Chapter 8
Smart Water Management and eDemocracy in India

Prabh Bedi and Neha Goel Tripathi

Abstract Water management has become a key issue in the 21st century, with increasing population, economic growth and climatic variability. Water is a stressed resource in India. Annual per capita water availability is expected to decline to 1140 m^3 by 2050, from 1545 m^3 in 2011 (Government of India in Water management, [1]). With 45% of population living in urban areas by 2050 (Shukla in How India earns, spends and saves: unmasking the real India. Sage Publications, India, [2]), the availability of water will become a paramount issue. The availability of water is fundamental element to human life, economy and political stability and hence, sustainable water management is critical for existence. Government of India has launched a Smart City Mission for building 100 Smart Cities, in which 24 × 7 availability of water is one of the major emphasis. Traditionally water allocation decisions have been the exclusive domain of technical experts, public officials or political interests, but now there is a shift towards participative involvement of other stakeholders, namely citizens. Adequate water being the essential input in Smart City, calls for an inclusive and participatory management of this resource which extends beyond the city limits. Smart Water management in cities seeks to address challenges in the urban water management through integration of ICT and eDemocracy. Hydro-Informatic approache that is data driven and is technology based can form the basis of analyzing the complexities in water management, particularly in water scarce areas. This chapter looks into inclusive and eDemocratic measures for planning of water smart cities. The need is to develop eDemocracy based collaborative planning efforts to tackle pervading water issues.

Keywords Water · Smart city · HydroInformatics · Smart water management · eDemocracy · India

P. Bedi (✉)
Geospatial Information Technology Consultant, Visiting Faculty,
School of Planning and Architecture, 4, Block-B, I. P. Estate, New Delhi, India
e-mail: prabhb@gmail.com

N.G. Tripathi
School of Planning and Architecture, 4, Block-B, I. P. Estate, New Delhi, India
e-mail: nehagtripathi@gmail.com

T.M. Vinod Kumar (ed.), *E-Democracy for Smart Cities*, Advances in 21st Century Human Settlements, DOI 10.1007/978-981-10-4035-1_8

8.1 Introduction

Water is the lifeline of human civilization. Since time immemorial, access to water has been a defining factor in the location of settlements. Important civilizations have developed on the banks of rivers like Indus, Ganga, Nile, Euphrates, as the rivers have provided water for farming and led to the thriving of cities. Dynasties have been setting up their capitals on the banks of rivers and even today, major cities like New Delhi, Moscow, London and many others are on the banks of rivers and lakes.

As the population of the settlements have grown, the need for management of water has been realised. Water has been ported through channels and disposed off through drains since the times of Indus Valley Civilization. The means have been provided by the various rulers for the consumption of water for various domestic and non-domestic uses. The emphasis has been a lot on its conservation as well. In the modern context, water became a prime concern in 1972 with it being identified in United Nations Conference on the Human Environment as one of the natural resources that must be safeguarded. In 1977, in Argentina, a conference was exclusively devoted to discuss emerging water resources problem, where, there was a growing recognition that technology and infrastructure alone were not sufficient to address persistent water management concerns. Discourse about water governance began to emerge focusing on deliberative democracy, environmental governance and multilateralism, during the Dublin Conference in 1992 [3].

Water management is the activity of planning, developing, distributing and optimum use of water resources under defined water policies and regulations. It includes management of water resources, including for irrigation, flood protection, water treatment of drinking water, industrial waste and sewage and for maintaining the water table.

The ideology of water management has evolved from provisioning water for use in an urban area to include sewerage and drainage to integrating it like a water cycle to the present-day inclusion of democratic governance technology. Water management includes management of water resources systems, which are both natural and man-made. While the natural water resource systems include watersheds, river channels, groundwater floodplains and sub-surface water, man-made systems include conveyance channels, dams and reservoirs, storage facilities, wells and tanks, treatment plants and pumping stations.

When addressed specific to urban areas, water management involves water supply for domestic, commercial and industrial uses, drainage, wastewater treatment and sludge handling. Urban water refers to all the water that occurs in an urban area, either naturally, from atmosphere or on surface through rivers, streams, wetlands and natural aquifers or below the surface as underground water or through human intervention through piped networks and storage facilities.

The objective of urban water management is to build resilience in the urban centers such that they become livable and sustainable. With the advancement in technology and changing ideology, the need has arisen to manage the earth's resources in an integrated manner, leading to Integrated Water Resource Management, which promotes the coordinated development and management of water, land and related resources to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystem [4].

The chapter traces the water management practices in India since earliest times to the water policies and schemes of the present day to bring to light the changes that came about in management practices. The post-modern development like hydroinformatics and smart water management that are being adopted for the betterment of the cities, citizens and the environment have been discussed and learnings from historical management practices have been highlighted, which when clubbed with the post-modern technological innovations may provide lasting solution to the water problems.

8.2 Historical Perspective

Despite being crisscrossed by a complex network of rivers, some stretches of India have neither river nor lake to depend on. The history of India tells us that floods, droughts or both have been a perennial occurrence. Depending on the agro-climatic conditions, over time and with experience, people developed varied water management practices. Water management practices in India from historical perspective were largely in rural context, as those were the settlement types that existed mostly in the country.

The most important aspect of water management was harvesting of water, which depended largely on the ecological region inhabited by the people. In arid and semi-arid areas of Rajasthan, people developed covered wells for drinking water purposes. In the highlands, comprising of western Himalayas systems as *Zings*[1] and *Kuls*[2] were built for carrying water from the glaciers to the villages and for storing water melted water collected from the glaciers in small tanks. In the northern plains, *Kuis*,[3] *Johad*[4] and *Baandh*[5] were constructed for harvesting the water to recharge the groundwater. These water conservation structures were constructed in the urban settlements as well like stepwells and water soak pits.

[1]*Zing* is a small storage tank for collecting water melted from glaciers.

[2]Kul is channels for carrying water from glaciers to villages.

[3]*Kui* is deep tanks 10-12 meters in depth used for collection of water.

[4]*Johad* is an earthen checkdam used in the states of Haryana and Rajasthan, India, that collects and stores water throughout the year, to be used for the purpose of drinking by humans and cattle.

[5]*Baandh* is a dam to contain the flow of water.

Water management as it existed in pre-British period received patronage from the rulers in the form of construction of storage facilities for water supply to the capital cities and important towns. The citizens were also encouraged to build independent as well as community facilities to meet the domestic needs as in the form of wells and storage tanks. All the aspects of management, from identification of a suitable site to construction of the facility was based on experiential knowledge of the people based on the necessities of the people's daily livelihoods [5]. Embree [6] mentions that a thing of value was regarded as being part of aggregate rather than belonging to a single person and water was considered as a valuable resource, common to all for use and a basis of life. The close-knit structure of the communities enabled in managing labor and materials needed for such facilities as water was a common resource and basis of life. As stated by Bhaduri and Singh, pre-British institutions in India were created on the principles of duties and obligations and the rights were overlapping in nature with a strong local fervor in management of resources. There existed a high rate of participation by the people in activities linked to the management of the community resources common to all. It was obligatory for the citizens to perform one's duties towards the maintenance and upkeep of the common resources

During the pre-British period, all over the country traditional practices of managing water were practiced and was decentralized [7]. Having a monarchial system of governance throughout its history, the rulers apparently gave full support to the people and allowed the local communities to nurture the local knowledge base. The use of common properties for developing water facilities was the practice as people rarely owned any property in individual capacities.

Water has been traditionally perceived as a common resource and is the collective responsibility of the community for management. This entails conceptualization of the design based on the requirement of each fraction of the community based on sharing of knowledge and experience of the older people of the community. As highlighted by Singh [8], the decisions by the members of the community are based on collective choices made by mutual discussions under the leadership of senior men of the community, thereby informally following the concept of community participation at the grassroots within the framework of democracy.

Traditional water management practices declined during the British period due to its imperialistic rule. Lack of local ecological knowledge and systems introduced by the British led to disruption of the existing social structure in the country [5]. The traditional water management (harvesting) structures were de-legitimized by the British. To make management easier for themselves and have a complete control over the basic needs of the people, the British made laws to govern the water bodies under the ownership of state. This change gravely impacted the age-old water management practices as land, water and forest resources were addressed in an integrated manner traditionally.

8.3 Post Independence

The Constitution of India does not explicitly address the citizen's right to water. The Supreme Court of India has recognised the 'right to water' as part of the 'right to life' through Article 21 of the Constitution [9] through interpretation of the fundamental right to life in a series of cases making right to safe drinking water as a fundamental right. Further, during its review of the Constitution in 2002, National Commission recommended insertion of a new Article 30D as '*Every person shall have the right—(a) to safe drinking water…*'

As per India's constitutional setup, the authority to formulate, legislate and implement policies on water that entails water supplies, irrigation, canals, drainage, water storage and water power lies at the state level [10, 11]. Water being a state subject, it is the responsibility of the states to formulate policies, administer and implement various schemes pertaining to water and this includes the development and maintenance of urban water supplies as well. At the national level, Ministry of Urban Development and to some extent Ministry of Urban Employment and Poverty Alleviation are responsible for formulation of broad policies, their role being limited to advisory rather than regulatory.

8.3.1 Water Management Through National Five Year Plans

The earliest efforts of the government were to increase accessibility to water, as per the recommendations of the Bhore Committee in 1946 and Environmental Hygiene Committee in 1949, which was achieved by building large physical infrastructure like dams and reservoirs to increase water supply to urban areas amongst its other uses. At the time of independence, most of the towns lacked piped water supply services. To augment the situation systematic approach to provision of water supply commenced in 1950 with the Five Year Plans. However, until the end of the Fourth Five Plan drinking water supply programs were not given required precedence in the national planning process. One of the first policy initiative was in 1954 in the form of 'National Water Supply and Sanitation Policy' under the Central Ministry of Health with the main intention to assist the states in the execution of the water supply schemes. Later, the Fourth Five-Year Plan (1969–1974) stated that in urban areas, water supply schemes should be looked upon as a service which had to be paid for by the direct beneficiaries through capital contributions and water charges [12].

Until the Eighth Five Year Plan, the approach of the urban water schemes was to increase the coverage and access to water supply and sanitation services, having unrealistic targets, like 100% coverage at the end of the plan period, having achieved only 84%. The plan exemplified the problems mainly in the implementation of the schemes as related to operation and maintenance of installations and inadequate sewerage systems polluting the ground water, rivers and other water sources. In the eighth Five Year Plan (1992–1997) as far as drinking water supply was concerned, envisaged 3.85 percentage of total plan outlay on water supply, enlarging the coverage of drinking water to about 94 percentage of the urban population. However, the targets could not be achieved. The Planning Commission at the Centre rarely infringed on the constitutional right of the states with respect to water sector and merely set targets for the states to achieve not making an effort to articulate institutional or political difficulties, if any [13].

Ninth Five-Year Plan (1997–2002) recognised the integral link between rapid economic growth and quality of life. It identified the key urban concern as the growing gap between demand and supply of basic services like drinking water. It stated drinking water supply and sanitation facilities as being important and crucial for achieving goal of health for all. In the Tenth Five-Year Plan (2002–2007) the deteriorating level of urban infrastructure such as water supply and the low capacity on the part of city level administration to maintain it was recognized as a major area of concern. The tenth plan put special emphasis on urban sector reforms and bringing private sector expertise and capital through Public Private Partnerships (PPP) for improving efficiency and better water service delivery.

In these plans, the focus had been on the role of Urban Local Bodies (ULBs) in improving the development of water supply infrastructure, which changed in subsequent plans to demanding accountability from state governments for the deficiencies of development schemes. This national level shift has been due to the constitutional legitimacy attained by the ULBs under the 74th Constitutional Amendment Act (CAA), 1992. Urban planning, water supply and sanitation infrastructure and public health are among the eighteen items of the 12th Schedule that, the 74th CAA prescribes to transfer to the ULBs [14]. Moreover, the shift was from the mere statistical achievement to achieving assurance of water quality, high standards of operation and maintenance and accountability to customers. Reform based missions and schemes like Jawaharlal Nehru National Urban Renewal Mission (JnNURM) attempted to bridge the gap in physical infrastructure as well as governance.

The Twelfth Plan (2012–2017) emphasis, as important as the quantum of water to be supplied, is the problem of its management and equitable supply to all. In most cities, water supply is sourced from long distances. In this system of bringing water from far and in distributing it within the city, the length of the pipeline increases, as does the cost of infrastructure and its maintenance [15].

It needs to be highlighted that despite major programs and policies in India, today access to drinking water in remains a challenge despite massive outlays for drinking water even after six decades of planning and development.

8.3.2 Policies and Laws Governing Water Management

India adopted National Water Policy (NWP) in 1987 based on the recommendations of National Water Resource Council constituted in 1983. The policy aimed at optimum utilization of water resources, with the objective of sustainable development in harmony with the environment. The Policy gave foremost priority to the provision of safe drinking water to every human being followed by irrigation facilities, hydro-power, navigation and water for industrial use.

Subsequently, in 2002 National Water Policy was modified and reintroduced in response to the rapidly changing scenario in water sector to address the then emerging issues and provided critical policy inputs. NWP 2002 laid emphasis for the first time on ecological and environmental aspects of water allocation.

The policy was relooked into and in 2012 suggested an environmentally sound common integrated perspective to govern the planning and management of water resources within the local, regional, and national contexts. The Policy [16] clearly stated that water needs to be managed as a common pool community resource that is held by the State under the public trust doctrine to ensure equitable and sustainable development for all. NWP 2012 has done away with water allocation prioritization mentioned in NWP 1987 and 2002, but has emphasized on treating water, over and above the pre-emptive need for safe drinking water and sanitation, as an economic good. NWP 2012 also emphasized the fact that the service provider role of the State must gradually shifted to that of a regulator of services and facilitator for strengthening the relevant institutions.

The NWP 2012 recommended on aspects like enhancing water availability, water demand management through efficient water use practices, water pricing, conservation of river corridors, water bodies, and infrastructure, project planning and implementation, management of floods and droughts, water supply and sanitation, institutional arrangements, trans-boundary rivers, database and information system, capacity building, adapting to climate change and preparation of a plan of action by the National Water Board based on the National Water Policy.

The major guiding principles stated in the NWP 2012 [16] include:

- The principle of equity and social justice must inform the use and allocation of water resources.
- Planning, development, and management of water resources need to be governed by common integrated perspectives considering local, regional, and national context, having an environmentally sound basis, keeping in view the human, social, and economic needs.
- Safe drinking water and water for sanitation should be give utmost priority followed other basic domestic needs, agricultural needs for ensuring food security and minimum ecosystem needs. After meeting the above-mentioned needs, NWP mandates that water should be allocated in a manner to promote its conservation and efficient use.

- The focus in future needs to be on demand management particularly in view of impending impact of climate change by enhancing water use efficiency and minimizing water wastage.
- Water based activities need to be regulated in consonance with the local geo-climatic and hydrological situations.

Need has been felt for a model law as stated by Kumar [17] which may function as a guideline to the states for water governance. The Draft National Water Framework Bill, 2016 mandates the right to sufficient quantity of safe water for life within easy reach of the household making it the state's responsibility to provision water services even if delegated to private agencies [18]. The implementation of the National Water Framework if done in earnestness may bring in parity over space and time. The proposed law is not intended to centralize water management but, as clarified by the Sub-group on National Water Framework Law [19] set up by NITI Aayog, is 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 governance institutions.

In the recent years, many states have formulated State Water Policy documents and endorsed reforms in the urban water sector. The reforms have been either institutional/governance or financial/economic. States like Karnataka and Goa have formulated state policy documents specifically addressing urban water supply and sanitation. The institutional reforms pan the restructuring the roles and functions of the institutions involved, strengthening the ULBs, seeking participation of private agencies [20], separating the functions of regulation from execution and transferring regulatory functions to newly created independent regulatory bodies [21]. The economic reforms focused on cost recovery through rationalization of tariffs and maintaining accounts and budgets separate from those of other operations of ULBs to strengthen the agencies financially. However, the implementation efforts are not in tandem and ground realities have shown few sporadic and unconnected efforts to implement reform measures [22].

As stated by Ahluwalia [23], Groundwater use in India is currently governed by the framework of British common law sanctified by the Indian Easement Act of 1882. The Act has empowered the landowner with absolute right to draw any amount of ground water from under the land owned by him. The attempt at legislative reform in the past focused mostly on allocation and setting up a public regulatory authority for groundwater regulation and management empowering the state government to take the final decision. The government of India is currently working on a national water framework bill and a model groundwater bill, which may be adapted by the state governments as per their requirement and context. The issues being addressed are equitable access and aquifer protection. The focus on diluting the link between land ownership and control over groundwater. The intent is to treat groundwater as a common pool resource to be exploited only for public good [23].

Water laws in India are largely state based, due to the constitutional scheme, which since the Government of India Act, 1935 has in principle given power to the states to legislate in this sector. There are numerous water laws in the country [24], but water issues are addressed in response to emerging crises (not a proactive approach), resolving rights and settling disputes. No rational scientific framework is available to reconcile ambitious goals of economic prosperity and competitive claims for an increasingly scarce resource by different segments of the society.

8.3.3 Role Players

At the Central level, NITI Aayog (erstwhile Planning Commission) is responsible for allocation of financial resources to states and the ministry for various programs and schemes. Ministry of Water Resources is responsible for laying down policy guidelines and programs for development and regulation of country's water resources. Other than these, the Central Pollution Control Board under the Ministry of Environment, Forest and Climate Change (MoEFCC) deals with water quality monitoring and preparation and implementation of action plans to solve pollution problems. The Ministry of Urban Development is responsible for execution of schemes launched by the government spatially falling in the urban space.

Even though, water is the legislative responsibility of state governments, in the recent years the process of water service delivery has been marked by top-down approach from the center, where the schemes and missions (like JnNRUM) were are launched by the center, to the states and from the state governments to the municipalities or the local government. All the programs and the policies are decided at the central or the state level and passed on to the local level agencies for implementation.

The state level parastatals like Public Health Engineering Department (PHED) are responsible for water supply to urban areas despite the devolution of powers to the ULBs under the 74th CAA in 1992. In some cases, the responsibility of urban water supply is fragmented between different agencies. Besides the PHED at the state level, Water Supply and Sewerage or Drainage Boards at state levels and local government levels, share the responsibilities. Multiplicity in responsibility sharing is one reason for non-accountability in performance.

Water supply in urban areas which is at local level in the hierarchy of governance, is managed by state authorities or parastatal agencies. With increasing mismanagement and huge inefficiencies, the task of water management has now been off-shored to private organisations, making water into a commodity.

8.3.4 Smart City Initiative

Government of India's most recent initiative is of SMART Cities which defines a Smart City as one that provides core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions [25]. It is suggested that through Smart City solutions, the government should bring in smart water management through smart urban planning using smart Information and Communication Technology (ICT). As stated by Leinmiller and O'Mara [26] smart water system is designed to gather meaningful and actionable data about the flow, pressure and distribution of a city's water. Smart water system not only considers reducing the losses and managing the distribution but addresses energy consumption issues and suggests measures for its optimal use. Water loss management is becoming increasingly important as water supply agencies are stressed due to ever increasing population growth in urban areas clubbed with water scarcity. Incorporating smart water technologies allows water providers to minimize Non-Revenue Water (NRW) by identifying leakages using technology. Such systems help in predicting possible leakages in the near future based on models and simulations using real-time Supervisory Control And Data Acquisition (SCADA) data.

Some Indian cities which are on path to becoming Smart Cities have adopted smart systems to reduce water losses and for efficient management of water supply. Bengaluru,[6] which had maintained an average of 20 h of supply per day in the 1980s, was able to sustain an average of just 2.5 h in 2000s. Bangalore Water Supply and Sewerage Board (BWSSB), the agency that supplies water to Bengaluru city, launched a program designed to test the feasibility of providing metered individual water and sanitation connections to unauthorized slum households in the city, departing from its traditional practice of servicing such communities via free and shared public taps. For this purpose, it waived its requirement that only households with legal tenure could avail of an individual connection. As a result of this initiative, BWSSB succeeded in mobilizing 46 poor communities by early 2005, accounting for 10% of the city's slums [27].

Thiruvananthapuram city is using IBM Analytics and Mobility solutions to analyze, monitor and manage water distribution [28]. The utility grid is installed with smart sensors working in conjunction with the IBM Intelligent Operations Water software which enables Kerala Water Authority (KWA) workers to receive alerts via smart devices about water leakage cases in near real time. In addition, the sensors installed throughout the treatment process allow KWA to measure water turbidity, salinity, conductivity, PH and chlorine levels in real time. This smart system helps in monitoring and management of both quality and quantity. The smart system has helped to curb NRW losses due to leaking infrastructure and unauthorized use of water as well. The smart water system has helped KWA in tracking its 210,000 water meters across the city on consumption, thereby reducing billing anomalies and improving revenue collection by more than 10% [28].

Surat city, another budding Smart City, has taken control of its high-value and bulk consumers to check for water consumption especially the industrial users where each user has been metered using electromagnetic instruments and water consumption is carefully monitored. The city has adopted initiatives like imposing a leakage charge of 5% on industry. All newly developed areas are metered while in

---

[6]Bangalore city's name was changed to Bengaluru in November 2014 (http://www.karnataka.com/govt/karnataka-city-name-changes/).

the rest of the city, water bills are charged as a component of the property tax. The city has been mapped for leakage and old city area has been found to be the worst in this regard for which the agency is in the process of taking remedial steps to improve piping. With just one percentage of its area metered, the city has a cost recovery of 92% and its efficiency in collection of water charges is 94% [29].

Cities in India have started adopting technological solutions with the aim of providing better services to the citizens, though the initiative is not as widespread This can be attributed to the issues in water supply management which range from hardcore technical water supply and management problems to those linked to financial constraints and governance issues as discussed below.

8.3.5 Emergent Issues

Urban India has been experiencing limited, irregular, unreliable, inequitable and polluted water supply. The authorities responsible for supply of water are not responsive to the maladies faced by the citizens. With growing urbanisation, the demand for water is increasing as is the generation of wastewater. These issues can be broadly categorized as those linked to quantity and quality.

There is a large spatial and temporal variation in the availability of freshwater. Per capita water supply grossly varies from 40 L per capita per day (lpcd) to 200 lpcd. Only 62% of urban households have access to treated tap water and about 50% are directly connected to a piped network. The average connected household receives water only for approximately 2 h per day [30].

In the near future, urban concentration is likely to be in small and medium sized towns which are ill-equipped in their infrastructure for water and sanitation. Moreover, these towns do not have the required mechanism for generating revenue to cope up with increasing infrastructure demands. Unplanned peri-urban growth too has a low pace of infrastructure development [31].

The issue of adequate quantity, quality and the distance of the nearest available water source is emerging to be the most contentious issue about urban water supply. As the traditional water sources are all drying up, transporting water from far off places (100–400 km) is becoming a common feature and is thus becoming an expensive affair.

Leakage and inefficiencies in the water supply system causes wastage of nearly 50% of usable water. The ground water level is declining at the rate of 10 cm per year. Over 70% of surface water and ground water resources are contaminated [17]. In the absence of strong regulation, industrial and domestic waste water is discharged in rivers, canals and underground water sources. About 70% of underground and surface water resources in India have been contaminated [17]. All this is leading towards a water scarce situation in most urban areas of the country.

Table 8.1 Per capita average annual availability of water in India during 2010, 2025 and 2050

Average annual water resources potential	Estimated population (million)			Estimated per capita average annual water availability M^3		
	2010	2025	2050	2010	2025	2050
1869.3	1162.31	1394.02	1640.00	1608.26	1340.94	1139.82

Source B.P. Directorate, CWC. $: Reassessment of water resources potential of India March 1993, CWC. #: Report of the Standing sub-committee for assessment of availability and requirement of water for diverse uses in the country, August 2000 [32]

As per the report of the Standing Sub-Committee for assessment of availability of water as the population of the country will increase, the per capita water availability will reduce as shown in Table 8.1.

Another serious problem is the lack of maintenance of water supply and sanitation infrastructure, leading to contamination of ground water sources in most of the cities and towns today. The main cause of contamination of groundwater and surface water is the improper discharge of sewage. More than half of the cities have no sewage treatment facilities. The much-needed water quality monitoring and surveillance is a rare phenomenon, except in the case of few privileged metropolitan cities.

Meagre finances with the urban water supply authorities is one of the biggest challenges in Indian urban water supply system. In India, most of urban local bodies are dependent on the state government for investment in water supply system. There are not enough sources for revenue generation to maintain water supply infrastructure. In India, water supply is responsibility of both state government and urban local bodies. Most municipal governments continue to rely heavily on state and central financing, not only for capital investments but also for a significant part of operational expenditures. As a result the Municipal Governments do not feel fully empowered and responsible for service delivery, and continue to 'look up' to state governments for financial and technical support, feeling little need to involve, consult or inform end users about proposed schemes [27]. Unequal distribution of water is a big challenge where poor people do not even have access to potable water system.

Water utilities are not legally bound to report on their performance to customers, and they are only required to report to higher tiers of government on budgets and expenditures. Further, many municipal water departments have no definitive measures and mechanical tracking systems by which to monitor and record water flows, and hence are unable to assess the extent to which poor metering, theft, or breaks and leakages to estimate water losses [33].

No clear-cut distribution of responsibilities to different urban agencies having overlapping roles and responsibilities causes delay in most water projects. Lack of accountability and regulatory framework for core and peri-urban areas is not proper. Lack of initiative taken for public participation in decision making to improve water supply system is another major hindrance for its improvement.

The inability to provide citizens with the necessary infrastructure has caused problems, including the growth of the informal supply of drinking water and improper wastewater collection and disposal systems. These informal systems operate largely unregulated, posing major health risks to the population.

The urban water supply and sanitation sector which is suffering from inadequate levels of service, an increasing demand-supply gap, poor sanitary conditions and deteriorating financial and technical performance needs to be addressed on highest priority. There is a growing realization that government alone cannot solve and manage the water scarcity challenges faced by the country. The approach in water management in urban areas in the near future is likely to focus on water conservation and efficiency, distributed storm water management which captures and uses rainfall, water reclamation and reuse and water treatment and reuse with the involvement and participation of citizens.

8.4 HydroInformatics

The current urban water sector scenario seeks just for technical quick-fixes that may enslave the communities to technology. The high expenses of such technologies may bind the communities to funding agencies eventually alienating the local population from its own resources. The solution to be sought needs to be a combination of technology and people's involvement.

The solution to these problems lies in hydroinformatics based water eDemocracy, where the ultimate objective should be to increase the water table through judicious use of water and conservation practices with emphasis on electronically enabled citizen participation to contribute to decision-making and take ownership to any changes that may be sought in the water regime in their area. eDemocracy is the support and enhancement of democracy, democratic institutions and democratic processes by means of technology [34].

There is an essential need for shift from water 'management' to water 'governance'. Whereas, water management is rooted in centralized decision-making with the government as the prime stakeholder, water governance is the political, social, economic and administrative systems that influence water's use and management. The key factor in water governance is citizen's participation and should be essentially based on informatics approach.

Hydroinformatics is information about hydro, a Greek word meaning water, hence information about water. Hydroinformatics can be defined as a branch of informatics which concentrates on the application of information and communications technologies (ICTs) in addressing the increasingly serious problems of the equitable and efficient use of water for many different purposes. As stated by Price and Vojinovic [35] hydroinformatics which emerged in 1980s integrates the social and technical knowledge to create solutions for the water problems of an area. Social dimension is important in hydroinformatics for understanding the impact of technological changes brought about by ICT. The objective of hydroinformatics is to bring in complete transparency in the decision-making process by involving all the stakeholders. Some kind of information about water has existed since the time man started using water for fulfilling his needs. This information or knowledge has been passed on generation to generation and has been shared between communities. Hydroinformatics, as is understood today, can be said to have emerged largely due to the advancements in the field of information technology.

Hydroinformatics has evolved from a stage where methods used by manual calculation were programmed to run on a machine [36] followed by a period when software codes began to be written initially in mainframes using paper tape and punch cards and later using programming languages as PASCAL and FORTRAN. This period of writing codes for specific application developed into coding for more generic applications in 1970s [36] and grew into software modelling systems. During 1980s commercial modelling packages for personal computers began to be marketed like MOUSE and MIKE 11 by Danish Hydraulic Institute and WALLRUS and WASSP from Wallingford Software. These software empowered the engineers with the ability to manage the water systems even without the core knowledge of computational hydraulics. Modelling become the core of the software for water management and gradually became available to a larger group of people other than water engineers and water management experts. In all the advancement that took place in the water modelling and management software, the parallel developments in computer hardware, software, programming, database management, Geographic Information System and Remote Sensing technologies have played an important role.

Since 1980s till date, as stated by Price and Vojinovic [35], the advancement in hydroinformatics transformed the 'performers of projects' into 'providers of products' and the society too transformed from that of 'knowers' to societies of 'consumers of knowledge'. Internet has played a vital role in this transformation. It has not only facilitated the communication of information but has facilitated access to data and information stored in servers and websites by a large number of people through a wide range of devices from a computer to a mobile phone connected through Internet anywhere in the world. With the information being available online, stakeholders can participate in the decision-making process. In the future, the option of accessing the information is likely to increase tremendously, which will bring in more transparency and bring a change in the society in social terms. As Abbott and Vojinovic [37] state, the purpose of stakeholder participation is to induce a change in the built environment that bring a positive change in the social environment. The societal changes caused by hydroinformatics may lead to more stakeholders participating in decision-making in not a reactive manner to the decisions of the government but in a positive manner [35].

The biggest benefit of hydroinformatics in water management is in the planning, design, construction, installation and operation of water assets [35]. It is necessary to understand that hydroinformatics is not just automatic collection of data on water consumption but should allow for remote access of data on water flow, consumption, quality, pressure at a required resolution, so that the data details can be used to improve the operational decisions. Hence, hydroinformatics is not just collection of Big Data but essentially includes the intelligent processing of the same such that right decisions for the customers can be taken.

Hydroinformatics, which delivers smart water management, uses ICT to address water issues with extensive automation to increase the response time. It helps in capturing data in near real-time and has the ability to transmit the data to remote locations for data processing, interpretation and modelling by the stakeholders [38]. The smart water management tools can be categorized into data acquisition and integration, where network sensors, smart pipes and smart meters are used; data dissemination, where Internet and radio transmitters are used; data processing, storage, modelling and analytics, where GIS and specialized software are put to use; management and control where SCADA and optimization tools are used; and visualization and decision support where web-based communication is used.

There exist some challenges in the adoption of hydroinformatics as a smart water solution. Lack of standardization in the relevant technologies like sensor networks and Internet of Things. Standardization is essential for the success of the solution as it brings in integrity. Organisation and agencies following the standards reduce their risks as there is compatibility and interoperability in the systems. Coherent cross-sector policies and a multi stakeholder formulated water resources management strategy are essential to the success and sustainability of smart water management tools [39], which needs to be supported with appropriate ICT governance as lack of investments in ICT can hamper the planning and implementation of the smart solution. As stated by Boyle et al. [40], a number of factors need to be considered in implementation of smart water management system, amongst which customer satisfaction needs to be the key. The water agency in India is in government's domain and the focus on customer satisfaction is the least. Adoption of hydroinformatics is a re-engineering effort and not just adoption of technology. The problems of water supply and management that are faced by the urban areas can be overcome only by better understanding the customer problems which can be achieved by installing smart water solutions. By the installation of the smart solutions, the water managers will be able to understand the water consumption patterns and trends for various uses and enable in better urban water planning. As stated by Beal and Stewart [41], designs from environment, engineering and economic perspectives can be efficiently designed based on up-to-date and accurate data collected through the smart solution. It will help the managers in proactively reduce water losses by reacting to leakages and alarms [42]. Smart management can lead to development of customized tariff systems as well which can further influence the consumption pattern of the consumers.

The installation of a smart solution like SCADA by Pimpri Chinchwad, near Pune, Maharashtra, in 2008, has helped the municipal corporation is equitable water supply in the city. The system provides information on raw water lifted from the Pavana river, treated at the water treatment plants (WTPs), sent via the pipelines, and received at 85 elevated storage reservoirs. The department has set up benchmarks for the flow of water through the system and if there is any deviation, the official concerned is sent a message on his cell phone, after which he determines the reasons for the deviation and takes corrective action. The municipal corporation embarked on a pilot project to implement 24 × 7 water supply in a specified area which has reduced the water demand as now there is no need to store water with corresponding wastage. Further electricity bills of residents have reduced as there is no need to pump water as the pressure is being maintained in the system [43].

Singapore embarked on a Smart Water project to overcome the challenges of leakages and pipe bursts due to ageing infrastructure in collaboration with the water utilities company, academia, ICT institutes and private agencies called WaterWise. The project has been successful in aiding event detection like leaks and bursts, provides real-time monitoring and decision support [39]. Two important components of WaterWise are the Integrated Data and Electronic Alerts System (IDEAS), and the Decision Support Tools Module (DSTM). Whereas, IDEAS is responsible for data stream management, analytics and alerts, DSTM uses the data aggregated by IDEAS to provide decision support tools on a demand-zone basis. The system can be integrated to the existing GIS platform to display the data collected in real-time spatially. The project has expanded from an eight-node network of integrated smart tools to a 50 nodes network spread over 80 Km^2.

City of Seoul is another example of implementation of smart water solution through which the city has been able to increase its revenue water to 94.3% in 2013 from 64.1% in 1998 [44] This has been possible by maintaining a stable water pressure despite the hilly terrain of the urban area, construction of reservoirs at the correct height, measurement of minimum night flow, leak detection and reorganization of pipes not in use. This has been possible due to use of appropriate smart water management tools clubbed with local knowledge.

Water security ensures the reliability and availability of water in terms of quantity and quality. In present times security means protecting the water supply system from contamination as well, which may come in the form of pollution, accidents, and terrorist attacks. Ensuring the security of water has been the concern for utility managers [39]. United States Environmental Protection Agency (EPA) is entrusted with the task of Water Security, which comprises of online water quality monitoring, consumer complaint surveillance, public health surveillance, routine sampling and analysis and enhanced security monitoring. Developed on ICT, the smart solution is capable of providing timely detection of potential contamination. The system consists of Event Detection Systems (EDS) which is designed to monitor water quality data in real time and produce an alert if water quality is deemed anomalous [45].

Hydroinformatics supported smart water management helps in identifying and rapidly addressing the leakages and reducing the water losses in the distribution network, understanding the consumption time during the day by residential and commercial users to enhance water supply designs and management, enhance customer satisfaction by providing targeted services as leak alerts and taking feedback from customers through web portals and mobile applications to know about changing consumption patterns so as to deliver better services.

8.5 eDemocracy an Essential for Smart Water Management

As stated above, the true benefit of hydroinformatics is when not only are the stakeholders, which includes citizens, are benefited by the equitable distribution of water, reduction in water losses and by capping of the loopholes in appropriate tariff collection by the water utilities, but when the stakeholders are able to participate in the decision-making process linked to water supply in their area.

Thus, such a decision-making process is needed in which water managers inform the initial decision and participate in planning the appropriate responses, interacting with the principal actors, particularly citizens and with the managers of other sectors. Thus increasingly, collective governance ‘beyond governments’ is part of the solution, with state and non-state actors working together. In this rapidly changing world, it is best to adapt in time to prevent crises rather than adapting in response to them. In the end achieving the goal is a political challenge. It involves determining the distribution of power and resources within a given community well as the interrelationship(s) between communities.

Canadian provinces have amended their laws and introduced new policies to promote delegated governance, which involves delegating decision-making over water management to the local level. Initially, citizen participation in environmental governance tended to emphasize citizen consultation, centered on project-review processes of mega-projects which developed into integration of citizens into decision-making through either consensus-building consultation processes or shared decision-making processes [46]. The Netherlands is another example of the changing policy paradigm for water management towards more integration and adaptiveness. Dutch governance system on water management emphasizes on new governance paradigm that is oriented towards more close collaboration between public, private and societal actors in interactive processes [47, 48].

During the pre-British period, water was managed in the country in a decentralized manner, where water was not considered a commodity, but a community resource. Tasks related to water were handled at a community level and were highly sanctified, which made the people follow the unsaid rules for judicious use and conservation of water. Considering the present-day situation of water crisis in nearly all urban centers in the country, the need is to take on the learning from the historic times by involving the people in the decision-making process. Making people aware about the issues through dissemination workshops, holding relevant and age-appropriate seminars and workshops in schools so as to educate the youth of tomorrow about the essentials of water management and conservation may go a long way in establishing a democratic water regime. Similar educative content needs to be readily available through web portals, where the citizens should have an option of giving suggestions and possible solutions to their problems. The final decision may rest with the relevant agency, but with citizen involvement, there will be better acceptability and improvement in the water situation. With the adoption of hydroinformatics by the agencies, the benefit will incur not only in terms of preventing losses and better management. The benefits would accrue to and from the citizens when the information generated through hydroInformatics is shared and made accessible to the citizens and other stakeholders. Once the information is crowd-sourced, there will be many options and solutions that may be provided by the citizens, again the adoption of which would finally rest with the water supply and management agency. However, that would entail eDemocracy in the true sense.

The democratic model of water governance entails delegation by relevant authority of the government to a lower level, involvement of a wide variety of non-state actors, use of a hydrographic boundary as watershed rather than political boundaries, collaborative decision-making processes, often emphasizing consensus and trust-building, science-based decision-making, often requiring extensive fact-finding and use of hydroinformatics for decision making.

ICT based good governance and community participation in water management are the essential building blocks for water sector reform. Only through a partnership between people who are the users of water and water agencies who believe in democratic functioning can safe, equitable and adequate water distribution be ensured. Such systems and set-ups can understand the need for conservation of resources and ensuring sustainable water systems.

8.6 Conclusions

Traditionally, water resources have been managed by the community as water has been considered as a common resource and not a commodity or private property. The perception about water as a resource changed during the British rule with the gradual privatization of land and removal of water as a common resource. This brought the change in water management practices as well from collectively deciding and building water infrastructure based on experiential knowledge of the older generation to a science based approach which in many cases was not based on local knowledge.

The management of water became the responsibility of the government, which mainly included provisioning and maintenance services for domestic and non-domestic uses. This changed approach continued after independence. With increase in population and urbanisation, the stress on the water sector too increased. Centralised management of water has resulted in weakening of the water infrastructure, depletion of water quality and quantity of water supplied. Disparities have emerged in distribution of water supply. All these issues are primarily due to mismanagement and centralized approach of the government.

As growing scarcity of water is going to put more and more pressure on the water availability, the efficient and democratic governance of water is going to be needed more than ever. Smart cities need to meet their water requirement through successful water management which in turn would depend on co-operation, the active involvement of all water users in a city. There is an essential need of learning from the historic water management practices of involving all stakeholders concerned in the management of the water issues. There needs to be adoption of eDemocratic approach in governance based on hydroinformatics. While eDemocracy will ensure accountability and transparency, hydroinformatics will ensure that decisions taken are well informed. Since eDemocracy is based on electronically enabled citizen's participation, it will entail inclusion of local knowledge and the availability of database from ICT will lead to amalgamation of the localized expertise with scientific knowledge for a lasting solution to transform the urban areas as water sensitive centers.

References

1. Government of India (2016) Water management. Accessed http://sscgj.in/water-management/, 12 Sept 2016
2. Shukla Rajesh (2010) How India earns, spends and saves: unmasking the real India. Sage Publications, India
3. World Meteorological Organisation (n.d.) The Dublin statement on water and sustainable development. Accessed http://www.wmo.int/pages/prog/hwrp/documents/english/icwedece.html on 03 Oct 2016
4. Global Water Partnership (2012). Accessed http://www.gwp.org/the-challenge/what-is-iwrm/ on 03 Oct 2016
5. Bhaduri S, Singh A (n.d.) Decline of traditional water harvesting systems during British india: exploring the issues of 'knowledge incompatibility', 'breaking down of commons' and 'free ridership', Center for Studies in Science Policy, JNU
6. Embree AT (1969) Landholding in India and British Institutions. In: Frykenberg RE (ed) Land control and social structure in Indian history. The University of Wisconsin Press, London
7. Vani MS (2009) Community engagement in water governance. In: Iyer RR (ed) Water and the laws in India. SAGE Publications, New Delhi
8. Singh, Nandita (2004). Water management traditions in rural India: Valuing the unvalued. KTH Royal Institute of Technology. Accessed at https://www.researchgate.net/publication/228435348_Water_management_traditions_in_rural_India_Valuing_the_unvalued
9. IDFC (2011) Water: policy and performance for sustainable development, India infrastructure report-2011, Oxford, India
10. Narain V (2000) India's water crisis: challenges of governance. Water Policy 2(6):433–444
11. Government of India (1950) Constitution of India, seventh schedule, article 246. http://lawmin.nic.in/olwing/coi/coi-english/Const.Pock%202Pg.Rom8Fsss(35).pdf. Accessed 01 Dec 2016
12. Planning Commission (n. d.) Regional development, housing and water supply in fourth five year plan. http://planningcommission.nic.in/plans/planrel/fiveyr/index4.html. Accessed on 10 Oct 2016
13. Government of India (2007) Tenth five year plan. Planning Commission, New Delhi
14. Government of India (1950) Constitution of India, seventh schedule, Article 246. http://lawmin.nic.in/olwing/coi/coi-english/Const.Pock%202Pg.Rom8Fsss(35).pdf. Accessed 01 Dec 2016
15. Sahu S (2009) Politics of access to drinking water in urban areas in India: state and market interventions a case study of Hyderabad, pp 46–80
16. Government of India (2012) National water policy-2012. http://wrmin.nic.in/writereaddata/NationalWaterPolicy/NWP2012Eng6495132651.pdf. Accessed 28 Nov 2016

17. Kumar SV, Bharat GK (2014) Perspectives in water resources policy for India. TERI, New Delhi
18. Government of India (2016) Draft national water framework bill 2016, Ministry of water resources, river development and ganga rejuvenation. http://wrmin.nic.in/writereaddata/Water_Framework_May_2016.pdf. Accessed on 10 Nov 2016
19. Planning Commission (n.d.) The draft national water framework act: an explanatory note. http://www.planningcommission.nic.in/aboutus/committee/wrkgrp12/wr/wg_wtr_frame.pdf. Accessed on 09 Nov 2016
20. World Bank (2006) Indian water supply and sanitation: bridging the gap between infrastructure and service, background paper. World Bank, New Delhi
21. Ehrhardt D, Groom E, Halpern J, Seini C (2007) Economic regulation of urban water sector: some practical lessons. Water sector board discussion series, paper no. 9, The World Bank Group, Washington, DC
22. Wagle et al. (2011) India infrastructure report 2011: policy and performance for sustainable development IDFC, New Delhi
23. Ahluwalia IJ (2016) Cities at crossroads: a looming crisis http://www.financialexpress.com/opinion/cities-at-crossroads-a-looming-crisis/329941/. Accessed 06 Dec 2016
24. Iyer RR (2007) Towards water wisdom. Sage Publications India
25. Government of India (2015) Smart cities: mission statement & guidelines. http://smartcities.gov.in/writereaddata/SmartCityGuidelines.pdf. Accessed on 15 Nov 2016
26. Leinmiller M, O'Mara M. (n.d.) Smart water: a key building block of the smart city of the future. http://www.waterworld.com/articles/print/volume-29/issue-12/water-utility-management/smart-water-a-key-building-block-of-the-smart-city-of-the-future.html. Accessed on 29 Nov 2016
27. Malick B (2004–05) Engaging with citizens to improve services: overview and key findings. The water and sanitation program funded research
28. Financial Express (2015) How analytic tools are helping in fixing water woes in Bengaluru, Kerala. http://www.financialexpress.com/economy/fixing-water-woes-with-data-analytics/169143/. Accessed on 15 Nov 2016
29. Shah M (2016) Urban water systems in India: a way forward, working paper 323: Indian council for research on international economic relations
30. Anonymous (n.d.) http://shodhganga.inflibnet.ac.in/bitstream/10603/8807/9/09_chapter%201.pdf. Accessed on 15 Nov 2016
31. UN Habitat (2012) State of the world's cities 2012/2013: prosperity of cities. https://sustainabledevelopment.un.org/content/documents/745habitat.pdf. Accessed on 24 Nov 2016
32. Central Water Commission (2000) Report of the standing sub-committee for assessment of availability and requirement of water for diverse uses in the country
33. McIntosh AC (2014) Urban water supply and sanitation in Southeast Asia: a guide to good practice, Asian Development Bank, Philippines
34. eParticipation.eu. (2016) E-Democracy. http://eparticipation.eu/information/e-democracy/. Accessed on 23 Dec 2016
35. Price Roland K, Vojinovic Zoran (2011) Urban hydroinformatics: data models and decision support for integrated urban water management. IWA Publishing, London
36. Abbott MB (1988) Contirbutions of computational hydraulics to the foundation of computational hydrology. In: Recent advances in the modelling of hydrological systems, vol 345. NATO ASI Series C. Kluwer Academic Pub, Sintra, Portugal
37. Abbott MB, Vojinovic Z (2010) Realising social justice in the water sector: 1. J Hydroinform 12(1)
38. International Telecommunication Union (2014) Smart water management in cities, United Nations. https://www.itu.int/…/web-fg-ssc-0122-r7-smart_water_management_in_cities.docx. Accessed on 15 Dec 2016
39. International Telecommunication Union (2014) Partnering for solutions: ICTs in smart water management, UNESCO

40. Boyle T, Giurco D, Mukheibir P, Liu A, Moy C, White S, Stewart R (2013) Intelligent metering for urban water: a review. Water 5:1052–1081
41. Beal C, Stewart RA (2013) Identifying residential water end uses underpinning peak day and hour demand. ASCE J Water Res Plan Manage. doi:10.1061/(ASCE)WR.1943-5452.0000357
42. Britton C, Stewart RA, O'Halloran KR (2013) Smart metering: enabler for rapid and effective post meter leakage identification and water loss management. J Clean Prod 54:166–176
43. India Water Portal (2011) PLC & SCADA based water quality, treatment and distribution management system for 428 MLD PCMC water supply system. http://www.indiawaterportal.org/articles/plc-scada-based-water-quality-treatment-distribution-management-system-428-mld-pcmc-water. Accessed on 16 Nov 2016
44. Choi YJ, Ahn JC, Im HT, Koo A (2014) Best management practices for water loss control in Seoul. In: 16th conference on water distribution system analysis, WDSA
45. EPA (2013) Water quality event detection system challenge: methodology and findings. Office of water (MC-140) EPA 817-R-13-002 April 2013. Retrieved from: http://water.epa.gov/infrastructure/watersecurity/lawsregs/upload/epa817r13002.pdf. Accessed on 30 Dec 2016
46. Paper for the BC Water Governance Project, a partnership of the Fraser Basin Council, Ministry of Environment, Fraser Salmon and Watershed Program, Georgia Basin Living Rivers Program and Fisheries and Oceans Canad, Linda Nowlan and Karen Bakker, November 2007
47. Tortajada C (2010) Water governance: a research agenda. Int J Water Res Dev 26(2):309–316. doi:10.1080/07900621003683322. (To link to this Article)
48. Biswas A, Tortajada C (2010) Future water governance: problems and perspectives. Int J Water Res 26(2):129–139