Chapter 13
IoT Technology-Based Urban Water Management Strategies Using Indian Traditional Knowledge System

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13.1 Introduction

Water though covers more than 70% of the earth's surface, less than 1% is fit for human use. The pressure on this limited quantity increases tremendously because of different uses, pollution, and contamination [1]. The per capita availability of water is decreasing rapidly. Water scarcity can be observed more in urban areas due to the ever-increasing population and migration from rural to urban areas along with other factors such as industries, population density, mismanagement of watersheds, pollution of groundwater resources, and water-intensive traditional farming practices. Water is one of the basic needs of living organisms, and it is

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needed to sustain all the activities carried out by human beings; thus, it should be available for use at the desired quantity, quality, and time [2]. The United Nations has identified this as a fundamental challenge and has added water sustainability in the Millennium Development Goal and then later added it to goal number 6, "clean water and sanitation," of the Sustainable Development Goal 2030 [3].

Taleshi [4] observed that to have sustainable development and focus of managing water, equipping and conserving natural resources are among the most critical factors. Water management is also dependent on a country's or region's social, cultural, and traditional values and is also dictated by the country's or region's economic capital [4, 5]. Cities in developed countries are doing much better than those in developing countries because of the availability of better infrastructure and financial resources [5]. Nations worldwide are taking severe measures to manage water efficiently by implementing water taxes, using technology, or having a central management system [6, 7].

In India, after independence in 1947, the Ministry of Water Resources, Government of India, suggested implementing a central water management policy throughout the country and directed the state water resource departments to make necessary changes. The Ministry of Water Resources also suggested implementing the water management techniques adopted during India's British rule, such as the drought mitigation strategies and increasing the canal irrigation networks. The water management plan mostly ignored the local geographic characteristics and wholly ignored traditional water management knowledge [2]. Dwevedi et al. [8] observed that there is already stress on India's water sources, and the water resources available at the surface level are drying up faster than any country in the world. The water infrastructure developed after India's independence is in poor condition in most Indian cities, and now, either up-gradation to new methods of water management or moving towards the traditional knowledge systems seems like a difficult task [2, 7].

In today's context also, the relevance of traditional knowledge can be gauged by the fact that the Indian villages and rural areas can still meet water demands with their indigenous knowledge and with minimal support from the government. Traditionally, people used to take ownership of the water bodies; they considered them sacred, worshipped them, and had unique water harvesting knowledge systems [2, 9].

Thus, the need for the study arises because of the primary reason that fresh and human usable potable water has a finite source and is in limited quantity and there is a lack of sustainable management of the resource. This study also highlights the importance of traditional water management knowledge in the Indian subcontinent and understands the practical implications and modern application of the traditional water management knowledge systems. This study is not just an exercise to revisit and appreciate the past traditional sociocultural knowledge systems pertaining to water use and management. It further investigates the problems and challenges faced by the following 12 selected HRIDAY cities: Amaravati, Gaya, Dwarka, Badami, Puri, Amritsar, Ajmer, Kanchipuram, Velankanni, Warangal, Mathura, and Varanasi. Finally, the study recommends socially and culturally acceptable, feasible, community-focused strategies that are mostly long-term solutions. This study tries

to identify some of the best successful water management practices in the Indian context and how to replicate such practices in regions with similar geographic characteristics. The feasibility, upscaling of such a project, and detailed water management documentation of such practices are not the scope of this research and may be taken up in future research or taken up by government agencies as a pilot/consultancy project. The research questions that this study tries to answer are as follows:

RQ1: Is the traditional water management knowledge still relevant culturally or technologically for Indian cities, and if technological interventions, specifically IoT, help use the traditional knowledge in the present scenario?

RQ2: Do cities with complex heritage characters face unique and distinctive water management challenges compared to other urban areas?

RQ3: Which traditional water management system has the potential to help solve the problem of water shortage in urban areas, and which of the two, long-term or short-term solutions, is better economically, culturally, or sustainably?

The structure of the research is as follows. Section 13.2 of the chapter discusses the methodology used in this research. The literature review is presented in Sect. 13.3 of this chapter. It discusses the traditional water knowledge system and its importance and the importance of IoT, the AMRUT scheme, and the community's role in managing water. The study area and its associated problems and challenges are discussed in Sect. 13.4. Long-term and short-term strategies are presented in Sect. 13.5 "discussion and strategies." Sect. 13.6 concludes the chapter, and throws light on the managerial implications and the study limitation.

13.2 Research Methodology

The research methodology used in this study is as follows:

Step 1: Review of Relevant Literature The literature search was carried out from December 5 till December 21, 2020. The broad area of the literature review was the "traditional Indian water management system." The study used Google Scholar (scholar.google.com) and Scopus (scopus.com) search engines to collect relevant literature. To obtain the desired articles, the keywords used for the literature search were water management, water conservation, water tax, planning strategies, traditional knowledge, community, government, water infrastructure, Internet of Things, smart cities, and India. The articles without digital object identifier (DOI) were screened out during the first-level screening. Only the articles which were published in the English language academic journals were considered. The search result gave 231 articles, and after careful screening, the authors finally used 41 articles related to the broad objective of the study. Further, some articles,

book chapters, and theses cited in the selected articles were reviewed, and after careful reading, four more research works were added to the study.

Step 2: Review of Government Schemes, Policies, and Programs The varying geographical features in India have diverse location-specific issues which need location-specific approaches and solutions. The study identifies the different kinds of schemes, policies, and programs undertaken by the government at the center and state levels to address water management-related issues. The study further tries to identify the different water availability and management problems faced by the selected 12 HRIDAY cities and possible reasons for the problems.

Step 3: Study Area Review The selected twelve cities under the HRIDAY program, namely, Amaravati, Gaya, Dwarka, Badami, Puri, Amritsar, Ajmer, Kanchipuram, Velankanni, Warangal, Mathura, and Varanasi, are facing water shortages due to the old water infrastructure and rapid unplanned growth postindependence [10]. Further, the study lists the vital common issues in the selected cities where the traditional Indian knowledge of water management can be used and implemented using the Internet of Things (IoT) technology.

13.3 Literature Review

The literature review section is divided into three sections. The first section discusses the traditional Indian water management knowledge from different cultures and geographies across India and the need and benefits of bringing in the knowledge in the present age of development driven by technological interventions. The study reviews the AMRUT scheme launched by the Indian Government in 2015 and its provisions for water management in urban areas. The study further discusses the IoT-based water management strategies and interventions suggested by contemporary researchers. Further, the study lists the benefits of integrating traditional knowledge with IoT technology and sheds light on the community's vital role in water management.

13.3.1 Importance of Indian Traditional Water Management Knowledge

Traditional knowledge in water conservation and management has proved time and again its importance. Emperor Akbar ignored the centuries-old knowledge while laying out a new city and had to abandon Fatehpur Sikri's city in Uttar Pradesh, India, only after fourteen years of building the city. Some of the best known

flourishing ancient civilizations thrived because they respected and practised the traditional knowledge and knew the importance invested in watershed management technology. The civilizations such as the Roman, Mohenjo Daro, Indus Valley, and Mesopotamian and the Chinese drainage system used the traditional knowledge available at those points to flourish [1].

People in the rural areas have used the indigenous water management system for centuries and have been able to meet the growing needs without much help from the government at the local (gram panchayat), state, and center levels [7, 11–13]. Though there is no denying the fact that there is migration from rural to urban areas, the population trend has shown that the birth rate in rural areas is much more than the urban areas [14]. Without water conservation methods, increasing per capita water demand would have been catastrophic for the rural Indian population [12].

City planners need to look at their "less affluent" neighbors and introspect the mistakes they are committing in utilizing traditional water management knowledge. Urban and regional planners need to understand the importance of traditional water management. This very knowledge system is the sole reason for humankind to survive even in the regions where water is hardly available [1, 5]. Honwad [11] noted that the education system developed postindependence was a significant catalyst in ignoring our centuries-old knowledge base and giving more importance to the Western education system. Western technology was incorporated in Indian city planning during the colonial period through their water supply and sanitation policies through municipalities. This brought about a significant discontinuity in traditional watershed management practices in urban areas. India's robust system of transferring knowledge from one generation to another has become vulnerable. In 2018, Chennai became the first city in India to run out of human-use water [1, 15]. In India, indigenous knowledge's success was mainly because water, water bodies, and water sources are considered sacred and worshipped by many communities [11]. A gradual sociocultural shift is notable towards this reverence for water, especially in urbanized contexts. Fast-paced industrialization led to the exploitation of water policies by using loopholes in the system. This exploitation and poor planning are the primary reasons for water mismanagement in the Indian urban areas presently [16, 17].

The following points and observations by contemporary researchers highlight and identify the relevance, importance, and need of protecting the traditional water management knowledge system in India, and why we need to respect and revisit that knowledge and reinvent it:

1. The traditional knowledge system has evolved over centuries and respects the local values and traditions, and fits well in India's sociocultural system [2, 18].
2. The indigenous knowledge is used and developed by the community and has more acceptance as it respects the community's culture [7, 19, 20].
3. It is the outcome of experiments and experience and has faced the harshest of disasters and is still relevant [21, 22].

4. The knowledge is passed from generation to generation through practical demonstrations, and changes are made according to the changing context [2, 9, 11].

It is pertinent to mention that the focus on revisiting cultural practices and reinventing their practices for contemporary applications in the field of climate-responsive architecture, watershed management, and use of local materials has gained academic ground since the building industry shifted towards sustainable development agenda, pushed by international efforts on climate change and sustainable development.

13.3.2 Review of AMRUT Scheme

The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) Scheme is mainly focused on improving the quality of life of the disadvantaged communities and the urban poor by providing essential city services like transportation facilities, proper sanitation, and safe and optimum quantity of water regularly [23, 24]. The Indian Government launched this scheme in 2015. Under this scheme, transportation and sanitation programs are addressed because of already existing mechanisms, but the urban planners and policymakers faced problems in managing water because of the poor infrastructure condition and unavailability of large-scale best practices [22]. The reason for focusing on the poor and disadvantaged is because the affluent societies can afford water at premium prices, as has been the case in the national capital territory of Delhi [16]. The main objective of the scheme related to water is to ensure that each house in an urban area has a tap water supply. The scheme's target is to get the desired result in 20 years, i.e., by 2035, with an estimated cost of rupees 39.2 lakh crore (3.92 trillion) at 2009-2010 prices. The scheme will solely operate as the centrally funded scheme and will be fast-tracked as the scheme has only one funding source, thus reducing confusion [23].

13.3.3 IoT in Water Management

The growing need for water due to the rapid increase in population and depleting water resources makes it necessary to optimize, monitor, and distribute water efficiently [13, 25]. The use of the Internet of Things (IoT)-based technology in our daily use has increased tremendously in the last decade. Barbhuiya et al. [26] suggested that water management-based systems should also use IoT-based sensors to manage water efficiently. However, this use of IoT is not straightforward and simple. It is done through a series of IoT sensors placed at desired locations and generates massive data that needs to be stored for future up-grading of infrastructure [27]. The real-time analysis and solutions suggested to problems by the IoT sensors

are much appreciated, but there is a considerable amount of minute detailing that goes in the process [10, 28]. This micromanagement, detailing, and proper networking need resources, in terms of human, technological, and financial, which is a significant amount of commitment in the Indian context.

The literature review in Sect. 13.3.1 gives a detailed impression of the need and importance of using traditional water management knowledge. Traditional management can be made "smart" by integrating indigenous knowledge with IoT technology [27]. Planners and architects have started using IoT-based solutions in managing water at the city level as the national capital territory of Delhi and micromanagement of water at the building level as in the case of most residential universities and college campuses in India. This use of IoT has increased effectiveness, brought in efficiency to the system and improvements to the water distribution process, and decreased the water loss during the distribution process [28, 29].

13.3.4 Benefits of Using IoT and Traditional Knowledge in Water Management

There is a considerable amount of literature on traditional water management and IoT technology, but very few talk about integrating sustainable use knowledge. This section lists the various benefits of using IoT and traditional knowledge in water management in the Indian context. The reason for city administration for not being able to upgrade the existing infrastructure is mainly that the city municipal corporations are not able to generate enough money; with the use of IoT technology, the city will be able to detect leaks and excessive use/waste of water due to illegal connections and will also have a set mechanism for revenue collection [16, 30]. This will lead to the improvement of services and better management of wastewater. Thus, IoT's foremost benefit in water supply monitoring is surveillance and detection, consequently saving valuable resources, person-hours, and finance. This method is a reinvention of a traditional concept where water tanks and wells were part of state or temple complexes and monitored vigilantly. Researchers have also noted that the local ecosystem can be re-established with water savings to improve overall human quality of life [5, 31]. The depletion of water resources and drying up of the natural channels have entirely shut off the natural drainage system and, in turn, increased the risk of floods, stressing the importance of managing stormwater [17, 32]. Proper and efficient water management will gradually recharge the water bodies, rejuvenate the natural drainage paths, and decrease disaster risks. This requires technology-assisted real-time monitoring of watershed drainage patterns and protection from further disruption in natural water recharge. What was an embedded feature of reverence needs to be reinvented through IoT and incorporated into best practices.

The traditional Indian water management methods like use of wells, stepwells, distillation process, sedimentation process, rainwater harvesting, and using wastewater for kitchen garden are some of the methods which are still in use but are not able to meet the individual, family, or community demands for which they are designed and thus people are relying on the municipal connection which again is not compelling enough [21, 33]. IoT technology can efficiently address this gap, but presently it is only predominantly used in the municipal water supply system to measure household water usage and generate bills. The technology can help identify the areas where water is lost in the traditional systems and can be used to optimize the overall traditional water management process [8, 34, 35]. Further, IoT can detect the overuse or nonuse of resources and strategies can be developed accordingly.

13.3.5 Role of Community in Resource Management and Sustainability

Community plays an essential role in the management and sustainability of water resources. It is mainly through the community that the knowledge is transferred from one generation to another. The elderly play a critical role in the overall process of knowledge transfer and are considered the traditional knowledge hub [21]. Their contribution is immense as most of the knowledge is based on experience over the years. Since the local people are more aware of a particular geographic location's intricacies, the indigenous knowledge is based on the harshest of the crisis and reduces the disaster risks to a great extent. Kumar et al. [12] strongly support integrating the local community in water management development program discussions as they will bring in the angle of disaster reduction among many other important insights to the traditional water management system. Because of the strong community culture, the traditional knowledge system survived even though this knowledge system was not given due importance postindependence and is also not well documented [34].

The reason for dropping the traditional water management system was due to the water wastage during the process. To make the water management process sustainable, city planners and managers should look for ways to decrease water wastage and decrease the overall water demand [10, 29]. This becomes challenging for a country like India, with large population size, and the level of technology and management measures are not adequate due to insufficient financial resources [36].

Pingale et al. [37] suggested that in order to have a more sustainable water management system, the urban policymakers and the municipal corporations need to drop the present inefficient method of water supply, that is, to take water from the source, make it usable, use it, and then finally dispose of it. The study suggested that a circular economy approach should be used to make water management sustainable and suggested that instead of disposing of the water, there should be a strategy to reduce, recycle, recover, and reuse the used water [37].

13.4 Study Area

The AMRUT scheme has 500 Indian cities and has included all twelve identified cities under the National Heritage City Development and Augmentation Yojana (HRIDAY) scheme. The cities selected under the HRIDAY schemes have vibrant cultural heritage, namely, Amaravati, Gaya, Dwarka, Badami, Puri, Amritsar, Ajmer, Kanchipuram, Velankanni, Warangal, Mathura, and Varanasi. The scheme's objective is to improve the city's existing infrastructure, make it barrier free, restore and improve the city image, and conserve the city's rich heritage.

The reason for selecting the HRIDAY cities in this study is because a city cannot move forward in the long run without strengthening the water infrastructure and making policy-level changes for water-related challenges. The HRIDAY scheme is again centrally sponsored, and thus the policy-level suggestions and planning interventions can be implemented at an accelerated rate. The scheme's objective is to plan and design heritage-sensitive water management plan keeping in mind the delicate nature of the city's core area. These cities also experience a high number of domestic and foreign tourist visits, thus adding pressure to already limited water resources.

Eleven out of twelve selected cities have more than a million population, with eight cities having a population between two and four million. The city with the least population is Dwarka, Gujarat, with an estimated population of more than 750,000. The city with the highest number of people residing, with a population of nearly 4.4 million, is Gaya, Bihar (Fig. 13.1). Uttar Pradesh and Tamil Nadu are the two states which have two cities each in the HRIDAY scheme. Gaya is known as one of the important Buddhist pilgrimage places. All the cities have their mentions in the ancient Hindu mythologies and are known for their rich cultural and traditional heritage.

Table 13.1 shows that all the twelve selected cities are along major rivers in India or have access to essential lakes as in Ajmer city. The quantity of water available in these cities is not an issue, but the water quality and how the water is managed and distributed are areas of concern. It is worth noting that this problem needs to be handled carefully because of the city core's heritage importance and delicate nature.

13.4.1 Water Problems in the Selected Cities

In the selected cities, tourism activities, significant economic and cultural activities, rural to urban migration, constrained city core, and presence of unauthorized settlements and slums are the significant reasons for depleting water resources. Heena and Rai [15] noted that the ever-increasing population is further increasing the gap between the supply and demand of water. The problems are aggravated due to the poor management of administrative officers [33]. Urban water planning in most cities is not futuristic and has failed to forecast the demand that may arise due

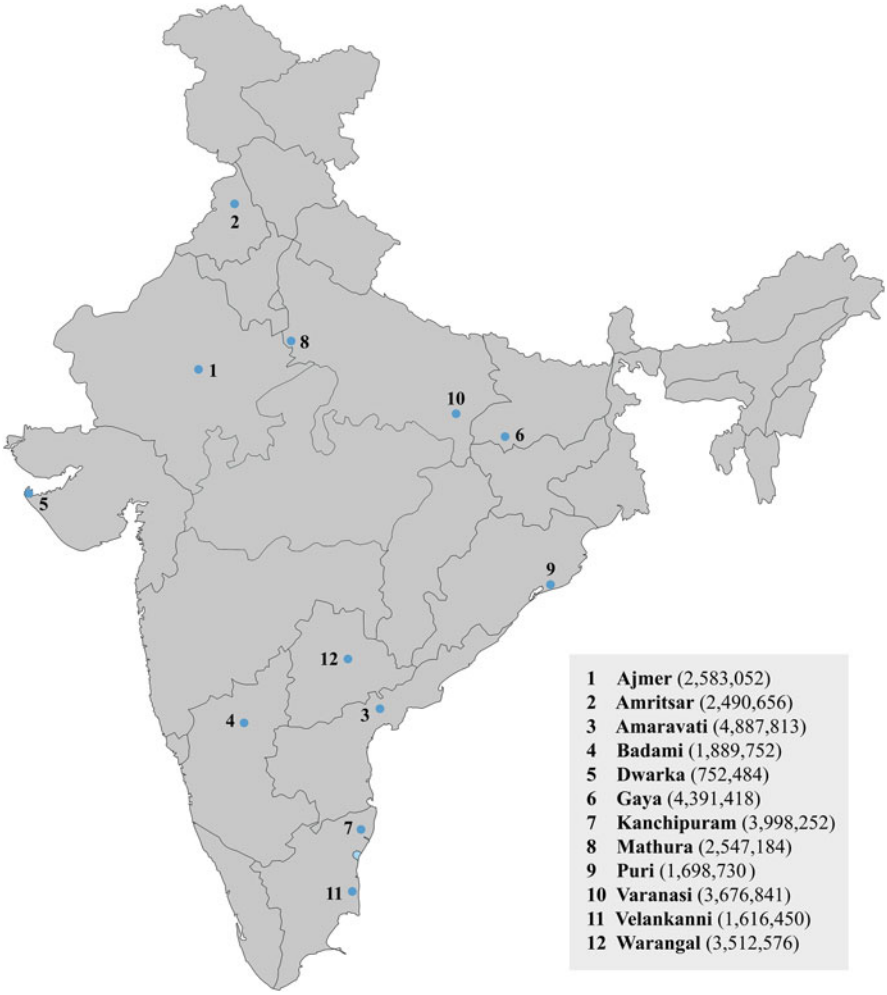

Fig. 13.1 Location of the selected cities along with the population it is catering to. Data: Census 2011

to population growth and floating population [10, 38, 39]. Another important reason for water scarcity is climate change [5].

Water disputes between communities have also halted many development-related projects in the selected cities [40]. Due to these disputes within the community and the gap between rich and poor societies within a city, there is an imbalance in water distribution [15, 40]. Heena and Rai [15] further observed that high-income groups consume considerably more water than the low-income group communities. Nandimandalam and Reddy [32] observed that due to the multiple uses of the limited

Table 13.1 Major sources of water for the selected HRIDAY cities

SN	HRIDAY city	Lake water source	River water source
1	Ajmer	Ana Sagar LakeFoy Sagar Lake	Luni River
2	Amritsar		Ravi RiverBeas RiverUpper Doab Canal
3	Amaravati		Krishna River
4	Badami		Krishna RiverMalaprabha
5	Dwarka		Gomti River
6	Gaya		Phalgu River
7	Kanchipuram		Palar RiverCheyyar River
8	Mathura		Yamuna River
9	Puri		Mahanadi Basin
10	Varanasi		Ganga River
11	Velankanni		Cauvery River
12	Warangal		Godavari RiverKrishna River

water source such as public, industrial and commercial use, and irrigation purposes, a water management plan is urgently needed for every Indian city.

Depletion of groundwater and unavailability of a mechanism to recharge groundwater at the desired scale are further opening up the cracks of water scarcity [41–43]. Though there is a ban on the use of bore wells beyond a certain depth, people are illegally using deep bore systems; this, along with improper rainwater harvesting, inadequate groundwater recharge, and problem of overdraft, will become a standard feature in every Indian city [32]. Below is the list of reasons for which almost every city is facing similar problems:

1. The water tax in India is set at a low rate and is highly subsidized. Thus, municipal corporations cannot generate an adequate amount of money to carry out the necessary development works because of low revenue generation. The municipal bodies are always revenue deficit and have to wait for funds from the center or state, even to carry out the regular maintenance works [44]. Because of the highly subsidized rates, people are not able to realize that water is a limited resource [15, 36, 40]. To make its importance and relevance felt, water tax must be levied at a higher rate.
2. Water loss is a significant challenge in every Indian city, regardless of its location. IoT sensors have been able to track the water pressure and flow at different nodes to check the water loss, but this technology up-gradation needs huge financial capital [31, 34, 36]. Without sensor-based technology, it is impossible to keep track of water loss at various city critical points. Though the process needs massive financial capital, corrective measures need to be taken. Cities worldwide have brought in more private investments to improve the water infrastructure; similar methods can be done in India [43]. The municipal corporations can also think of issuing municipal bonds, which will bring in the much-needed revenue [40].

3. Lack of autonomy and decision-making power is a significant setback for sustainable water management [4]. Many projects are delayed because of the existing lengthy procedures and unnecessary paper works. With more autonomy, municipal corporations can work independently and can get the projects cleared and completed within the sanctioned time frame [44].
4. Urban flooding is another problem faced by almost every city. The flooding is mainly due to the lack of proper drainage facilities and set mechanisms to mitigate such regular urban flooding.
5. The quality of water is at an unhealthy level for domestic use in many cities in India. This directly affects the health of the users and indicates the urgent need to bring in modern technology [6, 17, 29].
6. Surface water and groundwater contamination has been a significant challenge for every water resource department in the recent past [5, 16, 30]. Municipal corporations could not do much as these come under the jurisdiction of the state pollution control board. With increased autonomy, such problems can be managed better.
7. Though the water sources for the selected cities are lakes and rivers, there is a constant decline in the water level, which puts extra pressure on the existing machines and infrastructure, and it sometimes leads to system failure [32, 41].
8. The wastewater from domestic and industrial use further aggravates the problems by contaminating the surface water. A short-term solution to this problem is identified by Kakwani and Kalbar [31] and Starkl et al. [39] in improving the city's waste management.
9. Poor and not-well-thought-off urban planning is also a reason for poor water management in most Indian cities. Proper urban planning and water management plans can help cities meet the current and future water demands and manage the demands sustainably [1].

13.4.2 Integrating Existing Schemes, Programs, and Policies

Lack of proper coordination among the government ministries and departments results in inefficiency in water management. Though there is a strong need for water for both public use and irrigation purposes, water resources are not appropriately managed [19]. The major problem with this issue is the lack of clarity for the funding sources for various schemes, programs, and policies. The projects with only one funding source do much better than those sanctioned with state and central government partnerships. These issues are leading to delays in many important water development projects.

The existing levels of governance in India are shown in Fig. 13.2. As shown in Fig. 13.2, the organizational structure is excellent, but it needs more autonomy and decentralization at the lowest hierarchy level. Bassi and Kumar [44] suggested bringing in overall reforms in institutional, financial, managerial, and administrative departments of water management. They [44] further recommended decentralizing

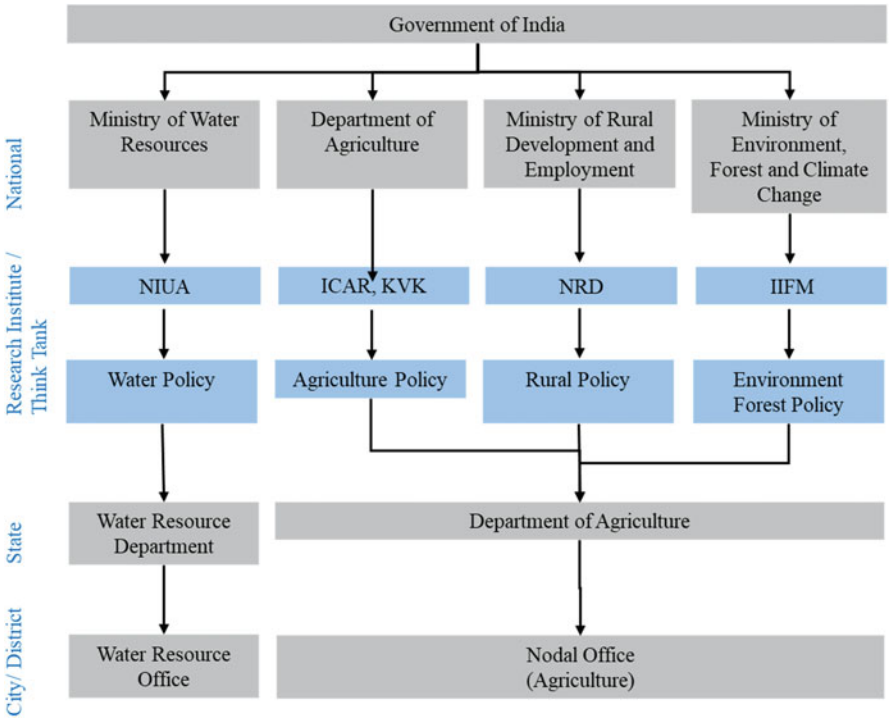

Fig. 13.2 Organizational structure of Indian water resource department

the organizations and giving more autonomy to the government institutions. Increasing the presence of the private sector and bringing in more community participation will be critical to sustainable development.

13.5 Discussion and Strategies

The importance of traditional knowledge and IoT technology and the benefits associated with their use were discussed in Sect. 13.3. Section 13.4 highlighted the problems associated with the study area and the government working framework. This section lists the problems identified and strategies to address the problems.

1. *Strategy 1:* Revisiting the process of rainwater harvesting using IoT. A city rainwater harvesting network can be created so that IoT sensors detect the areas with overdraft, and such areas can be given priority in water harvesting by directing more water.

2. *Strategy 2:* Timely cleaning of drains is crucial to reduce the risks of floods. During floods, water quality is at the most dangerous level, and such humongous water volume does not recharge the groundwater.
3. *Strategy 3:* Using IoT-based sensors to maintain the minimum water level so that the water bodies/sources do not dry up. This is needed as most of the natural running water paths are lost due to the water bodies' drying up.
4. *Strategy 4:* The 74th Constitutional Act of India gave extraordinary powers to the urban local bodies (municipal corporations), but the power transfer has not happened yet in the desired manner in many states, and there is an urgent need to strengthen the urban local bodies in India.
5. *Strategy 5:* At present, the citizens' water tax is not enough as they are not paying for environmental costs or giving any pollution fees. Unless there is a complete overhaul of the revenue generation model, water management and its related infrastructure development will not happen as desired.
6. *Strategy 6:* It is understood that water is an essential resource, and the government does not want to involve a private player, but the government can be more open to getting private investments. The private investments will help in the timely completion of development projects which are mostly delayed due to lack of clarity of funding.
7. *Strategy 7:* Government can further lease the cities to private companies to manage the city's water resources and manage water efficiently. Such practice will generate revenue, and overall water management will be the private companies' sole responsibility.
8. *Strategy 8:* Participation from the local community, especially the elderly, should be encouraged to bring in traditional water conservation knowledge. This traditional knowledge experience will help in dealing with water disasters.
9. *Strategy 9:* Human resource development is a vital aspect of any development. In the government setup, the departments that lack behind are the finance and the executive departments. With proper training and capacity building, these departments can work efficiently and coordinate in a better manner.

13.6 Conclusion

The importance of traditional knowledge cannot be underestimated. Many historic civilizations were located near a water body, and many times it gave them a strategic advantage over other civilizations. While there are many stand-alone exemplary examples of water management, there is a complete disconnect of such practices and literature. The study strongly suggests that such work's immediate documentation should be carried out and replicated in other locations with similar geographic characteristics with the government's help at local, state, and central levels. The traditional or indigenous knowledge system has been developed from the experiences and experiments of many centuries and should be implicated as they respond to the various contexts and have also survived many disasters. The

present use of IoT is limited chiefly to the use of smart metering. The scope of IoT usage needs to be increased, and the necessary infrastructure development should be made.

The HRIDAY cities have cultural and historical importance and also have a very delicate city core. Proper care should be taken to upgrade the city water infrastructure. It is essential to involve all the stakeholders of the city during the development-related discussions. Also, the citizen should be made aware of the importance of water conservation. The study suggests that long-term solutions and strategies should be implemented rather than short-term strategies. Long-term strategies may require more time to show results but are sustainable and will show positive results to the local ecosystem in the long run. Administrative and managerial changes are needed, along with the need for capacity building and human resource development. Finally, a water tax needs to be introduced, and water should not be readily available at a very high subsidized rate. Else, the citizens fail to identify its importance, and we as a society might lose this precious resource that is vital for our survival.

References

1. Selvaraj T, Yadav A, Bahuguna H, Drewnowski J, Ganesapillai M (2020) Ancient settlements-atavistic solutions for present water supply and drainage problems engendered by urbanism. Environ Dev Sustain 23(5):8076–8088. https://doi.org/10.1007/s10668-020-00954-0
2. Singh N (2004) Water management traditions in rural India: Valuing the unvalued. 18th European Conference on Modern South Asian Studies. pp. 6–9
3. Bank W (2017) Annual Report 2017: End Extreme Poverty & Boost Shared Prosperity
4. Taleshi M (2009) The experiences of participation in sustainable operation of water resources. World Appl Sci J 7:1176–1182
5. Singh S, Tanvir Hassan SM, Hassan M, Bharti N (2020) Urbanisation and water insecurity in the Hindu Kush Himalaya: Insights from Bangladesh, India, Nepal and Pakistan. Water Policy 22:9–32
6. McGrane SJ (2016) Impacts of urbanisation on hydrological and water quality dynamics, and urban water management: a review. Hydrol Sci J 61:2295–2311
7. Wijaya N (2016) Coastal community's responses to water infrastructure under climate-related disaster in Semarang city, Indonesia. ASEAN Eng J Part C 5:14–33
8. Dwevedi R, Krishna V, Kumar A (2018) Environment and big data: Role in smart cities of India. Resources 7:1–10
9. Rawat AS, Sah R (2009) Traditional knowledge of water management in Kumaon Himalaya. Indian J Tradit Knowl 8:249–254
10. Silva BN, Khan M, Jung C, Seo J, Muhammad D, Han J, Yoon Y, Han K (2018) Urban planning and smart city decision management empowered by real-time data processing using big data analytics. Sensors 18:6–12
11. Honwad S (2018) Learning in schools about traditional knowledge systems in the Kumaon Himalayas. J Folklore Educ 5:180–193
12. Kumar KS, Kumar A, Khanduri VP, Singh SK (2020) Indigenous knowledge for disaster solutions in the Hilly State of Mizoram, Northeast India. In: Srivastava PK, Singh SK, Mohanty UC, Murty T (eds) Techniques for disaster risk management and mitigation, First. John Wiley & Sons, pp 23–32

13. Vijai P, Sivakumar PB (2016) Design of IoT Systems and Analytics in the Context of Smart City Initiatives in India. Procedia Comput Sci 92:583–588
14. India G (2011) Census 2011. New Delhi
15. Heena RSC (2020) Sustainable water resource management in Chota Nagpur Plateau, India. Sustain Water Resour Manage 6:1–15
16. Rai SC (2011) Water management for a megacity: National Capital Territory of Delhi. Water Resour Manag 25:2267–2278
17. Yegemova S, Kumar R, Abuduwaili J, Ma L, Samat A, Issanova G, Ge Y, Kumar V, Keshavarzi A, Rodrigo-Comino J (2018) Identifying the key information and land management plans for water conservation under dry weather conditions in the border areas of the Syr Darya River in Kazakhstan. Water 10(12):1754. https://doi.org/10.3390/w10121754
18. Mahanta NR, Samuel A, Rajput B (2020) Community participation and bio rights possibilities in the conservation of urban wetlands: a study of Deepor Beel (Lake), Guwahati, India. In: IEEE 8th International Conference on Reliability, Infocom Technologies and Optimisation. pp. 1367–1372
19. Adhikary PP, Dash CJ, Chandrasekharan H, Rajput TBS, Dubey SK (2012) Evaluation of groundwater quality for irrigation and drinking using GIS and geostatistics in a peri-urban area of Delhi, India. Arab J Geosci 5:1423–1434
20. Ahari SS, Habibzadeh S, Yousefi M, Amani F, Abdi R (2012) Community based needs assessment in an urban area; A participatory action research project. BMC Public Health 12:161
21. Dixit U, Goyal VC (2011) Traditional knowledge from and for elderly. Indian J Tradit Knowl 10:429–438
22. Ramírez-Agudelo NA, Anento RP, Villares M, Roca E (2020) Nature-based solutions for water management in peri-urban areas: Barriers and lessons learned from implementation experiences. Sustainability 12:1–36
23. Dhyani S, Lahoti S, Khare S, Pujari P, Verma P (2018) Ecosystem based disaster risk reduction approaches (EbDRR) as a prerequisite for inclusive urban transformation of Nagpur City, India. Int J Disaster Risk Reduct 32:95–105
24. Mohapatra H, Rath AK (2019) Detection and avoidance of water loss through municipality taps in India by using smart taps and ICT. IET Wireless Sensor Syst 9:447–457
25. Maksimovic M (2017) The role of green internet of things (G-IoT) and big data in making cities smarter, safer and more sustainable. Int J Comput Dig Syst 6:175–184
26. Barbhuiya MR, Munoth N, Rajput RS (2020) Performance of smart cities concerning the use of internet of things: a case study of four Indian Himalayan cities. Smart Cities: A Data Analytics Perspective doi:https://doi.org/10.1007/978-3-030-60922-1
27. Mazhar Rathore M, Ahmad A, Paul A (2016) IoT-based smart city development using big data analytical approach. IEEE International Conference on Automatica. https://doi.org/10.1109/ICA-ACCA.2016.7778510
28. Patil AS, Nadaf M (2017) Study on ICT, IoT and big data analaytics in smart city applications. Int Res J Eng Technol 4:59–64
29. Mohanasundaram SV, Joyce A, Sri Naresh K, Gokulkrishnan G, Kale A, Dwarakanath T, Haribabu P (2018) Smart water distribution network solution for smart cities: Indian scenario. Global Internet Things Summit 2018:1–6
30. Marlow DR, Moglia M, Cook S, Beale DJ (2013) Towards sustainable urban water management: a critical reassessment. Water Res 47:7150–7161
31. Kakwani NS, Kalbar PP (2020) Review of circular economy in urban water sector: challenges and opportunities in India. J Environ Manag 271:111010
32. Nandimandalam JR, Reddy TVK (2006) Urban development and the Looming water crisis - A case study from Tirupati, South India. In: The Geological Society of London. pp. 1–5
33. Bowonder B, Chettri R (1984) Urban water supply in India: environmental issues. Urban Ecol 8:295–311
34. Gupta A, Mishra S, Bokde N, Kulat K (2016) Need of smart water systems in India. Int J Appl Eng Res 11:2216–2223

35. Mahmoud WH, Elagib NA, Gaese H, Heinrich J (2014) Rainfall conditions and rainwater harvesting potential in the urban area of Khartoum. Resour Conserv Recycl 91:89–99
36. Sharma SK, Vairavamoorthy K (2009) Urban water demand management: prospects and challenges for the developing countries. Water Environ J 23:210–218
37. Pingale SM, Jat MK, Khare D (2014) Integrated urban water management modelling under climate change scenarios. Resour Conserv Recycl 83:176–189
38. Durga Rao KHV (2005) Multi-criteria spatial decision analysis for forecasting urban water requirements: a case study of Dehradun city, India. Landsc Urban Plan 71:163–174
39. Starkl M, Brunner N, López E, Martínez-Ruiz JL (2013) A planning-oriented sustainability assessment framework for peri-urban water management in developing countries. Water Res 47:7175–7183
40. Nair KS (2007) Socio-economic and environmental issues associated with urban water management in India. International Symposium on New Directions in Urban Water Management
41. George BA, Malano HM, Khan AR, Gaur A, Davidson B (2009) Urban water supply strategies for Hyderabad, India future scenarios. Environ Model Assess 14:691–704
42. Singh S, Samaddar AB, Srivastava RK (2010) Sustainable drinking water management strategy using GIS: case study of Allahabad City (India). Manage Environ Qual Int J 21:436–451
43. Sugam RK, Neog K (2018) A multi-dimensional approach for building water-secured cities in India. J Resour Energy Devel 13:1–22
44. Bassi N, Kumar MD (2012) Addressing the civic challenges: perspective on institutional change for sustainable urban water management in India. Environ Urban ASIA 3:165–183