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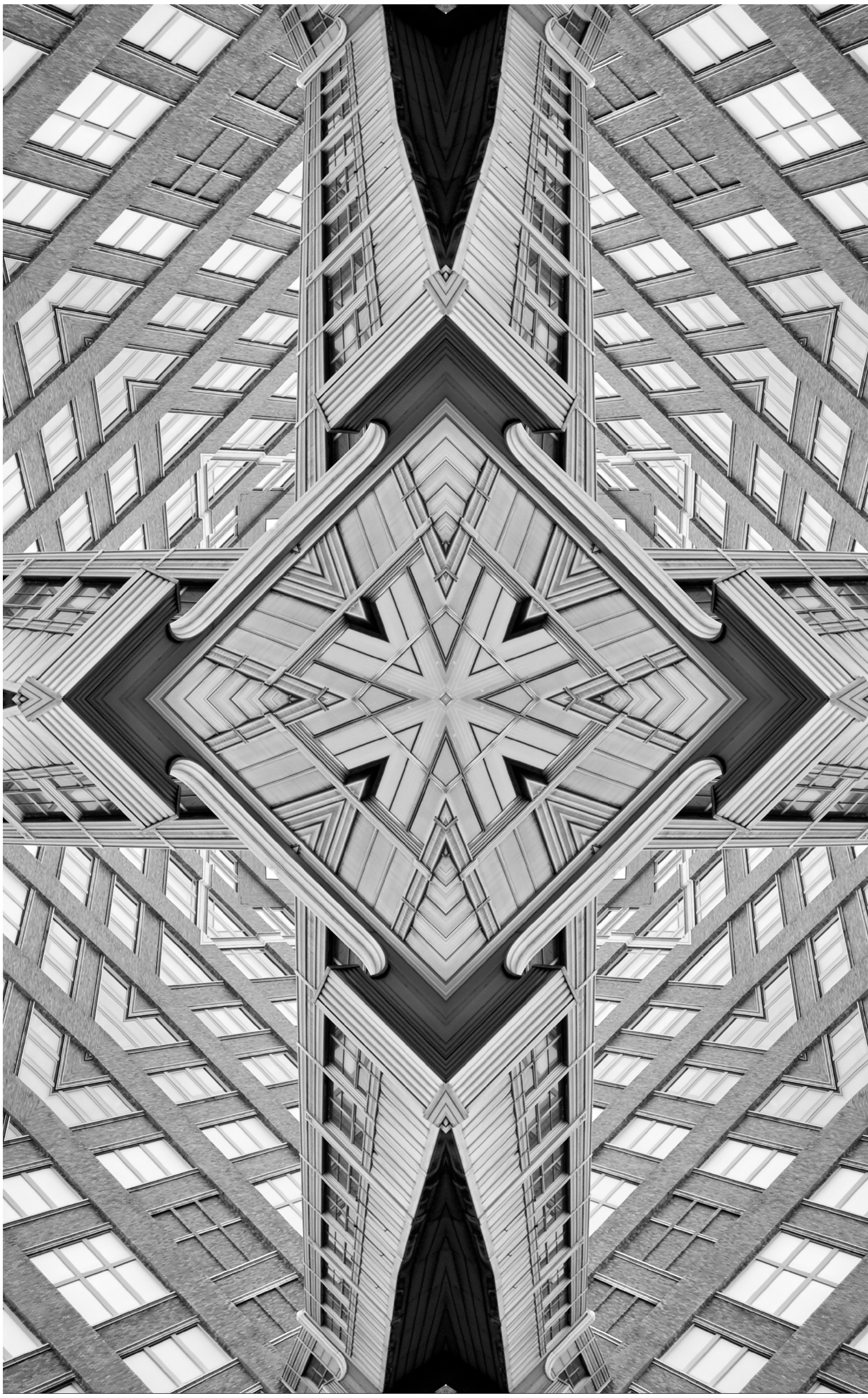

Arresting India's Water Crisis: The Economic Case for Wastewater Use

Mitali Nikore and Mahak Mittal

Abstract

In India, 600 million people face acute water shortages, and the demand for domestic water has risen by some 20 percent since COVID-19, as awareness increased about hygiene. The use of treated wastewater is among the strategies that can be employed to address the shortage. This brief makes an economic case for using treated water to plug the increasing demand-supply gap by comparing key learnings from successful global models and highlighting how public private partnerships (PPPs) can be leveraged to bridge India's US$257-billion gap in water infrastructure funding. It recommends specific policy changes, including the introduction of central schemes to incentivise greenfield sewage treatment plants and common effluent treatment plants on PPP basis, as well as the application of technological solutions.

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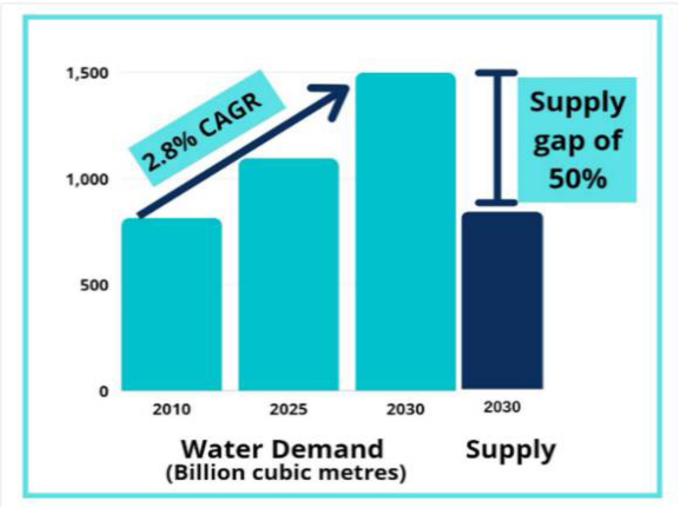
Introduction

This year's World Water Day, being marked on 22 March, is a sombre occasion. After all, 600 million people in India currently face acute water shortages, and almost 200,000 lose their lives from lack of access to safe water.[1] More than 12 percent of the country's population (or approximately 163 million) are already living the "Day Zero" scenario,[a] with no access to clean water within or near their homes.[2] The COVID-19 pandemic has exacerbated the water crisis by increasing the demand for domestic water by 20-25 percent, as hygiene awareness has grown and households are practicing handwashing more regularly.[3]

The future scenario gives no hope, as water demand is projected to exceed supply by 50 percent by 2030 (See Figure 1). Agriculture would be the worst hit, followed by industries that are heavily dependent on water, such as food processing, beverages, textiles, metals, chemical, paper and leather. The water shortage could result in a six-percent loss in GDP by 2050.[4, 5,6]

Figure 1:
Water demand and supply scenario by 2030 in India



Source: The 2030 Water Resources Group Data[7]

Note: The demand for water in India is expected to grow at a 2.8% Compounded Annual Growth Rate (CAGR) from 2010 to 2030, facing a supply gap of 50% by 2030.

a Day Zero is defined as the point in time when a region runs out of water.

Water shortage brings with it other consequences, among them, worsening already existing rural-urban and gender-based inequalities. To begin with, water scarcity in India impacts women more severely than men. Indian women spend some 150 million days collecting water annually, losing an estimated INR 10 billion (US$133 million) in incomes.[8] Moreover, water supply systems are unevenly distributed: 52 percent of households in urban areas have tap access, against a much lower 18 percent of rural households.[9]

Among India's fundamental problems is the lack of freshwater resources. While the country is home to 18 percent of the world's total population, it accounts for only 4 percent of global freshwater resources.[10] Freshwater sources fulfil 85 percent of India's water demand (See Figures 2 and 3), and it remains the world's largest consumer of groundwater, consuming 124 percent more groundwater than China or the US.[11]

Figure 2: Water use across sectors in India

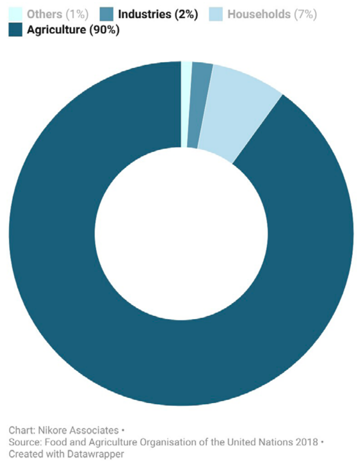
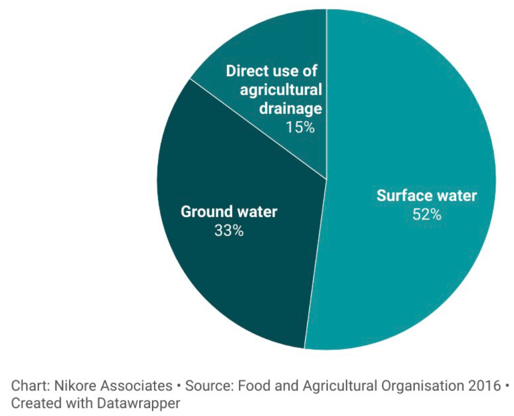


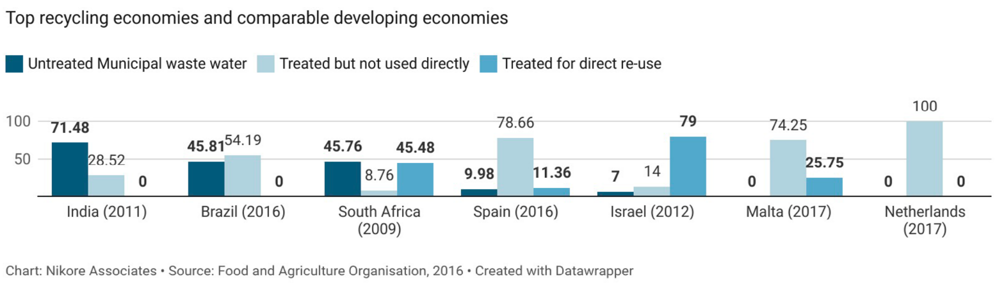
Figure 3: Water use by source in India



Source: Food and Agriculture Organisation of the United Nations Data[12]

At the same time, a potential source of water – wastewater, is highly underutilised. If India reuses 80 percent of its untreated wastewater from 110 of its most populous cities, 75 percent of projected industrial water demand can be met by 2025.[13] Sludge from treated wastewater can irrigate from one to three million hectares of land annually, while providing nutrients to crops and reducing fertiliser dependence by 40 percent.[14] Moreover, the use of treated wastewater for non-potable industrial and agriculture purposes frees up freshwater for drinking water consumption.[15] India generates approximately 62,000 million litres per day (MLD) of domestic sewage in urban centres. There are 920 sewage treatment plants (STPs) operated primarily by municipal corporations, with a treatment capacity of close to 23,000 MLD, i.e., merely 37 percent of generation. Only 33 percent of India's urban wastewater is actually treated, and an even smaller portion is reused.[16,17] These figures are low when viewed against those of comparable countries. For instance, BRICS nations Brazil and South Africa treat 45-55 percent of their wastewater (See Figure 4).

Figure 4: Wastewater treatment and reuse (% of wastewater generated)



Source: Food and Agricultural Organisation of the United Nations Data[18]

The Central Pollution Control Board (CPCB) estimates that sewage generation will increase to over 120,000 MLD by 2051. Moreover, approximately 13,500 MLD of industrial wastewater is generated by manufacturing clusters, 60 percent of which is treated at the country's 193 common effluent treatment plants (CETPs).[19,20] The gaps in treatment capacity are amplified at local levels, as STPs are concentrated in larger cities and CETPs are unevenly distributed across states.[21]

Introduction

Recognising this challenge, the Indian government shifted its focus to solid waste, sludge and greywater management under the Swachh Bharat Mission 2.0 (SBM 2.0), the second phase of the central government's country-wide campaign to eliminate open defecation and improve solid waste management. Following a sustained focus on achieving open defecation-free (ODF) status, the Ministry of Housing and Urban Affairs (MoHUA) developed detailed criteria for cities to achieve ODF+, ODF++ and Water+ statuses in May 2020.[22] As per this definition, cities must satisfy three criteria to be declared Water+ (the highest rating):

1. 100% of domestic, industrial and commercial wastewater must be treated.

2. There should be adequate capacity to treat wastewater and sewage.

3. Infrastructure should be properly maintained, and cost recovery should be ensured through the reuse and/or recycling of treated water.

Despite these new targets, the budget allocation for SBM Urban has remained flat between 2020-21 and 2021-22, at INR 23 billion.[23,24] Thus, as state governments and city-level agencies pursue Water+ status, two questions arise: How will municipal bodies and city authorities mobilise the additional financing required to bridge wastewater treatment capacity gaps? And how will they ensure the operational efficiency and maintenance of these facilities? This brief argues that partnerships with the private sector will be key.

> If India reuses 80% of its untreated wastewater from 110 of its most populous cities,75% of projected industrial water demand will be met by 2025.

Modern wastewater treatment plants (WTPs) are capital-intensive and require the use of innovative technology, such as sensors, Internet of Things (IoT) devices and Artificial Intelligence (AI)-based trackers. The high upfront capital requirements in machinery and equipment, combined with unpredictable revenue streams, make this a high-risk sector, deterring private sector investment.

Global experience suggests that countries which have transformed wastewater treatment into a business opportunity succeeded by leveraging the public private partnership (PPP) model. In this scenario, governments provide financial support to WTPs, lowering investment risk, and private sector firms accord technical expertise alongside capital investment. This allows PPPs to be more cost-efficient than purely government-run projects. Furthermore, it allows for scale: a larger number of WTPs can be established through PPPs given the fiscal constraints of government-led investment. Israel and Singapore are two leading international examples in this regard. Both countries have leveraged advanced technology, enacted clear regulations, and built strong institutional capacity in the wastewater sector. The following paragraphs describe their experience and outline the lessons that can be learned by India.

Israel

Israel has historically faced severe water scarcity, primarily due to its geography and location. More than half the country is occupied by desert land, and it experiences a semi-arid climate; prolonged periods of drought are common. However, it is now a global leader in the sector of recycled water utilisation and recycles 87 percent of collected wastewater. Treated water met one-third of national demand in 2015, effectively reducing groundwater dependency and improving drought resistance.[25]

Success factors:

1. **An Integrated Water Authority and a new financial framework.** Established in 2007, the Israel Water Authority (IWA) is the national water planning body that regulates freshwater, wastewater, and irrigation. This streamlines water management. Wastewater is optimally directed to water-stressed/intensive sectors. IWA also devised a new financial framework, integrating tariffs with cross-subsidies across user groups and financial incentives for operational

performance. Consequently, Israel's water sector achieved near-complete financial autonomy in 2017.

2. **Subsidies for construction of wastewater treatment plants (WWTP)**. Israel recognises that the construction and operation of WWTPs is capital cost-intensive. Therefore, the treatment and storage of recycled water is subsidised by IWA. Around 18 percent of water tariff collections cover sewage treatment costs, and 4.5 percent, subsidies.

3. **Farmer price subsidies.** Over 87 percent of treated wastewater is used for agriculture, meeting half the national irrigation demand. Tertiary treatment has an average cost of around US$3.15/$m^3$. However, farmers are offered treated water at US$0.22-US$0.34/m^3, below freshwater prices (US$0.22-US$0.7/m^3). The government subsidises the conveyance costs of treated water, further incentivising substitution away from freshwater.

4. **Transparent regulations.** Between 2010-2015, Israel specified effluent quality standards and sewage treatment rules for better public health. Information on water use and prices is publicly accessible.[26]

5. **Technological innovation.** The private sector is incentivised to deploy high-tech solutions in wastewater treatment. For instance, the indigenous firm Solidat developed sensor-equipped gauges that are resistant to high-methane environments and which track sewage-level fluctuations. The municipality deployed these sensors and began delivering SMS alerts to on-ground teams for real-time maintenance, transforming the city of Holon's sewer systems. National utilities also leverage PPPs to improve operational performance, e.g., the biogas production PPP at Kfar Saba Hod Hasharon WWTP began in 2016 and cut energy costs by 20 percent.[27]

Singapore

Singapore is a water-scarce country heavily dependent on Malaysia for water imports. In 2003, they first began reusing treated wastewater to produce NEWater, i.e., ultra-clean, high-grade reclaimed water.[28] Currently, NEWater meets 40 percent of Singapore's total water demand. By 2030, they aim to meet 50 percent of this demand.[29]

Success factors

1. **Circular reuse.** Singapore has four water reclamation plants which conduct primary and secondary sewage treatment to produce effluent-free, treated used water in line with international standards prescribed by the World Health Organization. The country's five NEWater treatment plants then undertake tertiary treatment, passing the treated used water through microfiltration, reverse osmosis, and ultraviolet disinfection.[30] NEWater is piped to industries from five reservoirs through a 515-km transmission network. Industry effluents return to the sewer network following appropriate treatment, regenerating NEWater. The treatment is highly efficient, offering reuse potential of up to 0.75 units and yielding 0.64 units of treated water per unit of wastewater.[31]

2. **Revenue risk borne by national water authority.** The private sector finances, constructs and operates Singapore's four NEWater plants under 'Design-Build-Own-Operate' concession agreements (≥25 years). The Public Utilities Board (PUB) purchases NEWater at pre-agreed tariffs for the agreement's duration, guaranteeing revenues for NEWater plants.[32]

3. **Tariffs.** PUB prices water to cover the costs of production, collection, treatment and reuse. It levies taxes to reflect water's scarcity value and encourage conservation. Industrial users pay two tariffs: one for treated freshwater and a lower one for NEWater.

4. **Performance-based procurement.** PUB's procurement is driven by performance, with NEWater quality as the key selection criteria, rather than just the lowest provision cost.

PPPs in Wastewater: The Indian Experience

Estimates from the World Bank show that globally, there were 1,025 PPP projects between 2007 to 2020 in the sector, covering integrated municipal solid waste, water treatment, and disposal, with an investment of US$81.6 billion.[33] Of these, only 65 PPPs were from India, involving US$2.8 billion investment or a mere 3.4 percent of global expenditure.[34] Various challenges inhibit India's private sector from establishing wastewater PPPs:[35]

1. **Investment risks.** High capital costs discourage private players from entering the market. Furthermore, to merely break even, firms need to wait three to eight years.[36] PPPs have typically been successful in India when private firms enjoy low fixed capital costs, i.e., when projects are funded by government schemes.

2. **Demand risks.** Low water tariffs and little regulation governing user charges make it difficult to collect fees on wastewater to cover costs. The cost of utilities is rarely covered by the revenue from dried sludge, and firms face high uncertainty in demand. Compounding this challenge, freshwater and treated wastewater are not differently priced.

3. **Payment risks.** Delayed or total non-payment of contractually agreed annuities from government agencies discourage PPPs, particularly with financially weaker water boards and in non-metro cities.

4. **Quality and quantity of municipal sewage.** The inadequate supply of raw/secondary-treated sewage affects operational efficiency and profitability. Sewage adulteration with industrial effluents (due to ill-designed municipal systems) impairs treatment functions, resulting in costly and avoidable repairs.

In spite of this, there are WTPs established on the PPP model successfully operating in India. Notable examples include the Hindustan Zinc STP in Udaipur, Rajasthan, and the Thane Belapur CETP in Maharashtra.

> "High capital costs discourage private players from entering the wastewater market."

Hindustan Zinc Sewage Treatment Plant (Udaipur, Rajasthan)

In 2012, Hindustan Zinc Limited (HZL) established a PPP with the Udaipur Municipal Corporation (UMC) and the Rajasthan Urban Improvement Trust to build Udaipur's first STP. The aim is to treat 100 percent of Udaipur's domestic sewage by 2022.[37]

Success factors

1. **Anchor investor.** The STP was constructed and commissioned on a 'Design-Build-Own-Operate-Transfer' basis and funded completely by HZL. HZL financed the US$27-million capital cost and built a 78-km pipeline linking the STP to its industrial complex. Government agencies contributed 70 percent of costs for a seven-km pipeline linking the sewerage system with the STP.[38]

2. **Community buy-in.** Acquiring land close enough to the city and HZL's industrial complex was a challenge; residents were concerned about the STP's appearance and odour. The government ran successful community consultations, thereby building public trust.

3. **Treated water diversification.** As of 2016, the STP treated 30 percent of Udaipur's sewage, 20 MLD, and provided 3.5 million m^3 of wastewater to HZL for smelting/mining operations annually. This reduced HZL's freshwater withdrawals by 60 percent, from 16,500 to 7,000 m^3/day. Given the excess capacity (~10,000 m^3/day), 1.1 million m^3/year of treated effluents was diverted towards recharging rivers, and 730,000 m^3/year for horticulture. Moreover, the plant produces 120 tonnes of sludge yearly which the UMC sells to local farmers, generating US$156,000 in revenue.

4. **Regulatory compliance.** The government and HZL secured project approvals through clear, codified roles and responsibilities which optimised risk transfer when building pipelines across busy urban/tourist areas.

Thane Belapur CETPs (Maharashtra)

Common effluent treatment plants (CETPs) offer common facilities for Micro, Small and Medium Enterprises (MSMEs) that cannot otherwise afford water treatment.[39] The first CETP in the Trans Thane Creek (TTC) industrial area was established in 1997 with a capacity of 12 MLD, at a cost of INR 45 million (US$0.6 million). It was upgraded by 15 MLD in 2006 for INR 80 million (US$1.06 million). The plant serves 572 small-scale and 91 medium/large-scale members of the Thane-Belapur Industrial Association (TBIA), and 2,582 non-member users.[40] This model is now being replicated across Maharashtra.

Success factors

1. **Compulsory membership.** The Maharashtra Pollution Control Board (MPCB) mandates membership for all MSMEs located in the TTC. Greater participation helped the plant achieve economies of scale, keeping operating costs low and treatment charges affordable.

2. **Support to small industries**. TBIA defined three categories of membership: small-scale, medium/large, and associate. They introduced a differentiated pricing system, allowing smaller industries to bear only 15-20 percent of capital and treatment costs. Associate members who do not generate effluents, paid a one-time capital contribution; their domestic sewage is treated for free.

3. **Capital costs.** The government funded 25 percent of the capital cost of the 12 MLD plant and 50 percent of the 15 MLD plant. The Maharashtra Industrial Development Corporation provided common infrastructure (drainage networks, pumping stations, transformers and biological tanks).[41,42]

4. **Anchored by industry association.** TBIA's in-house technical experts designed the CETP, meeting industry needs right from the design stage. The CETP Thane-Belapur Association special purpose vehicle manages operations under guidance from its Board of Directors, several of whom are TBIA members serving in an honorary capacity. The Board also has technocrat engineers and other experienced professionals who are part of subcommittees, ensuring efficient management.[43]

As demonstrated in the examples above, a strong anchor, be it a firm or industry association, is essential to drive project implementation. Government support with capital costs is essential for the MSME sector, while large industries can bear these expenses. The government must set clear regulations around user charges, water quality and treatment processes to help private investors estimate total costs, identify revenue streams and establish long-term financial sustainability.

Way Forward: Incentivising PPPs in the wastewater sector

The water and wastewater treatment market in India is a US$4-billion industry, growing at 10-12 percent annually (pre-COVID-19).[44] In a post-pandemic economy, central and state governments must work in partnership to create markets for treated water.

1. **Clear targets for wastewater reuse to create demand.** The CPCB, State Pollution Control Boards (SPCBs) and state governments must together develop five-, 10- and -15-year transition plans as well as guidelines with clear wastewater reuse targets for urban local bodies and industrial area authorities. This will ensure that at least 75 percent of wastewater generated is recycled and of this, 50 percent is treated for direct use in the medium term, in line with global best practice standards established by leaders such as Israel and Singapore. This plan must specify user categories, e.g., industrial users, construction sector, agriculture sector and urban landscaping projects, which slowly become ineligible for freshwater supply as per phased transition plans. This will ultimately create a market for treated water.

2. **Establishing a predictable water tariff regime.** Water tariffs rarely include costs of service, transport, treatment and disposal.[45] Only ~58 percent of households are charged for water supply,[46] and in agriculture, costs far exceed receipts for irrigation.[47,48] There is a need for central and state agencies to devise general water tariff principles, while ensuring that differentiated tariffs for treated and freshwater, reflecting the scarcity value of freshwater. The applicability of limited term financial incentives and subsidies can also be studied to encourage the use of treated water. For instance, industries which pay the highest water tariffs, or agriculture-sector users, who account for 90 percent of freshwater users, can be offered rebates for using treated water.

3. **Innovative financing options.** India's water sector faces an investment gap of ~US$257 billion between 2015 and 2030.[49] NITI Aayog and the central government should evaluate innovative instruments to leverage financing for the Indian wastewater sector including: (i) municipal bonds;[b] (ii) impact

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b A municipal bond is a debt security issued by an Urban Local Body (ULB), Special Purpose Vehicle (SPV) or State level Parastatal, to finance capital expenditures such as the construction of highways, bridges or schools or any other project of public utility such as water saving project, energy saving project, etc. See: The Institute of Chartered Accountants India, Municipal Bonds for Financing Urban Infrastructure in India: An Overview, The Institute of Chartered Accountants India, 2018, https://cpfga.icai.org/wp-content/uploads/2019/06/municipal-bond.pdf bonds;[c] (iii) ring fenced funds[d] for CETPs and STPs managed by the National Infrastructure Investment Fund (NIIF); and (iv) central government guarantees[e] to cover delayed/non-payment of dues by project sponsors.

4. **Sector-specific model concession agreements.** Concession agreements are legal agreements between government authorities and the private sector presenting the terms of a PPP, specifying the outcomes to be delivered by the private party, and the payment conditions. Model Concession Agreements (MCAs) are standard documents issued by government agencies which can be used as a guide to develop project-specific concession agreements. While NITI Aayog recently issued an MCA for the establishment of integrated liquid and solid waste management plants,[50] states and municipal agencies can be provided with sector-specific MCAs for CETPs and STPs, for a variety of alternate PPP models to ease procurement even further. This has been done in the transport sector, where separate MCAs exist for four and six-lane national and state highways, and for highway Operation and Maintenance (O&M). Further, MCAs should be regularly reviewed and updated, as was done with the MCA for Major Ports in 2018.[51]

5. **Harnessing technological advancements.** The MoHUA issued guidelines in July 2020 encouraging urban local bodies (ULBs) to partner with the private sector for sewage management through transparent tendering processes. State governments and ULBs should also be guided to explore innovative PPP models and procurement conditions that incentivise bids from tech-based private players that can improve efficiency in wastewater sector projects. Moreover, given the scarcity of private sector firms with requisite skills and experience, a panel of experts (firms/individual) may be constituted at the central and state levels to advise on technological innovations in the sector. Some of these high technology areas include:

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c Impact bonds are outcomes-based contracts. They use private funding from investors to cover the upfront capital required for a provider to set up and deliver a service. The service is designed to achieve measurable outcomes specified by the commissioner. The investor is repaid only if these outcomes are achieved. See: University of Oxford Government Outcomes Lab, "Impact bonds," University of Oxford Government Outcomes Lab Website, https://golab.bsg.ox.ac.uk/the-basics/impact-bonds/

d A ring-fence is a virtual barrier that segregates a portion of an individual's or company's financial assets from the rest. See: Investopedia, "Ring-Fence," Investopedia Website, https://www.investopedia.com/terms/r/ringfence.asp

e A guarantee is a promise by a guarantor to a beneficiary (or beneficiaries) that, in the event of a specified default by an obligor, the guarantor will pay the beneficiary a specified amount. Although similar to insurance, a guarantee does not entitle the issuer to review a claim before it is paid; rather, the payment is triggered by specified events. See: United Nations Development Programme (UNDP), "Public guarantees," United Nations Development Programme Website, https://www.sdfinance.undp.org/content/sdfinance/en/home/solutions/public-guarantees.html

a. **Smart hybrid infrastructure.** *Predictive maintenance technology*, such as big data to predict leakages; AI-based risk management of water networks;[52] *Performance monitoring of treatment plants* using video and augmented reality-based systems on a real-time basis;[53] and *optimising operating efficiency* using smart water meters, energy-saving sensors and other IoT devices, which should be integrated at the design stage of WWTPs.

b. Continuous Emission Monitoring System (CEMS) upgrade. Poor compliance standards plague the CPCB's real-time pollution monitoring system CEMS. Declining expenditure across SPCBs reduces the effectiveness of physical inspections. To solve this issue, the Delhi Pollution Control Committee (DPCC) publishes real-time emission/effluent readings online as public information, managed through a centralised software. Such technology-enabled transparency measures can improve accountability and should be replicated across states. Training CPCB, SPCB staff to use cameras for real-time monitoring is also essential.

c. **Energy efficiency.** Energy expenditure is the highest cost associated with water supply (40–60 percent of operating expense). Higher incentives and tariff subsidies can be extended to project sponsors co-investing in solar/wind/biogas energy generators to power CETPs and STPs for both public and PPP projects.[54]

6. **Soft interventions.** Behavioural changes and respect for water stress lie at the core of any intervention in the water sector. Public awareness campaigns by governments and community organisations targeted at industrial, agricultural and domestic users are essential to bring about lasting change. Most importantly, capacity-building programmes for staff and officials at treatment plants are required to improve implementation.

> "Behavioural changes and respect for water stress lie at the heart of any intervention in the water sector."

Conclusion

Avoiding a day-zero scenario in major Indian cities requires urgent and dedicated effort, not only from governments and municipal agencies, but also from the private sector and the citizens. The experience of the COVID-19 pandemic has lifted the veil on the frailties of current economic pathways, which now need to be set on a more environmentally sustainable foundation.

Wastewater recycling offers a solution that could benefit all parties involved. With the public sector providing a clear regulatory framework, tariff regime and risk mitigation instruments, PPPs can be leveraged to create CETP and STP infrastructure, and bridge financing gaps. A market for treated water can be established to maximise the circular use of scarce freshwater. Under a differentiated tariff regime, the cost of water as an input for select consumer categories such as agricultural or industrial users can be reduced, and freshwater conservation can be encouraged. SBM 2.0 offers the perfect opportunity to implement these initiatives and achieve the goal of 100% Water+ cities.

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Endnotes

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