Water resources management in India – challenges and the way forward

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Management of water resources in India has been a challenge whose magnitude has risen manifolds over the past 50 years due to a variety of reasons, notably the rising demands and growing environmental degradation. Broadly, most of the challenges in water management in India can be categorized in the following groups: (a) water availability, variability and increasing withdrawals, (b) environment and quality, (c) project construction, (d) water sharing disputes, (e) water governance and institutions, and (f) challenges induced due to climate and land-use cover changes. Here we discuss each of these challenges in detail. It is suggested that conservation of water and management of variabilities should be a cornerstone of water resources management in India. This note also suggests remedies to address the challenges and covers new initiatives by the Government of India (GoI).

Keywords: Artificial recharge, biodiversity, climate change, water governance, water resources.

Water availability, variability and increasing withdrawals

All the rivers of India can be grouped into four classes: (i) Himalayan rivers, (ii) Deccan rivers, (iii) coastal rivers and (iv) rivers of the inland drainage basin[1]. Figure 1 shows the major rivers of India.

The Himalayan rivers receive contribution from rain, snow and glacier melt. The three main Himalayan river systems are the Indus, Ganga and Brahmaputra, which account for more than two-third of water in India. It is important to regulate the flow of the Himalayan rivers so as to conserve water as well as save society and infrastructure from flood damages. Note that the three Himalayan rivers are transboundary. These rivers or their major tributaries originate in India's neighbouring countries. After flowing through India, these rivers enter Pakistan or Bangladesh. Thus, India is a downstream country in some cases and an upstream country in some others. Major rivers in the Deccan group are the Mahanadi, the Godavari, the Krishna, the Narmada, the Tapi and the Cauvery. All these rivers are rain fed and carry much less sediment compared to the Himalayan rivers. Most peninsular rivers (except Narmada and Tapi) flow towards east and join the Bay of Bengal. Coastal rivers of India typically have small lengths and catchment areas. The rivers of West Coast have very high flow.

Annual precipitation in India has been estimated at about 4000 billion cubic metres (bcm) and the water resources potential is 1869 bcm. Due to topographical and other constraints, the utilizable water resource potential is 690 bcm of surface water and 447 bcm of groundwater, totalling to 1137 bcm. Per capita annual water availability in India was about 1544 cubic m in 2011, which has now further fallen due to rise in population. The Falkenmark Index is a commonly used measure of water scarcity[2] and a country with per capita annual renewable water below 1700 m^3 is said to be under water stress. Although this criterion is not directly applicable to India where lifestyle and water usage are very different compared to countries in Europe and Americas, falling per capita water availability implies tighter constraints in water management.

Three major issues concerning the variabilities in water resources in India are:

(i) India has large temporal variability in water availability, leading to, among other issues, disasters such as floods and droughts.
(ii) The regional mismatch between water availability and demands is high and the demands for various uses are increasing rapidly while the availability is nearly the same.
(iii) Withdrawal of water from surface and subsurface water bodies to meet growing demands is rising and becoming unsustainable.

Variability in water availability

India faces large temporal variability in water availability, leading to, among other issues, disasters such as

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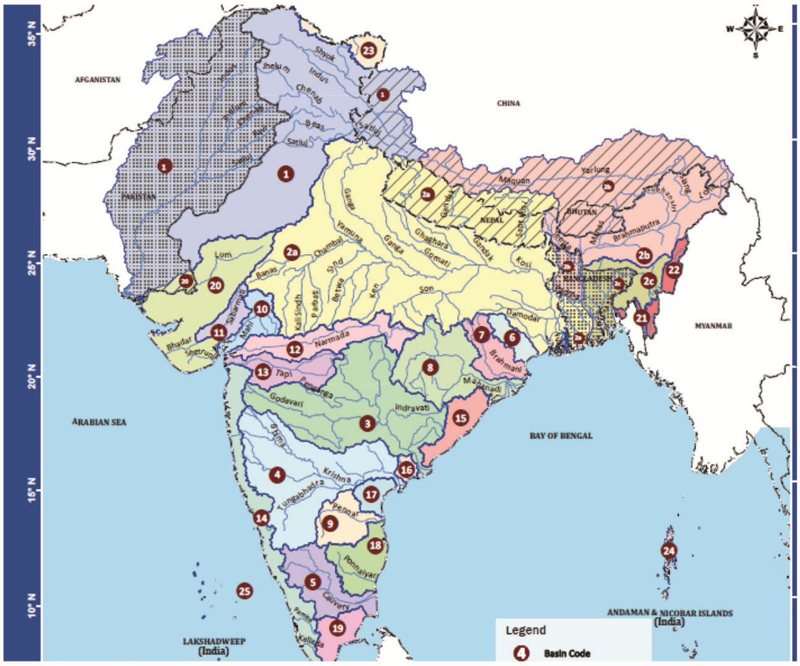

Figure 1. Important rivers of India (Source: CWC[11]).

floods and droughts. Due to monsoon climate in India, more than 70% of the annual precipitation takes place in a limited period of about four months. Consequently, this is the period when the rivers carry more than 70–75% of the annual flows, at times exceeding the capacity to safely pass this water. The remaining eight-month period accounts for the balance 25–30% of river flows and many rivers do not flow for some summer months. Groundwater levels also show somewhat similar rise and fall, with some delay. Large variability in water availability gives rise to a host of problems, including floods and droughts.

In addition to temporal variability, water availability in India also has huge variations with respect to location, resulting in surplus water in some river basins/regions and water scarcity in others, frequently at the same time. It will be better to address both types of variabilities together, since the tools are the same. Management of variabilities should be a cornerstone of water resources management in India. Jain[3] has outlined the key elements of sustainable water resource management in the country.

Increasing gap between water availability and demands

Population is the key determinant in water demand. As the population of India is increasing, lifestyles are changing and economic activities are increasing, the demand for water is also rapidly rising. Agriculture sector accounts for more than 85% of the annual water demand in the country. As there is no major trend in annual rainfall in India, the gap between demand and supply of water is increasing. In many regions, the demand is already much more than the supply, leading to water scarcity.

Unsustainable water withdrawals

To meet the increasing water demands, progressively larger quantities of water are being withdrawn from surface and subsurface water bodies. Increasing withdrawals have adversely affected the health of many rivers in different reaches and some rivers in different stretches have stopped flowing round the year. This is highly detrimental to the river as well as the environment.

Although groundwater use has provided the much needed drinking water and food security to India, due to unsustainable extraction at many places, water tables are falling resulting in wells going dry, rising pumping cost, falling base flows in the rivers, and entry of harmful substances (such as arsenic) in the water supply. A large number of districts in India have reported groundwater contamination of some form or the other. These include contamination due to fluoride, iron, salinity, arsenic, etc. Excessive withdrawal from groundwater also results in land subsidence, which may lead to a number of other harmful consequences. In the near future, India is likely to face a situation where water availability in an average year would be nearly the same or less than the demands. The situation will become really precarious in the years of below-normal monsoon.

Suggested remedies

While attempting to solve the water crisis, it is important to look at the water resources in totality (i.e. water resource = surface water + groundwater), rather than managing surface water and groundwater separately. Three distinct actions are required: reduce demands, conserve water and move water across geographies. First, all options should be exercised to check water demands in general, particularly in regions facing water scarcity. Demands from the agriculture sector account for more than 80% of the total demands in India and this sector provides the largest opportunity for water-saving. Estimates show that water use efficiencies in agriculture are very low in India; surface and groundwater use efficiencies hover around 40% and 50%. Clearly, there is a huge scope to improve these efficiencies. As the current irrigation water use in the country is about 550–600 bcm, about 20% rise in these efficiencies would yield enough water to substantially meet the demands from environment and municipal sectors. Savings of this order are possible by adopting sprinklers, drips and other water-saving measures. Farmers should be incentivized to save water by improving water use efficiency (per drop, more crop), particularly in the regions where water availability is low.

Conserving flood flows: As noted earlier, India has a monsoon climate and the rivers carry more than 70% of the annual flows during four monsoon months. Hence it is essential to conserve flood flows and use them to meet the demands in the lean season to a larger extent. In places with limited groundwater, management of river flows in accordance with crop water requirements is necessary to ensure food security for the nation, since the water and land productivity of rainfed agriculture is much lower compared with irrigated agriculture. Water can be stored on or below the surface. Actions are needed at various levels. At the macro level, it is important and essential to conserve surplus monsoon or flood flows, either in the storages on the ground or below ground, since the flows in the remaining months are inadequate to meet the various demands. To store water on the surface, storage reservoirs have to be developed. Good sites for storages are limited in the country and numerous problems arise due to the submergence of forests, displacement of population, threat to biodiversity, environmental issues, etc. To conserve water below the surface, suitable hydro-geology is a must and facilities for large-scale managed aquifer recharge (MAR) need to be created. Thus, it can be seen that both options have some merits as well as demerits. It will be unwise to outrightly reject any option. Keeping in view the problem and feasible options, an alternative option has to be implemented, clearly knowing that any solution will entail some costs and some adverse consequences. Further, no action is not a good decision either since left to themselves, problems rarely get solved. It is also essential that groundwater withdrawals are regulated particularly in the zones where annual withdrawals are more than the annual recharge to arrest monotonic decline of the water table.

To make plans for artificial recharge, it would be necessary to estimate the amount of water available for recharge and the recharge potential of aquifers. Currently, only macro-scale information on recharge potential of aquifers is available, whereas the recharge activities need to be planned at local levels. Hence, it is necessary to identify and obtain the aquifer data at local scale, and delineate recharge sites by collecting and analysing geological data. Also, there is a need to identify the desaturated aquifers and determine their water-holding capacity. Similarly, the amount of water that can be utilized for recharge needs to be estimated at local levels. Properly calibrated hydrologic models can give such estimates.

Rough estimates show that the volume of flood flows in Indian rivers could be about 500 bcm. A major part of this could be conserved through large, medium and small projects, and in subsurface zone through induced recharge. At present, the storage capacity in basins with large water potential such as the Ganga, Brahmaputra, Indus, Godavari, Mahanadi, etc. is quite low. It would help to conserve more water in these basins in the monsoon season and use it to meet the demands during the remaining water year. Conservation of flood waters will also help in partially mitigating two water-related disasters, namely floods and droughts. At the micro level, villagers and farmers may construct/rejuvenate village and farm ponds to store rainwater to satisfy farm water demands. Conservation of water at local levels by check dams can also help in meeting the local water demands. However, if a large number of such structures are created, availability of water in the downstream areas is significantly reduced. Therefore, planning for such interventions should be coordinated at the river basin-scale, so that the impacts of interventions at upstream locations are known and factored in the river basin plans.

Loss of reservoir storage due to deposition of sediments is a concern for India since it reduces the ability to regulate river flows. About 0.8–1% of the created storage of more than 300 bcm is lost every year due to sedimentation. Replacement of this space by construction of new projects is becoming progressively more difficult. Hence it is important to control the sediment inflows into the storages by treatment of catchment areas. Flushing out stored sediments using low-level outlets is another attractive proposition. For this purpose, spillway crests of several new projects are being kept at low levels. In the early stages of the wet season when high sediment inflows are expected, spillway gates can be raised to allow sediments to exit the reservoir without settling down. This arrangement helps in checking the loss of storage capacity due to siltation. Possibility of efficiently removing sediments deposited in existing reservoirs also needs to be explored.

Managing floods: To satisfactorily manage floods, a range of actions is required. High flows likely to cause damage may be temporarily stored in reservoirs and subsequently released at lower rates. A number of storage reservoirs have been created in India to control floods – Hirakud, Rihand, Tehri, and so on. Since the development of storage projects is becoming progressively difficult and these cannot provide complete flood protection, we also need to develop robust systems for flood forecasting and warning so that people, livestock, and movable assets can be relocated to safe locations before a flood strikes. Flood forecasting also helps in better regulation of reservoirs and efficient use of limited flood control space in them. Robust long-period flow forecasting will also help in better management of inflow variability.

To check flood damages, it is essential that floodplains of rivers are used wisely – residential and commercial buildings should not be built too close to a river. Besides carrying flood flows, floodplains also perform other useful functions. A part of flood flows recharges groundwater and rejuvenates riparian vegetation. Hence, no development should be planned such that it impairs the beneficial functions of floodplains. Recall that the main reason behind huge damages during the Uttarakhand floods of 2013 was that many structures had been built on the floodplains and were washed away by flood waters.

Since complete protection against floods is not possible, we need to make plans for flood management or flood governance. A combination of structural and non-structural measures needs to be implemented to create resilient systems and reduce vulnerabilities. To that end, flood management should not be the responsibility of a single department. A number of government agencies, including Water Resources Department, Transport Department, disaster management authorities, local administration, police and NGOs have to work in close coordination. It would also be necessary that mock drills are carried out before the flood season so that the different organizations are aware of their responsibilities and duties, and work as a team if and when a flood strikes. Coordinated use of various measures would ensure resilient and sustainable flood governance. Riparian population needs to be involved in such measures as active partners, rather than passive onlookers.

Rationalizing cropping patterns: Analysis of data shows that in the past five or six decades, cropping patterns across the country have dramatically changed. Sugarcane which requires a large quantity of water is being cultivated at many regions of low rainfall where it was not grown earlier. Similarly, rice is also cultivated in many such places. Therefore, to control agriculture water demands, it is essential to review the cropping patterns, particularly at places where annual rainfall is below, say 600 mm, or annual pumping from groundwater exceeds recharge and yet high water-consuming crops such as sugarcane and paddy are being grown. However, a major change in cropping pattern will be difficult to implement. There are many reasons why farmers prefer sugarcane crop. It gives high returns, is easy to plant, does not require much care, and is relatively safe from diseases. Many farmers have some type of agreement with factories. So it is easy for them to sell the crop, although in many instances, payment does come easily. An option would be to replace high water-consuming crops by those that were grown traditionally in these places or by coarse grains and pulses. In drought-prone areas, drought-resistant crops must be preferred. Deficit irrigation is another option to manage scarcity. It can help save about 10–15% of the agricultural water demands without much reduction in crop yield. Crop pricing mechanism has also played a role in the shift in cropping pattern. Free supply of electricity to farmers is partly responsible for over-irrigation and wastage of water. It might be better to let the farmers pay for the energy consumed at normal rates and directly send subsidy to their bank accounts to partly cover related expenditure.

Long-distance water transfer: India also faces substantial spatial mismatch between demand and supply as the places where water is needed and those where it is available are frequently far apart. A viable and tested way to overcome spatial supply–demand mismatch is by transferring water from surplus regions to deficit regions by way of long-distance water transfer (or interlinking of rivers, as is popularly known in India). This requires construction of reservoirs to store surplus water and transfer links (canals or pipes) to move water. Interbasin water transfer involves both technical and non-technical problems. Costs of these schemes are rapidly rising and soon many such schemes may be difficult to justify in financial terms, even though there may not be any other alternative to provide adequate quantity of water at the desired reliability. Experiences with projects such as Ken–Betwa and others show that technical matters are comparatively easy to solve; difficulties lie in resolving water-sharing, political and funding issues. In addition to long-distance water transfer, short-distance water transfer may also to investigated since here the expenditure, gestation period and opposition will not be much less.

Recycle and reuse: At present, very little quantity of water supplied is recycled and a considerable amount of water is wasted in urban water supply networks due to leakages and thefts. Estimates show that about 40% of water from municipal supply for drinking purposes is lost due to leakage or theft in some cities. There is huge potential of water saving by reducing these leakages (replacing worn-out pipes, valves and other components), and by recycle and reuse of water in municipal and industrial sector. For instance, the Arab states produce more than 10 km^3/yr of wastewater. Of this, about 55% is treated and 15% is reused in farms and landscaping irrigation, environmental protection, and industrial cooling. By recycling a higher amount of water in India, it is possible to considerably reduce the shortage of drinking water in most cities. Poorly planned urbanization is also responsible for water woes in some cities. It is reported that large open areas near Chennai, which were aquifers recharging and flood absorbing areas till a few decades back, have been paved in recent times. This has markedly reduced their recharging capacity, resulting in declining water availability and increased flooding.

Any resource that is provided free is commonly wasted, water being no exception. Hence it is important to charge the users for the water supplied, covering the cost of providing services, with expenditure for maintenance of facilities and some amount for future expansion. All the water supplied should be metered. Clean water to meet the basic needs can be provided to the weaker sections at subsidized rates and the quantity consumed over and above the basic requirements (say, 50 litres per capita per day, or LPCD) should be charged at slab rates which increase with increasing consumption to discourage wastage.

Water resources development plans should be prepared for each river basin and these should clearly identify the projects (including their location, size, etc.) that will be constructed in each river basin. These plans should ensure that the cumulative impacts of all the projects are within acceptable range and the carrying capacity of a river basin is not exceeded[4].

Quality of water and environment

While good-quality water is a boon and helps in environmental and spiritual rejuvenation, poor-quality water is a curse. Due to dumping of untreated or partially treated wastes from municipal and industrial areas as well as return flow from agricultural areas, orchards and plantations carrying polluted water, water in many of our natural water bodies such as rivers, lakes and ponds is highly polluted. Estimates indicate that over 50% of urban India's sewage enters water bodies untreated. Dumping of industrial and other wastes in subsurface zone has resulted in contamination of the top 10–20 m of subsurface zone. Highly polluted water from hand pumps at many places is an evidence of this contamination. Some big and medium industries are doing appreciable service by carefully treating wastewater, but we also have industrial units which are injecting waste in aquifers to save sewage treatment costs. Needless to say, contaminated aquifers will be a curse for future generations.

Forty-five per cent of India's children are stunted and 6 lakh children under five die each year, largely because of inadequate water supply and poor sanitation[5]. According to a WHO study, in 2002, unsafe water and poor sanitation contributed 7.5% of total deaths and 9.4% of total disability-adjusted life years in India[6]. About 73 million working days are lost in India due to water-borne diseases each year. Many or almost all of these deaths can be prevented by providing clean drinking water to children and adequate sanitation.

In terms of water quality index, India ranks near the bottom. Adequate sewage treatment capacity is to be created and made operational to treat the sewage generated. Strict monitoring and punitive actions are needed to restore water quality of natural bodies.

Every new water resources development (WRD) project should be environment-friendly and existing projects should be retrofitted to also make them environment-friendly. To ensure that the rivers remain in a healthy condition and continue to provide ecosystem services, location-specific assessment of environmental flows needs to be carried out and implemented.

Environment impacts

One of the reasons why WRD projects face opposition is the perception that such projects harm the environment. Adverse environmental impacts of WRD projects include submergence of lands, forests and residential areas, fragmentation of rivers, barriers to the movement of fishes and other aquatic life, etc. While constructing some projects in the past, large populations were moved from their places of living and there are claims that some of the displaced people did not get due compensation even after a long wait.

Two important developments have taken place in India in this context. GoI enacted the Environment Impact Assessment Notification 2006. It laid down a robust procedure for assessment of environmental impacts of WRD projects and creating a management plan to mitigate them. To provide fair compensation to the project-affected population, Indian Parliament passed The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. This Act has provisions to provide fair compensation to those people whose lands have been acquired to construct a project. Due to liberal provisions of this Act, now the opposition to WRD projects is much less. A critical issue that remains to be addressed concerns development works in an area where a project is proposed. If an area is identified to fall in the submergence zone of a project, no development work is taken up. In many cases, the time between this identification and actual construction could be 2–3 decades, and local population is deprived of any development in this long period. There are instances where people who were supporters of a project turned into opponents due to this reason. Clearly, decision making process for WRD projects needs to be expedited.

Long gestation periods in planning and construction of WRD projects

The planning for WRD project typically begins with the preparation of a feasibility report. If this report is accepted, a detailed project report (DPR) is prepared and then a number of approvals such as technical clearance, forest clearance, environment clearance, investment clearance, interstate clearance, etc. are sought. At times, all these approvals take considerable time which may extend to several years. There are instances when a project was dropped after spending considerable time and effort in preparing the DPR and seeking clearances. There is nothing wrong in dropping a bad project, except that if such a decision is taken after spending substantial resources, all the resources (which may be quite high) go waste. In too many cases, by the time a project gets mandatory approvals and construction begins, its cost may already have increased manifold.

For obvious reasons, the entire process needs to be made more efficient. To that end, in the first step, a detailed feasibility report for a project may be prepared and carefully examined by a group representing key ministries and regulators. This group must have the authority to decide whether to continue with the project or not. Provisions must be made to see that all objections/concerns regarding the project and its impacts are addressed at this stage itself. If the decision is to continue with the project, in the second step, the objective should be to implement the project in the best possible way, and within the estimated time and budget. A design and implementation group should decide the best design and other parameters of the project and also look after the construction. Arrangements should be put in place to ensure that no project work is halted due to agitations, court cases, etc. at this stage.

Dispute resolution and decision-making mechanisms

Inter-state water-sharing disputes pose a hindrance in water resources utilization in the country. Besides loss of precious resource, these also result in delays, cost overruns, and law and order problems.

To avoid disputes related with inter-state issues, it would be helpful if all major rivers are gauged at the state borders so that all stakeholders know exactly how much water is entering into a given state. At present, we do not have a complete picture of water utilization at different places. Thus, it is difficult to identify places where water is being wasted and where savings are possible. Hence it would be helpful if water use is measured so that its wastage is checked.

In order to create awareness among people and sensitize them to use water wisely, we need to launch a new mission similar to Swachha Bharat Abhiyan, with the same or higher vigour and involving all sections of society. Students need to be educated for conservation of water and keeping our water bodies clean; overexploitation of rivers should be stopped and adequate water should be allocated for river and environment rejuvenation.

Based on the experiences, there is near consensus that we need to evolve a national framework law as an umbrella statement. The basic premise is that water is a scarce resource which is also essential to sustain life and ecology. This law should encourage inter-state coordination for optimum development of water resources of the country, while realizing that a river basin is the best unit for water resources planning and management. Further, currently use of groundwater is haphazard and the users withdraw water from the aquifers according to their wish, without bothering about the adverse consequences to themselves and others. Although efforts are being made to regulate groundwater exploitation, much more needs to be done for sustainable use of groundwater resources. We also need to introduce the best practices being followed in other parts of the world by involving academicians, researchers and NGOs in various activities.

A matter of concern is that a large number of groundwater assessment units fall in the dark category, which means that the withdrawal is more than the recharge and the number of such blocks is increasing with time. This needs to be addressed by regulating withdrawals, checking water use and encouraging artificial recharge, particularly in dark blocks. To control unsustainable groundwater exploitation, all electro-mechanical extraction means need to be registered and monitored. Information pertaining to geology, hydrology and climate could be used to issue permits to withdraw defined quantities from groundwater. A decentralized framework for groundwater governance, which is based on sound scientific understanding, engagement of stakeholders of the resource and congruent regulatory instruments, is clearly required for addressing India's groundwater problem.

Water governance and institutions

Keeping in view the magnitude, range and extent of water-related problems in the country, the institutions involved in WRD and management in India require significant transformation. The main reason is that practice of water management has undergone large changes over the past four decades or so, and the profession is gradually becoming more multidisciplinary. Besides having knowledge of hydrological principles, water professionals need to know about the environment, forestry, agriculture, geology, meteorology, soil science, sociology, economics, law, management and so on. It would be necessary to transform the existing organizations by inducting persons from key relevant backgrounds and some tasks may be accomplished by outsourcing.

For WRD, GoI has to play multiple key roles as a developer, evaluator and regulator, and this requires strengthening of institutions involved in the development and management of water. Many multidisciplinary teams will be needed that can provide expert technical support on divergent issues. A strong monitoring mechanism has to be developed by involving experts from the government sector, academic and R&D institutions and non-governmental organizations as well as individuals. A comprehensive review of water governance challenges in India has been provided by Singh[7].

At present, water is dealt with by a number of ministries. This frequently results in delay in decision-making, inter-sectoral conflicts and problems in governance. To avoid such situations, it would be helpful to develop a unified framework for decision making wherein all the key sectors are represented. In the Indian context, the key sectors are agriculture, drinking water, hydro power, environment, floods and climate change. There can be an apex body for national level planning and decision making. At the next level, committees may be constituted for management of river basins with representatives from these key sectors from co-basin states.

A beginning has been made in this direction. Recently, the Ministry of Jal Shakti was formed by merging the Ministry of Water Resources, River Development and Ganga Rejuvenation with the Ministry of Drinking Water and Sanitation, GoI. Further, a draft 'River Basin Management Bill' has been prepared which aims at creation of river basin management boards. This Bill needs approval of parliament before it comes into practice. It is hoped that the Bill would be approved soon and the creation of river basin authorities according to its provisions would help overcome many roadblocks in scientific management of Indian river basins. Another positive initiative for WRD is the proposal to establish a single tribunal to adjudicate interstate river water sharing disputes. Note that in the present dispensation, such disputes may take decades to resolve.

In the mid 1990s, GoI had constituted a National Commission for Integrated Water Resources Development and Management. The Commission had completed a comprehensive review and analysis of the water sector and submitted its report[8], which had many useful suggestions on how to address problems in WRD and management. In the intervening period of about 25 years, there has been a sea change in the ground situation with respect to the water sector in India. It is now time that a similar Commission is appointed for another review and to suggest the way forward at the national level.

Currently, no R&D institution or think-tank in the water sector has a multidisciplinary team and infrastructure to take up challenging tasks such as development and implementation of integrated water resources management plan for a large basin, say, for example, the Krishna basin. The reasons behind this should be brain stormed and remedial steps may be taken up so that the country has several such teams which can help in technically sound integrated WRD and management in India.

Despite a number of challenges as well as opportunities to work in the water sector in India, the best students rarely think of joining this sector. It would be necessary and useful to attract talent to the water sector by providing service conditions and incentives which are at par with the other sectors. Mujumdar and Tiwari[9] cover the status of science and technology vis-à-vis water management in India.

Climate change

India is highly vulnerable to impacts of climate change on water resources due to its unique climate, geography and topography. Warming of the lower atmosphere will impact snowfall. glaciers and snow cover, and crop water requirements; increase in extreme weather will impact incidence of floods and droughts; rising sea levels will increase flooding in coastal areas and seawater intrusion; rising temperatures will impact the quality of water in rivers and lakes, and so on. Remedies suggested here will be helpful in lessening the vulnerabilities due to climate change and increase resilience of the society. In addition, more focused R&D is needed to identify what changes are expected, and where and how to initiate specific adaptations.

Concluding remarks

This paper has presented a broad view of the key challenges in water resources management in India and suggest measures to resolve them. These challenges arise due to a range of causes – technical, socio-political and financial. Political will to urgently and firmly address the issues is necessary to find and implement the solutions.

An encouraging signal is the commitment/plan of GoI to provide water security to the entire population by 2022–23 by way of adequate availability of water for living, agriculture, economic development, ecology and environment[10]. The goals set include: providing piped drinking water to every rural household by 2024; provide irrigation to all farms and improve water-use efficiency or produce more crop per drop; encourage industries to utilize recycled/treated water and ensure zero discharge of untreated effluents from industrial units; ensure uninterrupted and clean flow in the Ganga and other rivers and their tributaries; create additional water storage capacity to ensure full utilization of the utilizable surface water resources potential of 690 bcm, ensure long-term sustainability of finite groundwater resources, and ensure proper operation and maintenance of water infrastructure with active participation of farmers/consumers. Work has restarted on many WRD projects that were stalled for a long time due to different reasons. Sanitation drive initiated by the government will also benefit the water sector immensely in future. River rejuvenation efforts are beginning to show some results. Attainment of identified goals is possible by developing and adopting appropriate technologies in the water sector and with greater involvement of public in WRD and management.

Disclaimer: The views expressed here are those of the author and not necessarily of the institution to which he belongs.

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