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Chapter 25

Implementation challenges for new projects and technologies

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ABSTRACT

Implementations of new water infrastructure projects must overcome several challenges. Many difficulties are faced while introducing new and emerging technologies for water and wastewater treatment. These challenges stem from the irregular availability of (1) financial resources, (2) skilled personnel for planning, design, and operation, and (3) implementation agencies for executing the project works. Challenges are also faced because of inadequate institutional structures and the absence of facilitating government policies. Quite often societal acceptance is not guaranteed. In this chapter, we discuss various challenges one can expect while implementing new water infrastructure and adopting new technologies for water and wastewater treatment. We discuss infrastructure financing, resources required for implementation, and institutional and policy framework. The importance of social acceptance is also stressed.

Keywords: new technology adaptation, water infrastructure financing, water governance, water policy, social acceptance

25.1 INTRODUCTION

There are many challenges to the implementation of new water infrastructure and the adaptation of new technologies for water and wastewater treatment. Water infrastructure requires significant capital investment and a continuous flow of funds throughout their lifetime for operation and maintenance (O&M). This makes it necessary to have an appropriate finance model which not only considers capital investment but also the running costs. Planning and design of sustainable water infrastructure whose design life usually spans several decades is a complex process. Well-trained and knowledgeable personnel are required to carry out these tasks. This requirement becomes crucial, especially in the context of adopting emerging technologies for resource recovery and optimal planning, design, and operation of integrated water utilities. There is always a fear of the unknown which prevents many

decision makers from adopting new technologies for water and wastewater treatment. Innovative technologies may be expensive as well. Highly skilled personnel are also required for managing all the complexly interlinked processes and tasks involved in the implementation and operation. The availability of implementation agencies is also crucial.

The nature and scale of water infrastructure have been changing over the last decade because of the aim to achieve sustainable development goals (SDGs). The Government of India has initiated many large mission modes projects, such as Swachh Bharat Mission (SBM) and Jal Jeevan Mission (JJM) for providing sanitation and water supply services to all the people in India. Implementation and sustainability of these projects require a change in the institutional structure and governance. Water supply services and environmental protection are highly emotional matters as they intimately affect the lives of all people. Technically sound and economically viable projects may be unacceptable to the people due to various reasons, and governments may find it very difficult to implement them, without delays.

25.2 INFRASTRUCTURE FINANCING

Water infrastructure projects in India are either implemented completely by the governments or through public–private partnerships (PPP). These projects are generally financed using project finance arrangements.

25.2.1 Public financing through the government

Until the recent past, the government used to be solely responsible for the implementation of water infrastructure projects through the utilities. Funds for the implementation, operation, and maintenance of the infrastructure by the utilities are provided by the state governments as part of their annual budgets. In the recent past, there has been a significant increase in the grants provided by the Central Government under schemes such as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Atal Mission for Rejuvenation and Urban Transformation (AMRUT) scheme, Clean Ganga Mission, and so on, considering all these under mission mode so that the project implementation takes place efficiently and on time.

Part of the water infrastructure financing also comes from tariffs. However, in most of the cases in India, especially in publicly owned and operated utilities, the tariff is not based on the high cost of providing and maintaining water infrastructure. Most of the utilities do not have meters to measure the amount of water supplied, except in the case of bulk supply. There is no metering of wastewater collected from households. Therefore, there is only a nominal tariff for domestic users in most of the cities. Financing of stormwater drainage systems is done entirely through the taxes collected. Thus, water infrastructure falls under the immature asset class from the perspective of investment. Although the investment requirement for the water infrastructure is estimated to be USD 129 billion (Sethi, 2019), expenditure on water infrastructure in India is approximately 6% of its GDP, which is less than that in many other countries in the region.

As the requirement for investment in water infrastructure has been growing significantly due to overall economic development and rapid urbanization, it is becoming increasingly challenging for the government to adequately fund the utilities. Humphreys *et al.* (2018) have identified the two following problems with public financing, especially in the case of small towns: (a) the limited ability to generate local resources, and (b) the manner in which limited resources are allocated among competing projects. Water, including treated water, is perceived as a free or minimally priced commodity to be supplied by the Government or relevant agencies. Local bodies often give more importance to health, education, and agriculture. Among the water infrastructure facilities, potable water supply is given priority, followed by the sewerage system. Although the focus has shifted to PPP in recent years, public financing of water infrastructure is expected to continue because many towns may not be able to attract investment from the private sector. It is important to note that existing models for water infrastructure financing do not consider the ground realities of small towns (Humphreys *et al.*, 2018).

In publicly financed water infrastructure projects, there is a general unwillingness to adopt new technologies because the decision makers tend to be averse to taking risks. This is especially so if the technology is emerging and has not been tried earlier at a scale comparable to their own project and in similar situations. There is always a worry about accountability. The introduction of new technology in general follows a gradual scaling up. For example, Chennai city recently implemented a 10 MLD scheme for recycling treated wastewater for potable use only after the successful implementation of a 4 MLD scheme in IIT Madras campus for five years. Successful implementation of this scheme will help in further scaling up not only in Tamil Nadu but also elsewhere.

25.2.2 Public–private partnerships

For long, water was considered a social good, and hence water infrastructure became an essential public service that should be handled by the public authorities. The context changed in the early 1990s mainly because of the people's frustration with the poor service quality offered by public utility providers and their difficulties in managing the huge investments required due to rapid urbanization. The estimated investments exceed the government's resources, underscoring the necessity of private sector participation to address the existing gap in water infrastructure development.

> The Department of Economic Affairs, Ministry of Finance, Government of India, defines PPP as: *A PPP means an arrangement between Government or statutory entity or Government owned entity on one side and a private sector entity on the other, for the provision of public assets and/or related services for public benefit, through investments being made by and/or management undertaken by the private sector entity for a specified period of time, where there is a well-defined allocation of risk between the private sector and the public entity and the private entity receives performance linked payments that conform to specified and pre-determined performance standards, measurable by the public entity or its representative.*

Typically, a PPP project addresses two main issues: (a) inadequate financial resources and (b) inadequate managerial and operational know-how. To address these issues and different challenges, across cities, the PPP projects act to remedy one of the challenges. The typology of PPPs can be divided into three main categories: (i) PPPs to build infrastructure and/or operate (build–operate–transfer (BOT)-type models), (ii) PPPs to improve operational performance (concession contracts; O&M contracts, service and management contracts, performance-based contracts), and (iii) other types of PPPS (output-based contracts, PPPs with small local private entrepreneurs).

A detailed financial analysis is one of the most critical tasks to determine the financial viability of the PPP project based on the costs involved and the expected revenues. PPP projects rely on the cash flow generated by the project to repay the loans and earn a return on the investments. Funding by loan can be obtained from sources such as: (1) commercial banks and (2) public financing through multilateral or national development banks, and (3) institutions which may provide preferential treatment in relation to repayment and limit the political risk. Tariff setting, which will often determine the financial feasibility of the project, is also the most politically sensitive factor of a PPP contract. The general principle for setting the tariff is that charges to customers should be sufficient to allow an efficient company to operate its existing assets, fund new obligations, and provide a reasonable return on equity and debt capital. Regularly planned tariff increases, that at least follow the inflation, are key to avoiding delays in the investment scheme that will downgrade the quality of the service. Many PPPs have failed because of a lack of appropriate communication with the public, especially when the project induces tariff increases without immediate improvements to the service delivery.

Over the years, many treatment plants have been constructed under DBO (design, build, and operate) schemes. The technology provider intervenes as a general contractor and must assume the operation during some initial years after the commissioning of the works. In the DBO model, the public entity takes full financial responsibility. In the BOT model, the private player actively participates in the financing of the works. The private entity designs, finances, constructs, and

operates the facility or system commercially for the project period, after which the facility/system is transferred to the authority. Build–own–operate (BOO), build–own–operate–transfer (BOOT), and build–operate–train–transfer (BOTT) models have been derived from the BOT model. Obstacles to the implementation of water infrastructure projects in India will likely remain because water remains highly subsidized and a non-lucrative proposition. Political opposition to private participation at various stages including ownership and control of water is strong.

Major financing sources for PPP projects are: (a) viability gap funding (VGF) scheme, (b) India Infrastructure Project Development Fund (IIPDF), (c) equity contributions, (d) long-term/short-term debt contributions, (e) India Infrastructure Finance Company Limited (IIFCL), (f) National Bank for Financing Infrastructure and Development (NaBFID), (g) bond/capital markets financing – municipal bonds, and (h) mezzanine/subordinated contributions. Usually, an SPV (special purpose vehicle) company is set up by the proposer solely to implement the PPP project.

The possibility of implementing newly developed technologies for sustainable water management is higher under the BOT models because private agencies are more likely to take risks associated with new partially tested technologies to increase the financial viability, as compared to public utilities which are averse to risk taking. BOT models also encourage new technologies (since it is out of normal purview) in the hope of bringing in efficiency and overall cost reduction.

25.2.3 International financing

With the help of the Government, utilities try to get funding from international development agencies such as the World Bank, the Asia Development Bank (ADB), the Japan International Cooperation Agency (JICA), and so on. ADB has invested in water supply improvement in Karnataka, to privately owned systems on an experimental basis in various cities. In recent years, World Bank has provided finances for efficient water supply and sanitation services in Amritsar and Ludhiana, and peri-urban areas in Uttarakhand and Shimla among others. Several case studies by Head (2006) revealed that the multilateral development banks (MDBs) could finance water infrastructure projects through the following three channels: (a) direct commercial loans to the project company, (b) indirect concessionary loans through the government, and (c) taking minority shareholding to assist financing. The last route of financing motivates the participation of other shareholders. The equity/debt ratio of projects is usually 30/70. To handle the risk of devaluation, MDBs can provide finance in local currencies as has been done in the case of the Allain-Duhangan project in Himachal Pradesh, India. It is important to note that the host government should take the responsibility for determining the most appropriate project financing model.

25.3 RESOURCES

Resources other than finances must be available for the successful implementation of sustainable water infrastructure projects, as discussed in this section.

25.3.1 Trained personnel for planning and design

In October 2021, the Government of India launched the AMRUT scheme for universal piped water supply coverage in 500 cities. One of the goals of this scheme is to transition from the present intermittent water supply scheme to a 24×7 supply scheme to achieve qualitative, quantitative, equitable, and sustainable water supply in urban areas. Innovative technologies for water and wastewater treatment are being developed for resource recovery and for recycling treated wastewater for both potable and non-potable uses. Processes must be designed and tailor-made based on the water quality requirements for specific water use. Similarly, in recent years, there has been a paradigm shift in stormwater management towards sustainable drainage systems for reducing flood risk in urban areas. Also, there will be a need for integrated implementation of water supply, sewerage, and stormwater drainage systems in order to increase the resilience of water supply projects, reduce the

impact of floods and provide maximum protection to the environment. For example, Chennai city has already started introducing the recycling of treated wastewater for potable use. Similarly, Mahagenco in Maharashtra reuses the treated wastewater from the City of Nagpur in Koradi Thermal Power Station (TPS). The State of Gujarat's Policy for Reuse of Treated Waste Water (2018) aims for the full reuse of treated wastewater by 2030.

The planning and design tasks for water infrastructure require in-depth and updated domain knowledge in the area of water and wastewater treatment technology, the use of GIS, and the latest mathematical modelling tools for simulating hydraulics of flow, consideration of water loss reduction programmes, the inclusion of district metering areas, inclusion of low impact development measures, and so on. However, there is a scarce availability of trained personnel to carry out these tasks. At present, only a few higher educational institutions and top consulting firms are capable of undertaking these works in India. A major drawback of engaging external consultants for this purpose is their lack of knowledge about local ground realities and inadequate sensitivity to sociocultural issues. The importance of considering sociocultural issues during the planning, design, and implementation stages on the sustainable implementation of a water infrastructure project cannot be overemphasized. Also, the existence of trained and knowledgeable in-house personnel will facilitate the utilities to make informed decisions regarding the adaptation of new technologies.

JJM launched by the Government of India in 2019 aims to provide functional household tap connections by 2024 in every village in India. JJM is being implemented as a decentralized, demand-driven, and community-managed programme. It is envisaged to empower the Gram Panchayat and/or its sub-committee/user group, that is, Village Water & Sanitation Committee (VWSC)/Pani Samiti to plan, implement, manage, operate, and maintain in-village water supply systems. Thus, the successful implementation of programmes such as JJM crucially depends on capacity building at all levels. Training and capacity building of Pani Panchayats is reliant on: (a) community action planning, (b) O&M, (c) community-based water quality monitoring, and (d) catchment protection and source sustainability. The Ministry of Jal Shakti, Government of India, has identified several key resource centers (KRCs) to carry out capacity building.

25.3.2 Availability of implementation agencies

It is obvious that contracting firms should be available for the successful implementation of water infrastructure projects at different scales. Several construction companies are capable of implementing large-scale water resources projects. However, the availability of local implementation agencies poses a significant challenge to the implementation of projects in rural areas. For many of the large and experienced contractors, it may not be profitable to undertake rural infrastructure projects due to inefficient mobility of equipment and labour. Also, they may not be willing to take the risks arising out of the local socio-political atmosphere.

Aditya *et al.* (2017) have studied the delays and cost overruns in many of the infrastructure projects in India and have found that the non-performance of contractors is one of the main reasons. Non-performance of the contractor occurs because of: (i) the safeguarding of self-interests, (ii) inadequate resource mobilization due to inefficient management, (iii) improper use of advance payments, and (iv) improper human resources management. Contractor internal coordination deficiencies, including cash flows, the poor performance of sub-contractors, and labour non-availability have been identified as risk factors in the implementation of infrastructure projects (Makarand, 2001; Xu *et al.*, 2010). This underscores the importance of the availability of good contractors with high professional ethics and managerial skills along with good reciprocation by water boards.

Non-availability of local implementation agencies with the necessary skills also delays the adaptation of new technologies. For example, in many cases of water supply projects, the adaptation of HDPE pipes was discouraged because of the non-availability of skilled labour for pipe laying and jointing. Nature-based solutions for wastewater treatments in rural and peri-urban areas are suggested because not only are they economically viable but they can also be implemented by local contractors.

25.3.3 Trained personnel for O&M

In general, difficulties in the sustainability of water infrastructure arise due to O&M and cost recovery. Many projects in India and elsewhere have deteriorated within a few years after the completion of the project due to poor O&M. Dillon (2023) suggests careful planning of O&M as the external implementation agencies plan the withdrawal and hand it over to local owners. Among other factors, the sustainability of O&M highly depends upon the availability of trained personnel. It is not rare to find a wastewater treatment plant being inefficiently operated and badly maintained due to poor training, absence of opportunities for frequent upgradation of skills, and lack of domain knowledge on the part of plant operators. In India, several wastewater treatment plants employ electrical and mechanical engineers for O&M who have no knowledge of biological and chemical processes involved in wastewater treatment. There have been many instances where local bodies have delayed the acceptance of facilities from the implementing agencies because of the non-availability of trained personnel.

Non-availability of trained personnel for O&M prevents the decision makers in many urban utilities from adopting new efficient technologies. For example, even now many of the decision makers in charge of sewerage and storm drainage systems in India like to go with an entire gravity system and discourage systems with pumping citing difficulties in O&M, even when a system with pumping could be more efficient.

25.3.4 Funds for O&M

Many of the water infrastructure projects in India and other developing countries are poorly operated and maintained because of a lack of funds. In general, planners and decision makers focus on technical aspects of planning, design, and financing of capital investment. However, it is important to plan a provision for financing O&M even before the project starts. Emphasis on post-construction activities should be as much as that on the design and construction (Brikke, 2000). Issues related to O&M should be made integral to planning and design because the aim of O&M is to ensure efficiency, effective service delivery, and sustainability (Castro *et al*., 2009). Selection of a project alternative should be based on life-cycle assessment, and the project finance model should explicitly consider the provision for O&M.

25.4 INSTITUTIONAL STRUCTURE

Water supply and sewerage services are municipal responsibilities in India, following the enactment of the 74th Constitution Amendment Act. However, the national government continues to have a significant role in the urban water sector. The Ministry of Housing and Urban Affairs (MoHUA) and its Technical Wing, the CPHEEO are responsible for developing the overall policy framework and guidelines, defining technical standards and norms, and financing the largest amount of capital. Additionally, The Central Ground Water Board and Central Pollution Control Board have monitoring and regulatory responsibilities.

Urban local bodies continue to face ‘administrative and legislative’ constraints based on their level of urbanization. While many cities have fully functional water supply departments, in some states, public health engineering departments or parastatal agencies (in the form of corporations, boards, authorities, etc.) are involved in capital works, provision of services, or both. Revenue functions are typically a municipal responsibility. In certain cases, such as metropolitan cities, special city-specific water/sanitation agencies exist and these are legally and financially separate from the local government. Typically, a state-level agency oversees planning and investment, while the local government (ULBs) oversees operation and maintenance.

Despite decentralization, ULBs remain dependent on capital subsidies from state governments. Tariffs are also often set by state governments that often even subsidize operating costs. Furthermore, when no separate utility exists, there is no separation of accounts for different activities within a

municipality. This creates a vicious cycle of increased involvement of various actors within the territory of urban local bodies and lesser autonomy. This is especially complicated for smaller ULBs, where connected parastatal and state authorities have different roles to play as compared to megacities and large ULBs, which have operational independence and encourage financial support from various sources to manage service and infrastructure levels.

25.4.1 Existing institutional arrangements

In a single agency/water supply institution, a single central agency is responsible for the provision of water supply in the urban area. This might be the city municipal body or a state level department/agency, or a specially set up water board. The agency is responsible for planning, designing, and constructing water schemes, maintaining bulk assets, and internal city-wide distribution as well as O&M with or without external support. There are also institutions that single-handedly manage the water supply provisions in urban, corporations, and ULBs. For instance, the Rural Drinking Water and Sanitation Department (RDWSD) is responsible for ensuring sanitation and providing clean drinking water to the rural areas of entire Karnataka. However, BWSSB (Bengaluru Water Supply and Sewerage Board) is responsible for the complete water supply and sewerage of Bengaluru city and extended areas.

In multiple agencies/water supply institutions, multiple agencies manage urban water supply systems within the city. The agencies either have separate responsibilities for planning, design, and construction of water schemes, maintenance of bulk assets, and internal city-wide distribution and O&M, or overlapping roles. This model is seen in most of the cities. In many cases, the agencies are different for water supply and sewerage provision. In decentralized system-through parastatal, water supply provision is decentralized. While the central/state urban department or water supply and sanitation department is responsible for planning, administrative and technical approvals, scheme funding, setting performance standards, the implementation and O&M of the projects, and so on is the responsibility of the parastatal. Such an operational model is seen in Indian cities of Shimla and Bhubaneswar. For instance, the Shimla Jal Prabhandan Nigam Limited (SJPNL) and Water Corporation of Odisha (WATCO) are responsible for the end-to-end delivery of water supply and sewerage services in their respective city areas.

Peri-urban areas have low/no coverage by municipal services and because of their administrative setup, may be served by multiple agencies with no single accountability. In most of the states, the Department of Industries and Commerce (DIC) is responsible for planning the supply of raw water to large-scale industries by liaising with the water resources department (WRD). Under this arrangement, large-scale industries and water-intensive industries can directly source water from the river basins (through relevant permissions and approvals from WRD). In many cities, the smaller industries/industrial estates which fall within the urban areas get their water supply from the city water utilities either through direct application or via industrial areas development board/respective industries corporations. The private sector and SPVs are typically seen in cities that are experimenting with PPPs.

Apart from the above formal institutional structures, various non-government organizations (NGOs) and civil society organizations (CSOs) are involved in the water sector. In many cities, NGOs and CSOs have been demonstrating community-led processes, advocacy, and capacity building in the water sector. In the present context, strong and capacitated community structures have huge potential to contribute significantly to achieving functional goals as well as to providing feedback on the progress of different government initiatives. With due training, they can be involved in service delivery operations and monitoring as well.

25.5 SOCIETAL ACCEPTANCE

It is very important to have societal acceptance for the successful implementation and sustainability of new projects. Societal acceptance is also crucial for adopting new technologies. Citizens are one

of the main stakeholders in any water infrastructure project and their opinions should be sought via the stakeholder consultation process and should be duly considered in the planning. Many times, inputs from stakeholders have improved the design of the processes. In a project jointly implemented by IIT Madras and the University of Guelph for improving the drinking water quality in a low-income peri-urban community in Chennai, input from stakeholders had a significant effect on the final design of point-of-use treatment method for potable water supply. Non-consultation or ineffective consultation with stakeholders has resulted in delays in the implementation of several 24 × 7 water supply projects in India in the last decade. Citizens take a confrontational attitude and resort to either street demonstrations or stalling of the project through lawsuits. For example, the employees of Delhi Jal Board made a massive sit-in protest to oppose the 'one zone-one operator' policy of the Delhi Government to privatize water utilities in Delhi. Similarly, protests have erupted in the past in other cities such as Khandwa in Madhya Pradesh, Vijayawada in Andhra Pradesh, and Coimbatore in Tamil Nadu. Many complaints are being made about the 24 × 7 project in Nagpur city. Recently, Langsdale and Cardwell (2022) have argued that appropriate stakeholder engagement results in improved decisions, savings in time and money, and improved relationships between the Government and people. This is especially so in the context of increasing conflicts due to population growth, climate change, and the ageing of existing infrastructure.

25.6 GOVERNMENT POLICIES AND INCENTIVES

Successful and sustainable implementation of water infrastructure is critically dependent on government policies and incentives. In India, the first national water policy was adopted in 1987, which was reviewed and updated in 2002 and 2012. The key points which are directly relevant to urban water infrastructure are: (a) recycling for providing maximum availability, (b) due consideration of the impact of projects on human settlements and the environment, (c) regulation of groundwater extraction, (d) first priority to drinking water while allocating scarce resources. In this latest version of policy, government is responsible for facilitating the service and the government need not be a direct service provider. The emphasis to treat water as economic good paved the way for increased participation of the private sector in water infrastructure projects. The policy on recycling has been driving many cities to go for recycling treated wastewater for potable and non-potable use. Many wastewater treatment technologies which were considered too costly and unnecessary earlier are becoming acceptable because they are able to meet more stringent discharge standards. Decentralized water supply schemes which were not adopted earlier for urban areas, will soon become popular because of the adaptation of recycling. The policy has also provided impetus for adopting decentralized greywater recycling using nature-based solutions in rural areas. The last priority for industrial water supply in the water policy is driving the industry towards adaptation of zero liquid discharge (ZLD) technologies. The government is encouraging the industry to procure either primary or secondary treated wastewater and treat it to suit their specific requirement. These factors in turn are propelling the adaptation of innovative tailor-made technologies for water and wastewater treatment.

There has been some criticism regarding the water policy in India on the grounds that: (i) water as an economic good may lead to inequity, (ii) the rich are not deterred from misuse of water, and (iii) incentives for effluent treatment is causing society to move away from the natural law of polluter pays. A study conducted by Ahmed and Araral (2019) indicates that water governance has shown improvement in the past few years in eight states as per their evaluation. They attribute this improvement to the National Rural Drinking Water Program, Accelerated Urban Water Supply Program (AUWSP), Water Framework Law of India 2016, and Namame-Gange and National Water Policy. All the states are required to appraise the NITI Aayog, which is an apex body directly reporting to the Prime Minister and is responsible for coordination among all stakeholders involved in the implementation of SDGs. Ahmed and Araral (2019) opine that all the above factors have contributed to the reported improvement in water governance.

25.7 SUMMARY

There are many challenges to the sustainable implementation of new projects and adaptation of new technologies. These are affected by a lack of (i) adequate investment funds, (ii) skilled human resources over the entire gamut of decision-making, planning, design, implementation, and O&M, (iii) proper institutional structure, and (iv) government policy. The lack of adequate funds for public finance can be overcome by adopting the PPP mode of financing, without jeopardizing the equitability concerns. Central and state governments have to invest heavily in skill development and capacity building in order to make the water infrastructure projects sustainable beyond a few years after their implementation. Although several changes are being brought about in water governance in India through changes in institutional structure and policies, more such efforts are called for. To summarize, the adaptation of new technology, innovative financing, capacity building, and effective involvement of all stakeholders in decision making are all equally critical for the implementation of water infrastructure projects sustainably.

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