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Water Governance: Challenges and Prospects

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Foreword by Dr. M. S. Swaminathan

The Indian subcontinent faces particularly severe water crises. While India's population is expected to cross 1.6 billion by 2050, the annual per capita freshwater availability in the country is expected to drop down to 1,200 cubic metres. In addition, the spatial and temporal variations in precipitation are likely to be accentuated significantly by climate change. As a result, many parts of the country are likely to be severely water stressed.

It has to be recognized, however, that the availability of water along with fertilizers and improved seeds has helped the country achieve **food self-reliance**; the production of food grains has gone up from around 50 mmt at the time of independence to about 275.7 mmt today. In 2012–2013, India exported food grains worth US $41billion vis-à-vis imports of US $20 billion. However, the *food security has come at the cost of water insecurity*. The water crisis is going to be further exacerbated by the growing demand for food grains; it is projected to be 450 mmt by the year 2050. At the same time, the availability of water for agriculture is likely to go down further (proportionally) as a result of increased usage of water by the industry and domestic consumers. Much would, therefore, depend on Improving Water Resources Management for agriculture.

Today, more than 60 percent of India's irrigation needs and 85 percent of its rural domestic water supplies come from groundwater. Although this ubiquitous practice has been remarkably successful in helping people to cope with seasonal water shortages in the past, it has led to rapidly declining water tables. In about 16 percent of the blocks, groundwater resources are overexploited. Dramatic regional aquifer depletion is observed, particularly in the northern regions such as Punjab, Haryana and Western UP, where the Green Revolution took root and much of the national grain production comes from.

The scarcity of water, which is being experienced in many parts of the country, is paving the way for interstate conflicts over sharing of this precious resource. This in turn is posing an enormous challenge to India's economic development in the coming decades. This requires urgent efforts at planning and implementing water infrastructure development plans and policies for conservation to avert a crisis in the coming years.

There is a dichotomy today in water resources distribution and economic development. Areas facing human migration (e.g. Bihar) are blessed with plentiful water resources but lack access to irrigation, while the recipients of migration, the states in the north-west have current access to irrigation, but depleting groundwater stocks. Land, water and labour resources, therefore, need to be considered in an integrated manner at the national as well as at the local level to assess strategies for economic development. Water constraints have to be identified and an infrastructure development and management pathway developed that is sustainable and appropriate for each region.

Water pollution is another major concern threatening health and economic productivity of people and ecosystem. Presently, municipal wastewater is responsible for approximately 80 percent of total surface water pollution in India as only about 10 percent of industrial and municipal wastewater is treated. Apart from seeping into the groundwater, the untreated waste is discharged into water bodies. A large swath of the country's groundwater is affected by geogenic contamination, which many researchers argue is triggered by overexploitation. Driven by ungainful employment in agriculture sector, unplanned cities are largely responsible for deteriorating water bodies all around. Together with lean season flow depletion, the resulting water pollution has the potential for disease epidemics and irreversible ecological loss resulting in collapse of the ecosystem as is evident from the disappearance of dolphins from Ganges, for example.

We have to be less dependent on the monsoons, and the focus should be on water use efficiency and agronomic advancements. Community participation could greatly facilitate this process. There are success stories available from different parts, and we must learn and replicate them after enriching with proper science and technological inputs. Unless this issue is addressed, it is likely to be the most significant source of risk for India's sustained economic growth and development.

Development efforts in various sectors without factoring water sensitivities, as being practiced at present is no more a viable option for the enhancing happiness, welfare and well-being of people. Actions to refine water management by improving water system reliability and resilience are needed. Governance of such a vital constituent of life on earth and its security needs to be objective, inclusive and transparent. While promoting economical and efficient use of water and preserving equity of use in support of overall development, particularly for enhancing rural livelihoods, greater awareness building of development managers in various fields is needed. There is a need to engender the capacity of different actors in this complex endeavour for overall sustainable development through continuously informed and active engagement of all the stakeholders as follows: the governments and administrative institutions, the development managers, the academia and research, the civil society and the individual users of water.

I am happy to see this book addressing some of these key issues through a wide array of articles contributed by the domain experts. The enriching articles range from surface and groundwater resource assessment and mapping, water quality, flood mitigation, involvement of civil society and community participation, rejuvenating the depleted aquifers, governance and financial issues of water sector and some well-laid-out thoughts on reforming the water sector, which is long due. I am sure the book will serve its intended purpose of generating informed debate while taking decisions in various sectors of development that are influenced by water and its timely availability in desired quantity and quality.

Our gratitude goes to Dr. Amarjit Singh for taking the trouble to compile such an informative book on water governance. I hope the book will be widely read and used.

Founder Chairman of M. S.
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Dr. M. S. Swaminathan

Foreword by Amitabh Kant

India is suffering from the worst water crisis in its history, and millions of lives and livelihoods are under threat. Currently, 600 million Indians face high to extreme water stress, and about two lakh people die every year due to inadequate access to safe water. The crisis is going to get worse by 2030 when India's water demand is projected to be twice the available supply (as per the McKenzie analysis). Therefore, how we manage our water, at the local, state and national levels, would determine India's ability to achieve rapid economic growth. It would determine whether we are able to improve the quality of life of our people in a sustainable manner.

The Sustainable Development Agenda 2030 adopted by the global community lays down a framework for the peace and prosperity on earth. Among the 17 goals adopted to monitor the progress of the Agenda, all the goals, except a couple, are intricately related to Goal 6 "Ensure availability and sustainable management of water and sanitation for all". Accordingly, all major development schemes such as Pradhan Mantri Krishi Sinchai Yojana (PMKSY) Swachh Bharat Abhiyan, Har Khet Ko Pani, Mahatma Gandhi National Rural Employment Guarantee Scheme, Pradhan Mantri Awas Yojana or Smart Cities focus on the efficient management of water resources.

Availability of both surface and groundwater in the country varies from one region to another. In view of limitations on availability of water resources and rising demand for water, sustainable management of water resources has acquired critical importance, for our country to move on a path of equitable development to ensure well-being and happiness of all its citizens. Despite large investments in the water management and a series of reforms undertaken in the water sector over the years, the situation is far from satisfactory. One of the shortcomings has been the lack of monitoring and assessment of impacts of development initiatives and reforms undertaken.

NITI Aayog has developed a Composite Water Management Index as a useful tool to assess and further enhance the effectiveness of management of water resources. The index serves as a useful tool to track performance in the water sector and take corrective measures. It provides useful information for the states and also for the concerned central ministries/departments enabling them to formulate and implement suitable strategies for better management of water resources. The Index has a set of 28 Key Performance Indicators (KPIs) covering irrigation status, drinking water and other water-related sectors. Critical areas such as source augmentation, major and medium irrigation, watershed development, participatory irrigation practices, sustainable on-farm water use practices, rural drinking water, urban water supply and sanitation and policy and governance have been accorded high priority.

Just like the water resources development process, reporting and monitoring of the index, however, is a multi-department and multidisciplinary task. It requires an understanding of water issues by the development workers who are not specialists in water sector, on the one hand, and the larger users and public, on the other. I am, therefore, delighted that this book, ***Water Governance – Challenges and Prospects***, edited by the former union secretary, Water Resources, Dr. Amarjit Singh and his colleagues, Dr. Dipankar Saha (former member of CGWB) and Sh A. C. Tyagi, ex-secretary general, International Commission on Irrigation and Drainage, is bringing out various facets of water management. The experts from various disciplines have lucidly brought out the challenges and prospects in the sustainable management of water resources. I am sure this will serve as a useful reference book for all those engaged in the efficient management of water resources for sustainable development of our country.

Water, if not managed properly, has the potential to change governments. There is a need to link good governance with good politics so that water becomes the top government priority.

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Amitabh Kant

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Emerging Issues in Water Resources Management: Challenges and Prospects

Amarjit Singh, Dipankar Saha, and Avinash C. Tyagi

1 Introduction

Water resources management impacts almost all facets of the economy. Water is also the primary medium through which climate change influences the earth's ecosystem and therefore people. Water stress is already critical, particularly in most of the developing countries, and improved management is essential for sustainable management of this resource. Recognition of the centrality of water in the development process has not yet permeated the political and policy echelons in most of the countries of the world and India too it is not reflected adequately in national plans. To shape our water future – there should be a coherent approach involving science and technology, policy initiatives and community participation.

In 1961, when India was on the brink of mass famine, Dr. M. S. Swaminathan led the country to usher in the *Green Revolution* by making available water, chemicals (fertilizers and pesticides, etc.), and high-yielding variety seeds to the farmers that helped the country achieve food self-sufficiency. The production of food grains which was around 50 MMT at the time of independence has gone up to about 252 MMT in 2014–2015 (Ministry of Agriculture, 2017, 1). In 2012–2013 India exported food grains worth US $41 billion against imports worth US $20 billion, reflecting food security at national level.

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However, this hard-earned food security has been achieved by compromising with water insecurity which is evident from the growing water crises being experienced in from community to sub-city to big city and basin level. Clashes between communities on account of sharing of this precious natural resource are no more exceptions. Further, majority of water bodies such as ponds, lakes, reservoirs, rivers, as well as aquifers are getting polluted. The present water crises are going to be further exacerbated by the growing demand for food grains, which is projected to be 450 MMT by the year 2050. At the same time, the availability of water for agriculture is likely to go down further (proportionally) as a result of increased usage of water by the industry and domestic consumers.

Growing complexity of water management in India as well as in most of the countries due to its limited availability, demographic and lifestyle changes, competing demands from different users and societal sectors and across administrative boundaries, and potential climate change poses increasingly intricate challenges for sustainable exploitation and management of this resource. Inter- and intrastate water disputes due to emotional, motivated, and biased approach, rather than the science-based discourse, are making cooperation and collaboration among basin states, the stakeholders, and sectors increasingly difficult. Ambitious societal development goals such as doubling the net income of farmers in the next 5 years, eradicating open defecation by building more toilets, scientific management of municipal solid waste, wastewater and industrial pollution management for cleaner water bodies, and building of smart cities have raised the bar for water management further.

This book, with contributions from renowned experts from various disciplines and on various facets of water management – with experience at the state, central, and global levels – attempts to present holistic perspective on how to use water as the key sustainable development tool. The articles in this book cover various perspectives such as water resources development, groundwater mapping and management, public-private participation in the sector, hydropower development, drinking and wastewater management, flood and environmental management, community management of water, civil society in water sector, its governance and financial issues, and need for research and development inputs. The articles identify good practices to assist different levels of governance 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 interaction between science, polity, and society and harnessing the power of the people. With a view to improve water governance, various gaps such as policy gaps, institutional gaps, financial gaps, information gaps, accountability gaps that exist, and the capacity gaps that impact the water governance in the country have been identified and discussed.

2 Water Resources and Its Information Flow in India

India with 17.5% of the world's population has only 2.4% of the world's land resources and roughly 4% of the world's freshwater resources (India-WRIS 2012). Most of the rainfall in India, ~76% of it, occurs as a result of the southwest monsoon between the months of June and September, except in the state of Tamil Nadu, which falls under the influence of northeast monsoon and receives rainfall during October and November. The precipitation is highly variable both in time and space. More than 50% of precipitation takes place in about 15 days and less than 100 h altogether in a year.

Water resources management is essentially the management of a variety of risks. They include risks related to floods and droughts, risks related to health, as well as economic and financial risks. One of the most important inputs in water resources management, therefore, is the knowledge of the factors that influence the risks to water resource systems, in terms of both their current dynamics and future evolution. Hydrological data and forecasts are essential for the assessment of these risks and evolving suitable strategies to manage them ensuring the safety of people. Hydro-meteorological data and information enable people to think together in solving the various water-related problems. They help building trust essential for cooperative efforts and in avoiding interstate conflict. Success of policy-making, planning, development, and management of resources depends on timely dissemination of accurate water-related data and information to all stakeholders.

If the water resources are to be managed, distributed, and used equitably and efficiently, all the stakeholders need to share water resources data and information. Unfortunately, in India the collection, management, reporting, and quality of water and environmental data are often poor and incomplete. They are not easily accessible for a variety of reasons including security concerns. Even when the data does exist, it is not made available in public domain in an easily retrievable format. As a result more often than not, debates on water issues, even among government departments and among states, are bereft of scientific and data and information and are largely governed by perceptions, emotions, and myths.

Water information and data in India is collected by many different agencies both at central and state level. Indian Meteorological Department (IMD), Central Water Commission (CWC), Central Ground Water Board (CGWB), Central Pollution Control Board (CPCB), State Pollution Control Board (SPCB), etc. are some of the main agencies engaged in the process. Besides huge data is generated by activities of several departments in central and state governments like Ministry of Drinking Water and Sanitation (MOWS), Ministry of Rural Development (MORD), state water resources/irrigation departments, and state Public Health Engineering Departments (PHED). At the same time, each of the states has its own statistical agencies or departments that collect basic hydrological information including water use information. CWC and CGWB have contributed substantially in collection of hydrological data all over the country. Despite well-laid out standards by Bureau of Indian Standards and World Meteorological Organization (WMO), the collection, processing, and storage of data and information in the states lack quality, uniformity, and accessibility. Country lacks a structured quality management framework to enforce laid down standards and practices and ensure the authenticity of data being collected by multifarious agencies.

CWC and Indian Space Research Organisation (ISRO), since January 2009, are jointly executing the project "Generation of database and implementation of Web-enabled water resources information system of India" – India-WRIS – to provide water resources and related data, and information in a standardized GIS format to all concerned departments, organizations, and stakeholders provide "single-window" solution to the water-related issues. The system lacks authentic water use data, which many state departments fail to update in a timely manner. A lot more needs to be done to make the WRIS system transparent and operational for creating awareness about water issues, water budgeting, and accounting at various levels and enabling informed public debates.

With a view to improve the density of water observation stations, quality of data collection reliability, and accessibility and processing and to enable users to derive useful products, central government has been implementing the National Hydrology Project (NHP) with the objective to strengthen the capacity of water resources management institutions in the country (World Bank 2004). Despite 20 years of efforts under the project, the objectives of making data easily accessible to all the users is far from satisfactory. The NHP, now in its third phase, needs to be made a priority project with certain urgency and political commitment.

3 Water Resources Assessment

A reliable and scientific assessment of water resources availability is a prerequisite for proper planning, design, and operation of water resources projects catering to competing demands like irrigation, drought and flood management, domestic and industrial water supply, generation of electrical energy, fisheries, navigation, and other environmental issues. After initial empirical approaches to water resources availability assessment in the 1940s by Dr. A. N Khosla, the first statistical assessment of water resources potential in the country was made by CWC at 1869 billion cubic meters (BCM) in 1993 (Central Water Commission 1993) and was later reviewed and confirmed by "*National Commission for Integrated Water Resources Development*" in 1999. Till recently, the assessment of water availability has been based on this statistical approach.

Greater water usage in India for an increasing population, intensive irrigation, urbanization, and industrialization has resulted in the annual per capita water availability slipping from 5000 m^3 in 1950 to 1200 m^3, a water-stressed condition. Simultaneously, there are huge variations in the per capita water availability in different parts of the country. While the annual per capita water availability in the northeastern parts of the country is still around 5000 m^3, it is less than 300 m^3 in the South! Some of the sub-basins in India are already water scarce (Falkenmark et al. 1989).

3.1 Surface Water Resources

R. N. Sankhua and *V. V. Rao* in their article on *Water Resources Assessment of Basins of India Using Space Inputs* present a new approach using hydrological modeling and aggregation of meteorological data based on water budgeting exercise.

They assess the average annual water resource of the basins for the 30-year period (1985–2015), as 1914 BCM. Deterministic approaches to water resources assessment help create realistic scenarios. As the future is uncertain, discussing various possible futures with stakeholders creates more awareness of what to do in case of undesirable developments taking place.

In addition to the diminishing per capita water availability, there are huge temporal variations as most of the rain falls over a limited period of 2–3 months. In order to mitigate the risk of long dry spells and to meet the constant demand for water from domestic, industrial, and agriculture sector throughout the year, the monsoon flows need to be stored. The capacity for storage of surface runoff in the country is a lowly 300 BCM being low, large quantities of floodwater drains into the sea.

The new methodology, based on the conceptual model, will facilitate in generating various future scenarios of water availability as a likely consequence of climate change and assess the impact of various development scenarios such as future demands on water management. It would help in a scientific understanding of continuously growing demands and increasing stress on freshwater due to overabstraction, pollution, and climate change. It would provide better opportunities for improved water management, which are crucial for addressing the water insecurity and is likely to make hydrological dialogue among the basin states more scientific.

3.2 Groundwater Assessment

Aquifers serve as natural storages for precipitation that infiltrates into the ground. This groundwater plays a significant role in meeting the water demand for various purposes, particularly for its ubiquitous presence. In India, it contributes to 85% of rural drinking water needs, 50% urban water needs, and nearly 60% irrigation needs.

Assessment of groundwater that could potentially be withdrawn every year without touching the static or in storage resource is essential for its sustainable use. First such assessment was made in 1997 based on the "guidelines for assessment of groundwater," laid down by Groundwater Estimation Committee (GEC) in 1984 based on groundwater level fluctuation method. The methodology was later improved in 1997 to be based on water balance approach. CGWB, along with the states groundwater agencies, assesses the dynamic groundwater resources of the country periodically (2004, 2009, 2011, and 2013).

Groundwater development in the country is highly uneven (Saha et al. 2017). Out of the 6607 assessment units, 1071 units in the country with stage of development (SOD) of more than 100% are categorized as "overexploited." Another 217 assessment units, with SOD between 90 and 100%, are categorized as "critical." However this lump-sum data fails to enumerate the wide spatial and vertical variation in availability of water resources and aquifer complexities. The National Aquifer Mapping and Management Program (NAQUIM) launched in the year 2012 for scientific management of groundwater resources has been taken up for the entire country through intense hydrogeological investigations and data acquisition.

The article on *National Aquifer Mapping and Management Plan – A Step Toward Water Security in India*, *by Dipankar Saha*, *Sanjay Marwaha*, and *S. N. Dwivedi* discusses the key aspects of the NAQUIM. According to the authors, protection, preservation, and augmentation strategy for groundwater resources occurring in the aquifers under different hydrogeological environment call for an in-depth understanding of the groundwater system. A rigorous data collection, collation, and new data generation and its interpretation have been taken up for 2.9 million km^2 mappable area of the country. The two important aspects to the success of this program are (i) scientific part, which depends on the accuracy of the data proper understanding of the aquifers, groundwater resource availability, its regime dynamism and chemical quality, and its meticulous compilation to prepare the aquifer maps and management plans, and (ii) the implementation part, which depends on the involvement of the states and various stakeholders including the communities. The assessment unit would be largely aquifer based, with separate assessment to be undertaken for phreatic and confined aquifers making use of GIS.

The program provides scientific inputs for community-based management of groundwater to empower the communities for community-based management of aquifers through demystification of science. The strategy of demand management and supply augmentation, or a combination of both, with varying weightage will have different results under different hydrogeological conditions and the prevailing stress levels in the aquifers. Therefore, the outputs of the NAQUIM are unique and indispensable.

4 Quality of Water

A minimum good quality water flow should be ensured in all water bodies at all times as required for sustaining life and livelihoods dependent thereon. Freshwater ecosystems, such as river networks, lakes, wetlands, and groundwater, and their functions are closely intertwined with the characteristics of the watershed or catchment of which, they are a part. They literally act as the “sinks” into which landscapes drain, influenced by various hydrological and terrestrial processes, including waste generated through human uses.

Allocation of water for various purposes, including conserving the environment, preventing groundwater quality deterioration and seawater intrusion in coastal areas, supporting livelihood based on aquatic life and other uses of water, recreation, and cultural activities like bathing and festivities, should factor the needs for maintaining water quality in water bodies.

Unfortunately, even the monitoring of river water quality is disjointed and far from minimal. CPCB and CWC monitor water quality of rivers in India on a very limited scale at intermittent intervals varying from weekly to quarterly and with different objectives. The methodology adopted for collection of samples, the range and quality of testing, and management of resulting data and information are vastly disparate and do not always follow internationally acceptable standards (WMO 2013). CGWB is monitoring about 14,000 wells pan India once in a year, besides issue-specific analyses of groundwater samples as and when required. The Drinking Water and Sanitation Ministry under the Government of India is analyzing huge number of groundwater samples for specific contaminants like arsenic, iron, fluoride nitrate, salinity, etc. through PHED in states.

Freshwater ecosystems have specific requirements in terms of quantity, quality, and seasonality of their water supplies. Many of the lakes are in urban areas and face more threats of pollution and encroachment. The Ministry of Environment, Forests and Climate Change (MoEF&CC) developed a separate program called the National Wetland Conservation Program in 1983 and subsequently a National Lake Conservation Plan to conserve the urban lakes. However, according to the comptroller and auditor general's (CAG) report 2011, even an inventory of the lakes has not been initiated. Cataloguing, mapping, and earmarking of the water bodies on the ground and in the city maps, along with the channels feeding the water bodies, are the first initial step that needs to be undertaken to prevent further deterioration and extinction of water bodies. This information along with the legal framework for the protection of the water bodies need to be shared with key stakeholders and ownership of the water bodies, and the responsibility of the concerned administrative authorities needs to be clearly defined.

The issue of contamination of our water bodies has been highlighted by *Vinod Tare* in the article on *Managing and Sanctifying our Water Bodies*. He reiterates the key recommendations of the Ganga River Basin Management Plan-2015 that the "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. According to him, there is an urgent need for a concerted effort to salvage our threatened and rapidly degrading water bodies. He advocates decentralized action not only for greater synergy but also to ensure traditional and hands-on knowledge, and insights of many people can complement the compartmentalized actions of formal institutions and programs.

A large part of the country is affected by groundwater contamination, and many of them are already posing serious threat to public health (Saha et al. 2016). *S. P. Sinha Ray* and *L. Elango* deal the issue of groundwater contamination due to geogenic and anthropogenic sources in their article on *Deterioration of Groundwater Quality: Implications and Management*. Their article is based on the review of the contamination from geogenic sources like fluoride, arsenic, iron, nitrate, uranium, other trace elements, etc. in the groundwater system of India. It tries to raise awareness stakeholders and policy-makers and highlights the groundwater quality issues, its health impact, and its possible mitigation measures to enable sustainable management of groundwater resources.

Country needs a comprehensive approach to water quality monitoring and assessment (WMO 2013) covering various perspectives such as uses to which water is put; control and regulation of water quality in time and space; capacity of water bodies to assimilate pollutants; influence of human activities or natural processes on water quality; trends in water quality and the influences of policies on it; insight into future trends; and influence of water quality on other parts of the environment, such as marine coastal waters, soils, biota, wetlands, etc.

5 Legal Provisions

India is a republic with states having considerable autonomy. As most of the river basins in India encompass areas from more than one state despite water being in the State List under the Indian constitution, the union government has to play an important role as water management issues are best tackled by considering the river basin as a unit of management. Decision-making processes on interstate river issues are guided by the hydro-geographic context (upstream-downstream relationships), the existence/absence of central authority, inter- and intraorganizational, the socioeconomic characteristics, power balance, institutional and cultural differences, etc. (Clevering 2002). Almost all major river basins in the country are interstate in nature. With the existing constitutional provisions, the union government cannot proceed toward preparation of integrated river basin plans on its own and ensure the implementation without taking the concerned states into confidence.

M. E. Haque, *H. K. Varma*, and *Avinash C. Tyagi* in their article on the *Constitutional Provisions Related to Water* identify measures for ensuring reforms toward better management of water sector and suggest a road map for initiating the process of integrated planning for water resources. Drawing from various reports of the Central/State Finance Commissions as well as international experience, they counsel that integrated river basin planning of water resources with a focus on resolving existing hydrologic, ecologic, and socioeconomic problems must be initiated without any loss of time. Simultaneously actions would have to be initiated for (a) creating suitable mechanisms for pooling the expertise and develop integrated plans and (b) initiating dialogue for consensus building for legislative measures. They point out that the development of a comprehensive National Framework Law as envisaged under National Water Policy (2012) would facilitate this process.

Groundwater resources are often extracted exceeding the sustainable limit in various parts of the world particularly in Asia and North America. Worldwide about 1.7 billion people live in areas where groundwater resources and/or groundwater-dependent ecosystems are under threat (Gleeson et al. 2012). In Indian subcontinent the threat is looming large particularly affecting the northwestern part of India covering the states of Punjab, Haryana, and Western Uttar Pradesh and Rajasthan (Rodell et al. 2009). As per the replenishable groundwater resource estimation, about 16% of the assessment units are overexploited. It is really a challenge to make groundwater extraction sustainable. Regulation of groundwater extraction is being done in India by Central Ground Water Authority (CGWA) since 1997; however effectively the activity is boiling down to controlling industrial extraction (5–6% of total groundwater extraction of the country), while the issues related to irrigation extraction remain unattended.

Phillipe Cullet in his article *Governing Groundwater Fostering Participatory and Aquifer-Based Regulation* points out that the groundwater in India has been governed by legal principles developed in the nineteenth century that are neither appropriate today nor supported by the recent developments in the groundwater science. In the present scenario, it is imperative to evolve a legal regime that is adapted to the key role of the GW as well as to the environmental challenges that have arisen. According to him, the current legal framework based around near absolute claims of landowners over the groundwater found under their piece of land is socially as well as technically inappropriate. It does not leave space for aquifer-based protection and sustainable development of groundwater. At the same time, it is also socially inequitable, as the land ownership is skewed. He points to the need for a contemporary legal framework for effective governance of the GW sector. According to the author, the draft Model Groundwater (Sustainable Management) Act, 2017, under the consideration of the government, addresses these issues and proposes a new basis for protecting, regulating, and using groundwater. It is built around the recognition of groundwater as a common heritage of the community that must be appropriately protected and equitably used. It reflects existing legal provisions of the constitution, legal developments, as well as judicial pronouncements, in particular in the field of environmental law.

6 Agriculture Water Management and Participatory Approach

The water challenge is closely tied to food security, defined as the condition when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 2002). Food insecurity can trigger conflict, for example, the sharp increases in food prices in 2008, accompanied by cuts in food and fuel subsidies, reduced real incomes of, mainly urban, populations and triggered food riots in many countries. Water productivity in agriculture becomes a major concern when water is scarce. Water resource depletion has explicit economic costs as well as perceived social and environmental costs. In water-scarce regions in the country, water diversion for agriculture is in direct competition with the environmental and social needs of water. Water-use efficiency in irrigation is a highly misunderstood concept so much that even the targets set by national water mission are grossly vague (MoWR 2009).

In almost all the states, agriculture water is managed by irrigation managers who are essentially civil engineers with little exposure to water management let alone agriculture. Further, new agronomical practices often do not get transferred to the field. The need for dissemination of experience and knowledge on latest developments and international best practices in the field of water resources and other related allied fields needs to be recognized. It is desirable that the latest innovations and best agronomical practices reach state-level functionaries through a well-organized platform such as India Irrigation Forum (ICID 2016).

Currently, the ultimate irrigation potential (UIP) of India is estimated to be 139.9 Mha. Huge public investments have been made, providing irrigation facilities through major, medium, and minor irrigation projects creating 110 Mha of irrigation potential up to the year 2012. Forty-two percent of the irrigation is contributed by major and medium irrigation, while the rest is contributed by minor irrigation, largely based on groundwater resources. Presently, India's irrigation infrastructure is expanding at a slow rate of by 1.8 Mha per annum, which is one-third less than the maximum growth achieved in the past. The gross water demand for multiple uses is expected to double by 2025, requiring huge capital outlays to meet the demand. Government of India has launched the Prime Minister's Agriculture Irrigation Scheme (PMKSY) (Niti Aayog 2017) to complete 99 ongoing major and medium irrigation projects to irrigate 7.6 Mha of agriculture land.

For the last 20 years, efforts have been made in various states, supported by the World Bank to reform water sector, particularly the irrigation management. However, except for a couple of cases, the success of these efforts has been far from satisfactory and sustainable. The state of Madhya Pradesh has successfully revitalized its water resources sector for optimizing its use in agriculture. Apart from enhancing power supply to agriculture, the focus has been on canal reforms such as restoring canal management protocols, last-mile investments, reducing deferred maintenance, constant monitoring, animating irrigation bureaucracy, and vitalizing farmer organizations. The irrigated area in the state has gone up from 0.8 M ha to 3.6 M ha, a fourfold increase in the last 5–6 years.

However, the most important issue is equity in water resources development and distribution among the co-riparian farmers. This entails fairness, dignity, respect for mutual rights, and obligations. Unfortunately, management of irrigation projects in India has miserably failed in this important aspect. Tail-end farmers are often deprived of the benefits of the project, while others do not necessarily get their allocated water at the time required by them.

Since 1985, Union Ministry of Water Resources has been advocating farmers' participation in water distribution and management of tertiary systems. Special incentives have been given under the Centrally Sponsored Command Area Development Program. The concept of involvement of farmers in management of the irrigation system has been accepted as a policy of the Government of India and has been included in the National Water Policy adopted in 1987. In the article on *Farmers Participation in Managing Water for Agriculture*, *Phanish Kumar Sinha* traces the history of participatory irrigation management (PIM). The author indicates that PIM has not succeeded in India to the desired extent not because the idea is wrong but because the professionals implementing it have either not understood the process or the rationale of PIM concept does not suit their comfort zone of power and non-accountability. PIM is considered successful if it results in (i) an increase in percentage of water charges collection, (ii) expanded area under irrigation, (iii) ensuring equity of water distribution in terms of water availability in tail end, and