Figure 3: Variation in 5-year Average BOD5 at Various Locations along the Ganga River [IITC, 2015b]

Ecological Status of Ganga

The Ganges river system contains the richest freshwater fish fauna in India with over 140 fish species, 90 amphibian species and 5 areas supporting birds found nowhere else in the world, besides 5 species of freshwater cetaceans including the endangered Ganges River Dolphin and the rare freshwater shark, *Glyphis gangeticus*; while the unique Sundarban delta supports over 289 terrestrial, 219 aquatic, 315 bird, 176 fish and 31 crustacean species [Wong *et al.*, 2007]. But the biodiversity of the Ganga river is hardly monitored by any agency, with only a few sporadic studies being conducted at times. Thus only a very rudimentary (if not outdated) idea about other biodiversity can be arrived at from the present monitoring (or non-monitoring) system. For instance, the fish catch at Allahabad since the last century is documented. Thus the progressive loss of fish catch at Allahabad from 1950 to 2010, vide Figure 4 [IITC, 2015c], gives a preliminary idea of the steep ecological decline in the middle stretch of River Ganga. However no quantitative estimate can be made from such data about the overall biodiversity or its loss in the Ganga River near Allahabad or elsewhere.

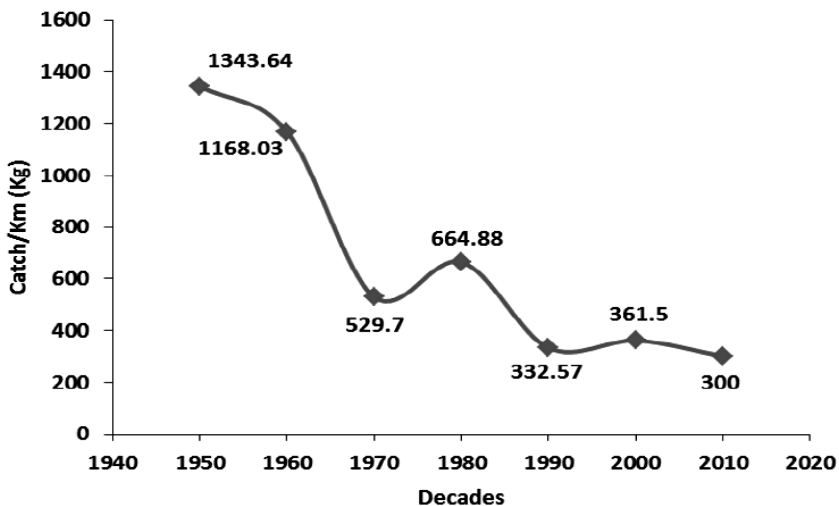


Figure 4: Fish Catch per km at Allahabad between 1950 and 2010 [IITC, 2015c]

India is a vast country having many significant water bodies, but many of India's numerous water bodies are vastly neglected. While large rivers are monitored to some extent, other water bodies are virtually outside the knowledge purview. Even in major cities that house India's administrative and knowledge centres, there is no credible monitoring of water bodies; and this despite the fact that devastating floods in Indian cities like Chennai and Srinagar in recent years have been widely attributed to the rapidly degrading wetlands and the blocked or disappeared natural waterways in the catchment.

In the absence of any systematic monitoring mechanism for water bodies it is natural that one depends on stray information from sporadic studies and news reports to arrive at a very sketchy idea of the status of our water bodies. A few illustrative examples of such information may be cited here to realise how the lack of authentic monitoring has contributed to the deplorable status of our water bodies:

“Bangladesh, India, Nepal, and Pakistan annually pump a total of about 210–250 cubic kilometres of groundwater ... Groundwater use will increase by 30 percent, with the PRC, India, and Pakistan accounting for 86 percent of total groundwater abstraction in Asia. Such rampant expansion in use and its impact on declining water tables, water quality, and the continued demand for energy will become more pressing,” said the ADB, in its report Asian Water Development Outlook 2016.[Saeedi, 2016]

Uttar Pradesh has lost more than 1 lakh water bodies (out of 8, 75,345 tanks, ponds, lakes and wells) to the hands of illegal encroachment in one year till November 2013 as per the state revenue department [Babele, 2014].

According to a survey conducted by Lucknow Municipal Corporation, there were around 964 ponds in the city in 1952. The number declined to 494 in 2006. [Verma, 2016]

There are 1,012 water bodies in Delhi but, only 905 could be traced (in 2016). Of the total water bodies traced, 338 are dry, 168 encroached and 107 non-traceable. [Sharma and Singh, 2016]

There were 159 water bodies spread in an area of 2003 ha (in Greater Bangalore) in 1973; that number declined to 147 (1582 ha) in 1992, which further declined to 107 (1083 ha) in 2002, and finally there were only 93 water bodies (both small and medium size) with an area of 918 ha in the Greater Bangalore region, in 2007 [Bharadwaja, 2016].

The physico – chemical characteristics of 80 lakes of 3 different valleys (of Bangalore) monitored for a period of 24 months (revealed that) 98% lakes are encroached and 90% lakes are fed by sustained inflow of untreated sewage and industrial effluents. [Ramachandra et al., 2016].

In Central Kolkata ... there is fall of 7 to 11m in ground water level in last 45 years from 1958 to 2003 [KMC, undated].(But) in a confidential interview a Kolkata Municipal Corporation official told that ... groundwater levels have plummeted in various parts of the city. ... Kolkata officially has about 17,000 stand posts, 12,000 hand tube wells and around 2,500 large tube wells mainly catering to multi-story buildings, but the actual figures are far higher [Basu, 2015].

Report Card of Orinoco River Basin: A Case Study

It should be noted here that basins of large water bodies are diverse in nature, and hence there are no standardized metrics that perfectly define the health of a water body or its basin. As an example of basin-wide monitoring, the “Orinoco River Basin Report Card 2016” of the Orinoco river, Colombia [Garcia, 2016] may be cited. The report card is based on the conception of basin values in terms of water, biodiversity, management/governance, economy, ecosystems & landscapes, and people & culture as depicted in Figure 5. And the key indicators of basin health were conceived as given in Table 2. The data needed were accordingly culled from various sources to arrive at a composite value (63%) for the basin’s health. This method is not a given absolute, however, and it is possible that for other basins or for the same basin at a future date, different indicators and their weights may be adopted to obtain a better overall indicator of basin health. What is significant is the attempt to obtain a quantitative indicator of basin health, which is entirely lacking in India. It is imperative, therefore, that environmental valuation of our water bodies and their basins are carried out, water audits and accounts are conducted, and

a regular mechanism of their monitoring and comprehensive basin-specific data banks are established at the outset, in order to holistically manage and sanctify our water bodies.

BOX: Key Health Indicators of Orinoco River Basin
[WWF, 2016]

Water Quality Index: The water quality index assesses the status of water quality variables (dissolved oxygen, total suspended solids, chemical oxygen demand, electrical conductivity, and pH) based on data from the Environmental Information System Indicators (IDEAM).

Risks to Water Quality: The risks to water quality index estimates pressure to water quality due to pollution loads discharged by industry and water use by domestic, livestock, and coffee processing sectors (IDEAM).

Water Supply and Demand: The water supply and demand index is the balance between the availability of water in the watershed, environmental flow requirements, and the water demand by different economic sectors (IDEAM).

Natural Land Cover: The natural land cover indicator measures landscape conversion by comparing the area of natural to non-natural (developed) in the basin, based on satellite imagery for 2012. Loss of natural land cover impacts biodiversity in the basin (PEMO).

Stable Forest Area: This indicator measures the amount of forest that has remained stable in the Amazonian transition sub-basins for the period 1990–2014, where forests are the main or dominant ecosystem. Forest area was calculated using satellite imagery (IDEAM 2015, Forest monitoring system).

Terrestrial Connectivity: Wildlife depends on connectivity between different ecosystems and habitats. The Landscape Shape Index (from University of Massachusetts, Amherst) was used as a measure of fragmentation of terrestrial habitats within each basin.

Fire Frequency: Fire has been shaping parts of the savanna ecosystems for thousands of years. The fire indicator examines the average frequency of fires over the last three years (2013-2015) in each sub-basin compared to historical fire trends.

Ecosystem Services: The Ecosystem Services Regulation Indicator is based on the average of Climate Regulation by Carbon Storage, (PEMO 2013), Hydrologic Regulation Index that measures the amount of moisture that can be retained in basins (IDEAM 2015), and the Soil Erosion Susceptibility Zoning that shows the different erosion rates based on land assessment methods (IDEAM 2015).

Human Nutrition: The human nutrition indicator assesses the percentage of children aged 0-4 with a healthy body weight. This indicator is a proxy for the capacity to provide enough food for people in the basin. Information on human weight was available from the National “Survey of the Nutritional Status in Colombia” conducted in 2010.

Mining in Sensitive Ecosystems: This indicator examines the presence of mining concessions within sensitive ecosystems including: páramos, montane forest, riparian forest, wetlands, and flooded savannas.

River Dolphins: River dolphins are listed as a vulnerable species in Colombia and are an important indicator species of river health where they are present. Data from the Omacha Foundation includes estimates of abundance and habitat use patterns in the Meta, Orinoco, Bitá, Arauca, Guaviare, and Inírida.



Figure 5: Conceptual Framework of Orinoco River Basin Values [WWF, 2016]

Managing Water Bodies for Enabling them to Provide Eco-services

As evident from the previous section, our water bodies are both neglected and over-exploited. This is probably because they continue to be considered as natural entities whose conditions and usefulness are independent of human acts. Hence there has been no meaningful attempt to estimate the economic value of our water bodies, even of the important ones. Now India is a vast country having many significant water bodies, but it has only 26 Ramsar wetlands (refer Table 1). Even if one were to consider only the Ramsar sites as our important water bodies, their environmental valuation could lead to some meaningful appraisal of the importance of our water bodies, thereby providing an impetus for their monitoring.

Table 1: List of Ramsar Wetlands in India [ENVIS, undated]

S. No.	State/UT	S.No.	Name of Ramsar Site
1	Andhra Pradesh	1.	Kolleru
2	Assam	2.	Deepar Beel
3	Gujarat	3.	Nalsarovar Bird Sanctuary
4	Himachal Pradesh	4.	Pongdam
		5.	Renuka
		6.	Chandratal
5	Jammu & Kashmir	7.	Wullar
		8.	Tso Morari
		9.	Hokersar
		10.	Mansar&Surinsar
6	Kerala	11.	Ashtamudi
		12.	Sasthamkotta
		13.	Vembanadkol
7	Madhya Pradesh	14.	Bhoj
8	Manipur	15.	Loktak
9	Orissa	16.	Chilika
		17.	Bhtarkanika
10	Punjab	18.	Harike
		19.	Kanjli
		20.	Ropar
11	Rajasthan	21.	Sambhar
		22.	Keoladeo NP
12	Tamil Nadu	23.	Point Calimere
13	Tripura	24.	RudraSagar
14	Uttrakhand	25.	Uppar Ganga
15	West Bengal	26.	East Kolkatta wetland
	Total		26 sites

To manage our water bodies well, therefore, a definitive step is that their environmental valuation is carried out at the earliest. However, since value-specific data may be scarce at present, the valuations should be a continuous process based on updated and more reliable data as and when they become available.

To assess actual water use and availability, water accounting and water audits should also be carried out regularly, preferably on basin or sub-basin scales. In case such audits indicate that anthropogenic water

usage exceeds sustainable limits during a specified time span (say one year), water budgets should be prepared and implemented for future time-spans so that water bodies are not dewatered into extinction while avoiding human water-wars. Demand-side management with emphasis on recycle/ reuse of grey water (instead of freshwater) on the supply side can effectively solve most of our persistent water problems.

Simultaneously basin-wide scientific, technical and socio-economic databases should be created through a well-organised monitoring process [see e.g. IITC, 2015d] in order to formulate suitable management measures. Since such a monitoring system is presently ignored despite there being a plethora of government agencies in the water sector. An appropriate agency must therefore be established or designated to co-ordinate and oversee such monitoring. An example of such a body is the NRGBMC proposed for the National River Ganga Basin [IITC, 2015e]. Pending such a focussed and institutionalised programme, management of our water bodies will continue to remain ad hoc and inadequate in the foreseeable future.

1. Issues Related to Managing Wastewater

The main problems with anthropogenic wastewater management relate to the quantity and quality of the waters. From the overall national perspective, industrial wastewaters may not be quantitatively very high at present, but they often contain very harmful chemicals that are toxic or degrade very slowly in the natural environment or are high in salt content; hence it is necessary to fully treat and reuse them, while discharging an absolute minimum at a safe location such as into oceans instead of inland water bodies [IITC, 2015b].

Domestic wastewaters are often voluminous, especially those produced from urban clusters. They are harmful to the environment for their significant organic content and pathogen components. Hence they must be treated as completely as possible before releasing them into water bodies or— a better option —reusing them [IITC, 2015b].

Agricultural wastewaters are probably the largest volumetric

component of wastewater generation in India. Since this wastewater generation is distributed over vast agricultural lands, wastewater treatment may not be a feasible option. The obvious measures needed, therefore, are: (i) to minimize their waste generation potential by minimizing soil tillage and the use of chemical fertilizers and pesticides, as well as the recycling of agricultural refuse; and (ii) minimizing the wastewater generation and spillage into water bodies by minimizing irrigation water use and recycling the irrigation return flows [IITC, 2015f].

The above measures need to go hand in hand with detailed data inventory of actual wastewater generation and their management, without which efficient wastewater management cannot be sustained over the long term.

2. Sanctifying Water Bodies – Applying Science with Traditional Wisdom

According to Government of India 2009 data, the per capita water availability was more than 5000 m³/year in the year 1951. This per capita quantity has been declining with increasing population and now stands at less than 1200 m³/year by pushing the nation from the water adequate status to water-stressed country. Majority of nation's fresh water supply comes from the surface water and replenishable groundwater sources. Although rainfall frequency and intensity may have changed, historical average annual rainfall volume may not have changed drastically. Thus in calculation of per capita water availability, while the numerator has remained same, the denominator has increased exponentially and likely to increase further in the coming decades indicating that water stress situation could further exacerbate unless steps are taken in the direction to change the water equation.

There are several steps that can be taken immediately to reverse the situation. The water availability can be increased by using the water a number of times through much enhanced reuse and recycle practices. The cities should embrace decentralized wastewater treatment mechanisms and reuse the water as much as possible where it gets generated reducing fresh water demand. Government and local

authorities should consider developing policies to promote the grey water techniques by separating the fecal stream from the rest of the wastewater stream. The wastewater stream that has not been in contact with fecal matter can be treated to tertiary level and can be further treated using advanced treatment mechanisms such as reverse osmosis to supplement the fresh water demand. It is important to note that it is much less expensive to treat sewage than desalination of sea water.

However, for all of the above solutions to prevail, understanding the water budget at local level is the key. Once the data is available at the local level, the data can be aggregated at the city, state or at the national level. Every local municipality should conduct water audits to understand the consumption, immediate and future water demand including the assessment of the available water quantities. The audit should include assessment of the non-revenue water and the losses through water distribution networks as well. This will prepare local authorities to understand how efficiencies can be brought to lessen the demand for fresh water and at the same time will also increase the preparedness to face drought years.

Interlinking of water bodies at local scale (town/village)

At present there is a debate going on the merits and demerits of interlinking of water bodies on national scale. However, the fact is that with rapid urbanization, to fulfil the water demand from these urban areas, the water is already being imported from hundreds of kilometres faraway places for meeting the current water demands. For example, the city of Indore in the state of Madhya Pradesh gets its water from Narmada River where as the City of Bangalore in Karnataka state gets its water from Cauvery River located about 100 kilometers from the city; similarly City of Hyderabad gets its water from River Krishna located 116 kilometres away. The cost of conveying this water from its source to destination requires pumping and comes with huge costs in terms of power and there are losses associated with distributing over such a long distance as well. In case of Indore, it costs about INR 30 per cum and in case of Bangalore it costs about INR 82 per cum. Furthermore, this

horizontal conveyance alone cannot meet the growing demand and there is vertical transport of water from groundwater aquifers to meet the additional water demands.

At present, the water that is being imported into urban areas both horizontally and vertically gets converted into sewage and is being transported over 15 to 20 kilometres for treatment and gets partially treated. In most cases, either partially treated or untreated wastewater is allowed to flow into lakes, ponds, *nallabs*, rivers or any nearby water body. This has already contaminated majority of the urban water bodies across the country. In addition to contaminating the surface water bodies, this eventually percolates into groundwater with organic load and contaminates the groundwater and renders it useless.

Now that the water is already being transmitted across great distances, as opposed to conveying further away for partial treatment, a good solution would be to develop decentralized wastewater treatment systems. The decentralized treatment systems if maintained and operated properly, can provide water for reuse and recycling. The treated water can then be let into the local water bodies for maintaining a healthy flow through the water body. Most of the small tributaries in India are seasonal with flows showing up only during the monsoon season. However, with importing millions of litres of water on continuous basis and converting most of this water into sewage and instead of letting it into our water bodies, if tertiary treated water is let into these water bodies, the fully treated sewage can serve as source of fresh water and the water bodies once contaminated can be turned into fresh waterbodies.

The interlinking of the waterbodies at local level can serve multiple objectives. At present, lack of water resources management plans has led to urban flooding during the heavy rains causing massive traffic problems and in some cases deaths as well. However, interlinking of local waterbodies will create a network of water bodies and work as bulwark against flooding. There are other benefits such as developing recreational areas in the middle of the cities, providing with fresh water source leading to enhanced water security for the region as a whole and most importantly reducing the huge costs associated with transportation of the water over hundreds of kilometres.

Separating Sewage from Storm Water Drainage Network

The development and management of natural/storm water drainage systems go hand in hand with the development of the sewer systems. Majority of urban drains today carry sewage throughout the year as well as storm water runoff for 3 to 4 months during the monsoon season. This has to stop. The sewage needs to be collected and treated at local level that can be reused and recycled. The usage of septic tanks, soak pits, open drains carrying mostly swage, etc. needs to be addressed so that only sewage is conveyed to locally decentralized treatment facilities.

Catchment Clean-up

Any good watershed management plan is not complete without a comprehensive solid waste management (solid waste and animal dung) component. This is especially true where animal waste generated is not managed properly. The solid waste can ultimately reach the water bodies as non-point source or through *nallabs* and increase the organic load significantly. The solid waste management components include educating the population living inside the catchment area to providing facilities for solid waste management. Also, it is important to note that the animal waste produced, especially the cow dung can be used as manure in the organic farming. The cow dung that can be a valuable fertilizer, if not used properly and disposed off as a waste can be a liability on the water bodies.

Traditional Knowledge and Science

Worshipping water bodies has been a part of Indian culture since time immemorial. Even today, most of the households across the nation keep Ganga water in the prayer room and it is part of all the daily rituals. This is extremely scientific when analysed carefully. When looked at Indian civilization that has thousands of years of history, the current sorry state of the water bodies can be attributed only to the last few decades of rapid urbanization that has cut off the population from its traditional value based system and not yet fully integrated with the Western scientific education system. The water that was revered and considered sacrosanct will naturally be protected

by the users who rely on this very water for their survival. This served as a governance mechanism that needed no constant vigilance or enforcement. This can be illustrated with a few examples.

Ancient scriptures had cautioned against misusing the Ganga river. For instance, the following edict in Sanskrit prohibited thirteen types of human actions, viz.: defecation; ablutions; discharge of wastewater; throwing of used floral offerings; rubbing of filth; body shampooing; frolicking; acceptance of donations; obscenity; offering of inappropriate praises or even hymns in a incorrect way; discharging of garments; bathing and, in particular, swimming across.

गंगां पुण्यजलां प्राप्य त्रयोदश विवर्जयेत् । शौचमाचमनं सेकं निर्माल्यं मलघर्षणम् ।
गात्रसंवाहनं क्रीडां प्रतिग्रहमथोरतिम् । अन्यतीर्थरतिचैवः अन्यतीर्थप्रशंसनम् ।
वस्त्रत्यागमथाघातं सन्तारंच विशेषतः ॥

ब्रह्माण्डपुराण (८०० ई०)

Further, a verse from another scripture says “A sin of human being is purified by taking bath in Holy River *Saraswati* for three days, in Holy River Yamuna for one week and in Holy River Ganga in one dip. However, all sins of human being are purified only by viewing the holy River Narmada.”

त्रिभिः सारस्वतं तोयं सप्ताहेन तु यामुनम् ।

सद्यः पुनाति गांगेयं दर्शनादेव नार्मदम् ॥

(मत्स्य पुराण १८५/१० – ११)

This clearly suggests how simple norms were used to protect rivers having different biophysical settings from human impacts.

Traditional knowledge has many more such examples not only in the scriptures but also in the practise. However, with urbanization and more importantly, the drinking water that gets imported into urban areas from distant places has taken water out of our mind and similarly, the disappearance of the wastewater from the houses has disconnected the water pollution from the people. Making water an important part of education and reviving our traditions can be a very successful and essential tool for keeping our water bodies healthy.

Conclusion

The present article highlights the urgent need for a concerted effort to salvage our threatened and rapidly degrading water bodies. Such effort must be led by the government, but cannot remain confined only to government policies and programmes. Decentralised actions must be allowed, even encouraged, to fortify the process. Thus non-state actors – such as local bodies, user communities, NGOs and academia – should be accommodated into the management space. This is not only because the whole population is a beneficiary of the water bodies, but also because traditional and hands-on knowledge and insights of many people can complement the compartmentalized actions of formal institutions and programmes [IITC, 2015e].

It should be also noted that water bodies, especially surface water bodies, need to be managed on basin scales, which implies systematic monitoring and documentation of basin-wide processes that is grossly lacking in India. As noted in the Ganga River Basin Management Plan-2015, “Basin planning and management combine diverse natural resources (water resources, land resources, biological resources, etc.) and processes (river dynamics, geological phenomena, atmospheric processes, etc.) with traditional wisdom and grassroots knowledge. Hence, it is necessary to build a comprehensive data bank to enable meaningful analyses and obtain quantitative indicators” of the basin’s status [IITC, 2015e]. The monitoring requirements need to be detailed and revised from time to time based on improved understanding of human-technology-environment interactions in the basin. And this is one activity in which the government must focus its efforts irrespective of contributions from non-state actors.

Acknowledgements: Assistance provided by Dr Gautam Roy and Mr Shyam Prasad in collating the information and preparing the manuscript is highly appreciated.

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Sharad K. Jain and M.K. Sinha

Research and Development in the Water Sector in India

Abstract: Research provides basic input for initiating a new dimension to the development. In fact, civilizations have grown with the pace of how well water resources were harnessed to meet the demands of water, which depends on the innovations and validations backed by the research. India has the twin challenges of meeting its increasing water needs along with sustaining pace of development. Added to this, the temporal and spatial variability compounded by climate change and competing demands for this limited resource for various uses – drinking water, sanitation, irrigation, industry, to name a few – underlines importance of research and development to meet these challenges in equitable and judicious manner on sustainable basis. This paper takes stock of the current status of R&D in water sector in India by presenting details of apex research institutions, key funding ministries and schemes to promote research in water sector. A SWOT analysis of R&D in water sector has been presented. It is suggested that there is a need to broad base research activities to all aspects of water management, such as hydrological measurements and assessment, increasing water use efficiency, Integrated Water Resources Management, water pollution control and treatment, river rejuvenation, flow forecasting, climate change impacts assessment and real time decision support systems, etc. This paper outlines paradigm shift required in approaches towards research and development in water sector in our country.

Present Challenges in Water Sector

India has the twin challenges of meeting its water needs along with sustaining pace of development. It has more than 18 percent of the world's population and 15% of livestock, but has only 4% of

world's renewable water resources with 2.4% of world's land area. India receives on average annual precipitation of about 4000 Billion Cubic Meter (BCM), which is its basic water resource. Out of this, after considering the natural evaporation- transpiration, only about 1869 Billion Cubic Meter (BCM) is average annual natural flow through rivers and aquifers. Due to topographical constraints and spatio-temporal variations in resources, it is estimated that only about 1,123 BCM, (690 BCM from surface water and 433 BCM from groundwater) is utilizable. There are further limits on utilizable quantities of water owing to uneven distribution over time and space, which may increase substantially due to climate changes, leading to water crisis and possible water related disasters, i.e., floods, increased erosion and increased frequency of droughts, etc. Further, competing demands for this limited resource for various uses – drinking water, sanitation, irrigation, industry, to name a few - underlines importance of research and development to meet these challenges in an equitable and judicious manner on sustainable basis.

As per the international norms¹ (Falkenmark and Widstrand 1992), a country is categorized as 'water stressed' when per capita per year freshwater availability is less than 1700 m³ and 'water scarce' if it is less than 1000 m³. India's current average per capita water availability is 1413 cubic meter per year for its present population of 132 million, which is expected to reduce to 1154 cubic meter in the year 2050 with the projected population of 1620 million. Note that the average value does not reflect the real water stress in many parts of the country since nearly two-thirds of our water resources are confined to Ganga-Brahmaputra-Barak (GBB) basins. Clearly, India is heading towards water scarcity. The scarcity of water availability poses several challenges since water is an economic resource also in addition to being vital for life, living and livelihood.

Another challenge is ensuring food and energy security, which is integral to and dependent upon water security. National Commission for Integrated Water Resources Development (NCIWRD), in

¹Falkenmark, M. and Widstrand, C. (1992). Population and water resources: a delicate balance. Popul. Bull., 47 (1992), pp. 1–36.

its report in 1999, had assessed that India would need about 450 Million Tonnes (MT) of food grains annually for its projected stabilised population of 1.70 billion by 2070. Increasing food grains from present level of about 280 MT to the level of food security of 450 MT would require not only higher water use efficiency but also higher food productivity, i.e., “more crop per drop”. Similarly, ensuring energy security would require substantial development of hydropower generation.

Climate change adds to these existing challenges. Preliminary estimates indicate almost same amount of rainfall in fewer number of days, implying more extreme events and larger dry spells. India has also committed itself to Sustainable Development Goals by 2030 in line with the United Nations resolution. Ensuring proper water and sanitation to all by 2030 in India is itself a herculean task by any means.

Research & Development Needs

The challenges in water sector, enumerated above, can be mitigated only through sustained research & development. The wide reach of water sector cutting across all sections of society demands multi-disciplinary research and development. In this context, a number of recommendations were advanced by Jain et al.² (2007) and the *Sub-committee on Technology Interventions in the Water Sector* (2014)³, constituted by the Scientific Advisory Council to the Prime Minister (SAC to PM). Most important research needs in the present context have been categorized under broad themes and are discussed next.

Systematic collection of data and their analysis.

Water management resources management requires, inter alia, databases of key hydro-meteorological data. Preferably these databases should be shareable and available on-line. To measure the variable, there is a need to develop robust and cost-effective

²Jain, S. K., P. K. Agarwal and V. P. Singh (2007). *Hydrology and Water Resources of India*. Netherlands, Springer.

³Sub-committee - SAC to PM (2014). *Technology Interventions in the Water Sector*. Scientific Advisory Council to the Prime Minister, Govt. of India, New Delhi.

sensors. We also need to strengthen data collection networks for rainfall, streamflow, and other variables such as evapotranspiration and soil moisture. Development of methodologies for integrated water resources assessment in a river basin under the various scenarios of land-use land-cover change and climate change along with their temporal and spatial variation requires urgent attention.

Increasing water use efficiency

This is an important research need of India since our present level of water use efficiency in irrigation, water supply, industries, etc., is very low even when compared to developing countries. Extensive research is needed in all water uses to reduce water footprints and make available water for further developments and environmental needs. This calls for research in irrigation application methods; increasing utilization of green water (soil moisture), efficient water distribution and reducing non-revenue water; flow measurements and water metering; improving industrial processes and technologies; reduce, recycle and reuse; etc.

Integrated Water Resources Management

Next important research need is achieving Integrated Water Resources Management (IWRM). This calls for models and other tools for optimal allocation of water, real-time estimation of demands, water accounting/budgeting and development of SCADA (Supervisory Control and Data Acquisition) and decision support systems. This would ensure equitable and judicious water allocation and management fulfilling the larger needs of the Society.

Climate change impacts assessment

Climate resilient water management requires projection of climate change impacts at river basin scale. This calls for research in downscaling of climate change models, projecting likely impacts at river basin scales and evolving mitigation strategies.

Rehabilitation of Hydro-infrastructure

Another area of research is in the field of rehabilitation techniques

for dams, canal and other water resources structures. Considerable resources go in development of water resources structures and it makes techno-economic sense to maintain these structures and rehabilitate them whenever and wherever found necessary. This would require newer investigation methods, instrumentation technologies, research & development in repair materials and their applications without disrupting operation of dams, canals, such as under water repairs, etc.

Water quality and environment

Most of rivers, water bodies (ponds/lakes), and groundwater becoming highly polluted. While emphasizing the need to prevent pollution, it is urgent to take up research to develop technologies of water purification at community level, in-situ purification of rivers, ponds, lakes and groundwater, cost effective removal of fluoride and arsenic contamination, etc. to increase availability of fresh or potable water. Reverse Osmosis, which is prevalent for household water purification, is not only costly but wastes almost four times the water it purifies. A challenge is to design and develop engineered natural systems of sewage treatment requiring equivalent land area and life-cycle costs comparable to or lower than those for electro-mechanical systems.

River rejuvenation

There is a need to be innovative in planning and design of water resources structures so that hydrologic (longitudinal and latitudinal) connectivity, environmental flow, flood plain retention, groundwater recharge, etc., can be achieved without compromising developmental needs. This would require research in assessing ecosystem needs, environmental flow, silt management, river training and bank protection, analysing surface and ground water interactions to augment ground water recharge as well as base flow, etc.

Managing Water related disasters

Hydrologic extremes continue to hit India year after year. This calls for a need to develop methodologies for: (a) long range forecasts

for planning purposes (e.g., magnitudes and frequencies of floods and droughts, change in water demands, water availability etc.), (b) real-time short-term forecasting products (e.g., rainfall, river stage, stream flow, urban and river floods, etc.), and (c) integrated real-time multi-reservoir operation, with forecasts for irrigation, flood-control, hydropower generation, and municipal & industrial supplies.

Water policy research

Government of India had formulated a National Water Policy in 1987 which was subsequently revised in 2002 and 2012. We also have a National Environment Policy (2006) and policy on Hydropower Development. Ministry of Water Resources, River Development & Ganga Rejuvenation has prepared a draft National Water Framework Bill. Keeping in view these developments, there is a need for more research on water policy and legislation related issues. Institutes such as Center for Policy Research and IWMI – Tata Water Research Programs are active in this field. However, efforts need to be scaled up. There is an urgent need to initiate research on water policies and their impacts. Evidence based water policies will certainly facilitate better water management.

Current State of R&D in the Water Sector

Indian researchers have done commendable work in the field of hydraulics, hydrology, sediment transport, and irrigation management. The R&D work on design of unlined channels in alluvial soils by Kennedy, Lacey and several other irrigation engineers; and design of weirs on permeable foundations by Dr. Khosla and his team have got worldwide appreciation. In recent decades, a large number of technical papers are being published by Indian experts in international journals, conferences; books and technical reports by Indians have created a major impact in the field of water resources. Over the past 100 years or so, a wide network of organizations involved in R&D in water sector, such as Central Water and Power Research Station, Pune; National Institute of Hydrology, Roorkee; Indian Institute of Tropical Meteorology (IITM), Pune; National Environmental Engineering Research Institute (NEERI), Nagpur; Indian Institute of Remote Sensing (Dehradun); G.B. Pant Institute of Himalayan

Environment & Development (GBPIHED), Almora, State Irrigation Research Institutes, IITs/NITs, other Central and State universities, and some private universities/ colleges have evolved.

In India, R&D activities in almost all sectors and more so in the water sector are chiefly funded by the Central/State Government. A number of Ministries / Departments provide funds for R&D either by running Research Institutes or through sponsored research projects. Many Ministries provide financial assistance to promote research in the field of water resources through grants to academicians in the Universities/IITs/IISc/NITs, R&D institutions and NGOs. Among the ministries and departments, Department of Science and Technology (DST) is the largest extramural R&D funding body. In the field of water, the other major ministries are Ministry of Water Resources, RD&GR (MoWR, RD&GR), Ministry of Earth Science (MOES), Ministry of Agriculture (MOA), and Ministry of Environment & Forest and Climate Change (MOEF&CC). Table 1 lists the major Central Ministries who provide R&D support in water sector and the areas covered by them.

Table 1: Major Central Ministries who fund R&D in water sector

Ministry / Department	Areas covered
Ministry of Water Resources, River Development and Ganga Rejuvenation	All area in water resources planning and management. Hydrologic modelling, irrigation and drainage, flood management, surface and ground water, climate change, water quality, cryosphere,
Department of Science and Technology (DST)	All the above areas
Ministry of Earth Sciences	All the above areas plus hydrometeorology,
Ministry of Agriculture / Indian Council of Agricultural Research (ICAR)	Water and soil management in agriculture, watershed development,
Ministry of Environment and Forests & Climate Change	Environmental, water quality, and climate change issues
Department of Space (ISRO) / National Remote Sensing Centre	Application of remote sensing data to water resources
Council of Scientific and Industrial Research (CSIR)	Water quality, purification

Ministry / Department	Areas covered
Ministry of Power	Hydropower Development
Ministry of Drinking Water and Sanitation	Rural Drinking Water
Ministry of Urban Development	Urban Drinking Water, Industrial water use
Ministry of Home Affairs / National Disaster Management Authority	Management of Water related Disaster (Flood)

The Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD & GR) has constituted 3 Indian National Committees on Surface Water (INCSW), Ground Water (INCGW) and Climate Change (INCCC) to review and promote research in respective aspects of water. DST processes research projects through Science & Engineering Research Board (SERB) and Water Technology Initiative (WTI). For the Ministry of Earth Sciences, the Project Appraisal and Monitoring Committee (PAMC) on Hydrology and Cryosphere mainly processes the research proposal concerning water sector. The Indian Space Research Organization (ISRO) undertakes research through its institutes namely SAC, (Ahmedabad), NRSC (Hyderabad), Indian Institute of Remote Sensing (Dehradun), CAZRI (Jodhpur) and others. Of all the extramural research funding for the 10 year period (till 2012), only 1.97% of the fund was allocated for water research⁴. Clearly the investment on R&D in water sector is very small.

Irrigation/water resources research and training institutes have been working for quite some time and doing appreciable work in some States, e.g., UP (Irrigation Research Institute), Gujarat (Gujarat Engineering Research Institute), Maharashtra (Maharashtra Engineering Research Institute), Kerala (Center for Water Resources Development and Management), etc. However, such institutes in many States are deteriorating with time. There are some State S&T Councils, but their involvement in water R&D is not much and varies considerably.

Many states have set up water and land management institutes and these are known as WALMI / WALAMTRI / NERIWALM, etc.

⁴ Mandal, K. and Priti (2015). 'Water R&D in India: Trends and Intervention'. ISTIP Policy Bulletin No. 10, CSIR-NISTADS

Many WALMIs are doing good work in their focus areas and are conducting training courses. Some important research outcomes have been reported by the Institutions under ICAR, particularly Water Technology Centre. Similarly, good works have also been reported by some Agricultural Universities in the country. There are some notable contributions from individual water users (e.g. Mr. Anna Hazare); many farmers in water scarce areas have adopted innovative techniques for water conservation as well as efficient use of water. These efforts need to be appropriately recognized and multiplied.

Some Major Schemes on R&D in Water

Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD & GR) implements a Scheme on “R&D in Water Sector”, which funds the research activities of the three apex R&D institutions of the Ministry, namely, Central Water and Power Research Station, Central Soils and Material Research Station and National Institute of Hydrology and funds sponsored research works in the water sector through the three Indian National Committees, viz., INCSW, INCGW and INCCC. In addition, under the National Hydrology Project, being implemented with the assistance of World Bank, a research component in the form of Purpose Driven Studies has been launched with the aim of solving real life problems. Such studies would be able to galvanize the State government organizations dealing with water resources in taking up and working on research projects.

To actively associate academic institutions in studies related to impact of climate change on water resources in some river basins, MoWR, RD & GR has established six “Professorial Chairs” in selected IITs/ NITs. Water Technology Initiative is a program of the DST which started in 2007 with the aim to promote R&D activities to provide safe drinking water at affordable cost and adequate quantity. It also promotes related activities such as human and institutional capacity building by fellowships, training of water managers, promoting etc. Many water related R&D projects have been completed under the Natural Resources Data Management System (NRDMS) program of DST. It was launched to demonstrate and promote the use of

spatial data technologies for local level planning under diverse terrain conditions and promote S&T inputs for framing policies related to spatial data technologies.

Indian scientists are also working with groups from other countries on many bilateral research projects. For example, MOES is partnering with NERC of UK in supporting R&D projects in the field of hydrology & meteorology. DST and the US Govt. Jointly fund the Indo US Science & Technology Forum (IUSSTF) which supports bilateral academic activities. Similar R&D activities are undertaken with many other countries. Council of Scientific & Industrial Research (CSIR) has established a large network of publicly funded research organization. CSIR has identified drinking water and water treatment as its niche research areas.

Critical Review of R&D in Water Sector in India

Before we embark on critical review of water sector R&D in India, let us do Strength, Weakness, Opportunity and Threats (SWOT) analysis of R&D in water sector in India, as under;

Table 2: SWOT Analysis of R&D in water sector in India

Strengths	Weaknesses
<p>Very good research work has been carried out in the past, resulting in strong legacy.</p> <p>Highly qualified manpower.</p> <p>Adequate infrastructure and groups in many institutes which can be replicated.</p> <p>Excellent opportunities for research and innovations.</p>	<p>Engineering/science oriented research with weak social science component.</p> <p>Small number of Scientists compared to the size of the country and extent of problems.</p> <p>Vast challenges.</p> <p>Bureaucratic processes and delays.</p> <p>Less incentives and opportunities to choose R&D as career.</p> <p>Poor linkages of Indian R&D institutes with industries and foreign counterparts.</p> <p>Lack of strong scientific leadership – role models.</p>

Opportunity	Threats
Indian R&D Institutes can give much needed scientific orientation / inputs. With support from Govt. reasonable global leadership can be provided.	Better career options in other fields. Inadequate funding for R&D projects. Bureaucratic delays in sanctioning of research projects

Water sector in India is at very low level of development marred by poor efficiency, inadequate database, lack of evidence based policy formulation and decision making, implying vast opportunities for research and development. This is the region that a large number of foreign institutions are interested in carrying out research on water related issues of India. Though outside initiatives are generally welcome, sometimes there may be conflict of national interests. And therefore, there is a need to promote R&D culture amongst Indian Institutes and Universities. It can be seen from the SWOT analysis that there is a need to make research career as a better option. The recent initiatives undertaken by the Government in promoting research with more incentives including Flexible Complimenting Scheme, have started yielding positive results but lot still remains to be done. There is an urgent need to professionalise research activities with little interference from bureaucrats and finance. Uncertainties are inherent in research and expecting well determined outcome before sanctioning a research project is too much. Too many questioning and very restrictive work culture prohibits creativity and innovation resulting into Scientists stopping application of their minds. Flexibility in operation is the least which should be ensured to promote R&D.

A reason hindering research in water sector is the presence of high subsidy. Since water charges are highly subsidised there is hardly any incentive for the users to be water savvy. Technological developments are driven by economics and absence of economics virtually eliminates the importance of R&D in water sector. Even though water subsidy has a social and livelihood aspects, the driving force for research and development gets missing. Thus, there is an urgent need to evolve economic based water policies to drive research in water sector and mitigate present and future challenges.

Disconnect Between Laboratory & Field and Science & Decision Making

The proverbial gap between laboratory & field and science and decision making is too evident in water sector in India. Water sector is primarily in Government sector and due to poor career advancement opportunities, aging, no new projects, and negative peer pressure, bureaucratic rule/precedence based procedures, etc., people in Central/State Governments do not show interest in taking up new challenges and implementing new developments. There does not appear to be much keenness to try new ideas and take risks since rewards are few or non-existent but risks are typically large. As a result, R&D developments remain in technical journals and conference/seminar proceedings with little developments on the ground. Many such departments have research institutes and design offices which also act as interface between the R&D and academic world but officers are seldom enthusiastic about postings to these places.

Establishing linkages between industries and research institutes can facilitate implementation of new technologies on ground. Research Scientists, even in Government sector, should be permitted to take up industry sponsored research, rising above the vigilance syndrome of promoting a particular industry.

Information is power and well informed citizens hold the key to steering developments. Unfortunately there is no proper exchange of information in the water sector regarding current status and developments taking place from people dealing with the issues. As a result, unconnected people raise irrelevant issues distracting the focus needed in the water sector. Being a democratic set up, decision makers get swayed by conjectures rather than evidence based scientific research. There is a need to authorise water professionals and researchers to present correct perspectives on water related issues so that people at large and decision makers, in particulars, get benefitted from evidence based scientific research.

Physical and Financial Resources

India lacks significantly on availability of physical and financial

resources for R&D in water sector. And prime reason is too much dependence on Government funding caused by poor linkages with industries. A review of data shows that the expenditure on R&D in many developing countries as a percentage of GDP generally varies in the range 1.6 to 3.5%. In Israel, it was about 4.27% and the figure for India was 0.87% in 2009. This clearly shows that a significant increase in R&D outlay is necessary for India to catch up with developing countries. More than budgetary outlays, functional flexibility is necessary to boost research activities. As a result even limited budgetary outlays are not fully utilized. There is a need to ensure faster approvals after peer reviews with little or no interference from bureaucrats and finance.

The recent Government policies to promote and incentivize research appear promising, but due to poor implementation, these policies have little impact on the ground. For example, Flexible Complimenting Scheme (FCS) assures time bound promotion but meeting of Assessment Boards for promotions under FCS seldom takes place in time resulting into delayed promotions with consequential loss. Further, the highest position to which a bright researcher can rise is at relatively much lower rank in the Government set up and this is yet another disincentive for young generation to enter in R&D sector.

Suggested Way Forward

Following suggestions are made to boost R&D in water sector.

- a. There must be intra and inter-institutional linkages between Scientists in addition to strong industry linkages to promote multi-disciplinary research in water sector. This would enable comprehensive and holistic approach towards water issues.
- b. There is a need to synergise developments in allied sectors, like instruments, sensors, geo-spatial IT technologies with water sector. Scientists should be given adequate exposure to these developments as well.
- c. There should be strong linkages between academic institutions and Government and Industrial Research institutes so that basic research as well as applied research for optimum solutions to real life problems is taken up in a balanced manner.

- d. Regular interactions between academia, applied researchers and working professionals should be ensured to identify research needs, field constraints and priorities.
- e. R&D set-up in India needs to be revamped and energized. There is need to create conducive environment though functional autonomy and positive work culture which encourages people to excel.
- f. Scientists and faculty of academic / research institutes should be encouraged to take more industry sponsored research projects to make research more practical. They need to address the existing challenges by using the information available and provide solutions.
- i. Scientists should also be encouraged to network with foreign institutions and go for sabbatical leaves to upgrade their skills.
- j. There is urgent need to increase investment in water related R&D. Currently R&D funding is project based with typical duration of 2-3 years. Effective technology development and implementation / testing require support over longer period of time.
- k. A Vision Plan needs to be developed with a vision for taking up R&D for the next 15- 20 years. More studies on social aspects of water management, e.g., governance and conflict resolutions should be included.
- l. India requires multidisciplinary centres of excellence to tackle big issues like water system response to climate change, forecasting of intense precipitation and floods, medium-range weather forecasts for agricultural water management and water contamination.
- m. Indian research organizations should be benchmarked with global reputed water research institutes to promote centres of excellence and competitiveness.
- n. Promote multi-disciplinary Masters Programs in water resources in academic institutes.

Hydropower – The Way Ahead

Abstract: India's hydro power (HP) potential is estimated at 148,701 MW. Of this, only 34,204.9 MW has been developed so far. 12,252 MW is reported as "under construction" but implementation work on most of these projects is stalled, mostly due to environment related concerns which are mostly misunderstood, or are wrongly projected. When a hydro power project installation is rejected on environmental grounds like related deforestation, the nation does not reduce correspondingly its energy need target, and the resulting gap is considered to be made up by the ever available - coal based thermal energy! Unfortunately, such alternative choice effectively replaces one time felling of forest at one location, by undertaking perpetual mining of coal and resultant emission of corresponding additional GHG at some other location.

Of the 114,500 MW, or 77% of the potential that presently remains undeveloped, 93,020 MW is in the river basins of Indus, Ganga, Brahmaputra and Western Ghats. All these basin areas are perceived as ecologically sensitive and hence the HP projects located therein as causing damage to the environment. Further, the activists supporting such perceptions enjoy a constitutionally 'unrestricted right' to file a PIL against these projects at any stage of the project, and invariably succeed in obtaining a stay order. As years after years pass with work stalled, the project loses its financial viability and the investor pulls out. The Government seemingly remains aware of the advantages of HP, does include it in energy planning, but continues to lack the resolve to make it happen on ground. Forces working against it look to be too strong while the support is too feeble. In this scenario, any significant addition to HP seems unlikely. The Governments need to take cognizance of and remove such hurdles from the path of hydro

power soonest. Or else, the country's energy mix will remain ever handicapped due to deficit of additional hydro power.

Terminology

For about the past 30 years HP development in India is facing an ill-advised opposition, and consequent slow down on two planes. One, HP versus other sources, mainly coal. The murmurs of a “thermal lobby” are too strong to be ignored. Two, conventional energy sources, e.g., hydro-, fossil fuels, and nuclear on one hand versus the non-conventional basket comprising solar, wind, ocean waves, etc, on the other. The focus of this paper is to explain the debate that surrounds HP; to explain why HP is a must; why is it facing opposition; unraveling the objections against it, and finally to recommend what needs to be done to reinstate HP. To understand the debate that surrounds the need and feasibility of HP vis-à-vis other energy sources, it would be useful to have clarity on many terms that are used to describe certain attributes of electricity generation and supply.

Conventional: Electro-mechanical generators, coal based steam engines and hydro turbines to drive the generators, all date back to approximately 1880s. For a long time: the fossil fuels comprising coal, oil, gas, and the flowing water were the only sources of energy to drive the generators. The first nuclear reactor was commissioned in 1942. The fossil fuels, flowing water; and nuclear fission, are considered as conventional sources. The wind, solar, tidal, geo-thermal, bio-mass energy sources, are of much more recent times, some are still under development, and they are considered as non-conventional sources.

Renewable: Mankind started energy generation with a certain stock of coal, oil, gas, and uranium. As we use it up, the stocks is not regenerated. Therefore, these are called non-renewables. In contrast, hydro power, solar, wind, tidal, and geo-thermal sources are regenerated in short term, and are called renewables.

Sustainable: In 1987 the United Nations World Commission on Environment and Development released the report “Our Common Future”, now popularly known as the Brundtland Report, after Gro

Harlem Burndtland who was the chairperson of the Commission. The report suggested the idea of Sustainable Development (SD) as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

It was soon realized that this very laudable definition had many flaws. Any consumption of non-renewable resources, no matter how miniscule, would some day result in that resource being exhausted and denied to the future generations, and therefore must be seen as “not SD”. Such perception did not suit the developed nations, who are the largest per capita consumers of natural resources. This also amounted to restrictions on the growth of developing nations, in the name of environment. And it was also pointed out that when we are not able to fulfill the demands of even the present generation, where is the question of meeting the demands of the future generations?

The original definition of SD thus now stands discarded. Now, it means development that is economically feasible, socially acceptable and environmentally conservative. This vague definition however enables the activists to declare anything they do not like, as unsustainable. Wind energy, once their darling, has now fallen out of their favour and is considered by them not SD. In environmental discourses, hydropower is branded as not SD. The fact remains that hydro power is 100% renewable, causes no pollution, and is decidedly SD.

Grid Quality: Large energy generation plants do not supply electricity to a captive group of consumers. Instead, they feed electricity in to a distribution network called a grid, and consumers draw from the grid. The advantage is that supply to a consumer is not tied up with a particular generation plant remaining operational. However, to feed to the grid, the voltage, the frequency, and some other parameters of the electricity needs to be within a tight range. Such electricity is called grid quality electricity. Small generation plants, typically within a few 100 KW range, may not be able to generate electricity that conforms to grid quality parameters. Such plants supply to only a small group of consumers, and are called isolated plants. These attributes are summarized in **Table-1**

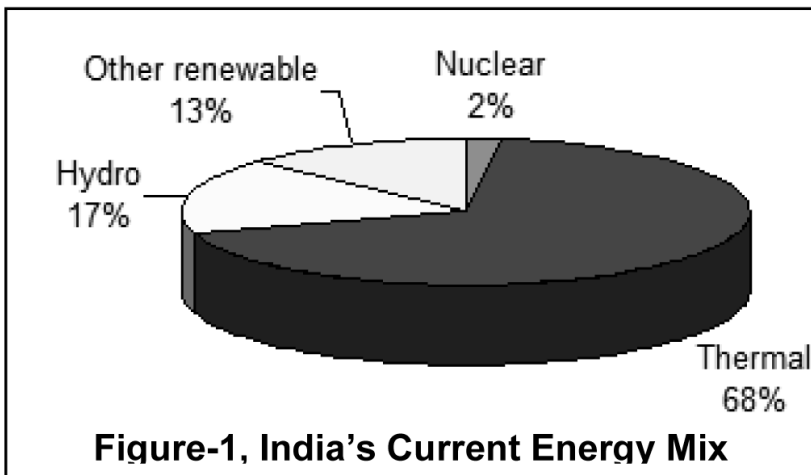
Table 1: Comparison of Different Energy Sources

Source	Conventional	Renewable	Sustainable	Grid Quality
Coal, Oil	Yes	No	No	Yes
Gas Turbine	Yes	No	No	Yes
Hydro	Yes	Yes	Yes	Yes
Nuclear	Yes	No	Yes	Yes
Wind	No	Yes	Yes	Possible
Solar	No	Yes	Yes	Possible
Tidal	No	Yes	Yes	Yes

India's energy requirement projections and supply options.

Agriculture, industry, services, infrastructure all sectors of economy require electricity. With the given land resources remaining constant but land use changing very rapidly; with population continuing to increase but rapidly migrating; India is shifting from a predominantly rural and agriculture based economy to urban habitats and industry/ services based economy. Responding to these changes, the demand for electricity will continue to increase and the estimated demand forecast for the year 2021-22 is 19,04,861 MU¹ of energy, and 2,83,470 MW of peak power².

The conventional options for grid quality electricity are fossil fuel based thermal power; hydropower; nuclear fission power; and gas



¹MU, Millions Units, is the unit for measurement of electricity. 1 Unit = 1000 W X 1 Hour.

²Power Capacity Addition in India, Performance and Challenges. Sudhir Vadehra, The Journal of Governance, Vol 12, January 2016.

Table 2: 12th and 13th Plan Targets

Source	Target (MW)	% share
Coal	1,15,800	72.9%
Gas	1,086	0.68 %
Nuclear	20,800	13.08%
Hydro	21,204	13.34%
Total Conventional	1,58,890	
Renewables	49,000	

turbines. **Figure-1** shows India's current energy mix. More than two-thirds of the energy comes from thermal, i.e. from burning fossil fuels.

For the 12th and 13th Plan, the Central Electricity Authority (CEA) projects a conventional capacity addition of 1, 58,890 MW³. Its source-wise break up is shown in **Table 2**. It is obvious that this is not what is desirable. It is what the CEA thinks feasible. Thus, a large target for coal seems to be a *fait-accompli*, because of expected impediments in the path of nuclear and hydro, and limitations of wind and solar. This assessment is dated January 2012. In the five years since, there has been very little progress on installation of hydro / nuclear schemes. It is certain that the stated targets for hydro and nuclear energy are already jeopardized.

With growing concern about global warming and climate change, it is necessary to shift to non-fossil fuel based, 'low-carbon', energy sources. Also, with stress on "sustainable development", nations are attempting to move towards renewable energy. Solar and wind energy, being available over a part of a day only, were earlier not considered as suitable for absorption in the power grid, and their cost was also relatively very high. But recent developments in technology have reportedly brought down the cost of solar energy, and have enabled consideration of solar and wind energy sources also as eligible grid contributors. HP is, of course, renewable, and a zero carbon, grid quality source. Therefore, in the next decade or so, hydro (all sizes), wind, and solar should be the preferred options for capacity addition.

³National Electricity Plan, Central Electricity Authority, January 2012

About HP, the Plan says “India’s hydroelectric resources are estimated to be 84 GW at a 60% load factor. Low carbon growth Strategy would ensure clean hydropower is used to its maximum potential for meeting peak loads and all new projects must be designed with this objective in mind. However the full development of India’s hydro-electric potential, while technically feasible, faces issues of water rights, resettlement of project affected people and environmental concerns – issues that must be resolved.”

Since HP faces all these concerns, and since wind and solar seem to be very environment friendly, can India’s future needs of electricity be met by renewable energy sources? This, in fact is the title of an analytical paper by Prof. S P Sukhatme⁴ of IIT-Bombay. In the conclusions he writes “Meeting an annual requirement of electrical energy is necessary, but is not enough. It is also necessary to meet the daily need for electricity on a continuous round-the-clock basis all over the country. Because of the intermittent nature of both solar and wind energy, there is a serious mismatch between the diurnal variation of the supply and the diurnal variation of the demand. Thus, many technical challenges exist and these problems will have to be successfully resolved if matching is to be achieved and renewable energy sources alone are to meet our electricity needs in the future.”

Here is what ecology.com⁵ says about the future of wind and solar. “The sun also provides enough energy that can be stored for use long after the sun sets and even during extended cloudy periods. But making it available is much easier said than done. It would be cost prohibitive to make solar energy mainstream for major world consumption in the near future. . . According to the European Photovoltaic Industry Association, solar power could provide . . . 26 percent of global energy needs by 2040.”

A more detailed discussion on shortcomings of solar and wind, will be a digression. Suffice to say that no one expects wind and solar to replace a significant part of other sources of energy in foreseeable

⁴“Can India’s future needs of electricity be met by renewable energy sources? A revised assessment” Current Science, 25th November 2012.

⁵<http://www.ecology.com/2011/09/06/fossil-fuels-renewable-energy-resources/>

future. Solar and wind sources are not competitors for hydro power. Hydro power is as clean and as renewable as are solar and wind, and there are some other advantages that are unique to hydro power which makes hydro power an irreplaceable part of the energy mix.

Understanding Hydro-Power

Since the present paper is about understanding HP, it would be useful to appraise its basic engineering concepts. HP plants that generate some significant quantum of energy come in three different types/locations, each having its own plus and minus points.

Storage Based

Water is stored in a reservoir created by construction of a dam across a river. The power house is typically located at the toe of the dam, and after driving the turbines the water rejoins the river within a short distance down-stream of the dam. The Power house can be located on surface at the dam's toe or can be placed in an underground cavern. If the river bed downstream has substantial level drops, then an underground power house can use these to increase the hydraulic head and thus increase the potential installed capacity.

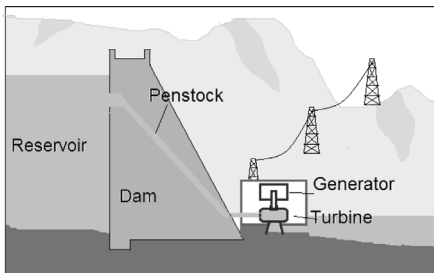


Figure -2 Storage type HPP

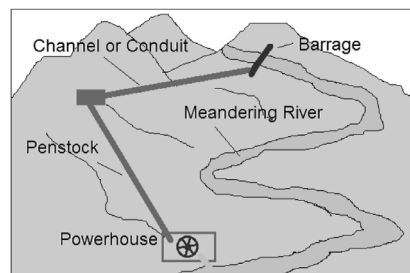


Figure-3 RoR Type HPP

Run-of-the-River

Water is diverted from the river by construction of a barrage or a small dam across the river. The diverted water is allowed to flow in a channel or a conduit at a gentle slope for some distance, while the river bed drops more steeply, thereby creating a level difference between the diverted water and the river bed. In this type, the power

house is located considerable distance away from the diversion point, and can even be in another basin.

Canal Head Regulator or Canal Falls

Most dams provide for head-regulators for main canal outlets. A hydro-power plant can be placed in the canal, where the water is released from the dam. The canal head power house in Sardar Sarovar Project has an installed capacity of 250 MW, larger than the total capacity of many small hydro power projects. The bed slope of a canal is usually flatter than the slope of the landscape through which the canal passes, thereby gradually increasing the level difference between the canal and the surrounding land. For structural reasons, it becomes necessary to construct a fall in the canal bed at suitable intervals and locations, to reduce cost of canal construction. A long canal may have several such falls in quick succession along its course. Instead of allowing the water to merely drop down, a Power House can be installed to utilize the head for generation of electricity by passing the flow through a turbine.

Main Advantages of Hydro-power

For meeting the Peak Load demand.

The demand curve for electricity during a 24 hour day cycle usually has two peaks, one during the morning hours and the second during the evening when, respectively the day's 1st work shift starts and when the lighting load for the night takes shape with the 2nd work shift. The fossil fuel based thermal plants and the nuclear plants are unable to respond quickly to the load changes as it takes some time for the boiler to generate more steam to obtain more power from the turbine. Neither the burning of the fuel nor heating of water can be quickly stepped up or stepped down in response to changes in demand in power load, unless thermal efficiency is sacrificed. Therefore, these plants are run to supply approximately an average of daily load barring the peaks, constituting what is termed as the base load. Hydro power plants and gas turbines on the other hand can respond very quickly to changes in load with tap like open/close operation possible for both resources. Therefore, as the demand

increases over and above the base load, hydro power plants or gas turbines are brought in to supply the peak load. Wind and Sun energy any way constitute intermittently available resources and hence can't generate energy on demand.

Frequency Control and Grid Management.

If additional power is not fed into the supply grid within minutes to match the peak load the frequency of the AC supply drops. If the drop is below an acceptable limit, then load has to be cut to limit it to generation, or else there could be a collapse of the distribution system. This power shading disrupts processes at user's end and compels the user to invest in portable or fixed oil based generators, lead-acid battery based invertors, and UPS, for the critical equipment. It all leads to a waste of precious resources. The captive diesel generators are also a major source of air pollution in cities. Therefore, sufficient hydro power capacity is essential for frequency control and grid stabilization.

Cost.

Sun light and wind resources are abundant and freely available, but utilizing them for generating electricity costs sizeable finance. As of 2016, the cost of Hydro power at the scale of its potential for development and use is undoubtedly the most economic source of renewable energy.

Multi-purpose

Most hydro-power dams serve multiple purposes of flood control, and water storage for irrigation, and hence impart flexibility in energy generation and utilization to suit the needs according to the variability in rainfall pattern and economic activities in the areas being served.

As a way to store energy.

During off-peak hours, there may be excess electricity in the grid, from thermal or nuclear sources. If there was a way to store it, then it would be available for use during peak hours. But storing large

quantity of energy is a challenge. Rechargeable batteries are good enough to store standby power of a few units only. A special type of hydro power project, known as ‘pumped-storage project’, offers a way to store large quantum of energy. The pumped storage scheme is like a routine hydro power project, but the turbine is designed to operate also as a pump, and the generator is designed to operate as an electric motor. Such machines are called reversible machines.

Excess thermal energy during off-peak hours is used to run the turbine-generator combine in the reverse mode and the water is pumped from storage at a lower level to one at higher level, thereby storing the energy. During peak hours the water pumped earlier to a height is released through the turbine to generate hydro power to generate energy. It may be reiterated that pumped storage schemes are not a primary source of electricity, but only a way to utilize the excess electricity in the grid, generated from other sources in off-peak hours, by storing it for use in peak hours of demand.

Reduce fuel import bills

Inadequate peak generation capacity results in load shedding during peak hours. The consumers protect themselves against such load shedding by use of captive diesel generator sets. The total capacity of such generation is presently estimated at 90,000 MW⁶ which is about half of total installed capacity in the country. The diesel genset capacity is estimated to be growing at the rate of 5000 to 8000 MW per year. The diesel electricity is no doubt very expensive, at about Rs. 14 per unit. This makes Indian services / products more expensive and India loses out to foreign competitors. It also adds hugely to nation’s fuel import bill. Development of hydro power can hugely reduce fuel import bills.

Hydro-power potential in the Country

The HP potential of the country has been estimated at 1, 48,701 MW. **Table 3** indicates it in different river basins / river systems⁷.

⁶<http://indianexpress.com/article/india/india-others/gensets-add-up-to-under-half-of-installed-power-capacity/>

⁷http://www.india-wris.nrsc.gov.in/wrpinfo/index.php?title=Hydro_Electric_Projects

Table 3 River Basin Wise Potential (MW)

Basin / River System	Total Capacity	Capacity Developed		Under Construction		Balance Potential as per present assessment	
	Total MW	MW	%	MW	%	MW	%
Indus	33,832	10,779.3	32.6	4,581	13.9	17,667.7	53.5
Ganga	20,711	4,987.2	24.6	1,136	5.6	14,128.6	69.8
Central Indian Rivers	4,152	31,47.5	81.4	400	10.3	320.5	8.3
West Flowing Rivers	9,430	5,660.7	62.9	100	1.1	3,236.3	36.0
East Flowing Rivers	14,511	7,783.2	56.5	470	3.4	5,521.9	40.1
Brahmaputra	66,065	1,847.0	2.8	5,565	8.5	57,988.0	88.7
Total	148,701	34,204.9	23.5	12,252	8.4	98,863.0	68.0

A watt (W) is a unit of *power*, i.e. the *rate* at which energy is produced or consumed. The energy is the rate of production or consumption, multiplied by time. 1000 W power produced or consumed over one hour is identified as one unit of electricity. The potential of a source and also the planned installed capacity of a project are expressed in units of Kilo Watts (KW = 1000 W) or Mega Watts (MW = 1000,000 W). It is used to identify the rated capacity of the machines. However, when comparing the energy expected to be generated by a power plant, it is necessary to take in to account the number of hours for which a plant is likely to generate during one year.

A 1 KW plant running 24 hours a day for all 365 days will generate $1 \times 24 \times 365 = 8760$ units of energy in a year. In practice however, a power plant doesn't run at full capacity for all the 8760 hours in a year. There would be shutdowns for maintenance or there could be shortage of fuel, etc. The ratio of actual energy generated to theoretical maximum that can be generated is called Plant Load Factor (PLF). Thermal power plants can be run at a very high PLF of 90%. Hydro power plants can also be run at a high PLF, but, as explained in the foregoing, these are usually deployed to supply peak demand, and their typical PLF is 60%, although like thermal plants it can be very high.

A solar panel can generate electricity at its rated capacity say only for 8 hours, in a day, which is 33% of total time. Further, it doesn't generate

8 hours a day round the year. During monsoons there is cloud cover and the output of solar panels is much less than rated capacity. The typical PLF for a solar power plant is 15 %, with a maximum of 20%. A 1 KW hydro power plant running at 60% PLF will generate $1 \times 24 \times 365 \times 0.6 = 5265$ units of energy. A solar plant of the same installed capacity will generate $1 \times 24 \times 365 \times 0.2 = 1752$ units of energy. What it means is, for the same installed capacity, the actual energy generated by the solar plant will be one third to one fourth of that generated by the hydro power plant. Alternatively, to generate the same quantum of energy, the installed capacity of the solar plant will have to be 3 to 4 times that of hydro power plant.

Arguments against Hydro-Power

Immediately after independence, India took up construction of many large multipurpose River Valley Projects, many of which had a hydro power component. The HP capacity and also its share in the total energy mix increased from 34.86% during the first plan period, to 45.68% during the 3rd plan period⁸. However, starting from about 1985, a climate of hostility towards hydro power projects seems to have been carefully nurtured by interested parties. Meanwhile other forms of plants went ahead full steam. As such, the share of hydro power in the total energy mix fell to 18% in 2014. **Table 4** shows installed capacity at the end of various Plan periods⁹. The 3rd column of the table shows growth in % over the previous value. During 1956-61 the hydro power capacity grew by 80%. By 1974-79 the growth had slowed down to 55%, and by 1997-02 it was only 21%.

Opposition to the 240 MW “Silent Valley” HP project in the state of Kerala was one of the earliest cases of organized protests against HP. The project was approved in 1978 and was finally abandoned in 1984, ostensibly to save Rain-Tree forests in the submergence. Notwithstanding name of the river – SILENT – it was said that the protests made lot of noise and were successful! Nobody seems to have assessed how far the forests were conserved. 1980s saw

⁸The Hydro Power Development in India - Challenges and Way Forward, M M Madan.
http://inae.in/wp-content/themes/inae-theme/pdf/hydro_power_development.pdf

⁹ <http://www.eai.in/ref/ae/hyd/hyd.html>

emergence of organized protests against the 1000 MW Tehri Project on Bhagirathi river, and 1450 MW Sardar Sarovar Project on Narmada river supposedly to avoid displacement and submergence. PILs were filed against both these projects and the work remained suspended for several years. Amidst development of best ever R&R packages, both the projects made halting progress. Objections against both projects were rejected finally by the Supreme Court, but the opponents of HP had “tasted blood” and from then onwards practically every project has faced organized opposition and PILs. Now there are activist groups and individuals for whom protesting against any and every hydro power project is a full time activity.

Table 4: Growth of Hydro Power

Plan	Capacity MW	% growth
1951-56	1,061	
1956-61	1,917	80%
1961-66	4,124	
1966-69	5,907	
1969-74	6,966	
1974-79	10,833	55%
1979-80	11,384	
1980-85	14,460	
1985-90	18,307	
1990-92	19,194	
1992-97	21,658	
1997-02	26,269	21%

Initially the target of such opposition used to be multi-purpose dams that store waters used for HP generation. But presently, the Run-of-the-River schemes are also targeted. Some of the popular arguments aired by opponents of hydro power are now dealt with. These arguments can be divided into two groups. The first group comprises arguments that are, to some extent reasoned, but their demerits have been exaggerated and merits discounted. The second group largely comprises myths, and/or convoluted / invented arguments.

Relatively Reasoned Arguments.

The water storage for HP projects causes i) submergence of land; some of which could be forest land; ii) displacement of people

living on these lands; iii) a discontinuity in the river flow adversely affecting aquatic ecology in such discontinuities; iv) prevention of certain migratory species of fish from crossing a dam; v) an interception of the flow of sediment / nutrients in the river from upstream to downstream; vi) limited service life of reservoir because of sedimentation; and vii) a risk of flooding in downstream due to release of a very large volume of water from the reservoir, and in rare instances, due to dam break.

Here, one must try to understand the psyche of opponents of HP. It flows mainly from opposition to dams / high dams, which have been main instruments for HP generation world-over. Very good work has been done by ICOLD, IHA, ICID and other global professional organizations led by mainly developing countries to counter the opposition to dams during the last 3-4 decades. The World Commission on Dams was the last unsuccessful attempt by opponents. Fortunately, it was thwarted successfully.

Submergence

It is necessary to project this issue in proper perspective. Any infrastructure development project whether a dam, a road, a building whatever, calls for acquisition of land along with the bio-mass grown on it, for the structure itself, the ancillary works, the quarries, and facilities. Yes, for a dam some concentrated area is submerged and / or its nearby land-use undergoes change due to a project. But it has always some compensatory trade-offs. One must realize that the submerged area constitutes a small fraction of the total area of the basin, whereas the benefitted area is several times larger. Also the Benefit Cost analysis most of the times shows that B / C ratio is significantly high.

It is well known that a lot of noise was made about submergence in the Narmada Basin projects. **Table 5** shows the area submerged by the five main projects in the basin. The total submerged area is 170,030 Ha, or 1,700 Sq Km. The catchment area of Narmada basin is 98,796 Sq Km. Thus, the area submerged by the five man-made lakes on mainstream Narmada is just 1.7% of the catchment area. For this, these projects provide 3470 MW of hydro power, while

irrigating 13 times larger 22 lakh Ha of land. As far as submergence / acquisition of forest is concerned, well laid out procedures have been developed / adopted to replace them with appropriate mix of plantations, located either in the project area or elsewhere as needed. Test-tube forestry also is now deployed to replace specific variety of bio-mass going under submergence.

Table 5: Submergence in Narmada Project

Project	Area (Ha)
Bargi	26,800
Indira Sagar	91,348
Omkareshwar	9,336
Maheshwar	4,856
Sardar Sarovar	37,690
Total	170,030 Ha

Displacement

The perception that only the dams displace people, and also the perception that those displaced are happily settled people in their homesteads, both are incorrect. With continued unabated population rise and repeated sub-divisions of land with each generation the agriculture in plains has already reached the limit of supporting livelihoods per hectare of agricultural land, and a large number of rural population is migrating to city in search of livelihood opportunities in manufacturing, and in services sector. This too is displacement, forced by due to lack of development. Entire villages have been displaced for protection of tiger core area in various sanctuaries. But no NGO has ever come forward to speak for these other displaced people, no PILs have been filed, no stay orders sought.

Commenting on the displacement of tribal people in the PIL filed by the Narmada Bachao Aandolan against Sardar Sarovar dam, the Hon'ble Supreme Court in their judgment of 18-10-2002 noted that:

“The tribal who are affected are in indigent circumstances and who have been deprived of modern fruits of development such as tap water, education, road, electricity, convenient medical facilities etc. The majority of the project affected families are involved in rain-

fed agricultural activities for their own sustenance. There is partial employment in forestry sector. Since the area is hilly with difficult terrain, they are wholly dependent on vagaries of monsoon and normally only a single crop is raised by them.”

When people shift to cities in search of livelihoods, are displaced by circumstances, it is without an organized support system for the displaced family. There is no rehab package, no house ready for occupying, no policy to provide any employment, no transfer allowance, nothing. The rehab package for those displaced for wild life protection is inferior to the rehab package for those displaced for construction of dams. The rehab package for those displaced due to construction of a dam has been evolved and adopted after decades of analysis, and its content is such that the displaced people are invariably better off than what they were before displacement.

Myths about HP

The rest of the objections against dams or hydro-power mostly arise out of ignorance.

Reservoir Induced Seismicity

This phenomenon has been variously described in publications as Associated (RAS), or Triggered (RTS). Large reservoirs created by construction of dams have been attributed through more than half a century to have triggered earthquakes. However, the fact remains, that there is no instance of a large tectonic earthquake that has been conclusively proved to have been caused by a reservoir. Here is what the Seismology Research Center¹⁰ says about RIS.

“Reservoir induced seismicity is a transitory phenomenon which will occur either immediately after filling of the reservoir, or after a delay of a few years. If there is a delay, this depends on the permeability of the rock beneath the reservoir. Once stress and pore pressure fields have stabilized at new values, reservoir induced seismicity will cease. Earthquake hazard will then revert to similar levels that would have existed if the reservoir had not been filled”

¹⁰<http://www.src.com.au/earthquakes/seismology-101/dams-earthquakes/>

Nevertheless, people citing this objection do not appreciate that such local seismic potential never exceeds the native proneness to tectonic earthquake events for which the dam structure is designed.

Dams cause floods

Dams constitute the most reliable and long proven flood control measure adopted the world-over. Upon receiving a flood forecast, a filled reservoir can be appropriately emptied by releasing the stored water over a period of time, to absorb the incoming flood and reduce flood intensity in the down stream area. Starting with Damodar valley dams, thousands of dams constructed during the past 60 years provide ample proof of improved flood management due to construction of large dams.

Sedimentation limits reservoir life

The argument that a reservoir has a limited 'life' because the sediment accumulating in the reservoir will one day completely fill it up with sediment, is theoretical. The time (number of years) it takes to fill the reservoir with sediment so as to impair hydro power generation is called its service life. Projects are planned to maximize the service life by i) soil conservation measures in the catchment area to reduce the generating of sediment; ii) by providing outlets to flush the sediment downstream; and iii) by judicious operation of reservoirs to maximize flushing. As a result of all these measures, the service life is very long, typically in excess of 100 years. For example, Bhakra reservoir has a gross storage capacity of 9340 Million Meter Cube (MCM). The average sedimentation rate over 32 years data has been estimated as 20.84 MCM by hydrographic surveys¹¹. Thus, it will take 448 years for the Bhakra lake to get filled with silt. This takes the probable date of silting up well beyond the upper limit of planning. No human endeavour indeed is planned to last that long!

Dam break flood

Due to acts of commission and / or omission, accidents can result

¹¹SK Jain, Pratap Singh and SM Seth in Journal of Hydrologic Sciences, April 2002. http://hydrologie.org/hsj/470/hysj_47_02_0203.pdf

in a breach of dam. The argument is, that such failure can release a huge flood wave in downstream area that can damage life and property. Every human endeavour has a risk of failure. Ships sink, aircrafts crash, even the space shuttle, designed and engineered with a care unparalleled in other spheres of scientific work, can (and did) explode mid-flight, trains collide, buildings collapse, patients die on operation table. et al. Risk of failure is inherent to any human activity. It is more so when it is used to manage highly varying natural resources like water, land and biomass. A fail-proof structure is itself a myth! The correct question to ask is – what is the probability of a dam break. And the answer is, for a well engineered structure it is very, very low. Dams are designed and built with adequate safety factors.

To grasp the risk of dam failure and fatalities, compare the accident statistics of dams and civil aviation. During the 15 years period 2000 to 2014, there were 16 dam failures where fatalities occurred, and the total number of deaths is 653 (source Wikipedia). In the same period, there were 218 air crashes with 7045 deaths¹². Still, good engineering calls for a Disaster Management Plan comprising an Emergency Action Plan to be in place, before commissioning a dam.

Submergence of archeological and other heritage sites

The case for a hydro power project is too strong to negate it because some ancient archeological heritage site is likely to be submerged / displaced by/due to a reservoir. It is always possible to shift such a heritage to a suitable location for preserving it for posterity. There are scores of instances where it has been achieved. The best instance is that of Aswan high dam on the Nile which had threatened the temple of Isis at Philae, dating back to 380 to 362 BC. The entire temple complex was dismantled piece by piece and reassembled / rebuilt at the nearby Nile Island of Agilkia, situated on a higher ground some 500 meters away.

¹²http://www.airfleets.net/crash/stat_year.htm

We worship our rivers, so don't spoil them; don't silence them

A question that is never answered is: Really Do We? If we really did, we would not throw all the filth in the rivers and reduce them to stinking drains. In any case, construction of a dam for a HP Project in no way insults the river, which is meant for the human welfare. This is again just a specious argument.

Environmental Flow

The argument is, dams reduce the flow downstream, affecting aquatic ecology. The environmental flows debate is too complex to be addressed in this paper. Very briefly, hydro power does not consume water. After driving the turbines the water is released back in the river. It is the consumptive use of water, mostly for irrigation and some for domestic use, industry etc. that reduces the flow in the river. And there is absolutely no way to grow enough food for India's population, without using the water for irrigation. Whether this is water diverted from the river, or it is rainwater captured before it even reaches the river, or ground water, the net impact on the river is the same.

Then, what really ails HP sector?

Despite all its advantages and importance the hydro-power generation is neglected and seems to be losing the battle to the sector's opponents. There are some very strong reasons for this situation, and this last section attempts their analysis to right the balance in the narrative, once more. The issue is simple. On HP, the Government seems to have lost the plot, story, and thread; Govt functionaries seem not sure what to do; and are seen floundering around. Following cases provide some pointers to the prevailing confusion.

First and foremost, a complete lack of clarity and resolve pervades the Governance. Hydro-power Sector is a part of Government's proclaimed energy mix. At National level, the Govt. projects a potential of 1,48,701 MW for hydro installation; in Arunachal Pradesh even strategic reasons are cited for setting up infrastructure; the Government sets up several PSUs for development of HP potential; and invites private sector to participate. However it is

difficult to identify one major decision in the past two decades, for enabling hydro power installation. On the contrary, to satisfy a motley crowd of activists in environmental and social sectors, new rules, regulations and procedures are introduced frequently to make construction of HP projects increasingly difficult. The Government obviously needs to firm up its mind about trade-offs in securing HP generation.

At present it seems the three concerned Union Ministries, of Power (MoP), Water Resources (MoWR) and the Environment and Forests (MoEF) don't see eye to eye on developing hydro power. Following examples are eye-openers, if necessary.

Dibang Project

In 2008, the then Prime Minister Man Mohan Singh laid the foundation stone of the 3000 MW Dibang project in Arunachal Pradesh. Five years later in 2013 the MoEF rejected the project application for Environmental Clearance (EC)!! The project promoter (NHPC) resubmitted the application in 2014, which was granted in June 2015. It was however challenged in the National Green Tribunal (NGT) by the activists in July 2015. The NGT raised a procedural issue whether - while granting the EC the provisions of a MoEF order of 28.5.2013¹³ were or were not complied. For the past one year, the MoEF has not been able to say before the NGT, whether or not the order of 28.5.2013 is complied. Eight years after the foundation stone laying ceremony, nobody seems sure whether the project will at all proceed, or will be rejected.

HP in Uttarakhand

On 13.08-2013, the Hon'ble Supreme Court *suo motu* took note of voices raised by the activists and the media, that the hydel projects in Uttarakhand had aggravated the damage caused by the very high floods in June 2013, and ordered stoppage of work on 24 ongoing projects, directing the MoEF to constitute an expert body (EB) to review the problems and submit a report in two months. MoEF took two months to constitute the so desired expert body! Instead

¹³http://www.moef.nic.in/sites/default/files/om_ia_120813.pdf

of experts, the EB (Chair and Members) was packed with the same environmental activists who had publicly opposed these projects. The EB members from CWC and CEA projected severe differences with these activists in the EB. They then resigned from the EB and submitted their independent report.

The developments thereafter are unclear. For a while, it appeared that MoEF was not inclined to clear the projects, though MoWR remained either neutral or willing. Then the Scenario got inverted. Now the MoWR seemingly is opposing the projects while MoEF is inclined to allow at least six of them to proceed. It is not clear whether the MoP has taken any stand on these issues and if so, what. During the hearing before the Supreme Court in April 2016, the internal differences within the Government were brought out by the advocate representing the activists. Faced with this situation, different ministries saying different things, the Supreme Court directed that there must be a unified stand (of the GoI) on the issue and all (related) Ministries must file their affidavits to make their stand clear.” The situation looks obviously ridiculous.

E Flows

The MoWR has recently constituted a Committee to take a view on how much E flow is necessary in the rivers post WRD, even though deciding it was in the domain of MoEF. The MoWR had thereafter issued stipulations for EF, including what they called “maintenance of the latitudinal and longitudinal connectivity”, which remains undefined. MoWR has also issued formal orders that no dam or barrage be designed unless their directions on EF are complied with.

Usual Surface Water versus Ground Water debate

About a year back, the MoWR had appointed a Committee to study and advice it on restructuring of its own apex organizations: CWC / CGWB. Ostensibly, it was considered necessary as the structure was not relevant enough to the changed context of Water Sector. But the Committee meant to advice on administrative restructuring of the organizations, took upon itself to advice the MoWR on reforming

the water sector. Despite not having a single WR engineer as a member (the Committee was packed with opponents of large WRD projects!) the committee has submitted a Report that effectively puts a stop to river infrastructure. While the Committee thought they are addressing the water management issues, recommendations against river infrastructure will put a stop to HP also.

For the purpose of present discussion, the issue is not whether the projects in Arunachal, or in Uttarakhand, or anywhere else, should or should not be implemented. The issue is, the Governance Structure itself seems to be not sure what is needed. Different ministries say different things, and they say different things at different times. On river valley projects in general, and hydro power in particular, the Government seems to have lost the plot, the story, and the thread altogether.

Conclusions

Finally, the question – what next? Can the HP sector be revived? If yes, how. At present, i) commissioning of new HP projects, ii) installation of new generating units, or even iii) starting an otherwise needed HP project seems impossible. The opponents are too many, not only from outside the Government but from within also, and the outsider opponents (activists) seem to have made in-roads within it via various committees. The present laws/rules seem to be against HP development altogether. Friends of the Sector are too few, and do not have the support of the present Governance Structure. Therefore, in the ‘Business As Usual’ scenario, any addition to the presently installed capacity of HP seems out of question. Table 3 indicated the HP potential in the country. The last column of the table showed balance potential waiting to be developed, as 98,863 MW. If one more column was to be added to this table, “Realistic Balance Potential”, then the entry in that column would be ‘nil’, or ‘close to nil’. If hydro power sector is to be revived, following actions are necessary from today rather than from tomorrow.

Lack of policy coherence

Decide once for all, whether hydro-power is required, or is not required. The arguments against hydro power are all known.

Details such as exact number of trees to be cut for a given project will become known only after the EIA is done. But surely it is known that any large hydro power project in Arunachal Pradesh or in Western Ghats will need cutting of tens of thousands of trees. If these impacts are not acceptable, then the GoI should boldly remove addition to HP from the country's future energy mix. If it is to be retained, then the GoI needs to take MoEF on board, and reign in the activism, MoEF has laid down guidelines for Compensatory Afforestation. Insistence on following them should help clearance of project specific deforestation. The absurd situation where the government bases its energy projections based on 148,701 MW of HP, and the MoEF settles down to scraping HP project after project, must end by judicious Governance. Alternatively, the MoEF, (and not the MoP), should be tasked to assess India's HP potential. Since the MoEF has the ultimate authority to stop any and every HP project, and often exercises it unreservedly, the potential assessed by MoEF is likely to be more realistic.

**Mainstream integrity and transparent policies and practices
Accept that some adverse environmental impacts are unavoidable.**

A position that hydro power project (or any large infrastructure) will be allowed only if it causes no harm to the environment, needs to be discarded at the earliest. Any large infrastructure project necessarily causes a mix of some beneficial and some adverse impacts on the environment. The Environmental Impact Assessment (EIA) ought to comprise a study to assess both. Only then a balance can be achieved. Secondly, the EIA must address a study of the status: i) 'before and after' the project fructifies, and also ii) scenario of 'with and without' the project. It is well known that social/environmental cost of not doing a project in a developing Country or one with emerging economy, is more than that of doing it! Secondly, the BC ratio must account for balance of +ve and -ve impacts, failing which India will either continue to remain condemned to be an energy deficit nation, or miserably fail on their commitment to reducing GHG emissions, while also incurring huge fuel import bills.

Compare environmental impacts of alternatives.

This is the single most important requirement that will go a long way in correct evaluation of HP status. The present environmental thinking compares the benefits of a project with environmental impacts. This is not correct, as it ignores the consequences of not approving the project. The question “whether to allow cutting of say 3, 24,000 trees for a 3000 MW capacity power plant?” (As in case of Dibang project) may invariably get the answer ‘No’. Because 3,24,000 trees are a physical object, and cutting them results in a visible loss, whereas 3000 MW of power is an abstract, intangible, and sacrificing it does not result in a visible loss. What is not appreciated is, if the said HP project is scrapped, the nation is not likely to scale down its installed capacity needs by 3000 MW. The energy demand projections remaining same, the reduction of 3000 MW from HP sector will have to be made good by, very likely, thermal sector. Once this is appreciated the question becomes different. “To generate 3000 MW power (say at 80% PLF), whether to allow one time cutting of 3, 24,000 trees, or to allow 15 million T of GHG emissions every year, for ever”. (GHG emissions assumed at 0.71 Kg/KWh.) Put thus, the one time cutting of 3, 24,000 trees seems more acceptable compared to perpetual emission of 15 million T of GHG every year. But deforestation can and should be certainly replaced by compensatory afforestation at another needy site.

Pointing out the replacement source of energy of the project is not approved, and evaluating its environmental impacts too, ought to be made obligatory in the EIA of not only hydro, but all electricity projects, so that the decision leads to the option with least “environmental costs”.

Equity in environmental impacts.

If a HP Project in Arunachal Pradesh or in Western Ghats is rejected to save the environment in Arunachal/ Western Ghats, and is replaced by thermal generation in – say – Vidarbha region of Maharashtra, then it amounts to taking away a significant quantity of water from the farmers of Vidarbha and subjecting those people to increased atmospheric pollution. How does one justify subjecting the people

at one place to death from Asthma or COPD (Chronic Obstructive Pulmonary Disease), or to water scarcity, so as to enable people at another place to retain their forests?

Legislative changes

The present situation where any citizen can file a PIL against any project, at any time, also needs to be addressed. Such consideration is necessary not only for HP sector, but is required for all infrastructure projects. While retaining the rights of the citizens to judicial review, limitations have to be defined to such a right. PIL against a development project should be permitted only in the most pressing circumstances, and not as a matter of routine, and that too when sufficient evidence exists to question the project. Following restrictions may be considered.

- MoEF should evolve norms of acceptable environmental costs per MW.
- PIL against the project should be admitted only if these norms are exceeded, or, if there is *Prima-facie* evidence of any other environmental costs.
- If a project is challenged on the grounds that it will cause certain environmental damage, the legal system presently puts the onus on the defendant / respondent to prove that it will not cause the said damage. This enables PILs to be filed merely on a doubt that a certain damage may take place. Instead, the burden of proof should be on the petitioner to prove that the alleged damage will take place.
- If a PIL is admitted, the Court must conduct a quick preliminary hearing to determine whether the objections raised, if sustained, would call for scrapping the project or only a remedial action. If remedial action is sufficient then no stay order to stop the work be allowed. Stay order should be allowed only if scrapping the project seems imminent.
- A PIL infringes on the right of public at large, to obtain the benefits of the project. Presently the PIL is a zero-cost game. This must change. If the petition is found to be frivolous,

unfounded, then exemplary costs to be imposed on the petitioner.

- The time limit for filing a PIL needs to be reduced to about 6 months after the public hearing. The mandatory public hearing places in public domain the DPR, the EIA and all other information required for filing the PIL. Therefore, there is no need for a prospective petitioner to wait till the EC is accorded. As soon as the public hearing is held, the prospective petitioner may scrutinize the records and file the PIL, if so deemed fit. After 6 months from the date of public hearing, no PIL be entertained.
- All PILs against infrastructure to be heard and decided by fast-track courts.

Indeed, there is no reason why HP sector in the Energy-Development Nexus should not be revived. Actions on the aforesaid Conclusions hopefully will bring back the developments in the Energy Sector to an even keel, so that India regains its capacity to march ahead with confidence.

M. E. Haque, H. K. Varma & Avinash C. Tyagi

Constitutional Provisions Related to Water *Integrated Planning and Management of a River Basin – A Review*

Introduction

Challenges in development and management of water resources in India are many and of varied nature. These challenges are required to be understood in proper perspective and addressed on priority because they directly impact each and every member of the society. The challenges are related to several aspects of the resource – declining per capita water availability, deterioration in water quality, increasing and competitive demand for water for various purposes e.g., drinking water needs and irrigation requirements for growing population, water demands for industrial development, environmental needs etc.

Water is a subject which impacts all citizens. Therefore, participation of people from all section of the society in such discussions is desirable. However, many a times such discussions lack an appreciation of the complexities associated with water and water management, restricting discussions to specific issues, with an urge for arriving at simplistic instantaneous solutions. As a result, a series of faults in earlier planning and deficiencies in water management are flagged and in general, emphasis is laid on integrated planning.

Although, there is urgent need for integrated planning for water resources, and undertaking measures for reforms towards better management of created facilities for efficient and optimal water resources utilization, on most of the occasions, the issues of addressing challenges in water sector ends up with call for review of constitutional provisions.

This paper confines itself to review of the constitutional provisions relevant to integrated planning and management of water resources

in the country. In this background, the contents of this paper have been restricted to (a) review of the constitutional provisions related to water resources, (b) suggesting road map for initiating the process of integrated planning for water resources, and (c) identifying measures for ensuring reforms towards better management of water sector.

Constitutional Provisions

Specific provisions

Three most often referred-to provisions related to water in Constitution are: (a) Entry 17 of the List I (State List) of the Seventh Schedule; (b) Entry 56 of the List II (Union List) of the Seventh Schedule; and Article 262 of the Constitution. These provisions are as under.

Entry 17 of List II (State List) of the 7th Schedule

Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to provisions of entry 56 of List I

Entry 56 of List I (Union List) of the 7th Schedule

Regulation and development of inter-state rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest

Article 262

Disputes relating to Water - Adjudication of disputes relating to waters of inter-State rivers or river valleys

1. Parliament may by law provide for the adjudication of any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any inter-State river or river valley.
2. Notwithstanding anything in this Constitution, Parliament may by law provide that neither the Supreme Court nor any

other court shall exercise jurisdiction in respect of any such dispute or complaint as is referred to in clause (1)

Other related provisions

Apart from above mentioned provisions in Constitution about water resources, the issues related to water and water uses also appear in several Articles and / or Schedules of the Constitution as under.

- i. Article 243ZD in respect of Committee for district planning which inter-alia provides that every District Planning Committee shall, in preparing the draft development plan, have regard to matters of common interest between the Panchayats and Municipalities including spatial planning, sharing of water and other physical and natural resources, the integrated development of infrastructure and environmental conservation and the extent and type of available resources, both financial or otherwise.
- ii. Similar provision exist in respect of Committee for Metropolitan planning under Article 243ZE
- iii. Additional powers of the Bodoland Territorial Council to make laws Article 244(2) – Sixth Schedule – Entry 3B (vii) flood control for protection of village, paddy fields, markets and towns (not of technical nature) and Entry 3B (xiii) irrigation.
- iv. Following Entries of List I (Union List) of Seventh Schedule
 - Entry 24. Shipping and navigation on inland waterways, declared by Parliament by law to be national waterways, as regards mechanically propelled vessels; the rule of the road on such waterways,
 - Entry 25. Maritime shipping and navigation, including shipping and navigation on tidal waters; provision of education and training for the mercantile marine and regulation of such education and training provided by States and other agencies,
 - Entry 30. Carriage of passengers and goods by railway, sea or air, or by national waterways in mechanically propelled vessels, and
 - Entry 57. Fishing and fisheries beyond territorial waters.

- v. Following Entries of List III (Concurrent List) of Seventh Schedule
- Entry 20. Economic and Social Planning, and
 - Entry 32. Shipping and navigation on inland waterways as regards mechanically propelled vessels, and the rule of the road on such waterways, and the carriage of passengers and goods on inland waterways subject to the provisions of List I with respect to national waterways.
- vi. Following Entries of Eleventh Schedule
- Entry 3. Minor irrigation, water management and watershed development,
 - Drinking water, and
 - Roads, culverts, bridges, ferries, waterways and other means of communication.

Although there is no specific mention of “water”, in the Entry 20 of the List III (Concurrent List) of Seventh Schedule, this entry undoubtedly covers the matter related to planning of water resources – a resource which is not only lifeline of the social system but also an essential input for economic development.

Review of the Constitutional Provision Related to Water

Without giving any commentary on several provisions related to water in the constitution, it may be mentioned that the need or desirability of re-consideration of the provisions have been highlighted from time to time and that such points have been considered and examined by several committees in past.

Need for review

Majority of the river basin in the country are inter-State river basins and the matters related to water dispute continue to be in news in one form or the other. The water disputes and delay in dispute resolution has undoubtedly affected the process of planning of water resources in an integrated manner and has contributed to relatively poor planning in respect of development of water resources.

For example, for very long time, many of the envisaged projects of Krishna basin could not be taken for techno-economic appraisal and investment clearances from central agencies for want of final award on water sharing by the Tribunal. At the same time, respective State Governments have gone ahead with launching of such unapproved projects, without all needed evaluation and also without ensuring the availability of adequate funds essentially required for timely completion of the projects, perhaps with the objective of laying their claims on more and more water of the basin. Such exercise has two distinct impacts – first a setback to the integrated planning and second long gestation periods for the projects resulting in unproductive investment for relatively longer time.

Another very serious problem arises when the water sharing is decided by the Tribunal on the basis of claims of the respective States without any comprehensive and serious exercise with the objective of planning the optimal utilization of the scarce water resources. It remains a fact that the decision for allocation to the States for various uses and for various projects limit the scope of integrated planning and put certain degree of constraint in achieving the objective of optimal utilization of scarce water resources. Almost similar situation exists in case of regulation of various facilities created for utilization of water resources. In the absence of integrated regulation policy, the complaints of lower riparian States have become a regular feature. Interestingly, the complaints are not limited to release of lesser water during the lean years but also relate to excess water resulting in flood like situation in years having more water in the river system.

Reviews undertaken in the past

Many a times, and through most recommendations at various fora, a message has been conveyed that integrated planning and reforms cannot be taken up and implemented without reviewing the existing constitutional provisions and in this regard the suggestions are, generally, limited to either (a) bringing the subject of water in the List III (Concurrent List) of the Seventh Schedule of the Constitution or (b) considering suitable Act under entry 56 of the List I (Union List) of the Seventh Schedule.

Relevant extracts from the report of such Commissions are reproduced hereunder.

Sarkaria Commission¹

With a view to reviewing the working of the existing arrangement between the Union and the States in the Changed socio-economic scenario, the Union Government constituted a Commission under the Chairmanship of Justice R. S. Sarkaria in June 1983. The Commission in its report submitted in January 1988 also discussed the issues related to inter-State water disputes. The matters related to optimum utilization of the water resources and need for its comprehensive planning have also been examined and discussed in the Report of the Commission. Specific recommendations made by the Commission in respect of constitutional provisions are as under.

We are, therefore, of the view that the existing arrangements which allow the States competence in regard to matters in entry 17, List II—subject, however, to Union's intervention when found necessary in public interest only in inter-State river and river valleys—is the best possible method of distributing power between the Union and the States with respect to this highly sensitive and difficult subject. We are, therefore, unable to support the suggestion that 'Water' should be made a 'Union subject'.

National Commission on Integrated Water Resources Development²

The High Powered Commission for Integrated Water Resources Development Plan set up by the Government of India in 1996 also examined the issues related to Constitutional provisions about water. Specific observations of the Commission in its report submitted in September 1999 are as under

We are not, therefore, proposing any change in the scheme of the constitution. What is needed now is for the Union to pass laws to more effectively deal with inter-state rivers. There is also need for the Union to put in place Centre-

¹Government of India (1988), Report of the Commission on Centre- State Relation [Sarkaria Commission Report], Inter-State Council Secretariat, Ministry of Home Affairs, New Delhi

²Ministry of Water Resources (1999), Report of the National Commission for Integrated Water Resources Development (Volume I), New Delhi

State consultative mechanisms of an effective kind, through which the Centre and the States could agree on a number of issues relating to water.

Punchhi Commission³

The Government of India constituted a Commission on Centre-State Relations under the chairmanship of Justice Madan Mohan Punchhi, former Chief Justice of India in April 2007 to look into the new issues of Centre-State relations keeping in view the changes that took place in the polity and economy of India since the Sarkaria Commission. The terms of reference, inter-alia, included examination and review of working of the existing arrangements between the Union and the States in respect of sharing of resources including the inter-state river waters. The role, responsibility and jurisdiction of the Centre vis-à-vis States in the planning and implementation of the mega projects like the inter-linking of rivers was also included as one of the terms of reference. Specific recommendation of the Commission in respect of constitutional provisions related to water is as under.

A view has been expressed that perhaps such a harmony can be achieved by shifting 'water' to the Concurrent List or by "nationalization" of inter-State rivers. We do not see merit in these proposals. Items in the Concurrent List can be acted upon both by the Centre and States. The Constitutional provisions at present do not preclude this. Moreover such a shift in the case of water would lead to similar demands say in the case of "land". We are not in favour of initiating such a ripple effect in Centre-State relations.

Moreover, good governance calls for decentralization, because of the variety of local problems and solutions. This is more so in the case of water. The Constitution gives a direct responsibility to the States and through Parts IX and IXA enjoins upon them to proceed with a further set of devolutions to Local Bodies. This to our mind is the appropriate path to a decentralized action on water related matters. Nationalization connotes ownership and this is difficult to establish in the case of flowing water. What is required is regulation of water use and for that nationalization is not a requirement.

The Constitutional provisions as they stand are sufficient to address the

³Government of India (2010), Report of the Commission on Centre- State Relation [Punchhi Commission Report], Inter-State Council Secretariat, Ministry of Home Affairs, New Delhi

issues of water use and management. A national consensus must emerge on water policy and this in turn should guide the enactments of the Centre (under Entry 56 of List I) and those of the States (under Entry 17 of List II). We are not, therefore, proposing any change in the scheme of the constitution. What is needed now is for the Union to pass laws to more effectively deal with inter-state rivers. There is also need for the Union to put in place Centre-State consultative mechanisms of an effective kind, through which the Centre and the States could agree on a number of issues relating to water.

Chawla Committee

The Government of India constituted a Committee under Shri Ashok Chawla, the then Finance Secretary with a view to examine the issues related to enhancing the transparency, effectiveness and sustainability in utilization of natural resources, consistent with the needs of the country to achieve accelerated economic development. The Committee also examined the matters related to water resources. Specific recommendations of the Committee in respect of constitutional provisions are as under.

The Committee sees an urgent need to have a comprehensive national legislation on water. This can be either done through bringing water under the Concurrent List and then framing the appropriate legislation; or, by obtaining consensus from a majority of the States that such a “framework law” is necessary and desirable as a Union enactment. The legal options in this regard need to be examined by the Ministry of Water Resources.

The national legislation should clarify a common position on a number of issues, e.g., need to consider all water resources as a conjunctive, unified whole; water as a common property resource; principles of allocations and pricing and so on. The framework legislation should recognize that pollution also leads to conjunctive use of water, which makes the resource unusable for other purposes.

From the specific observation of the Sarkaria Commission and Punchhi Commission on Centre State Relations, it is clear that changes in constitutional provisions are not favoured by these commissions, probably, in view of sensitivities associated with the subject and its direct impact on various other matters on the Centre

and State relations. It is also observed that the National Commission on Integrated Water Resources Development Plan has also indicated that specific changes in the constitutional provision may not be needed and that the water related matters can be addressed through appropriate legislative measures by the Union Government. However, Chawla Committee which was primarily to look into the issues of natural resources has come out with the suggestion of comprehensive national legislation on water but even the Chawla Committee has also not suggested for any change in the constitutional provision. In this regard, provisions for water policy are very amply clear and explain the situation.

Proposed National Framework Law

The National Water Policy 2012⁴ adopted by the National Water Resources Council specifies the need for evolving a National Framework Law.

There is a need to evolve a National Framework Law as an umbrella statement of general principles governing the exercise of legislative and/ or executive (or devolved) powers by the Centre, the States and the local governing bodies. This should lead the way for essential legislation on water governance in every State of the Union and devolution of necessary authority to the lower tiers of government to deal with the local water situation.

Such a framework law must recognize water not only as a scarce resource but also as a sustainer of life and ecology. Therefore, water, particularly, groundwater, needs to be managed as a community resource held, by the state, under public trust doctrine to achieve food security, livelihood, and equitable and sustainable development for all. Existing Acts may have to be modified accordingly.

There is a need for comprehensive legislation for optimum development of inter-State rivers and river valleys to facilitate inter-State coordination ensuring scientific planning of land and water resources taking basin/ sub-basin as unit with unified perspectives of water in all its forms (including precipitation, soil moisture, ground and surface water) and ensuring holistic and balanced development of both the catchment and the command areas.

⁴Ministry of Water Resources (2012), National Water Policy 2012, New Delhi

Such legislation needs, inter alia, to deal with and enable establishment of basin authorities, comprising party States, with appropriate powers to plan, manage and regulate utilization of water resource in the basins.

Integrated Planning for Water Resources

The constitutional logjam

Majority of the water resources development planning in India is carried out in isolation for specific sites. No doubt, there are multipurpose projects but even in case of such individual projects, the concept of integrated plan for utilization of available resources is missing. The detailed project report (DPR) in respect of individual project are never prepared after due consideration of the process of identification of all possible alternatives and their critical evaluation.

As most of the river basins in India encompass areas from more than one State, the Union Government has to play an important role in this direction. However, in view of the existing constitutional provisions, the Union Government cannot proceed towards preparation of such integrated plan on its own and ensure the implementation without taking the concerned States into confidence. It also remains a fact that the idea of establishment of River Boards has not materialized despite the existence of a River Board Act since 1956 as the states are generally not interested since they perceive this as a loss of power.

River basin management in India, to date, has explored solutions of specific problems and all the boards established function as Advisory Committee/Board with the exceptions of Cauvery River Authority and Narmada Control Authority which are formed under the directions of Tribunals. The only example where the objective was integrated planning was in the establishment of Damodar Valley Corporation which resulted in the preparation of 'Preliminary Memorandum on Unified Development of Damodar River' by M. L. Voorduin⁵ (August 1944). Based on that plan, work was taken up. However, all the components included in the Plan have not yet been fully implemented because of various reasons.

⁵Damodar Valley Corporation, Web Site, Preliminary Memorandum on Unified Development of the Damodar River submitted by Mr. M. L. Voorduin in August 1944

The Bhakra Management Board, often cited as a successful example, was constituted under the Punjab Reorganisation Act, 1966. A master plan was drawn to harness the potential of three eastern rivers namely the Sutlej, the Beas and the Ravi, Bhakra and Beas Projects being a major part of the plan, and were established as a joint-venture of the erstwhile States of Punjab and Rajasthan. Pursuant to this Bhakra Management Board was renamed as Bhakra Beas Management Board (BBMB) with effect from 15th May 1976. Since then, the Bhakra Beas Management Board is engaged in regulation of the supply of Water & Power from Bhakra Nangal and Beas Projects to the States of Punjab, Haryana, Rajasthan, Himachal Pradesh, Delhi and Chandigarh.

Invoking the Constitutional provision under entry 20 of List-III (concurrent list) of the Seventh Schedule which provides for social and economic planning could also be considered. Undoubtedly, a question whether such exercise will be acceptable to the concerned parties i.e., the State Governments is quite pertinent. However, a professional approach will definitely help the stakeholders in appreciating the issues and selecting a better option, thus achieving the objective of improved management of the resource.

The Union Ministry of Water Resources, River development & Ganga Rejuvenation and Niti Ayog (erstwhile Planning Commission) are fully involved with the process of appraisal of almost of the major and medium irrigation projects and multi-purpose projects for water development. Central Water Commission undertakes technical evaluation and also provide technical support in improving the Project features. The Central Water Commission is also actively associated with the appraisal of hydropower projects which are given necessary clearances by the Ministry of Power.

During the course of appraisal, several reform measures towards improving the efficacy of the system is suggested and incorporated in the plans by central agencies. The reform measures are also introduced in respect of projects which are provided necessary financial assistance by the Union Government under various projects such as Accelerated Irrigation Benefit Programme (AIBP), Command Area Development and Water Management Programme (CAD&WM), Flood Management Programme, Pradhan Mantri Krishi Sinchai Yojna (PMKSY) etc.

While several projects in the country have been developed based on bilateral or multi-lateral agreements among the party states, the only sincere effort made towards the preparation of comprehensive plan through such a mechanism was the establishment by Union Government Sone River Commission for development of Sone River Basin. The Commission was created with the agreement amongst the party States. However, no serious efforts were made towards consensus building among the stakeholders towards the process of implementation of the plan prepared by the Sone River Commission. With changing scenario, particularly the creation of more States and related social issues, the review of the works of Sone River Commission is necessary. Creation of Brahmaputra Board and Ganga Flood Control Commission are right step towards effort for development of comprehensive and integrated plan for water resources management.

Perhaps, it is in this background that the issue of review of constitutional provisions has been flagged from time to time. Further, keeping in view the opinion expressed by various Commission/ Committees as also the suggestions emerging at different fora, the changes in the existing constitutional provisions related to water appear to be a very challenging exercise.

Other regulatory mechanisms

While undertaking exercise of integrated water resources planning (IWRP) in a comprehensive manner it is essential to take into account all possible aspects such as water availability from all sources (rain water, surface water, ground water, etc.), water demand from all sectors (domestic, agriculture, industries, energy, environment and ecological), water quality (surface and ground water), water related disasters (floods, droughts), environmental protection and enhancement, hydraulic structures, and financial planning with due consideration to impacts of climate change on water resources and involvement and consultation of different stakeholders in a transparent manner.

Lack of appropriate regulatory mechanism in respect of ground water has led to its overexploitation in large parts of the country. Further,

indiscriminate discharge of untreated or partially treated industrial, domestic and agricultural waste and effluents into water bodies is polluting these water sources making them unfit for use. So there is need to regulate ground water development and effluent discharge into fresh waterbodies. Governance issues related to ground water development, management and regulation, and water quality aspects are discussed in detail elsewhere in the Journal. Water related disasters especially floods are affecting large section of the society every year at different places. So it is important to consider various aspects of integrated flood management encompassing both structural and non-structural measures (etc.), community participation, climate change adaptation mechanism. Various legal issues related to flood forecasting and warning, flood plain zoning, flood risk hazard mapping are discussed in respective articles in this Journal.

It is high time for the Union Government to strengthen the constitutional and legal mechanism for facilitating the process of preparation of integrated plan for development and management of water resources of the country in the right earnest.

Institutional mechanism

Apart from the conceived loss of power and an independent say in the development, one of the prime reasons for disagreement between the states on the development of water resources of an inter-state basin is the lack of trust on the scientific studies, even if they are undertaken by independent authorities. In this regard, the following extract from the Note of the then Labour Department, under Dr. B. R. Ambedkar to the Finance Department vide file no. DW.I-1(25) CWINC/47 page 36⁶ is quite relevant.

“... It is essential that the Centre should take over such responsibility it can in respect of waterways control. The problems are immense and there must be an All-India body with sufficient weight to be able to give an opinion with conviction which Provinces will respect and accept. ...”

Obviously, with the element of respect, many hurdles can be

⁶Central Water Commission (1993), Ambedkar's Contribution to Water Resources Development, New Delhi

overcome as the concerned parties will be willing to accept a plan which is based on professional and unbiased approach and presents a win-win situation from overall perspective. But it would require competence of highest order. The task is an achievable task for a highly competent team of professionals who can visualise all possible alternative, and are capable of evaluating the pros and cons of such alternatives not merely through a questionable set procedure but in wider perspective of social and economic planning. Such exercise will definitely help the decision makers in convergence and arriving at the most logical conclusions.

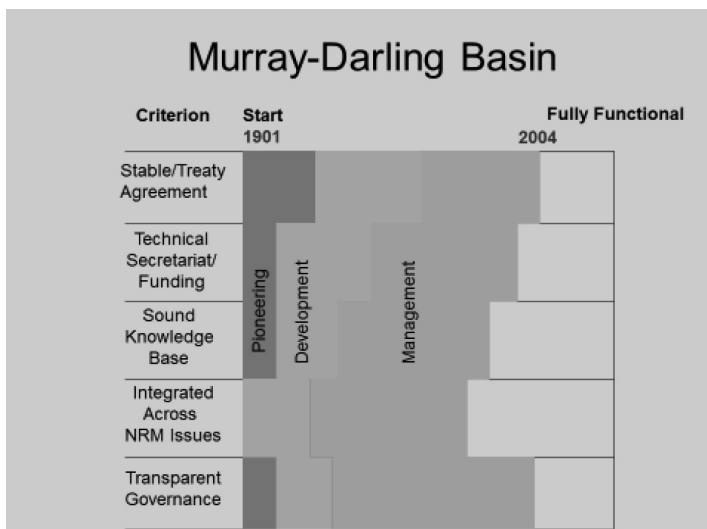
Further, the latest knowhow in respect of integrated planning and system studies are also available with various academic institutions and research stations in the country. What is required is the translation of such knowledge to address the field problems. A sincere efforts towards pooling of the available expertise would definitely help in moving towards the goal of preparation of integrated plan for development and management of water resources in the country. A beginning in this direction will undoubtedly support the decision makers in appreciating the gains from such approach. Such exercise can be initiated without any delay by re-organization and strengthening of the existing institutions with suitable mechanism for involving the stakeholders as well as the experts and professional.

Towards Consensus Building

It remains a fact that water related issues have inherent contradictions which often emerge as conflicts among “uses” as well as among “users”. Such conflicts are visible at all level – from a community well in rural areas to municipality tap in semi-urban to supply of water to different utilities in cosmopolitan to inter-State disputes of serious nature. Any effort towards integrated water resources planning, development and management would succeed only if such contradictions and causes of disputes are understood and addressed in proper perspective. It has to be accepted that these contradictions and disputes have roots in socio-economic and socio-political profile of different sections of the society who are dependent on and aspire to get benefitted from specific source of water.

Therefore, for putting in place an integrated water resources planning, development and management process, it is necessary to (a) initiate a proper understanding of the expectation of all stakeholders, (b) to undertake critical evaluation, (c) identify all possible scenario and then (d) bring them closer through a plan with win-win situation for all. In this background, a step by step, sincere and persistent effort is essential. Further, such initiatives have to be taken up at all levels – professional, administrative and political. It may not be out of place to mention that despite a number of successful model for integrated basin management in the form of River Basin Organization etc. in practice world over and also a few models for integrated planning and management with limited objectives, the task of putting in place an effective mechanism for integrated water resources planning, development and management is Herculean Task. It would be interesting to see how some of the successful models have evolved.

The process of evolution of Murray Darling Basin can be described as consisting of three phases namely, (a) Pioneering Phase 1900-1920, (b) Development Phase 1920-1967 and (c) Management Phase 1968 onwards. The evolution of various components is illustrated as under.



Constitutional and Institutional Reforms for Better Management of Water Resources

Integrated approaches to (transboundary) river basin management that focus on resolving existing hydrologic, ecologic and socio-economic problems through holistic policies is not currently practiced in India. Given the emerging challenges of water scarcity and the need to address all development in a sustainable manner, integrated river basin planning of water resources must be initiated without any loss of time. Delays, due to whatsoever reasons, are not desirable as such delays are bound to result in less than optimal benefits from the most precious gift of the nature i.e. water. Undoubtedly actions have to be initiated simultaneously for (a) creating suitable mechanism for pooling the expertise and develop the integrated plans, and (b) initiating dialogue for consensus building for legislative measures.

The exercise to build consensus on constitutional reforms and evolve suitable mechanism is required to be pursued vigorously, it would not be appropriate to simply wait and hope for the best. A confidence building exercise in the spirit of federalism needs to be initiated and consistently pursued at the highest political level. There is need also to expedite work on developing the well-intentioned National Framework Law as envisaged under National Water Policy.

Persistent and sincere efforts are needed to build and share common information platform, understand the development issues involved, undertake confidence building measures, and create an environment of trust among communities sharing the basin. In the present scenario of political and professional mistrust prevalent in the country, as is evident from multifarious legal stalemates, such a persistent approach has been missing for want of clear vision and lack of leadership at political, professional and administrative levels.

Need for changes in the process of planning, development and management at the earliest is duly established. These efforts have to be institutionalized. Union Government has to play a very effective role of advisor, evaluator and monitor. In this regard, three important elements as under are necessarily required:

- i. Well established multi-disciplinary system which can provide sound technical support and advice on purely evidence

based and scientific basis. This may call for pooling of all available human, technical and financial resources.

- ii. The plan produced by the Union must include all possible alternatives along with the pros and cons of all such identified alternatives which will help in decision making process with due consideration to all factors including the social and economic factors.
- iii. A well-established monitoring mechanism involving not only the professionals and official from the union Government and the State Government but should also include experts from academic and research institutions and Non-Governmental Organization actively associated with the related activities.

Flood Management Strategy for Brahmaputra Basin

Abstract: Brahmaputra water is the prime resource endowed to the NE region. It has the potential to bring all the desired growth and prosperity to the region. If left unmanaged, it becomes the biggest bottleneck against development due to recurring floods. Flood is a major concern for the development of North Eastern Region. The mighty Brahmaputra and its tributaries flow above the danger level across Arunachal and Assam almost every year and affect lakhs of people, inundating human habitations and farm land in several districts. It also damages the unique wild life and fauna of the region. The average annual yield of Brahmaputra is about 540 BCM at the terminal point of the basin within India. However, just about 6 to 7 judiciously located storage projects leading to about 14 BCM of storage can turn around the biggest bottleneck of recurrent floods into a great opportunity of cheap and reliable non-polluting power with an efficient round the year navigation approaching all the way across the region. In the present paper mainly flood management approach for Brahmaputra basin through strategic storage projects has been discussed.

Introduction

Brahmaputra River originates as Yarlung Tsangpo River from Mansarovar near Mt. Kailash in the Himalayas, flows via Tibet, China, India and Bangladesh into Bay of Bengal. The total length of the river is about 2900 km. The drainage basin of the Brahmaputra extends to an area of about 580,000 sq.km, from 82°E to 97° 50' E longitudes and 25° 10' to 31° 30' N latitudes. The basin spans over an area of 293,000 sq. km (50.51%) in Tibet (China); 45,000 sq. km (7.75%) in Bhutan; 194,413 sq.km (33.52%) in India; and 47,000 sq.km (8.1%)

in Bangladesh. The mighty Brahmaputra and its tributaries flows above the danger level across Assam almost every year and affects more than one lakh people inundating human habitations and farm land in several districts of Assam and Arunachal Pradesh of North Eastern region of India.

Brahmaputra water is the prime resource endowed to this region, which has the potential to bring all the desired growth and prosperity to the region. If left unmanaged, it will become the biggest bottleneck against development due to recurring floods as this also gives sense of insecurity for sustainability of infrastructure. Ultimately results in reluctance of investor to put his money for development in such region. Accordingly, flood is a major concern for the overall development of North Eastern Region. Besides, Assam suffers an average loss of more than Rs 200 crore every year due to floods, it loses large swathes of land to river bank erosion and recovering such lost land has become a challenging task for the state. The above problem can be solved effectively to a great extent through an appropriate flood management approach, where flood peaks of Brahmaputra are curtailed through storage of flood water in different sub basins of Brahmaputra. About 6 to 7 judiciously located storage projects leading to about 14 BCM of storage can turn around the biggest bottleneck of recurrent floods into a great opportunity of cheap and reliable non-polluting power with an efficient navigation round the year approaching all the way across the region. All over the world including India, the storage projects are playing key role to moderate the flood peaks and are bringing relief from devastation and fury of floods. In India, Bhakra Nangal dam in Sutlej basin, Bargi dam in Narmada basin, number of storage projects in Damodar valley and Tehri Dam in Ganga basin are some live examples, which are efficiently controlling the floods in their region. Similarly, in Murray Darling basin (Australia), Yellow river basin (China), Brantas river basin (Indonesia) and many other basins in all over the world, basin authorities are relying on flood management mainly with the help of large storage projects. The present paper discusses the flood wave formation phenomena in Brahmaputra and measures required to mitigate the flood in Brahmaputra.

Siang at Tuting (About 25 km d/s of India-China Border)		Brahmaputra at Guwahati	
Date	Observed flood Peak (cumec)	Date	Observed flood Peak (cumec)
08/09/2007	12180	12/9/2007	44508
01/09/2008	13485	4/9/2008	49659
01/07/2009	9230	24/08/2009	36138
05/09/2010	11300	19/09/2010	39469

From the above rainfall scenario and flood peak data of Tuting and Guwahati, it can be said that the flood or high discharge in Brahmaputra basin is basically due to very high rainfall in the Indian catchment of the basin. This may further get worsen due to climate change leading to more erratic and intense rainfall pattern, resulting in increase in the intensity of floods.

Flood Storage Requirement in Brahmaputra Basin

In addition to all nonstructural measures, it is essential to adopt all possible and effective structural measures for integrated flood management so as to tackle the problem of floods in Brahmaputra basin. The catchment area of Brahmaputra at Guwahati is about 417000 sq.km in which the catchment area of Siang alone is about 251521 sq.km. The Catchment area of Lohit near Parsuram kund is about 21,000 sq.km, while Subansiri at Gerukamukh is about 26000 sq.km. Due to natural topography and availability of limited storage sites, it is possible to construct storage projects on Siang, Dibang, Lohit and Subansiri rivers at those sites only. Further, a large catchment area of about 108669 sq.km up to Guwahati lies in plain, where no storage project is possible. It has been estimated that from the unregulated catchment of Brahmaputra plain a flood discharge of about 22000 to 25000 cumec is expected during the flood events of 100 year return period. However with judicious storage of flood waters in Siang, Dibang, Lohit and Subansiri rivers at identified locations, the flood peak of Brahmaputra can be mitigated to safer levels. The adequate flood storages can be provided in Upper Siang storage project in Siang sub basin, Dibang multipurpose project in Dibang sub basin, Subansiri lower, Kamla and Subansiri upper projects in Subansiri sub basin. In Lohit sub basin the storage

available between operating level during monsoon and Full Reservoir Level (FRL) of Demwe lower, Demwe upper, Hutong-II, Kalai-II and Kalai-I can be used to meet the flood storage requirements. The location of above projects is shown in Fig. 2.

In order to estimate the flood storage requirement in Brahmaputra basin, a Committee under Chairmanship of Member (D&R), CWC with experts from NHPC, CEA, Brahmaputra Board, Govt of Arunachal Pradesh and Govt of Assam was constituted by MoWR in July, 2013. The Committee after detailed analysis and several deliberations identified that the major contributor of flood in Brahmaputra is Siang. The other rivers which contribute significantly in Brahmaputra flood peak formation are Dibang, Lohit and Subansiri. In order to mitigate the Brahmaputra flood fury, the Committee estimated a flood storage requirement of 9.2 BCM in Siang, 0.6 BCM in Dibang, 1.61 BCM in Lohit and 1.91 BCM in Subansiri sub basins.

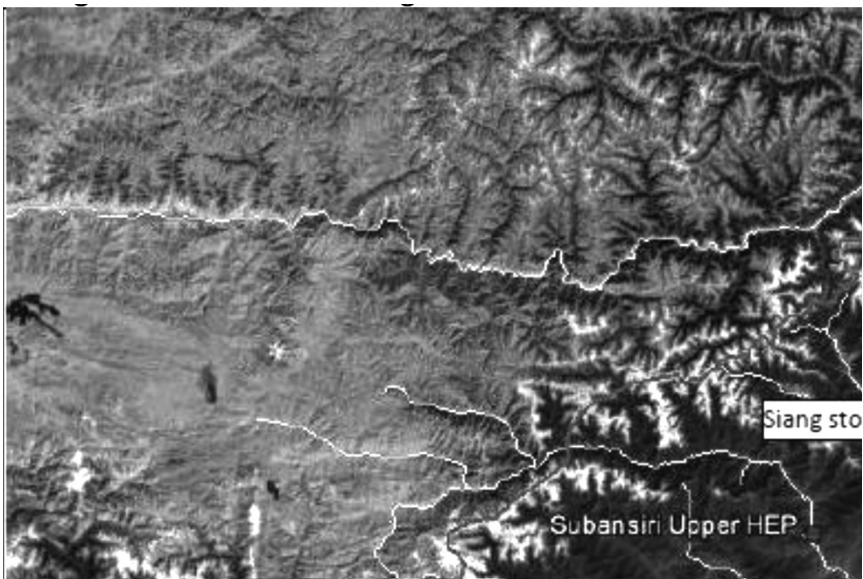


Fig. 2: Major River Valley Projects in Brahmaputra basin

Benefits of Storage Projects

Flood mitigation

Efficient management of water resources potential including sustainable flood management in Brahmaputra basin may be achieved by ensuring the availability of the required quantity of water at the required point of time. This may be made possible through storing flood water during flood season by moderating the flood peaks and releasing it at an appropriate time of requirement. With aforesaid proposed flood storage projects, it will be possible to reduce the 100 year flood peak at Guwahati from 62000 cumec to about 42000 cumec. The 25 year return period flood of about 55000 cumec will be possible to reduce below 40000 cumec. Depending upon the contribution from the unregulated catchment, the proposed flood storage scenario will result in to reduction in water level at Guwahati by about 1.1 m to 1.5 m. This will bring a major relief from floods and recurrent flood damages. Apart from the floods on account of rainfall occurrences, floods from Glacial Lake Outburst, breaching of land slide dams will also be effectively attenuated by proposed reservoirs, thus effectively mitigating their downstream impact. The benefits of flood moderation besides water security and better navigability during lean period would also be available up to Bangladesh which is a lower riparian country.

Through these storage projects in upper reaches of the Brahmaputra basin the flood levels in the main stem of Brahmaputra River will be reduced considerably. This will also facilitate removal of flood congestion and consequent reduction in flooding in the drainage area of the tributaries joining Brahmaputra River in downstream areas. One of such prominent area besides other areas where relief due to removal of flood congestion would be available is Bodoland Territorial Council area in Assam.

Hydropower generation

The maximum flood storage is essential in Siang sub basin where the proposed Upper Siang Storage Project with installed capacity of 10,000 MW shall generate about 48000 million unit of electricity annually even during the dry years.

Apart from the flood mitigation, these storage projects will help in overall development of NE region's economy through hydropower

generation, major employment generation, industrialization, education, better medical facilities etc. Large reservoirs will also provide the huge employment generation through Tourism and fisheries for the local people. Other benefits are better navigability of Brahmaputra, water sports and enhanced river flows during lean period resulting in better river ecosystem besides adding the effectiveness to anti erosion/flood management and infrastructural works in Brahmaputra basin.

Water Security Aspects of Brahmaputra

Being a snow fed, Siang River is the major contributor of non-monsoon (November to April) flow of river Brahmaputra. The contribution of non-monsoon flow in Brahmaputra by Siang during November to April is about 22 BCM, out of which about 18 BCM is contributed from the drainage area in China. The possibility of diversion of Siang water by China has been raised by media from time to time. Also, as apprehended, the climatic change is reducing the size of glaciers which may also result in reduction of availability of water during non-monsoon period. Considering the possibility of reduction of Siang water in future, the upper Siang storage project will also ensure the non-monsoon water security in Brahmaputra basin besides becoming a safeguard to power projects and providing protection to ecology and environment.

Need of an Empowered Basin Authority for Brahmaputra basin

Integrated water resources management (IWRM) of any basin for its overall development including integrated flood management may be achieved if there exists a well-structured and appropriately empowered authority at basin level. In Brahmaputra basin there exists an autonomous body namely Brahmaputra Board at Guwahati, Assam since 1982, with certain limitations on its mandate. Presently Board is certainly not a regulatory authority. However, Brahmaputra Board may be revamped appropriately as a basin authority and may be made responsible for Brahmaputra basin's water resources management with the mandate of all activities of water resources including management of floods and regulation of reservoirs etc. As

the effectiveness of flood storage can only be ensured by integrated operation of the proposed reservoirs in Brahmaputra basin hence, whenever projects come in to existence, a Reservoir Regulation Committee within the basin authority comprising of all stakeholders for coordinated operation of reservoirs during monsoon shall be essential to ensure optimum flood moderation benefits adding to integrated flood management. The advice given by the Committee should be binding to all the project owners of the basin.

Further, policy for operation of multipurpose reservoirs is needed for reducing the impact of flood cushion requirement vis-à-vis power generation from the project. For coordinating large reservoirs in real time, comprehensive data collection and Decision Support System will be required to be set up. Land use planning, flood plain zoning in unregulated catchment of Brahmaputra will further enhance the effectiveness of integrated flood management approach.

Conclusion

As already discussed, all over the world including India, the storage projects are playing key role to moderate the flood peaks and are bringing relief from devastation and fury of floods. Most of the basin authorities all over the world are relying on integrated flood management mainly with the help of large storage projects. Brahmaputra basin is also not exception to that and strategic storage projects in the basin are essentially required for integrated flood management. Flood storage projects can be provided only in North Brahmaputra where storage sites are available in Subansiri, Siang, Dibang and Lohit sub basins. The major contribution of flood in Brahmaputra is from the Siang river. With the proposed flood storage provisions it will be possible to mitigate the Brahmaputra floods substantially. The proposed storage will provide a major relief to frequently affected flood areas in the basin with average annual saving of more than Rs 200 crore from flood damages in Assam. These projects will also provide effective relief from flooding in Arunachal Pradesh. Apart from the flood mitigation benefits, Government of Arunachal Pradesh will get renewable energy and other benefits from all these projects. Hence, management of Brahmaputra waters

through construction of strategic storage projects with stakeholder's active participation and integrated management of floods could be a key to overall development of NE region.

Disclaimer: *The views expressed in the paper are purely personal and not necessarily the views of the organisation.*

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N. N. Rai and J.Chandrashekhar Iyer

Integrated Development of Reservoirs *Unified Control for Efficient Flood Moderation in Ganga Basin*

Abstract: The Ganga River basin is one of the largest and complex river network traversing eleven States of India, revered and regarded as lifeline of the region. Ganga River Governance is a multi-dimensional and multi-disciplinary task and poses a formidable challenge for administrators, decision makers and water sector professionals, both in Central and State Government. This paper focuses itself on one such river governance dimension i.e. integrated approach in tackling the recurrent floods. The primary responsibility for flood control lies with the States. The Union Government renders assistance to States which is technical, advisory, catalytic and promotional in nature. We need to remind ourselves that floods per se do not understand State boundaries. Further, for a large basin like Ganga, the cooperation and synergy among the riparian States on the issue of tackling flood is very vital. In this context, the significance of integrated development and operation of storages in the major sub-basins of Ganga river system to mitigate the flood damages is emphasized in this paper presenting outcome of a study.

General

The Ganga River basin is one of the largest and complex river network traversing eleven States of India viz. Uttarakhand, Himachal Pradesh, Haryana, Rajasthan, Delhi, Madhya Pradesh, Uttar Pradesh, Bihar, Jharkhand, Chattisgarh and West Bengal. River Bhagirathi rises from the Gangotri glacier in the Himalayas at an elevation of about 4000m above mean sea level (MSL) in Uttarkashi district of Uttarakhand. River Alaknanda rises from the confluence of Satopath and Bhagirathi Kharak glaciers at an elevation of about 5000 m, in Chamoli district of Uttarakhand. The Alaknanda and the Bhagirathi

rivers unite near Devprayag and form river Ganga which traverses its course of 2525 Km (1450 Km in Uttarakhand and Uttar Pradesh, 110 Km along Uttar Pradesh-Bihar border, 445 km in Bihar and Jharkhand and 520 km in West Bengal) before its outfall into the Bay of Bengal. Ganga River is joined by a number of tributaries in its course, such as Ramganga, Yamuna, Tauns, Gomti, Ghaghara, Sone, Gandak, Kosi, Damodar and other small streams. The total drainage area of Ganga river at Farakka barrage, including the drainage area in Nepal and China estimated works out to about 9,31,000 sq.km. The drainage area map of Ganga basin up to Farakka barrage is presented in **Fig.1**. The drainage area of some of the rivers of Ganga river system is presented in **Table-1**.

Table-1: Drainage area of some of the rivers of Ganga basin

River	Drainage area (km ²)
Ganga at Allahabad	93,989
Yamuna at Allahabad	3,47,703
Tauns	17,523
Ghaghra	1,32,114
Gandak	41,554
Sone	67,330
Kosi	60,178
Bagmati	29,466
Tributaries of Yamuna	
Gambhir	25,685
Chambal	1,41,948
Sind	27,930
Betwa	43,770
Ken	28,706

The southwest monsoon makes landfall at the mouth of the Ganga around the first week of June and advances upstream. By the end of July, the monsoon reaches the western end of the basin. The mean annual rainfall in the basin is about 1,170 mm. About 88% of the annual rainfall is received during the period of June to October. The bulk of the remaining 12% occurs mostly in the periods of March to May and November to December. During monsoon, cyclonic disturbances cause heavy spells of rainfall in the Ganga River Basin. On an average seven cyclonic disturbances (mainly depressions) form in the Bay of Bengal during the 4 months from June to September.

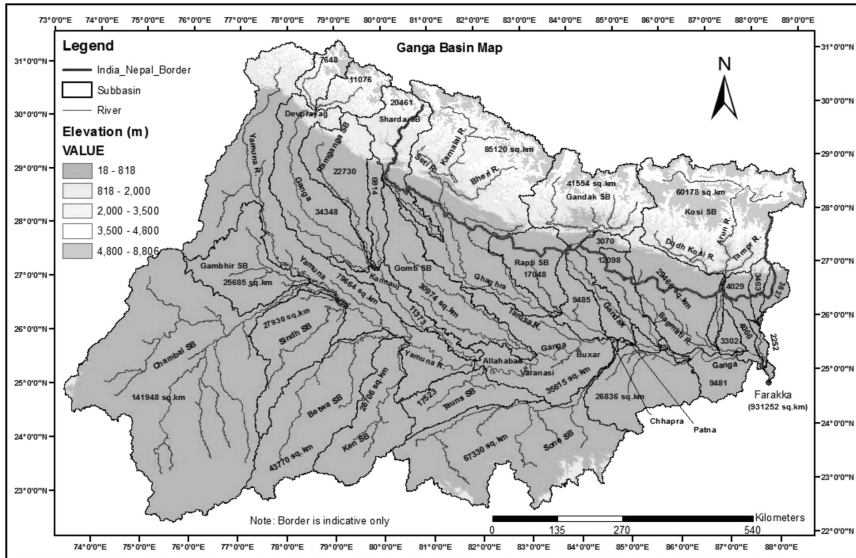


Fig.1: Drainage area map of river Ganga at Farakka barrage

These disturbances generally move in a west-northwest direction after their formation at the head of the Bay of Bengal up to the central parts of the country before weakening. It is well known that heavy rainfall occurs in the south western sector of the monsoon depressions due to strong convergence in that sector. The part of basin comes in the southwest of monsoon depressions tracks and as such heavy to very heavy rainfall occurs over different parts of the Basin.

The topography of the basin including Himalayas also plays an important role in causing heavy rainfall in the parts of the basin during the southwest monsoon season. The main synoptic situations of the southwest monsoon system that produce heavy rainfall over the Ganga River Basin are formation and subsequent movement of monsoon depressions, low-pressure systems from the head Bay of Bengal and well-marked seasonal trough.

The August 2016 floods in the Gangetic plains was also due to low pressure depression formations. As per IMD two low pressure systems were active during the period 1st to 10th August which affected the areas of Gangetic West Bengal, Jharkhand, Madhya Pradesh and East Rajasthan. Consequent to these two low pressure

systems heavy to very heavy rainfall occurred in the sub-catchments of Koel, Rihand, Sone, Tauns, Ken, Betwa, Urmil, Lower Chambal, Kalisindh, Gambhir, Yamuna and Ganga downstream of Dalmau sub-catchments.

Meanwhile a slow moving deep depression also formed in Gangetic West Bengal and adjoining Bangladesh on 16th August 2016 and moved very slowly west wards after intensifying from 16th to 21st August 2016. It finally weakened in East Rajasthan. Rainfall of heavy to very heavy intensity at a few places with extremely heavy rainfall at isolated places were witnessed in the basins of Koel, Rihand, Sone, Tons, Ken, Betwa, Urmil, Lower Chambal, Kalisindh, Gambhir, Yamuna and Ganga downstream of Dalmau sub-catchments.

Flood Management - A State Subject

The subject of flood control, unlike irrigation, does not figure as such in any of the three legislative lists included in the Constitution of India. However, Drainage and Embankments, are two of the measures specifically mentioned in Entry 17 of List II (State List), reproduced below:

“Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provision of entry 56 of List I (Union List).”

Entry 56 of List I (Union List) reads as follows:

“Regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest.”

It may be seen that the primary responsibility for flood control lies with the States. A number of States have already enacted laws with provisions to deal with the matters connected with flood control works. However, there exists a significant provision that the powers to be exercised are subject to Entry 56 of Union List.

Floods in Ganga Basin

The management of the recurrent floods in Ganga River is a

formidable challenge for the Central and State Governments. The flood control & management schemes are planned, investigated, formulated and implemented by the State Government. The Union Government renders assistance to States which is technical, advisory, catalytic and promotional in nature. The flood prone area in this basin as reported by States to the 12th Plan Working group is around 242 lakh hectare.

The country is witness to several flood events in the recent past when the wrath of the river in spate has left behind a trail of destruction spread across many States. *There are several structural and non-structural measures in flood management.* Nevertheless, reservoirs along the river basin are central to the issue of flood management as they can moderate the intensity and timing of the incoming flood. They are more effective for flood management if, apart from the incidental moderation available, specific flood volume is earmarked as in the case of DVC dams. At present, of the 80 odd large dams having height more than 100 m and capacity above 1 km³, dedicated flood cushion has been provided only in 10 dams.

The August 2016 floods in the Gangetic plains is fresh in our minds that brings to the fore several intricate issues pertaining to management of a river basin reeling under floods. A study initiated recently post August - 2016 floods in Bihar at the instance of Ministry of Water Resources, River Development and Ganga Rejuvenation by Central Water Commission to holistically understand the flood peak formation phenomenon in river Ganga and to estimate the flood storage requirements in the Ganga basin has interesting revelations that is briefly discussed in this paper. The other structural and non-structural possibilities in flood management, sediment issues etc. are not dealt in this paper to ensure focus on the significance of flood storages in the basin and surrounding issues.

Flood Peak Pattern Analysis of Ganga River System

The vast historical data available on Ganga river system has been examined and an attempt has been made to understand the flood peak formation phenomenon in the main stem of river Ganga between Allahabad and Patna for which the annual flood peak patterns

of different contributing rivers have been plotted in **Fig.3**. The flood peak data of river Ganga and its tributaries for more than 50 years has been used. From the flood peak pattern plot and date of occurrence of flood peak at respective locations, the study concludes that the flood peaks in main stem of river Ganga i.e. at Varanasi and Gandhighat, Patna is being governed by the flood peaks in river Yamuna at Partappur. Further, the second most important contributor in flood peak of river Ganga at Patna is Sone river system.

It is seen that in Ghaghra river system, most of the flows gets spread out in vast territory of UP and Bihar creating huge floods. Thus Ghagra's contribution in flood peaks in the main stem of river Ganga is of the order of about 8000 to 10000 cumec. One of the important revelations is that the concurrent occurrence of Kosi flood peak with Ganga flood peaks is very rare. However, the huge discharge in Kosi river results in flooding within its drainage area in Bihar.

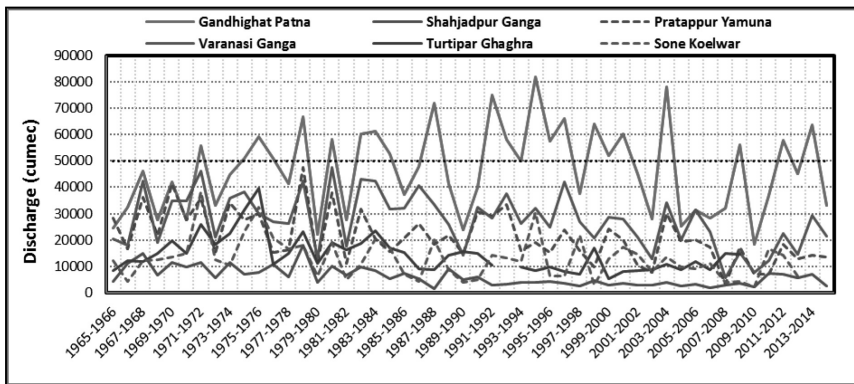


Fig.3: Annual flood peak pattern in river Ganga and its tributaries

The flood peak pattern analysis carried out for the Yamuna river system as presented in **Fig.4** reveals that majority of the flood peaks occurrences in Yamuna are due to significant contributions from its tributaries viz. Chambal, Betwa and Ken.

In Chambal River, the major storage projects viz Gandhi Sagar and Ranapratap Sagar were commissioned way back in the year 1970. As can be seen from the annual flood peak pattern, number of flood peaks with a significant discharge of more than 20,000 cumec have continued even after the year 1970. As per the study, some significant

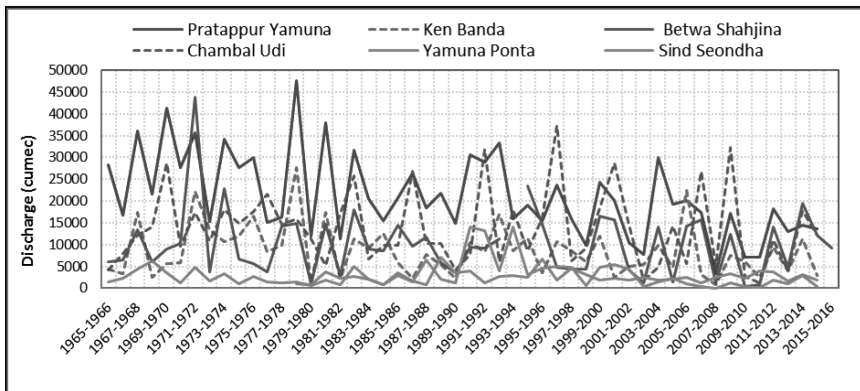


Fig. 4: Annual flood peak pattern in river Yamuna and its tributaries

additional flood storage is essential on river Chambal and some dedicated flood cushion in existing projects coupled with inflow forecast may help further mitigation of flood peaks.

As on date, there is no storage project on the river Ken, and contribution of river Ken during the major flood events is more than 10,000 cumec, the study concludes that significant flood storage is essential on river Ken. Similarly, provision of dedicated flood cushion coupled with inflow forecast in the existing projects on river Betwa and additional storage will help in mitigating the flood peaks of river Betwa.

Flood Storage Estimate for Ganga Basin

As a sequel to the flood peak pattern analysis, flood storage estimate study for the entire Ganga basin too has valuable findings. It is worth mentioning here that the drainage area of river Ganga at Gandhighat Patna is about 7, 25,000 sq.km. Considering the possibilities of storage on Yamuna river system viz Ken, Betwa, Sind, Chambal etc. and Himalayan part of Yamuna, Tauns, Sone, Ghaghra, the total drainage area which can be tapped is about 2,70,000 sq.km only. About 4, 55,000 sq.km (i.e. about 63% of the drainage area) shall remain untapped due to topographical constraints. This contribution from untapped catchment may vary from 30,000 cumec to 40,000 cumec in a flood scenario of above 65000 cumec.

From the data of flood peaks at Gandhighat, Patna, Hathidah and Farakka on main stem of river Ganga, it has been found that the magnitude of flood peak at Gandhighat Patna is maximum in almost all the flood events that have occurred so far. The lesser flood peak at Hathidah and Farakka in comparison to Patna due to attenuation of flood peak by Mokama Taal and spillage of water in flood plains. To illustrate, daily discharge pattern of four worst flood events of years 1987, 1991, 1994, 2003 and 2016 each of them having peak discharge of more than 70,000 cumec has been picked up and analysed to estimate flood storage requirement. In the analysis the flood volume has been estimated considering a target to curtail the flood peak at Patna by about 20,000 to 25,000 cumec,. Accordingly, for the flood events with peak flow below 75000 cumec, volume has been estimated above 50,000 cumec discharge. For the flood events with peak flow above 75000 cumec, volume has been estimated above 55,000 cumec discharge. The study reveals that:

- For September 1987 flood, maximum recorded peak was 71900 cumec and flood volume above 50,000 cumec was about 4.8 BCM.
- For September 1991 flood, maximum recorded peak was 72608 cumec and flood volume above 50,000 cumec was about 11.9 BCM.
- For August 1994 flood, maximum recorded peak was 81839 cumec and flood volume above 55,000 cumec was about 10.9 BCM.
- For September 2003 flood, maximum recorded peak was 78000 cumec and flood volume above 55,000 cumec was about 16.8 BCM.
- For August-September, 2016 flood the flood volume at Patna above 55000 cumec was about 12 BCM.

As stated above, the maximum influence on Ganga flood is mainly from Yamuna and Sone river systems. Considering that, a total flood storage of about 12 BCM in Yamuna, Sone and Ghaghra sub basins may be beneficial in moderating the floods in the main stem of

river Ganga between Allahabad, Patna and downstream of Patna. In order to mitigate the flood peaks at Patna by 20,000 cumec to 25,000 cumec, flood storage estimates for Chambal, Betwa and Ken river systems as per the study works out to 3.0 BCM, 2.5 BCM and 2.0 BCM respectively. The estimate for Sone river system is projected as 2.5 BCM. In the drainage area of Ghagra, Gandak and Kosi river systems, and flood storage of 3.0 BCM, 2.3 BCM and 3.25 BCM respectively has been estimated.

As per the study, efforts should be made to ensure some dynamic flood cushion supported with inflow forecast in existing projects viz Gandhisagar in Chambal sub basin, Bansagar, Rihand in Sone sub basin, Rajghat, Matatila in Betwa basin. The major projects being considered on Ghaghra river system are Pancheshwar multipurpose project on Sharda, Karnali (Chisapani) multipurpose project on Karnali (Ghaghra), Namure multipurpose project on River West Rapti which are at different stages of preparation in association with Government of Nepal. Similarly, on the Kosi river system, Saptakosi & Sunkosi multipurpose projects, Bagmati multipurpose project and Kamla Dam project are being investigated jointly with Government of Nepal. Substantial moderation of floods in Uttar Pradesh and Bihar can be expected from these projects.

Discussion

The paper focuses on appreciation of two key aspects relating to flood moderation in Ganga basin. One is the flood peak pattern analysis and the other is the estimate of flood storage requirement in different sub basins of Ganga river system. There is no doubt that the flood flows have to be managed effectively by the State and Central Government to mitigate the adverse flood impacts. We need to remind ourselves that floods per se do not understand man-made State boundaries. Floods have been inflicting damages to almost all the States in Ganga basin. While tackling floods in a large basin like Ganga, the cooperation and synergy among the riparian States on the issue of tackling flood is very vital in the interest of all. Integrated development and operation of the reservoirs in a river basin world over has significantly helped inefficient flood moderation.

As already stated above, water is mentioned in the State List of the Constitution and the primary responsibility for flood control lies with the States. The flood control & management schemes are planned, investigated, formulated and implemented by the State Government. The Union Government renders assistance to States which is technical, advisory, catalytic and promotional in nature. From State to State, the priority of projects normally differ and therefore all States may not necessarily agree to the integrated planning approach.

From the study outcome above, it is seen that large storage volumes are needed supported with reliable inflow forecast network for moderating floods in a large basin like Ganga implying huge financial implications. These reservoirs in all likelihood would be inter-state projects requiring consensus among the party States and hence agreement on cost-benefit sharing would be vital. Difference of opinion between two States is enough to jeopardize the entire project. Above all, the proposed projects have to be environmentally sound and socially acceptable. River Ganga is a holy river, worshipped, revered and regarded as lifeline of the region. Any interference in the river environment and its regime will not be taken lightly by the people and therefore building storages would require serious consideration and consultation of all stakeholders on all issues at the planning and developmental stage itself.

On the operational front, the best practices calls for all the major reservoirs (from storage volume consideration) to ideally come under integrated operation to ensure that the flood waters are efficiently routed and regulated. Further, for real time integrated operation, a robust state-of-art data acquisition, storage, and retrieval and transmission system to and from the centralised control and command centre is paramount. However, with water being in State domain, the control over releases from reservoirs remain with the State Governments. Further, with increasing water conflicts among stakeholders in the basin, integrated operation would have to negotiate many hurdles. The issues on trans-boundary rivers too pose multiplicity of challenges. Confidence and Consensus building through participatory approach is therefore important and sincere efforts should continue diligently.

Disclaimer: *The views expressed in the paper are purely personal and not necessarily the views of the organisation.*

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Farmers Participation in Managing Water for Agriculture

Introduction

India is expected to face a water gap of around 750 billion cubic meter (BCM) by year 2030. Experts suggest that this gap can be solved with 'improving agriculture's water efficiency and productivity' only. This makes a strong case for increasing water use efficiency and crop productivity in irrigated agriculture. The irrigated agriculture in the command of major and medium irrigation projects suffer from low performance in terms of efficient water use and equitable distribution of water due to all pervasive presence of government machinery handling every aspect of irrigation water delivery without participation from the farmers. In addition, the small and marginal land holdings are burgeoning which are economically unviable for agriculture.

There is a growing concern and realization that the existing government centric institutional setup, particularly in canal systems, for irrigation water management requires a paradigm shift. The National Water Policy, 12th Five Year Plan document and National Water Mission Comprehensive Mission Document have stressed on community involvement in irrigation water management through Water User Associations (WUAs), generically known as participatory irrigation management (PIM). The State Water Policies have, by and large, also shown consensus and resolve to promote farmers' participation in irrigation management.

Currently, out of the total 28 States, some 24 States of India have adopted the PIM approach partly or fully by forming Water User Associations (WUAs). Although over 93000 Water Users' Associations, covering an area of 17.84 million hectare (m ha), have been formed in India, yet their success in making desired impact on

land and water productivity through better irrigation management is quite limited.

The paper examines the reasons for success and failure of Water User Associations in India and concludes that the lackluster performance of WUAs is not because the idea is wrong, but because the people implementing it (often Irrigation/Water Resources/Command Area Departments) have not understood the process right. Instead of rigid acts, rules and target oriented WUA formation, focusing on principles of water management and change management in implementing the WUA Program has great potential to pay rich dividends.

Background: Why Farmers' Participation in Managing Irrigation Water Is Important

In effect, India's year 2030 water gap of around 756 BCM could also be solved with 'improving agriculture's water efficiency and productivity only', but it would imply a net annual expenditure of \$ 8.4 billion in 2030 (including annualized capital and net operating expenditures) on managing the resource. In comparison, 'infrastructure only' solution would run up an annual expenditure of \$ 23 billion (3 to 4 times more) in 2030 and would only meet 60% of the gap. This makes a strong case for increasing water use efficiency and crop productivity in agriculture but the McKinsey report does not elaborate upon the institutional resources/framework required to implement identified technical options. It is also very important to know the environmental settings in which these institutional resources and framework will function.

The environmental settings for irrigated agriculture

All pervasive presence of the government in major and medium irrigation projects

The total ultimate irrigation potential of the country is estimated at 139.9 million-hectare (Major and Medium Irrigation Projects: 58.5 m ha and Minor Irrigation Projects: 81.4 m ha)¹ with four States (Uttar Pradesh, Bihar, Madhya Pradesh and Andhra Pradesh) accounting for a little more than half share. A gap of 23.6 % in irrigation potential created (IPC) and irrigation potential utilized (IPU) is reported on the

major and medium irrigation schemes.² Major and medium irrigation projects are funded, planned, constructed, maintained and operated exclusively by the government and this sector is under-performing primarily due to poor service delivery and inadequate maintenance of irrigation systems compounded by very low revenue recovery and galloping establishment expenses.

Various evaluation studies of major and medium irrigation projects in India show that the water use efficiencies at project level are around 30-35%. It is estimated that even a rise of 5 per cent irrigation efficiency can increase the irrigation cover to another 10-15 million ha.³

Rapidly increasing number of small and marginal land holdings which are not economically viable for agriculture

Another major concern is rapidly increasing number of small and marginal land holdings⁴, on which stand-alone agriculture is not economically viable. As shown in Fig. 1, the size of average land holding in India has shrunk to 0.93 ha which is categorized as a marginal land holding. Consequently, the task of irrigation water delivery, irrigated-area recording, revenue collection, day-to-day water distribution, conflict management etc. for a large number of land holdings in government managed major and medium schemes has become unmanageable for the state irrigation departments (IDs). To take advantage of modern package of agricultural practices as well as economy of scale in irrigation and other input management, the farmers shall have to adopt a model of community management ably backed and supported by the government and private agencies.

The Participatory Irrigation Management Approach

There is a growing concern and realization that the existing government centric institutional setup, particularly on tank and canal systems, for irrigation water management requires a paradigm shift where farmers have to play the key role in irrigation water management. The National Water Policy as well as the state water policies have reached a consensus to promote farmers' participation in irrigation management through Water User Associations (WUAs), generically known as participatory irrigation management (PIM).

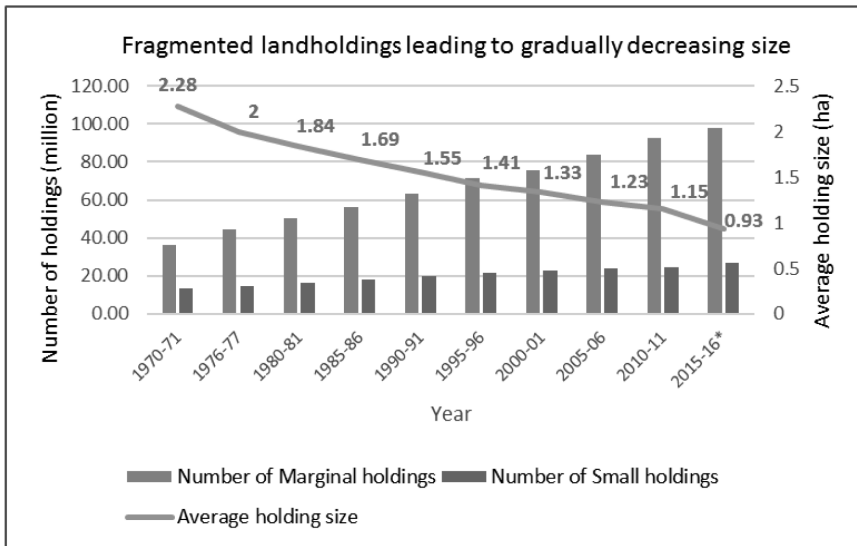


Fig. 1: Increase in numbers of small and marginal land holdings and their decreasing size in India ⁵

Para 7.5 of NWP 2012 says that ‘Water Users Associations (WUAs) should be given statutory powers to collect and retain a portion of water charges, manage the volumetric quantum of water allotted to them and maintain the distribution system in their jurisdiction. WUAs should be given the freedom to fix rates subject to floor rates determined by water regulatory authorities (WRAs).

The rationale of promoting PIM through WUAs can be summarized as follows:

- i. The user’s participation promotes sense of ownership with the irrigation system. Users are more likely to abide by rules and regulations set for management of the system and water distribution if they are part of the rule setting process and regulation.
- ii. Users have better information and access to local resources. Management, operation and maintenance (MOM) is need based, cost effective and timely.
- iii. The livelihood of water users depends on canal system, hence their stakes and motivation in maintaining the canal system are higher than government agencies.

- iv. WUAs are not constrained by the bureaucratic functioning and will be more responsive to farmer's needs.
- v. In India, 72% landholdings are below one hectare in size and 12% landholdings vary from 1 to 2 ha which are not viable for modern agriculture methods and technological interventions on 'stand-alone' basis. The economy of scale for backward and forward linkages is also not possible unless small and marginal landholders form an organization to manage it.
- vi. A management entity is required at the on-farm level as an interface between the main system supplier and the individual farmer if water distribution and system maintenance are to be carried out effectively at this level. A farmers' association can address this need and does so in many countries with smallholder irrigation (Mexico, Turkey, Philippines, Kyrgyzstan etc.)

History and Current Status of PIM

International Scenario

The farmers are managing irrigation water amongst themselves in some countries like Netherlands, Spain and Nepal since centuries. Vijayanagara canals and large number of tanks in South India were also managed by the farmers in ancient times. The formal transfer of irrigation management to farmer groups/ associations was initiated in 1950s in USA. It was followed in 1960s by France and in 1970s by Taiwan. Between 1980 to 1990, there was prolific spread of PIM in all developing countries, namely, Chile, Peru, Mexico, Brazil, Dominican Republic, Haiti, Senegal, Mauritania, Niger, Zimbabwe, Tanzania, Sudan, Somalia, Madagascar, Turkey, Pakistan, India, Sri Lanka, Bangladesh, Laos, Vietnam, China, Indonesia, Philippines, Vietnam and many more which started experimenting with their own version of PIM.

The impact of PIM largely depends upon the social conditions, institutional arrangements, commitment and enabling environment but, more or less, some universal results observed are:

- i. Better water availability in the irrigation system
- ii. Increase in equity of supplies between head and tail reaches of the system

- iii. Although the cost of maintenance and repair of the system did not reduce substantially but the quality of maintenance and repair was found to be superior.
- iv. Increase in productivity and
- v. Increase in water rates collection.

The institutional arrangements across the countries for PIM range between complete agency / government control to complete WUA control as summarized below (Table 1).

Table1: Overview of type of institutional arrangements for PIM around the World

Type of Institutional arrangements	Responsibilities for					Example countries
	Regulation	Ownership of assets	O &M	Collection of water charges	Unit of Representation	
Full agency/ government control	Agency	Agency	Agency	Agency	Agency	In most of developing countries
Agency control but O & M with user input	Agency	Agency	Agency	Agency	WUA	Sri Lanka, Thailand, Vietnam, Philippines
Shared Management	Agency	Agency	Both	Both	WUA	Turkey, Albania
WUA owned/ Agency Regulation	Agency	WUA	WUA	WUA	WUA	Dutch Water Boards, Japan, Mexico
Full WUA control	WUA	WUA	WUA	WUA	WUA	New Zealand, Nepal
Irrigation Management Company / Board	Agency	Company	Company	Company	Company and User Committees	France, China, Australia, USA

Indian Scenario

The Government of India (GOI) took up the initiative of promoting PIM through the Command Area Development (CAD) program in several States in 1985. Later, the National Planning Commission set up a Special Working Group on PIM to review and suggest the strategies

for the 9th Five Year Plan (1997-2002). PIM has also been actively promoted through State Water and Land Management Institutes (WALMIs), the World Bank Assisted Water Resources Consolidation / Restructuring Projects, and by the Indian Network on Participatory Irrigation Management (IndiaNPIM). Some Non-Governmental Organizations (NGOs) like Society for Promoting Participative Ecosystem Management (SOPPECOM), Samaj Parivartan Kendra in Maharashtra, and the Development Support Centre (DSC) in Gujarat have contributed significantly in promoting PIM. Currently, out of the total 28 States, some 24 States of India have adopted the PIM approach partly or fully by forming Water User Associations (WUAs) by enacting specific PIM Acts or amending existing irrigation acts. The leading States are Andhra Pradesh, Telangana, Chhattisgarh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, and Uttar Pradesh. According to the latest estimates, the number of Water Users' Associations (WUAs) formed in India is 93668 ⁶, covering an area of 17.84 million ha (Table 1). A large number of WUAs, unfortunately, have been established on paper to complete the official targets without any organizational and capacity building efforts to make them functional.

Table 1: State-wise Number of Water Users' Associations (WUAs) and Area covered by them

Sl. No.	State	Number of WUAs formed ⁷	Area Covered (000 hectare) ⁸	Irrigation Potential Created (000 ha) on Major / Medium / minor schemes ⁹	% area covered by WUA
1	Andhra Pradesh	10884	4179.25	9699.7	43.1
2	Arunachal Pradesh	43	10.97	92.6	11.8
3	Assam	847	95.02	790.3	12.0
4	Bihar	80	209.47	8127.9	2.6
5	Chhattisgarh	1324	1244.56	1578.8	78.8
6	Goa	84	9.54	56.0	17.0
7	Gujarat	8278	662.99	7229.1	9.2
8	Haryana	8490	1616.27	4669.2	34.6

Sl. No.	State	Number of WUAs formed ⁷	Area Covered (000 hectare) ⁸	Irrigation Potential Created (000 ha) on Major / Medium / minor schemes ⁹	% area covered by WUA
9	Himachal Pradesh	1173	140.56	263.0	53.4
10	J & K	383	32.79	770.0	4.3
11	Jharkhand	0	0.00	1025.8	0.0 ^a
12	Karnataka	2787	1418.66	4543.2	31.2
13	Kerala	4398	191.22	2030.2	9.4
14	Madhya Pradesh	2062	1999.64	7639.0	26.2
15	Maharashtra	2959	1156.22	9363.8	12.3
16	Manipur	69	29.40	157.4	18.7
17	Meghalaya	159	20.17	96.9	20.8
18	Mizoram	390	18.23	13.6	134.0 ^b
19	Nagaland	24	3.44	135.0	2.5
20	Orissa	20794	1757.71	3744.9	46.9
21	Punjab	4845	610.29	9130.4	6.7
22	Rajasthan	1994	1144.45	9235.6	12.4
23	Sikkim	0	0.00	33.8	0.0
24	Tamil Nadu	1910	935.66	5825.7	16.1
25	Tripura	0	0.00	113.6	0.0
26	Uttar Pradesh	9691	318.69	29222.1	1.1 ^c
27	Uttarakhand	0	0.00	1023.8	0.0
28	West Bengal	10000	37.00	5351.6	0.7 ^d
	Total	93668	17842.20	121963	14.6

Source: Main sources are 'Water & Related Statistics 2010' and 'Water & Related Statistics 2016' published by Central Water Commission, New Delhi. However, the data related to Uttar Pradesh has been updated by the author based on his investigations

Note:

- a - WUAs are sporadically constituted without any funds / IMT or specific legal back up. They are for namesake and as good as not constituted.

- b - Value may be more than 100% due to the fact that status of WUA area covered is based on 2015 data while irrigation potential created is up to 2007
- c - Uttar Pradesh has huge irrigation potential created in comparison to any other state in India. That is why the low coverage by WUA is seen.
- d - The 10000 WUAs shown in the table are on state tube wells with very small command. Hence the low coverage is seen.

Impact of PIM

The success of WUAs in handling irrigation management has been mixed. Wherever WUAs have been formed based on principles of organizing on water management and principles of change management with participatory procedures for example, WUAs supported by Development Support Centre (DSC) in Gujarat and Madhya Pradesh, WUAs in Waghad Irrigation Scheme supported by Samaj Parivartan Kendra in Maharashtra and Tank User Groups supported by Dhan Foundation in Karnataka, the results are encouraging. But wherever the PIM is implemented in top-down fixed target mode, it has failed to take off. In a nutshell, PIM has so far failed in India not because the idea is wrong, but because the people implementing it (often engineers) have either not understood the process and rationale of forming the WUAs or the PIM concept does not suit to their comfort zone of power and non-accountability. So far, a suitable model for implementing PIM on large scale in India has yet to be found – it doesn't mean however that the idea is wrong, rather the implementation. A few positive impact studies are summarized below:

Uttar Pradesh Water Sector Restructuring Project Phase-1 (UPWSRP-1)

418 WUAs were established and registered under 'Societies Registration Act' in 2004. The WUAs were entrusted with a limited activity of maintenance of the minor with funding arrangement through UPWSRP-1. Impact of this intervention was evaluated in

terms of (i) increase in irrigated area (ii) equity in water distribution across the head to tail and (iii) reduction in the cost of silt clearance of the minor canals.

Increase in irrigated area

It was seen that average irrigated area in a WUA in rabi season rose from 76.84 ha to 80.37 ha (4.6%) in year 2004-05 (Rabi 1412 Fasli ¹⁰) in comparison to previous five years' average (Fig. 2). Further rise of 6.9% in average Rabi irrigated area was seen in year 2005-06 (Rabi 1413 Fasli) in comparison to year 2004-05 (Rabi 1412 Fasli).

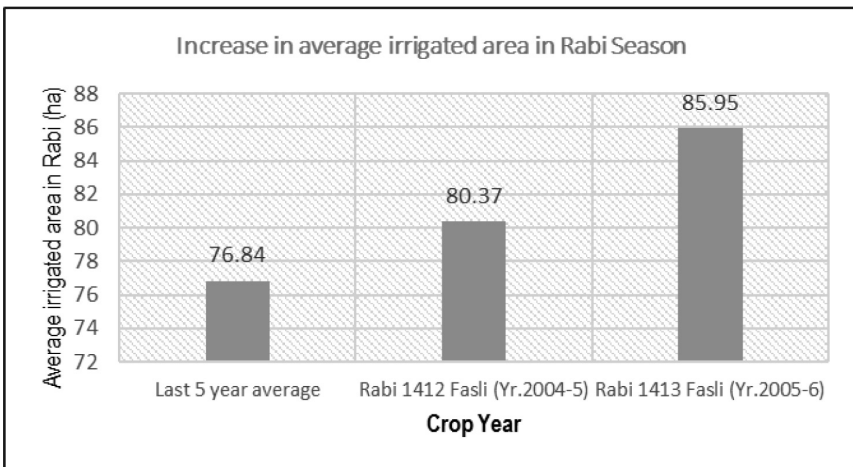


Fig. 2: Increase in irrigated area after partial management transfer to WUA

Similar results were obtained for kharif irrigated area also.

Equity in irrigation in head and tail areas

In addition to the increase in the total area irrigated as shown above, the further analysis of increased area shows that the equity in water supplies improved significantly. Out of total increased area, the maximum increase in area was observed at the tail reach followed by the middle reach while the head reach area was reduced. It is a remarkable achievement by any standard (Fig. 3).

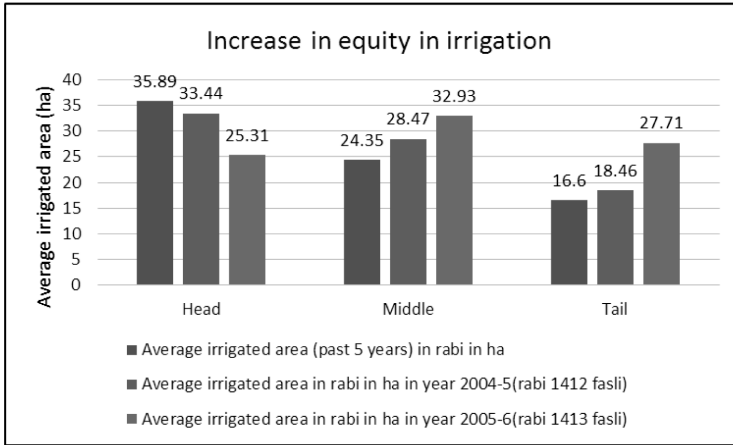


Fig. 3: Increase in equity of rabi irrigation

Reduction in the cost of silt clearance of the minors

One of the objectives of bringing about institutional change in irrigation sub-sector in the form of WUAs is to improve cost effectiveness of maintenance work by utilizing indigenous know-how, community supervision and local wisdom. The results in Fig. 4 show that the number of minors de-silted at less cost increased from 34% to 53% while the number of minors with higher costs of silt clearance gone down from 25% to 17%.

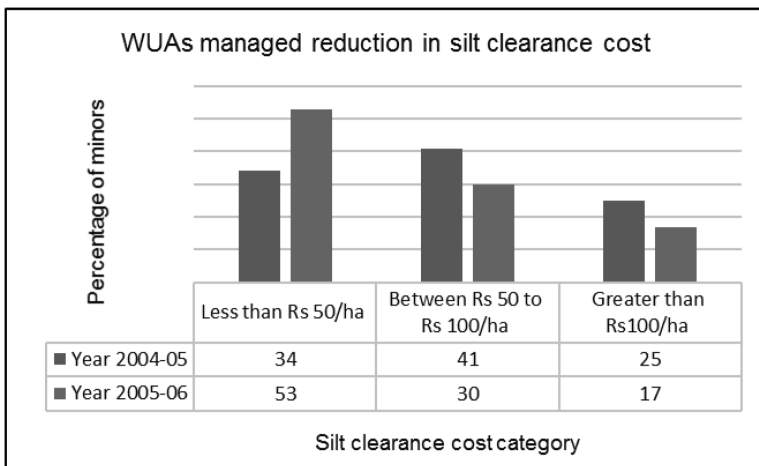


Fig. 4: Reduced cost of silt clearance in Canals after IMT

Dharoi irrigation scheme of Gujarat

PIM has been adopted since 1995 in the Dharoi irrigation scheme in Gujarat. Today irrigation management in the Right Bank Main Canal Command area of Dharoi dam is carried out by 196 irrigation cooperatives (ICs). About 129 Irrigation cooperatives (IC) have been formed by an NGO named Development Support Centre (DSC) whereas remaining cooperatives have been constituted by Irrigation department directly or by other NGOs. All these cooperatives are managing canal water irrigation. In addition, there are several private mandalis who are also managing bore well irrigation where source of water is groundwater.

The impact of PIM in the Right Bank Main Canal Command area was evaluated by Arid Communities and Technologies with Support from DSC and Agha Khan Foundation. Increase in irrigated area, switch over to more remunerative crops and improvement in water use efficiency were observed after irrigation management transfer to WUAs. It was found that the area covered under irrigation rose to around 62% after PIM.¹¹ Wheat, mustard and castor crops significantly increased in the command areas whereas slight decrease was seen in cumin seed, isabgol, grass and vegetable crops. Another major impact was seen in terms of adoption of improved crop variety by the farmers. Indigenous cotton and castor sown earlier in the area were replaced by BT cotton and hybrid castor. Efficient water use was also recorded. Annually computed water use per hectare area was about 0.4031 MMscf (0.01141 Mm³) /ha during year 1979-80 which reduced to 0.188 MMscf (0.00532 Mm³) / ha during 2009-2010.

Waghad Project of Maharashtra

In 1991, the Maharashtra Government taking cue from guidelines for participation of farmers in water management of irrigation systems (issued by the MoWR, GoI) established 3 WUAs on three minors at Ozar off taking from Waghad Right Bank Canal namely (i) Mahatma J. Phule WUA (ii) Jay Yogeshwar WUA and (iii) Banganga WUA. Water entitlement to each WUA was given at minor head on a volumetric basis. Though the Maharashtra Government fixed volumetric rates of water cess to be paid to the department, the WUAs were free to

determine the rates to be paid by the farmers to the WUA. WUAs had freedom to grow crop of their choice within their sanctioned entitlement. With the success of WUAs formed at Ozar, the farmers in the command of other minors of Waghad Project came forward to form WUAs and all 24 minors of the project had its WUA by the year 2004. The federation of WUAs, namely, Waghad Project Level WUA (PLWUA) was also established in 2003 and the irrigation management of the project was transferred to Waghad PLWUA in November 2005. A brief overview of improvement in some measurable indicators is given in Table 2.

One of the positive impacts of PIM in Maharashtra is the introduction of volumetric supply and pricing of water to WUAs. The State has made it mandatory to allocate water to WUAs on volumetric basis. Irrigation water is supplied to WUAs at the minor/ tertiary level where it is measured by an inbuilt measuring structure like Standing Wave Flume (for discharge > 300 lps) or Cut Throat Flume (for discharge <300 lps, Figure 4) and charged on volumetric basis, which enables the WUA to know how much water it is receiving against the planned allocation, and to use it more efficiently. The WUA has the freedom to provide water to its members either on crop-area or supply time basis (proxy to volumetric basis at the field level) and also to decide water charges to be paid by the members. The water rates on volumetric basis to be charged by the Water Resources Department are fixed by the government.

Table 2: Improvement in measurable indicators after Irrigation Management Transfer (IMT) to Project Level WUA at Waghad Irrigation Project ¹²

S l . No.	Measurable Indicator	Before IMT (2006-07)	After IMT (2013-14)
1	Area Irrigated (ha)	8393	9745
2	Volumetric delivery	At minor head	At main canal head
3	Water Saving	-	30% in comparison to 2004-05
4	Water charges recovery (million INR)	1.012	2.577

S 1 . No.	Measurable Indicator	Before IMT (2006-07)	After IMT (2013-14)
5	Percentage of recovery of water charges	72% of the water billed for the actual irrigated area	100%
6	Change in cropping pattern	Cereal, grapes, vegetables	Crop diversification to floriculture, medicinal plants in addition to grapes and vegetables
7	Irrigation methods	75% flood, 25% drip & sprinkler	60% flood, 40% drip and sprinkler
8	Average net income of farmer (INR/ha)	80000	120000

WUAs usually charge higher water rates to their members than the Water Resources Department in order to cover the additional costs associated with management, operation and maintenance of the on-farm system. By providing improved levels of service and assured water supply and transparency in the billing system, farmers willingly pay the higher rates. An important factor in the improved level of service provision is that the additional service fee charges enable the WUA to employ paid field staff to manage the water distribution and maintain the system on a daily basis.

The major achievements of PIM visible at Waghad Project Level WUA are (i) increase in irrigated area (16%), (ii) cent percent realization of water charges (iii) increase in drip irrigation to get better yields and saving in water (iv) adopting more remunerative cropping pattern (grape, pomegranate, rose and medicinal plants) and (v) development of rural entrepreneurship.¹³ There is increase in irrigated area especially at the tail ends as all WUAs (24 Nr) under the Waghad Project Level WUA have adopted the rule that the turn to take canal water will start by tail and gradually reach to upstream of the canal. Increasing the supply of water to the tail ends make good business sense for the WUAs as it increases the number of users willing to pay the service charge, thus spreading the MOM costs over a greater number of water users.

WUA-managed Collective Action in Chhattisgarh Irrigation Development Project

Chhattisgarh Irrigation Development Project (CIDP), an ADB supported project initiated around 2005 is also a good example of what can be achieved through WUAs collective action. When the project started, PIM was a new idea, WUAs were weak, farmers were poor (and many were tribal), irrigation efficiency and crop yields were at very low levels (CIDP baseline surveys reported 2.8 t / ha in 2008). The pivotal mechanism adopted was capacity building of WUAs through ‘learning by doing’. WUAs were mobilized, motivated and assisted by TA Consultants, NGO Specialists and Senior Community Organizers (SCOs) and Community Organizers (Cos). The COs and SCOs were selected from market in a transparent way and promotions and incentives were based on participatory performance assessment. WUAs are motivated and assisted to:

- i. Managing water, “year-round” (100% by WUAs in most of Minor systems including sluice control and shared management in Medium systems),
- ii. Construct field channels collectively (progress is slow)
- iii. Organize seed production and be self-sufficient in seeds,
- iv. Organize group and “advanced” nurseries, to minimize “staggered cultivation”,
- v. Undertake input supply and output marketing to members,
- vi. Organize the adoption of improved package of (agricultural) practices (POP). This include on-farm water management; seed testing, weed control; soil testing and fertilizer management; pest and disease control including the identification of major pests and diseases, Integrated Pest Management (IPM), and precautions in the application of chemicals, and
- vii. System of Rice Intensification (SRI), which “saves water and time”

As a result of above interventions through WUAs, the kharif yield rose from 2.8 t/ha in 2008 to 5.9 t/ha in 2012 in an area of 100000 ha covered under Intensive Intervention Programme (IIP) of CIDP. Self-sufficiency in WUA managed seed production system and accelerated adoption of system of rice intensification (SRI) were also witnessed between year 2010-2012.

Strengths of Successful Water User Associations

To define a successful WUA is a very complex task. If the WUAs are assessed with reference to achievement of objectives mentioned in the State PIM Acts, hardly any WUA will pass the test of success. On a pragmatic note, a WUA which has succeeded in increasing (i) percentage of water charges collection, (ii) area under irrigation and (iii) equity of water distribution in terms of water availability in tail ends, (iv) encouraging water saving, and (v) collective action for input and produce can be considered as a successful WUA. By this standard, there are many examples of successful WUAs in Gujarat and Maharashtra on Government Irrigation Schemes. Many informal water user associations have been found quite successfully running in Gujarat, Madhya Pradesh, Maharashtra lifting water from rivers for irrigation through community efforts and resources. The success of WUAs constituted on public irrigation systems is heavily dependent, at least in the initial stages, on the attitude and support of irrigation department/ line agencies. Main strengths and weaknesses of successful WUAs in Gujarat and Maharashtra as well as good practices adopted by Water Resources Departments (WRDs) / line agencies to support them are briefly discussed here in the following para.

Strengths of WUA

WUAs in Gujarat

In Gujarat, fixing hourly rates for irrigating a unit area, authorization to collect water charges over and above rates fixed by the government, payment of water charges to the government after retaining WUA share of water charges collection (30% + 20% for 100% collection in time), stress on consensus than election, taking irrigation charges

in advance and good upkeep of financial records and annual balance sheet make the WUA effective and responsive. The assistance and support of an NGO namely Development Support Centre (DSC) is also an asset for WUAs.

WUAs in Maharashtra

In Maharashtra, volumetric supplies of water to WUAs, hourly charging system for irrigation water from the farmers, tail to head irrigation scheduling, separate office building for WUA, stress on consensus for office bearers and good rapport between lower and upper level WUAs make the WUAs an engine of entrepreneurship. The system of transparent accounting and publication of annual reports by WUAs and the assistance and support of an excellent NGO, Samaj Parivartan Kendra (SPK) is also an asset for WUAs.

Good Practices by WRD/ line agencies contributing to success of WUAs

Supplying irrigation water through WUAs

WRD, Maharashtra and Sardar Sarovar Narmada Nigam Limited, Gujarat have taken a policy decision that irrigation water will not be supplied direct to farmers, instead it is supplied to WUAs and the WUAs will supply water to the farmer members.

Supplying irrigation water on volumetric basis / per irrigation basis

Department of Water Resources in Maharashtra and Gujarat supply irrigation water to WUAs on volumetric basis and the WUA supplies it further to farmers on volumetric/ hourly basis which prevents wastage and improves water use efficiency. In Madhya Pradesh it slightly differs but on the lines of volumetric basis as the irrigation fee is charged on “per irrigation basis” which prevents the farmers to provide extra irrigation.

Consultation with WUAs in construction and rehabilitation work

Maharashtra Government has taken a decision that work of distribution system having discharge capacity not exceeding one

cubic meter per second shall be carried out only after constituting WUAs. Also, execution of rehabilitation work done by contractors will be done under supervision of contract management committee which constitutes chairman of WUA, one member especially from tail end/divisional accountant and Executive Engineer of the concerned project. Under Gujarat PIM Act, the WUAs are expected to carry out ordinary repairs of irrigation facilities up to minor canal level but in case special repairs are needed, the department will carry out the special repairs in consultation with WUAs.

Special treatment to WUAs in carrying out new works, remodeling and rehabilitation works

Gujarat PIM Acts provides that WUAs may enter in to contract with the WRD for construction of new works and remodeling and rehabilitation of existing works. The work entrusted to the WUA shall be treated equivalent to the work carried out departmentally as per policy of the government. Earnest money or security deposit shall not be asked from the WUA. Deduction of income tax shall not be made at the time of payment for the work done as the WUA is working on the principle of no-profit. 2% of the estimated cost of work will be admissible to WUA as contingency. Inclusion of labors welfare up to 2% and outside consultancy cost up to 10% shall be acceptable by the department provided the expenses do not exceed the approved estimated cost. The WUA shall have to share 10% of estimated amount as contribution to implement the works of repair and rehabilitation. In case of new works, WUA shall have to share 5% of estimated amount. At the time of entrusting the sanctioned work to WUA, one third of sanctioned amount shall have to be given to WUA without any mortgage. While releasing funds to the WUA by the Government, the contribution of WUA will be deducted.

Taking assistance from NGOs in formation and capacity building of WUAs

Gujarat PIM Rules provide for engagement of NGO for purpose of formation or establishment of WUA and carrying out various activities laid down under the rules by the officer not below the rank of Superintending Engineer (SE). The SE may invite and engage the competent and reputed NGO or a successful WUA which works

actively in different irrigation sector and is capable of promoting WUA and supporting them in PIM through motivation as facilitator or community organizer. In case of non-availability of facilitator or community organizer, the SE may assign the competent assistant engineer (AE) or additional assistant engineer (AAE) who is devotee and capable of promoting WUA and supporting them in PIM through motivation. The Government shall give incentive to that AE or AAE for such assigned activity as per norms laid down from time to time for payment of facilitator or community organizer.

In Gujarat (Dharoi Irrigation Project), Maharashtra (Waghad Irrigation Project), Chhattisgarh (CIDP) and Uttar Pradesh (UPWSRP-1), the NGOs have helped establishment and capacity building of WUAs. It has been observed that the continuous hand holding is needed by an NGO for 3-4 years for capacity building of WUAs. After exit of NGO, the good will, cooperation and assistance of the WRD to WUA is essential for their sustainability.

Critical Issues in Up-Scaling of PIM

PIM Acts should be farmer friendly, simple and practical

The PIM Acts and Rules in each state have been prepared by the Government, mainly by the WRD/CAD without wider consultations with the stakeholders, particularly, farmers. These rules are rigid, lengthy, cumbersome, procedure ridden and cut-off from the ground realities. These acts can be crudely termed as the wish list of the water sector reforms which the government could not implement all through the years. That is why even the most successful WUAs in terms of managing distribution of canal water and maintenance and repair of irrigation system have not been able to implement many provisions of the Act.

Andhra Pradesh enacted the first PIM Act in 1997 which coincided with the emergence of donor support to irrigation reforms in India with PIM as the core component of reform projects. Though the consultation process before the Act was conducted but being maiden act of its kind, the first-hand experience was not available. The Madhya Pradesh PIM Act 1999 and Rajasthan PIM Act 2000 were enacted in hurry probably to avail the donor funding as these acts are

remarkably similar to AP PIM Act although the ground conditions of M.P. and Rajasthan are quite different to each other as well as Andhra Pradesh. The Maharashtra PIM Act 2005 and the Gujarat PIM Act 2007 were based on feedback from existing WUAs and a lot of consultations were made. So far, the Maharashtra PIM Act 2005 is better in providing enabling environment to the WUAs. Maharashtra PIM Act is also the best act in terms of provision for women participation as it reserves a 2-year term for a women president besides one third reservation for them in each level of management committee. Still all acts have many weaknesses in common:

- i. PIM was initially driven by donor support to irrigation reforms in India and most officials perceived it as an outside agenda. The concept, need and rationale of PIM was not adequately discussed with government agency officials which lead to weak commitment of the agency officials and hasty drafting of PIM Acts.
- ii. All acts are based on the premise that office bearers of a WUA will be keen to provide voluntary services and notifying every farmer as a member in the command area of WUA will act as a binding force.
- iii. The process of formation of WUAs is full of procedures and WUAs are expected to carry out more functions voluntarily with resource generation from own efforts than the WRD was carrying out with salaried staff and resources at their disposal
- iv. The training and capacity building, involvement of NGOs and private sector participation in PIM are vital yet neglected areas in all PIM Acts. Only Gujarat PIM Rules associated with the Act provide for deployment of NGO for formation and handholding of WUAs.
- v. While provisions of women participation have been made in the PIM Acts (except Andhra Pradesh, Gujarat, Rajasthan and Tamil Nadu), the social constraints and difficulties related to women participation have not been addressed.
- vi. The PIM Acts stress on elections for WUA management committee and office bearers. It has been experienced that

the elections generally create undesirable after effects to spoil the collective action environment in the community. There should be inbuilt incentive on consensus and elections should be conducted as the last resort. For example, Andhra Pradesh Government provides a financial incentive to those WUAs which are constituted through the proposal / election of consensus candidates. It will be proper to revisit the PIM Act in each state and make it realistic and farmer-friendly as each state have enough experience and feedback to undertake mid-course corrections.

The responsibilities of office bearers of WUA under the PIM Acts call for their full time involvement. It also calls for cash contributions and fund raising from the farmers to support an agenda in which the farmers do not perceive any gain or incentives for themselves. The whole concept of PIM is based on voluntary WUAs. It needs to be compensation oriented. The farmers have to be convinced that there are adequate compensation and incentives for their effort in the formation of robust WUAs.

It is noteworthy that most successful WUAs in Maharashtra and Gujarat are not, strictly, functioning according to PIM Acts of their state. These WUAs in Gujarat were already functional under cooperative act before the Gujarat PIM Act 2007 came to existence. Most WUAs in Gujarat are still functioning as irrigation cooperatives and are reluctant to switch over to PIM Act. Similarly, successful WUAs in Waghad Project, Maharashtra have informally abrogated certain provisions of Maharashtra PIM Act for smoother functioning.

There is immediate requirement to modify the State PIM Acts based on experiences gained in implementing PIM Acts since last fifteen years.

Need to adopt a step-by-step approach for large systems

On large and medium irrigation systems, farmers are traditionally dependent on the government for irrigation water delivery since the British period and they lack initiative to organize for water management unless backed up and regularly supported by the WRD.

On the other hand, WRDs do not like this democratic system to encroach in their comfort zone of ‘powers without accountability to the users’.

Besides the attitudinal constraints, there are technical and organizational constraints as well. The canal irrigation systems are often quite large and it is difficult to organize WUAs on them for two reasons: (i) the number of the farmers are quite large requiring investment of huge resources at the initial stages and (2) water users at lower level of the irrigation system are not able to establish the cause- effect relationship between their efforts and commensurate gains. The State PIM Acts elaborate in detail how higher level WUA organizations at the distributary and up-to project/scheme level should be formed in one go. Experience from other countries, such as Mexico and Turkey, have shown that it is important to get the lower order WUAs functioning correctly before moving above the outlet or minor canal. Once the WUAs are able to manage, operate and maintain their systems within the outlet or minor command, they will be interested, and able, to start getting involved in the management of the higher order canals. The best example of this is Gujarat where the act provides for WUAs at minor level canal only. But once the minor level WUAs began functioning well and stabilized, the informal WUAs at distributary level have been set up by the farmers without waiting for amendment in the Act. Conversely, Madhya Pradesh started with formation of WUAs at minor, distributary and project level in one go but had to backtrack to WUA at minor canal level only.

It was also noted that in the projects supported by international funding agencies like the World Bank, Asian Development Bank, Japan International Cooperative Agency etc where the formation of WUAs was mandatory, PIM was implemented in project mode with rigid targets focusing more on number of WUAs formed and ignoring the quality of processes and other aspects of strengthening and capacity building of WUAs.

The WUAs shall have to extend their scope

Right now, WUAs are focused on repair and maintenance of

irrigation facilities below minor head, canal water distribution amongst farmers, irrigation recording and revenue collection. The core objective of establishing WUA, namely, using canal water efficiently and economically, saving canal water to extend more area under irrigation facility, ensure equitable distribution of water up to the tail end and maintain canal infrastructure will not attract the real participation of farmers unless these objectives are clearly linked with agriculture productivity and income generation for the farmers. For this to happen, the WUAs need to have an entrepreneurial orientation and should extend their scope to backward and forward linkages of agriculture. The WUAs have to be a hub of rural development through proper mix of local labour, available resources and developmental schemes like MNREGA, National Horticulture Mission and various schemes in Agriculture Sector. WUAs have to develop new markets and strategies to satisfy myriad needs of the farmers on one hand and, on the other hand, WUAs have to discover new sources of water in the framework of integrated water resources management including rainfall conservation, ground water and surface water.

WUAs must be sustainable without subsidies

The WUAs will be able to carry out their functions only if they are financially sustainable. The authority to fix water rates to be charged from the farmers lies with the state government. The only exception is Maharashtra where WUAs can fix water rates to be charged from the farmers. WUAs determine and collect water charges from the users directly in Gujarat, Maharashtra and Rajasthan. Except Gujarat, the water charges collected by the WUAs are deposited in government treasury and prescribed % of collected revenue is paid back to WUAs by the state governments. In Uttar Pradesh and Andhra Pradesh, the water charges are collected by the Revenue Department but the prescribed % of collected revenue is paid back to WUAs by the state governments. In Maharashtra, 75-93% of the revenue collected is ploughed back to the WUAs. In Rajasthan, 50% of the revenue collected is ploughed back to the WUAs. In UP, 60% of the revenue collected and in AP, 90-95% revenue collected is ploughed back to the WUAs. In Gujarat, WUAs are allowed to retain 30% of revenue collected for ordinary repairs and maintenance of canal and can retain

additional 20% if 100% tax is collected in time.

Since the water rates fixed by the States are very low, the resultant share to WUAs is also low in terms of absolute value. Another difficulty faced by WUAs in this regard is bureaucratic delays in ploughing back of collected revenue from the government treasury to the WUA. This process varies from a few months to a few years. Since WUAs have not generated any other sources of income, the delay in ploughing back of money cripples the WUAs. The only good point is that the funds to WUA are linked with water charges collection which motivates WUA to increase area under irrigation as well as cent percent recoveries. All WUAs can also avail one-time management grant of Rs 1200/ha under Command Area Development and Water Management Program (CADWMP).

WUAs in all states have common concern and complaints that the funds given by the government are too meagre to provide salary to staff and carry out repair and maintenance of the irrigation system simultaneously. Since staff salary cannot be stopped, the repair and maintenance of the system suffers. The PIM Acts allow WUAs to resort to multiple sources of fund collection, viz., set their own service fee and levy taxes, seek contribution from members and get donations, grants and many more. For financial sustainability of WUAs, the following measures are necessary:

- i. The government rationalizes the irrigation rates. The increase in irrigation rates will proportionately increase the share of WUA
- ii. Instead of plough back of funds causing inevitable delays, WUAs may be allowed to retain funds as in Gujarat.
- iii. The WUAs should be trained and motivated to seek alternative sources of funding as provided in the PIM Acts.
- iv. The WUAs should be made aware of financial avenues available to them. For example, it was observed in Rajasthan that fixed deposit against one-time management subsidy was renewed every year with interest and the WUA office bearers did not know that they could utilize its interest portion.

WUAs should be made capable to manage the environment

Waterlogging, salinity, unsustainable ground water extraction and contamination of soil and land are major issues in irrigated agriculture which are crucial for agriculture productivity. Since surface water (canal water) and ground water (wells, tube-wells) are integrated source with mutual interdependence, the focus on canal water only will not be helpful in tackling environmental problems. In addition, a single source either canal water or ground water may also not be able to provide adequate irrigation around the year. PIM Acts in all the states provide for role of WUA in ground water management also. The Maharashtra PIM Act even allows WUAs to levy water charges on use of ground water and recycled water (Para 27(3) of the Act). But the WUAs are entirely focused on canal water management leaving the ground water management as an individual responsibility. It is necessary for WUAs to focus on all water resources in the command and should extend their role in integrated irrigation water management for their sustainability.

Training is required at all levels

Participatory Irrigation Management (PIM) is a new approach which encourages the involvement of the users' viz., the farmers in all the decision making and implementation process of irrigation water conveyance, delivery, application, utilization and drainage initially at minor canal level and gradually moving upwards in the canal system. This kind of integrated interaction and joint management is new for both the irrigation agency and the farmers. Such a change requires special skills and attitudes on the part of both the irrigation agency and the farmers to modify their present roles and responsibilities. Unfortunately, the training and capacity building efforts for the farmers and officials for the implementation of PIM have been inadequate and largely unsynchronized with requirements on the field.

State WALMIs, Krishi Vigyan Kendras (KVKs), NGOs, agriculture universities, IndiaNPIM and other training institutes should have a network to pool training resources and generate training resources through training of trainers (ToT) as the challenge of training and

capacity building is huge in comparison to resources available in the States.

The major problem with the training of farmers arises from largely class room trainings being imparted by WALMIs, KVKs and other training institutes. New and innovative training methods like Farmer Field Schools (FFS) which are conducted at the farmers' fields and are based on 'learning by doing' are much more effective. Similarly, the 'exposure visits' to successful projects during the training have been found quite effective than mere class-room training which has very limited impact on the participants. Chhattisgarh Irrigation Development Project (CIDP) is a good example where the training based on the concept of 'learning by doing' and through FFS resulted in strengthening of WUAs and achievement of project objectives.

Government agencies need to be reoriented

WUA requires interaction and support from many government agencies like ID/WRD, CADA, Department of Agriculture (DoA), Department of Horticulture (DoH), Ground Water Department, and Rural Development Department etc. These agencies work in isolation and often at cross-purposes. The Department of Agriculture promotes crop varieties and crop practices while IDs are suppliers of irrigation water. Both the departments never sit together to sort out which crop varieties and crop practices are to be promoted based on available water. Across the states, the presence of agriculture and other agencies to support WUAs is negligible. In Madhya Pradesh, an ex-officio member from agriculture department is co-opted in the management committee of WUA as per MP-PIM Act. Still the support of agriculture department is not visible in field.

It is suggested that WRD / agency responsible for promoting WUA should constitute multi-disciplinary PIM cells in each irrigation division, on the pattern of Uttar Pradesh and Tamil Nadu, which should provide single window support to WUAs on training and capacity building requirements and act as an interface between WUA and various farmer friendly schemes of other line agencies/ departments so that WUAs develop as a credible and efficient institution for the water users.

Effective Monitoring of WUAs at each level

Monitoring is an effective tool to guide the WUAs on right track for sustainability. The PIM Acts of each state have provisions for monitoring of WUAs by the WRD at each level but WRD are mostly reluctant or short of time/skill to do it in a proper manner. Mostly it is a crude exercise in controlling / restraining WUAs. Many important activities like quality, relevance and timing of training deliveries, routing of water charges to WUA and audit compliances etc. are not focused in monitoring which may lead to misappropriation of WUA funds and weak WUAs. Therefore, it is necessary to establish regular monitoring mechanism through dedicated PIM Cells created for this special purpose.

Conclusions and Recommendations

A big gap is visible between the PIM policies, acts and rules declared by the State Governments/ Central Government and its implementation on ground. The acts and rules are made in haste without wider consultations with the stakeholders and thus lack practical perspective. A criticism of the participatory irrigation management programme in India to date is that it has been mandated on paper, but often not supported in practice with the resources and expertise required to change the status quo. The reason of this lackluster performance emanates from attitudinal and operational constraints which are listed below:

- i. On large and medium irrigation systems, farmers are traditionally dependent on the government for irrigation water delivery since the British period and they lack initiative to organize for water management unless backed up and regularly supported by the WRD. On the other hand, WRDs do not like this democratic system to encroach in their comfort zone of ‘powers without accountability to the users’.
- ii. PIM was initially driven by donor support to irrigation reforms in India and most officials perceived it as an outside agenda as the idea was not adequately discussed and internalized by them.

- iii. PIM was implemented in project mode with fixed targets focusing more on numbers than the desired results
- iv. The legal framework for PIM was prepared in haste ignoring ground realities.
- v. The training and capacity building efforts for the farmers and officials for the implementation of PIM have been inadequate and largely unsynchronized with requirements on the field.

Building any organization requires meticulous planning, time, effort and resources; formation of effective water users' associations is no different. Building sustainable, self-reliant water user organizations is a time and resource-consuming activity, which cannot be achieved without full and strong commitment from the State governments and particularly Irrigation/ Water Resources Departments. Evidence exists in several locations in India that where adequate time, effort and resources are committed viable WUAs can be formed, with significant benefit to the users, and to the wider society in that irrigation scheme which becomes more efficient and productive.

Main Recommendations

- i. The state PIM Acts/ rules and other legal framework for PIM needs to be revised in the light of past experiences in implementing PIM on ground and feedback from the stakeholders. The revised act should be more farmer-friendly, simple and based on ground realities. It's a good idea that the Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India issues a model draft of PIM Act for the guidance of the States.
- ii. For the financial sustainability of the WUAs, it is very important that the WUAs are given the responsibility of collection of water charges and are allowed to retain prescribed water charges with them for operation and maintenance of the system and administrative expenses. The current system of deposition of all collected moneys with the government and then reallocation of the money through government channels is time consuming and restrains the financial viability of WUA.

- iii. Each state government and the Central Government should institute annual awards to encourage best performing WUAs at the State and the National level respectively to motivate WUAs to perform better and keep verifiable records.
- iv. There should be a PIM Directorate at MoWR, RD, GR, Government of India level to act as a National Resource Centre for PIM. It should guide and assist the States in awareness, communication, training, research and benchmarking related activities in PIM implementation.
- v. Each state WRD should have PIM Directorate at the apex level which should be responsible for regular monitoring of WUA activities in the State. Each division of WRD should have PIM Cells to assist and coordinate WUA activities.

By focusing on the core principles of water management and change management robust WUAs can be multiplied to bridge the management gap between the main system run by the Irrigation Department and the field plots managed by large numbers of smallholder farmers. There is enormous potential for saving water and increasing productivity of land and water in agriculture through formation and strengthening of WUAs. It is the time for mid-course corrections in the light of a decade of implementation experience to make combination of WRD and the Water Users' Associations more effective and productive.

References

- 1 The irrigation projects in India are classified in to three categories: (i) Major (ii) Medium and (iii) Minor irrigation projects. Projects having more than 10000 ha cultivable command area (CCA) are termed as major projects, the projects having more than 2000 ha (up to 10000 ha) are termed medium projects and the projects below 2000 ha CCA are termed as minor projects.
- 2 Of India's 58.5 m ha Ultimate Irrigation Potential on Major and medium projects, the irrigation potential created is 45.34 m ha and irrigation potential utilized is 34.66 m ha (Water and Related Statistics, December 2013, published by CWC, Government of India)
- 3 The report on the State of Indian Agriculture placed by the

Government to the Rajya Sabha in March 2012, (<http://pib.nic.in/newsite/erelease.aspx?relid=80852>)

- 4 The landholdings up to one hectare are termed as marginal landholdings and between 1-2 ha are termed as small landholdings
- 5 Source: All India Report on Agriculture Census 2010-11, Ministry of Agriculture and Farmers Welfare (2015). The figures of 2015-16 have been projected by the author.
- 6 Original figure of 84779 Nr. WUA /17842.20 thousand ha area covered adopted from Hand Book on Water and Related Statistics 2016 (page 65) published by CWC. The number of WUAs in UP (802 WUA) given in CWC publication are corrected to 9691 WUA) by the author.
- 7 Original figures (84779 Nr. WUA /17842.20 thousand ha area covered) adopted from Hand Book on Water and Related Statistics 2016 (page 65) published by CWC. The figures of UP (802 WUA) are corrected (9691 WUA) by the author
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Vidyanand Ranade

Governance in the Water Sector

Abstract: Out of the four life support systems, air and solar energy are freely available; land is owned by the state or the individuals, but 'Water' is the only system which is amenable to be managed to meet needs of humans for their survival & wellbeing, and that of all other life forms on the Earth. With the advancement of civilization, demand for land & water for human use started increasing, thereby causing degradation of terrestrial and aquatic ecosystems. To this quantitative degradation, since eighteenth century, qualitative degradation commenced with the industrialization and urbanization. During later half of the twentieth century these issues attained such a level that rethinking of present policies about Water Resource Development and Management was started at the World level. Attempt has been made in the paper to present all these recent developments in 'Water Sector', proposed to be carried out with a view to meeting all competing and conflicting water demands of humans, now and in the distant future till the population stabilizes, duly causing minimum degradation of environment and natural ecosystems. Brief review of historical development of time tested water resource development infrastructure and its management in the Peninsular India has been taken. However, detailed review of problems associated with Governance of WR Development and Management of the infrastructure constructed in Maharashtra State after independence has been taken to highlight the issues and challenges to be addressed to, and their possible solutions for achieving a desirable future.

Preamble - Water is a prime natural resource, fundamental to life, livelihood, food & water security and sustainable development. It is characterized by spatial and temporal variation, variability from year

to year, which is likely to get further distorted in future due to effects of Global Warming and Climate Change, but still on an average its availability would be finite at any given place. It is a dynamic and reusable resource, but is vulnerable to pollution. However, Nature has provided two stabilizing factors to this dynamic resource viz. temporary storage in the form of snow in temperate regions and as Ground Water in most of the River basins. Any type of Water Resource Development infrastructure planned for human use has to be designed duly taking into consideration all these characteristics. Rapid growth in demand for water as a result of rise in population and increased rate of urbanization & industrialization has been posing serious challenges to food security, water security and access to adequate safe drinking water. Release of untreated or partially treated effluent generated after non irrigation use of water, into natural streams has added new dimension to this issue. Time has come to take a holistic and inter-disciplinary approach towards water related problems, by resorting to 'Integrated Water Resource Development and Management' (IWRDM). Planning, development and management of surface and groundwater resource needs to be governed by rational perspectives in an integrated and environmentally sound basis. When development & management of water resource falls short in meeting growing needs of water, issue of Governance of development and management of infrastructure starts getting prominence as a soft option.

Historical review of water resource development in the Peninsular India - Eight – nine centuries before, irrigation facilities were provided to grow three crops in a year in the fertile Delta region of most of the East flowing Rivers in the Peninsular India, by constructing masonry weirs and diverting the perennial river flow. These schemes were constructed by the then Rulers, but were managed mostly by the beneficiaries. Some of these schemes were modernized during British Regime. Another development during last three centuries was in the form of construction of small earthen dams, planned and constructed on the basis of time tested technique, to store water to deliver it to the paddy crop during water-stress period and ensure good land productivity. All along East coast from Odisha

to Tamil Nadu state, about 10 lakh such small tanks were financed by the big landlords (Malgujars) and the then Rulers, with active contribution from the beneficiaries. Management of these schemes was done entirely by the beneficiaries. 'Phad system' which consisted of diverting river flow by means of a series of small weirs one below the other to irrigate crops, was in vogue on some Rivers in the Tapi basin for the last 2–3 centuries. Schemes were financed by the then Rulers but were managed entirely by the beneficiaries.

In the pre independence period, five large masonry dams were constructed in high rain fall zone in Sahyadri ranges in the Maharashtra state to store monsoon runoff and to convey it to drought prone area towards East (Intra-basin water transfer) to grow seasonal and perennial crops. Seven medium earthen dams were constructed in eastern part of the state, for achieving crop diversification (from paddy crop). Irrigation management of these relatively large schemes was, however, done by the Govt. machinery. Some small earthen dams were constructed in the drought prone zone, purely as famine protection works during scarcity years.

Emerging trends in Water Resource Development activities in the Maharashtra state, during post independence period - To tide over food grain shortage faced by the country in the fifties, several major irrigation projects were taken up in hand in most of the states in the country. Many major irrigation projects which ensured Intra-basin transfer of water were also taken up in Maharashtra state. With the limited three and a half-month monsoon season and about 35 to 40 % area of the state being drought prone & having no perennial rivers, all projects consisted of storing monsoon runoff to use the stored water all the year round. In order to extend irrigation benefits to the rain-fed cultivation bypassed by major dams (more than 10000 ha irrigation potential), many medium size dams (2000 to 10000 ha) were also taken up and later on priority shifted to taking up minor dams (250 ha to 2000 ha). With the result, more than 40% of the 4500 Large Dams (dam of height more than 15 m or storage more than 3 Mcum) in the country are in the Maharashtra state. On considerations of equity in dispersal of irrigation benefits in the basins, projects to irrigate land below 250 ha each were concurrently

taken up. The mosaic of large to very small schemes ensured optimum development of water resources and equitable allocation of irrigation benefits in the River basins. On consideration of social equity, many large size Lift Irrigation schemes were also taken up by Govt. to provide irrigation facilities to the parched lands on the plateau where conventional irrigation by gravity canals was not possible and GW availability was poor.

In more than 90% area of the state, availability of groundwater is limited and confined to shallow (less than 25 to 30 m deep) disconnected GW aquifers in the residual soils, decomposed strata and basaltic rock flows below. Every year, rain water seeps below ground and gets stored in decomposed strata and in cracks, crevices and joints between two flows of rocks and hence availability of GW is finite & limited. Reduction in family land holding size (due to partition of land) to about 1/3rd of what it was at the time of independence, induced rain-fed farmers to exploit GW to increase land productivity of the reduced land holdings to meet family needs for survival. Coupled with the availability of electricity in the rural area, pace of GW exploitation increased rapidly during last 30-40 years and with the result, some watersheds in the drought prone areas became critical or over exploited. With the availability of drilling rigs and deep well multistage submersible pumps, indiscriminate drilling of bore wells up to 200-300 meter depth to exploit deep GW aquifers (aptly called as mining of water) to grow high value cash crops was also started in the state from the eighties. Overexploitation of GW by shallow wells necessitated introduction of 'Drip Irrigation' on large scale on private wells where water shortage was acutely felt. Use of poly houses and shed nets was also on the rise to grow vegetables, floriculture and other high value crops.

Concept of 'Watershed Development' was introduced and successfully experimented in the seventies and eighties in the state by some enlightened social workers. Looking to the potential of this scheme in the comprehensive development of rural area through local water conservation works, Govt. took a conscious decision in the nineties to take up these schemes as Govt. schemes. Watershed development schemes help in meeting basic needs of rural population

viz. water, food & fodder, fuel and livelihood security, through increased land productivity & employment generation brought about by conservation and harvesting of rain water to augment GW recharge to provide protective irrigation to seasonal crops. It meets developmental needs of the disadvantaged section of the society by bringing social justice & equity in the water sector. Bio measures (growing trees & pastures in the watershed) meet fodder needs of cattle and fuel needs for cooking and thus help in preventing degradation of the environment. Cooperation of the beneficiaries in operation of the scheme for equitable sharing of all the common benefits is the key to success of these schemes.

Demand and Supply Dynamics - Historically, as the size of human settlements started increasing, demand for water also increased but could then be met with by simple human interventions. With the industrialization and consequent urbanization in the eighteenth century, water demand increased appreciably and it became location specific, requiring large size well designed complex WRD infrastructures. With the increase in population of the World, the water demand increased further in the twentieth century. Growing concern about deforestation for bringing more land under cultivation put restrictions on the availability of agricultural land for food production. Choice then available to increase land productivity for ensuring food security to the teeming millions of the World was to develop additional water resource structures to provide more and more irrigation facilities. As a result of this situation, even if population of the World increased by three times during the twentieth century, water demand increased by seven times in the same period. To meet rapidly increasing demand for water all over the World, number of Large Dams in the world increased from 5,000 in 1950 to 48,000 in the year 2000. As long as water resource availability in a country / River basin was much more than the water demand and adequate finances & technology was available to develop appropriate infrastructure, it was possible to match rising demand with the supply.

In the developing countries and countries with emerging economy, severity of the problem of matching supply with the demand increased because of higher rate of population rise, increasing

rate of industrialization & urbanization, inadequacy of finances for construction of WRD infrastructure and inherent inadequacy in availability of water resources in the river basins. Increased demand for non irrigation purposes curtailed availability of water for irrigation, giving rise to Urban-Rural conflicts. Partial treatment of industrial effluent and practically non treatment of city effluent resulted in pollution of long stretches of rivers on downstream of these locations. Use of such polluted water by lifting it for irrigation on both banks of rivers by the needy cultivators, not only contaminated the agricultural produce & polluted groundwater, but it became a health hazard for the affected population.

Water Resource availability and scope of Development - In any River Basin, natural availability of water resource and the limits put by the scope of structural interventions to make it available for human use, decide the limits of water-related development in the basin. It also requires some regulatory mechanism in implementation of ongoing schemes so as to get early benefits from the scarce financial resources available with the developing countries and countries with emerging economies. Hard option to expand scope of development in water-short basins would be to explore possibilities of Inter-Basin water transfer from adjoining or distant water-surplus river basins, which is generally a costly alternative and involves social problems associated with such transfer of water. Other alternative for water-short basins would be to plan such developmental activities in the basin which would not require high consumption of water. Soft option would be to carry out performance review/evaluation of all completed WRD schemes, with a view to exploring possibilities of introducing structural modifications and to implement them in a phased manner to improve water availability from the same structure. Lastly, very vital soft option would be to review present set up of operation and management of all WRD schemes for all its competing uses of water and take non structural measures to improve their performance and water-use efficiency. Even if it is less cost intensive when compared with above alternatives, it calls for reorganization of water management set up and involvement of beneficiaries in the management of water. All the activities stated above fall within the ambit of 'Water Governance'.

Water Governance - Water governance plays very important role both in the development and management of water resources, and more so in the river basins where natural availability of water resource is less in relation to water demand for people in the basin. In what manner Maharashtra state in the Peninsular India is trying to handle the problem of matching the supply with the dynamics of various competing demands on water, by appropriate governance is explained below;

Governance in implementation of WRD projects - Paucity of financial resources is a chronic problem and major constraint with developing/emerging economies. With the limited funds, planning should aim at creating maximum storage of water together with infrastructure for water use, from the investment made. Instead of completing ongoing projects expeditiously to get early benefits, elected representatives of people clamour for taking up more and more new WRD schemes in their constituencies (their appeals are many times responded favourably), thereby resulting in thin spreading of financial resources and delay in completion of in-progress schemes in advanced stage of completion. Sometimes new projects are investigated, approved and included in the budget as special case, or scope of existing projects is changed, as per their demand. With the result projects in advanced stage of completion languish for years, cost of their balance work continues to increase due to inflation and benefits from investment get deferred.

With a view to controlling/improving this situation, Govt. of Maharashtra passed an Act in the year 2005, to constitute an independent 'Maharashtra Water Resource Regulatory Authority'. It was supposed to monitor preparation of Integrated State Water Plan consisting of Basin wise WRD plans by the Irrigation Development Corporations for the respective River Basins and get them approved from the State Water Council (Chaired by the Chief Minister) within a year and a half from its formation. As per provisions in the Act, new projects were to be taken up only out of the approved ISWP/ Basin wise plans. However, ISWP could not be approved even after 10 years from formation of MWRRRA, but many new projects were approved by the Water Resources Department. (WRD) of GoM with

the connivance of MWRRRA and same were included in the budget, defeating the very purpose of instituting a regulatory mechanism. Powers given by the Act to MWRRRA to approve allocation of water for industries were withdrawn by the GoM and were given to a Committee of Ministers. MWRRRA has, however, given some good decisions to resolve conflicts in allocation and use of stored water in water-short basins. MWRRRA has also finalized the complex issue of Tariff structure for use of water for various purposes, after holding several public consultations. Maharashtra is the first state in the country which has instituted a regulating authority in the water sector. There is scope to improve its performance by following provisions of the MWRRRA Act strictly.

WRD of GoM should strictly ensure that first priority of allocation of funds should be given to projects in advanced stage of construction, even by deferring projects in the initial stage of construction. Stage wise completion of major projects should be planned so as to accrue early benefits of storage and creation of irrigation potential from lesser investment. More expenditure should be incurred towards available soft options which would improve performance of completed projects.

Governance in operation, maintenance and management of irrigation

Operation and maintenance of WRD infrastructure – Any hydraulic structure requires routine periodical maintenance to get sustained performance over years. Since such structure has to face and negotiate the effects of unpredictable precipitation pattern, occasionally it gets damaged due to high floods and requires special repairs to spillways. Maharashtra state has set up Dam Safety Organisation which carries out periodical inspection of major dams, monitors results of routine pre & post monsoon inspections of smaller structures carried out by the management staff and publishes Annual Reports. It is experienced that due to financial constraints, more funds are allocated for construction activities and routine maintenance of dams and canal network gets neglected. However, funds are usually allocated for special repairs. Lack of adequate and

timely maintenance impairs performance of schemes in the long run.

Performance evaluation of completed projects – There is no mechanism to evaluate performance of works after 5/10/20 years after their completion. Irrigation structures are planned and designed on the basis of some assumptions about availability of yield with certain dependability (75% to 50% from major to minor dams) from its catchment and use of stored water for various purposes. Actual availability is seen to be many times less than the designed one, but water demand is always on the increase and is dynamic in nature for the competing water demands. Actual cropping pattern may be much different from the designed one. Water demand for non-irrigation use usually increases affecting availability of water for irrigation. Hence it is necessary to review performance of every completed project periodically, take possible structural/nonstructural measures to improve its performance and revise its actual potential. If utilization of stored water is poor for irrigation use, dialogue should be established with the water users and actions should be taken to increase use of water. Results of such review gives good guidelines for planning and implementation of new projects

Management of irrigation – Irrigation management of all projects in the state used to be done by canal management staff of WRD. After taking up several pilot projects to explore mechanism of transfer of irrigation management to water users and after holding discussions with many NGOs and elected representatives of people, GoM formulated and passed Maharashtra Management of Irrigation Systems by Farmers Act (MMISF Act) in the year 2005, for transfer of irrigation management of surface irrigation schemes to Water Users Associations (WUA). Each WUA gets canal water on volumetric basis at specified rates for each season. They have to operate & maintain distribution system in their jurisdiction and members are free to grow any crop by making conjunctive use of Ground Water. It is expected that there is good incentive for the water users to get more crop, cash and jobs per drop of water by making more efficient use of water. It was seen that some improvements in the water distribution network of projects would have to be carried

out to enable transfer irrigation management to WUAs. Substantial funds would be required for these works. With the result, transfer of irrigation management to WUAs was seen to be a slow process, but water-use efficiency is expected to improve appreciably.

Introducing Micro Irrigation System (MIS) on Surface Irrigation Projects – MWRRA has recently issued Notification to introduce on pilot basis, adoption of MIS (Drip Irrigation) for perennial crops in the command area of 8 major projects in the state. It is planned to complete this transformation on the selected 8 projects up to the year 2018. To enable introduction of MIS, it would be necessary to construct a balancing pond at the head of jurisdiction of WUAs to enable the change to introduce MIS and it would be essential to provide some subsidy to the water users for capital investment for MIS equipment. There would be appreciable saving in water use on this account. On considerations of equity, water so saved is proposed to be delivered to irrigate seasonal crops in the tail reach of the canal. Learning from this experience, it is proposed to introduce MIS to irrigate perennial crops on all major projects in the state. This is a proactive step taken by MWRRA to improve water-use efficiency on surface irrigation schemes.

Treatment of generated effluent and its reuse for irrigation – Non treatment or partial treatment of effluent and releasing it into natural streams has been degrading natural and man-made ecosystems (Reservoirs). There is no mechanism to enforce the polluters (urban water users i.e. Municipal Corporations) to treat all the effluent prior to its release in Rivers. Maharashtra Pollution Control Board falls short in ensuring full treatment of industrial effluent prior to its release in rivers. Implementation of ‘Zero Effluent Policy’ for industrial effluent would appreciably mitigate the situation. Unless fool-proof Governance mechanism (duly supported by enabling Acts and Rules) is introduced, situation of degradation of all aquatic ecosystems would deteriorate further to the detriment of people.

Governance in Ground Water (GW) management – Implementation of GW Acts and Rules to control and regulate use of GW has always been a difficult problem to handle in most of the countries all over the World. GoM has passed enabling Acts to

regulate exploitation of GW, but its implementation is poor. GW is a cheap and fairly dependable (Except during severe drought years) and cheap source for drinking purposes in rural area. It gets undermined if new wells are taken around the drinking water wells. GW from deep aquifers can also be a reliable source for drinking water. Quest to grow cash crops by digging and drilling wells to exploit shallow and deep GW aquifers has seriously affecting source of drinking water. In effect, costly and unreliable measure of providing drinking water by means of water tankers is hence becoming practice per force. Strict implementation of recently passed Ground Water Regulation and Control Act by GoM would be a right step for good Governance of GW.

Governance in Demand Management – Telescopic water rates should be charged for urban use of water to induce Municipal Corporations to introduce metered supply and to take measures to identify sources of leakage in the underground distribution network and rectify it.

Water rates should be used as an economic instrument for industrial use of water, so as to induce recycling of water, with ultimate aim of achieving ‘Zero Effluent’. Demand of water for irrigation use should be controlled by entrusting irrigation management to WUAs and by introducing MIS on surface irrigation schemes, as explained in paragraphs above.

Conclusions – Governance in water sector on the lines as suggested above is possible only if relevant Acts and Rules are strictly followed by the Govt. machinery. NGOs working in water sector have important role to play in educating water users about their rights and duties and make them ‘Water Literate’ in the real sense. Pressure imposed by water literate stake holders and by the enlightened media can certainly keep check on the aberrations in rigid implementations of Acts and Rules by the functionaries of concerned Departments and on deviations because of political expediencies.

OUR CONTRIBUTORS

Avinash Chand Tyagi is the Secretary General of the International Commission on Irrigation and Drainage. He was Director of the Climate and Water Department of the World Meteorological Organization (WMO) and was Commissioner of Policy and Planning in the Ministry of Water Resources. He graduated from University of Roorkee and earned M.Tech from IIT Delhi.

C.D. Thatte was Secretary in the Ministry of Water Resources and held several positions in State and Central Governments, including Chairman of Central Water Commission. He was also Secretary General in the International Commission on Irrigation and Drainage (ICID). He graduated in Civil Engineering with a Post Graduate in the subject of Soil Mechanics and did his Ph.D. in Hydraulic Modelling.

Chetan Pandit graduated in Civil Engineering from IIT Delhi and then obtained M.Tech. in Hydrology from Galway, Ireland. He joined “Central Water Engineering Services” and worked for over 35 years in the CWC, and other organizations under the Ministry of Water Resources. He was Member-Secretary, Upper Yamuna River Board; CE National Water Academy; and Executive Member, Narmada Control Authority.

D.T.V Raghu Rama Swamy is Professor and Director, School of Infrastructure, RICS School of Built Environment, Amity University, NOIDA, India.

Harish Kumar Varma is an Executive Director at the International Commission on Irrigation and Drainage and has more than 36 years of work experience in various aspects of water resources planning, development and management working in Central Water Commission, Water and Power Consultancy Services (India) Limited and Asian Development Bank.

J.B. Ravinder is Joint Adviser, Public Health and Environmental Engineering Organisation under Ministry of Urban Development. He has a Master's degree in Public Health Engineering from All-India Institute of Hygiene & Public Health, Calcutta University. He served as Member of Expert Committee during the preparation of the Manuals on Sewerage & Sewage Treatment Systems (2013) and on Municipal Solid waste Management (2016).

J.Chandrashekhhar Iyer is Commissioner (FM), Ministry of Water Resources, River Development and Ganga Rejuvenation

L. Elango is a hydrogeologist with Masters Degree in Science (Applied Geology), Masters Degree in Engineering (Hydrology & Water Resources Engg.,) and Ph.D in Hydrogeology (1992), with his postdoctoral work at the University of Birmingham under Indian National Science Academy and The Royal Society fellowship programme.

M. E. Haque has been a Member of Central Water Commission with wide professional experience in water resources planning, particularly in the areas of policy issues, hydrological analysis, and teaching & research in hydrology. His experience includes teaching at post graduate level at Department of Hydrology, University of Roorkee and research at National Institute of Hydrology, Roorkee. He also worked as Consultant with Asian Development Bank and National Water Development Agency.

Mukesh Kumar Sinha, presently Director of Central Water and Power Research Station, has varied experience in all aspects of water resources management and has been associated with planning, design and detailed engineering of several water resources & hydropower projects and river basin management. He was Member Secretary of Indian National Committee on Hydraulic Research and was one of the authors of the CBIP Publication on Repair, Renovation & Life Extension of Hydro Power Projects and the BMTPC Publication on Vulnerability Atlas of India.

Nitya Nand Rai is a graduate in Civil Engineering and Masters in Hydrology from IIT, Roorkee. He is Vice Chancellor Gold Medal of Avadh University. He has over 20 years of experience with Central Water Commission and is currently working as Director of Hydrology with focus of hydrological and hydrodynamic studies of Himalayan catchments. He has authored more than 26 technical papers in the field of hydrological and hydrodynamic studies, Environmental flow estimation at various journals, National and International Conferences.

Phanish Kumar Sinha is presently serving as a Participatory Irrigation Management Consultant with the World Bank. He graduated in Civil Engineering from Roorkee University and obtained post graduate degrees in Sociology and Business Management. He is a Fellow of Institution of Engineers (India) and Indian Water Resources Society and Member of Governing Council of Indian Network on Participatory Irrigation Management.

Rajendra Singh an Ayurvedic medicine graduate is also known as “waterman of India”. He was honoured by Asia’s most prestigious Ramon Magsaysay Award’ 2001, for Community Leadership for his pioneering work in water harvesting and water management. He won the Stockholm Water Prize, in 2015 and the prestigious ‘Jamnalal Bajaj Award’ in 2005. He is the Chairman of an NGO called ‘Tarun Bharat Sangh’ (TBS), which was founded in 1975, and heads a national network of organizations working on water issues. He is a member of the National Ganga River Basin Authority (NGRBA).

S. P Sinha Ray is a former Member of the Central Ground Water Board and has very extensive experience in ground water exploration, development and management. He got his Post Graduate degree in Applied Geology and PhD (Science) from Jadavpur University. Presently, he is working as Chairman Fluoride Task Force, West Bengal, Convenor, Core Committee on Water Quality, West Bengal, Member, Arsenic Task Force,

West Bengal, President Emeritus, Centre for Ground Water Studies and Visiting Faculty, School of Oceanographic Studies, Jadavpur University.

Sathishkumar S is working as Technical Officer (PHE) in Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India. A post-graduate in Environmental Management from Anna University, he is currently involved in providing technical assistance to the Ministry in urban water supply & sanitation sector and in various Policies, Programmes and Missions of the Ministry including the flagship Swachh Bharat Mission.

Sharad K. Jain is Scientist-G and Head (Water Resources Systems Division), NIH Roorkee. He has a PhD from Univ. of Roorkee and MTech from IIT Kanpur. Dr He has co-authored four books: a) *Water Resources Systems Planning and Management*, Elsevier, b) *Hydrology and Water Resources of India*, Springer, c) *Risk and Reliability Analysis*, American Society of Civil Engineers, and d) *Water Resources Systems*.

Sunita Narain is the Director General of the Centre for Science and Environment (CSE) and Editor of the fortnightly magazine, Down To Earth. In her years at the Centre, she has worked hard at analysing and studying the relationship between environment and development and at creating public consciousness about the need for sustainable development. She was awarded the Padma Shri in 2005 and received the World Water Prize for work on rainwater harvesting and for its policy influence in building paradigms for community based water management.

T.S. Mehra, a water management professional, is currently Commissioner, Ministry of Water Resources, River Development, and Ganga Rejuvenation.

Tushaar Shah an economist and public policy specialist, is a former director of the Institute of Rural Management at Anand in India. Over the past 35 years, Shah's main research interests have been

in water, land and livelihoods in South Asia, a subject on which he has published extensively. His notable contributions have been in comparative analyses of groundwater governance in South Asia, China and Mexico. More recently, his interests have lay in comparative analyses of water institutions and policies across Asia and between South Asia and Sub-Saharan Africa.

Vidyanand Ranade is former Secretary, Irrigation, Government of Maharashtra.

Vinod Tare is a Professor of Environmental Engineering and Management at the Indian Institute of Technology Kanpur and also holds Sir M Visvesaraya Chair Professor established by Ministry of Water Resources, River Development and Ganga Rejuvenation. He is the founding Chairman of the Centre for Ganga River Basin Management and Studies at IIT Kanpur.

V.K. Chaurasia is Joint Adviser(PHEE) & Adviser (I/C) of Central Public Health and Environmental Engineering Organization of M/o Urban Development, GOI. He is a post Graduate in Environmental Engineering from IIT Roorkee and has over 23 years of experience in public health engineering and is currently involved in implementation of Swachh Bharat Mission(Urban), AMRUT & Smart cities Programmes.

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- Shri T.S.Krishna Murthy
Former Chief Election Commissioner of India
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Chairman, Asian Institute of Transport Development
- Shri N. Vittal
Former Central Vigilance Commissioner
- Shri Shanti Narain
Former Member, Traffic Railway Board

Contributors

Avinash C. Tyagi * C.D Thatte * Chetan Pandit
D.T.V Raghu Rama Swamy * H. K. Varma * J.B. Ravinder
J.Chandrashekhhar Iyer * L. Elango * M. E. Haque
M.K. Sinha * N.N. Rai * Phanish Kumar Sinha * Rajendra Singh
S.P. Sinha Ray * Sathishkumar S * Sharad K. Jain
Sunita Narain * T.S. Mehra * Tushaar Shah
Vidyanand Ranade * Vinod Tare * V.K. Chaurasia

This Issue of the Journal has been sponsored by:



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IC CENTRE FOR GOVERNANCE

3, Palam Marg, 3rd Floor, Vasant Vihar, New Delhi-110057

Telefax: 91-11-26146236/40809939

E-mail: iccfg@yahoo.co.in • Website: www.iccfg.net