WASTE TO WORTH

MANAGING INDIA'S URBAN WATER CRISIS THROUGH WASTEWATER REUSE

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Research direction: Depinder Singh Kapur

Authors: Faraz Ahmad and Sumita Singhal

Editor: Rituparna Sengupta and Souparno Banerjee

Cover and design: Ajit Bajaj

Layouts: Surender Singh

Production: Rakesh Shrivastava and Gundhar Das

Acknowledgement

Micro Irrigation and Command Area Development Authority, Government of Haryana
Public Health Engineering Department, Government of Haryana
Gurugram Metropolitan Development Authority
Delhi Jal Board, Delhi
Uttar Pradesh Jal Nigam, Uttar Pradesh
Urban Improvement Trust, Government of Rajasthan
Hindustan Zinc Limited, Udaipur, Rajasthan
Bangalore Water Supply and Sewerage Board, Bengaluru, Karnataka
Biome Environmental Trust, Bengaluru, Karnataka
Chennai Metropolitan Water Supply and Sewerage Board, Chennai, Tamil Nadu
Maharashtra State Power Generation Co. Ltd. (Government of Maharashtra Undertaking)
Ecosan Services Foundation, Pune, Maharashtra
Jheel Sanrakshan Samiti, Udaipur, Rajasthan

The Centre for Science and Environment is grateful to the Swedish International Development Cooperation Agency (SIDA) for their institutional support.

Citation: Faraz Ahmad and Sumita Singhal 2024, *Waste to worth: Managing India's urban water crisis through wastewater reuse*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000, Fax: 91-11-29955879
E-mail: sww-aaeti@cseindia.org, Website: www.cseindia.org

CONTENTS

CONTENTS

FOREWORD

Every society must understand how the excreta it produces is managed. It teaches us many things about water, about waste, about technologies to clean, economics and politics: of who is subsidised to defecate in our societies. Today, the challenge also is that every society must connect the dots between the excreta it produces, the pollution it causes, and the opportunity it has to reuse and recycle that waste so that it becomes a resource. This is what our report, Waste to Worth is about—it puts together the best practices to make wastewater into water and not pollution.

Remember, unlike the use of water in agriculture where it is 'consumed' for growing food, in the case of urban consumers, or even industrial, the bulk of the water is used, but then not discharged. Today, the discharge of effluent is adding to the water crisis by degrading available water through pollution. It is also adding to our health crisis as societies continue to drink this 'sewage' laced water. All this then points to the solution ahead—the way to take that 'wasted' water and make it 'used' water so that it can be returned to the hydrological cycle.

Over the years, my colleagues have studied the excreta sums of different cities. The city 'shit-flow' diagram shows that the situation is grim as all cities either do not treat or safely dispose the bulk of the human excreta. This is because we often confuse toilets with sanitation. But the fact is that toilets are mere receptacles to receive waste; when we flush or pour water, the waste flows into a piped drain, which could be either connected, or not, to a sewage treatment plant (STP). This STP could be working, or not. In this case, the faecal sludge—human excreta—could be conveyed, but not safely disposed as it would be discharged into the nearest river, lake or a drain. All this will pollute the environment. In most cities, this connection from the flush to the STP does not exist. According to Census 2011, the flush water of some 30 per cent of urban India is connected to a piped sewer. But our survey found that in most cases, these underground drains have either lost their connections—they need repair—or are not connected to the sewage plants.

There is another route for excreta to flow. The household flush or pour latrine could be connected to a septic tank, which, if it is well constructed, will retain the sludge and discharge the liquid through a soak pit. The faecal sludge would still need to be emptied and conveyed for treatment. But in most cases, our survey found the septic tank is not built to any specifications—it is a 'box' to contain excreta—and it is either connected to a drain or emptied out. This is where the drama of faecal sludge begins. Who collects it? How is it transported, and most importantly, where does it go? Nobody knows.

This is why the focus has shifted and is now towards intercepting the sewage—not through capital-intensive underground pipes but through tankers to transport this for treatment. The fact is that septic tanks are decentralised waste collection systems. Instead of thinking of building an underground sewerage network—that is never built or never completed—it would be best to think of these systems as the future of urban sanitation. After all, we have transitioned to mobile telephony, moving away from the landline. Individual septic tanks could be the way to achieve full sanitation solutions.

For this, the government has made changes in policy and now practice—it has recognised that these systems exist and that they need to be incorporated in sanitation plans. Secondly, they are providing regulation for the collection and transportation of faecal sludge so that the waste is taken for treatment, and not dumped somewhere. And most critically, city governments are working the treatment system for faecal sludge – which in turn will reduce the pollution in rivers and lakes. But now the challenge is that we must reuse this treated water.

This is where the real opportunity lies. The fact is that this treated water and sludge is nutrient rich. Today, the global nitrogen cycle is being destroyed because we take human excreta, which is rich in nutrients, and dispose it in water. In this case, we can return the human excreta back to land, use it as fertiliser and reverse the sanitation cycle. The treated water or faecal sludge, after treatment, can be given to industry or cities to reuse as water and farmers for soil enrichment.

This is when we know that climate change will impact the hydrological cycle of cities—it will bring more water in fewer number of rainy days, which in turn will add to the challenge of drought and flood, particularly in urban areas. Currently our cities are dependent on long distance sources; pumping and piping this water meant both losses in distribution as well as costs of electricity, and this in turn made the available water expensive and more inequitable. As water supply dried up, people turned to groundwater and without recharge—ponds and tanks had been decimated up by real estate or simply through neglect—meant declining water levels.

In all this, new solutions have emerged—if affordable water supply was critical, then cities needed to cut the length of their distribution pipelines, which meant increased focus on local water systems like ponds, tanks and rainwater harvesting. Then, if cities needed to ensure affordable sanitation for all and affordable treatment of wastewater, then on-site systems could be re-engineered so that waste was collected from each household, transported and treated. But most importantly, we have learnt that if this urban-industrial wastewater is treated for reuse then water is not lost. More importantly, our rivers will not be lost.

In all this we must minimize our use of water—become much more efficient with every drop. This means doing everything from investing in water efficient irrigation, household appliances and changing diets so that the crops we eat are water prudent. It means turning every drop of used water into water for use again.

Our *Waste to Worth* publication advocates for a fundamental shift in policy and practice from a linear water economy—where water is used once and disposed off—to a circular economy model where water is reused and recycled in a sustainable loop. The book analyses the current national and state-level status and context of policy actions for re-use of treated wastewater.

Case studies from seven states (Haryana, Delhi, Uttar Pradesh, Karnataka, Tamil Nadu, and Maharashtra), documenting few towns in each state, highlight what is happening on the ground and what more needs to be done. Cities like Bengaluru have demonstrated the value of linking water supply, treated wastewater and the city lakes and water bodies, and an understanding of aquifers and groundwater, to forge a re-imagined urban water supply and wastewater management for the cities of future.

The reuse of treated wastewater from STPs for the purposes of lake recharge, park maintenance, industrial processes, shallow aquifer recharge, and irrigation ensures not only a significant addition of 'new water', but also ensures that treatment standards at the STPs are followed and compliance is monitored all stages of re-use. It makes the users of this treated water the agents to ensure compliance with standards. Just imagine, if you were to be a consumer of this treated water for your horticulture needs, you would be vigilant of its quality and ensure that it does not contaminate your land. This is why this approach adds to the enforcement of standards.

But this also means that we need new standards to be set for reuse of treated wastewater so that basic nutrients needed for land are not lost in the treatment. We need quality standards to be defined by the use of the treated water and we need enforcement so that this can be ensured.

This is the opportunity—this decade can be about putting our learnings to practice and to turn around the water-story of India—a need, particularly at a time of climate change. In this decade, we will witness nature's retaliation as the effects of climate change intensify. The need then is to scale up our work to invest in local water systems to capture every drop of rain so that we can build local resilience against drought. We also need focus on our cities, and the lakes and ponds that act as sponges that will allow us to harvest the rain-flood and make sure that it does not turn into wasted water. We also need to protect our forests and green spaces as they play a critical role in water recharge. More importantly, in the times of water stress, we must not only must be making sure that wastewater is treated but more importantly, it is recycled and reused. It is here that the water bodies we protect in our cities—those ponds and tanks we use to divert and collect rainwater—can also be used to channel treated sewage, thereby recharging groundwater. It's a cycle of water to water, ensuring we achieve water security through wise water management.

Sunita Narain

EXECUTIVE SUMMARY

India is witnessing rapid urbanization, but most of it appears to be unplanned. One of the critical concerns has been the management of wastewater and stormwater, which have largely been considered from a 'disposal' perspective, and not from a 'reuse' point of view.

India is in dire straits when it comes to water availability. There is an overall decline in the annual per capita freshwater availability—it is now below 1,700 cubic metres(m^3), making India a 'water stressed' country, ranked 132nd among all nations with respect to per capita water availability.[1] According to international norms,[2] a country is classified as 'water stressed' when water availability is below 1,700 m^3 per capita per year, while 'water scarce' is defined as availability below 1,000 m^3 per capita per year.

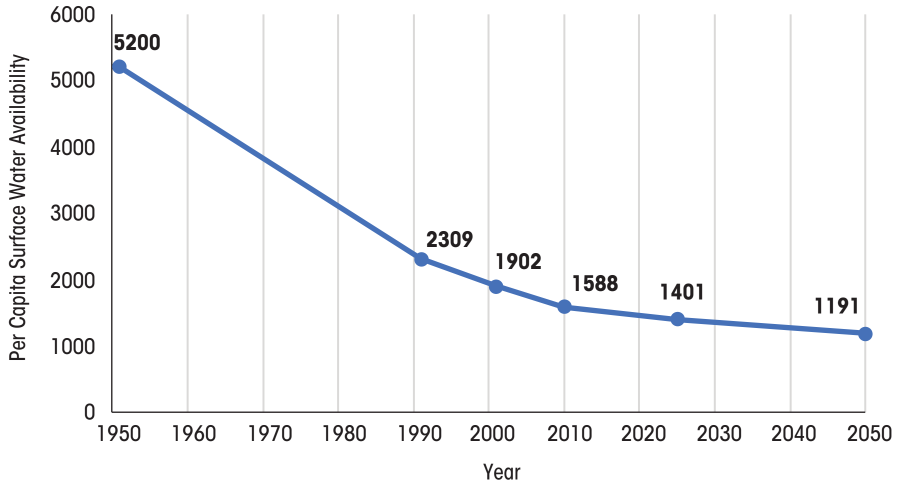
Between 1951 and 2024, there has been a decline of 73 per cent in per capita surface water availability in the country[3] *(see Graph 1: Trends in per capita availability of surface water resources in India)*. Occupying only two per cent of the Earth's landmass and harbouring four per cent of its freshwater resources, India supports 18 per cent of the human population and 15 per cent of the world's livestock.[4]

As per the NITI Aayog Composite Water Management Index,[5] Indian states are demonstrating progress in water management, but the overall performance remains well below adequate: 80 per cent of the states assessed on the Index between the year 2017–2019 have shown improvement in their water management scores, with an average improvement of +5.2 points.[6] But worryingly, 16 out of the 27 states still score less than 50 points on the Index (out of 100), and fall in the low-performing category. These states collectively account for 48 per cent of the population, 40 per cent of the agricultural produce, and 35 per cent of the economic output of India.

Most of our cities have not been planned with a focus on integrated and decentralized systems of water supply, stormwater and wastewater management, *in-situ* water conservation and reuse of treated water. Engineering solutions to secure water from faraway sources to meet the ever-increasing water demand in urban areas has its limits, as is being witnessed in almost all Indian cities today. The cost of transporting this water is huge. Cities such as Delhi, Bengaluru, Mumbai, Pune, Hyderabad and Chennai, among others, as well as many small and medium towns, are staring at a scenario where their sources will eventually completely run out of water, and fail to meet the current as well as future water needs. Already, the inequity in water supply within a city results in massive under-supply in certain parts, especially in the urban peripheries, and in a majority of the unplanned and informal settlements.[7]

Delhi is dependent on three rivers (the Satluj, the Yamuna and the Ganga) and a dam (the Renuka dam on the catchment of Yamuna) for its water. For Delhi, water from the Ganga is pumped from 220 km away in Haridwar, through the Upper Ganga Canal. Bengaluru receives its water from the Cauvery, about 100 km away, while Hyderabad gets its water from the Krishna and Godavari rivers, both running at great distances from the city. As cities continue to grow, the distance and quantity of water required from faraway rivers have been increasing; only a small proportion of the water demand in such cities is being met by local water sources such as lakes and flood plains. For instance, in Delhi, less than 10 per cent of the total water supply is from groundwater.[8] This has led to a situation where cities are spending more on the conveyance of water from distant sources. This subsequently results in soaring prices for water, illegal water mafias and uneven access to water for the public.

Graph 1: Trends in per capita availability of surface water resources in India



Source: Water Resource Information System (WRIS)

All our large metro cities, and many other tier two and tier three cities, are now dependent on multiple riverine sources for their water supply, leading to a diversion of what were initially irrigation projects that have now become *de facto* urban water supply projects. Ironically, these big projects are still unable to meet the growing water demand of our cities. The Narmada project in Gujarat and the Bisalpur project in Rajasthan are prime examples of this.

Besides access to freshwater, cities have to also deal with the question of wastewater management. The volume of wastewater generated varies greatly across towns and cities and so does its treatment efficacy. The disposal of wastewater, untreated and treated, into waterbodies—streams, rivers, lakes, wetlands, or the sea—or simply on vacant land, has now reached epidemic proportions, and our rivers and waterbodies are choking from the pollution overload; in fact, many have turned into *nalas* and sewers.

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The unending thirst for freshwater has resulted in diversion of water meant for irrigation from rural hinterlands—this is leading to inter-and intra-state, intra-city, and rural-urban water conflicts. Add to all this the ravages being wrought by climate change, which is manifesting itself as an intensification of the water cycle; as a result, the country is witnessing frequent occurrences of droughts, water stress and floods, worsening the existing mismanagement and inequity in water supply and sanitation services.

REUSING TREATED WASTEWATER—A NEW OPPORTUNITY?

Reusing wastewater generated by cities, which has been adequately treated, is being seen as a new way of supplementing existing water supply. However, unless urban water demand is capped through administrative measures and we begin to look at cities as sites for *in-situ* water conservation, no amount of water supply augmentation, including reuse options, will address the problem of water stress.

Moreover, a reuse policy must adopt an equity and justice perspective, instead of being approached solely through the lens of economic efficiency and techno-managerial interventions, even though these are critical parameters.

CSE STUDY: KEY HIGHLIGHTS

This report is organized into state-wise chapters that include a state perspective on wastewater generation, followed by case studies of a few towns and the STPs where treated wastewater is being reused. Conclusions have been drawn based on a critical analysis of the findings from all the case studies.

Key highlights of the study and its findings

- **The discussion around reusing treated wastewater must start with the assumption that sewage and septage management is happening as per norms;** only then can we talk about how to reuse the treated sewage/septage. For this to happen, firstly, sewage treatment plants (STPs) must be functional as per CPCB discharge norms. Secondly, no industrial effluent must be allowed to enter the STPs as that would compromise the biological treatment process.

- **Reuse of treated wastewater is more feasible if we have planned city-wide wastewater treatment with some clear objectives. In the past, reuse of treated wastewater was never seen as an objective** while setting up STPs in a city. Hence, STPs were located away from the town, wherever land was available. It is, therefore, imperative that all new STPs in future should define their reuse options. The urban local body (ULB) or the state should highlight the prioritization of reusing treated water for STPs in their plans before they get permissions to start operations.

  Large STPs like Bharwara in Lucknow (with a capacity of 345 million litre a day, or MLD) and Okhla in Delhi (564 MLD) require close monitoring to ensure that they are functional and do not release untreated wastewater. Options for reusing large volumes of treated water locally are very limited.

- **Reusing treated wastewater should be seen as a public good.** Treated wastewater is a new water resource. Using treated wastewater for irrigation and groundwater recharge through lakes and waterbodies' rejuvenation should be prioritized. It should be seen as a public good and managed by the ULB or the water utility through a transparent public policy. While industry's need for water is undeniable, we have now come a long way from the time when selling treated water to industry without considering its need and use for other purposes was considered justified.

  Other priorities are environmental and biodiversity considerations, creating public spaces with green-blue infrastructure for people, etc.

  The reuse of treated wastewater may require substantial infrastructure to transport it appropriately for public use, or use for industrial purposes. In Uttar Pradesh, reusing treated wastewater for canal irrigation may require a major infrastructure initiative to transport treated wastewater upstream from the river head-based STPs to canals from where it can be fed for irrigation. The irrigation department of Bengaluru pays for pumping treated wastewater from the city to 200 km away in Kolar and also to suburban Bengaluru for rejuvenation of its lakes.

  Secondary treated water is used to rejuvenate lakes, helping revive the shallow aquifer through natural percolation. This process enhances the domestic water supply, as demonstrated by Bengaluru's Sihineeru Lake rejuvenation project, and provides water for the town. Secondary treatment is adequate for the recharge of lakes and waterbodies.

- **State-level policies on reuse must define priorities and lay down guidelines and implementation norms in a time-bound manner along with monitoring compliance.** Most states that have treated wastewater reuse policies do not explain how a certain prioritization for reuse of treated water was arrived at. Questions that need to be answered adequately include what public consultation or research were conducted to formulate these reuse policies; what are the priorities for reuse in different parts of the state; and what are the trade-offs of reusing treated water for one use over another.

  Reuse prioritization is often guided by an initial lack of sewage treatment infrastructure. In Udaipur city, when untreated wastewater was polluting the lakes and there was a dearth of sewage treatment infrastructure, a private company (Hindustan Zinc Limited) came forward to lay down sewerage infrastructure and convey the sewage to its industrial plant for reuse. This was welcomed by the residents. However, as the demand for freshwater kept increasing, Udaipur started relying on water from reservoirs and rivers that were located far away from the city; treated wastewater was shifted to rejuvenate lakes and recharge the groundwater instead.

  Where civil society is proactive, both treatment as well as prioritization of the reuse is better. Residents Welfare Associations of Bengaluru take an active interest in and monitor the rejuvenation of lakes and waterbodies with treated wastewater from STPs. The civil society of Bengaluru works closely with and supports the city water utility

(BWSSB) in its initiatives of water conservation and reuse of treated wastewater. This is not seen in other states or cities, except perhaps Chennai.

- **What exists as policies are mostly water and wastewater utility-level projects and town-level initiatives.** In case of Uttar Pradesh, the reuse of treated water in cities like Prayagraj (formerly Allahabad) and Lucknow is done in project mode and is implemented in small pockets by the Uttar Pradesh Jal Nigam. In Rajasthan as well, the reuse of treated wastewater by industries is implemented more in a project mode in towns like Udaipur and Beawar and is not part of the larger state-level or town-level treated water prioritization policy.

- **Progressive reuse policies are needed at the state-level to address different scenarios within a state.** In most Indian states, 50 per cent of the total urban wastewater as well as the treated wastewater, is generated by just a couple of towns alone. Several small and medium towns either do not generate sufficient volumes of wastewater or lack the infrastructure to treat it, or both. Priorities for reuse of treated water vary greatly between coastal and inland towns, small and medium towns, and large metros.

  Therefore, a more nuanced policy framework for treated wastewater at the state level is needed, where the kinds of reuse that need to be prioritized for each town and city need to be studied and city-wise reuse planning needs to be undertaken. Making blanket policy statements without a disaggregated visualization of the reuse of treated water for different categories of cities will not help in securing treated wastewater for the best purposes.

- **Prioritize groundwater recharge and environmental and biodiversity considerations.** State-level reuse policies mostly provide open-ended reuse prioritization. Reuse for securing groundwater recharge and for environmental and biodiversity considerations are not identified as priorities. Delhi is an exception where a significant environmental flow in the Yamuna has been mandated by the National Green Tribunal (NGT). This is because the river is completely dammed at the entrance of the city and therefore, it must be recharged by treated wastewater; most other cities have flowing streams and rivers. State-level policies must consider reuse for enhancing the water intake in such streams, rivers and wetlands.

  Haryana's reuse policy is well drafted and backed by the Haryana Water Resource Authority, where reuse prioritization has been defined for irrigation and agriculture. Gurugram is the largest township in terms of generating treated wastewater in the state. It is observed that the town is diverting treated wastewater away from the Najafgarh Jheel (a large natural wetland that is now water-starved) for irrigation purposes to the neighbouring district.

  Rajasthan and Haryana, both semi-arid states, do not prioritize groundwater recharge in their reuse policies.

- **Securing the reuse of treated water for those who need it: institutional strengthening is required for effective reuse of treated wastewater.** In order to secure the water supply for large, dense and unplanned settlements of Delhi, both water supply and sanitation systems need to be reimagined as decentralized systems. In a recent study by CSE on Sangam Vihar (one of India's biggest unplanned settlements),[9] it was found that the city's million-plus unplanned settlements received water supply of only 45 litre per capita a day. Sangam Vihar lies at the tail-end of the Delhi Jal Board's water supply pipelines. The solution lies in augmenting water supply from dedicated decentralized sources—from recharged and tertiary treated water supply through four lakes and four STPs that are within a 10-15 km radius of Sangam Vihar.

For this to happen, not only do we have to reimagine water and wastewater planning from the perspective of decentralized systems, water utilities/boards need to be restructured and strengthened to undertake aquifer mapping for recharge, as well as the discharge and reuse of treated wastewater—a shift from pipeline-based water supply and the 'discharge and dispose' way of thinking.

ABOUT THE STUDY

Promoting a circular economy is at the core of a sustainable and climate-resilient future in India; this has also been the focus of CSE's work in water and environment. Reuse of treated wastewater, or used water as it is now called, is an important part of this work. Managing the demand for freshwater is only possible if we increase the reuse of our treated used water for agriculture, industry and domestic needs. We must also acknowledge the urgency with which this needs to be done, as we now confront incremental climate change risks.

The primary aim of the study by CSE and the resultant report is to present a well-analyzed, state-of-the-art assessment of what the country is doing to mitigate the situation, specifically in the context of reusing treated wastewater—what are the challenges, what is working and what is not, and why. The report also offers recommendations for a further roadmap for the country.

Reusing treated wastewater serves a two-fold purpose: it augments water resources, and reduces the environmental impacts of disposing untreated wastewater. The concept is not a new one. Ancient civilizations have been known to have reused their wastewater generated from urban settlements for irrigating agricultural fields. The first well documented instance of wastewater reuse in India is from Mumbai where the textile industry in the year 1964–65 observed that about 15–20 per cent of the wastewater generated could be reused without any pre-treatment for certain applications like blanket washing, thereby reducing the costs. The recycling was carried out in as many as 22 mills of Mumbai and later few more industries started recycling.[10] Mumbai's Air India building was the first commercial building in India to treat blackwater generated from its toilets and reuse it as cooling water in centralized air conditioning systems. The use of wastewater for irrigation dates back to the 1970s in Chennai.[11]

India has now emerged as one of the fastest growing markets for reuse of treated wastewater, especially for various reuse avenues. A National Framework for Safe Reuse of Treated Wastewater has been published by the National Mission for Clean Ganga (NMCG) has been introduced in 2022.[12] This publication, therefore, is a very timely initiative towards developing a sound understanding of this sector.

SCOPE

The desk research has focused on assessing the extent of water reuse adoption in various urban areas and the government initiatives supporting these practices at city as well as at the state level. The field research has concentrated on reuse of treated used water in seven states: four in north India (Haryana, Delhi, Uttar Pradesh and Rajasthan), and three in south India (Maharashtra, Tamil Nadu and Karnataka).

It then goes on to identify areas of convergence and divergence and lessons learnt, outlining recommendations for different reuse sectors (agriculture, industry, construction and thermal power plants, among others).

The study has selected some of the most significant case studies from the states. It does not focus on decentralized treatment facilities such as at household, institutional or community level; it only concentrates on the reuse of treated wastewater from centralized treatment facilities. We hope that the documentation of these best practices and the lessons therefrom, will help programmes like SBM-Urban 2.0, AMRUT 2.0, and the National Mission for Clean Ganga (NMCG) in promoting a menu of reuse options and strategies.

METHODOLOGY

The research methodology employed for this study can be outlined as shown in Table 1.

Table 1: Research methodology

Sl No	Component	Details
1	Desk research based on secondary sources and mapping reuse of treated used water in India	Conducted secondary research to map the current status of wastewater generation and reuse.
		Collected and analyzed data on wastewater reuse practices, policies and technologies from various states.
		Used this information to refine the research scope, including the selection of states, cities and case studies.
		Identified and focused on states that have issued or drafted reuse policies and demonstrated significant progress in reusing treated water.
2	Analytical assessment of wastewater generation and reuse	Analyzed the feasibility, benefits, challenges and potential impacts of reusing treated wastewater.
3	Primary research	Prepared questionnaires, list of data sets for collection and engaged with targeted stakeholders (see Annexure-1).
		Scheduled visits to various case study sites, ensuring adherence to timelines and stakeholder availability.
		Interviewed stakeholders, including water utilities, local authorities, facility managers, farmers, industry representatives, community members and researchers.
		Gathered ground-level evidence, along with insights into the potential and challenges of treated water reuse.

Sl No	Component	Details
4	Case study development	Developed detailed case studies for each site visited, incorporating contextual information, treatment processes, and types of reuses, benefits, challenges, and stakeholder perspectives.
		Collected and analyzed both quantitative data (such as statistics) and qualitative insights.
5	Report	Compiled the analysis into a comprehensive report, presenting findings and conclusions based on the collected data.
		Taken inputs from webinars/meeting from relevant stakeholders for finalization.

Source: CSE

CHALLENGES

The process of identifying best practices encountered several challenges that were consistent across all states. Table 2 below outlines the challenges in the identification of best practices.

Consultation workshop on 'Reuse of treated by-products from sewage and faecal sludge treatment plants'

Table 2: Challenges in conducting the study

Sl No	Challenges	Details
1	Limited data availability	Obtaining data proved to be a major hurdle during the study, both in terms of secondary research and primary visits.
		The data available for secondary research was scarce and outdated. During site visits, there was reluctance in sharing data.
2	Emphasis on planned reuse of treated wastewater	The study specifically focused on case studies where the reuse of treated wastewater followed formal processes and was regulated by authorities.
		This emphasis excluded informal reuse practices that are prevalent throughout India, limiting the pool of examples for best practices.
3	Selection of large-scale projects demonstrating significant reuse	The projects selected for analysis were based on their capacity for substantial reuse of treated wastewater.
		This criterion aimed to highlight projects that showcased notable achievements in terms of reuse volume.
4	Limited geographic coverage	Upon conducting secondary research and telephonic interviews, it became evident that the reuse of treated wastewater was predominantly limited to a few cities within each state.
		As a result, the case studies may not encompass the full range of typologies found across different cities within the states.

Source: CSE

INTRODUCTION

- Southern Asia has the lowest rates of used water collection, treatment and reuse compared to other regions globally.
- 72 per cent of India's wastewater goes untreated, polluting nearby rivers, lakes and groundwater aquifers, and degrading the water quality.
- Reuse of treated wastewater helps create a closed-loop system where water resources are continuously recycled, providing environmental and economic benefits in line with circular economy principles.
- Maintaining sewage treatment plants effectively and ensuring the treated wastewater meets the standards laid down by the Central Pollution Control Board are critical for wastewater management and reuse.

Dhanwapur Sewage Treatment Plant in Gurugram, Haryana. The total treatment capacity of this plant is 218 MLD.

Water scarcity remains a pressing challenge across the world, with millions facing limited or no access to clean and safe water for drinking and sanitation. Factors such as population growth, urbanization, climate change and inefficient water management exacerbate this crisis. Some of the poorest regions of the world that have a history of grappling with water stress, such as parts of Africa, the Middle East and South Asia, are particularly vulnerable. According to a report from the World Health Organization (WHO), water scarcity has impacted 40 per cent of the world's population, and as many as 700 million people are at a risk of being displaced as a result of drought by 2030.[13]

The World Bank estimates that water scarcity could cost some regions up to six per cent of their GDP by 2050, as industries dependent on water face disruptions, and communities grapple with increased competition for limited resources. Urgent action is needed to mitigate these effects, including investment in water infrastructure, adoption of efficient irrigation techniques, and policies promoting water conservation and equitable distribution. Addressing global water scarcity requires collaborative efforts at the local, national, and international levels to ensure access to clean water for all, while safeguarding ecosystems and sustaining economic development.[14]

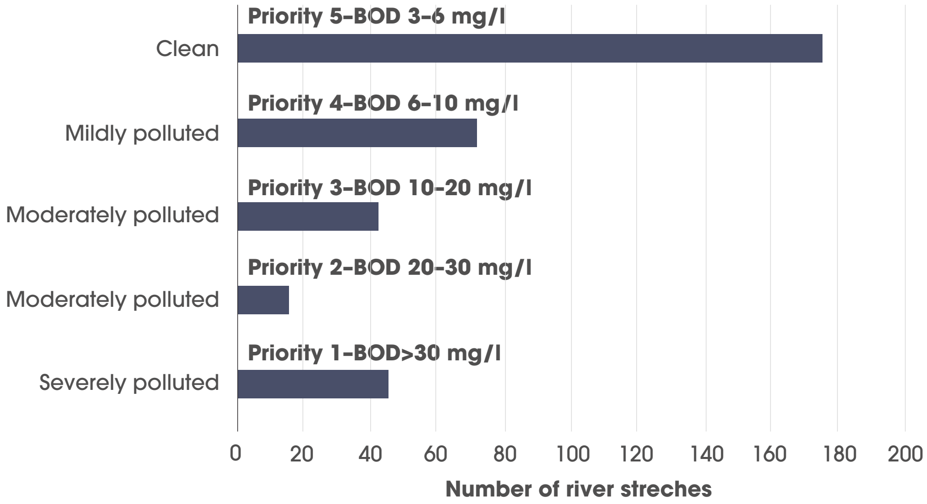
The CPCB has identified 351 stretches on 323 rivers for monitoring river water quality using Biochemical Oxygen Demand (BOD) as an indicator of pollution.[15] The monitoring results *(see Graph 2: Priority-wise number of polluted Indian river stretches)* show that 13 per cent of Indian river stretches are in priority 1, which indicates that they are severely polluted; 17 per cent in priority 2 and 3 are moderately polluted. Apart from high and Chemical Oxygen Demand (COD) levels, high levels of heavy metals, arsenic, fluorides, and hazardous chemicals have also been found in many places, especially in the groundwater in these regions (CPCB, 2018).

Rapid urbanization, coupled with population growth and agricultural practices, has led to extensive extraction of groundwater. Its overexploitation has led to rapidly depleting water tables and aquifers. Add to this a deficient water infrastructure including storage and distribution systems that exacerbates scarcity issues, which are further aggravated by inadequate maintenance and outdated facilities.

The UN World Water Development Report 2023: What does it say

- In 2020, two billion people (26 per cent of the world population) did not have access to safe drinking water; 3.6 billion (46 per cent) lacked access to safely-managed sanitation.
- Between two to three billion people experience water shortage for at least one month every year, posing severe additional risks to livelihoods and food security.
- The global urban population facing water scarcity is projected to double from 930 million in 2016 to 1.7–2.4 billion people in 2050.
- Some countries will lose six per cent of their GDP by 2050 due to water scarcity, spurring migration and conflicts.

Graph 2: Priority-wise number of polluted Indian river stretches



Source: CPCB, 2018

There is also the spectre and reality of climate change that is putting a strain on water availability. Irregular rainfall patterns, increasing frequency of droughts and soaring temperatures disproportionately affect vulnerable regions, intensifying the water crisis. The situation demands urgent action, including improved water conservation practices, investments in infrastructure, equitable distribution policies and recycling and reuse to ensure sustainable access to this vital resource for current and future generations.

OPTIMIZING WATER RESOURCES: TREATED WATER IN THE CIRCULAR ECONOMY

The concept of circular economy presents a promising approach towards addressing the increasingly pressing demand for water. By minimizing waste and maximizing resource utilization, the circular economy framework offers a pathway for realizing the value of water in a holistic way. In this model, water is viewed as a finite resource, prompting efforts to reduce its consumption and promote reuse.

This approach aligns closely with the UN's 2030 agenda, which emphasizes the interconnectedness of environmental, social and economic sustainability goals. Recognizing the need for collective action, initiatives such as Platform for Accelerating the Circular Economy, launched by World Economic Forum and UNEP, aim to mobilize public and private sector leaders. Collaboration between UNEP and Ellen MacArthur Foundation further underscores the commitment to scale up the transition to a circular economy.

Additionally, efforts by organizations like the World Business Council for Sustainable Development underscore the importance of circular economy principles in mitigating climate change, biodiversity loss and resource scarcity. Through initiatives and programmes focused on circular economy integration, businesses are encouraged to embrace sustainable practices that contribute to broader societal and environmental goals.[16]

Figure 1: Circular economy in water

The reuse of treated wastewater plays a key role in the circular economy of water. Reusing treated wastewater has significant environmental benefits—it helps create a closed-loop system where water resources are continuously recycled, benefiting both the environment and the economy. By reusing treated wastewater, the volume of effluent discharge into natural water bodies is reduced, minimizing the environmental impacts and improving water quality downstream *(see Box: Advantages of using treated wastewater)*.

Regulatory and policy support to encourage wastewater reuse, clear guidelines for water quality, permitting processes, and water pricing are crucial enabling factors for the optimum utilization of treated wastewater. Offering incentives, subsidies or tax breaks to encourage businesses and municipalities to adopt wastewater reuse technologies will help as well. Various strategies can be used to recover the cost of treating wastewater. These include promoting the use of greywater in homes and communities, exchanging water between different sectors, replenishing natural resources, generating value through on-site aquaculture linked to water treatment, and selling reclaimed water for various purposes.

Hierarchy should be established for water reuse that prioritizes non-potable uses over potable ones to optimize resource efficiency; common non-potable uses include landscape irrigation, agriculture, industrial processes, construction, toilet flushing, and others. Direct and indirect potable reuse systems with appropriate treatment processes should be implemented, depending on local regulations and community acceptance.

Advantages of using treated wastewater

The large volumes of wastewater produced by urban centres presents a valuable opportunity for reuse and recycling. Instead of seeing wastewater solely as waste, it should be perceived as a resource with the potential of meeting diverse urban water needs. Here are several ways in which wastewater can be harnessed and utilized beneficially:

- **Irrigation:** Treated wastewater can be used for landscape irrigation in parks, golf courses and agricultural fields, reducing the demand for freshwater and lowering the costs of water supply.
- **Industrial processes:** Many industrial processes can use treated wastewater, reducing the demand for freshwater and minimizing the environmental impact of industrial discharges.
- **Toilet flushing:** In some buildings, treated wstewater can be used for flushing toilets, which is a significant source of water consumption in urban areas.
- **Cooling systems:** Treated wastewater can be used in cooling systems for power plants and other industrial facilities.
- **Aquifer recharge:** Treated wastewater can be used for underground aquifers as a means of aquifer recharge. This helps replenish groundwater resources and prevents land subsidence in areas experiencing excessive groundwater pumping.
- **Build drought resilience:** Treated wastewater can serve as a reliable source of water during droughts and water shortages, helping to ensure a consistent water supply for urban areas.
- **Reduce pollution:** Properly treated wastewater reduces the pollution load discharged into natural waterbodies, thereby protecting aquatic ecosystems and improving water quality.

India: A strong case for circular economy of treated used water sector

- Low per-capita water availability at 1,545 m^3
- 20 per cent of groundwater blocks in critical condition or overexploited
- 55 per cent of households with open or no drains
- 91 per cent of 302 river stretches polluted
- Untreated sewage flow of 37,000 MLD
- Freshwater abstraction by industries is estimated to be 8.1 per cent in 2025 and 10.1 per cent in 2050
- 23 per cent of industries cannot access water easily or do so at high costs

Source: https://www.2030wrg.org/wp-content/uploads/2017/01/Circular-Economy-Pathways-India.pdf, as viewed on September 18, 2023

TREATED WASTEWATER AND ITS REUSE: THE CURRENT SCENARIO

Global

It is estimated that 380 billion m^3 of wastewater is generated annually across the world. Based on the rate of population growth and urbanization, the daily wastewater generated is expected to increase by 24 per cent (470 billion m^3) by the end of the SDG era in 2030 and 51 per cent (574 billion m^3) by 2050 over the current estimates. As per the NITI Aayog report on Urban Wastewater Scenario in India, published in August, 2022, Asia generated the largest volume of wastewater globally, amounting to 42 per cent (159 billion m^3) of the world's total. By 2030, this figure is expected to climb up to 44 per cent.[17]

An analysis by Jones et al., in 2020 on country-level and gridded estimates of wastewater production, collection, treatment and reuse shows that high-income countries generate 42 per cent of global wastewater, which is almost twice that of low- and lower middle-income countries. Wastewater treatment and collection percentages follow similar patterns, with high-income countries collecting and treating the majority of their wastewater (82 per cent and 74 per cent, respectively), while low-income groups collect only nine per cent and treat four per cent of their total wastewater.

The proportion of treated wastewater reuse is higher in the upper-middle (25 per cent) and lower-middle income groups (25 per cent) than in the high-income group (19 per cent); low-income groups are able to reuse only eight per cent of the treated wastewater generated.

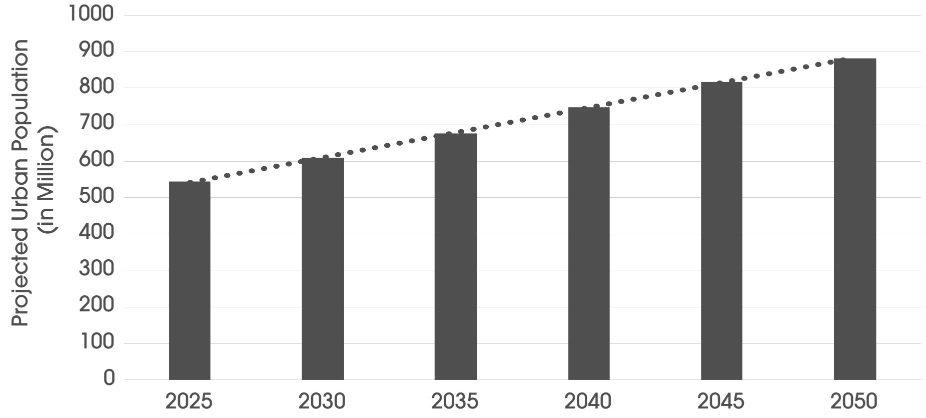
Regionally, East Asia and the Pacific generate the largest volume of wastewater, coinciding with the largest population share (31 per cent). Wastewater collection and treatment rates were found to be the highest in Western Europe and lowest in South Asia. In fact, South Asia has not only had the lowest treatment rates, but has also seen low levels of reuse. These results suggest that even though developed countries generate more wastewater, they also have the infrastructure to reuse treated wastewater.

India

Indian cities generate a large amount of wastewater. According to a recent assessment by the Central Pollution Control Board (CPCB), sewage generation in urban centres across India was 72,368 million litre per day (MLD) for the year 2020–21.[18] Currently, the installed sewage treatment capacity in the country is 31,841 MLD, but operational capacity is 26,869 MLD, which is much lower than the load generated. Of the total urban sewage generated, only 28 per cent (20,236 MLD) is being treated. This implies that 72 per cent of the wastewater remains untreated and is disposed of into waterbodies or on land.

Data on urban population projections suggests that wastewater generation will increase by about 75–80 per cent in the next 25 years, which by volume, works out to be 50,000–55,000 MLD, thus taking the total estimated wastewater generation to 0.13 million MLD. At this rate, about 0.8 billion cubic metre (BCM) of wastewater will be generated additionally every year. Thus, the total annual wastewater volume is expected to reach close

Graph 3: Projected urban population (in million)



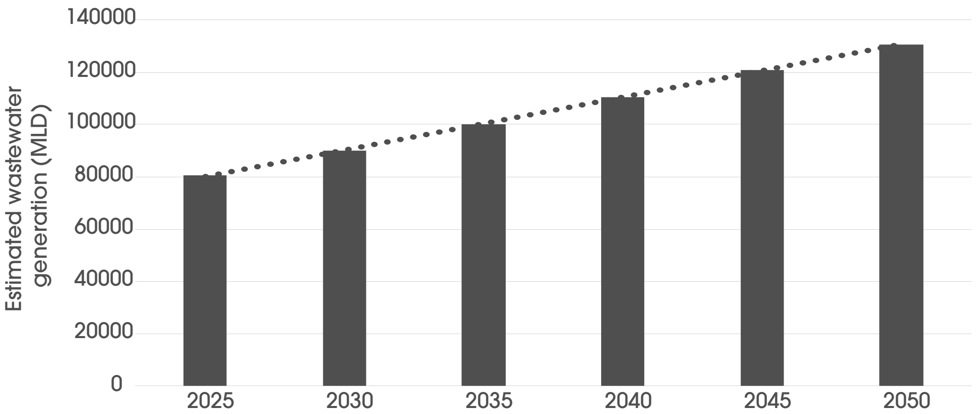
Source: Adapted from NITI Aayog Data

to 48 MLD by 2050 *(see Graph 3: Projected urban population in million and Graph 4: Estimated wastewater generation in MLD)*. This volume is about 3.5 times the existing installed treatment capacity, which underlines the necessity of scaling up treatment capacity, creating robust systems for wastewater collection, and formulating a well-accepted framework for the reuse of treated wastewater.

CHALLENGES IN TREATED WASTEWATER REUSE IN INDIA

Sewage treatment plants (STPs) are essential wastewater treatment facilities in India, as they play a crucial role in treating and purifying domestic and municipal wastewater before its discharge into natural waterbodies, or its safe reuse for various purposes. There are challenges and considerations in managing wastewater in urban India on account of a variety of reasons—including mixing up of all kinds of wastewater, lack of sewage networks, improper/lack of maintenance, not prioritizing wastewater management, and

Graph 4: Estimated wastewater generation (MLD)



Source: Adapted from NITI Aayog Data

the underlying misconception that we have enough freshwater, among others. Effective operation and maintenance (O&M) of STPs and ensuring that the treated wastewater meets the standards set by the CPCB are critical challenges as well.

Addressing these challenges requires coordinated effort involving government agencies, utilities, regulatory bodies, and the private sector. Adequate funding, capacity building, regular training, and technology upgrades are essential in maintaining effective O&M of STPs and ensuring treated water compliance with CPCB/SPCB standards.

Treatment technologies in India

Sequential Batch Reactor (SBR) and Activated Sludge Process (ASP) are the prevalent and adopted technologies all across the country. Table 3 below provides the full list of technologies.

Table 3: Technologies used in sewage treatments plants (STPs) in India

Technology	Technology type	Number	Capacity (in MLD)
Activated Sludge Process (ASP)	Conventional	321	9,486
Sequencing Batch Reactors (SBR)	Conventional	490	10,638
Extended Aeration (EA)	Advanced	30	474
Fluidized Aerobic Bed Reactor (FAB)	Advanced	21	242
Moving Bed Biofilm Reactor (MBBR)	Advanced	201	2,032
Upflow Anaerobic Sludge Blanket (UASB)	Advanced	76	3,562
Oxidation Pond (OP)	Natural	61	460
Waste Stabilization Pond (WSP	Natural	67	789
Others (Aerated Lagoon (AL), Trickling Filter (TF), Bio-Tower, Electro Coagulation (EC) etc)		364	8,497

Source: National Inventory of Sewage Treatment Plants, CPCB, 2021

Dhandupura STP, located in Agra, was commissioned in 2001. It has a total treatment capacity of 78 MLD. The treated wastewater from this STP is discharged into a nearby canal from where the farmers tap the water for agricultural purposes.

POLICY, REGULATORY AND INSTITUTIONAL FRAMEWORKS

- The evolution of India's water policies shows a clear shift from focusing solely on infrastructure creation to embracing circular economy principles. Recent policies emphasize the reuse of treated water as a critical strategy for conserving resources and enhancing sustainability.

- India has established a robust national framework for promoting wastewater reuse, with key policies and legislations like Water (Prevention and Control of Pollution) Act (1974), Environment Protection Act (1986), National Urban Sanitation Policy (2008), Guidelines for Swachh Bharat Mission and Atal Mission for Rejuvenation and Urban Transformation (AMRUT), providing a regulatory foundation for the reuse of treated wastewater.

- Central government agencies, such as the Ministry of Housing and Urban Affairs and the Central Pollution Control Board (CPCB), play a pivotal role in regulating and promoting treated water reuse through guidelines, standards, and financial incentives, thereby driving the adoption of sustainable practices.

- Despite the progress, there remains a need for more explicit guidelines and regulations at both national and state levels to enhance the implementation and scalability of water reuse projects across the country. Increased state participation and the development of region-specific policies will be essential to address these challenges.

Tertiary treatment plant in Kodingaiyur, Chennai from where the treated wastewater is supplied for industrial reuse.

India's policy landscape on treated water reuse is evolving to address water scarcity through improved infrastructure, service enhancements, and a recent focus on circularity, reflecting shifting priorities towards sustainable water management (*see Figure 2: India's policy shift towards circular economy of water*).

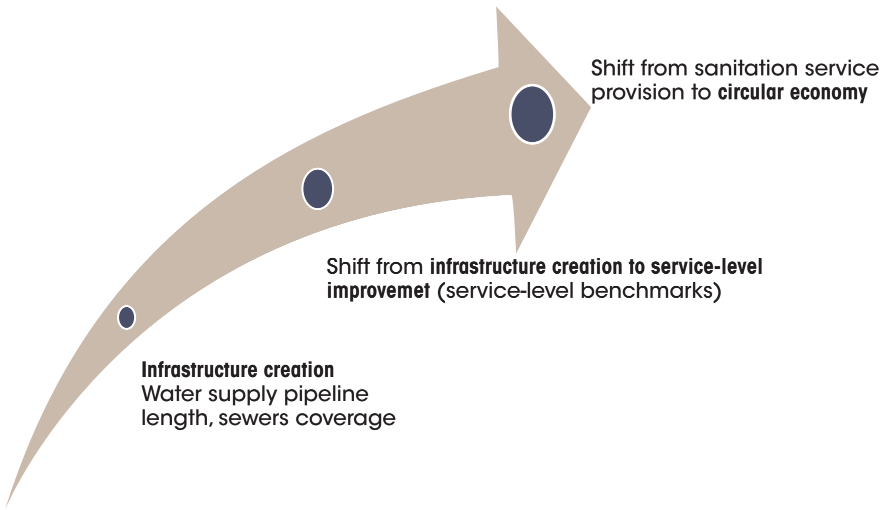
Initially, the emphasis on infrastructure development was primarily driven by the need to address basic water supply and sanitation challenges. The focus was on constructing sewage treatment plants and developing wastewater treatment infrastructure to ensure proper sanitation and to protect public health.

As the understanding of water management evolved, the focus shifted towards service-level improvement of the overall sanitation system. This phase recognized that merely building infrastructure was not enough, it was equally important to ensure efficient operation and maintenance of the infrastructure, along with improving service delivery and access to water and sanitation services.

In recent years, there has been a growing recognition of the need for circularity in water management policies. Circular economy principles emphasize the sustainable use and reuse of resources, including water, to minimize waste and maximize resource efficiency.

Policies and regulations play a crucial role in ensuring the safe and effective reuse of treated wastewater and for creating a closed-loop system of use and reuse, as they provide a framework to guide proper management, treatment, and distribution of reclaimed water for various non-potable purposes.

Figure 2: India's policy shift towards circular economy of water



NATIONAL POLICIES AND REGULATIONS

According to the Constitution of India, water, sanitation and used water are state subjects. In India, several policies and initiatives have been introduced to promote the reuse of treated water from sewage treatment plants (STPs) and enhance water sustainability. Some of the laws and policies that have referenced and influenced the reuse of treated wastewater are as follows:

- **The Water (Prevention and Control of Pollution) Act, 1974:** It is an important legislation in India that addresses various aspects of the prevention and control of water pollution. Under this Act, the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) are responsible for regulating and enforcing pollution control measures, including those related to wastewater treatment and reuse. These bodies have the authority to set standards, issue guidelines and monitor compliance with respect to the quality of treated wastewater.
- **The Environment Protection Act, 1986:** This comprehensive legislation aims to protect and improve the environment, and prevent and control environmental pollution. While the Act does not specifically address the reuse of treated water, it provides a framework for environmental regulation that indirectly supports and influences reuse practices.
- **National Environment Policy (NEP), 2006:** This policy serves as a guiding document for environmental management and sustainable development in India. The policy mandates that states develop and execute action plans for their major cities to tackle water pollution, utilizing regulatory frameworks that incorporate both mandatory measures and incentive-based instruments as necessary. The policy also emphasizes the implementation of projects through public agencies as well as public–private partnerships for treatment, reuse, and recycle, where applicable, of sewage and wastewater from municipal and industrial sources before their final discharge into water bodies.
- **National Water Mission:** This mission promotes recycling wastewater in order to meet a significant portion of the urban water needs. The mission document has outlined five primary goals and thirty-nine strategies to achieve its objectives. Strategy 4.2 mentions incentivizing the recycling of water, including wastewater. The points mentioned under the strategy are:
  (a) Incentivize recycling water, including wastewater.
  (b) Prepare the necessary guidelines for encouraging a public-private-partnership (PPP model) for recycling water and wastewater treatment.
  (c) Provide technical and financial support for common wastewater treatment and recycling plants.
  (d) Provisions related to wastewater treatment should be strictly enforced.

Apart from these policies, several other programmes, policies and guidelines have supported the reuse of treated water at the national level. Some of them are Guidelines of National Building Code 2016, National Guidelines on Zero Liquid Discharge (ZLD) developed by CPCB, and CGWB Master Plan for Artificial Recharge to Ground Water in India (2013).

A few of the main policies, programmes and guidelines that promote the reuse of treated water are mentioned in Table 4 and Figure 2.

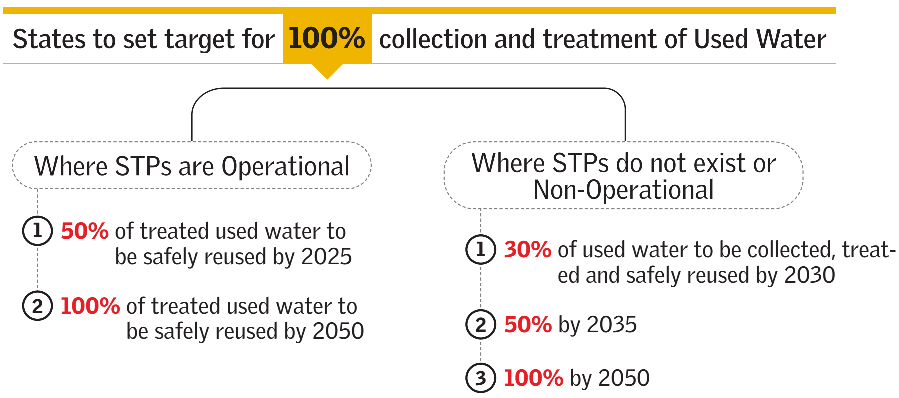
Table 4: Timeline of national policies and programmes promoting and mandating reuse of treated wastewater

Year	Policy
2008	**National Urban Sanitation Policy:** Promotes the recycle and reuse of wastewater. The policy mandates that treated wastewater should comprise a minimum of 20 per cent of the water used in a city.
2010	**Service-Level Benchmark Framework:** Encourages the reuse of wastewater in cities.
2012	**National Water Policy (NWP), 2012:** NWP 2012 focuses on reducing water pollution; the draft of the revised NWP 2020 embraces the imperative of recycling and reuse.
2012	**Jawaharlal Nehru National Urban Renewal Mission (JNNURM):** This mission mandates the treatment of 100 per cent of the wastewater in 63 cities and promotes the reuse of treated wastewater. This mission also focuses on the development of bye-laws for reuse of recycled water.
2013	**CPHEEO Manual on Sewerage and Sewage Treatment Systems:** Provides various technological options and norms for treated sewage quality for specified activities. Reuse guidelines were added in 2016.
2014	**National Mission for Clean Ganga (Namami Gange):** This programme focuses on the rejuvenation and conservation of the Ganga. It includes initiatives for the treatment of sewage and industrial effluents, with an emphasis on promoting the reuse of treated wastewater.
2015	**Atal Mission for Rejuvenation and Urban Transformation (AMRUT):** Encourages cities to provide the basic needs of sanitation and water supply. Encourages the reuse of wastewater for sustainability. **Smart Cities Mission:** Sanitation (particularly wastewater recycling and storm water reuse) is one of the core infrastructure elements included in the programme.
2015	**Namami Gange:** MOUs were signed by NMCG with the Ministry of Power, Ministry of Railways, and Ministry of Agriculture for reuse of treated wastewater.
2016	**Power Tariff Policy:** Mandates thermal power plants to use treated sewage water within 50kms of STPs.
2017	**National Faecal Sludge and Septage Management Policy:** This policy focuses on leveraging FSSM to achieve 100 per cent access to safe sanitation, achieving integrated city-wide sanitation, and the safe disposal of faecal waste in urban areas. It also mandates strict environmental discharge standards, and promotes an appropriate, affordable and incremental approach to achieving these standards.
2019	Central Pollution Control Board issued guidelines for **utilization of treated effluent in irrigation.**[19]
2021	**Swachh Bharat Mission (SBM) 2.0:** This mission aims to ensure that no untreated wastewater is discharged into the environment, all used water is safely contained, transported and treated, along with maximum reuse of treated used water in all cities that have a population of less than 0.01 million. The mission also aims to work on reuse policies with the states and organize trainings and capacity building programmes for ULBs on solid and liquid waste management. The mission recommends the **utilization of used water as much as is feasible, but not less than 20 per cent.**

2021	**Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0:** The mission mandates that all cities with a population of more than 0.01 million recycle their used water to meet 20 per cent of the city's water demand and 40 per cent of the industrial water demand at the state level.
2022	**National Framework on Safe Reuse of Treated Wastewater:** Published by the National Mission for Clean Ganga (NMCG), the framework acts as a guiding document for states to formulate their reuse water policies and implement the same in a time-bound manner. A draft policy template has also been developed as part of the framework to aid in the preparation of a reuse policy by the respective state governments.
2024	Central Pollution Control Board (CPCB) released a national guideline on the reuse of treated sewage (used water) in February, 2024 which emphasizes sectoral prioritization of the reuse of treated used water along with certain standards.

Source: Compiled by CSE

Figure 3: Targets in National Framework on safe reuse of treated water[20]



STATE POLICIES AND GUIDELINES

Currently, treated water reuse in India is limited in scope, primarily practiced in isolated instances and on a small scale. While several states in India have formulated their own policies and regulations to promote the reuse of treated water, they are yet to receive widespread attention in the policy planning of several state governments. Some states, such as Maharashtra, have a state water policy that encourages the reuse of treated wastewater, while Tamil Nadu has provisions for the reuse of treated wastewater in its Water Supply and Drainage Board guidelines. A few states have dedicated policies for the reuse of treated water while others have incorporated them in their water policies *(see Table 5: State-wise plan and policy for reuse of treated used water)*.

Table 5: State-wise plan and policy for the reuse of treated used water[21]

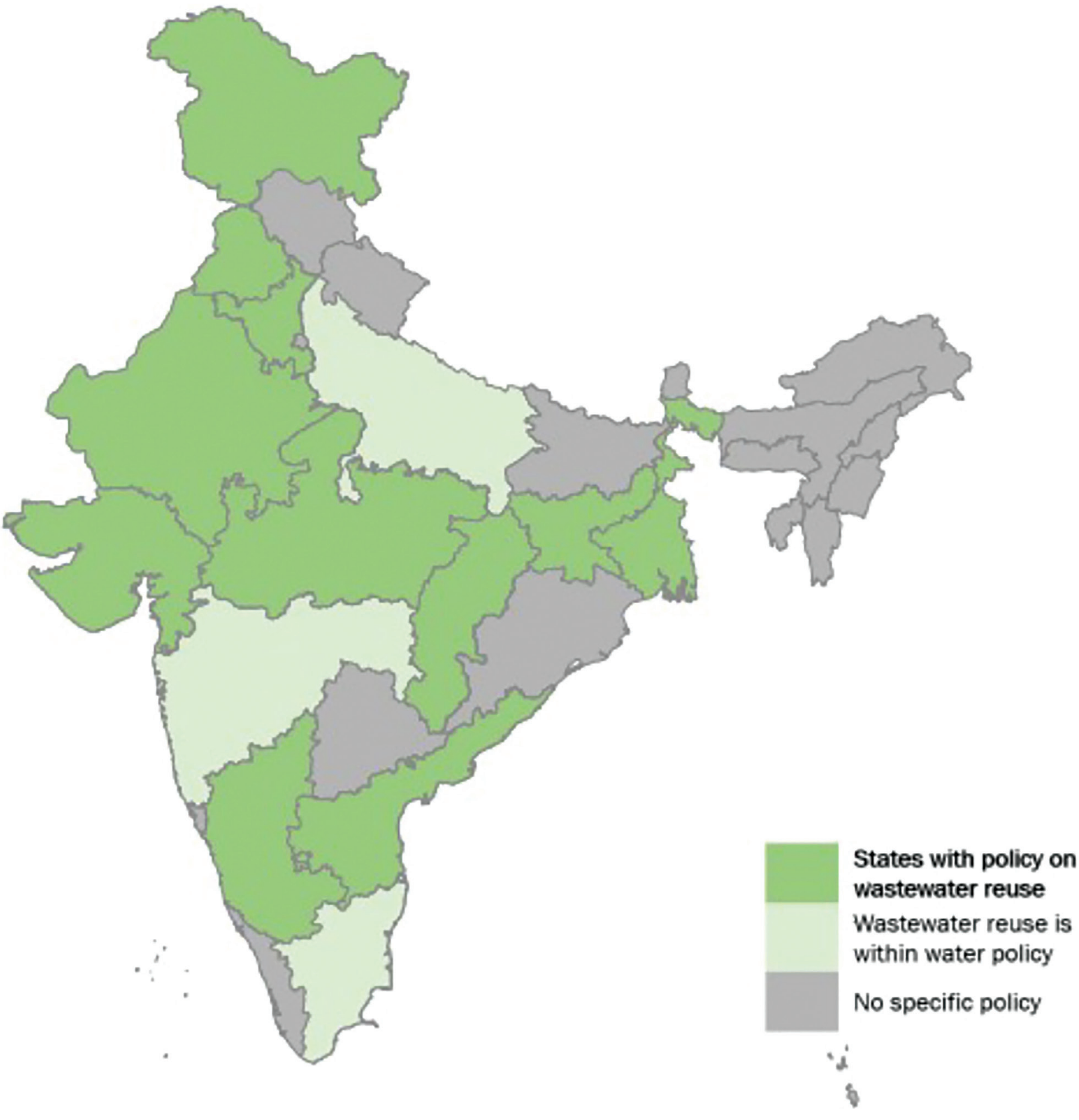
State	Plan and policy for the reuse of treated used water
West Bengal	**Treated Used Water Reuse Policy of Urban West Bengal,** published in June, 2020 this policy highlights the need for sustainable management of water resources by way of establishing an effective system for reusing treated used water in urban West Bengal, thereby reducing dependence on fresh ground/surface water resources and bringing reforms in planning, institutions, finance, technology, and legal and regulation.
Gujarat	**Policy for Reuse of Treated Used Water,** May, 2018 envisions to maximize the collection and treatment of generated sewage, and the sustainable reuse of treated water, thereby reducing dependency on freshwater sources. The policy sets a bold target of achieving 70 per cent reuse of treated wastewater by 2025, with the aim of reaching 100 per cent reuse by 2030.
Karnataka	In December 2017, Karnataka approved the **Policy for Urban Used Water Reuse** with a goal to establish an enabling environment for the reuse of municipal used water in order to maximize efficient resource use, protect the environment, address water scarcity and enhance economic output. Agriculture is one of the major categories of reuse in this policy. The policy also outlines the pricing of treated water and the recovery of operational costs for wastewater treatment plants.
Chhattisgarh	The Urban Administration and Development Department has come up with a **Used Water Recycle and Reuse Policy**, with the objective of promoting the reuse of treated used water that meets stipulated quality standards for non-drinking purposes. The document envisions that water reuse is for the coexistence of domestic, agriculture and industrial sectors, and for the prevention of conflict between states for precious water resources.
Jharkhand	**Used Water Policy, 2017** considers used water as a perennial water source and recognizes it as an integral part of renewable water resources. This policy urges urban local bodies to develop and manage used water systems, its treatment and reuse. However, the policy recommends a cautious approach towards the reuse for agricultural purposes owing to the lack of wide social acceptance and apprehension of health risks.
Madhya Pradesh	The Department of Urban Development and Housing, Madhya Pradesh, has prepared the **Government of Madhya Pradesh State-level Policy for Wastewater Recycle and Faecal Sludge Management, 2017** to accomplish the **objectives of the National Urban Sanitation Policy, 2008** and **Atal Mission for Rejuvenation and Urban Transformation Scheme.** Although the policy identifies agriculture as one of the potential areas for reuse of treated water, it limits the use in public parks, golf courses, urban green belts, freeway medians, cemeteries, and residential lawns citing that agricultural land is hardly available in urban areas.
Andhra Pradesh	Andhra Pradesh's policy on used water reuse and recycle for urban local bodies (ULBs) encourages the substitution of groundwater with treated used water. It also prioritizes the use of reclaimed water for industrial and agricultural uses as much as possible in order to save freshwater for domestic uses. The policy also outlines institutional arrangements, a participatory approach and legislative measures related to these.

State	Plan and policy for the reuse of treated used water
Rajasthan	In 2016, Rajasthan's Local Self Government Department published the **State Sewerage and Used Water Policy** to ensure improved health status of the urban population, especially the poor and under privileged, through provisions for sustainable sanitation services and protection of the environment. According to the policy, the treatment of used water shall be targeted towards producing an effluent that is fit for reuse in irrigation, in accordance with WHO guidelines as a minimum requirement. Possible financial models and approaches for incentivization are also included.
Haryana	Keeping in mind the limited availability of water resources in the state and also issues relating to quality of water, Haryana notified its policy on the reuse of treated used water in October, 2019. The priority of reuse in decreasing order is thermal power plants, industrial units, construction activities, dual water supply system in houses/offices/business establishments, large commercial use, municipal use, and agriculture/irrigation. The policy specifies that 'treated wastewater shall be used for agriculture/irrigation purposes provided surplus quantity is available after meeting the demands of the above-mentioned uses.'
Punjab	Punjab has notified its **Treated Used Water Policy, 2017** which prioritizes agricultural reuse of treated effluent for unrestricted irrigation. Policy states that crops to be irrigated with treated effluent or blend thereof with freshwater resources shall selected to suit the irrigation water, soil type and chemistry, and the economics of the reuse operations.
Maharashtra	Maharashtra's **State Water Policy** encourages recycling or reusing treated used water and mandates penal action against polluters of water resources. The policy assumes that at least 80 per cent of the water used for domestic purposes will be available for reuse. Therefore, it is the obligation of the local bodies to make the entire quantity of the generated sewage available for reuse after treating it in accordance with the standards prescribed by the Maharashtra Pollution Control Board (MPCB). There is no separate policy for used water reuse.
Tamil Nadu	Tamil Nadu has a policy for reusing treated wastewater for industrial and agricultural uses. Memorandums of Understanding (MoUs) are signed between urban local bodies and user agency for reuse of secondary-treated effluent water.

*Jammu and Kashmir's State Policy for Used Water Reuse was formulated in 2017 (before formation of UT of Ladakh and UT of J&K). Uttar Pradesh also has a draft policy on reuse of treated wastewater.

Source: Reuse of Treated Used Water in Urban/Peri-Urban Agriculture in India, National Institution for Transforming India (NITI) Aayog, New Delhi, June 2023

Map 1: Map showing states with and without policy on used water reuse[22]



In March 2018, the National Green Tribunal directed all the states and UTs in India to submit action plans for the utilization of treated wastewater by June 2019 (Press Trust of India (PTI), 2019). Nine states and five Union Territories (UT) have submitted their action plans for the reuse of treated water to the Central Pollution Control Board (CPCB). These states are the Andaman and Nicobar Islands, Andhra Pradesh, Chandigarh, Chhattisgarh, Daman and Diu, Delhi, Jharkhand, Karnataka, Kerala, Lakshadweep, Madhya Pradesh, Manipur, Odisha, Tripura. The rest of the states and UTs were ordered to submit their action plans to the CPCB within three months to the Central Pollution Control Board.[23]

REGULATORY FRAMEWORK AND STANDARDS

Despite the economic and environmental benefits of water reuse, its practical implementation on a large scale is an issue. The lack of stringent national regulations and guidelines for the safe implementation of wastewater reuse systems further complicates the situation.

The Government of India notified the general standard for the discharge of environmental pollutants—effluents (Part A) and wastewater generation discharge standards (Part B) under Schedule-VI of Environment (Protection) Rules, 1986. This notification outlined the standards for discharge in inland surface water, public sewers, land for irrigation and marine coastal areas are notified.[24]

Table 6: Effluent discharge standards for treated effluent of sewage treatment plants

S.No.	Parameters	Norms as per NGT direction dated 30 April, 2019 in the matter of OA No 1069 of 2018	MOEF&CC Notification dated October, 2017	
			Cities (more than one million population)	Areas/regions other than mentioned above
1	pH	5.5–9.0	6.5–9.0	
2	BOD, mg/L	10	20	30
3	COD, mg/L	50	-	-
4	TSS, mg/L	20	50	100
5	NH4-N, mg/L	-	-	-
6	N-Total, mg/L	10	-	-
7	Faecal coliforms, MPN/100 mL	100 desirable 230 permissible	1,000	

Note: Metro cities* and all state capitals except Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir and Union territory of Andaman and Nicobar Island, Dadar and Nagar Haveli, Daman and Diu, and Lakshadweep.

*Metro cities are Mumbai, Delhi, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad and Pune.
Source: Central Pollution Control Board

In 2017, the Ministry of Environment Forest and Climate Change (MoEF&CC) established effluent discharge standards for treated wastewater from sewage treatment plants (STPs). In 2019, the National Green Tribunal (NGT) introduced even stricter regulations regarding the discharge from STPs. The standards have been summarized in the Table above.

The Bureau of Indian Standards (BIS) notifies various IS standards to ensure that the water quality meets the needs of industrial and agricultural sectors. The Central Public Health and Environmental Engineering Organisation (CPHEEO) has recommended norms to ensure treated sewage quality for specified activities at the point of use. It has also issued norms for dissolved phosphorus, nitrogen and faecal coliform. If these prescribed standards/norms are met, treated sewage-water (without any advanced treatment) may be used in horticulture practices, golf courses, for irrigation of non-edible crops and some edible ones *(see Table 7: CPHEEO recommended norms of treated sewage quality for specified activities at point of use).*

Table 7: CPHEEO recommended norms of treated sewage quality for specified activities at point of use

S.No.	Parameters	Toilet flushing	Fire protection	Vehicle exterior washing	Recreational use (bathing etc.)	Non-contact impoundments	Landscaping, Horticulture and Agriculture			
							Horticulture golf course	Non edible crops	crops	
									Crops which are eaten	
									Raw	cooked
1	Turbidity (NTU)	<2	<2	<2	<2	<2	AA	AA	AA	AA
2	SS	AA	AAA	AA	AA	AA	AA	AA	AA	AA
3	TDS	2100								
4	pH	6.5 – 8.5								
5	Temperature °C	Ambient								
6	Oil & Grease	10	Nil	nil	Nil	nil	10	10	nil	nil
7	Nitrate Nitrogen as NT	10	10	10	10	10	AA	AA	AA	AA
8	BOD	<6	10	<6	<6	10	<6 – 10 (<6 Preferred)			
9	COD	AA	AA	AA	AA	AA	AA	AA	AA	AA
10	Total Phosphorous as TP	1	1	1	1	1	AA	AA	AA	AA

11	Minimum residual chloride	1	1	1	<0.5	0.5	nil	Nil	nil	nil
12	Faecal Coliform in 100 ml	nil	Nil	nil	<5.0	100	nil	100	nil	<5.0
13	Helminthic	AA	AA	AA	AA	AA	AA	<1	<1	<1
14	Colour	Colourless						AA	Colourless	
15	Odour	Aseptic which means not specific and no foul odour								

Source: Central Public Health and Environmental Engineering Organisation (CPHEEO)

There are various guidelines and standards related to effluent discharge and reuse that are updated from time to time. However, there is a lack of clarity amongst users about its use and application.

INSTITUTIONAL MECHANISMS FOR REUSE MANAGEMENT

In India, the governance model for the reuse of treated used water is multifaceted and involves various stakeholders at the national, state and local levels. The central government plays a crucial role in formulating extensive policies and regulatory frameworks to guide the reuse of treated used water across different sectors. These policies mainly focus on the solutions pertaining to public health and environmental protection. Additionally, state governments have the autonomy to develop region-specific regulations and incentives tailored to local needs and priorities. At the local level, municipal authorities are responsible for implementing used water treatment and reuse projects, as well as ensuring compliance with applicable regulations. Furthermore, partnerships between government agencies, private sector entities, academic institutions, and civil society organizations are often fostered to promote innovation, capacity-building and community engagement in treated used water reuse initiatives.

Central institutional mechanisms for reuse management

Several central government agencies and departments have the responsibility to oversee aspects related to water management and environmental conservation, which indirectly influence the management of water reuse. These agencies and departments are:

1. **Ministry of Jal Shakti:** The Ministry of Jal Shakti is the central government ministry responsible for water resources management and drinking water supply. While its primary focus is on water availability and distribution, it plays a crucial role in formulating policies and programmes related to water reuse and promoting sustainable water management practices.

Under the ministry, the Central Ground Water Board (CGWB) and the Central Water Commission (CWC) are key agencies that oversee water resources management, including the reuse of treated water. These agencies provide technical guidance, conduct studies, and develop guidelines related to water reuse.

The Ministry of Jal Shakti, through its various programmes and initiatives such as National Water Mission, Jal Jeevan Mission, Atal Bhujal Yojna and Namami Gange Mission, encourages the adoption of water reuse practices, particularly in sectors such as agriculture and industries where non-potable water can be utilized. Additionally, the ministry works towards creating awareness and providing technical support for the implementation of water reuse projects. It may provide financial assistance and incentives to encourage the adoption of water reuse practices and the development of infrastructure for treating and reusing wastewater.

a. Central Water Commission (CWC): The CWC is responsible for the planning and development of water resources in India. While its focus is primarily on water availability, irrigation and flood management, it plays a role in promoting efficient water use and management practices that can include the reuse of treated water.

b. National Mission for Clean Ganga (NMCG): The NMCG is a central government initiative dedicated to the rejuvenation and conservation of the Ganga. It focuses on pollution control, wastewater treatment and the restoration of the Ganga ecosystem. While its primary focus is on the river basin of the Ganga, its efforts and initiatives indirectly contribute to the management of water reuse in the region.

2. Central Pollution Control Board (CPCB): The CPCB is the central regulatory authority for environmental protection and pollution control. It establishes standards and guidelines for water quality and pollution control. The CPCB monitors and regulates the discharge of pollutants into water bodies, including treated wastewater. It indirectly influences the management of water reuse through its role in regulating water quality and pollution control and also issue guidelines pertaining to reuse of treated water.

3. Ministry of Agriculture and Farmers Welfare (MoAFW): This Ministry is responsible for developing the mandate for the use of treated water in irrigation based on crop pattern and also responsible for creating awareness among farmers on the reuse of treated wastewater for irrigation.

4. Central Public Health and Environment Engineering Organization (CPHEEO): Provide technical and planning support to states and urban local bodies (ULBs), including technical guidelines and training modules that can be adapted by states.

5. Ministry of Power: Directions/guidelines to use treated water for thermal power plants located within a 50 km radius of a STP.

6. National Green Tribunal (NGT): NGT provides relief and compensation for any damages caused to persons and properties and resolves various civil cases under the Water Act (Prevention and Control of Pollution), 1974.

These central-level institutions, among others, work in collaboration with state governments, local authorities, and other stakeholders to address water management and environmental conservation issues, including the reuse of treated water. The specific roles and responsibilities of these institutions may evolve and be further strengthened over time to enhance the management of water reuse at the central level.

State-level institutional mechanisms for reuse management

The institutional arrangements from states that show a well-defined and structured flow of roles and responsibilities have been provided below. The state-wise institutional arrangement is shown in the sections below:

HARYANA

Stakeholders and Responsibilities

Stakeholders	Responsibilities
State-Level High Powered Committee (SLHPC)	• Allocation of treated wastewater to different users • Implementing agency for the project • Financial and management structure of the project • Pricing of treated wastewater
State-Level Technical Committee (ISLTCI)	• Technical approval of the projects related to conveyance of TWW • Monitoring the progress of the projects • Monitoring the performance of the functional STPs across the state • Suggesting pricing formula for TWW for each notified area • Overview of the functioning of the Technical Cell created under the policy
Treated Wastewater Cell	• Identification and preparation of projects • Preparation of Detailed Project Report (DPR)
• Public Health and Engineering Department (PHED) • Haryana Shahari Vikas Pradhikaran (HSVP) • Urban Local Body • Gurugram Metro Development Authority • Haryana State Industrial and Infrastructure Development Corporation	These departments are also responsible for strengthening/upgradation of the existing infrastructure, and if required, to implement the policy for supplying treated wastewater to users
Private/External sector	• Financial resource mobilization • Option of PPP
Haryana State Pollution Control Board	Finalizing the legal framework and quality standards/TWW norms for using treated water for various purposes.
Users	Apply for permission to take TWW as per the terms and conditions of this policy.

KARNATAKA

Primary Departments

Department	Responsibilities
Urban Development Department Karnataka Urban Water Supply and Drainage Board (KUWSD&B) Karnataka Urban Infrastructure Development and Finance Corporation Bangalore Water Supply and Sewerage Board (BWSSB)	Establishment of the overall enabling environment, including supportive policies, capacity building, financing, IEC and awareness raising, information dissemination, market development etc. for wastewater reuse projects and investments.
Department of Industries and Commerce, through Karnataka Industrial Areas	Establishment of a voluntary target for treated wastewater to comprise 20 per cent of total state-wide industrial water use by 2020.
Department of Energy	In compliance with the Government of India's recently revised Power Tariff Policy (2015), coordinate partnerships of thermal power plants with urban centres within 50 km radius for off-take of all STW available; and facilitate operational sustainability of wastewater treatment plants.
Department of Forest, Ecology and Environment	Establishment of and monitoring of compliance to standards and regulations on wastewater quality norms for various reuse categories.

KARNATAKA

Secondary Departments

Department	Responsibilities
Water Resources Department	• Overall water resources allocation and prioritization. • Alignment and consistency with irrigation policies and practices, including minor irrigation, for reuse of wastewater by agriculture.
Department of Agriculture	• Monitoring irrigation practices and the use of (untreated) wastewater for food production. • Sensitizing farmers to adverse health impacts of untreated wastewater use.
Urban Local Bodies	• Preparation of integrated Urban Water Resources Management Plans, including consultations with stakeholder groups for STW demand assessment. • Outreach to Wastewater Reuse Resource Centre for support in project identification, structuring and pre-feasibility assessments. • Provision of funding for project feasibility assessments.

RAJASTHAN

Stakeholders and Responsibilities

Stakeholders	Responsibilities
State-Level High Powered Committee (SLHPC)	Apex body to take decision regarding implementation of the policy. The functions include project approval, price determination, allocation of water, selection of implementing agency, monitoring, policy advisory, resolution of disputes etc.
State-Level Technical Committee/SLTC	Approval of projects, finalizing formats of project agreements, monitoring project execution, laying guidelines for O&M etc, and carrying out such other functions as may be decided by the Government or SHPC.
Treated Wastewater Cell	• Preparation of Detailed Project Report (DPR) • Providing secretarial assistance to STC/SHPC • Management Information System • Public Awareness
• Water and Land Management Institute (WALMI) • Indian Institute of Management, Lucknow (IIM) • IIT • Agriculture Universities • Engineering Colleges	**Capacity Building, Research and Development** Focused action research, development and promotion of state of-art technology, and training for effective and economical management of water resources.
Urban Local Body	Capacity building for wastewater management, planning and implementation for water recycle plant infrastructure keeping in view availability of the funds.
UP Pollution Control Board	Finalizing the legal framework and quality standards/TWW norms for treated water use for various purposes.
Housing Board and Development Authorities	Provisions for use of TWW for landscaping, gardening, metro and car washing and flushing etc.
Department of Infrastructure and Industrial Development, Energy, Jal Shakti-irrigation, Agriculture	Enforcement of use.
User	Apply for permission to take TWW as per the terms and conditions of this policy.

UTTAR PRADESH

Suggested Stakeholders and Responsibilities

Stakeholders	Responsibilities
State-Level High Powered Committee (SHPC)	Apex body to take decisions regarding implementation of the policy. The functions include project approval, price determination, allocation of water, selection of implementing agency, monitoring, policy advisory, resolution of disputes etc.
State-Level Technical Committee (SLTC)/Uttar Pradesh Jal Nigam	Approval of projects, finalizing formats of project agreements, monitoring projects execution, laying guidelines for O&M etc, and carrying out such other functions as may be decided by the Government or SHPC.
Treated Wastewater Cell	• Preparation of Detailed Project Report (DPR) • Providing secretarial assistance to STC/SHPC • Management Information System • Public Awareness
• Water and Land Management Institute (WALMI) • Indian Institute of Management Lucknow (IIM) • IIT • Agriculture Universities • Engineering Colleges	**Capacity Building, Research and Development** Focused action research, development and promotion of state-of-the-art technology and training for effective and economical management of water resources.
Urban Local Body	Capacity building for wastewater management, planning and implementation for water recycle plant infrastructure keeping in view availability of the funds.
UP Pollution Control Board	Finalizing the legal framework and quality standards/TWW norms for use of treated water for various purposes.
Housing Board and Development Authorities	Provisions for use of TWW for landscaping, gardening, metro and car washing and flushing etc. by laying twin lines.
Department of Infrastructure and Industrial Development, Energy, Jal Shakti-Irrigation, Agriculture	Enforcement of use.
User	Apply for permission to take TWW as per the terms and conditions of this policy.

DELHI

Stakeholders and Responsibilities

Stakeholders	Responsibilities
Delhi Jal Board	Policy formation, regulatory oversight and involvement in issuing permits, monitoring wastewater treatment facilities, planning and executing the reuse of treated wastewater projects, and enforcing regulations. Financing and resource mobilization.
Irrigation and Flood Control Department	Managing floodplain, major drains and irrigation channels for groundwater recharge. The dept. is also responsible for upkeep of various village ponds and to provide irrigation facilities to the cultivators of Delhi through state tube eells, and to provide treated effluents water (available from various STPs at Okhla, Keshopur and Coronation Pillar) for farming.
Delhi Development Authority	Responsible for reuse of treated wastewater for horticulture purposes using various modes such as - through Pipeline from centralized STPs of DJB/DDA, through tankers from DJB STPs.
Central Public Work Department	Responsible for developing guidelines for reuse of treated wastewater in construction industries.
Delhi Pollution Control Committee	Quality control of treated water and compliance.
Delhi Parks and Gardens Society	To monitor and coordinate the management of all the parks and Gardens in NCT Delhi with respect to reuse of TWW.
Delhi State Industrial and Infrastructure Development Corporation	This corporation has several industrial estates under its jurisdiction and is also in the business of undertaking microconstruction projects. DSIIDC is responsible for reuse of TWW in these projects.

MAHARASHTRA

Stakeholder and Responsibilities

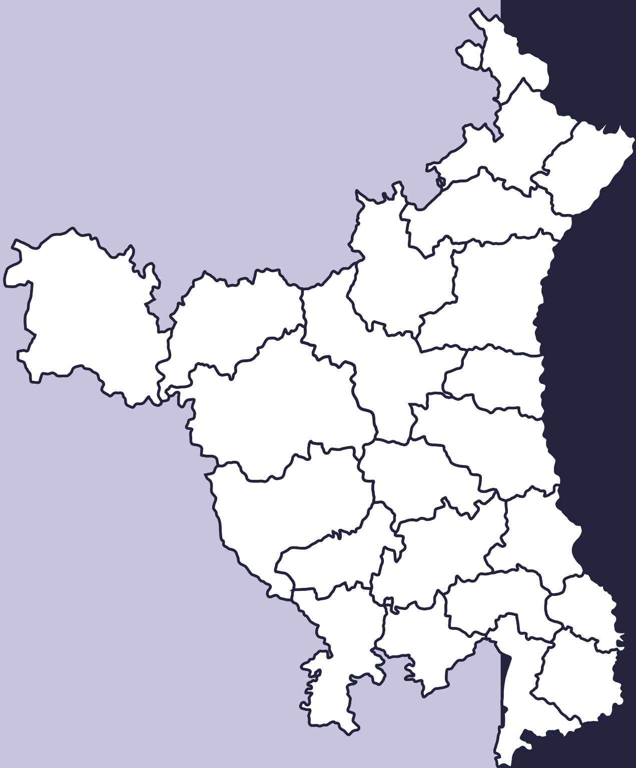
Stakeholders	Responsibilities
Maharashtra Urban Development Department	Policy formation, regulatory oversight and involvement in issuing permits, monitoring wastewater treatment facilities, and enforcing regulations. Financing and resource mobilization.
Maharashtra Public Health Engineering Department	Infrastructural development, providing technical assistance and support to municipalities, industries, and other stakeholders interested in implementing treated wastewater reuse projects.
Maharashtra Jeevan Pradhikaran (Water Supply and Sanitation)	Contribute to the formulation of policies and regulations related to treated wastewater reuse. This involves establishing guidelines, standards, and regulatory frameworks to govern the safe and sustainable reuse of treated wastewater in various sectors.
Maharashtra Water Resources Regulatory Authority	Collaboration and Partnership - local authorities, NGOs, and private sector entities to promote treated wastewater reuse as part of integrated water resource management efforts.
Department of Agriculture, Maharashtra	Monitoring of irrigation practices and use of (untreated) wastewater for food production. Sensitising farmers to adverse health impacts of use of untreated waste water.
Maharashtra Pollution control Board	Quality control and compliance
Maharashtra Industrial Development Corporation	Investing in the development of infrastructure for treated wastewater reuse within industrial estates and zones. Incentive programs to encourage industries to invest in treated wastewater reuse initiatives. Monitoring and reporting mechanisms to track the progress and performance of treated wastewater reuse projects within industrial estates.

CONCLUSION

There is an absence of a clear and definitive policy setting regarding the reuse of treated wastewater in India at the central level. Lack of institutional and regulatory structure also obstructs the establishment of treated wastewater reuse systems. Since water is a state subject, there is a lack of coordination between various sectors that are responsible for water supply and wastewater management. This fragmentation leads to delays in planning and implementation, unnecessary disagreements, division of resources, and complexity in interdepartmental agreements which result in increasing the complexity of reclaimed water reuse projects more than required. Due to fragmentation of the water sector, there is a limitation of data availability regarding water supply-demand gaps, wastewater volumes and water consumption, etc., which impacts reclaimed water reuse planning. Surplus availability of water in smaller cities and towns has made local bodies highly dependent on the available resources.

Tanker getting filled with treated wastewater for reuse in construction activities from hydrant located inside Behrampur STP

HARYANA



Haryana aims to reuse 80 per cent of treated water by 2030.

Agriculture consumes 85 per cent of reused treated water in Haryana, with IWRAP focusing on utilizing treated water from 177 STPs for micro-irrigation and agriculture.

Challenges to the reuse of treated water include non-compliance of STPs with CPCB norms, slow statewide project progress, and the need for monitoring to prevent untreated sewage mixing.

TOTAL WASTEWATER/ SEWAGE GENERATED (MLD)
1,655

TOTAL WASTEWATER/ SEWAGE TREATMENT CAPACITY (MLD)
1,965

TOTAL OPERATIONAL CAPACITY OF STP (MLD)
1,965

TOTAL WASTEWATER/ SEWAGE TREATMENT BEING TREATED* (MLD)
1,373

TOTAL TREATMENT CAPACITY COMPLIES WITH THE DISCHARGE NORMS (MLD)
1,501

AMOUNT BEING REUSED (%)
15.09

WATER AND WASTEWATER IN HARYANA: AN OVERVIEW

In 2021, Haryana's overall water demand was estimated to be 34,962.76 million cubic metre (MCM) —95,788 million litre per day (MLD); the total water availability from all sources was 20,935.96 MCM at 57,358 MLD.[25] The state receives 11,688 MCM of water from all its rivers and 11,580 MCM from its groundwater resources. In 2021, there was a demand-supply gap of 14,026.78 MCM (38,430 MLD).[26]

As Haryana is one of the more agriculturally developed states of India, the major share of the water demand is from agriculture and horticulture: 86 per cent and six per cent, respectively.[27] The water demand in other sectors such as infrastructure, households, industries, and power sectors is estimated at 4 per cent, 3.5 per cent, 3 per cent, and 0.5 per cent, respectively.[28]

Excessive extraction and insufficient replenishment have resulted in falling groundwater levels. The annual groundwater withdrawal in Haryana is 137 per cent of its annual extractable groundwater resources—the third-highest in the country and way above the national average, which stands at 63 per cent. In some places such as Kurukshetra, Kaithal, Bhiwani and Mahendragar, groundwater has dropped to 40 meters below the ground level. A 30-fold increase in number of tubewells between 1996 and 2016 has led to an increase in the number of towns and regions that are severely groundwater-stressed.[29]

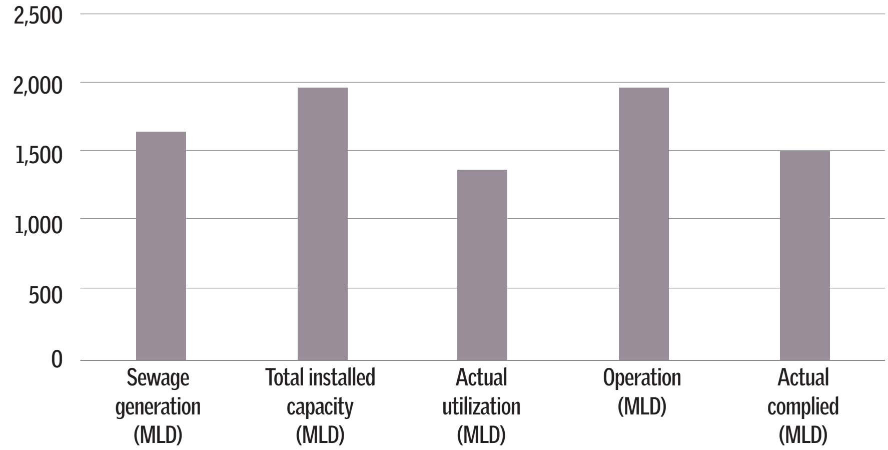
The three rivers of Haryana—Yamuna, Ghaggar and Markanda—are among the most polluted river stretches in the country. The pollution is caused by the industrial cities located along the rivers[30] as well as agricultural practices leading to contamination through surface water run-off of pesticides, insecticides, fertilizers, industrial discharge, etc.

According to a report submitted by the Haryana government to the National Green Tribunal (NGT) in November 2023, the estimated sewage generation in Haryana is 1,655 MLD.[31] The state has a total of 180 sewage treatment plants (STPs) with a combined treatment capacity of 1,965 MLD. All the STPs are operational, and 1,501 MLD of the total capacity complies with the discharge norms. Out of the 1,965 MLD total installed capacity, only 1,373 MLD is actually being utilized. Although the total installed treatment capacity exceeds the total sewage generated in the state, in towns like Faridabad and Gurugram, there is a gap between the sewage generated and the treatment capacity: it is 232.5 MLD and 93 MLD for Faridabad and Gurugram, respectively.Twelve STPs with a total capacity of 300 MLD are currently being constructed, and 11 new STPs with a total capacity of 444 MLD have been proposed.[32] *(see Graph 5: Sewage generation and treatment in Haryana)*

CURRENT POLICIES AND REGULATIONS

Haryana has various policies and legislation in place to conserve and preserve its water resources. It is also one of the first states in the country to establish a Water Resources Authority for the regulation of these resources in the state (*see Table 8: Existing policies and their reuse aspects).*

Graph 5: Sewage generation and treatment in Haryana



Source: NGT Monthly Progress Report, 2023

Table 8: Existing policies and their reuse aspects

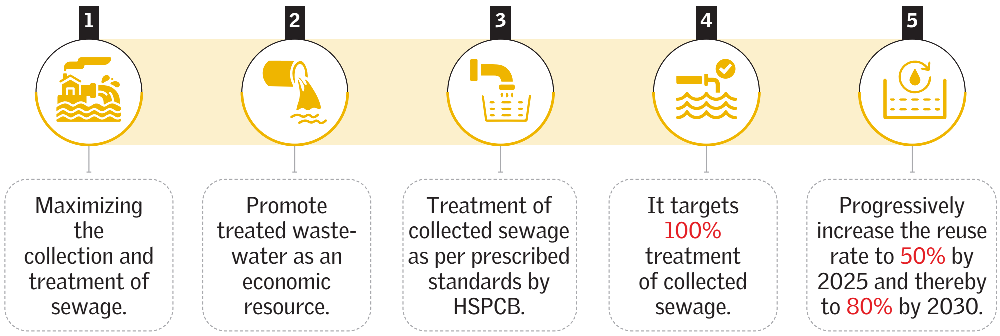
Policy	Reuse aspects
Policy on Reuse of Treated Waste Water, 2019	Haryana has a well-defined policy and a clear action plan for the reuse of treated wastewater. The policy envisages maximizing collection and treatment of the sewage generated and reusing the treated wastewater on a sustainable basis, thereby reducing the dependence on freshwater resources and promoting treated wastewater as an economic resource.
Haryana Water Resources Authority Act, 2020	The Act mandates the establishment of the Haryana Water Resources Authority for the conservation, management and regulation of water resources, including groundwater and surface water, within the state of Haryana. It aims to ensure the judicious, equitable and sustainable utilization of these resources. The Authority is also responsible for setting standards for the management and regulation of water, besides fixing the rates for use of water.
Integrated Water Resources Action Plan (IWRAP) of Haryana (2023–25)	This scheme's primary task is to harness treated used water (TUW) from 170 sewage treatment plants (STPs). This ambitious plan has a cumulative capacity of 1,985 MLD and targets a Command Area (CCA) of 0.25 lakh acre to be taken up in phases.

Source: Compiled by CSE

Policy on reuse of treated wastewater: Salient features

The policy states that a minimum of 25 per cent of treated water should be reused within two years in cities where sewerage system and STPs already exist; within three years, where a sewerage system exists but STPs are not available; and within four years, where there are no sewerage systems and STPs.

Figure 4: Salient features of Haryana's treated wastewater reuse policy



Source: Integrated Water Resources Action Plan (IWRAP)

Integrated Water Resources Action Plan (IWRAP) (2023–25)

The Haryana Water Resources Authority had projected a water demand and supply gap of 14,026.78 MCM for 2021.[33] The IWRAP aims to save water through demand-side interventions which include micro irrigation, crop diversification, direct seeded rice, conservation tillage, and water efficiency; and supply-side measures such as underground pipelines for irrigation, lining canal water courses, groundwater recharge, rejuvenation of ponds, reuse of treated water, and increasing surface water storages. These interventions aim to reduce the existing water gap by more than 49 per cent in the next two years (2023-25), instead of the three years as proposed in the earlier action plan.

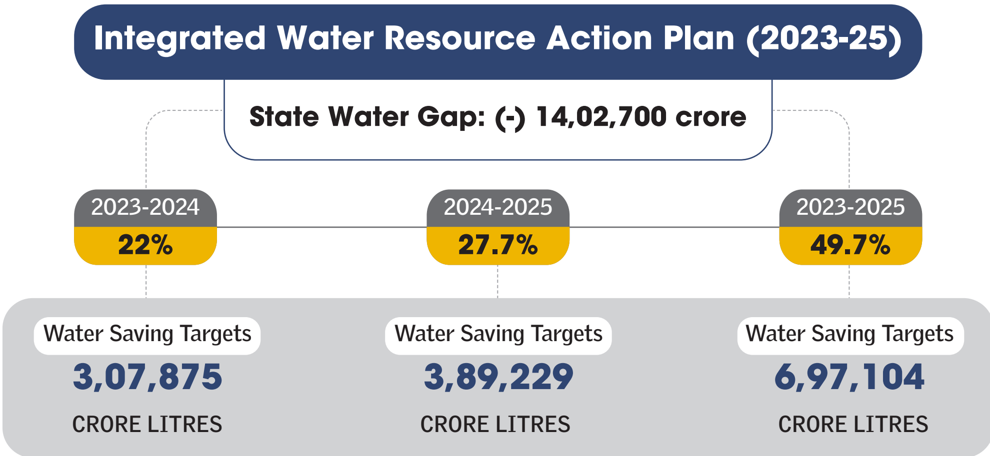
The objective of this action plan is to harness treated water from 170 STPs, and target irrigation in 0.25 million acre in phases.

- **Phase 1** (**till March 31, 2024**): Initially, 35 STPs were identified for Phase 1, out of which only 27 (339.50 MLD capacity) were found feasible. The targeted CCA (Cultivable Command Area) for Phase 1 is 43,380 acre. A project cost of INR 500 crore has been allocated, with INR 314.30 crore already sanctioned by the National Bank for Agriculture and Rural Development (NABARD).
- **Phase 2** (**till December 31, 2025):** For this phase, 57 STPs have been identified with a capacity of 528 MLD. The targeted CCA is 67,560 acre. This phase extends its reach to 14 districts across the state.
- **Phase 3** (**till December 31, 2026**): This phase identifies 78 STPs with a capacity of 1,118 MLD. The targeted CCA is 1,43,059 acre. An estimated INR 1,000 crore has been allocated for the project.

REUSE OF TREATED WASTEWATER

According to the IWRAP, only 15.09 per cent of the 1,130 MLD treated sewage is being reused for non-potable purposes in agriculture, horticulture, construction and the industrial sectors.[34] Only a few of the big districts are reusing treated wastewater. For example, Gurugram is reusing the highest amount (47 per cent), followed by Kurukshetra (35 per cent), Panchkula (34 per cent), Sonipat (31 per cent), Faridabad (25 per cent), Jhajjar (14 per cent) and Rewari (5 per cent). At other places, treated wastewater is directly discharged into drains.[35]

Figure 5: The Integrated Water Resources Action Plan (2023–25)



Source: Integrated Water Resources Action Plan, Haryana

Under an ambitious irrigation project initiated by the state for the Nuh region, the delivery of treated water from the Behrampur STP in Gurugram to Nuh is currently underway. This will include the laying of a 35-km pipeline which will connect to the existing Nuh distributary irrigation channel at Korali village in Tauru tehsil, Mewat district. This initiative aims to provide 200 MLD of recycled water to the water-scarce district for agricultural purposes. To understand how Haryana prioritizes and reuses treated water, a team from Centre for Science and Environment (CSE) visited two districts—Gurugram and Kurukshetra. Table 9 provides the details gathered from the STPs that the team visited.

Table 9: Details of the visited STPs

District	STP	Commissioned (year)	STP capacity (in MLD)	Technology (UASB/ASP/OP/SBR/MBR/FAB etc)	Reuse
Gurugram	Behrampur	2010	50	ASP	Reuse in industry, pond restoration, construction, green belt development, stadium
		2015	120	SBR	
	Dhanwapur	2002	68	ASP	No reuse
		2010	100		
			43		
Kurukshetra	Shahabad	2016	11.5	SBR	Irrigation (agriculture)
	Ladwa	2016	7	MBBR	Irrigation (agriculture)
	Pehowa	2015	8	MBBR	Irrigation (agriculture)

Source: CSE field visit

GURUGRAM

Gurugram is located 30 km south of New Delhi. It is one of Delhi's major satellite cities and is part of the National Capital Region (NCR). The city lies on the Sahibi river, a tributary of the Yamuna. The Sahibi originates from the Aravalli ranges in Rajasthan and flows through the west and south of Haryana before running into Delhi, where it is known as Najafgarh drain. Over the past 25 years, Gurugram has undergone rapid growth and urbanization, accompanied by a construction boom.

The drinking water supply in Gurugram is 640 MLD: 570 MLD of this is from the Gurgaon Water Supply Channel (GWSC). The channel brings water from the Yamuna near Kakroi village in Sonipat district and delivers it to various treatment plants in Gurugram, where it is processed and distributed for residential and commercial use while 70 MLD comes from tubewells.[36] Eighty-nine per cent of the supply is from surface water sources. This shift occurred due to the severe water stress in the region caused by over-exploitation of groundwater resources.

The total water demand is 585 MLD—the city's 2.7 million people receive 172 litre per capita daily, which adds up to 465 MLD. The remaining 120 MLD comes from industries, institutions and commercial users.[37]

Gurugram is currently generating 512 million litres per day (MLD) of sewage, and this figure is projected to increase to 592 MLD by 2024-25. The city has five sewage treatment plants (STPs) at two locations, Behrampur and Dhanwapur, with a total capacity of 388 MLD. Another 79 MLD is treated by small-scale treatment systems (residential buildings/apartments/ institutions etc) and micro-STPs, bringing the total being treated to 467 MLD. To address the city's rapid growth, an additional treatment capacity of 360 MLD has been proposed.[38]

Of the total 476 MLD of wastewater treatment capacity, 415 MLD of wastewater is treated: 135 MLD through secondary treatment and 280 MLD through tertiary treatment.[39]

Secondary treatment involves biological processes to remove dissolved and suspended organic matter from wastewater. This stage significantly reduces the organic load and prepares the water for further purification.

Tertiary treatment is an advanced cleaning process that follows secondary treatment. It involves additional filtration, chemical treatment, and disinfection to remove remaining contaminants, nutrients, and pathogens, producing water that is suitable for reuse or safe discharge into the environment.

Reuse of treated water

According to data from the Gurugram Metropolitan Development Authority (GMDA), in the fiscal year 2022-23, an average of 126 MLD of sewage was reused; this was 30 per cent of the total sewage treated.[40] The treated water was reused for agriculture, horticulture, industry, construction, and replenishing waterbodies *(see Table 10: Action plan for reuse of treated wastewater in Gurugram)*.

The action plan for reuse of treated water in Gurugram targets 100 per cent use of the treated water by 2024-25. The following have been proposed:

- **Increase the networked infrastructure for distributing treated wastewater:** Gurugram has a networked infrastructure for distributing treated wastewater across the city. This network stretches from Sector 1 to Sector 115, spanning a total length of 120 km. By 2024-25, an additional 26 km will be added to the master network.
- **Increase the lateral recycled network:** Currently, there is a 73 km-long pipeline (28 km of the pipeline is managed by the Municipal Corporation of Gurugram (MCG), while the remaining 45 km is under the GMDA. By 2023-24, MCG and GMDA aim to add 100 km of pipeline, followed by another 100 km in 2024-25 *(see Annexure: Recycled water network map of Gurugram)*.
- **Extend the infrastructure:** There are plans in place to reuse 840 MLD of treated water for lakes, expressways, biodiversity parks, agriculture, forest areas and nearby villages *(see Table 11: Proposed extension of infrastructure for treated used water utilization)*.

Table 10: Action plan for reuse of treated wastewater in Gurugram

Treated water	**2022–23 (MLD)**	**2023–24 (MLD)**	**2024–25 (MLD)**
	415 (T-280 + S-135)	**415 (T-280 + S-135)**	**512 (T-512)**
Treated water utilization:			
1. Horticulture	30	44	57
2. Textiles industries, Sector 34	5	5	15
3. Construction	9	20	40
4. Waterbodies and forest area	7	10	20
Total	**51**	**79**	**132**
5. Agriculture by IWRD	75	279	380
Total utilization	126	358	512
Percentage of utilization	30%	86%	100%

T – Tertiary treated water, S – Secondary treated water. Source: Gurugram Metropolitan Development Authority

Tariff system

Currently, treated water is supplied at Rs 4 per kilolitre (kl) at the STP site and Rs 5 per kl when delivered at the doorstep.[41] However, as per an agreement between Haryana Water Resource Authority (HWRA) and Public Health Engineering Department (PHED), treated water is free for use in agriculture.

BEHRAMPUR STP: A CASE STUDY OF REUSING TREATED WATER FOR MIXED USE

In Gurugram, treated used water is being mainly used for horticulture and green belt development (59 per cent). However, this is expected to change soon, and the use for industrial purposes, construction and waterbodies' rejuvenation will be much more in the coming years – as can be seen in the targets for the Behrampur STP (*see Table 12: Reuse of treated wastewater and action plan for Behrampur STP*).[42]

Table 11: Proposed extension of infrastructure for treated used water utilization

Name of project	Capacity of TWW (MLD)	Timeline
Pipeline from Botanical Garden Sector 52A to Wazirabad Lake	1	2023–24
Main distribution recycle pipeline from 55 MLD CETP Manesar to existing recycle pipelines in Sectors 81, 86, 87, 90, 91 and 92.	25	2023–24
Main distribution recycle pipeline at KMP Expressway from 55 MLD CETP Manesar	10	2023-24
Construction of underground tank along with laying of distribution pipeline from SPR near Village Ghatta to Biodiversity Park	6	2023–24
Agriculture purposes in Gurugram and Jhajjar district villages by the Irrigation Department through 550 MLD STP Channel	550	2023–24
Recycle pipeline from MDI Chowk to Sanath Road and TDL Park Sector 22	5	2023–24
Total	**597**	
Rising mains distribution pipe line from Golf Course Road to Police Training Centre Bhondsi and up to Damdama forest area, Gurugram	33	2024–25
Distribution pipeline for Kasan Forest area, Gurugram	10	2024–25
Distribution main for recycle water pipeline from STP Behrampur to Village Korali, Tehsil Taoru, District Mewat, Haryana	200	2025–26
Grand total	**840**	

Source: Gurugram Metropolitan Development Authority

Figure 6: Salient features of the Behrampur STP

Behrampur STP

Commissioned
2010 & 2015

Capacity
50 & 120 MLD

Technology
Activated Sludge Process & Sequencing Batch Reactor

Flow (MLD)
May, 2023. 45 & 110

Table 12: Reuse of treated wastewater and action plan for Behrampur STP

Treated water	2022–23 (MLD)	2023–24 (MLD)	2024–25 (MLD)
Treated water utilization			
Horticulture	30	44	57
Textiles industries, Sector 34	5	5	15
Construction	9	20	40
Waterbodies and forest area	7	10	20
Total	51	79	132

Source: Gurugram Metropolitan Development Authority

Horticulture and green belts: Treated wastewater is extensively used for the maintenance and development of green belts and parks in Gurugram. Water from the main pipeline is supplied to hydrants, located at 30-meter intervals. These hydrants play a crucial role in supplying treated water for green belt development in different parts of the city, including Sector 52 and South City, the Southern Peripheral Road, Sector 36, and Sector 38.

Smaller hydrant (access point) near Almeda Chowk, Sector 70, Gurugram from where the treated water is used for horticulture

Underground tank of 0.5 MLD capacity for storing treated water for horticulture purpose in Tau Devilal Stadium, Sector 38, Gurugram

Existing pipeline network at Behrampur STP used for supplying treated used water for textile industries in Sector 34, Gurugram

At Tau Devi Lal Stadium (TDL Stadium) in Sector 38, treated water is sourced from the main pipeline and stored in three underground tanks, each with a capacity of 0.5 MLD. This stored water is then utilized for horticultural purposes, primarily through a sprinkler system.

Industrial use: The Behrampur STP supplies five-seven MLD of tertiary treated water to the local textile industry in Sector 34. The water's Biochemical Oxygen Demad (BOD) is below 5 mg/l, TSS (total suspended solids) is less than 30 mg/l, and TDS (total dissolved solids) is under 500 mg/l. Individual textile units conduct rigorous water quality tests in their own laboratories four times a day. The economic benefits of this initiative are good, with the textile industry generating an additional monthly revenue of approximately Rs 3 lakh due to the cost-effectiveness of treated water, which is priced at a mere Rs 2 per kilolitre, outperforming the Rs 5-6/kl cost of using groundwater.

Restoration of waterbodies: Another use of treated water is for restoration of waterbodies in the area of Sakatpur/Gairatpur Bas village. Treated wastewater from Behrampur STP is used to recharge waterbodies in this area. In this endeavour, 20 waterbodies have been successfully restored, primarily through the installation of an eight-km treated water line.

Construction: Concerned over the negligible use of recycled water for construction purposes, the GMDA has now made the use of treated water at its project sites mandatory. As per its instructions, only tertiary treated water will be used in construction work, and the cost for supply and further treatment for construction purposes will be borne by the contractor/firm. Tertiary treated water is available at the STPs in Dhanwapur and Behrampur.

Restored water body in Aravalli hills (Sakatpur road) using treated used water.

Hydrant at Sakatpur road (leopard trail) in Gurugram through which supplied treated water is discharged in water bodies for restoration.

According to the guidelines issued for infrastructure projects, a grant of NOC for the use of groundwater for construction activity shall be permitted only if no treated sewage water is available within a 10 km radius of the site.[43] As per the licence conditions of the Department of Town and Country Planning, developers must use treated water for construction. If developers continue to violate this norm, then the Authority and other departments will prosecute them and impose environment penalty. It is the responsibility of the GMDA to ensure all contractors use recycled supply from sewage treatment plants at project sites.

Contractors need to register themselves with the GMDA and raise requests for water procurement. Once approved, an online token is provided, facilitating the collection of treated water from hydrants located within the Behrampur STP premises. Treated water is affordably priced at Rs 30 per kl for its use in construction activities, thereby reducing the demand for freshwater during the building process.

Additionally, nine other hydrants spread across the city enable the collection of treated water for various other purposes such as dust control, green belt development, etc. The treated water is recycled again at micro-STPs set up at construction sites, making it convenient for reuse.

The Behrampur STP in Gurugram demonstrates the importance of planning for the use of treated wastewater for various purposes from a single STP. A target of reusing 132 MLD of treated water has been set for 2024–25.

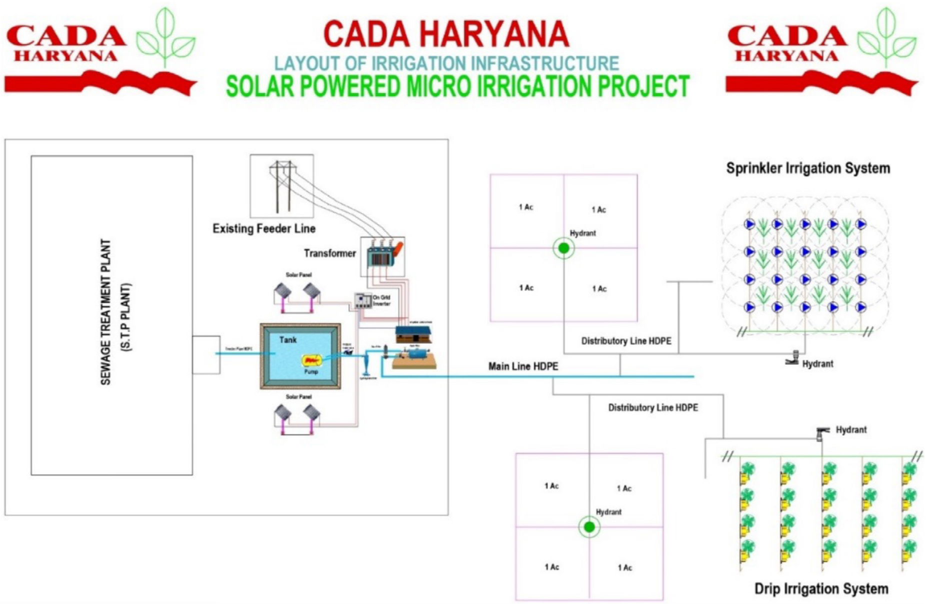
KURUKSHETRA

Kurukshetra, one of Haryana's 22 districts, has a population of over 10 million as per the 2011 Census. The district is largely a plain with an average elevation of 241-274 metre above sea level. It receives an average annual rainfall of 290.5 mm. The district's most important rivers are the Saraswati, Markanda and the Ghaggar. It also possesses a well-established network of canals, which facilitates irrigation in the area. Tubewell irrigation is widely practiced as well.

However, Kurukshetra faces challenges of groundwater depletion, fluoride concentration, and iron contamination, significantly impacting its groundwater resources.

Kurukshetra has five STPs with a combined capacity of 66.5 MLD, based on sequencing batch reactor (SBR) and moving bed biofilm reactor (MBBR) technologies. Except one STP at Pehowa, all the STPs are operational and comply with the national discharge standards *(see Table 13: STPs in Kurukshetra)*.

Figure 7: Layout of solar-powered micro-irrigation project



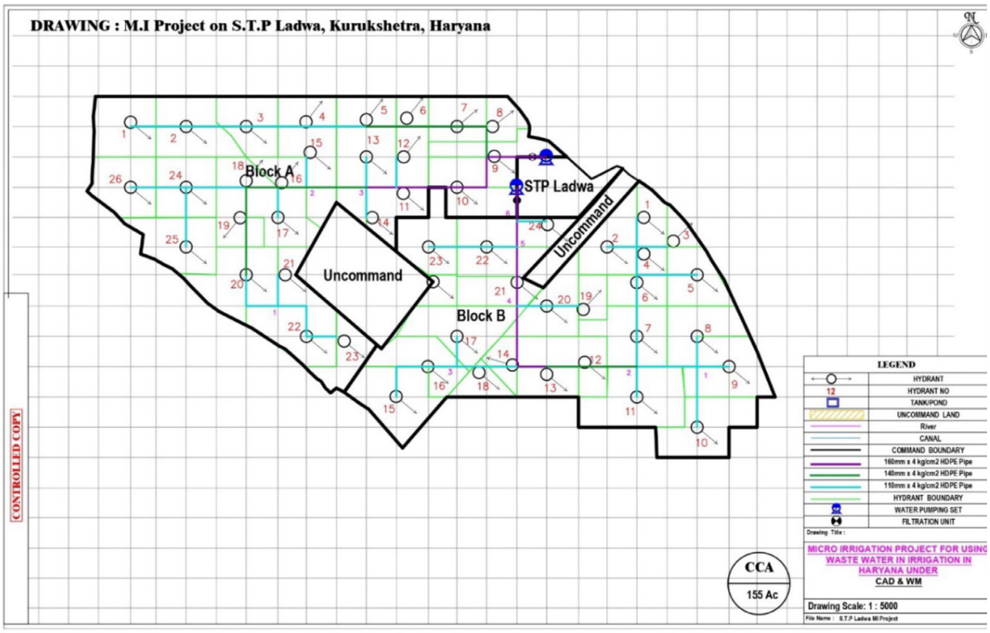
Source: MICADA, Department of Irrigation, Kurukshetra, Haryana

Table 13: STPs in Kurukshetra

District	Location of STP	Com-missioned (year)	Status (operational/ non-operational/ under construction/ proposed)	Installed capacity of STP (MLD)	Techno-logy	Compliance status (complying/non-complying/partially complying)
	Kurukshetra	2020	Operational	15	SBR	Complying
Kurukshetra	Thanesar	2019	Operational	40	SBR	Complying
	Pehowa	2019	Operational	8	MBBR	Non-complying
	Ladwa Road Shahabad	2016	Operational	11.5	SBR	Complying
	Ladwa	2016	Operational	7	MBBR	Complying

Source: NMCG (November, 2023)

Map 2: Plan of micro-irrigation project implemented in Ladwa STP



Source: Micro Irrigation and Command Area Development Authority, MICADA

Reuse of treated wastewater

At present, Kurukshetra reuses 30 per cent of the total wastewater that it treats, primarily for agricultural purposes.[44] The treated water being reused thus is supplied by the Shahabad, Ladwa and Pehowa STPs of the district under planned intervention.

The Micro Irrigation Command Area Development Authority (MICADA) of the Irrigation Department in Kurukshetra has implemented the reuse project in the three STPs. Under this project, the treated water is stored in a reservoir constructed within the premises of the plant, from where the water is pumped through solar power and supplied to farmers through a network of underground pipelines *(see Figure 7: Layout of solar-powered micro-irrigation project)*. The Department has designed the pressurized hydrant outlet in a way that it integrates seamlessly with the micro-irrigation scheme, enhancing the efficient utilization of treated wastewater.

Figure 8: Salient features of the Shahabad, Ladwa and Pehowa STPs

Commissioned **2016**	Capacity **11.5 MLD**	Commissioned **2015**	Capacity **8 MLD**	Commissioned **2016**	Capacity **7 MLD**
Technology **Sequencing Batch Reactor**	Flow (MLD) **September 2023 - 8 MLD**	Technology **Moving Bed Biofilm Reactor**	Flow (MLD) **September 2023 - 5.5 MLD**	Technology **Moving Bed Biofilm Reactor**	Flow (MLD) **September 2023 - 6.5 MLD**

Escape canal adjacent to the boundary of Shahabad STP where treated wastewater is discharged for reuse in agriculture by the nearby farmers in Chhapra village, Kurukshetra district, Haryana.

Hydrant installed in the field of farmers for treated water supply in Chhapra Village, Kurukshetra district, Haryana.

SHAHABAD SEWAGE TREATMENT PLANT

Once the used water is treated at the STP, it is stored in a reservoir. This water is distributed to farmers in Chhapra village through underground pipelines that cover a distance of 10,950 metre. A solar-powered plant with a capacity of 55 kiloWatt operates the pumps for 14 hours every day, providing the necessary power for water distribution.

Farmer accessing treated water from hydrant installed in the field for agriculture in Baraichpur village, Kurukshetra District, Haryana

The treated water is used for irrigation, benefiting 35 farmers and covering an area of 373 acre of agricultural land. The total amount of treated water used each day is three million litre.

The cost of the project, including that of the reservoir, pipelines and the solar plant, is Rs 18,628,623.[45] Leftover treated water is released into an open canal near the plant, which farmers can access for their irrigation needs through openings along the canal.

LADWA SEWAGE TREATMENT PLANT

A reservoir has been constructed within the premises of the STP in Ladwa to store treated water. This water is distributed to Baraichpur village located nearby. A network of underground pipelines stretching across a distance of 5,196 metre has been laid out to facilitate the supply of the water. Strategically-placed hydrants, with openings provided at an interval of two acre, ensure convenient access to water for irrigation. See Map 2 for a detailed plan of the micro-irrigation project implemented in Ladwa STP.

Constructed reservoir to store the treated water in the premises of Ladwa STP

To run the pumps responsible for distributing treated water, a solar power plant with a capacity of 27.5 kiloWatt has been installed. This renewable energy source operates the pumps for six hours each day, ensuring a sustainable and eco-friendly power supply for the system.

Pumping infrastructure with sand filters to distribute water for irrigation in Baraichpur village, Kurukshetra district, Haryana.

The impact of this project is significant, with 1.25 MLD of treated water being utilized for irrigation. This has brought about substantial benefits for the local agricultural community, specifically the 37 farmers who now have access to treated water for their crops. The total land area benefiting from this initiative spans 156 acre.[46]

In terms of cost, the project requires an estimated (implementation and operational) budget of approximately Rs 90 lakh.[47] This investment covers the implementation and operational expenses associated with the development of the infrastructure, distribution network, and the solar plant. Any excess treated water produced by the STP is discharged into the Rakshi drain, located approximately 1.25 km away from the plant.

There are plans to expand the project to Jainpur Jattan and Barhan villages. The work for a survey has already begun, and the implementation is scheduled to commence

Chamber constructed by farmer where the treated water enters from the canal which is then used for agriculture in Chhapra village, Kurukshetra district, Haryana

Solar panel installed in Pehowa STP premises to supply energy for pumping water for distribution in nearby villages.

tentatively in March, 2024. This extension aims to replicate the success achieved in Baraichpur village, providing additional communities with access to treated water for irrigation and promoting sustainable water management practices in the region.

PEHOWA STP

The Pehowa STP also has a reservoir that stores treated water within its premises. This water is distributed through underground pipelines to Pehowa and Morthali villages. The pipelines cover a distance of 6,084 meter, with openings provided at an interval of every two acre of land to enable easy access to the water. A solar power plant with a capacity of 27.5 kiloWatt operates the pumps for 14 hours each day. The project cost is approximately Rs 1 crore.

The 1.5 MLD of treated water produced here is used for irrigation, benefiting 16 farmers who collectively cultivate 188 acre of land. In addition to agriculture, the treated water is also supplied to a nearby seven-acre forest area upon request. An average of 1-1.25 MLD of treated water is provided every other day; this helps in maintaining and growing the forest.

Making the projects sustainable

The pilot projects in Shahabad, Ladwa and Pehowa have aimed at reusing treated wastewater for agriculture and have demonstrated promising results in their initial stages, thanks to meticulous planning and implementation. Moving forward, these projects will be scaled up. But to ensure their long-term sustainability, an efficient system of operation and maintenance is required. The MICADA (Micro Irrigation Command Area Development Authority) has implemented certain innovative measures to facilitate this.

O&M for the first three years by MICADA: MICADA is going to be responsible for the operation and management for the initial three years of project implementation, after which the projects will be handed over to the beneficiaries themselves. Proper operations include the uninterrupted supply of treated wastewater to farmers for irrigation. MICADA is also committed to enhancing the knowledge and awareness of farmers through training and awareness sessions, which focus equipping the beneficiaries with knowledge and skills required for ensuring optimal use of the treated water.

Water Use Association Committees (WUCs): Water Use Association Committees (WUCs) have been established and they are expected to play a pivotal role in overseeing and managing the operation and maintenance once MICADA hands over responsibilities. The composition of a WUC is designed to be representative and responsive to the needs of the beneficiaries. The WUC typically consists of a president, a vice president and a secretary; the formation of this committee is subject to the consent of the beneficiaries.

Determining water supply schedules: One of the primary tasks of the WUC is to establish water supply schedules for individual beneficiaries. The timing and frequency of water supply are essential considerations to ensure equitable access and efficient use of treated water resources. The WUC collaborates with beneficiaries to determine the most suitable water supply schedules based on their agricultural needs.

Figure 9: Scheduling of the water distribution Water User Committee

एस.टी.पी. लाडवा गांव बरेचपुर वाराबंदी जिला कुरूक्षेत्र

ब्लाक न. ए (मोटर न.1)

दिन	नाका न.	नाम	एकड़	समय	कुल घंटे
सोमवार	1	लखविन्द्र सिंह	2	10 से 11	1
सोमवार	1	बिना नाम	1	11 से 11:30 तक	1/2
सोमवार	1	संजय गौतम	1	11:30 से 12 तक	1/2
सोमवार	2	जसविन्द्र सिंह	1	12 से 12:30 तक	1/2
सोमवार	2	जसविन्द्र सिंह	1	12:30 से 1 तक	1/2
सोमवार	2	संजय गौतम	2	1 से 2 तक	1
सेमवार	3	जसविन्द्र सिंह	2	2 से 3 तक	1
सोमवार	3	जसविन्द्र सिंह	1	3:00 से 3:30	1/2
सोमवार	3	संजय गौतम	1	3:30 से 4 तक	1/2
मंगलवार	4 5	संजय गौतम	2	10 से 11	1
मंगलवार	4	संजय गौतम	2	11 से 12	1
मंगलवार	5 6	संजय गौतम	4	12 से 2	2
मंगलवार	6	लखविन्द्र सिंह	3	2:00 से 3:30 तक	1½
मंगलवार	6	जसविन्द्र सिंह	1	3:30 से 4 तक	1/2
बुधवार	7	संजय गौतम	1	10 से 10:30	1/2
बुधवार	7	बिना नाम	3	10:30 से 12 तक	1½
बुधवार	8	अमित गौतम	4	12 से 2 तक	2
बुधवार	9	गौरव	2	2 से 3	1
बुधवार	9	सतपाल नम्बरदार	2	3 से 4 तक	1
वीरवार	10	सतपाल नम्बरदार	2	10 से 11	1
वीरवार	10	गौरव	2	11 से 12	1
वीरवार	11 15	सुखा सिंह	2	12 से 1	1
वीरवार	11	मनप्रीत सिंह	2	1 से 2 तक	1
वीरवार	11	बिना नाम	1	2 से 2:30 तक	1/2
वीरवार	12	सतपाल	2	2:30 से 3:30 तक	1
वीरवार	12	सुखबीर	1	3:30 से 4 तक	1/2
शुक्रवार	13	सुखबीर	5	10 से 12:30 तक	2½
शुक्रवार	14 13	धर्मपाल	4	12:30 से 2:30 तक	2
शुक्रवार	15 14	कर्मबीर	3	2:30 से 4 तक	1½
शनिवार	15	बिना नाम	1	10 से 10:30 तक	1/2

"I am using water from the plant for the last five years. Earlier, we were using this water only during the summer months when the tubewells would go dry. But seeing the impact on productivity and also growth that the treated water had on the crops, we started using this water round the year. It is more productive when compared to crops irrigated with groundwater."

Gulab Singh, resident and farmer, Chhapra village, Kurukshetra district, Haryana

"I have been using the water supplied from the Ladwa plant since 2019. Earlier, we used to irrigate our fields with water from tubewells. Now all nearby farmers are using treated water. We are receiving a regular supply of water in all seasons. Major crops in this area are wheat, rice and potato. We have seen that the productivity of crops is more if we use treated water for irrigation which helps us save Rs 4,000-5,000 (approximately) per killa (1 killa=1 acre) due to reduced need of urea etc in crops. Also, since we have stopped using tubewells, we are saving Rs 8,000-9,000 in electricity bills every year."

Pankaj Kumar, resident and farmer, Baraichpur village, Kurukshetra district, Haryana

These schedules are not static; they can be adjusted as required to accommodate changing circumstances, ensuring that the distribution of water remains efficient and fair. To monitor and ensure the smooth implementation of these schedules, local officials like the patwari play a crucial role in overseeing the process.

Financial sustainability through user fees: To ensure financial sustainability of these projects, beneficiaries are required to contribute to the cost of using supplied water. The WUC, in consultation with the farmers, decides the appropriate user fees. These fees can range from INR 10 to 50 per acre per irrigation cycle, depending on factors like the costs of operation and maintenance.

The funds collected through these user fees are deposited in the committee's account, which is used to cover the ongoing operation and maintenance expenses. This self-sustaining financial model ensures that the projects can continue to serve the community effectively without undue burden on any individual beneficiary.

Addressing breakdowns and failures: Any reported breakdown or failure is promptly communicated to the MICADA, which initiates a survey to identify the cause of the issue. Following the survey, MICADA provides a detailed report and cost estimate for the necessary repairs. The committee is responsible for covering the estimated repair costs, ensuring a swift resolution to the problem. Once the expenses are paid, the repair work is carried out by the department, ensuring that the system is back in operation as quickly as possible.

THE LEARNINGS

In Kurukshetra district, the three STPs in Shahabad, Ladwa and Pehowa play a pivotal role in promoting sustainable agricultural practices by facilitating reuse of 5.75 MLD of used treated water. To distribute this wastewater, a well-planned underground pipeline network has been established, which connects the STPs to agricultural lands in the vicinity. A combined total of 717 acre of agricultural land benefits from the availability of this water, which supports the livelihoods of 88 farmers.

While Haryana is currently reusing only 15 per cent of its treated wastewater, the state policy aims at reusing 80 per cent of the total treated water by 2030. The State Action Plan mandates 37.4 per cent reuse of treated water in the state by March 2024, 56.7 per cent by March 2025 and 54.3 per cent by December 2028.[48] Since agriculture is the largest consumer of treated wastewater (85 per cent), the IWRAP aims to reuse treated water from the existing 177 STPs of Haryana for micro-irrigation and agricultural purposes.

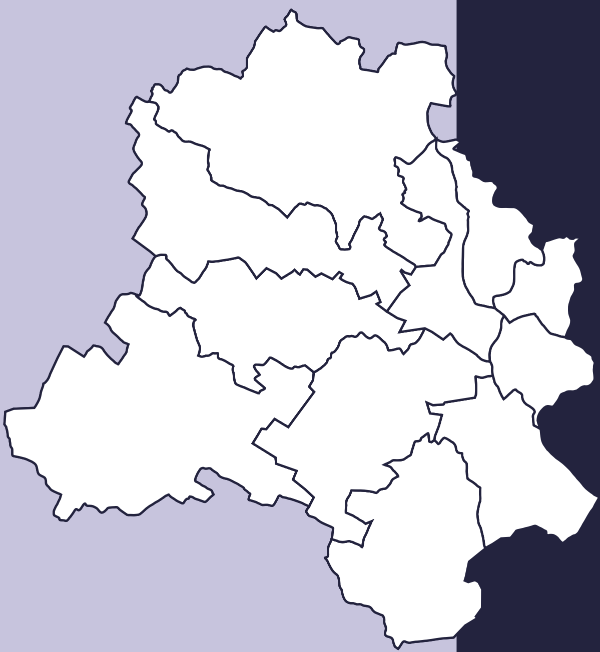
The Integrated Water Resources Action Plan (IWRAP) and the Reuse of Treated Water Policy are crucial initiatives in Haryana that ensure the planned and timely execution of projects related to the reuse of treated water. Under IWRAP, all the major departments have prepared a month-wise, block-wise, district-wise and intervention-wise action plan for the next two years, from 2023 to 2025. Additionally, the establishment of the Haryana Water Reuse Authority (HWRA) has provided significant momentum to the reuse of treated water in the state. These initiatives also bring together all stakeholders onto a unified platform, fostering collective efforts towards the successful implementation of treated water reuse projects in the state.

There are a few districts where substantial reuse of treated water is happening. Gurugram is leading in this direction, followed by Kurukshetra. Gurugram itself accounts for approximately 50 per cent of the total treated water generated in Haryana. The GMDA has systematically planned reuse projects in the city for diverse purposes through a well-defined strategy.

At present, Kurukshetra is reusing 30 per cent of its treated water for agricultural purposes under the Micro Irrigation Command Area Development Authority (MICADA). MICADA is implementing projects under a well-defined strategy and plans to scale it up further. Operating and maintaining the project during the first three years of its implementation, forming water use associations, determining water supply schedules and ensuring financial sustainability through user fees are a few of the innovative steps adopted by MICADA for the success of the reuse projects.

However, non-compliance of sewage treatment plants with the Central Pollution Control Board's (CPCB) norms and the slow progress of reuse projects state-wide remain areas of concern. It is crucial to closely monitor reuse projects, particularly those involving pond rejuvenation and agricultural applications, to prevent the mixing of untreated sewage in the treated water. In the case of Kurukshetra, pilot-level micro-irrigation projects appear promising, but their economic feasibility needs to be thoroughly assessed.

DELHI



Of the 2,587 MLD sewage being treated in Delhi, 666 MLD is being reused for horticulture and lake rejuvenation.

Although Delhi's Draft Water Policy sets targets for decentralized reuse of treated wastewater, implementation is lagging behind in several projects.

Delhi's action plan for reusing treated water emphasizes using treated wastewater for groundwater recharge in designated areas, but the quality of treated water remains a concern, with many STPs not meeting DPCC norms.

TOTAL WASTEWATER/ SEWAGE GENERATED (MLD)
3,600

TOTAL WASTEWATER/ SEWAGE TREATMENT CAPACITY (MLD)
3,033

TOTAL OPERATIONAL CAPACITY OF STP (MLD)
3,033

TOTAL WASTEWATER/ SEWAGE TREATMENT BEING TREATED* (MLD)
2,587

TOTAL TREATMENT CAPACITY COMPLIES WITH THE DISCHARGE NORMS (MLD)
1,042

AMOUNT BEING REUSED (%)
49.0

* (and can be reused)

WATER AND WASTEWATER IN DELHI: AN OVERVIEW

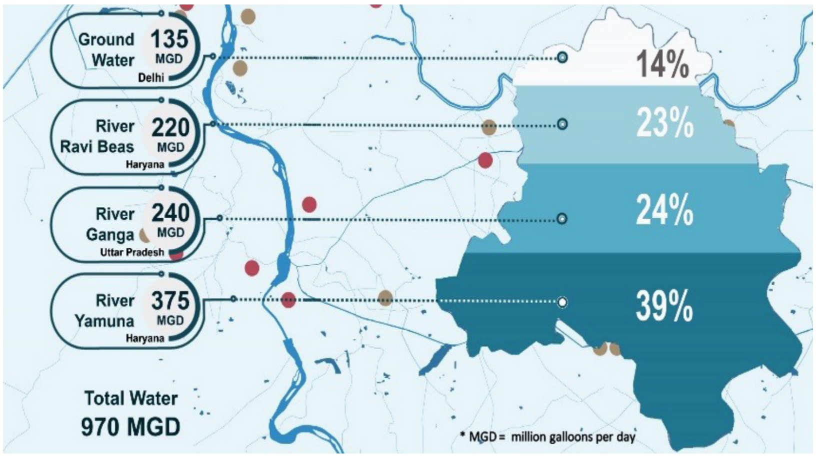
In order to meet the diverse water needs of its population, Delhi requires 172 litres of water per capita daily (lpcd) for domestic consumers (e.g households) and an additional 102 lpcd for non-domestic consumers (e.g industries, commercial establishments, hotels and fire stations etc).[49] Consequently, the city's total daily water requirement stands at 274 lpcd. This quantity adheres to the water supply norms established by the Central Public Health and Environmental Engineering Organization (CPHEEO) for metropolitan and mega cities.[50]

Of the projected demand of 1,260 MGD of water for 2019, the Delhi Jal Board produced 74 per cent i.e. 937 MGD of water.[51] Thus, there was a substantial gap of 323 MGD between water demand and supply. Potable water demand for domestic use in Delhi has been projected to rise to 1,364 MGD at 55 gallons per capita per day (gpcd) for an estimated population of 24.80 million by the year 2031, and to 1,500 MGD for an estimated population of 30 million at 50 gpcd by the year 2041.[52]

The groundwater resources assessment by Central Groundwater Board (CGWB) states that the total annual groundwater recharge in the state is 0.41 billion cubic meters (bcm) against the annual extractable groundwater resource of 0.37 bcm.[53] Currently, the annual groundwater extraction is 0.36 bcm (98.16 per cent).

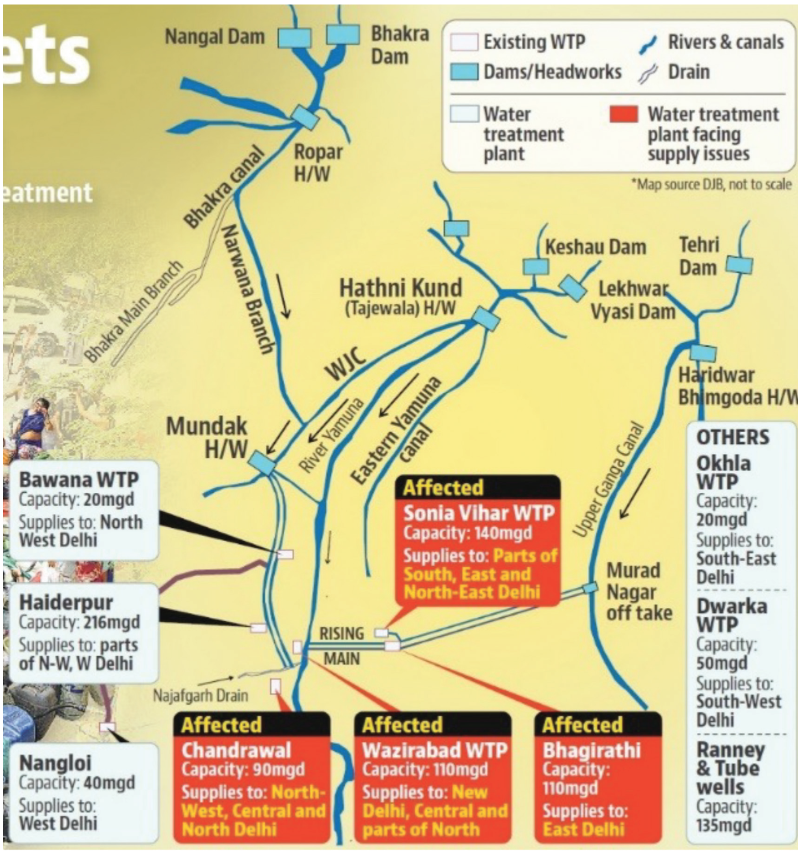
Delhi has limited internal water resource and is largely dependent on external resources over which it exercises no direct control and is always under pressure from upper and lower riparians. Out of the total 970 million gallons of water per day (MGD) that is supplied by the Delhi Jal Board (DJB), 39 per cent of the demand is met by the Yamuna, 24 per cent by the Ganga via the upper Ganga canal, 23 per cent by Bhakra storage (Ravi and Beas) and the remaining 14 per cent by groundwater aquifers[54] *(see Figure 10: Sources of water supply in Delhi)*.

Figure 10: Sources of water supply Delhi



Source: Delhi Jal Board

Figure 11: Status of distribution network of water supply network in Delhi)



Source: https://www.theguardian.com/world/2016/feb/22/india-caste-protesters-accept-offer-to-end-riots-and-water-crisis

Delhi's massive dependence on three rivers for its water supply, and the long conveyance canals, leads to great uncertainty and risk. In 2016, due to the Jat protests the canal was sabotaged and water supply to Delhi was cut down by two-thirds of its regular supply.[55]

Water supply from the canal is also disrupted during natural disasters and landslides. For instance, in February 2021, Delhi's supply was disrupted due to flash floods in Chamoli in Uttarakhand, which led to high turbidity levels in the canal water[56] *(see Figure 11: Status of distribution network of water supply network in Delhi).*

The quality of water in Delhi is also grim. Delhi relies heavily on the Yamuna River for waste disposal, and this has led to the city's waste being responsible for a staggering 80 per cent of the river's pollution. The water quality of the Yamuna in Delhi was monitored in eight locations (stretch from Palla to Okhla D/S of Yamuna River in Delhi) during 2019 and 2021 by CPCB and none of the monitored sites met the specified water quality standards for Biochemical Oxygen Demand (BOD).[57]

The extensive water supply and use in Delhi leads to the generation of a correspondingly large volume of wastewater. According to a report submitted to the National Green Tribunal (NGT), the estimated wastewater generation in the city is 3,600 MLD (792 MGD).[58] Delhi is equipped with 37 STPs that have a combined capacity of 3,033 MLD. Presently 2,587 MLD of this capacity is being utilized.

Among the 37 STPs, 21 have failed to meet the Delhi Pollution Control Committee (DPCC) standards of 10 Biological Oxygen Demand (BOD) and 10 Total Suspended Solids (TSS).[59] The Government of Delhi has undertaken several initiatives to address this issue:

- Rehabilitation of three existing STPs located at Kondli Phase-II, Rithala Phase-I, and Yamuna Vihar Phase-I
- Upgrade and increase in the capacity of the remaining 18 STPs
- Construction of three new STPs at Ohkla, Delhi Gate and Sonia Vihar
- Building 40 decentralized sewage treatment plants (DSTPs) with 26 planned for various locations across Delhi and 14 specifically within the Najafgarh drainage zone.

CURRENT POLICIES AND REGULATIONS

Prioritizing the reuse of treated wastewater has emerged as an important measure for most large metro cities in India. Efforts are underway to develop policies and enact legislative measures in this regard *(see Table 14: Reuse of treated wastewater policy of Delhi NCT)*.

TABLE 14: POLICIES FOR THE REUSE OF TREATED WASTEWATER FOR DELHI NCT

Policy		Resources
1.	Draft Water Policy for NCT of Delhi, 2016	Treated wastewater should be recognized as a viable resource with the potential for reuse/recycling in non-domestic applications. This can help replenish the groundwater table, facilitating the extraction of groundwater. Some of the options available in general have been suggested in the report prepared for the Delhi Jal Board, Delhi Water Supply and Sewage Project– Project Preparation Study – DFR 3 – Part C – Sewerage -Volume I by PWC below: • Discharge into natural bodies of water. • Utilization for irrigated agriculture where it is used only for agricultural produce that are consumed after being cooked. • Utilization for irrigated horticulture, parks, gardens, green areas, road flushing, firefighting storage, forestry etc. • Use in industries as cooling water, boiler feed water and any other industrial process water. • Recharge of groundwater after being treated to suitable standards or indirect recharge and creation of recreational reservoirs/ lakes.
2.	The Delhi Jal Board Act, 1998	• To provide for the establishment of a board to discharge the functions of water supply, sewerage and sewage disposal, and drainage within the National Capital Territory (NCT) of Delhi. • To promote measures for conservation, recycling and reuse of water.
3.	Policy to Utilize Treated Wastewater for Horticulture and other Purposes, 2018	To encourage the use of treated effluent for various possible purposes.

Source: Compiled by CSE

Policy on reuse of treated wastewater: Salient features

Delhi has a significant wastewater resource of 565 million gallons per day (2587 mld). In compliance with the directives of the National Green Tribunal, dated 21 May 2020 and 21 September 2020, an action plan for the utilization of treated wastewater from STPs was formulated by the Delhi Jal Board and submitted to the Central Pollution Control Board (CPCB).[60]

The Delhi Jal Board (DJB) has issued the following notices/orders regarding the reuse of treated wastewater:

- DJB is reaching out to stakeholders and park-owning agencies, urging them to begin accepting treated effluent from DJB's STPs for their parks that are located within a five-kilometer radius of the STP. This interim arrangement aligns with the directives of the monitoring committee. DJB has established filling points at all its major STPs to fill tankers.
- DJB has issued notices to the Delhi Development Authority (DDA), New Delhi Municipal Council (NDMC), Municipal Corporations, Central Public Works Department (CPWD), Delhi Metro Rail Corporation (DMRC), Public Works Department (PWD), and Delhi Urban Shelter Improvement Board (DUSIB), requesting them to submit Action Taken Reports (ATRs) to the Monitoring Committee. The reports pertain to the utilization of treated effluent in parks located within a five-kilometer radius of STP filling points.

Draft water policy for NCT of Delhi (2016)[61]

NCT Delhi will incrementally utilize recycled wastewater to meet its water needs, thereby reducing its freshwater footprint. It will establish goals to enhance recycled wastewater usage as follows:

- to 35 per cent by 2019
- to 70 per cent by 2024
- to minimum 80 per cent by 2026

The promotion of decentralized treatment of sewage/wastewater will be prioritized, alongside the encouragement of alternative treatment systems and the promotion of local reuse. New urban developments will be designed and built around decentralized STPs which will be located close to the source of sewage generation, and treating up to tertiary level for local reuse.

Sewage (including black and grey water) from areas lacking sewer systems will undergo tertiary-level treatment at appropriate sites. This treated sewage will primarily be utilized for non-potable activities, with a focus on indirect groundwater recharge. Subsequently, it can be reclaimed and reused for all purposes following further treatment. The treatment technologies will depend upon space availability.

The treated effluent from existing sewage treatment plants (STPs) will be utilized to the maximum extent feasible by users situated within command areas. Major sewage/wastewater generators, like the transportation sector or large campuses, will be required to install their own treatment facilities and recycle the resource.

- DJB has requested all District Magistrates to seal the borewells located in parks that are used for horticultural purposes.
- A request has been forwarded to the Divisional Commissioner to issue appropriate directives to the respective District Magistrates, urging them to commence or expedite the sealing of borewells in parks where treated effluent from nearby Sewage Treatment Plants (STPs) is not being used.

REUSE OF TREATED WASTEWATER

As of November 2023, the total volume of treated water in Delhi amounts to 565 MGD (2,568 mld), **of which the present and proposed use of treated water are as follows:**

Present use of treated STP water[62]

1. Delhi is obligated to ensure a mandatory return flow of 267 MGD (1214 mlt) under the Upper Yamuna Water Sharing Agreement as directed by the Supreme Court of India.
2. Currently, Delhi is reusing 146.5 million gallons per day (666 million litres per day) of treated wastewater.
    - 90 MGD (409 MLD) of treated wastewater have been allocated for horticultural purposes in various parks across Delhi. These include Millennium Park in I.P Estate, Japanese Garden in Rohini, parks managed by the NDMC, Delhi Transport Corporation (DTC) depots, and PWD facilities.
    - 35 MGD (159 MLD) of treated wastewater are designated for the development or rejuvenation of lakes and water bodies in Delhi. These include Pappan Kalan, Nilothi, Najafgarh, and Sanjay Van II.
    - Currently, 21.5 million gallons per day (98 million litres per day) of treated wastewater are reused by the Irrigation and Flood Control Department (IFCD) for horticultural and farming purposes.
3. In January 2024, a total of 446 tankers were filled up from various Sewage Treatment Plants (STPs) by a range of stakeholders including DTC, PWD, EDMC, DDA, private agencies, SDMC, the forest department, CPWD, NHAI, L&T, NBCC, DJB, IL&FS, NDMC, and North West MCD. Notably, since October 2015, PWD has incorporated a provision in all its contracts for horticultural works, mandating the use of recycled water.

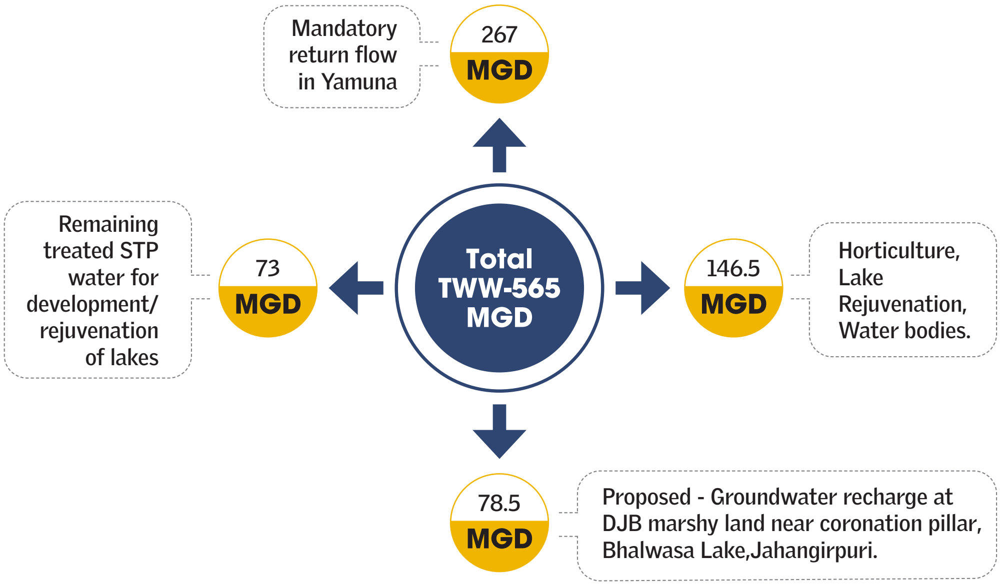
Proposed use of treated STP water[63]

The Delhi Jal Board (DJB) is pursuing plans to expand the reuse of treated water. It has approved a policy to supply treated effluent for irrigation purposes, with ongoing efforts to supply this treated effluent to farmhouses for horticultural use. The supply is planned from STPs located in Mehrauli, Kapashera, Narela, and Okhla areas *(see Graph 6: Reuse plan for the remaining wastewater available (75 MGD))*

78.5 MGD (357 MLD) treated effluent is generated at STPs in Coronation Pillar Ph-I and II.

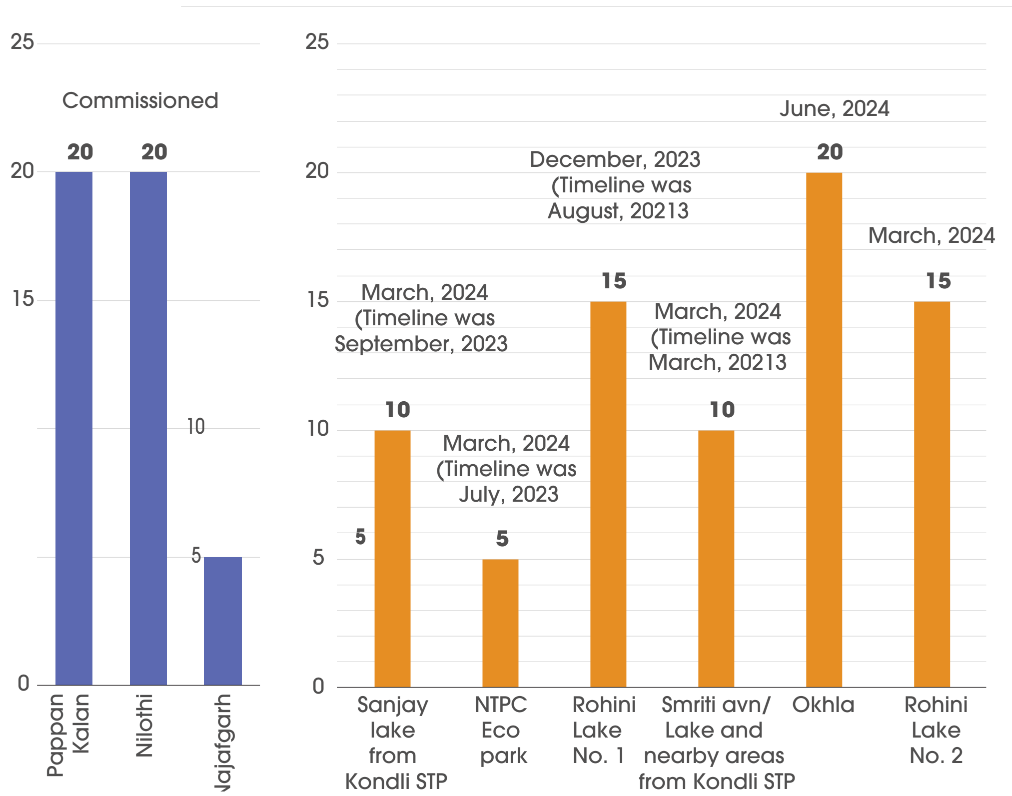
- The utilization of 28.5 MGD (130 MLD) of treated effluent has been planned for the marshy land around the Coronation Pillar sewage treatment plant.
- 30 MGD (136 MLD) of treated effluent is to be used in Jahangir Puri drain for groundwater recharge and
- 20 MGD (91 MLD) of treated effluent is to be used in Bhalsawa lake and DDA golf course.

Figure12: Plan for reuse of treated wastewater in Delhi



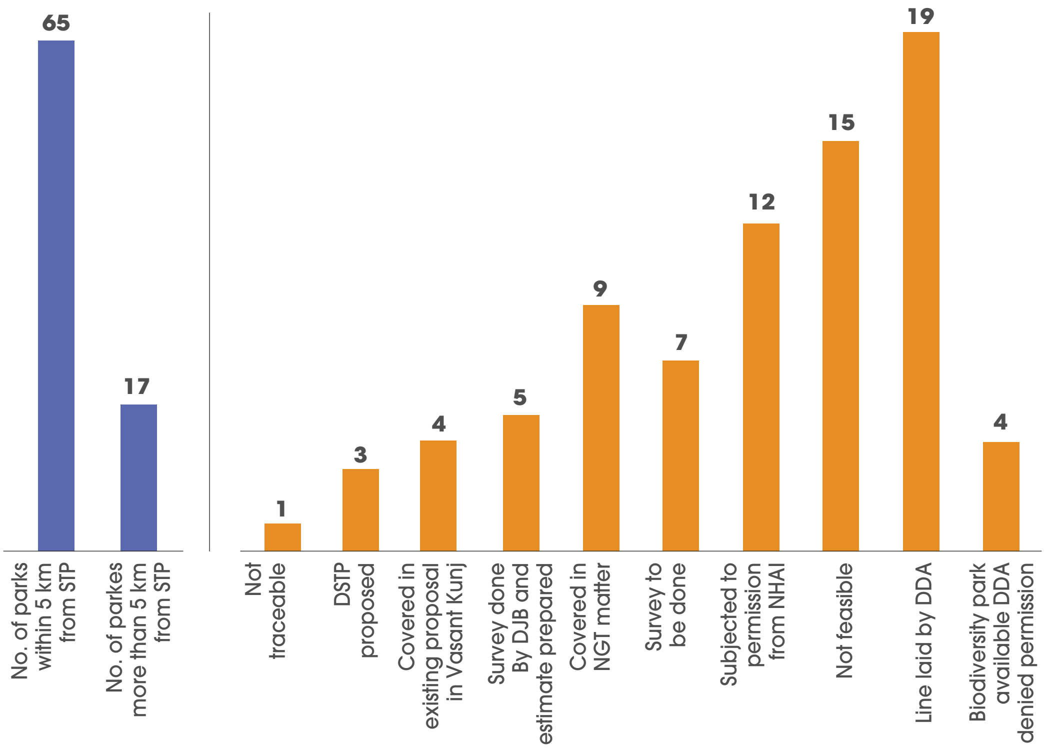
Source: Created by CSE from DJB data

Graph 6: Reuse plan for the remaining wastewater available (75 MGD)



Source: Based on data from Delhi Jal Board

Graph 7: Action plan for reuse of treated wastewater in parks of Delhi



Source: Based on data from Delhi Jal Board

- A total of 73 MGD (332 MLD) of treated effluent has been earmarked for reuse in development/water bodies. The action plan, however, outlines a utilization target of 75 MGD (341 MLD), as depicted in *(see Figure 12: Plan for reuse of treated wastewater in Delhi).*
- DJB will provide direct pipelines to ensure conveyance of treated wastewater from STP to DDA's parks and public spaces for horticulture.

Pricing of treated wastewater[64]

- The Delhi Jal Board facilitates agencies to install the conveyance system and pumping arrangements at their own cost. The O&M of the conveyance system is to be done by the beneficiaries. In this case the DJB charges the beneficiaries a nominal rate of INR 4/kilo litre for the supplied treated effluent.
- When the conveyance system is provided by the beneficiaries and pumping arrangements are made by DJB, then the beneficiaries are charged at the rate of INR 7/kilo litre for the supplied treated effluent.
- Treated effluent can also be received by the beneficiaries from the filling points at sewage treatment plants (STP) by deploying tankers and in such cases, rate of INR 7/ kilo litre is charged from the beneficiaries.

Decentralized water supply augmentation through reuse of treated wastewater

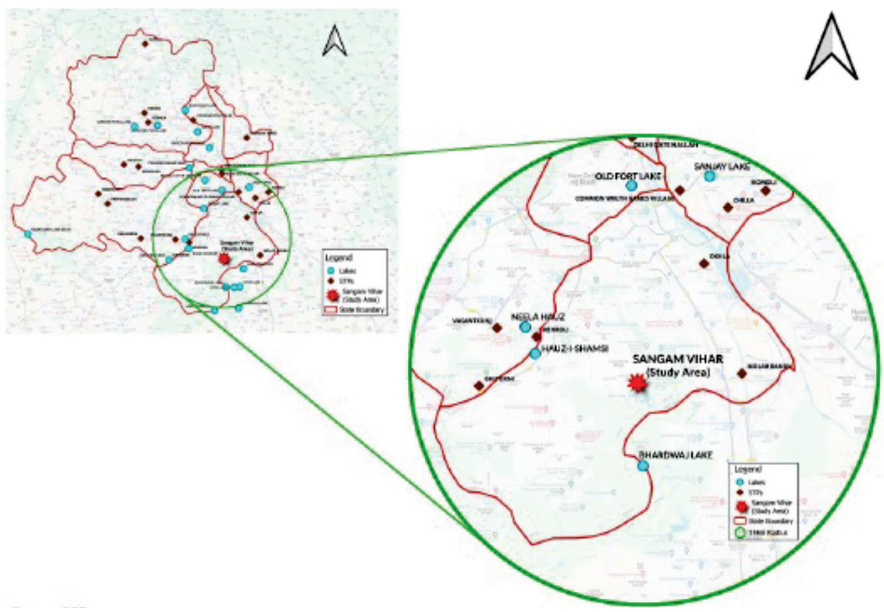
The five sq km area comprising 13 blocks of Sangam Vihar is heavily concretized and developed, limiting opportunities for in-situ groundwater conservation and recharge. However, the forested areas along its periphery, featuring small waterbodies, offer a chance of groundwater replenishment.

By constructing decentralized sewage treatment plants (STPs) around Sangam Vihar, particularly in the peripheral forest and open areas, the treated wastewater and stormwater from Sangam Vihar itself can be utilized to replenish existing waterbodies, facilitating groundwater recharge. This approach ensures a sustainable groundwater supply for non-potable purposes within the region.

A reimagined city-wide decentralized water supply system using treated wastewater for recharging a few big lakes, and allocating them for water supply to nearby areas need to be adopted as a strategy for a large metro city like Delhi. STPs in the vicinity of these lakes, including some big lakes near Sangam Vihar, can be a good option for assured water supply for DJB, with very little pumping cost.

Delhi has 1,045 listed waterbodies. These need to be mapped and matched with sewage treatment plants (STPs). Figure 13 shows 20 locations within Delhi where 35 sewage treatment plants (STPs) of the city are operational. Additionally, 20 lakes within or near Delhi with varied sizes have been highlighted. Moving to the map on the right, we narrow our focus to a 15-km radius around Sangam Vihar, Delhi in which we have depicted the spatial distribution of sewage treatment plants (STPs) and notable lakes exceeding 2 hectares (ha). Blue points on the map signify lakes that meet the size criterion, which includes Haus-I-Shamsi Lake (2.85 ha), Neela Haus Lake (3.65 ha), Old Fort Lake (5.30 ha), Bhardwaj Lake (11.8 ha), and the largest lake, Sanjay Lake (74.5 ha).

Figure 13: STPs and lakes surrounding Sangam Vihar



Source: Created by CSE

The visual depiction serves the purpose of identifying areas where treated wastewater can be accessed. Larger lakes, suitable for recharging and supplying water (after secondary and tertiary treatment) to nearby colonies, both planned and unplanned, have been emphasized. This approach aims to enhance water security in Sangam Vihar by ensuring a nearby water supply sourced from recharged lakes, thus reducing dependence on costly pumping and distant water sources (see Figure 13: STPs and lakes surrounding Sangam Vihar).

City of Lakes programme

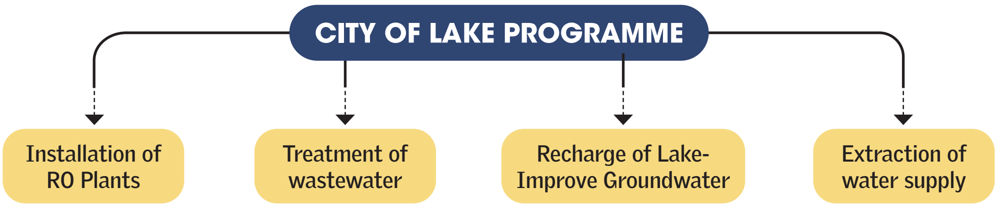
The City of Lakes project in Delhi was launched by the Government of Delhi with the vision that the rejuvenation of waterbodies and creation of lakes will help in the enhancement of groundwater recharge and will contribute to fighting water scarcity. The government launched the project in 2018 with a budget allocation of Rs 376 crore.

In the first phase of the City of Lakes project that was conceived around three years ago, 155 waterbodies were to be revived. As part of this plan, Delhi has created 14 new lakes and rejuvenated 35 waterbodies over a span of five to six years in neighbourhoods such as Sanoth, Pappankalan, Rajokri, Burari and Bhalaswa, among others. The next phase will extend to areas such as Naraina and Rohini, along with nearby regions.

A noteworthy instance is the Pappankalan Lakes 1 and 2, which have played a significant role in replenishing groundwater in their vicinity. Instead of being released into drains, treated wastewater from sewage treatment plants (STPs) is redirected to fill these lakes. Both lakes are furnished with essential infrastructure, including aerators to regulate dissolved oxygen levels, floating wetlands to absorb pollutants, and safety measures to ensure both public safety and efficient maintenance.

To accelerate the implementation of its ambitious City of Lakes project, the Delhi Jal Board (DJB) has greenlit a standardized set of operating procedures (SOPs) for the rejuvenation of waterbodies. Rather than addressing projects one by one, the approach involves grouping 30 to 50 waterbodies with similar characteristics into packages. Bids will then be floated simultaneously for execution. A comprehensive 10-step guideline has been devised and approved by the board. Additionally, a three-phase development plan has been endorsed for all waterbodies. Each site is mandated to incorporate a recharge pit equivalent to 50 per cent of the sewage treatment plant (STP) capacity to enhance groundwater replenishment.

Figure 14: Illustration showing reuse of treated wastewater under City of Lake Programme in Delhi



Source: Created by CSE

Reusing treated STP water for parks/horticulture

The Delhi Pollution Control Committee (DPCC), in collaboration with the Delhi Jal Board (DJB) and the Delhi Development Authority (DDA), will develop a network plan through Geospatial Delhi Limited (GSDL) for utilizing treated sewage treatment plant (STP) water in 83 specified parks[65] *(see Graph 7: Action plan for reuse of treated wastewater in parks of Delhi).*

According to the plan, the following measures are to be taken:

- DDA will check and verify the location of 10 parks as identified by GSDL.

- GSDL will calculate the distance between each of the 83 DDA parks and the nearest DJB STP.
- DJB will provide a list along with the brief status of survey conducted by DJB for use of treated water from STPs in 83 parks of DDA.
- DJB provided a brief status of 83 DDA parks and feasibility for providing supply of treated STP water.
- GSDL will create maps showing the locations of STPs and three DDA parks, along with the length of piped network required for each park from the nearest STP.

Reusing treated wastewater for recharge of lakes

The Jat agitation in 2016 resulted in a drinking water crisis in Delhi, primarily due to the sabotage of the critical Munak canal in Haryana, which supplied 60 to 70 per cent of Delhi's drinking water.[66] The water supply to over seven lakh households was affected due to this disruption. The incident underscored the susceptibility of Delhi's water supply infrastructure to external disruptions, prompting an accelerated push for initiatives like the lakes project. Within the state secretariat, efforts were underway to identify suitable land and draft maps aimed at achieving self-sufficiency in meeting the city's water requirements.

Additionally, as a result of excessive groundwater exploitation, the water table in the National Capital Territory (NCT) of Delhi has significantly declined. Consequently, it has become necessary to prioritize the extensive utilization of rainwater for recharging groundwater, utilizing both natural and artificial waterbodies, as well as rainwater harvesting structures. Notably, the National Green Tribunal (NGT) has directed the Government of NCT of Delhi, the Central Ground Water Authority, and the Delhi Jal Board to undertake the cleaning, maintenance, and restoration of all existing water bodies within the NCT of Delhi. DJB is also in the process of establishing new lakes at the following sites, each with its respective treatment capacity:

- Dwarka WTP
- Timarpur Oxidation Pond
- Rohini WWTP
- Nilothi WWTP
- Pappan Kalan WWTP
- Satpula

The lakes at Dwarka, Rohini, Nilothi and Pappan Kalan have been developed using the treated effluent underwent further treatment to meet the water quality standards set by the National Green Tribunal (NGT) for lakes. In total, approximately 40 MGD of treated effluent is utilized across these lakes.

The lakes at Timarpur and Satpula were developed using raw sewage which will subsequently undergo treatment to meet the water quality standards mandated by the National Green Tribunal (NGT) for lakes. Approximately six MGD of raw sewage has been processed and treated for the development of these two lakes. The revitalization of waterbodies and the creation of lakes will play a significant role in augmenting groundwater recharge efforts and will help in combating water scarcity.

CASE STUDIES

PAPPANKALAN SEWAGE TREATMENT PLANT

An example of the City of Lake project is the Pappankalan lakes 1 and 2, which can hold up to 55 million gallons of water. Instead of releasing recycled water back into the Najafgarh drain, it was redirected to replenish these lakes.

The overall aim of the project is to make the city self-sufficient in meeting its drinking water needs.

Figure 15: Salient features of the Pappankalam Sewage Treatment Plant

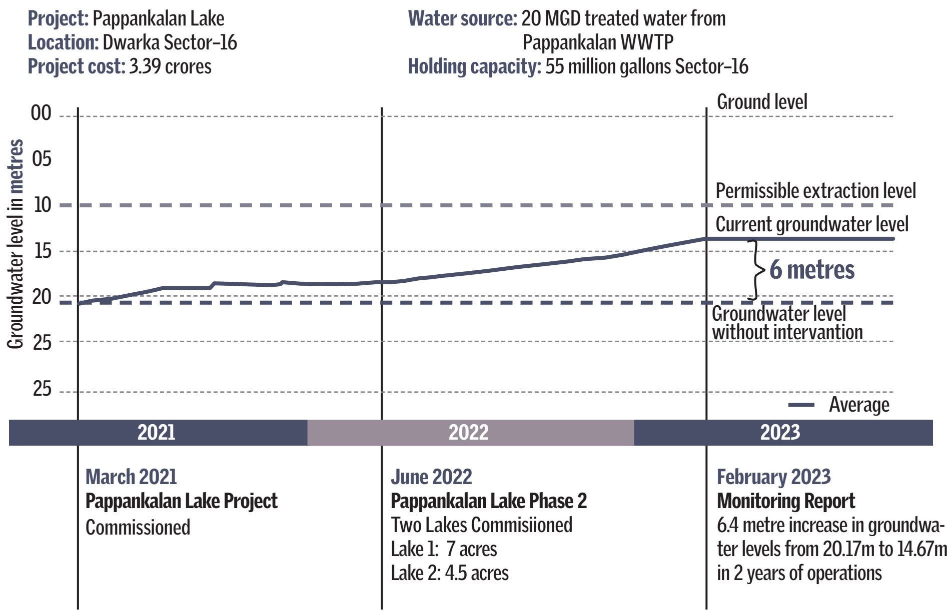
Commissioned **2002 & 2015**	Capacity **91 & 91 MLD**
Technology **Activated Sludge Process & Sequencing Batch Reactor**	Flow (MLD) **91 & 91 MLD**

Pappankalan Lake is an artificial lake that has been planned, commissioned and executed under Delhi Government's City of Lakes programme.

- The lake was tendered in 2021 to a third party for its construction, and it was commissioned in 2022. The purpose of the lake is to recharge groundwater by reusing treated wastewater from sewage treatment plants under the programme.

Artificial lake in the premises of Pappankalan Sewage Treatment Plant in Dwarka, Delhi receiving treated water for lake recharge.

Graph 8: Impact on groundwater level because of lake revival using treated wastewater



Source: Delhi Jal Board

- There are two lakes constructed within the Pappankalan STP premises under Delhi Jal Board. The STP plant is spread over 100 acres. The total area of the lake is 11 acres with a depth of six meters. The main lake carries treated wastewater from the STP through a drain and is seven acres in size. The second lake is connected to the first lake to maintain the overflow and is four acres in size.
- There are three piezometers installed within the lake premises to monitor the groundwater level.
- The installation of tube wells in the Pappankalan STP complex has been proposed. The extracted groundwater through these tube wells will be treated through a proposed Reverse Osmosis (RO) plant to produce potable water and stored in nearby Underground Reservoirs (UGR).
- The government has set a target of achieving an additional 20 million gallons per day (MGD) of potable water in a phased manner over the next 1–2 years. In the first phase, the government will extract 10 MGD water and eventually progress further.
- Automatically-operated aerators maintain dissolved oxygen in the water, which helps in the natural cleaning inside the lakes. Floating wetlands and the plants on them absorb pollutants, including phosphate, which is mostly found in detergents.
- These in-situ treatment systems help in increasing the dissolved oxygen levels above 5 mg/L, which is a crucial parameter for measuring the health of any waterbody. Islands created around the existing trees in the lake add to the scenic beauty and protect the wetland birds from predators.

Inlet point in Pappankalan receiving the treated wastewater for lake recharge.

Artificial lake in the premises of Pappankalan Sewage Treatment Plant in Dwarka, Delhi receiving treated water for Lake Recharge.

- To ensure safety within the premises, DJB has installed safety caution boards, pillar post, security room with guards and raised boundary walls. There are two paddle boats in the lake for monthly operation and maintenance of the lake.
- The land around the lake will also be landscaped and the lake will be opened to the public after cordoning off the area from the sewage treatment plant (STP). Two more lakes, in Najafgarh and Dwarka, are nearing completion and will soon guzzle up the remaining treated water from the STP.

Impact

Authorities have claimed a significant rise in the water table in the region, reaching up to six meters within a year, despite the area's reputation for extensive groundwater utilization. However, detailed reports regarding these claims are yet to be obtained.

NILOTHI SEWAGE TREATMENT PLANT

Nilothi Lake is also an artificial lake that has been planned, commissioned and executed under the Delhi Government.

- In 2021, Nilothi Lake was tendered to a third party for its construction, and it was commissioned in 2023. The purpose of the lake is to recharge groundwater by reusing treated wastewater from sewage treatment plants and supply it for domestic requirement after RO treatment.
- There are three lakes of 3.5 acres area, with a total water holding capacity of 10 million gallons which is fed by Nilothi STP (phase I and II)

Figure 16: Salient features of Nilothi Sewage Treatment Plant

Commissioned **2002 & 2015**	Capacity **182 & 91 MLD**
Technology **Activated Sludge Processor, Sequencing Batch Reactors**	Flow (MLD) **68 & 91 MLD**

Overall, the objective is to recharge lakes from treated wastewater for natural percolation, which will recharge shallow aquifers and augment groundwater resource. The groundwater will then be supplied for drinking water supply. *DJB* has proposed 70 tube wells within the lake periphery. The depth of the tube well will be 40–50 meters. The purpose of tube well is to ensure groundwater recharge and exploration. The explored groundwater will be further treated by the RO filtration process which will be eventually supplied for meeting the domestic requirement. The Delhi Treatment and Quality Control (DTQC) body under the Delhi Jal Board (DJB) is responsible for monitoring the groundwater level and water quality.

- Several other areas like Sanoth have got its first-ever artificial lake that is filled with recycled water from the nearby Bawana Common Effluent Treatment Plant (CETP). The department has beautified the lake and the land around for the public. It has swings, an open gym, and an amphitheatre, which is open to the public for free.

Nilothi lake receiving treated water from Nilothi STP for the lake recharge

THE LEARNINGS

Considering Delhi's escalating water demands in Delhi and constraints on the availability of water resources, the reuse of treated water for non-potable purposes is a good strategy to bridge the gap.

At present, Delhi is reusing 146.5 MGD (666 MLD) of treated wastewater, out of which 90 MGD (409 MLD) is used for horticulture in various parks across Delhi, 35 MGD (159 MLD) in development/rejuvenation of lakes/waterbodies and 21.5 MGD (98 MLD) is currently used by IFCD for horticulture/farming purposes which is being currently reused.

The Delhi Jal Board (DJB) has proposed that 78.5 MGD of treated wastewater should be used for groundwater recharge at DJB marshy land (wetland) near coronation pillar and Bhalwasa Lake recharge in Jahangirpuri. The remaining treated STP water to be reused for development/rejuvenation of lakes (73 MGD). The co-location of Sewage Treatment Plants (STPs) with lakes and parks has been undertaken to assess potential reuse demands and formulate plans. Additionally, this initiative aims to pinpoint potential aquifer zones and designate priority areas for groundwater recharge in Delhi.

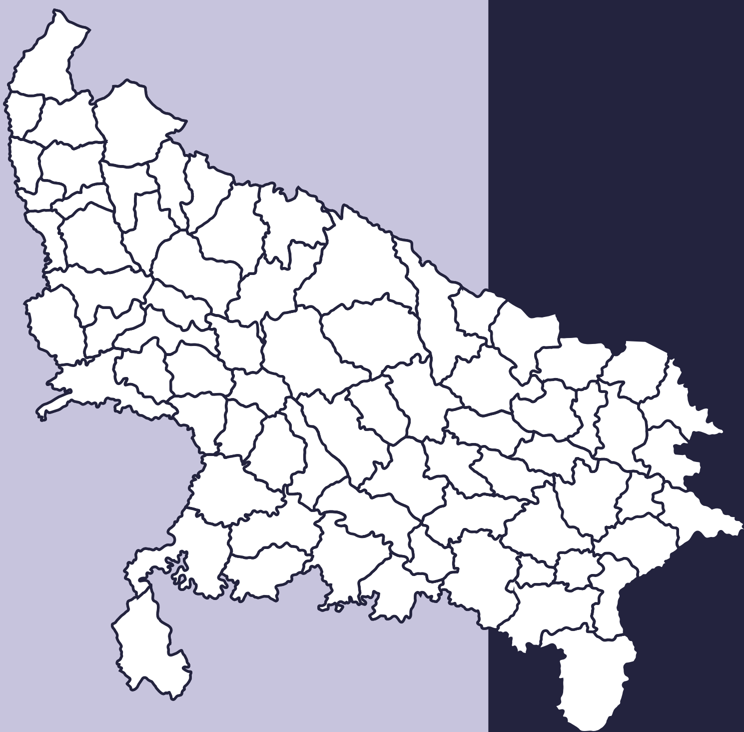
The Draft Water Policy (2016) of Delhi NCT has made a good effort at decentralizing the reuse of treated wastewater and set targets. Reuse policy needs to be adopted and implemented at an improved pace to achieve the targets defined for on-ground implementation. Although the policy and action plan for reuse of treated water are in place, they lack implementation strategy. Many reuse projects are lagging behind as witnessed in the case of Sanjay Van Lake and Smriti Van Lake project.

The action plan focuses on the revival of lakes, waterbodies, and parks for augmenting water supply through groundwater recharge from the treated wastewater from STPs. However, in case of this kind of reuse, the quality of treated water should be high, meeting the prescribed criteria. Currently, out of the 37 STPs, 21 are not complying with the DPCC norms of 10 BOD and 10 TSS. Emphasis should also be placed on adopting treatment technologies that adhere to state and national guidelines. Additionally, there should be a focus on maximizing the reuse of treated wastewater.

The industrial reuse of treated water has not been mentioned in the reuse of treated water. Delhi-NCR has 11 thermal power plants. The reuse of treated water in thermal power plants is mandated under policy but Delhi has stated no plans yet to use the treated water for thermal power plants.

Apart from this, a large volume of untreated water from large, dense unplanned settlements goes untreated and get mixed with water bodies that are closely located. This water needs to be tapped to centralized/decentralized treatment facilities to enable reuse.

UTTAR PRADESH



Uttar Pradesh generates 5,550 MLD of sewage but treats only 3,296 MLD, with limited reuse primarily in agriculture.

Uttar Pradesh's heavy reliance on groundwater for agriculture and other needs underscores the need for a stringent policy on treated water reuse and groundwater regulation.

Addditionally, there is a pressing need for city-wide reuse plans, infrastructure investment, and third-party monitoring to ensure safe and effective reuse of treated water.

TOTAL WASTEWATER/ SEWAGE GENERATED (MLD)
5,550

TOTAL WASTEWATER/ SEWAGE TREATMENT CAPACITY (MLD)
4,176

TOTAL OPERATIONAL CAPACITY OF STP (MLD)
3,970

TOTAL WASTEWATER/ SEWAGE TREATMENT BEING TREATED* (MLD)
3,296

TOTAL TREATMENT CAPACITY COMPLIES WITH THE DISCHARGE NORMS (MLD)
2,605

AMOUNT BEING REUSED (%)
NA*

* Data not available

WATER AND WASTEWATER IN UTTAR PRADESH: AN OVERVIEW

With a population of over 241 million, Uttar Pradesh accounts for 16.5 per cent of the total population of India. Due to its location in the fertile Indo-Gangetic plain, the state boasts abundant groundwater and surface water reservoirs. Nonetheless, these resources face significant strain due to escalating urbanization and heightened agriculture-based water needs. Uttar Pradesh contributes approximately 20.80 per cent of the nation's renewable water resources, encompassing 7.33 per cent of the country's land area.[67]

Despite Uttar Pradesh's significant renewable water resources that including one of the world's largest aquifer systems, their distribution across the state is uneven. Regions such as the southern part (Bundelkhand), western region, central region, and eastern region (including Vindhyans) face challenges with variable groundwater availability and erratic rainfall patterns.

Despite Uttar Pradesh's substantial availability of surface water resources, estimated at 128 billion cubic meters (bcm), the preference remains for groundwater resources, with a total extractable component of only 65.32 bcm. Groundwater serves as the primary source for over two-thirds of its irrigated agriculture, nearly all industrial extraction, and the majority of drinking water demands in the state. Consequently, there's a continuous and escalating abstraction of groundwater, leading to declining water levels across the state, affecting approximately 70 per cent of the blocks and over 80 per cent of the urban bodies.[68]

A total of 687 industries classified as grossly polluting are collectively discharging 269 million litres per day (MLD) of wastewater. Sugar, pulp, paper and chemicals are the major industrial sector discharging 70 per cent of the total wastewater generated in the state. Out of 688 industries, 594 are located in the main stem of the Ganga River, among which the sugar industry generates the maximum wastewater.[69] As a result, 17 rivers were found to be non-compliant with the prescribed Water Quality Criteria with respect to BOD.[70]

CURRENT POLICIES AND REGULATIONS

Uttar Pradesh has 762 urban local bodies (ULB), the highest among all states of India. According to the NGT, 5,550 MLD sewage is generated in Uttar Pradesh.[71]

There are 139 STPs with a treatment capacity of 4,176 MLD that are treating 3,296 MLD of sewage in 56 towns of the state. A total of 73 STPs with a capacity of 2,244 MLD are under various stages of construction, tendering etc.

Previously, the Uttar Pradesh state policy framework on water prioritized groundwater use management. 2020 onwards, however, the focus has shifted to the reuse of treated waste water from its STPs (see *Table 15: Policy and regulation on reuse of treated wastewater in Uttar Pradesh)*

Table 15: Policy and regulation on reuse of treated wastewater in Uttar Pradesh

Policy	Salient features
The Uttar Pradesh Municipal Corporation Act, 1959	The statute gives complete authority and jurisdiction of all urban amenities, including water supply and sanitation to municipalities.
Uttar Pradesh State Water Policy, 1999	This policy aims to ensure the preservation of scarce water resources and to optimize the utilization of available resources, along with ensuring self-sustainability in water resource development. Section 11.3 mentions the need for water conservation and pollution control for extensive industrial use. The treatment of industrial discharge and water reuse shall be strictly enforced.
Uttar Pradesh Water Management and Regulatory Commission Act 2008, 2014	The Government of Uttar Pradesh established the Water Regulatory Commission to achieve optimal and integrated development of water resources.
Policy for Groundwater Management, Rainwater Harvesting and Groundwater Recharge in Uttar Pradesh, 2013	Groundwater resource management, its regulated development/extraction, optimum use and conservation as well as detailed mapping of aquifers
The Uttar Pradesh Groundwater (Management and Regulation) Act, 2019	The Act was put in place to provide for the protection, conservation, control and regulation of groundwater to ensure its sustainable management in the state, both quantitatively and qualitatively, especially in stressed rural and urban areas. Under the Act, the user sectors to be regulated are industrial, commercial, infrastructural and bulk users. However, agriculture and domestic, have been kept out of the regulatory provisions of the Act.
Uttar Pradesh State Water Policy, 2020[72]	To ensure cohesive, participatory and inclusive water governance by mainstreaming Integrated Water Resources Management (IWRM) and climate resilience into the policy and institutional decision-making processes on water governance. The policy also emphasizes the importance of incentivizing reuse of treated water through a tariff system, promoting the recycling and reuse of water, and implementing a 'Wastewater Management and Reuse Policy' for sustainable wastewater management.
The Uttar Pradesh Groundwater (Management and Regulation) Rules, 2020	To enforce the provision of Groundwater Act, 2019
Draft Policy on the Reuse of Treated Wastewater from Sewage Treatment Plants (STPs)[73]	This policy is intended to direct the water sector towards more efficient use of water resources. It details the intention to reuse treated wastewater in irrigation that enables freeing fresh water to be utilized for municipal uses. It also provides for the use of treated wastewater for other economic activities. It calls for expanding the collection and treatment of wastewater, updating and developing standards and practices for substituting fresh water used in irrigation and industry by treated waste water after blending it.

Source: Compiled by CSE

REUSE OF TREATED WATER

The reuse of treated wastewater is not widely practiced in Uttar Pradesh. About half of the total installed capacity is concentrated in the five major cities of the state—Lucknow, Kanpur, Prayagraj, Ghaziabad, and Varanasi, resulting in the majority of reuse occurring within these urban centres and their surrounding districts.

The treated water is mostly utilized in agriculture through planned or unplanned ways with the existing canal system in UP *(see Table 16: Plan for reutilization of treated sewage in Uttar Pradesh)*.

Table 16: Plan for reutilization of treated sewage in Uttar Pradesh

S.No.	Reutilization of treated sewage	Timeline
1.	Treated water from Bingawan STP (210 MLD) to Panki Thermal Power Plant (approx. 40 MLD)	under consideration
2.	20 MLD treated water from Trans-Yamuna -1 and -II STPs at Mathura to be supplied to IOCL, Mathura	in progress
3.	Treated water from Shahjahanpur STP (45 MLD) to Rosa TPS (approx. 40 MLD)	June, 2025
4.	Treated water from Aligarh STP (45 MLD) to Harduaganj TPS (approx. 30 MLD)	July, 2025
5.	Treated water from Naini, Prayagraj STP (80 MLD)	December, 2025
6.	Treated water from Bulandshahar STP (40 MLD) to Rosa TPS (approx. 20 MLD)	July, 2025

Source: NMCG

A team from the Centre of Science and Environment visited 16 sewage treatment plants (STP) in Uttar Pradesh, prioritizing its large and medium towns *(see Table 17: Details of visited STPs in Uttar Pradesh)*

Table 17: Details of visited STPs in Uttar Pradesh

District	STP	Commissioned (Year)	STP Capacity (in 1MLD)	Technology	Reuse
Lucknow	Bharwara	2011	345	UASB	In Plan, as of now treated water discharged in Gomti.
	Daulatganj	2002	42	FAB	No reuse, treated water discharged in Gomti.
		2010	14		
Kanpur	Jajmau	1997	130	ASP	Irrigation (Agriculture)
			43		
Varanasi	Bhagwanpur	1989	9.8	ASP	Irrigation (Agriculture)
	Ramna	2021	50	ASP	Provision for irrigation (Agriculture)
	Dinapur	1990	80	ASP	No reuse, 80 MLD treated water discharged in Ganga River and 140 MLD in Varuna River.
		2018	140		

District	STP	Commissioned (Year)	STP Capacity (in 1MLD)	Technology	Reuse
Prayagraj	Naini 1	1999	80	ASP	Irrigation (Agriculture)
	Naini 2	2022	50	FCR	In Plan
	Salori	2007	29	FAB	In Plan
	Rajapur	2012	60	UASB	In Plan
	Numayadahi	2013	50	ASP	No reuse
Agra	Dhadupura	2001	78	UASB	Irrigation (Agriculture)
		2012	24		
	Jaganpur	2011	14	UASB	Irrigation (Agriculture)
	Peelakhar	2001	10	WSP	Irrigation (Agriculture)
Mathura	Masani	2022	30	SBR	No reuse, treated water discharged in Yamuna
	Lakshminagar	2000	14.5	WSP	Irrigation (Agriculture) and Industry
		2012	16	UASB	
		2022	20	TTP	

Source: CSE visit to Uttar Pradesh

1. MLD- Million litre per day
2. UASB - Up flow Anaerobic Sludge Blanket
3. FAB - Fluidized Aerobic Bio-Reactor
4. ASP – Activated Sludge Process
5. FCR – Food Chain Reactor
6. WSP – Waste Stabilization Pond
7. SBR - Sequencing Batch Reactor
8. TTP – Tertiary treatment plant

LUCKNOW

Lucknow is the capital of Uttar Pradesh. After Delhi, Lucknow is one of the fastest growing cities in the North India. Based on the 2011 Census, the city had a population of 2,815,601, with approximately 63.23 per cent of the population residing in urban areas.

The city's water supply primarily relies on groundwater, which accounts for 80 per cent of the total supply, and piped water sourced from the Gomti River via the Sharda Sahayak feeder canal. However, the Gomti River which is the main surface water source, is under severe pollution stress. There is widespread depletion of aquifers due to unregulated water extraction from private borewells and tube wells, leading to groundwater levels dropping by more than 1 to 1.4 meters annually.[74]

Around 500 MLD sewage is generated in Lucknow, which is treated at various centralized effluent treatment plants viz Daulatganj STP (56 MLD) and Bharwara STP (345 MLD)[75] *(see Table 18: Existing sewerage treatment scenario in Lucknow).*

Table 18: Existing sewerage treatment scenario in Lucknow

S. No.	Name of STP	Year of commissioning	Design Technology	Capacity of STP (MLD)	Primary Agency Maintaining the STP
1	Awas Vikas	2017	SBR	37.5	Complying
2	Bharwara	2016	UASB	345	Not complying
3	CG City	2020	SSBR	19	Under Stabilization
4	Hathi Park	2021	MBBR	1.5	Under Stabilization
5	Daulatganj	2003	FAB	42	Complying
6	Daulatganj – 2	2009	FAB	14	Complying
7	Jalkal	2010	SBR	6.5	Complying
8	Daulatganj and Barikala, Lucknow	–	Under Construction	42.5	–
9	Under Construction	–	Under Construction	120	–
			Total	628	

Source: NMCG

Two sewage treatment plants of 42.5 MLD and 120 MLD are under construction in the city. These projects seek to augment the capacity of the existing infrastructure to handle projected wastewater flow until 2041. Another project of 100 MLD along with Interception and Diversion (I&D) works under Hybrid Annuity Mode (HAM) was also sanctioned by National Mission of Clean Ganga (NMCG) in August 2023.

Current reuse of treated water

Sources have confirmed that the Bharwara Sewage Treatment Plant (STP) does not meet the Central Pollution Control Board (CPCB) discharge standards, whereas the Daulatganj, Awas Vikas, and Jalkal STPs have been meeting these norms.[76] At present, there are no organized reuse initiatives in place. However, the Uttar Pradesh Jal Nigam (UPJN) is actively investigating opportunities for using treated wastewater, particularly in urban forestry and railway cleaning operations.

KANPUR

Kanpur is the twelfth most populous city in India and second most in Uttar Pradesh (UP). As per 2011 Census, the city had a population of 2.7 million. Nearly 25–30 per cent of the population is estimated to be living in slums. The central region of the city is on high ground from where the local drains/nalas originate and flow towards either Ganga or the Pandu River. Kanpur is a hub for economic and educational activities. The city is also famous for its textile and leather industries.[77] The main source of surface water in the city is the catchment of Ganga and Pandu rivers. Kanpur has a domestic water demand of approximately 600 million litres per day (MLD), yet the current infrastructure can only deliver around 385 MLD.[78] The deficit in supply, including the total industrial water demand, is addressed through tube wells and hand pumps. Unfortunately, both groundwater and surface water sources in the city are significantly contaminated.[79]

Sewerage facilities

As per the City Sanitation Plan, the city collects 44 per cent of total wastewater generated in the city.[80] The major issue for the Kanpur Nagar Nigam is the inadequacy of the current treatment capacity as well as the deficient quality of the sewage treatment.

There are over 16,000 registered industrial units, of which leather processing units have the highest fraction. The Jajmau cluster of tanneries in Kanpur consists of 400 sites and while it is mandatory for tanneries to have an effluent treatment plant within their premises, most of them discharge effluent with only primary treatment.[81]

Six sewage treatment plants (STP) are in operation in Kanpur with a total treatment capacity of 457 MLD. A total of 327 MLD sewage is being treated in these sewage treatment plants. Out of these six, four STPs with a total capacity of 205 MLD are located in Jajmau, on the eastern side of the city. Details of the treatment plants has been provided in the table below[82] *(see Table 19: Existing sewerage treatment scenario in Kanpur)*.

Table 19: Existing sewerage treatment scenario in Kanpur

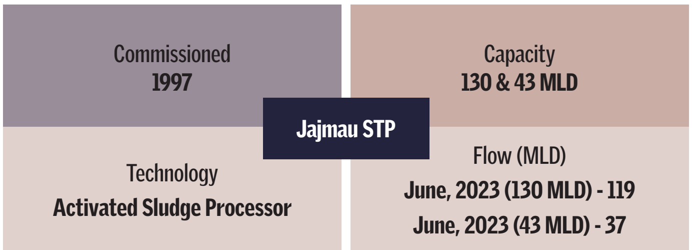
S. No.	STP name/ location	Existing STP Capacity (MLD)	Capacity Being Utilized (MLD)	Technology	Operational Status of STP	Compliance Status of STP
1.	Sajari	42	10	ASP	Operational	Complying
2.	Jajmau	43	35	UASB	Operational	Not Complying
3.	Jajmau 3	5	5	ASP	Operational	Not complying
4.	Bingawan	210	150	UASB	Operational	Not Complying
5.	Jajmau 2	130	100	ASP	Operational	Not Complying
6.	Jajmau	27	27	UASB	Operational	Not Complying
7.	Baniyapur	15	NA	SBR	Operational	Not operational
8.	Kanpur Pankha	30	NA	SBR	Operational	Complying

NA: Not available
Source: NMCG

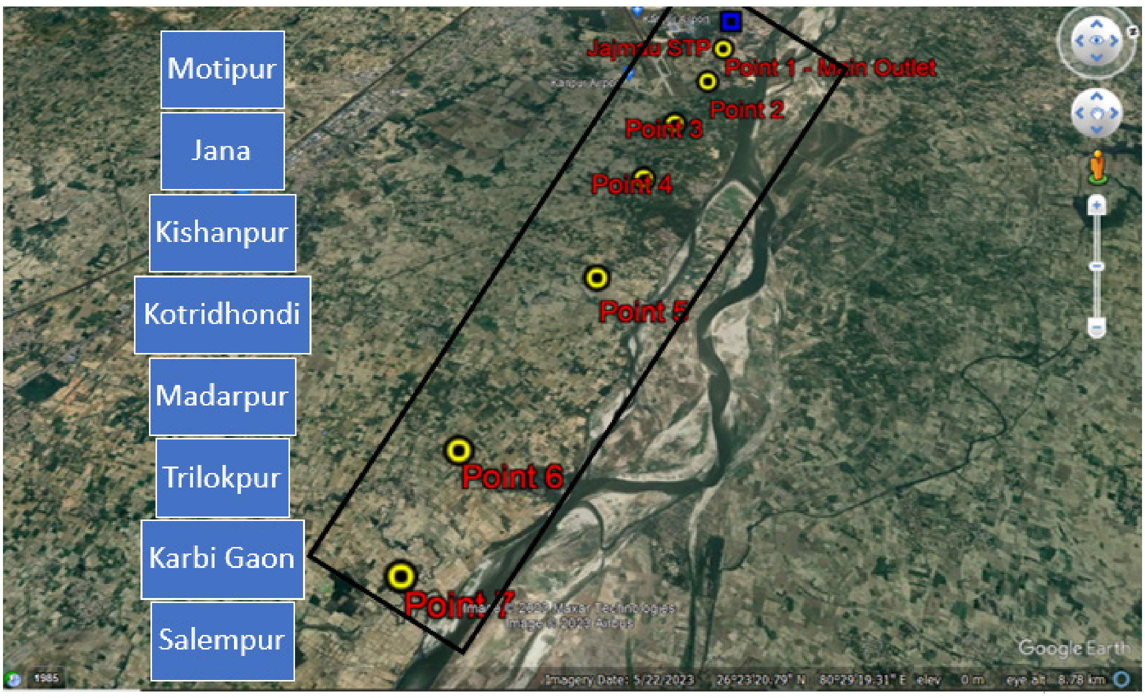
JAJMAU SEWAGE TREATMENT PLANT

CSE visited sewage treatment plant of 130 MLD and 43 MLD, that are located in Jajmau where more than 400 tanneries are located. The capacity to treat sewage is largely inadequate for the amount generated, with only 50 per cent of the sewage receiving treatment.

Figure 17: Salient features of Jajmau Sewage Treatment Plant



Map 3: Location of points traversed by CSE team along the canal during the visit and villages falling in the stretch



Reuse of treated water

As per the monthly progress report submitted by NMCG to NGT (December 2023), these plants comply with the effluent discharge standards prescribed by MOEF&CC. During CSE's visit, laboratory reports found the BOD to be 27 mg/l against the standards limit of <30mg/l. The TSS and FC results could not be retrieved.


Sewage treatment plat Jajmau, Kanpur


CSE team with Jajmau, STP team


Treated effluent outlet of Jajmau, STP flowing i escape canal, Kanpur


Canal which carries the treated water from Jajmau, STP

However, during our visit we observed that the quality of water was blackish and foaming. The treated water from the 43 MLD plant was comparatively dirty and seems to be not meeting the CPCB prescribed standards (*see Treated effluent outlet of Jajmau STP flowing in escape canal, Kanpur*)

Treated water from both the STPs (130 MLD and 43 MLD) together is channelled into an escape canal, designed to flow through gravity. The treated water from this canal is used by nearly 10 villages to irrigate 1,800 acres of farmland *(see Map 3: Location of pints traversed by CSE team along the canal during the visit and villages falling in the stretch)*

Until 1994, reports indicated that the irrigation canal contained a mixture of water from the Ganga River and treated sewage water.[83] However, following the implementation of STPs under the Ganga Action Plan Phase I, the canal exclusively transports treated water from these plants.

Factors driving the reuse of treated wastewater from sewage treatment plants (STPs)

Due to the escape canal's elevation, treated water reaches the fields of nearby farmers through gravity alone. Consequently, nearby farmers save on the cost of electrical/diesel pumping energy cost.

The distance between the treated effluent channel and villages ranges from 0.5 kms to 10 kms, covering a total stretch of 17 kms, including both lined and unlined sections, before it joins the Ganga River. Farmers have easy access to the treated water through openings placed along the canal. They have the flexibility to regulate the flow at their convenience.

Despite being a hub of industries, the region has been grappling with wastewater burdened with diverse pollutants. Improper treatment has led to the contamination of surface and subsurface water, rendering it unfit for both drinking and irrigation. High levels of Total Dissolved Solids (TDS) and chromium in groundwater have raised significant health concerns and necessitated an alternative source of water for agriculture. (Department of Civil Engineering, 2021).[84] In the absence of an alternative water source, villagers are forced to depend on canal water for irrigation due to contaminated groundwater

The year-round availability of treated wastewater for agricultural use is a significant boon for the community. During CSE's visit, the authorities further mentioned that in instances where the supply of treated water is interrupted due to service or breakdown of the STP, farmers often approach the STP demanding the release of treated water.

"The groundwater availability in the nearby villages is between 150–200 feet below ground level. Also, the groundwater is contaminated due to high TDS value. The groundwater is contaminated due to tannery industries nearby. The farmers are using this treated used water for 20–25 years for irrigation. Rice, wheat and fodder are the major crops in the Jajmau region."

Jagadeesh Prasad, Resident, Dhondhi, Jajmau, Kanpur.

"The quality of water received in the canal is satisfactory, it is better to use this water than from borewells. We are using this treated water from the canal from long time. As of now we are not facing any issues with the crop productivity. Also, there has been no problem on land and soil quality. We use this water for 7-8 months in a year. During rainy season when no water is required for irrigation the treated water goes to ganga which is 10-12 km from here."

Pawan Kumar Yadav, Resident, Motipur, Jajmau, Kanpur.

Opening near the field of farmers from where the water is take for irrigation in Motipur village

Interaction with the farmers using the treated water for irrigation in nearby villages of Jajmau STP

AGRA

Agra, is a historic town that is situated in the Indo-Gangetic plain of India. The city is built along the banks of the Yamuna River and has a total population of 1.58 million. The Yamuna River is the main drainage channel in the city and it flows from the north to the southeastern part of Agra. The economy of Agra is based on small-scale industries, commerce, and trade. Wheat, paddy, bajra, potato, mustard, petha, etc. are the major crops. About 40 per cent of the total economy of Agra is directly or indirectly dependent on industry.[85]

Agra relies on both surface water (280 MLD) and groundwater (9MLD) as water sources.[86] The city falls in the overexploited groundwater zone. The groundwater level ranges from 2.19 to 46.58 m.

Agra generates 306 MLD of sewage. According to information made available by Uttar Pradesh Jal Nigam, there are a total of nine sewage treatment plants, with a total capacity of 220.75 MLD. However, sewage amounting to 175 MLD is being treated at these STPs and the remaining sewage, i.e, 131 MLD (43 per cent) is being discharged, untreated, into the Yamuna River.[87] Presently, all nine STPs are functioning and are in good condition. Details of the STPs have been provided below in Table 20 *(see Table 20: Existing sewerage treatment scenario in Agra)*

In addition to the underground sewerage system, Agra also has several other wastewater treatment facilities. These include a total capacity of 7.65 MLD DEWATS (Decentralized Wastewater Treatment System) at Kachpura, a wetland at Kakretha, and a co-treatment plant with a capacity of 75 KLD. Furthermore, there are ongoing construction efforts for 10 DSTPs (Decentralized Sewage Treatment Plants) with a combined capacity of 11.60 MLD.

Table 20: Existing sewerage treatment scenario in Agra

S. No.	STP name/ location	Existing STP Capacity (MLD)	Technology	Operational Status of STP	Compliance Status of STP
1.	Dhandhupura	78	UASB	Operational	Complying
2.	Peelakhar	10	WSP	Operational	Complying
3.	NaglaBurhi	2.25	WSP	Operational	Complying
4.	Jaganpur	14	UASB	Operational	Complying
5.	Deori Road	12	UASB	Operational	Complying
6.	Bichpuri	40	UASB	Operational	Complying
7.	Dhandhupura- 2	24	UASB + EA	Operational	Complying
8.	Bichpuri-2	36	SBR	Operational	Complying
9.	Kalindi Vihar	4.5	UASB + EA	Operational	Complying

S. No.	STP name/ location	Existing STP Capacity (MLD)	Technology	Operational Status of STP	Compliance Status of STP
10.	Dhandupura	100	SBR	Proposed	
11.	Peelakhar	35	SBR	Proposed	
12.	Jaganpur	31	SBR	Proposed	

Source: NMCG

DHANDUPURA SEWAGE TREATMENT PLANT

Figure 18: Salient feaures of Dhandpura Sewage Treatment Plant

Commissioned **2001**	Capacity **78 MLD**
Technology **Up Flow Anaerobic Sludge Blanket Reactor**	Flow (MLD) **May, 2023 - 78**

According to the NMCG report submitted to NGT (December, 2023), the Dhandupura STP has been meeting treatment standards. During our visit, we collected laboratory reports and found BOD and TSS concentrations were found well within the limits. However, we could not procure the data for other parameters. This 78 MLD sewage treatment plant runs on full capacity.

Reuse of treated water

Commissioned in 2001, this sewage treatment plant discharges treated water into a nearby natural drain. No dedicated irrigation channel has been provided in the existing STPs. Farmers tap this drain and lay down small pipelines to irrigate their fields. Nearly 80 per cent of the treated water is consumed by the area's agricultural belt that spans a six-kilometer radius from the plant.[88] The remaining water ultimately flows into the Yamuna River through a seven-kilometer-long canal.

Pradeep, resident and farmer, Dhandupura: We are taking treated water from the canal for the last 5–6 years. We have found that this water is suitable for growing potato, bajra, and maize. This canal is helping farmers in an area spanning six kilometres. A majority of the farmers (more than 90 per cent) have been using this water for agricultural purposes. I have 25 bighas of land where I grow mostly potato. This water also provides a good yield. We now harvest 200–250 bags of potato (1 bag = 55 kg) per bigha without the use of urea compared to freshwater which provides 160–170 bags. We sell our potato in the local mandi and also in Mumbai, Pune, Jhansi. The treated water from the canal has ensured a regular supply of water even during drier seasons.

Pradeep, Resident and Farmer, Dhandupura

Pipeline network laid by farmers in Dhandupura village, Agra taking treated water from access point to their field.

The open canal adjacent to the Dhandupra STP where treated water is discharged to be used by farmers for agriculture.

Overall, nearly 570 small and marginal farmers use treated wastewater for irrigation and cultivate a diverse array of vegetables such as cauliflower, ladyfingers, chillies, and spinach and potato. Moreover, they use this resource to grow fodder for their animals, ensuring the well-being of their livestock. The reuse of treated water has increased from 340 hectares in 2001 to 800 hectares by 2021.[89]

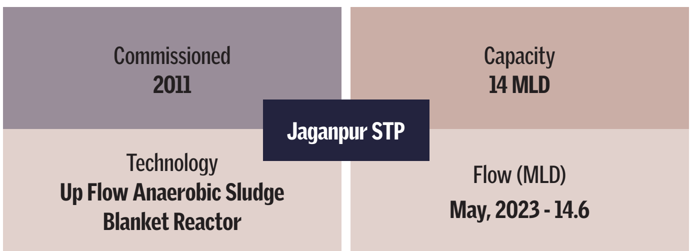
Following are the drivers of using treated water by the farmers of the nearby villages for the agricultural purpose:

- The use of treated wastewater for irrigation has helped farmers substantially **reduce their expenditure on chemical fertilizers and also reduced pumping cost.** Farmers are reporting increased yields by up to 45 per cent.

- Costly and low groundwater extraction has incentivized the use of treated wastewater. Farmers reported an increase in groundwater tables as a result.

JAGANPUR SEWAGE TREATMENT PLANT

Figure 19: Salient features of the Jaganpur STP



The sewage treatment plant (STP) located in Jaganpura, Dayalbagh, Agra, was built in 2011 as part of the JICA-assisted Yamuna Action Plan Phase-2. The plant has a capacity of 14 MLD (million litres per day) and uses UASB (Upflow Anaerobic Sludge Blanket) technology.

As per the NMCG report submitted to NGT (December 2023), the STP complies with discharge standards as per MOEF&CC.[90] Upon analyzing laborartory reports during the team's visit, it was found that BOD and TSS concentrations were well within the limits. However, the team could not procure the data for other parameters.

Reuse of treated water

The Radha Swami Satsang Sabha (RSSS) institute uses treated wastewater for its 1,200 acres farm. Before the installation of this treatment plant, RSSS used to withdraw water from the Yamuna River through a pipeline that was approximately 1,700 feet in length. A petition was filed against this water withdrawal and consequently, the Yamuna Pollution Control unit of the Uttar Pradesh Jal Nigam (UPJN) reached out to the Sabha, seeking to secure land at a discounted rate. The intention was to establish a sewage treatment plant in Jaganpur to substitute their water requirements.

An MoU was signed between RSSS and the Municipal Corporation of Agra, for the supply of 16 MLD treated sewage water from the STP to the Sabha for irrigation purposes free of cost. In 2009 the STP was built. The municipal corporation supplies treated water to the Sabha at the exit point of the STP, and the Sabha is responsible for the conveyance arrangements to distribute the treated water for agricultural use. The treated wastewater from the STP is channelled into an underground escape channel, leading it to an artificial pond constructed by the RSSS. This pond serves as a reservoir, holding the treated water until it is utilized for irrigation purposes. The treated water is used for cultivating wheat, as well as a variety of vegetables, for around 200–250 hectares.

Following are the drivers for using the treated water:

- The MoU has been **mutually beneficial**. The UPJN got free land at a concessional price to set up the sewage treatment plant in Jaganpur while RSSS used to pump water from Yamuna River to meet its agricultural needs which could be compensated by reusing the treated water from the treatment plant.

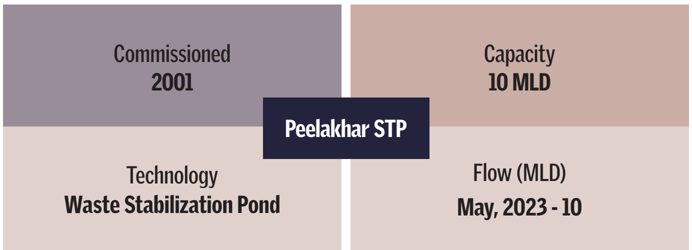
- By utilizing treated wastewater for irrigation, RSSS has **substantially reduced the use of water from the Yamuna river**. The use of treated water has also resulted in higher agricultural productivity.

The reuse of treated water from the Jaganpur sewage treatment plant (STP) in Agra to support the irrigation needs of the Radha Swami Satsang Sabha (RSSS) is a good example of a public-private partnership that began in 2005. However, the scaling up of such models is a challenge.

Artificial pond created by RSSS for storing treated wastewater coming from Jaganpur STP

PEELAKHAR TREATMENT PLANT: CASE STUDY ON THE REUSE OF TREATED WATER FOR AGRICULTURE

Figure 20: Salient features of the Peelakhar STP



The Peelakhar Trans-Yamuna STP, with a capacity of 10 MLD and based on the Waste Stabilization Pond (WSP) technology, was built under the JICA-assisted Yamuna Action Plan Phase-1. It was completed in 2000 and became operational in 2001. This STP is designed to treat domestic sewage sourced from open drains as well as pumped from the primary sewage pumping station, Peela Khar, via a rising main.

As reported by NMCG to NGT (December 2023), the STP complies with the discharge standards prescribed by MOEF&CC. During our visit, we collected laboratory reports and found BOD and TSS concentrations to be well within the limits but could not get the data for other parameters.

Reuse of treated water

The treated wastewater from the STP flows into an oxidation pond. The treated water accumulated in the oxidation pond is further reused by farmers practicing agriculture within 2–3-kilometre radius. Wheat, mustard, and bajra, are grown in these fields.

CSE team with farmers using treated water for irrigation in Nagla Vihari, Agra

Pipeline laid by farmer in Nagla vihari village to extract water from oxidation pond in Peelakhar STP

"We are using this water (treated water) since the plant started operations. Earlier whole area nearby this plant was using open well or borewell. However, over the year due to declining rainfall and dry spells the extraction of groundwater became erratic and costly. Slowly the dependency of this water scaled up in this area. This gives us regular supply of water except few days when cleaning and maintenance of the ponds is going on. This water gives good yield to us but we also use urea and DAP with this water. However, their quantity of use and frequency have been reduced over the year. The major crops grown in this area are wheat, bajra and mustard."

Latur Singh, Resident and Farmer, Nagla Vihari village

Following are the drivers for the reuse of treated wastewater:

- Through the utilization of treated wastewater for irrigation, farmers have **substantially reduced their expenditure on chemical fertilizers** and on **electricity used for pumping** the ground water. **Tiding over declining groundwater table, and assured irrigation from treated wastewater** together has improved water security.

The Peelakhar sewage treatment plant (STP) in Agra is a good example of the reuse of treated water for agriculture. The proposal entails utilizing 5 MLD of treated sewage from the 10 MLD STP in Peelakhar at the waste-to-energy plant located in Kuberpur, Agra.[91]

MATHURA

The city of Mathura is situated along the Yamuna River, approximately 50 km north of Agra and 150 km south of Delhi. Due to its proximity to Vrindavan and Govardhan, Mathura is an important pilgrimage centre. The city has one of Asia's largest petrochemical refineries that was established in 1982–83. According to the 2011 Census, the district has a population of 2.54 million and the current estimated population of Mathura metro population is estimated at close to 0.7 million.

Despite its proximity to the Yamuna River, the city relies heavily on groundwater due to the severity of pollution in the river that is caused by Delhi, located upstream. Various studies, including one by the CGWB in 2012, have reported a persistent issue of high salinity and the accumulation of other chemicals in groundwater. According to the Central Groundwater Board of India, this region is home to 61,456 tube wells and borewells. Before the monsoon, water levels range from 2.65 to 14.34 meters below ground level (bgl), while after the monsoon, they vary from 1.33 to 14.0 meters bgl.

The city is predominantly non-sewered (only five per cent sewerage) and 91 per cent of the households have septic tanks.[92] There are seven operational sewage treatment plants (STPs) in the city. The total sewage generated in the city is approximately 75 MLD while only 27.5 MLD reaches the STP. The details of the STPs are mentioned in the table below *(see Table 21: Existing sewerage treatment scenario in Mathura).*

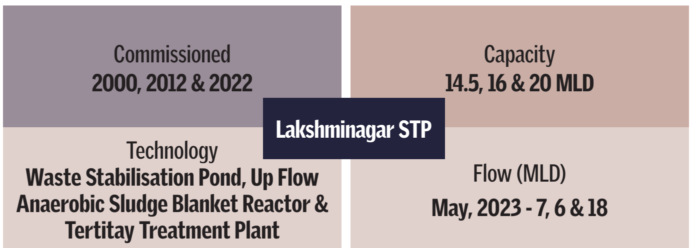
Table 21: Existing sewerage treatment scenario in Mathura

S. No.	STP Location	Existing STP Capacity (MLD)	Technology	Operational Status of STP	Compliance Status of STP
1.	Trans Yamuna- 2	14.5	WSP	Operational	Not Complying
2.	Trans Yamuna	16	UASB	Operational	Complying
3.	Masani	6.8	WSP	Operational	Complying
4.	Trans Yamuna	2.76	WSP	Operational	Not Complying
5.	Masani	30	SBR	Operational	Complying
6.	Pagal Baba	4	Oxidation pond	Operational	Complying
7.	Maat Road Near 100 bed hospital	8	UASB	Operational	Complying

Source: NMCG

LAXMINAGAR SEWAGE TREATMENT PLANT

Figure 21: Salient features of Laxminagar Sewage Treatment Plant



Reuse of treated water

In 2016, the Sewage Treatment Plant (STP) located at Lakshminagar and the Indian Oil Corporation Limited (IOCL) forged a strategic partnership for a 15-year duration.[93] This collaboration was established through a tripartite agreement involving IOCL, UPJN, and NMCG, and aimed at guaranteeing a consistent supply for the IOCL Mathura refinery.

Under this partnership a new tertiary treatment plant based on a membrane-based bio-reactor was constructed at Laxmi Nagar to meet the quality requirements of the Mathura refinery, and was operated by an authorized agency. A concession agreement was signed for the development of a sewage treatment plant through a hybrid annuity-based public-private partnership. As per the partnership agreement, 20 MLD (million litres per day) of treated water shall be bought by the Mathura refinery.

The agreement stipulated that IOCL would utilize the treated sewage water from the STP, provided it meets the quality standards for its industrial purposes. Currently, IOCL is utilizing only 8 MLD of the treated water out of the available 12 MLD. However, with the

Tertiary treatment unit of 20 MLD at Lakshminagar in Mathura

anticipated expansion of the refinery, there could be a further demand for an additional 7 MLD in the future.

The agency responsible for the operation and management of the STP will ensure the quality of water required at the Mathura refinery. The STP is located 20 kms away from the refinery. Therefore, to convey treated water from the STP to the refinery, a pipeline was laid from the STP to the Gokul barrage (approx. 9 km length). From Gokul barrage it was conveyed to the refinery by the existing /newly laid pipeline. The 8 MLD treated water is supplied at a rate of 8.7 Rs/KL to the IOCL refinery. Although the capital cost of setting up the plant was borne by NMCG, Indian Oil bears the O&M and power cost.

During our visit, we collected the laboratory reports and found BOD and TSS concentrations were well within the limits and at par with NGT standards as well.

PRAYAGRAJ

Situated in one of the south-eastern districts of Uttar Pradesh, Allahabad, now known as Prayagraj, stands as one of the largest cities in the state, positioned at the confluence of three rivers—Ganga, Yamuna, and the Saraswati. As of the 2011 Census, Prayagraj district has a population of 5.9 million. Being a pilgrimage city, Prayagraj sees a heavy footfall of tourists. The district's main rivers, Ganga and Yamuna, hold a pivotal role in the agricultural landscape, as the plain area between these two rivers is essential for the district's agriculture. Major industries in Prayagraj include glass and wire industries, alongside agriculture. Naini and Phulpur serve as primary industrial zones, contributing to the city's economic landscape.

A few parts of the city receive partial surface water supply, with some areas drawing from groundwater through tube wells. As per the dynamic groundwater resources report of Uttar Pradesh (March 2022), the total industrial water demand is estimated at 13.7 MLD.[94]

A continued expansion of the city over time, coupled with the exponential rise in the number of tourists, have resulted in the generation of massive amounts of sewerage, which has been directly discharged into the river. As per officials, around 407 million litre per day (MLD) sewage is generated into the Prayagraj city daily.[95] The city currently has nine sewage treatment plants (STPs) with a collective treatment capacity of around 310 MLD while another 80 MLD is in the construction phase.

Uttar Pradesh Jal Nigam (UPJN) is responsible for the construction, operations and maintenance of sewage treatment plants. As part of the 'One City One Operator' initiative, Prayagraj Water Pvt Ltd, a subsidiary of the Adani Group, is responsible for operating and maintaining 10 sewage treatment plants and 15 pumping stations in the Prayagraj district.[96] This operation is carried out under the Hybrid Annuity Model (HAM). Jal Sansthan is responsible for the maintenance of trunk sewers, lateral sewers and collection of revenue from house connections *(see Table: Existing sewerage treatment scenario in Prayagraj).*

Table 22: Existing sewerage treatment scenario in Prayagraj

STP name/ location	Existing STP Capacity (MLD)	Capacity Being Utilized (MLD)	Technology	Operational Status of STP	Compliance Status of STP
Numayadahi	50	63	Bio Tower	Operational	Complying
Ponghat	10	7.6	Bio Tower	Operational	Complying
Kodra	25	22.6	Bio Tower	Operational	Complying
Rajapur	60	80	UASB	Operational	Complying
Salori 1	29	43	FAB	Operational	Complying
Salori 2	14	14	SBR	Operational	Complying
Naini	80	115	ASP	Operational	Complying
Naini	42		FCR	Operational	Complying
Jhunsi	16		FCR	Operational	Complying
Phaphamau	14		FCR	Operational	Complying
Naini	50			Proposed	NA

Source: NMCG

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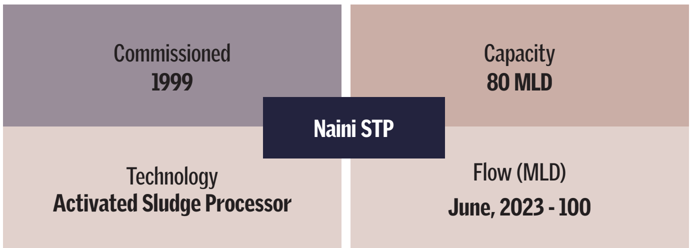
NAINI SEWAGE TREATMENT PLANT

Naini Sewage Treatment Plant is situated on the right bank of the Yamuna River. The sewage treatment plant (STP) is based on ASP + Chlorination technique. A plant of 60 MLD capacity was commissioned in 1998 and an additional 20 MLD was commissioned in 2013.

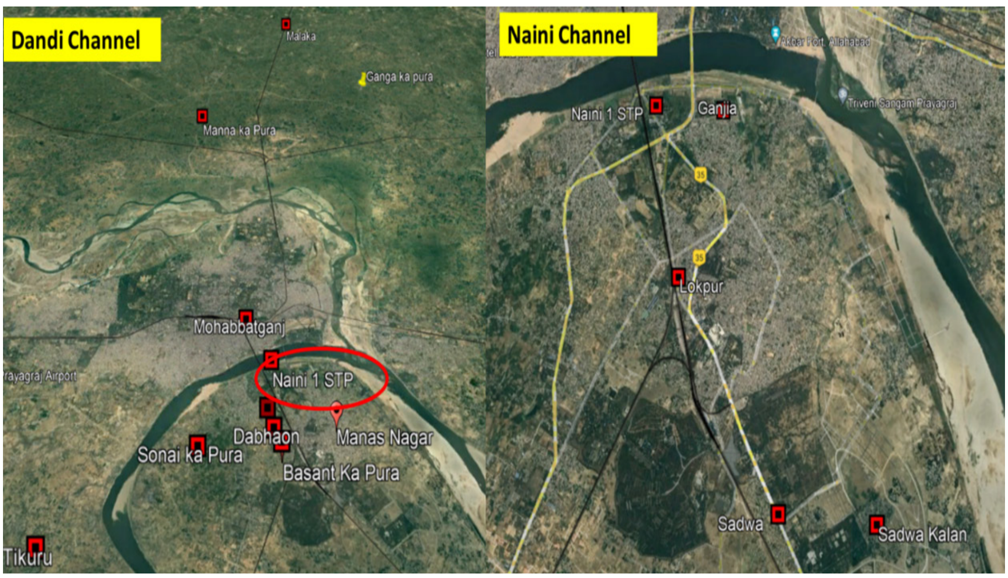
Figure 22: Salient features of Naini Sewage Treatment Plant



Reuse of treated water

The Naini Sewage Treatment Plant (STP) in Prayagraj recycles approximately 25–30 MLD of treated wastewater for agricultural purposes which is approximately 25–30 per cent of the total treated wastewater.[97] The treated water from Naini STP is distributed for the agriculture by dual-channel system (*see Map 4: Location of some of the villages where treated wastewater is used for irrigation using Dandi and Naini channels*) and the record of treated wastewater supplied for agriculture on a daily basis to Dandi and Naini Channel is maintained by UPJN.

Map 4: Location of some of the villages where treated wastewater is used for irrigation using Dandi and Naini channels



Following are the details of the dual system:

- **Dandi channel:** The Dandi channel is a closed overhead pipeline network. Every 30 meters along this extensive pipeline, there is a chamber or opening. These chambers serve as access points for farmers to collect treated water for their agricultural needs.

- **Naini channel:** In contrast, the Naini channel takes an open elevated approach. This channel functions as a conduit for the treated water, allowing it to flow freely. Farmers have direct access to the water as it is discharged from the Naini channel. There is access point available on both side of the channel for the farmers to collect water at a distance of approximately 50 meters. *(see Map 4: Location of some of the villages where treated wastewater is used for irrigation using Dandi and Naini channels)*

Impact

About 14–15 villages benefit from the reuse of treated wastewater from the Naini STP. Farmers in the Naini area report that they are able to grow a range of crops, including staples like wheat and rice, as well as more specialized crops like roses and tulsi, along with vegetables. Farmers are benefitting financially from the use of treated water, as it is helping them save the cost of pumping water for irrigation.

By reusing 25–30 MLD of treated wastewater for agriculture, the volume of effluent discharged into the Yamuna River has reduced, thereby mitigating pollution and preserving the ecological health of the river. The record for the reuse of treated water is maintained by the plant operator.

VARANASI

Varanasi is the fifth most populous city in Uttar Pradesh with a total population of 1.2 million (2011 Census). The total population within the urban agglomeration is approx. 1,4 million. The Ganga is the most important river in this area apart from Varuna, a minor tributary of the Ganga. Another rivulet called Asi joins the Ganga at Asi Ghat in the south of Varanasi. The city is dependent on the Ganga for 45 per cent of the city's water demand.

50 per cent of Varanasi's water supply comes from 112 deep tube wells operated by Jal Sansthan and the remaining 50 per cent is supplied by publicly and privately owned 1,559 hand pumps. The total industrial water demand for Varanasi is 12 MLD (as per 2018 data).[98]

During recent years, the water level of Ganga has decreased significantly due to regulated and unregulated extraction of water upstream. Water pollution is a big challenge.

400 MLD of sewage is generated in Varanasi each day. Only 102 MLD is treated at the six sewage treatment plants currently in operation. Untreated sewage flows into the Varuna and Assi rivers and ultimately flows into the Ganga. The details of the STPs are mentioned in the Table below:

Dandi channelo for distribution of treated wastewater for agriculture from Naini STP

Naini channelo for distribution of treated wastewater for agriculture from Naini STP

Access point on Dandi channel fro farmers to collect water

Discussion with farmers using treated wastewater for agriculture fro Naini STP

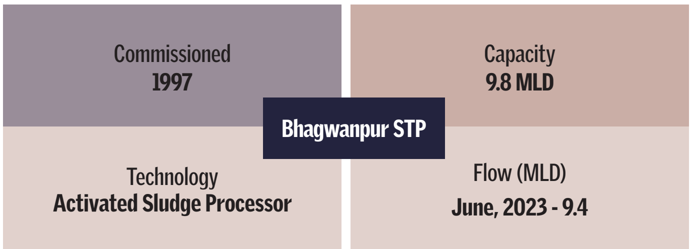
Table 23: Existing sewerage treatment scenario in Varanasi

STP name/ location	Existing STP capacity (MLD)	Capacity being utilized (MLD)	Technology	Operational status of STP	Compliance status of STP
Bhagwanpur	9.8	10	ASP	Operational	Complying
Dinapur	80	80	ASP+ TF	Operational	Complying
Dinapur	140	120	ASP	Operational	Complying
Goithaha	120	45	SBR	Operational	Complying
DLW	12	6	ASP	Operational	Complying
Ramna	50	50	SBR	Operational	Complying

Source: NMCG

BHAGWANPUR SEWAGE TREATMENT PLANT

Figure 23: Salient features of Bhagwanpur Sewage Treatment Plant



Set up in 1997, the Bhagwanpur STP is unique in its origin and operation. The STP is managed and maintained by BHU, and treats wastewater generated by the institute. It runs on full capacity and complies with the discharge norms of the CPCB.

Reuse of treated water

The treated wastewater from BHU flows into an escape stream known as Nakkha Nala, situated 2.5 kilometres from the plant which is reused by farmers residing nearby in Bhagwanpur. The distance between the treated effluent channel and these villages range from 0.5 kms to 3 kms. Farmers collect treated water through designated openings strategically placed along the nala. Subsequently, they transport the water to their fields via underground pipelines.

In this peri-urban area, where agricultural land is limited, farmers use treated wastewater for vegetable cultivation. Some of the vegetables grown include ladyfinger, brinjals, cauliflower, spinach, ashitaba, and drumstick depending on the season. This supports 40–50 farmers.

For the past 10–12 years, farmers have been benefiting from a consistent supply of treated wastewater. There have been no reported instances of land or soil degradation, and the yields have been reported to be satisfactory.

Following are the factors driving the reuse of treated wastewater:
- **Accessibility:** The close proximity of the treated wastewater source makes it readily available to farmers, thus eliminating the necessity for costly borewell construction or the electricity expenses typically associated with conventional irrigation methods.
- **Consistency:** Farmers benefit from a year-round supply of water, even during the arid summer months when water resources are typically scarce.
- **Productivity:** Farmers believe that using treated water positively impacts crop quality and yield.

Discussion with operators at Bhagwanpur STP, Varanasi

The outlet for dixposing treated wastewater in Nakkha nala

Opening in field through undergroud pipeline froj where the treated water is extracted by farmers in Bhagwanpur, Varanasi

Vegetable field in Bhagwanpur using treated wastewater

THE LEARNINGS

Uttar Pradesh possesses a significant volume of sewage water, which, if treated, could be efficiently repurposed to cater to the specific needs of urban areas while also sustaining river flow. In Uttar Pradesh there are 764 towns that generate 5,500 MLD of sewage of which 3296 MLD is treated.

The reuse of treated water is not widely practiced in Uttar Pradesh. Around 50 per cent of the total installed capacity is concentrated in five major cities of the state—Lucknow, Kanpur, Prayagraj, Ghaziabad, and Varanasi. As a result, most water reuse initiatives are concentrated within these urban centres and their surrounding districts. The treated water is predominantly utilized in agriculture, either through planned or unplanned methods, often integrated with the existing canal system in Uttar Pradesh.

Uttar Pradesh has no mandated policy or action plan on the reuse of treated wastewater. Major cities like Lucknow and Kanpur, along with large STPs, face challenges in reusing treated wastewater due to the absence of mandated policies and there is a pressing need for the same along with city-level action plans.

- For large STPs such as Bharwara, where substantial volumes of treated wastewater are discharged, there is a need for city-wide reuse plans. These plans should prioritize options like agriculture, groundwater recharge, and ecological flows, guided by the principles of equity and justice. Additionally, significant infrastructure investments are required to develop conveyance channels for treated water.

In some instances, observed in cities like Agra, Kanpur, Varanasi, and Prayagraj, farmers are allowed to utilize treated wastewater for irrigation. However, preventing the mixing of sewage with chemical effluents is imperative to maintain water quality. Regular testing of water by third parties at reuse sites ensures the safety and health of end-users, constituting a vital aspect of sanitation safety planning.

- Instances such as the Jajmau area in Kanpur highlight challenges where treated water quality is compromised due to mixed sewage and municipal effluents. Despite these challenges, farmers who are grappling with groundwater pollution and scarcity, resort to using treated wastewater for agriculture.

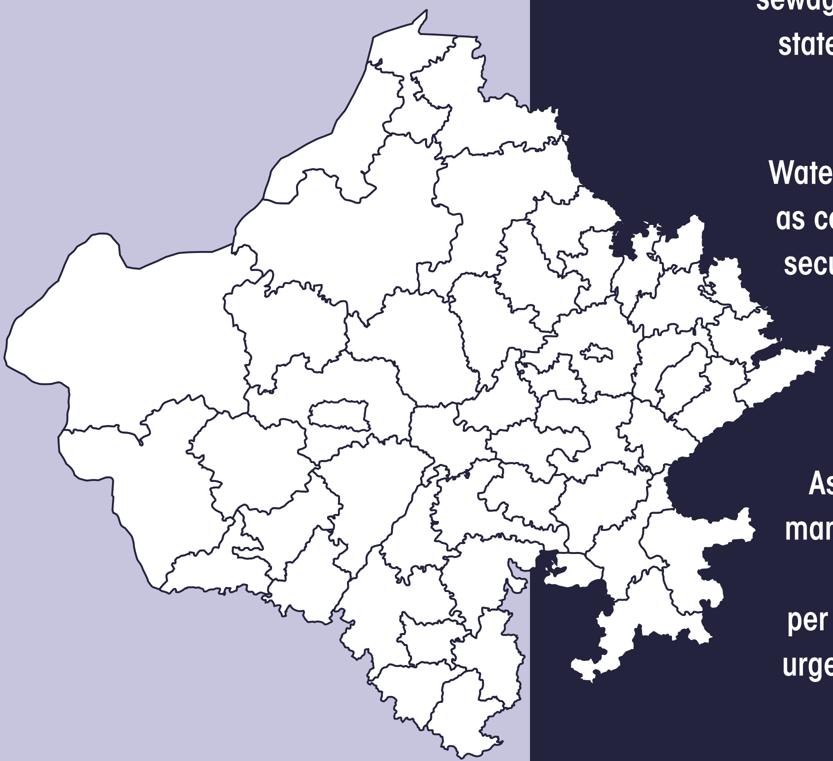
The recurring costs associated with infrastructure development for treated wastewater reuse pose a hindrance, particularly for industries and thermal plants. Mechanisms must be established to build consensus between industry and government for cost-sharing in infrastructure development and operational maintenance.

- The Mathura refinery's reuse of treated water from the Laxminagar STP exemplifies the public-private-partnership (PPP) model's effectiveness. Notably, revenue generated from supplying 20 MLD to the refinery covers the operation and maintenance costs, showcasing a sustainable financing model for reuse and environmental management initiatives.

Uttar Pradesh is highly dependent on groundwater when it comes to agriculture, drinking and industrial needs and the absence of stringent policy on regulating water extraction is severely restricting the reuse of treated wastewater.

Given that the primary reuse of wastewater in Uttar Pradesh is for agriculture, there is a critical need for the implementation of monitoring mechanisms to track both quantity and quality. Third-party oversight is essential to ensure the safety and health of end-users.

RAJASTHAN



Rajasthan generates 1,551 MLD of sewage and treats 956 MLD. The state lacks a detailed policy for reusing treated water.

Water-intensive industries, such as cement, iron, and zinc, have secured rights to reuse treated water, leading to concerns about monopolization and privatization.

As a water-scarce state, with many urban areas falling short of the 135 liters per capita per day benchmark, Rajasthan urgently needs equitable water reuse strategies.

TOTAL WASTEWATER/ SEWAGE GENERATED (MLD)
1,551

TOTAL WASTEWATER/ SEWAGE TREATMENT CAPACITY (MLD)
1,299

TOTAL OPERATIONAL CAPACITY OF STP (MLD)
1,299

TOTAL WASTEWATER/ SEWAGE TREATMENT BEING TREATED* (MLD)
956

TOTAL TREATMENT CAPACITY COMPLIES WITH THE DISCHARGE NORMS (MLD)
777

AMOUNT BEING REUSED (%)
29

WATER AND WASTEWATER IN RAJASTHAN: AN OVERVIEW

Out of Rajasthan's total population of approximately 69 million, around 25 per cent reside in urban areas.[99] This urban population is growing at a rate close to three per cent per annum. Although the state boasts 13.88 per cent of India's arable land and sustains only six per cent of its population, along with approximately 11 per cent of the country's livestock, the state only possesses a scant 1.16 per cent of surface water and 1.70 per cent of groundwater resources. In this context, Rajasthan can be considered a water-deprived state, with an average annual per capita availability of less than 800 m^3, compared to the commonly accepted requirement of 1,000 m^3. There is a 30 per cent disparity between water demand and supply in the state.[100]

Due to its hot and arid climate, the state has limited surface water resources. There are 14 defined river basins in the state but Chambal and Mahi are the only perennial rivers. Major parts of western Rajasthan are devoid of any major drainage systems and face frequent spells of harsh droughts.

The state is heavily dependent on groundwater for irrigation and about 90 per cent of the drinking water and 60 per cent of the irrigation water is sourced from groundwater supplies. The groundwater level in Rajasthan has reportedly declined by more than four metres over the last decade.[101] Almost all parts of the state face exploitation beyond annual replenishable levels. Substantial groundwater level decline is being witnessed both in hard rock and alluvial areas. The contributing factors are low rainfall, limited groundwater storage availability, and groundwater salinity in many areas, deep water levels in most of western parts of the state and desert conditions in nearly 50 per cent of the state.

Presently, out of the total 185 urban local bodies (ULBs) in the state, 1,833 are served by piped water supply. According to the State Planning Department, only 23 ULBs were able to provide more than 100 litres per capita a day (lpcd), 79 were able to provide 60–80 lpcd of water, and 74 were able to provide 40–60 lpcd as against a service-level benchmark of 135 lpcd. On the other hand, the frequency of water supply is another major focus area, with the gap between water supply hours ranging between one and three days.[110]

The quality of available water is also a matter of concern. Nationally, 25 per cent of all habitations with multiple quality issues in the country are located in Rajasthan, which include 40 per cent of all fluoride-affected areas and, 83 per cent of all salinity-affected areas, and 23 per cent of all nitrate-affected areas.[103]

Surface water pollution can be attributed to sewage water and industrial effluent. Rajasthan has clusters of textile printing units emitting wastewater containing dyes leading to heavy metal pollution of surface and groundwater. Industrial water pollution is mainly connected to Kota, Udaipur, Jodhpur, Pali, Balotra, Sanganer, Bhilwara, Jhotwara and Bagru areas.

CURRENT POLICIES AND REGULATIONS

Table 24: Policy and reuse aspect of treated wastewater in Rajasthan

Policy	Salient features	Reuse aspects
State Water Policy, 2010	Outlines the government's development framework for the long-term sustainable development and management of water resources in the State. This policy is unique as it was the first time that a State has acknowledged the major role of people in the management of water resources.	Preservation of traditional water harvesting structures and sources will be encouraged. Rooftop rainwater harvesting, storm water harvesting, recycling and reuse of wastewaters will be promoted.
Rajasthan Urban Water Supply Policy	The policy primarily focuses on identifying issues concerning urban water management, particularly in relation to drinking water. Subsequently, other components of the policy align with the government's vision to address these issues, encompassing implementation arrangements as well.	It has set directions on aspects related to sewerage, septage management and wastewater recycle/ reuse.
State Sewerage and Wastewater Policy, 2016	The policy earmarks priority issues of the Government of Rajasthan along with service-level benchmarks and implementation plans for critical indicators like the coverage of toilets and sewage network services, collection efficiency, extent of reuse and recycling of sewage and efficiency of redressal of customer complaints. The requirement of the next 30 years will be covered in this policy. In the next five years, it will be mandatory for every house in the state to connect with a sewage system in the cities that have 100 per cent sewage system.	Wastewater treated under it will be used in irrigation and for agricultural work.
Action Plan for Reuse of Treated Wastewater in Rajasthan, 2019	Action plan for reuse of treated water	Local self-government is separately preparing the guidelines for the use of treated waste water on a sustainable basis, thereby reducing dependency on freshwater resources. To achieve this vision, a time-bound and systematic action plan with the ultimate goal of reusing treated wastewater fully by 2030 has been proposed.

Source: Compiled by CSE

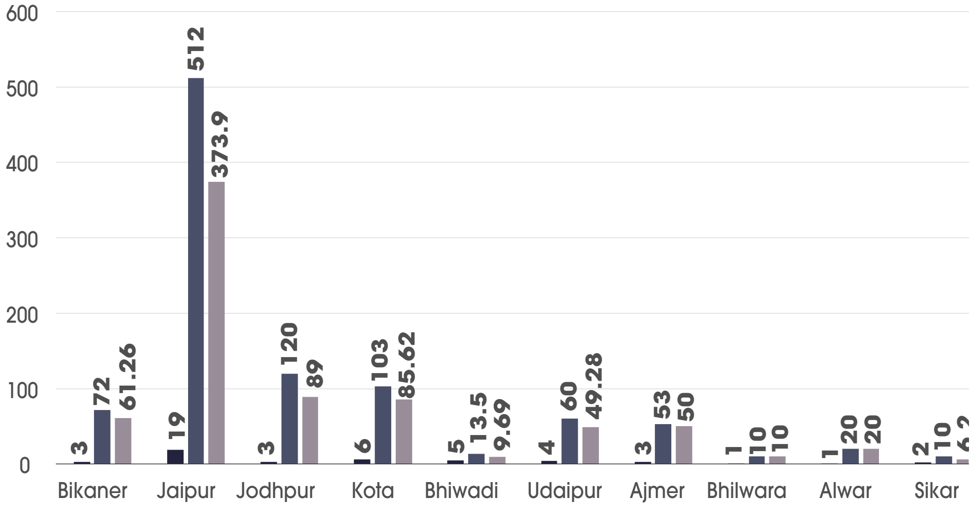
According to the latest report submitted to NGT by Rajasthan, 1,551 million litres per day (MLD) of sewage is generated in the state. Currently, there are 118 STPs in operation in the region, with a combined treatment capacity of 1,299 MLD. Furthermore, an additional 500 KLD of sewage is treated using alternative technologies, such as faecal sludge treatment plants (FSTP). Currently, 956 of the total 1,299 MLD capacity is being utilized for treating sewage, leaving a gap of 343 MLD. Furthermore, 13 STPs with a total capacity of 179 MLD are not compliant with CPCB (Central Pollution Control Board) norms. To fulfil this gap, 77 STPs with a total capacity of 586.35 MLD are under various stages of construction, tendering etc.[104]

Besides national policies on conservation of water resources, Rajasthan has state-specific policies and rules that mandate the conservation of water resources. The significant policies and their salient features have been mentioned in the Table below *(see Table 24: Policy and reuse aspect of treated wastewater in Rajasthan)*.

REUSE OF TREATED WATER

The state currently operates a total of 118 Sewage Treatment Plants (STPs) with a combined treatment capacity of 1,299 MLD. However, the actual treatment capacity in use is 956 MLD, indicating that approximately 61 per cent of sewage is being treated.[105] Of the total installed capacity in the state, Jaipur city alone accounts for 40 per cent, with 19 STPs that has a collective capacity of 512 MLD. Other major cities like Jodhpur, Kota, Bikaner, etc., also contribute significantly to the state's sewage treatment capacity (*see Graph 9*: *Potential of reuse of treated wastewater in big cities of Rajasthan*). So, keeping in mind the amount of treated wastewater, Rajasthan has a high potential for reusing treated water.

Graph 9: Potential of reuse of treated wastewater in big cities of Rajasthan



Source: NGT Monthly Progress Report, December, 2023

As per the report submitted to NGT by the state government, the reuse of treated water in Rajasthan is very less and limited to some areas only i.e. Udaipur, Pali, Bhilwara, Chittorgarh, Jodhpur, Sikar, Jaipur etc. for industrial purposes and in some places, for agricultural purposes.[106] The details are mentioned below in the Table *(see Table 25: Potential of reuse of treated wastewater in big cities of Rajasthan)*.

Table 25: Potential of reuse of treated wastewater in big cities of Rajasthan

Place	Capacity of reuse of treated wastewater (MLD)	Reuse of treated wastewater
Udaipur	45	Treated water is being reused by Hindustan Zinc Limited
Bhilwara	10	Treated water is being reused by Jindal Saw Limited
Chittorgarh	5	Treated water is being reused by Hindustan Zinc Limited
Jaipur	85	62.5 MLD (Agriculture), 22.5 MLD (Mahindra World City), 4.9 (Horticulture)
Sikar	7	Treated water is used by Uranium Corporation of India Limited
Jodhpur	85	Agriculture
Pali	15	Industry
Nawalgarh	5	Reused in cement plant
Beawer	7	Reused in cement plant
Ajmer	13	Lake revival
Total	277	

Source: Compiled by CSE

Table 26: Details of the visited STPs in Rajasthan

<table>
<tr><th>District</th><th>STP</th><th>Commissioned (Year)</th><th>STP Capacity (in 1MLD)</th><th>Technology</th><th>Reuse</th></tr>
<tr><td rowspan="4">Udaipur</td><td rowspan="4">CSTP Hindustan Zinc Limited (HZL)</td><td>2019</td><td>20
25
10</td><td>MBBR
MBBR
SBR</td><td rowspan="4">Industrial (sent to HZL)</td></tr>
<tr><td>2015</td><td>120</td><td>SBR</td></tr>
<tr><td>2010</td><td>100</td><td rowspan="2"></td></tr>
<tr><td></td><td>43</td></tr>
<tr><td rowspan="2">Beawar</td><td rowspan="2">Beawar</td><td>2019</td><td>2.5</td><td>SBR</td><td>Industrial (sent to Shree Cements Limited)</td></tr>
<tr><td>2019</td><td>1.5</td><td>MBBR</td><td>Irrigation (Agriculture)</td></tr>
<tr><td>Ajmer</td><td>Ana Sagar</td><td>2015</td><td>13</td><td>SBR</td><td>Lake revival</td></tr>
</table>

Source: CSE visit to Rajasthan

A team from the Centre for Science and Environment (CSE) visited various locations in Rajasthan to conduct a study on the utilization of treated wastewater from Sewage Treatment Plants (STPs). The objective was to gain practical insights into the processes involved and to assess whether any actual reuse of treated water was taking place on the ground. Another aim of the visit was to capture methods, results, and conclusions of used water reuse project if existing *(see Table 26: Details of the visited STPs in Rajasthan).*

UDAIPUR

Udaipur is the sixth largest city in Rajasthan with a population of 0.45 million (2011 Census) and an approximate floating population of 30,000 people. Udaipur is known as the City of Lakes and is a popular tourism site. Udaipur is a pivotal hub for industry, administration, and education within the region. Its main industries include marble, tourism, and both metallic and non-metallic mining. Due to the absence of a perennial river, Udaipur relies heavily on its intricate lake system for crucial resources such as drinking water, irrigation, and recreational activities.

With an average annual rainfall of 637mm, Udaipur has a great natural drainage system. The Ayad river flows through the town, collecting stormwater runoff and ultimately discharging it into the Udai Sagar, effectively managing the city's drainage needs. The total water demand estimated for 2021 was 101 MLD while the total water supply (freshwater and groundwater sources) was 83.15 MLD with an average of 155 LPCD.[107] The freshwater sources for the city of Udaipur include Pichola and Fateh Sagar lakes, as well as the Mansi and Wakal rivers. Additionally, the city relies on 50 tube wells, 32 step wells, 180 panghats and 2,650 handpumps to supplement its water supply.[108] 78.5 MLD of surface water is extracted from Pichhola lake, Fatehsagar lake, Jaisamand lake, Badi Lake and the Mansi Wakal Dam. 5 MLD of ground water is extracted to meet the total demand of the city from several tubewells and open wells which include several traditional baoris.

Reuse of treated water

The integrated underground sewerage system in Udaipur city does not cover the entire area and currently encompasses 62.5 per cent of the city. The city generates an average of approximately 70 million litres of sewage per day, posing a significant challenge for its proper cleaning and management. Previously, a significant portion of the sewage was finding its way into the lakes, resulting in water contamination.

Efforts have been made to address this issue by treating the wastewater. Presently, the city has a total of 60 MLD sewage treatment capacity and four sewage treatment plants. A substantial amount of the treated wastewater is utilized to meet the water needs of the Hindustan Zinc Industrial complexes, while a considerable portion is used for horticulture purposes.[109] This initiative aims to reduce the contamination of water bodies in Udaipur that is caused by untreated sewage *(see Table 27: Details of the visited STPs in Udaipur).*

Table 27: Details of the visited STPs in Udaipur

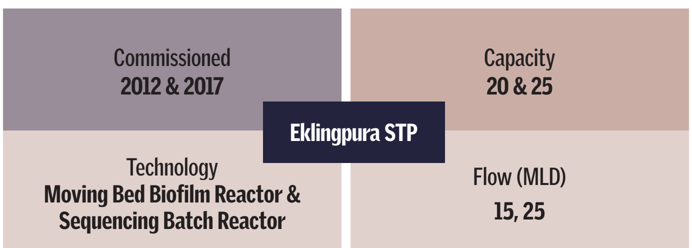
Name of town	Location	STP Capacity (MLD)	Capacity being utilized (MLD)	Treatment process
Udaipur	Eklingpura	20	14.58	MBBR
	Eklingpura	25	25	SBR
	FCI godown	10	5.5	SBR
	Kajrali house	5	4.2	SBR

Source: CSE visit to Udaipur

EKLINGPURA SEWAGE TREATMENT PLANT

Before 2012, Udaipur faced a substantial challenge in managing its sewage. The city generated a staggering 70 million litres of sewage per day. Most of this untreated domestic sewage was flowing unchecked into the Ahar River, a vital tributary of the Berach River, causing severe environmental degradation and posing significant health risks. Before the implementation of this initiative, Hindustan Zinc Limited (HZL), a Vedanta Group Company in the zinc, lead, and silver industry, used to extract water from the Udaisagar lake to fulfil its industrial water needs. By 2012, they were drawing 5,000 cubic meters of water per day. As the population grew and the demand for drinking and domestic water increased, social conflicts arose, particularly concerning the utilization of the lakes, which served as a vital water supply source. Recognizing the need to explore alternative water sources for its industrial operations, Hindustan Zinc Limited (HZL) collaborated with the Government of Rajasthan, with HZL spearheading the construction of the first PPP (Public-Private Partnership) Sewage Treatment Plant (STP) in Udaipur.[110] This STP has the capacity to treat 20 million litres of sewage daily, which accounts for 30 per cent of Udaipur's domestic sewage. The company has made a significant investment of approximately INR 170 crore in this project.

Figure 24: Salient features of Eklingpura STP



Taking this initiative forward, Hindustan Zinc is looking forward to scale up its Sewage Treatment Plant project to treat 100 per cent of Udaipur's domestic sewage. In July 2017, HZL entered into an agreement with Udaipur Smart City Limited (USCL) for the design, construction, supply, installation, testing, commissioning, and operation of an STP with a combined capacity of 40 MLD which involved the introduction of three additional STPs in

Inlet point for receiving sewage water at Eklingpura STP, Kaladwas village, Udaipur

Outlet point of treated water at Eklingpura STP, Kaladwas village, Udaipur designed for its disposal, after which it is transferred to storage tanks for further use.

Eklingpura (25 MLD capacity), FCI Godown (10 MLD), and Kazrali House (5 MLD), utilizing the Hybrid Annuity Model (HAM) with a 15-year concession period. The construction of the plants will be based on the Sequencing Batch Reactor (SBR) process. With the additional commissioning of 40 MLD STP, the total capacity of STP will now be 60 MLD. Under this agreement, operation and maintenance (O&M) responsibilities were allocated for a duration of 15 years under the Hybrid Annuity Model (HAM). The capital costs were divided, with 40 per cent funded by the Nagar Nigam and 60 per cent (amounting to 80 crore) contributed by Hindustan Zinc Limited (HZL) during the construction phase. The treated water output from the 25 MLD STP was shared, with HZL receiving 75 per cent of the treated water and 15 MLD going to USCL. Following the commissioning of the sewage treatment plants (STPs), Hindustan Zinc Limited (HZL) will receive INR 12.80 crore upfront and INR 1.28 crore annually for a period of 15 years as part of the arrangement.[111]

Upon the completion of the project, the Urban Local Body (ULB) has the capacity to treat 100 per cent of Udaipur's sewage. The sewage treatment coverage in the city is set to increase from 20.3 per cent to an impressive 62.5 per cent. Additionally, a substantial volume of treated wastewater will be allocated for use within Hindustan Zinc's industrial complexes.

After the operationalization of the Eklingpura STP (20+25 MLD) in Kaladwas village of Udaipur, the treated water is stored in two underground holding tanks, each with a capacity of approximately 2.5 MLD. It is then pumped and transferred to the Dariba and Dorba smelting complexes, covering a total distance of approximately 80.5 kilometres.

Impact

The STPs are vital for Udaipur which is witnessing rapid urbanization and is a popular tourist destination. The introduction of sewage treatment plants treating the city's sewage has resulted in a substantial reduction in the sewage inflow to the lakes and helped in enhancing their beauty. 60 million litres per day of freshwater is conserved every day. Wastewater previously disposed into the lakes (80 per cent of the city's wastewater) is now collected, and treated effluent is used for industrial production. The treated wastewater is then released into the river during summer months and used in horticulture. The quality of the water in the Ahar River, and Pichola and Udai Sagar lakes has improved due to the reduced volume of wastewater discharges.[112]

Tank constructed at Eklingpura STP, Kaladwas village, Udaipur where treated water is stored for further use.

CSE visit to with Eklingpura STP, Kaladwas village, Udaipur

AJMER

Ajmer is one of the major cities of Rajasthan. According to the 2011 Census, Ajmer has a population of around 0.55 million in its urban agglomeration and 0.54 million in the city. The city has a semi-arid climate and is on the trisection of three watersheds—Luni, Bans, and Shekhawat, making it inherently vulnerable to waterlogging and flooding. The city has a series of waterbodies connected along the slope. Two of the principal waterbodies in the region, Anasagar Lake and Foy Sagar Lake, have historically served as vital water supply sources for the city. The catchment of Anasagar was subjected to development, but Foysagar's undeveloped catchment remained protected. However, with the increase in water demand, the city has begun to rely on the Bisalpur Dam that is at a distance of 120 kms from Ajmer. The city currently faces a scarcity of water resource, flooding, waterlogging, and environmental pollution. This has resulted in dependence on water tankers to meet the water demand. The city's water system has been disrupted by a lack of foresight and implementation of the initial Master Plan. In addition to this, the city's water supply falls below the Indian norm of 135 LPCD. In the last decade, there were significant water scarcity issues, with reports indicating water supply occurring only once every two to three days during summer. The city is threatened by groundwater depletion due to a decline in recharge and an increase in withdrawal for industrial and domestic purposes.[113] The city has been included in various national policies and schemes such as the Smart City Mission 2015, Heritage City Development and Augmentation Yojana Scheme (HRIDAY) 2015, and the National Lake Conservation Policy (NLCP) of 2008.

The sewage generated from the Anasagar zone in the north of the city in and around the Anasagar tank is 10.5 million litres per day (MLD). This is to be treated in a sewage treatment plant (STP) with a capacity of 13 MLD and is situated next to the Anasagar tank. The Ajmer Municipal Corporation has created some diversion tanks in which the wastewater from some of the bigger drains flowing into the Anasagar tank are intercepted.

The rest of the city's wastewater, amounting to 53 MLD, flows through various drains and meets up with the main drain which flows towards the south and eventually empties into the Khari River. An STP complex has been built at Khanpur on the banks of this drain. An STP of 20 MLD capacity has already been constructed but is not operating because the sewers have not been connected to it. The Ajmer Municipal Corporation has taken charge of this STP but is yet to connect the sewers to it. Another STP with a capacity of 40 MLD is under construction[114] *(see Table 28: Detail of the STPs in Ajmer)*.

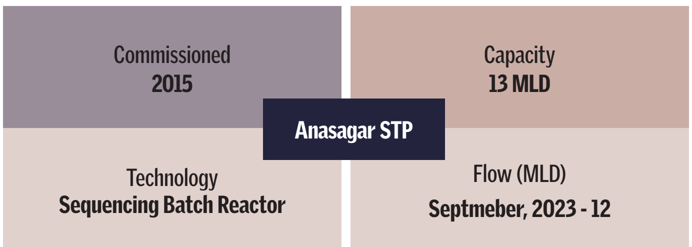
Table 28: Details of the STPs in Ajmer

Name of Town	Location	STP Capacity (MLD)	Capacity being utilized (MLD)	Treatment process
Ajmer	Khanpura	20	18	ASP
	Anasagar	13	12	SBR

Source: CSE visit to Ajmer

ANASAGAR SEWAGE TREATMENT PLANT: CASE STUDY ON REUSE OF TREATED WATER FOR LAKE REVIVAL IN AJMER

Figure 25: Salient features of Anasagar STP



Anasagar Lake, situated in the heart of Ajmer, is a remarkable historic waterbody. With a catchment area of 70.55 sq. km and a circumference of 12.88 sq. km, the lake spans a significant part of Ajmer's landscape. Its maximum depth reaches 16 feet, while the minimum depth is three feet. Anasagar Lake historically served as a crucial water supply source for Ajmer, with piped supply beginning in 1884 when the city's population was around 50,000.

The absence of a comprehensive sewer system for domestic wastewater in the nearby colonies led to the direct discharge of untreated sewage, municipal wastewater, and agricultural runoff into the lake through open drains known as *kachcha nallah/pucca nallah*. This uncontrolled inflow of pollutants led to a significant deterioration in water quality and increased primary productivity, ultimately causing eutrophication. Approximately 35 per cent of Ajmer's population resides in the catchment area of Anasagar Lake. The presence of 28,000 residential and commercial buildings in the lake's vicinity, with many lacking adequate sewer systems, exacerbated pollution concerns. To treat the sewage generated, a sewage treatment plant (STP) was established near Anasagar Lake. This STP has a capacity to treat up to 13 million litres per day (MLD) of sewage, adhering to the standard parameters set by the Central Pollution Control Board (CPCB). Additionally, under the AMRUT 2.0 scheme, another STP with a capacity to treat 7 MLD of sewage

Channel for treated effluent from where the water flows in pipeline for disposal in Anasagar lake

is under construction, increasing the total treatment capacity to 20 MLD. Out of 11 nallahs, only two are connected to the STP located at Anasagar Lake. On the other hand, nine nallahs are directly discharge wastewater into Anasagar Lake without any treatment.[115]

The treated water from the STP helps in maintaining a continuous water level throughout the year.

Impact

The comprehensive measures taken to address the environmental challenges facing Anasagar Lake have yielded significant positive outcomes such as:

Decrease in pollution*:* The construction of the Anasagar STP has led to a remarkable 90 per cent reduction in the disposal of untreated sewage water into the lake according to a claim by authorities. However, these claims could not be backed by sufficient evidence. Nonetheless, the water quality of the lake seemed to have improved visibly, and the eutrophic condition that once plagued the lake seemed to have been reversed as well.

Groundwater recharge*:* The treated water stored in Anasagar Lake now serves as a natural percolation source, enhancing both the quality and quantity of groundwater recharge in the lake's vicinity. This will have potential long-term benefits for the region's water resources.

Anasagar STP in Ajmer

Environmental and aesthetic improvement*:* The rejuvenation efforts have resulted in the transformation of the lake into a more attractive and peaceful destination for residents and tourists. The continuous water-level maintenance enhances its beauty throughout the year.

Anasagar Lake in Ajmer

Disposal point of the treated effluent into the Anasagar lake

BEAWAR

Beawar is a city in the Beawar district of Rajasthan. As of 2011, the population of Beawar was 0.34 million. The city is located 60 kms south of Ajmer amidst the Aravali hills. Beawar is the largest producer of cement in northern India and home to Shree Cement. It is situated in a mineral-rich region and has reserves of feldspar, quartz, asbestos, soapstone, magnesite, calcite, limestone, mica, emerald, granite, and masonry stone.

Beawar relies upon Bisalpur Dam for fulfilling the drinking water demand of the city and after allotment of more water to Jaipur, the city is struggling to meet its daily water supply.

BEAWAR SEWAGE TREATMENT PLANTS: CASE STUDY ON THE REUSE OF TREATED WATER FOR INDUSTRY AND AGRICULTURE IN BEAWAR

Beawar faced challenges related to sewage management and water availability for industrial and agricultural purposes. To address these issues, Beawar Municipal Corporation commissioned two Sewage Treatment Plants (STPs) in 2019, with a combined capacity of 6.5 million liters per day (MLD), using Sequential Batch Reactor (SBR) technology.[116] This case study explores the limited reuse of treated water from these STPs, primarily by Shree Cement Limited (SCL) in the cement industry and by local farmers for agriculture.

Figure 26: Salient features of the two STPs in Beawar

	Beawar I	Beawar II
Commissioned	2019	2019
Capacity	5 MLD	1.5 MLD
Technology	Sequencing Batch Reactor	Sequencing Batch Reactor
Flow (MLD)	2.5-3	1.5

Reuse of treated water by Shree Cement Limited (SCL): SCL, a cement manufacturing company in Bangur Nagar, Beawar, was previously reliant on harvested water from abandoned open-cast mines, along with rainwater and groundwater borewells from nearby villages. Due to the unavailability of water in the region, they decided to use treated water from Beawar STP I. Treated water from Beawar STP I is stored in an overhead tank with a capacity of 2 MLD capacity within the SCL plant premises. The water is pumped from the tank for use by SCL. Flow meters are installed near the pumping station to monitor water usage. SCL's shift to treated water has led to the reduction of stress on groundwater and other water sources available in that area to some extent but the visiting CSE team could not get hold of any reports confirming the claims. In addition to industrial use, this STP plant collaborates with Beawar Nagar Nigam to supply treated water for domestic needs to nearby areas via tanker trucks during summer (March-June). However, this supply is for limited usage.

Reuse of treated water by local farmers

Beawar STP II (1.5 MLD) plays a crucial role in supporting local agriculture. Treated water from Beawar STP II is supplied to nearby farmers through an escape channel and stored in a pond (known as the *Bichadali talab*) that is adjacent to the plant boundary, covering an area of approximately 0.18 square kilometers (Map 5: Google Earth imagery showing location of 1.5 MLD STP and Bichadali talab).

Local farmers predominantly use the treated water to irrigate a variety of crops, including cauliflower, chillies, brinjal, tomatoes, and other seasonal vegetables. This has improved crop yields and reduced the burden on freshwater resources for irrigation. During the rainy season when no water is required for irrigation, the treated water overflows and meets the Makreda River.

THE LEARNINGS

In Rajasthan there are 210 towns which generate 1,551 MLD of sewage, of which 956 MLD is treated. Rajasthan, as of now, is reusing 29 per cent of the treated wastewater.

At the policy level, Rajasthan lacks a comprehensive policy for the reuse of treated water and has a brief action plan. However, there appears to be a lack of implementation of the action plan and adhering to timelines on the ground. It is necessary to develop city-specific action plans to assess sewage treatment potential and determine their reuse based on local demand and circumstances.

A significant portion of treated wastewater in Jaipur and other cities is reportedly reused for agriculture, mainly due to the presence of canal systems. However, this practice is largely informal. In contrast, the reuse of treated water in industrial applications is carried

5 MLD Sewage Treatment Plant, Beawar, Rajasthan

Map 5: Google Earth imagery showing location of 1.5 MLD STP and Bichadali talab

Source: Prepared by CSE

out more systematically. Industries such as cement, iron, and zinc, which require large amounts of water, have established more formalized methods to secure their rights to treated water reuse, particularly where fresh water is scarce.

The Public-Private Partnership (PPP) model has played a role in securing fresh water sources in Rajasthan. However, it has also led to industries monopolizing and privatizing the reuse of treated water. The decision on whether this practice is appropriate should be

Pond adjacent to 1.5 MLD treatment plant in Beawar where treated water is stored for use by local farmers.

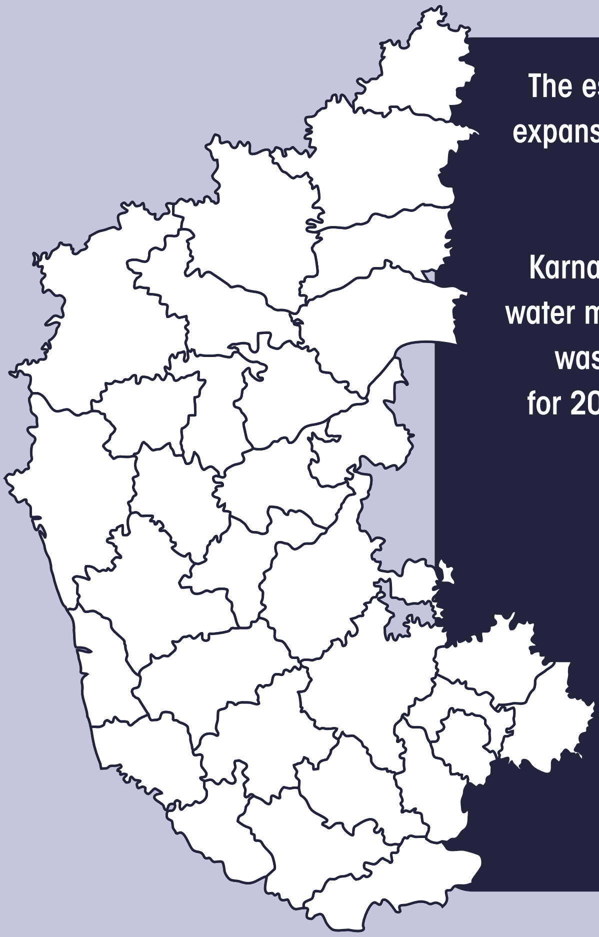
Escape channel in 1.5 MLD treatment plant in Beawar for disposing treated water to the pond adjacent to boundary of the plant.

Flowmeter installed in plant to monitor the quantity of water pumped to SCL made by state and city authorities, considering the water needs for other essential purposes within the state and city based on equity and justice.

Rajasthan is a water scarce state. According to the State Planning Department, only 23 ULBs were able to provide more than 100 litres per capita a day (lpcd), 79 were able to provide 60–80 lpcd of water, and 74 were able to provide 40–60 lpcd against a service-level benchmark of 135 lpcd.[117] The reuse of treated water must be guided by the principles of equity and justice. Other reuse options should also be explored and scaled up, such as lake revival and recharge of shallow aquifers, domestic water supply etc.

On the other hand, the quality of the treated water is an issue. 13 STPs in the state are not complyiant with CPCB norms.[118] In locations where treated water is used for industry, sewage treatment plants (STPs) maintain discharge standards suitable for industrial applications. However, in cities like Jaipur, Jodhpur, and others, the quality of treated sewage is often highly questionable.

KARNATAKA



The escalating water demand due to urban expansion has made the reuse of reclaimed water essential in Karnataka.

Karnataka's 2017 policy on reusing treated water mandates that 10 major cities develop wastewater reuse plans by 2020, aiming for 20% reuse by 2020 and 50% by 2030. However, state-level action plans are lacking.

Bengaluru houses 50% of the state's sewage treatment capacity and reuses 825 MLD of treated wastewater, primarily for lake revival and in water-scarce districts like Kolar and Chikkaballpur.

TOTAL WASTEWATER/ SEWAGE GENERATED (MLD)
3,357

TOTAL WASTEWATER/ SEWAGE TREATMENT CAPACITY (MLD)
2,677

TOTAL OPERATIONAL CAPACITY OF STP (MLD)
2,634

TOTAL WASTEWATER/ SEWAGE TREATMENT BEING TREATED* (MLD)
2,054

TOTAL TREATMENT CAPACITY COMPLIES WITH THE DISCHARGE NORMS (MLD)
2,041

AMOUNT BEING REUSED (%)
43

* (and can be reused)

WATER AND WASTEWATER IN KARNATAKA: AN OVERVIEW

Karnataka has a total population of 67 million, 22 million of which reside in urban areas.[119] Karnataka faces significant water stress, particularly in its drought-prone regions, and in Bengaluru that depends almost entirely on water supply from the Kaveri River to meet its growing water needs.

The state comprises seven major river basins, with surface water utilization of 35,916 mcm (1,268 TMC) and safe groundwater utilization of 11,477 mcm (405 TMC) during an average rainfall year.[120] However, water availability and demands vary spatially across the state (1,608 m3/person/year overall and approximately 1,072 m^3/person/year in eastward flowing rivers). Rainfall varies greatly across the state and ranges from semi-arid to sub-humid and humid zones. The coastal Dakshina Kannada district receives around 4,000 mm of rainfall, while drought-prone districts like Bijapur, Raichur, and Bellary receive only 500–600 mm of rainfall. Other than the Konkan area, a large part of Karnataka is semi-arid and does not receive more than 600–800 mm annual rainfall. Approximately 156 talukas in Karnataka are affected by drought. Karnataka has witnessed massive urbanization as well as commercial and industrial development since the 1970s. This has resulted in a major spike in population in Bengaluru, its largest city.

Rural Karnataka relies on lakes, tanks, and other minor surface irrigation structures to meet the water demand. Approximately 37,000 traditional and 20,000 irrigation tanks serve nearly 80 per cent of the minor irrigation potential.[121]

Agriculture accounts for about 84 per cent of water consumption in the state. Of the total water usage, approximately 26 per cent is from groundwater. However, the contribution of tanks to irrigation potential has declined over the years due to encroachment and siltation. Urban areas, including Bangalore, have a significant number of lakes and tanks used for impounding monsoon runoff to meet drinking water needs.

Groundwater, despite being considered ubiquitous, is not uniformly available in Karnataka. Weathered hard rocks, primarily granite and Deccan trap basalts, account for 97 per cent of the aquifers. Growing reliance on groundwater has resulted in 70 per cent groundwater development, surpassing the national average of 63 per cent.[122]

Surface water bodies are increasingly affected by pollution from untreated municipal sewage and industrial effluents. Groundwater depletion and pollution are also significant concerns, with 64 out of 234 watersheds facing serious water quality problems.[123]

If the current trend of urbanization in Karnataka continues, the state could potentially reach urbanization levels of around 50 per cent by 2030, up from the current levels of about 39 percent.[124] However, unless concerted policy measures are taken for balanced regional growth, the Greater Bengaluru area—which has become the hub of economic activity in recent years —is likely to add another 11.5 million citizens by 2030. The total population of Greater Bengaluru would therefore be more than 20 million by 2030.[125]

Demand for domestic consumption in urban areas is projected to rise from 46 TMC in 2011 to around 84 TMC by 2030. However, the current water supply from the government is only about 35 TMC, resulting in a deficit of approximately 11 TMC.[126] To cope with this, citizens have resorted to private arrangements that is largely dependent on groundwater which has resulted in excessive groundwater depletion in several large-and medium-sized cities in the state.

According to the latest report submitted by the state to the National Green Tribunal (NGT),[127] 3,356.5 MLD sewage is generated in Karnataka. There are 177 STPs with a treatment capacity of 2,676.51 MLD. Additionally, four FSTPs treat 26 KLD of sewage using alternative technologies. Currently, only 2,054 MLD (77 per cent) of the installed capacity is being utilized for treating sewage. Out of the 177 STPs, 164 STPs with a total capacity of 2,634 MLD are operational and 2 STPs of 13.5 MLD capacity are not complying with the CPCB norms.

Out of the total installed sewage treatment capacity of the state, approximately 51 per cent is present in Bengaluru itself, followed by Belagavi and Bellari.

CURRENT POLICIES AND REGULATIONS

Apart from the national policies on conservation of water resources, Karnataka has state-specific policies and rules as mentioned in the table below.

Table 29: Policy on reuse of treated wastewater in Karnataka

Policy	Salient features
The Karnataka Groundwater (Regulation and Control of Development and Management) Act, 2011	This Act makes provision for the regulation and control of the development and management of groundwater in Karnataka, and related matters. Its primary objective is to ensure the sustainable utilization of groundwater and prevent its overexploitation.
2016 Regulation by Forest, Ecology and Environment Secretariat	The regulations mandated apartment complexes above 50 units, and commercial and institutional buildings with more than 2,000 sq m to have an STP on site. This was issued to address the pollution of lakes due to the discharge of raw sewage from residential buildings and complexes.

Policy	Salient features
Policy for Urban Wastewater Reuse, 2017	The goal of this policy is to create an enabling environment for the reuse of municipal wastewater in Class I and II cities, focusing on recycling treated wastewater from STPs. Reuse is suggested for agriculture, industry, urban non-potable, environment, and energy and nutrient recovery adhering to quality standards. Policy targets: • By 2020, 10 major cities are expected to embrace wastewater reuse principles and formulate plans, with a goal to extend this to 100 per cent of all major cities/towns by 2030. • By 2020, the reuse target for 20 per cent of all Sewage Treatment Works (STW) across the state, complying with regulatory standards, will increase to 50 per cent by 2030. Subject to approval under Integrated Urban Water Management plans, incorporating responsible ecological return flow provisions.
Karnataka State Water Policy 2022	The policy envisages formulation of city-level integrated water management plans incorporating wastewater reuse and recycle in alignment with the Karnataka State Water Resources Policy 2012, including priority allocations across different sectors.

Source: Compiled by CSE

According to the 2017 policy, the prioritization for reuse of municipal wastewater appears to be agriculture first, followed by industry, urban non-potable use, environment, and energy. Requirements for large-scale reuse of treated water, as is being done in Bengaluru, requires the following:

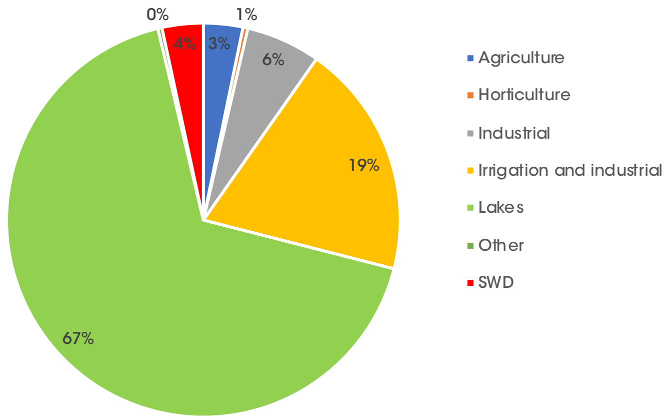
- Non-mixing of industrial effluents from CETPs into treated waste water from STPs.
- Functional STPs and treatment of wastewater

REUSE OF TREATED WASTEWATER

883.65 MLD of treated water, which is approximately 43 per cent of the total sewage treated, is reused from 50 STPs of the state for various purposes such as industrial use, lake recharge, irrigation and horticulture etc.[128] *(see Graph 10: Percentage of reuse of treated wastewater in different sectors in Karnataka)*. The details of the projects for the reuse of treated water have been provided in Annexure 3. According to CSE's analysis of the Karnataka government's March 2024 monthly progress report submitted to NMCG,[129] the major reuse of treated water is occurring in lake revival/rejuvenation, accounting for 67 per cent, followed by irrigation and industrial purposes.

While the lake undergoes revitalization from treated wastewater, direct reuse is uncommon in many instances. However, the augmentation of water availability and duration in lakes

Graph 10: Percentage of reuse of treated wastewater in different sectors in Karnataka



Source: NGT Monthly Progress Report, March, 2024

due to treated wastewater enhances natural percolation, resulting in improved groundwater availability in adjacent wells. This augmented groundwater is subsequently utilized to fulfil water demands in agriculture, industry, and domestic settings.

Reuse of treated water in Karnataka addresses water scarcity (rural areas/districts that are semi-arid), reduces freshwater demand (in Bengaluru City through lake rejuvenation and ground water recharge), supplies water to industry, and minimizes environmental pollution (lakes and water bodies).

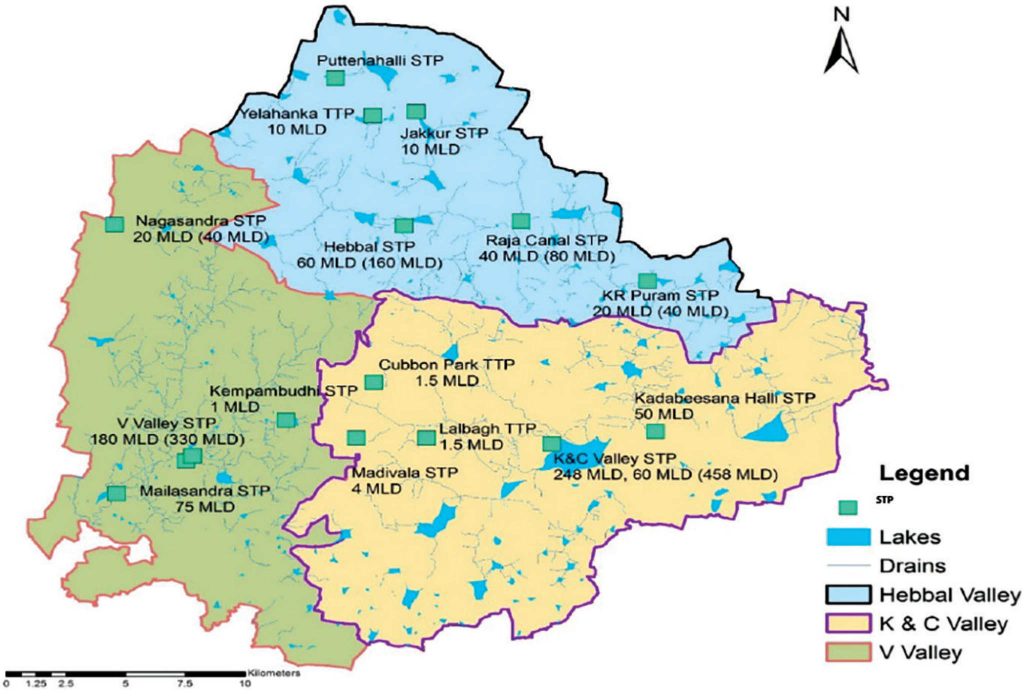
BENGALURU

Located in Southern India, Bengaluru is the capital of the state of Karnataka. Bengaluru city consists of several artificial lakes that were constructed for domestic water supply, and industrial, agricultural and recreational use. The city has witnessed a remarkable expansion of its urban area, growing from 226 sq km in 1995 to 741 sq km in 2010—an increase of 220 per cent over a span of 15 years.

Bengaluru has no proximal river of its own, and as a megacity of over 13 million people, it is unique in this regard. The undulating terrain (varying from about 700 m to about 962 m AMSL) has aided in the formation of interconnected lakes in the region.

Until 1896, Bangalore relied on unfiltered water from local wells and various tanks like Dharmambudhi, Sampangi, Ulsoor and Sankey. Inadequate supply of water led to the identification of the Arkavathi river as a reliable source in 1884, with filtered water introduced in 1896. To meet the growing demand, the Chamaraja Sagar reservoir was built in 1933 near Thippagondanahalli (TG halli) on the Arkavathi River. Due to monsoon failure over the years the reservoirs on the Arkavathi river last received water in 1988. Consequently, the reservoirs in the Arkavathi zone now receive water from the Cauvery

Map 6: Shows the demarcation of valleys in Bengaluru and location of STPs



Source: BWSSB

River. The Cauvery Water Supply Scheme (CWSS) Stage-I was initiated in 1974, boosting supply by 135 MLD.[130]

The drainage network in Bangalore carries water to the Cauvery River through its tributaries Arkavathi, Pinakini (or Pennar) and Shimsha. The central, northern and eastern area is undulating; the upland tracts are occupied by scrubs, while the low lands are occupied by a series of tanks formed by embanking the streams along the valley. These valleys consist of water bodies of varying sizes, ranging from small ponds to large lakes. The southern portion of the land consists of hills that are nestled close together and are surrounded by thick jungles.[131]

Due to its location on a ridge, the city has developed three watersheds where precipitation runs off in three directions along the valleys: Koramangala Challaghatta Valley (KC Valley), Hebbal Valley (H Valley), and Vrishabhavati Valley (V Valley).

The wastewater treatment in each of the three valleys has been planned keeping into consideration their terrain and geography.

Within the administrative boundary of Bruhat Bengaluru, the KC valley is the largest, covering an area of 255 square kilometers, followed by the Hebbal valley at 207 square kilometers and the Vrishabhavati valley at 165 square kilometers. Both the KC valley and

Hebbal valley converge at Nagondanahalli village, which then flows towards the Dakshina Pinakini River. The Vrishabhavati valley joins the Arkavathi River, a tributary of the river Cauvery.

Bengaluru's total freshwater demand is approximately 2,632 million litres per day (MLD). Most of this demand is for domestic purposes (72 per cent), followed by industrial demand (17 per cent) and commercial and institutional purposes (8 per cent).

Nearly 50 per cent of this demand is met by groundwater while rest of the city's water needs are met by pumping water from the Krishna Raja Sagar Dam, built on the Cauvery River. Water is pumped for over 140 km before it reaches Bengaluru. To give some context about how the city's water needs have grown—in 2007 Bengaluru used to draw 900 million litres a day from the Cauvery River, whereas currently it draws 1,400 million litres per day. This rapid urbanization has put immense pressure on the city's resources including its water supply, groundwater and lakes.

In Bengaluru, the total wastewater produced by the city is 1,940 MLD. Around 63 per cent of this wastewater is treated by 34 centralized treatment plants with a collective capacity of 1348.5 MLD and 13 per cent by decentralized treatment plants[132] *(see Figure 27: Water and wastewater scenario of Bengaluru).*

The unsustainable extraction of groundwater and inadequate replenishment measures have created an urgent need to conserve freshwater and promote the reuse of treated wastewater in Bengaluru. The water crisis has led to most on-site borewells running dry, leaving residents, builders and industries mostly reliant on tankers. As a result, tanker water prices have skyrocketed and gone from INR 60–90/KL to as high as INR 200/KL. Treated wastewater is being sold at INR 10–80/KL, depending on quality, making it competitively priced and building an economic case for wastewater treatment and reuse, turning onsite STPs into an asset rather than a liability.[133]

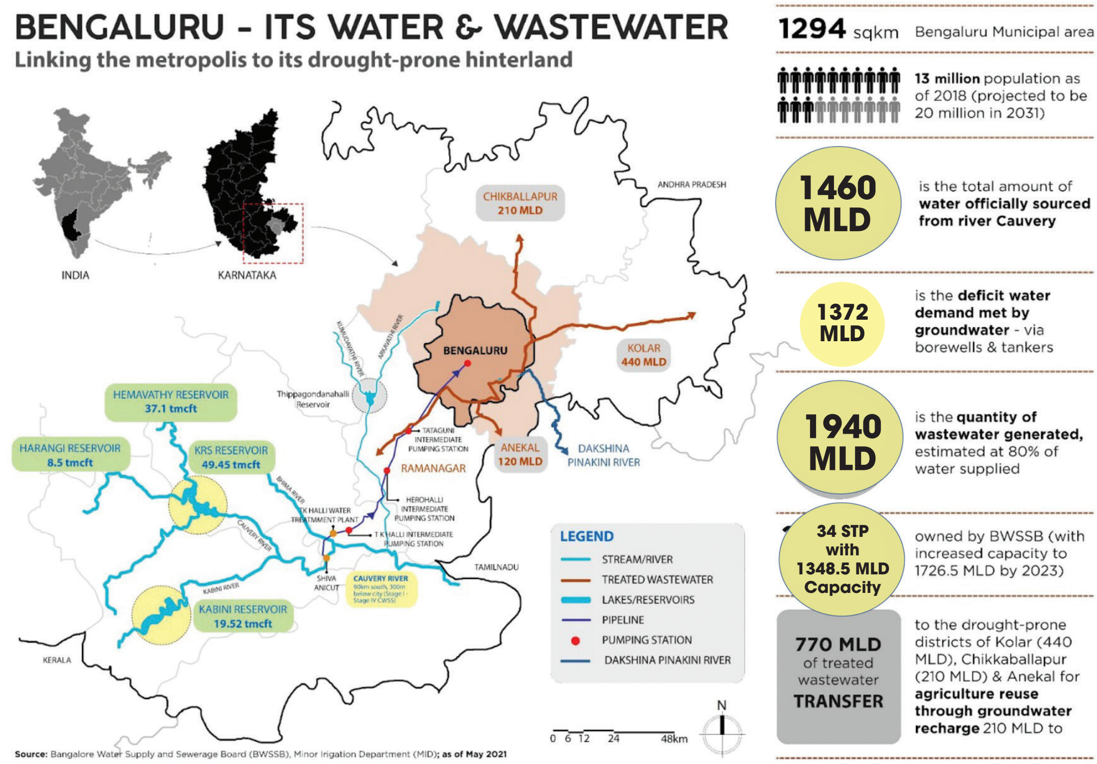
Reuse of treated wastewater

There are two notable projects involved in the supply of treated wastewater in Bengaluru—the Koramangala-Challaghatta (KC) Valley and Hebbal-Nagawara Valley projects. These projects provide water to the districts of Kolar, Chikkaballapura, and Bangalore Rural, and are managed by the Minor Irrigation Department. However, the current wastewater reuse accounts for only 43 per cent, indicating a significant potential for scaling up wastewater treatment infrastructure.[134]

In addition to these projects, several decentralized initiatives supply treated water to various industries. For instance:

- 40 MLD tertiary treatment plant (TTP) in Devanahalli supplies treated water to the KIADB Industrial Area.
- 10 MLD TTP in Yelahanka provides tertiary treated water to KIAL, IAF, BEL, Rail Wheel Factory, and ITC.
- 4 MLD TTP in Cubbon Park supplies tertiary treated water to Raj Bhavan, Vidhana Soudha, High Court, Golf Course, and Cubbon Park.

Figure 27: Water and wastewater scenario of Bengaluru



Source: Vishwanath S, Biome Environmental Trust and Well labs report on Bengaluru

- 1.5 MLD TTP in Lal Bagh supplies tertiary treated water to Lal Bagh
- 15 MLD TTP in Jakkur supplies tertiary treated water to the KPCL gas-based power plant in Yelahanka.

As per the latest NMCG data on reuse of treated wastewater in Bengaluru, of the 825 MLD of treated waste water reuse, 72 per cent is for lakes, followed by 21 per cent by irrigation and industry.

Table 30: Treated wastewater reuse in Bengaluru

Reuse Type	Treated sewage reused (MLD)
Horticulture	3.558
Industrial	24.04
Irrigation and industrial	169.89
Lakes	594.69
Other	2.954
Storm water drains	29.92
Grand Total	825.052

Source: BIOME Environmental Trust

KORAMANGALA-CHALLAGHATTA VALLEY PROJECT (KC VALLEY)

The government of Karnataka initiated the Koramangala-Challaghatta (KC) Valley tank-filling lift-irrigation project in March 2018. The primary objective of this project is to treat 440 million litres of sewage water per day and utilize it to recharge groundwater in the drought-prone districts of Kolar and Chikkaballapur. The project, carried out by the Karnataka State government, involves pumping secondary treated wastewater from five sewage treatment plants in Bengaluru city. The water is then stored in approximately 122 rain-fed tanks located in the arid Kolar district within the sub-catchments of Dakshina Pinakini and Palar rivers.

Kolar is a semi-arid region that frequently experiences droughts, with an average annual rainfall of 650 mm. Previously, the district had around four thousand unlined cascading man-made tanks and reservoirs designed to capture rainwater for various purposes, including groundwater recharge. However, due to the lack of rainfall over the past decade, many of these tanks and borewells have dried up, leading to a significant decline in the groundwater table caused by excessive exploitation (CGWB, 2020).[135] The depth of irrigation borehole wells has reached approximately 250–300 meters below the surface (Garg et al., 2020).[136]

Treated water for KC valley project comes from three sewage treatment plants (STPs). These include the K&C Valley STP, which provides 248 million litres per day (MLD), the Madivala STP, which supplies 4 MLD, and the Kadabesena Halli STP, which contributes 50 MLD. All these STPs are located near Bellandur and Varthur lakes.

The project has been executed at a cost of INR 1,342 crores and indirectly provides irrigation water by recharging groundwater with secondary treated wastewater.

The wastewater is pumped from the three treatment plants through closed pipes, covering a distance of approximately 53 km until it reaches Lakshmisagara Lake. From there, the wastewater follows the natural stream network, reaching subsequent lakes.

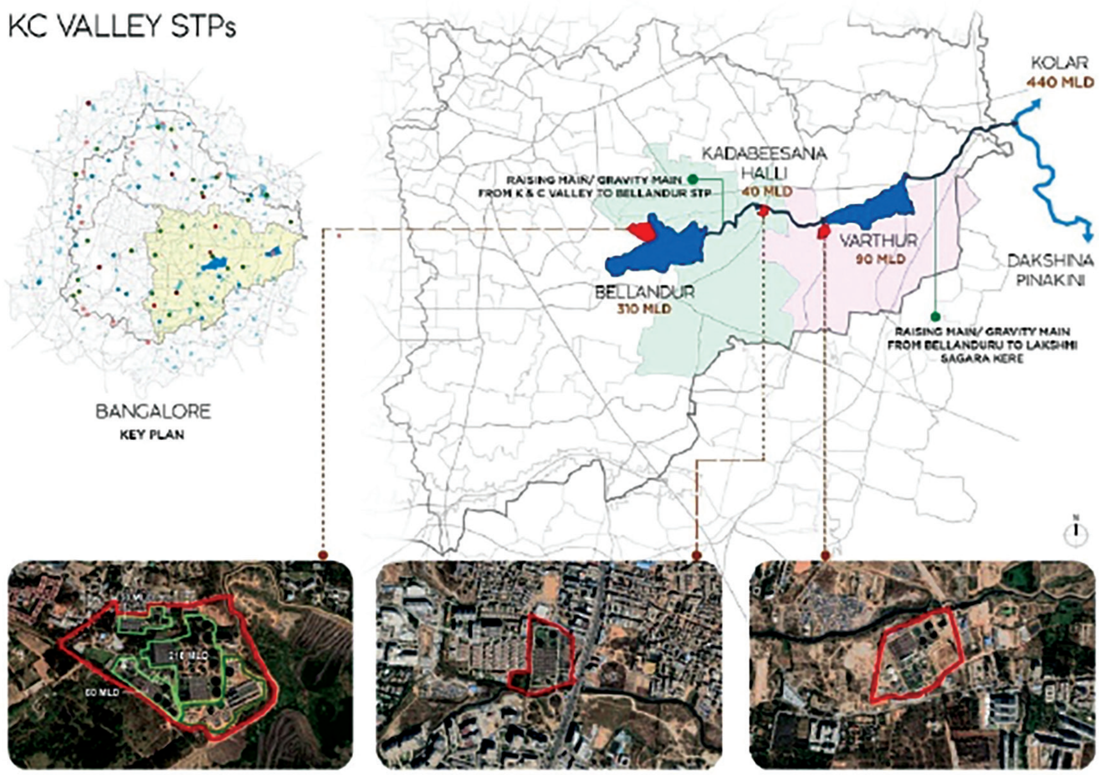
In cases where the natural flow is obstructed, the water is pumped to the nearest ridge point and then continues its course through the natural stream channels *(see Map 7: Location of STPs in KC valley and Map 8: Supply of treated water to lakes in KC Valley (Credit-Vishwanath, S, Biome Environmental Trust).*

Impact

A recent assessment by the Indian Institute of Science (IISc), Bengaluru, has documented the results of the KC Valley project. Headed by L.N. Rao from the Centre for Sustainable Technologies (CST), IISc, the study pointed out that the project provides a 'sustainable solution for freshwater security and wastewater management'.[137] The study records its four major positive outcomes: ten times improvement in daily groundwater recharge rates; increase in groundwater levels by 58–73 per cent; improvement in groundwater quality; and improvement in agricultural productivity.

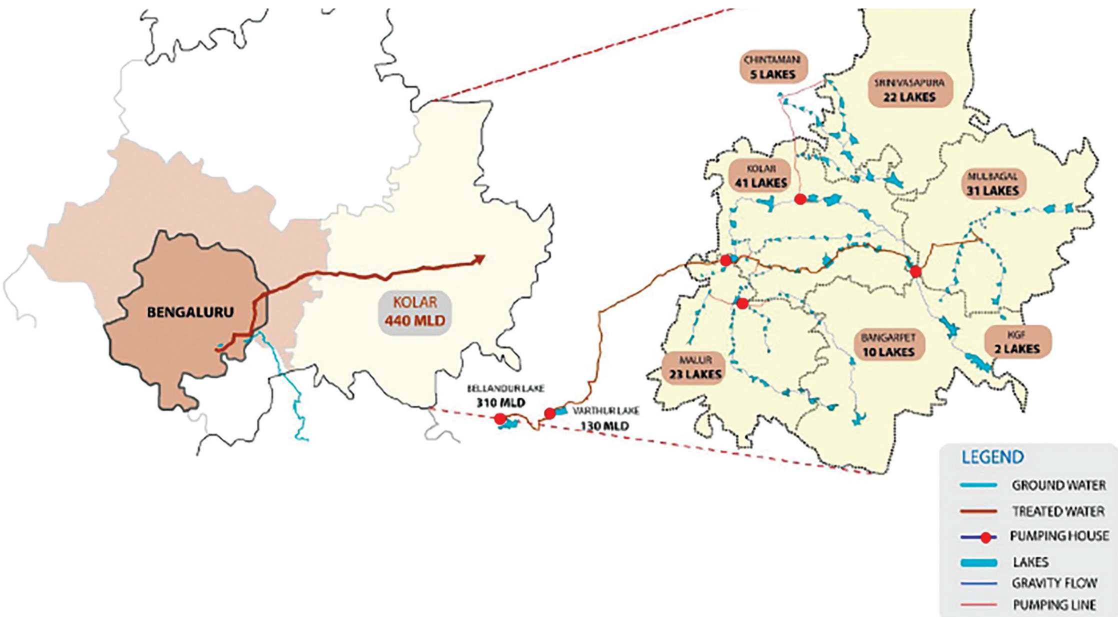
The shallow unconfined aquifer has responded well to the secondary treated water falling into JodiKrishna Pura Lake.

Map 7: Location of STPs in KC Valley



Source: BIOME Environmental Trust

Map 8: Supply of treated water to lakes in KC Valley



Source: BIOME Environmental Trust

The once dried up borewells are now filled with water which shows that there is an increase in the inground water table in the surroundings of JodiKrishnapura and Narasapura lakes The open well and borewells are full and irrigates 20 acres of land surrounding the lakes through drip irrigation

HEBBAL NAGWARA VALLEY PROJECT (HN VALLEY): REUSE OF TREATED WATER FOR SHALLOW AQUIFER RECHARGE THROUGH LAKE RECHARGE

The HN Valley project is a planned reuse of treated water projects for the treated water coming out of three STPs i.e. Hebbal (100 MLD), Raj Canal (40 MLD) and Horamavu (20 MLD). This project was launched in the 2021 *(see Map 9: Google imagery depicting the infrastructure (pathway) for treated water supply from STPs to Lakes in HN Valley project)*.

Under this project, treated water is directed to 65 tanks spread across Chikkaballapur, Bengaluru Urban, and Bengaluru Rural districts. This initiative specifically targets areas prone to severe drought conditions where regions experience drought for seven out of ten years. Of the 65 tanks, 43 are located in the Chikkaballapur district and spread across the taluks of Chikkaballapur (24), Shidlaghatta (9), Gauribdanur (8) and Gudibande (3). As many as 12 tanks are located in Yelahanka taluk (Bengaluru Urban) and nine are in Devanahalli.[138]

Direct use of treated water for drinking and agricultural purposes has been prohibited. However, farmers expressed the view that the project was contributing to a rise in the water table. As of now only 130 MLD, out of the total target of 210 MLD, is being reused for delivering water to the lakes.

Source: Minor irrigation Department

Lakshmisagara lake, Narsapura – first lake of the series

Figure 28: Salient features of the three STPs under HN Valley Project

Hebbal STP

Commissioned **1999**	Capacity **100 MLD**
Technology **Activated Sludge Process**	Capacity Utilized (MLD) **79.86**

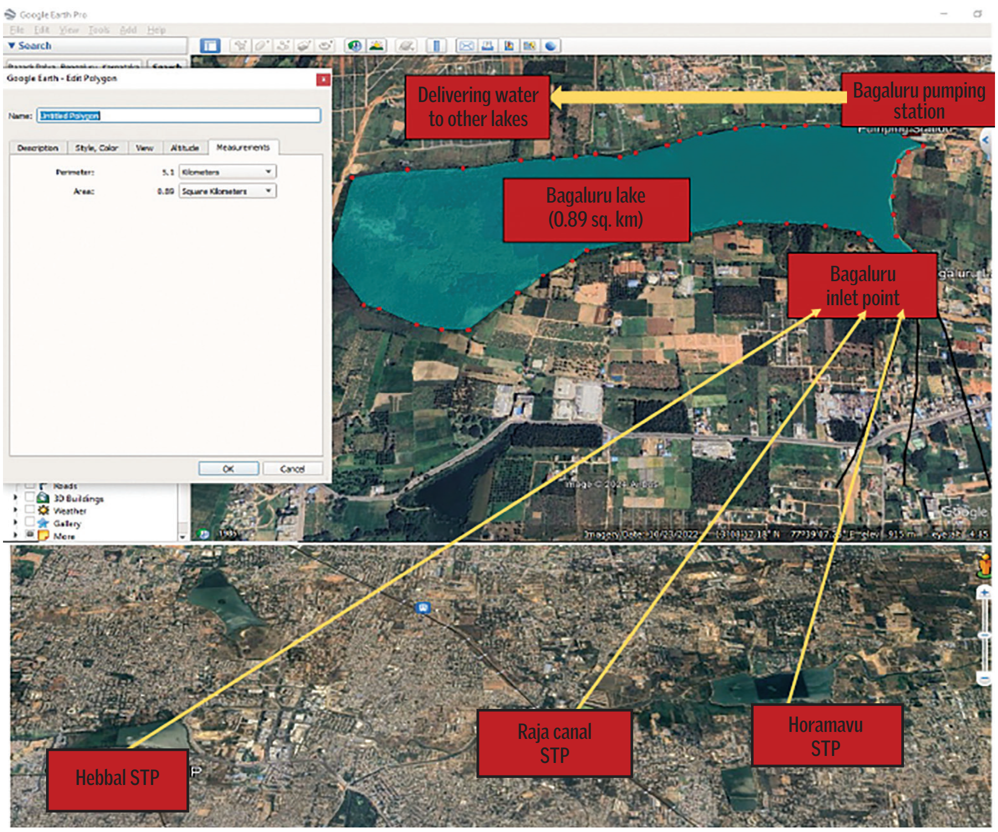
Horamavu

Commissioned **2018**	Capacity **20 MLD**
Technology **Sequencing Batch Reactor**	Capacity Utilized (MLD) **Flow (MLD) - 17.42**

Rajacanal

Commissioned **2004, 2018**	Capacity **40 MLD**
Technology **Activated Sludge Process & Extended Aeration**	Capacity Utilized (MLD) **Flow (MLD) - 31.37 & 41.81**

Map 9: Google imagery depicting the infrastructure (pathway) for treated water supply from STPs to Lakes in HN Valley project



Source: Prepared by CSE

The total cost of this project is INR 1,800 crores and the financials of the project fall under the aegis of a minor irrigation department.[139] All the infrastructural development, operation and maintenance under the project will be taken care by the department. BWSSB has to ensure that the treated water that is being delivered to the lake should be meet the required compliance standards.

Supply infrastructure of the three STPs under HN Valley

Treated wastewater from the three STPs mentioned above meet at the common discharge point which is Bagaluru Lake. From here, lake water is pumped and distributed to 65 tanks through the pumping station near the lake from where the water is lifted and supplied. In some cases, the treated water is also transferred through gravity through the cascading effect.

An outlet has been installed to channel the excess water away to periods of excess inflow into the lake, especially during the monsoon when water overflows. All the three STPs have been meeting the norms set by NGT.

The HN Valley project aims to improve the groundwater table in drought-affected areas and revitalize borewells and open wells. By ensuring the availability of locally sourced nutrient-rich water, it contributes to the betterment of farmers' livelihoods, especially considering the scarcity of fresh water. As a result, distress migration can be halted, and village economies are strengthened.

Inlet point from where the treated water from Hebbal, Rajacanal and Horamavu STP is getting released in Bagaluru Lake.

Bagaluru lake in Bengaluru receiving treated used water from the HN Valley project

The project also plays a vital role in achieving food security for the city and nutrition security for the villages. Additionally, it has various positive impacts, such as maintaining water supplies for residential, commercial, agricultural, and industrial purposes, preserving wetland habitats, protecting aquatic ecosystems through base flow, replenishing surface water during dry periods, and providing opportunities for stream flow-dependent recreational activities like boating and fishing. Furthermore, commercial fisheries are safeguarded during dry periods through base flow.

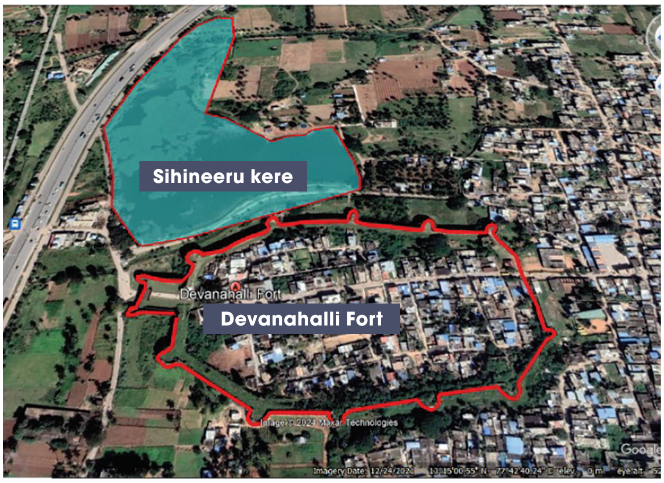
CASE STUDIES UNDER HEBBAL NAGWARA VALLEY PROJECT

Devanahalli town: Enhancing shallow aquifer recharge for domestic use

Devanahalli, situated in the Bengaluru rural district of Karnataka, is a small town renowned for the Kempegowda International Airport. It is positioned approximately 35 kms away from Bengaluru. Covering an area of about 16.63 sq kms, Devanahalli has 23 wards, and had a population of roughly 38,000 in 2023.[140] (28,051, according to the 2011 Census).

The town heavily relies on groundwater for its water supply, with borewells reaching depths exceeding 1,000 feet. Due to this, many borewells run dry, leading to the digging of new ones every year. Out of the 130 borewells in the area, 32 are currently non-functional. To cater to the current population of 38,000, the Town Municipal Council (TMC) provides approximately 2,090 kilolitres of water per day, amounting to 55 litres per capita per day (LPCD).

Map 10: Google imagery of Sihineeru Lake near Devanahalli fort



Revived open well near Sihineeru lakefor shalldow aquifer recharge and to supply water

Sihineeru Kere Lake, located near Devanahalli fort, used to be a reliable source of freshwater for nearby communities. However, over the years, it has been subjected to frequent droughts and a reduction in its catchment area due to infrastructural development. This has caused the lake to gradually dry up. The lake, spanning 17 acres and with an average depth of 2.5 meters, used to act as a reservoir for rainwater runoff, which in turn recharged the shallow aquifers.

Mid-2021, the HN Valley project started supplying treated wastewater to Sihineeru Kere, revitalizing the dried-up borewells and open wells in the vicinity. Additionally, several other lakes with a combined capacity of 316.5 million cubic feet (MCft) started receiving water. As a result of this project, open wells that had been devoid of water for the past two to three decades began to see water again through the natural percolation of the lake water.

A notable example is an aging open well near Sihineeru Lake where the water level rose by 10 feet marking a positive transformation *(see Table 31: Devanahalli lakes receiving treated water from HN Valley).*

Table 31: Devanahalli lakes receiving treated water from HN Valley

District	Taluka	Department incharge	Tank details as per tender	Capacity (MCft)
Bengaluru Rural District	Devanahalli	ZP	Kodagurki Kere	2.35
		MI	Devastan Amani Kere	16
		MI	Devanahalli Hire Amani Kere	30.47
		CMC	Devanahalli Chikka Amani Kere	1.73
		MI	Bettakote Amani Kere	130.6
		ZP	Avati Kere	4.27
		MI	Venkatagirikote Kere	53.76
		ZP	Dandiganahalli Kere	21.13
		MI	Vijayapura Amani Kere	56.21

Source: Bangalore Water Supply and Sewerage Board

In August 2021, the BIOME Environmental Trust took the initiative to revive this well in Sihineeru Lake, which yielded promising results. A pump test conducted during that month demonstrated its capacity to produce over 1.5 lakh litres of water, satisfying approximately 15 per cent of of Devanahalli's water demand. To utilize the water from this open well, it is pumped in to a water treatment plant (WTP) with a capacity of 200 kilolitres per day (KLD).

Each well surrounding the lake is outfitted with a flow meter for continuous monitoring and recording of water inflow. The treatment process includes a 130-micron filter disk, a multigrade filter, UV systems, and chlorine dosing. Routine operation and maintenance (O&M) activities are carried out to uphold the treatment's efficacy. Once treated, the water is stored in a sump with a capacity of 100,000 litres and subsequently pumped to an overhead tank through a distribution pipeline *(see Map 11: Integrating shallow aquifer to water supply system through reuse of treated used water)*

Map 11: Integrating shallow aquifer to water supply system through reuse of treated used water

Source: BIOME Environmental Trust

Filter borewell near Sihineeru lake for water supply

Water treatment plant near Sihineeru lake to treat the open well and borewell water before supply

Sump to store the water after treatment

Water from the overhead tank is distributed to households for drinking and domestic use. Please refer to Figure for a visual representation of the process. Adjacent to the open well, there are two additional filter borewells near the lake, with depths of 80 feet and 100 feet. Each borewell yields between 3,500 and 4,000 litres per hour. The water from these borewells is supplied to households using the same mechanism as the water from the open well.

The revitalized well now plays a vital role in the water supply infrastructure of Devanahalli. Since the revival of these borewells, a total of 30,104 kilolitres of water has been supplied to Devanahalli town (population 38,000), until February 2024, averaging approximately 159 KLD. The table below provides a summary of the treated water supply from recharged shallow aquifer to Devanahalli Town.

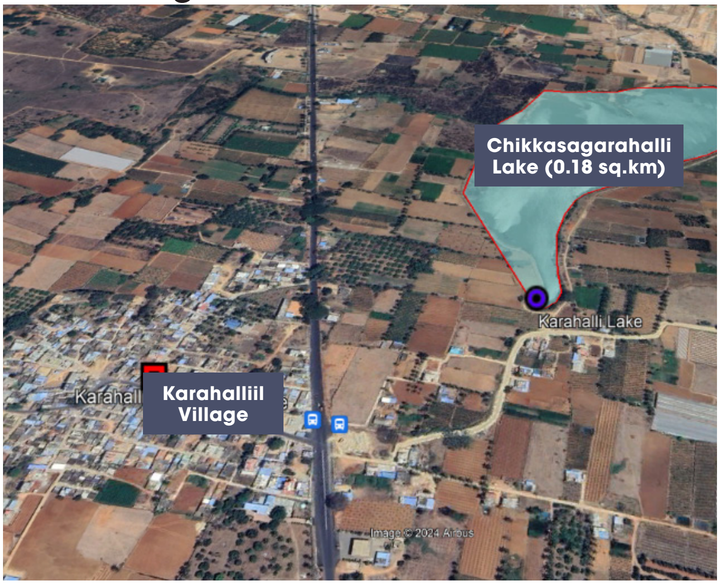
Table 32: Summary of treated water supply from recharged shallow aquifer to Devanahalli Town

Description	In KL	Percentage
Water pumped from filter borewell near lake	5,348	17.7
Water pumped from filter borewell near old house	6,637	22.05
Water pumped from open well	18,119	60.19
Total water treated and supplied	30,104	
Number of days	189	
Average water treated and supplied per day	159	

Source: BIOME Environmental Trust

Based on the successful outcomes of replenishing shallow aquifers by reviving lakes through treated wastewater, plans were formulated to expand this project in Phase-II. The proposed development includes the construction of four additional filter borewells in the vicinity of Sihineeru Lake, along with a water treatment plant (WTP) with a capacity of 320 kilolitres per day (KLD). These new additions are expected to adequately meet the water requirements of Devanahalli town. The quality of the water will be regularly monitored by the Indian Institute of Science, Bengaluru, and the corresponding report can be found in Annexure 4.

Map 12: Karahalli Lake in Devanahalli Taluk, Bengaluru



Source: Created by CSE


Chikkasagarahalli lake in Karahalli village, Bengaluru


Revived open well near Chikkasagara lake used for agriculture, Bengaluru

A similar water supply model from a recharged shallow aquifer will be implemented near Doddakere Lake, receiving treated wastewater from the HN Valley project.

Chikkasagarahalli Lake: Shallow aquifer recharge for agriculture using treated water

Chikkasagarahalli Lake is located in the village of Karahalli that is situated in the Devanahalli taluka of Bengaluru Rural district in Karnataka, India. Located 15 km away from the sub-district headquarter of Devanahalli, Karahalli village also serves as a gram panchayat and falls under the administrative jurisdiction of Bengaluru Rural, the district headquarters (*see Karahalli Lake in Devanahalli Taluk, Bengaluru*)

«Harish, farmer and resident of Karahalli village says 'I've been farming for seven years now. My farm is situated on the outskirts of Devanhalli, where I have been growing marigold, tomato, cabbage, and roses. For farming I rely on the water from Chikkasagarhalli Kere, which has consistently provided excellent quality water. This water source has also played a crucial role in replenishing our borewells, ensuring that we never face any water shortages on our farm.»

Harish, farmer, Karahalli village

According to 2011 Census, Karahalli village spans a total geographical area of 581.83 hectares and is home to a population of 2,152 individuals and 468 houses. Farming is the main occupation in Karahalli village, relying primarily on water from open wells and borewells for irrigation. However, over the years, the groundwater level has been steadily declining, resulting in wells drying up.

The village relies on Chikkasagarahalli Lake as a natural water source for recharging nearby wells. Unfortunately, the lake has dried up over time, causing the adjacent wells to also run dry. This depletion of water resources poses significant challenges to farmers, forcing them to either depend on rainfed irrigation or resort to tanker water to meet their agricultural needs. Many farmers had to abandon their wells after consecutive dysfunction for 3–4 years. The primary crops cultivated in the village are floriculture and vegetables.

In 2021, the implementation of the HN Valley project brought about positive changes. Chikkasagarahalli Lake underwent desilting and deepening to increase its storage capacity. This enhancement allows the lake to capture and collect maximum runoff, and even during limited rainfall, the treated used water that is released into it ensures a sufficient water supply for natural percolation and aquifer recharge. To the delight of farmers, the abandoned wells naturally revived, providing a sustainable source of water for irrigation. In 2022, farmers resumed

Raw inlet chamber to receive secondary treated water from Raja Canal STP at IT Park Industrial Area


CSE and BIOME team visit to 45 MLD TTP at IT Park Industrial Area

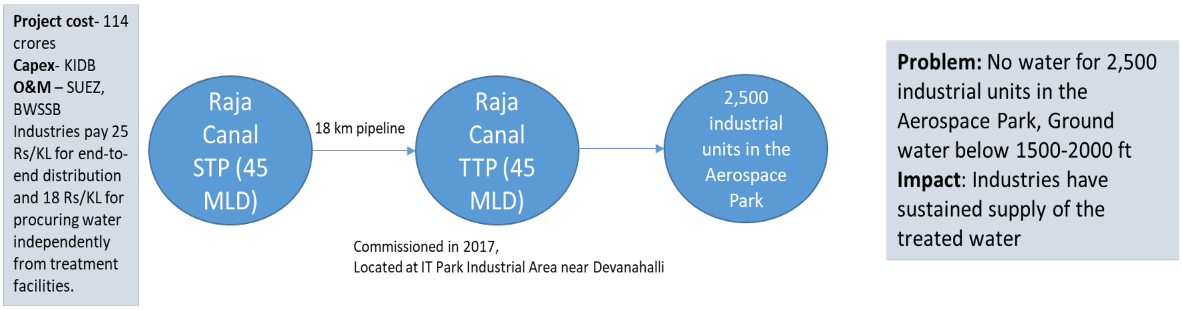
cultivating floriculture and vegetable crops, including major varieties such as marigold, rose, tomato, beans, cauliflower, and coconut. Some farmers also grow bajra and potato. According to the farmers, the climate in the region is not conducive for growing wheat or rice.

Raja Canal Sewage Treatment Plant: Reuse of treated water for industrial use

The Bengaluru Water Supply and Sewerage Board (BWSSB) has commenced tertiary treatment of secondary treated water from the Raja Canal STP for industrial water supply. The treated water from STP undergoes further treatment at the tertiary level in the tertiary treatment plant (TTP) with a capacity of 45 million litres per day (MLD) located at the IT Park Industrial Area near Devanahalli.

Commissioned in 2017, this TTP project is a collaboration between BWSSB and the Karnataka Industry for the Aerospace Park near Kempegowda International Airport, which stands as Asia's largest aerospace hub.[141] Facing a challenge with approximately

Figure 29: Snapshot of reuse of treated wastewater from Raja Canal STP



Source: Created by CSE

2,500 industrial units and groundwater levels receding to depths of 1,500–2,000 feet, supplying treated water emerged as the sole viable solution for the Aerospace Park.

In support of this initiative, a dedicated pipeline network extending 18 kilometers connects the Raja Canal Sewage Treatment Plant (STP) to the TTP. The entire project from treatment to supply including laying of the pipeline costed Rs 114 crore. The Karnataka Industrial Area Development Board bears all associated expenses, while BWSSB operates the plant. The operation and maintenance of the TTP are contracted to SUEZ, responsible for its construction, design and overall management.

Currently, the TTP is operating below its capacity, receiving only five million litres per day (MLD) of water from the Raja Canal STP.

This limited demand is attributed to a lack of substantial requirements from industries at present. The treated water is stored in a sump with a total capacity of 45 MLD, from where it is pumped and supplied according to demand. The predominant use of the treated water by industries is for horticulture within their premises. Industries are charged INR 25/KL for end-to-end distribution of treated water. If industries procure water independently from treatment facilities, the cost is INR 18 /KL. The plant monitors the quality parameters through in-house laboratory facility and also from the third-party quality assessments every month *(see Table 33: Quality results of the tertiary treatment plant for different parameters)*

Table 33: Quality results of the tertiary treatment plant for different parameters.

Sl.No	Parameter	Unit	Result
1	pH Value	–	7.68
2	Dissolved Oxygen	mg/L	4.4
3	Biological Oxygen Demand	mg/L	3.2
4	Chemical Oxygen Demand	mg/L	7.2
5	Total Suspended Solids	mg/L	3.8
6	Phosphate as PO4	mg/L	<0.4
7	Residual Free Chlorine	mg/L	1.3

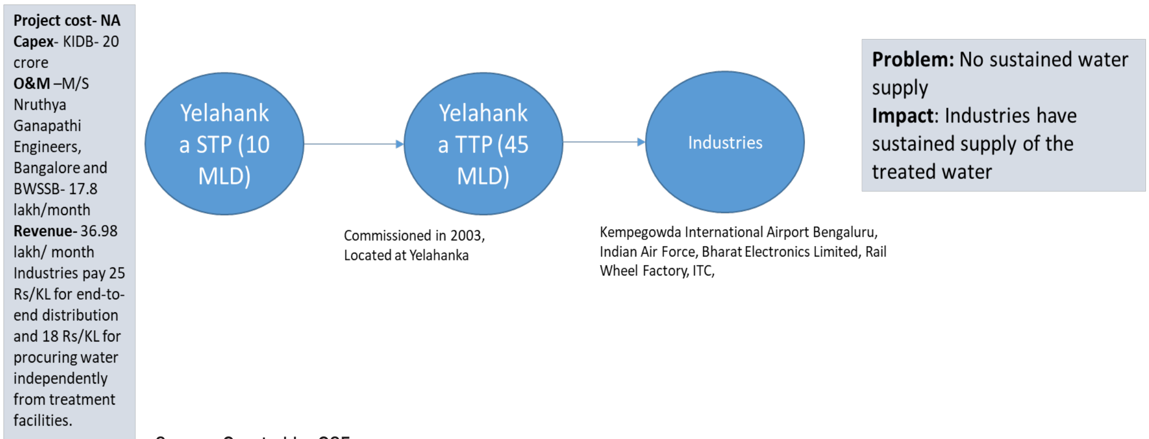
Source: Raja Canal STP office

YELAHANKA SEWAGE TREATMENT PLANT: CASE STUDY ON REUSE OF TREATED WATER FOR INDUSTRY

Similarly, the Yelahanka Sewage Treatment Plant (STP) that utilizes Conventional Activated Sludge Process (ASP) followed by filtration and chlorination, provides tertiary treated water for industrial reuse. The STP has a capacity of treating 10 million litres per day (MLD). The recipients of this treated water include Kempegowda International Airport Bengaluru, Indian Air Force, Bharat Electronics Limited, Rail Wheel Factory, ITC, among others. This facility commenced operations in the year 2003.

Through the sale of treated water, the Yelahanka STP generates a monthly revenue of INR 36.98 lakh, while the operational and maintenance (O&M) costs for the plant amount to INR 17.8 lakh per month.

Figure 30: Snapshot of reuse of treated wastewater from Yelahanka STP



Source: Created by CSE

The plant monitors the quality parameters through in-house laboratory facility and also from the third-party quality assessments every month *(see Table: 34 Quality results of the tertiary treatment plant for different parameters).*

Table 34: Quality results of the tertiary treatment plant for different parameters.

Sl.No	Parameter	Unit	Result
1	pH Value	–	7.7
2	Dissolved oxygen	mg/L	NA
3	Biological oxygen demand	mg/L	3.9
4	Chemical oxygen demand	mg/L	53
5	Total suspended solids	mg/L	3.5
6	Phosphate as PO4	mg/L	NA
7	Residual free chlorine	mg/L	NA

Source: https://mohua.gov.in/upload/uploadfiles/files/WW_Recycling_Bangalore_PPT_1.pdf

THE LEARNINGS

Karnataka has 281 towns and generates 3,356.5 MLD sewage out of which 2054 MLD sewage is treated. Out of the treated sewage 43 per cent is reused for different purposes such as industrial use, lake recharge, irrigation and horticulture etc.

The utilization of reclaimed water in Karnataka has become a necessity, rather than a mere compliance with rules, due to the escalating need for water as cities expand.

Urban wastewater reuse policy in 2017 mandates 10 major cities to prepare plans and embrace wastewater reuse by 2020 and extend this to 100 per cent for all major cities/towns by 2030.[142] The policy also targets 20 per cent reuse of treated sewage and to be increased to 50 per cent by 2030. But a clear action plan or timeline at the state level is missing. Karnataka has taken steps towards promoting decentralized STPs at the household level in Bengaluru.

The state has a well-defined reuse policy for treated wastewater. Apart from this, cities like Bengaluru have several other policies such as building bye-laws and notifications. The regulations mandates apartment complexes above 50 units, and commercial and institutional buildings with more than 2,000 sq m to have an STP on site and the sale of 50 per cent of the treated wastewater from apartments for non-potable uses, creating a wastewater market that could potentially meet 26 per cent of the city's water demand.[143]

50 per cent of the total installed sewage treatment capacity of the state is present in Bangalore itself and therefore the maximum opportunity to reuse the treated water lies in this city. Keeping in view the water scarcity in Bangalore, it is crucial for Bangalore to explore opportunities to address its recurring water scarcity.

Out of the total 1,193 MLD of treated wastewater in the state, 825 MLD is currently being reused for purposes such as lake revival, industrial use, and irrigation in Bengaluru and nearby water-scarce districts. The water parched districts of Kolar and Chikkaballpur have benefitted immensely by the KC Valley and HN valley projects. Apart from this, decentralized sewage treatment systems in the city have been supplying treated used water to parks and gardens and to some extent, industries.

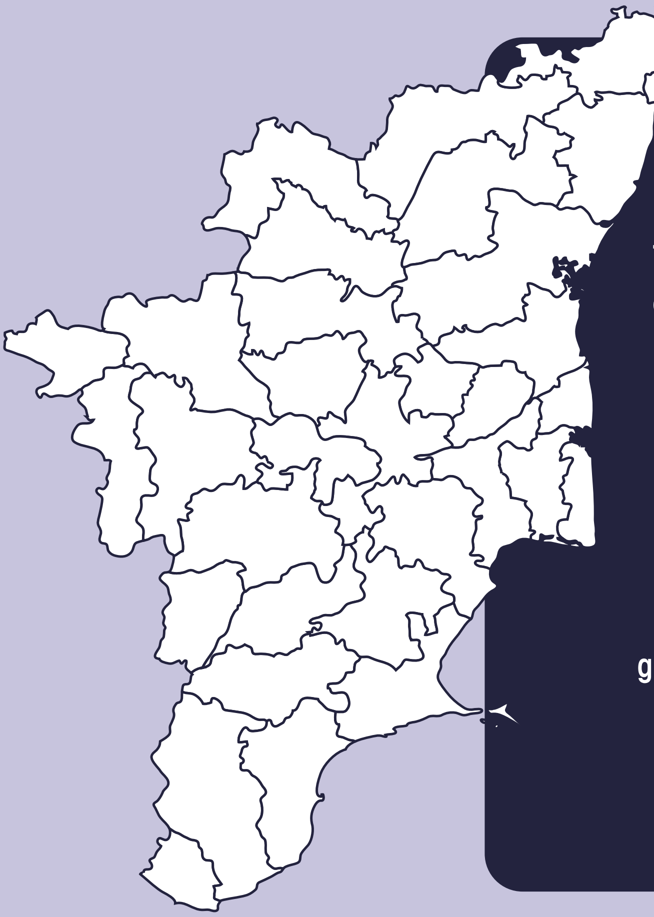
The primary focus of treated water reuse is directed towards lake recharge, constituting 75 per cent of the total, while the remaining 25 per cent is allocated to agriculture, industry, and horticulture, with industrial reuse being the least prominent. Bengaluru city has a high potential for reusing treated water in the construction industry which is still an unexplored area in Bengaluru.[144]

However, for optimal advantage, there is a critical need to boost treatment facilities to process the entirety of the city's wastewater. This would ensure the maximum reuse of treated water for non-drinking purposes and lessen the burden on freshwater sources.

Effective operation of Sewage Treatment Plants to meet quality standards is crucial to prevent pollution. Occasionally, even secondary treatment plants are non-functional. Professor T V Ramachandra Rao of IISc has advocated for tertiary treatment and an open-channel distribution system to promote aeration and photosynthesis, as transferring secondary treated water through pipes risks contaminating receiving areas. Additionally, rigorous monitoring is required to prevent contamination when secondary treated water is used for lake recharge. The entire water reuse infrastructure, including relocating water to and from distant areas, presents significant financial challenges and may prove unsustainable. Field visits and stakeholder discussions revealed a low adoption rate of treated water reuse in the industrial sector compared to its use in agriculture and domestic water supply. For instance, at the TTP located in the IT Park Industrial Area near Devanahalli, only 5 MLD of the total 45 MLD capacity is being used by industries.[145]

Most of the reuse happening in Bengaluru is for lake revival with an objective of recharging shallow aquifers which can be ultimately used for agriculture or domestic water supply. There is need for developing a groundwater monitoring unit in BWSSB to measure quantity and quality of groundwater near the lake vicinity to understand the impact of lake revival and recharge. Also, there should be a dedicated wastewater management cell to oversee and supervise all the planning and execution of the reuse of treated wastewater.

TAMIL NADU



Tamil Nadu, the most urbanized and industrialized state, generates 3,938 MLD of sewage, of which only 1,093 MLD is treated. Currently, 17% of treated wastewater is reused, with Chennai contributing to 58% of the state's total reuse.

Tamil Nadu lacks a clear action plan and timeline for wastewater reuse, and there is a pressing need for a state policy that prioritizes groundwater recharge through treated wastewater, guided by equity and justice principles.

TOTAL WASTEWATER/ SEWAGE GENERATED (MLD)
3,938

TOTAL WASTEWATER/ SEWAGE TREATMENT CAPACITY (MLD)
2,349

TOTAL OPERATIONAL CAPACITY OF STP (MLD)
1,093

TOTAL WASTEWATER/ SEWAGE TREATMENT BEING TREATED* (MLD)
1,093

TOTAL TREATMENT CAPACITY COMPLIES WITH THE DISCHARGE NORMS (MLD)
1,093

AMOUNT BEING REUSED (%)
17

* (and can be reused)

WATER AND WASTEWATER IN TAMIL NADU: AN OVERVIEW

According to the 2011 Census, the total population of Tamil Nadu is estimated to be approximately 83 million, while the urban population is estimated to be approximately 40 million. Tamil Nadu constitutes four per cent of India's land area and is inhabited by six per cent of India's population, but only possesses 2.5 per cent of India's water resources. Tamil Nadu is a state with limited water resources and the rainfall in the state is seasonal. The annual average rainfall in the state is 960 mm.

The total surface water potential of the major river basins of Tamil Nadu is assessed as 24,160 MCM (853 TMC).[146] It has 39,000 tanks with a storage capacity of 347 TMC, 79 reservoirs with a storage capacity of 243 TMC, contribution from the other states of 261 TMC and other storages of two TMC.

Tamil Nadu is home to the highest number of factories and industrial workers in the country, and is a leader in terms of industrial output. It is the industrial powerhouse of the nation and the second-largest state economy in the country, contributing to 8.4 per cent of India's GDP.[147] Currently, Tamil Nadu has approximately 11,750 major industries (2,400 State Industries Promotion Corporation of Tamil Nadu Limited (SIPCOT), 1,850 large industries, and 7,500 micro, small and medium Enterprises (MSME) industries) that are concentrated in districts such as Chennai, Coimbatore, Kanchipuram, Madurai, Tiruchirapalli, Tiruppur, and Vellore.[148] Tamil Nadu has a highly developed industrial manufacturing eco-system. It has evolved into the largest hub for the production of automobiles and auto-components, textiles, leather products, light and heavy engineering, pumps and motors, electronic software, and hardware.[149] Most industries in Tamil Nadu depend on groundwater; during drought, they rely on private water suppliers that, most often, exploit agricultural wells for water extraction.

The total annual groundwater recharge for the state of Tamil Nadu has been assessed as 20.22 billion cubic metre (bcm) and the annual extractable groundwater resources has been assessed at 18.20 bcm. The Annual Groundwater Extraction is 14.73 bcm and Stage of Ground Water Extraction as 81 per cent.[150] Tamil Nadu has been facing two consecutive years of drought and has been rated as 'extremely water stressed'.

The per capita availability of water resources however, is just 900 cubic meters when compared to the national average of 2,200 cubic meters. Agriculture is the largest consumer of water in the state using 75 per cent of the state's water resources.[151] Over extraction of groundwater is leading to salinity ingress in coastal areas and desalination plants are coming up in large numbers in Tamil Nadu. Districts with high water scarcity include Cuddalore, Nagapattinam, Tanjore, Tiruvarur, Chennai, Vellore, Salem, Namakkal, Tiruvannamalai, Trichy and Dindugal.[152]

Tamil Nadu's water needs for irrigation, domestic, livestock, and industrial sectors has been estimated at 52.7, 1.5, 1 and 2 billion m^3 respectively for 2025, against the available supply of 24.6 bcm of surface water and 23 bcm of groundwater during the same period.[153]

At the state level, the government of Tamil Nadu promotes wastewater reuse and has created a mandate that industries be supplied only with treated wastewater for their processes. Notable features of the policy are, first, identifying the current and future industrial water demand in the state; second, establishing a 10-year horizon for supplying all industries with treated wastewater; third, directing the state industries department to take the lead in developing and operating the needed infrastructure with industries and utilities/cities; and, finally, a stipulation that capital be financed through national/state government programmes or, preferably, through public-private-partnerships (PPPs).

Source: https://documents1.worldbank.org/curated/en/737251622708324921/pdf/Water-in-Circular-Economy-and

The state has developed 95 per cent of its total water potential. It has implemented several inter- and intra-state water transfer diversions from existing irrigation projects for meeting drinking water needs (transfer from Veeranam tank to Chennai city by a 250 km pipeline). Tamil Nadu also undertakes groundwater extraction, desalination of sea water, and cloud seeding, etc., to augment water for domestic sectors.[154]

As per the latest report submitted to NGT[155] by the state, 3,938 MLD sewage is generated in Tamil Nadu. There are 103 STPs in operation with a total treatment capacity of 2,348 MLD and 36 FSTPs of 0.999 MLD capacity. In addition, 957 MLD of sewage is treated using alternate technologies. Thus, the total installed capacity is 3,306 MLD. However, less than a third of the capacity is actually utilized (1,093 MLD). Another 267 MLD of STP are under construction[156] *(see Figure: Sewage generation and treatment in Tamil Nadu).*

CURRENT POLICIES AND REGULATIONS

Tamil Nadu has implemented state-specific policies and regulations aimed at conserving water resources, promoting the reuse of wastewater, and enforcing mandatory requirements for industries to utilize treated wastewater. The Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) has formulated a set of service standards mandating accelerated wastewater reuse and zero liquid discharge.[157] The treatment standards set by the CMWSSB lays out specific water quality parameters to ensure that industries do not need to repeat the treatment steps at their own facilities, thereby making it more cost-effective and efficient for end-users.

The following table details out the main policies and their salient features:

Table 35: Policy on reuse of treated wastewater in Tamil Nadu

Policy	Salient features
Chennai Metropolitan Area Ground Water (Regulation) Act, 1987	An Act to regulate and control the extraction, use, or transport of groundwater and to conserve groundwater in certain areas in the state of Tamil Nadu.
The Tamil Nadu Water Policy, 1994	Acknowledges water as a scarce resource and underlines the need for its planning, development and management to be guided by state perspectives.
The Tamil Nadu Panchayat Act, 1994	The Tamil Nadu Panchayat Act, 1994, was enacted with the primary goal of furthering the objective of decentralized democracy and making the systems and institutions of local self-governance solid and formal.
The Tamil Nadu Farmers Management-Irrigation Systems Act, 2000	Provides for the management of irrigation systems through the proper use of surface and groundwater, and for the recognition of Water Users' Associations.
Tamil Nadu State Groundwater Development and Management Act, 2003	An Act to protect groundwater resources to provide safeguards against hazards of its over exploitation and to ensure its planned development and proper management in Tamil Nadu.
The Tamil Nadu Protection of Tanks and Eviction of Encroachment Act, 2007	An Act to provide measures for checking the encroachment, eviction of encroachment in tanks that are under the control and management of the Public Works Department.
Tamil Nadu Wastewater Reuse Policy, 2019	The policy promoting the use of treated wastewater is designed with the vision to maximize sewage collection and treatment, as well as the sustainable reuse of treated wastewater. This initiative aims to reduce dependency on fresh water resources. Further, the policy promotes the use of treated wastewater as an economic resource.

REUSE OF TREATED WASTEWATER

As per the latest report submitted by the state to the NGT, 80.50 MLD (this is excluding the reuse in Chennai) of sewage is treated and reused for agricultural and industrial purposes which is only approximately four per cent of the total water treated in the state. At present, a Memorandum of Understanding (MoU) has been executed between urban local bodies (ULB) and the user agency for the re-use of secondary treated effluent water[158] *(see Table: Urban Local Bodies wise details for reuse of treated wastewater).*

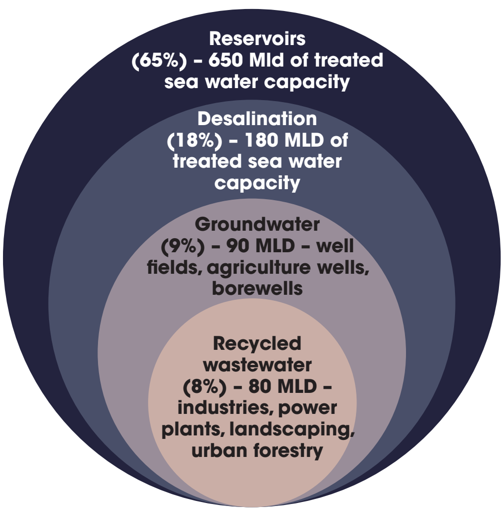
Table 36: Urban Local Bodies-wise details for reuse of treated wastewater

S. No	Name of ULB	Quantity (MLD)	Usage purpose
1	Nagapattinam	2	Industry
2	Dindugul	5	Industry
3	Tirunelveli	24	Nanguneri Special Economic Zone (SEZ)
4	Perambalur	3	Industry
5	Ramanathapuram	3	NTC Infra
6	Coimbatore	15	Agriculture
7	Pollachi	11.5	Agriculture
8	Chinnamannur	3	Agriculture
9	Karur	7	Agriculture
10	Arakkonam	7	Industry
11	Chennai	110	Industry and lake recharge for water supply
Total		**190.5**	

Source: NGT Monthly Progress Report, December, 2023

CHENNAI

Figure 31: Contribution percentage of various water resources meeting Chennai's water demand

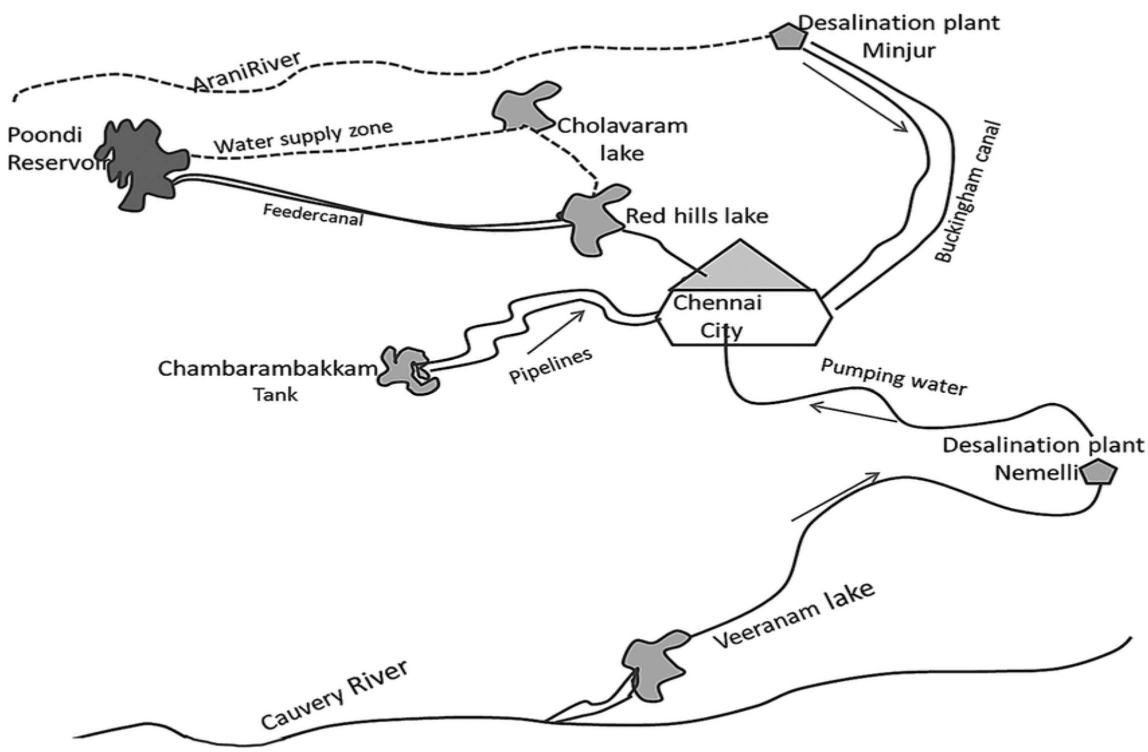


Chennai, a city on the southeastern coast of India and capital of Tamil Nadu, has one of India's fastest-growing urban economies. The region is the nation's automotive hub and home to several other manufacturing industries ranging from petrochemicals to electronic hardware, textiles and apparel. Urbanization and economic growth, over the last two decades have seen Chennai's population increase by 1.5 times, making it the fourth-largest city in India with over 10 million people.[159] There are no perennial water sources in Chennai. The city is entirely dependent on seasonal rains to replenish its water resources. While the city usually receives 1,200 mm of rain between mid-October and mid-December, the region experiences multiyear cycles of severe floods and droughts. Notably, the past two decades have seen floods in 2005, 2010, and 2015, interspersed with droughts in 2003–04 and 2016–18. Monsoon failures lead to acute water scarcity, prompting many households to resort to self-supplementation through borewells and tanker deliveries (*see Figure 31: Contribution percentage of various water resources meeting Chennai's water demand*)

The city is facing critical groundwater extraction of 172 per cent against India average of 63 per cent.[161] Increasing urban population has led to a mismatch in supply and demand and inequitable distribution of water supply. The per capita availability of water has consequently plummeted from 1,816 m^3 in 2001 to 1,545 m^3 in 2020.

Currently Chennai relies on four sources: surface water sources, groundwater, recycled wastewater and seawater desalination for its water supply. Chennai's water demand currently stands at 1,000 MLD. Previously, Chennai used to draw water from Adyar and Cooum Rivers but today these rivers are polluted and the city is dependent upon Poondi, Redhills, Cholavaram, Chembarambakkam and Veeranam lakes that are situated around 200 km from Chennai. Veeranam Lake receives water from the Cauvery River system through Kollidam, Lower Anicut and Vadavar canals, besides rainwater from its own catchment area. In addition to this, the city also relies on water from the neighbouring Andhra Pradesh (Telugu Ganga project), where water from the Krishna River in the Srisailam reservoir (400 km away) is diverted to the Poondi reservoir. *(see Figure 32: Urban water supply system in the city of Chennai)*

Figure 32: Urban water supply system in the city of Chennai[160]



The adoption of tertiary treated wastewater in Chennai began due to severe water shortages in 2001, leading to the Chennai Petroleum Corporation Ltd. (CPCL)—a refinery with an annual capacity of 10 million metric tonnes—halting operations for 35 days, resulting in financial repercussions. Between 2001 and 2004, the company relied on about 500 water tankers per day for its operations. Faced with frequent monsoon failures, CPCL, in 2005, decided to purchase secondary-treated wastewater from CMWSSB and further treat it (tertiary treatment followed by reverse osmosis) for the desired quality levels for its operations. It purchases and processes 24 MLD of wastewater which is sufficient to meet all its process water needs. Taking a cue from CPCL, Madras Fertilizer Ltd. (MFL) and Manali Petrochemicals Ltd. (MPL) each built a tertiary treatment plant for reuse, purchasing 10.50 MLD and 1.50 MLD of treated wastewater from CMWSSB, respectively.

Recently, Chennai explored alternative sources, tapping water from Porur Lake, Retteri Lake, and the quarries of Erumaiyur and Sikarayapuram. The reliance on reservoirs, while currently sustaining the demand, poses a potential risk due to the escalating strain on water resources attributed to the urban population growth.

Chennai collects nearly 100 per cent of its wastewater and treats it at 22 wastewater treatment plants with a cumulative capacity of 1,083 MLD.[162] These STPs treat approximately 540 MLD sewage.

Reuse of treated water

Chennai is the first city in South India to reuse municipal treated wastewater for industries. At the municipal level, Chennai actively embraces the principles of a circular economy. The Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) has introduced several bye-laws to enhance incentives for wastewater recycling and reuse. These regulations mandate all stakeholders, including government authorities and the private sector and citizens, to maximize water reuse.

For instance, the CMWSSB has implemented measures such as increasing freshwater tariffs for industries and enforcing a zero-discharge policy, obligating industries and manufacturers to achieve zero-liquid discharge in their operations. These initiatives aim to stimulate the industrial sector to adopt water reuse practices, ultimately reducing overall water consumption and promoting sustainable water management.

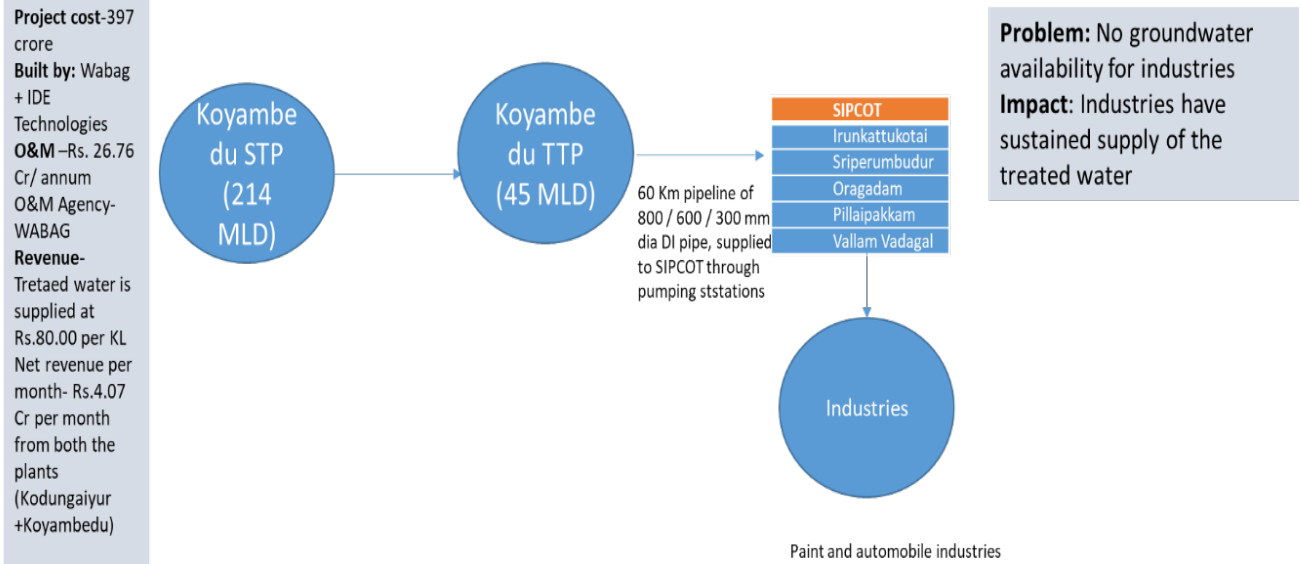
In the case of Chennai, the reuse of treated wastewater is primarily happening from the tertiary treatment plants as mentioned in the table below (*see Table 37: Overview of Chennai STPs implementing reuse practices*).

Table 37: Overview of Chennai STPs implementing reuse practices

District	STP	Commissioned (Year)	STP capacity (in MLD)	Technology	Reuse
Chennai	Nasapakkam	2022	10	TTP	Lake revival/ rejuvenation
	Perungudi	In Progress	10	TTP	Lake revival/ rejuvenation
	Koyumbedu	2019	45	TTP	Industry
	Kodungaiyur	2019	45	TTP	Industry

Source: CSE visit to Chennai

Figure 33: Snapshot of reuse of treated wastewater in Koyambedu treatment plant



Source: Created by CSE

KOYAMBEDU AND KODUNGAIYUR SEWAGE TREATMENT PLANTS: CASE STUDY ON REUSE OF TREATED WATER FOR INDUSTRIAL USE

Commissioned in 2020, the Koyambedu Tertiary Treatment RO plant is India's largest and the first reuse facility in India to use ozonation for disinfection. This tertiary treatment plant recycles municipal used water for reuse as industrial water *Figure 33: Snapshot of reuse of treated wastewater in Koyumbedu treatment plant*.

The plant uses a multi-stage treatment scheme that includes ultrafiltration, reverse osmosis, rapid gravity sand filters, and ozonation, and functions with an ultra-low specific power requirement of 1.88kWh/m3. The capacity of this plant is 45,000 m^3/day (45 MLD) and is expandable to 60 m^3/day (60 MLD). The plant was built by VA Tech Wabag Ltd. in partnership with IDE technologies on Design, Build & Operate model (DBO) and includes a 15-year operation and maintenance period. They have a 15-year contract with CMWSSB. WABAG is responsible for EPC (Engineering Procurement and Construction) along with operation and maintenance of the plant and the distribution network. The plant was commissioned in 2020.

The plant treats municipal secondary treated water to achieve drinking water standards *(see Table 38: Inlet and outlet water quality at the TTP)*. This effectively reduces the need for industries to use fresh water, thus saving over 13,000 million litres of fresh water annually.

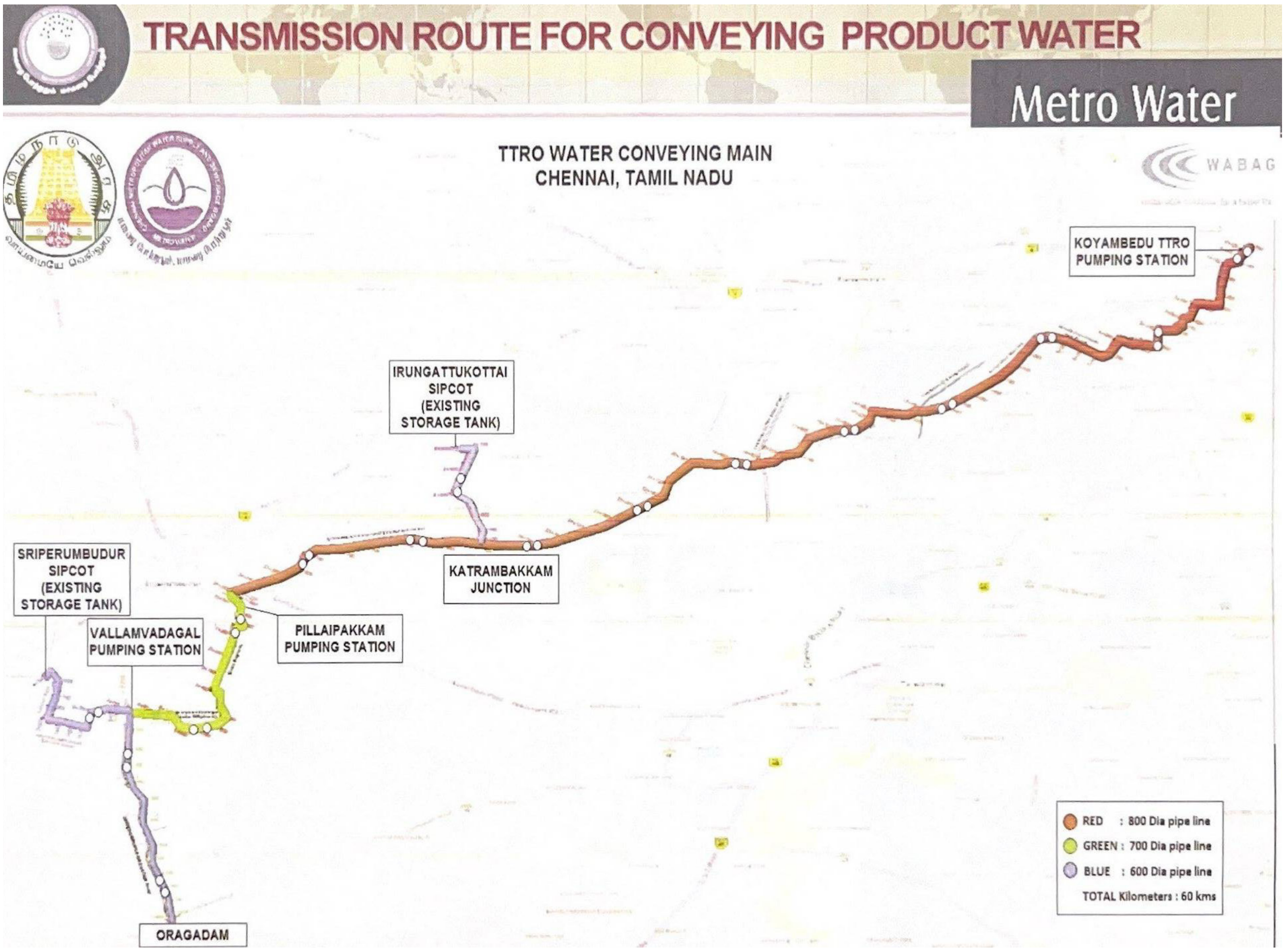
Table 38: Inlet and outlet water quality at the TTP

Parameter	Units	Inlet – average load	Required effluent quality
Total Dissolved Solids (TDS)	Mg/L	1,500 (maximum)	<70
BOD	Mg/L	20	BDL
COD	Mg/L	160	BDL
pH		7-8	6.5–7.5

Source: Koyumbedu Treatment Plant

The treated water after tertiary treatment is sent to a storage tank and then to the pumping stations. Prior to the network distributions, the water is disinfected with ozone for prevention of microbiological growth. Finally, the water is supplied through a distribution network of 60 kms to the industrial areas in Chennai. The water is first transferred to intermediate pumping stations at Pillaipakkam, Vallamvadagal and Orangadam through

Figure 34: Supply of tertiary treated water to industries from Koyambedu plant



Source: Koyambedu Plant

which it is finally supplied to State Industries Promotion Council of Tamil Nadu Limited (SIPCOT). After then it is the responsibility of SIPCOT to distribute/allocate the water to the industries as per their requirement and demand *(see Figure 34: Supply of tertiary treated water to industries from Koyambedu plant).*

The major beneficiary industries that are receiving treated water from the Koyambedu Plant are mentioned in the table 39 below.

Table 39: Beneficiary industries receiving treated water from the Koyambedu plant

Name of the SIPCOT	Name of the industries
Irunkattukotai	M/s. Hyundai Motor India Limited
	M/s. Hwashin
	M/s. ESAB India P. Limited
Sriperumbudur	M/s. Saint Gobain Glass India Limited
	M/s. Asian Paints India Ltd.
	M/s. CEAT Tyres Ltd.
	M/s. Sojith Motherson Industrial Park
Oragadam	M/s. Apollo Tyres Ltd.
	M/s. Renault & Nissan Automotive India Pvt. Ltd.
	M/s. Eicher Motors Ltd.
	M/s. Danfos Industries
Pillaipakkam	M/s. JK Tyres & Industries Ltd.
	M/s. Floking Pipes (P) Ltd.
	M/s. Minda Industries Ltd.
	M/s. Mando India Steering Systems P. Ltd.
Vallam Vadagal	M/s. India Yamaha Motor P Ltd.
	M/s Enfield Ltd.

Source: Koyambedu Plant

KODUNGAIYUR TERTIARY TREATMENT PLANT

Located at Kodungaiyur, the plant has a capacity to treat 45 million litres of sewage daily. The construction of the plant was done by M/s. BGR Energy Systems Ltd., Chennai for a contract value of INR 348 crore and INR 21.20 Cr towards operation and maintenance cost per year. The contract period of the plant is from 2020–35 *Figure 35: Snapshot of reuse of treated wastewater in Kodungaiyur Tertiary Treatment Plant.*

The plant uses a multi-stage treatment scheme—rapid sand filters, ultra filtration, reverse osmosis and ozonation ozonation. The treated water from this plant is sent to industries at Manali, Minjur, and Ennore through pipelines of 800/600/300 mm dia DI pipe to a total length of 28.50 km. The water is directly distributed to the industries by the plant.

The table 40 below lists the beneficiary industries that are receiving water from the Kodungaiyur plant.

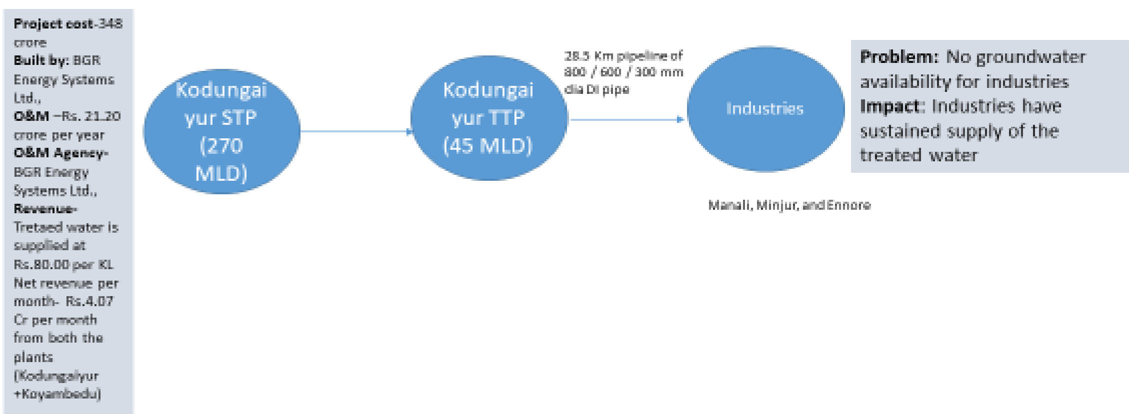
Table 40: Beneficiary industries receiving treated water from the Kodungaiyur plant

S. No	Name of the industries
1	MFL (Madras Fertilizers)
2	IAL (Indian Additives Ltd.)
3	CETEX
4	TPL LAB (Tamil Nadu Petroproducts Ltd.)
5	TPL HCD (Tamil Nadu Petroproducts Ltd.)
6	MPL -1 (Manali Petro Chemicals Ltd.)
7	MPL -2 (Manali Petro Chemicals Ltd.)
8	CPCL (Chennai Petroleum Corporation Ltd.)
9	KOTHARI Petrochemical Ltd.
10	NCTPS -1 (North Chennai Thermal Power Station)
11	NCTPS -2 (North Chennai Thermal Power Station)

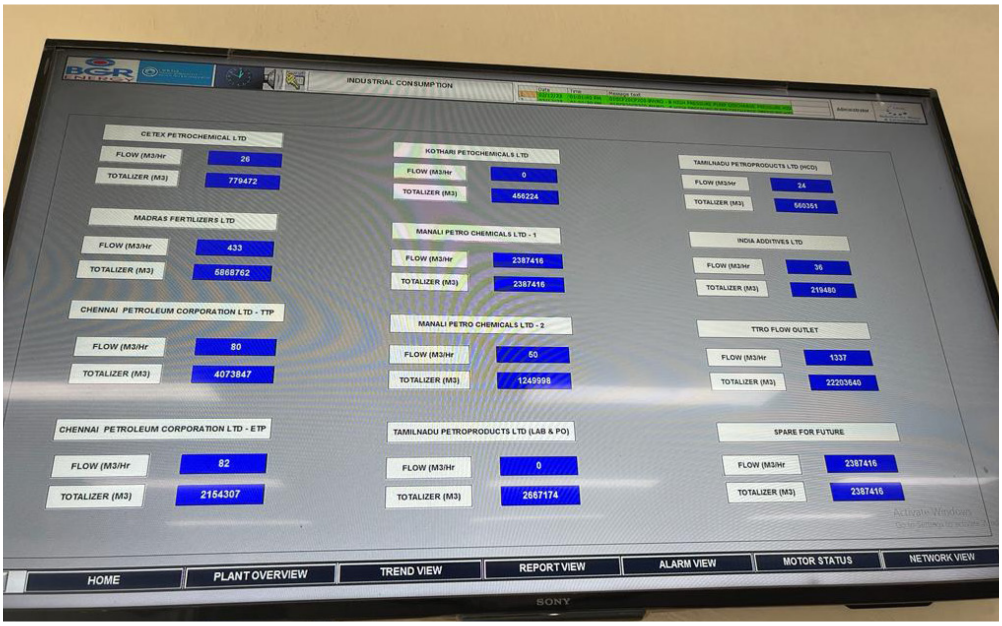
Source: Kodungaiyur Treatment Plant

Financial benefits: Both the tertiary treatment plants and the transmission mains were built with a total of INR 0.632 crore; the operating cost is INR 97.2 crore/year (at INR 36/kl, considering 300 days' operation to meet the diverse water needs of SIPCOT industrial parks and other industries). The TTRO water is supplied at INR 80/kl and the water production cost is INR 32/kl. Up until April 2023, a total of 38,947 million liters (ML) of

Figure 35: Snapshot of reuse of treated wastewater in Kodungaiyur Tertiary Treatment Plant



Source: Created by CSE



Dashboard monitoring the real time flow of water supplied to different industries at Kodingaiyur tertiary treatment plant, Chennai

water has been supplied to industries, with a monthly average of 45 million liters per day (MLD). This emphasizes the consistent efforts to address the dynamic water demands of SIPCOT industrial parks and other key industries. Until April 2023, a total revenue of INR 290.33 crore has been generated and the net revenue generation stands at Rs. 4.07 crore per month, indicating sustained financial success *(see Figure 36: A schematic of the reuse of treated wastewater for industrial use) (see Table 41: Details on TTRO water supply to industries and revenue generated from Koyambedu and Kodingaiyur TTRO plant)*

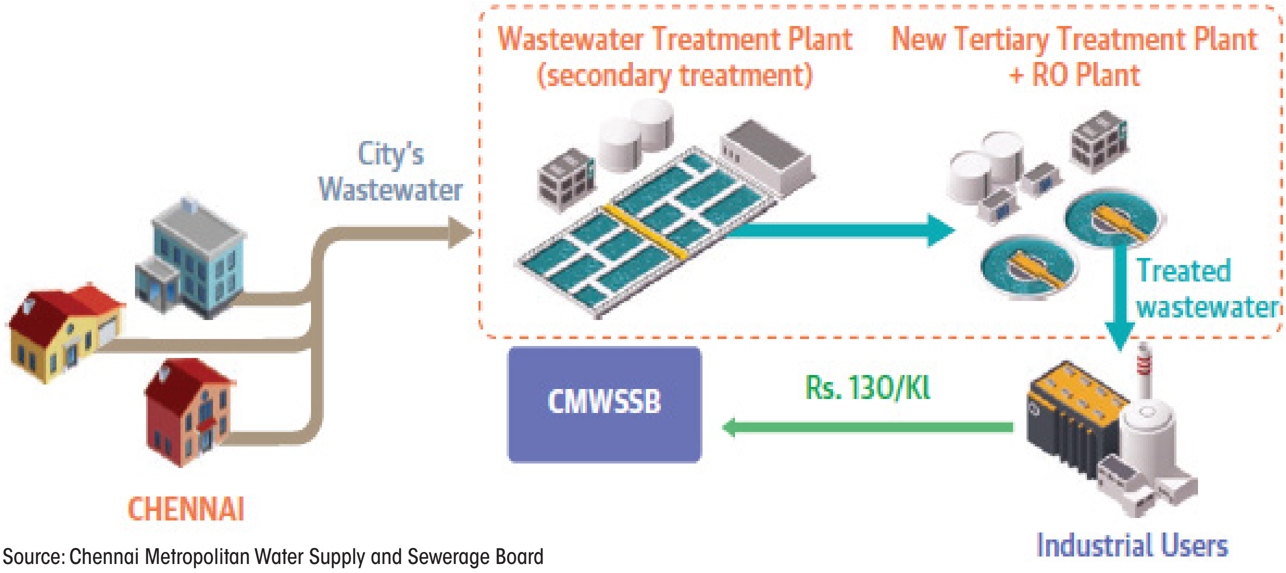
Table 41: Details on TTRO water supply to industries and revenue generated from Koyambedu and Kodingaiyur TTRO plant

TTRO plants 2 x 45 MLD capacity	Details
Cost of plant and transmission main	INR 928.41 crore
TTRO water supply cost/kl	INR 80.00 per KL
TTRO Water production cost/kl	INR 32.00 per KL
Total TTRO water supplied to SIPCOT industrial parks and other industries until April 2023	38,947 ML (monthly average 45 MLD)
Total revenue generated until April 2023	INR 290.33 crore
Monthly net revenue generated to date	INR 4.07 crore

Source: Municipal Administration and Water Supply Department, Govt of Tamil Nadu

Through strategic investments, efficient operations, and a focus on meeting industry demands, CMWSSB has not only achieved operational success but also established a financially viable and sustainable model for future initiatives.

Figure 36: A schematic of the reuse of treated wastewater for Industrial use.

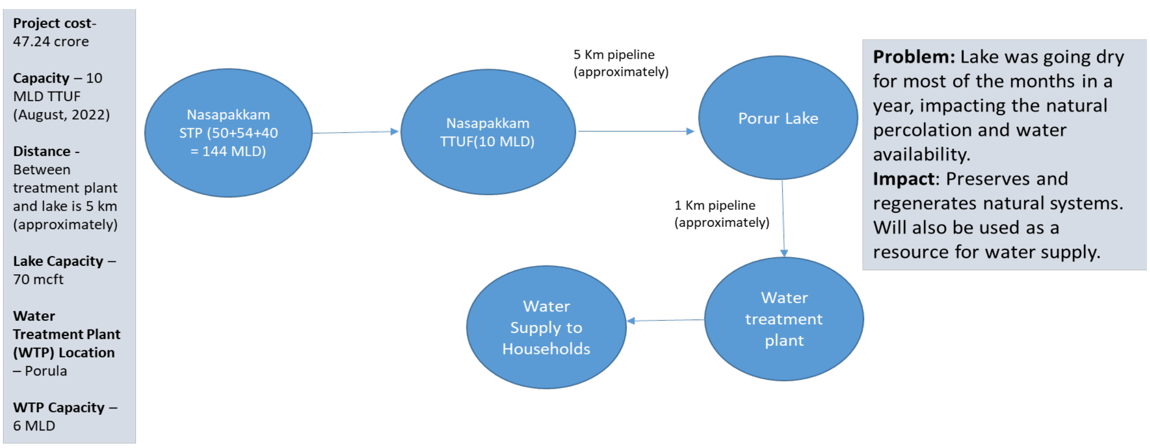


Source: Chennai Metropolitan Water Supply and Sewerage Board

NASAPAKKAM SEWAGE TREATMENT PLANT: CASE STUDY ON THE REUSE OF TREATED WATER FOR LAKE REVIVAL

Veeranam Lake, a key water source for the city, has dried up completely, recording zero million cubic feet (mcft) of water storage on 15 April, 2024, as per data from the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB).[163] Last year, on the same date, it held 687.40 mcft, while its total capacity is 1,465 mcft. Other reservoirs are also seeing a decline in their water levels. On 15 April, 2023, Poondi Lake stored 1,323 mcft out of a total capacity of 3,231 mcft, and Cholavaram Lake had 216 mcft, with a total capacity of 1,081 mcft.[164]

Figure 37: Snapshot of reuse of treated wastewater in Nasapakkam STP



Source: Created by CSE

Nasapakkam project is a pivotal element in CMWSSB's strategy for ensuring water sustainability. This initiative features a 10 MLD tertiary treatment unit and was constructed at a cost of INR 47.24 crore.

Water treatment plant of 6 MLD capacity which sources the inlet water from Porur lake. Water treated from this plant is supplied to Chennai city for non-potable use.

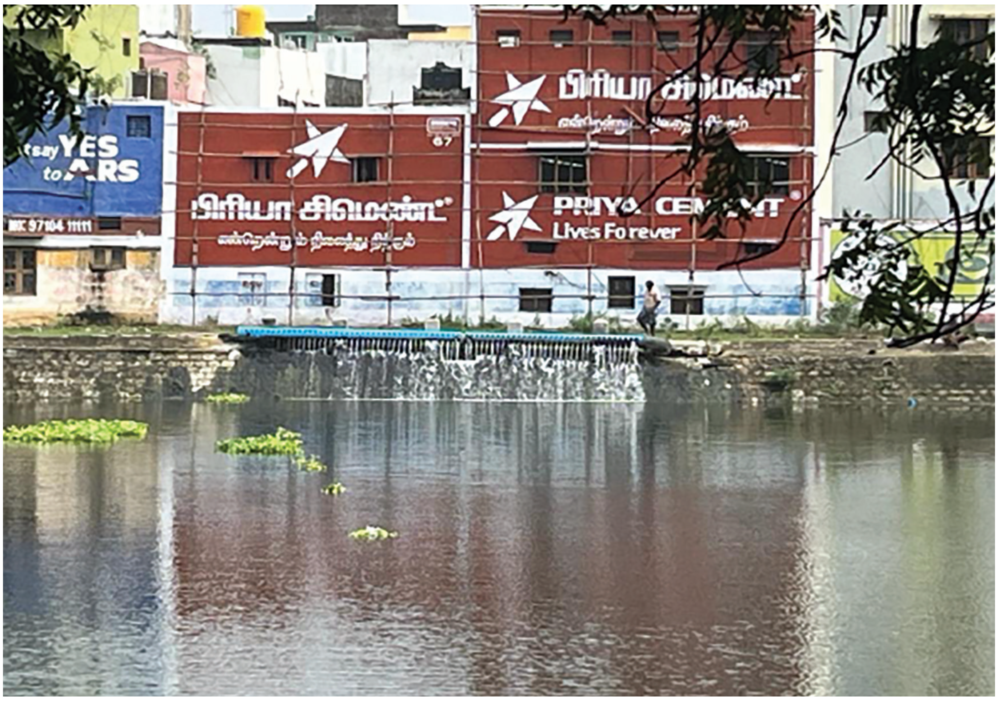
Post-tertiary treatment, the water is conveyed to Porur Lake via a five-kilometer pipeline. Porur Lake, which has a significant capacity of 70 million cubic feet, serves as a reservoir capable of receiving tertiary-treated water.

The blended water from the Porur Lake is directed to a 6 MLD Drinking Water Treatment Plant in 1:100 ratio. This WTP was commissioned in 2023 and is located approximately one kilometre from the lake.

This treatment facility acts as a crucial intermediary step, ensuring that the water meets the stringent quality standards before being supplied to the city for various purposes. A similar model for the reuse of treated wastewater is concurrently being implemented at Perungudi, where a 10 MLD tertiary treatment plant is in progress. This dual-pronged approach demonstrates a model of converting sewage water to drinking water.

Nasapakkam Secondary Treatment Plant; treated water from this plant feeds into the tertiary treatment plant

Porur Lake in Chennai where 10 MLD tertiary treated water from Nasapakkam plant is discharged.



Inlet point from where the tertiary treated water from Nasapakkam plant is discharged into the Porur Lake.

THE LEARNINGS

Tamil Nadu is the most urbanized and industrialized state with 528 towns. The state generates 3,938 MLD sewage of which 1,093 MLD is treated. 17 per cent of the total treated wastewater is reused out of which Chennai alone accounts for approximately 58 per cent of the total reuse in state.[165]

Each year, Tamil Nadu experiences a cycle of extremes, swinging from monsoon floods to summer water shortages, from cyclones to droughts. Chennai, in particular, endures alternating periods of water scarcity and flooding, exemplified by its 'Day Zero' declaration in 2019 following two years of insufficient monsoon rainfall and subsequent reservoir depletion.[166]

It is crucial for the state to promote the reuse of treated wastewater to augment its water supply, prioritized for drinking water, followed by shallow aquifer recharge and agriculture.

A clear action plan and timeline is missing for the state in policy.

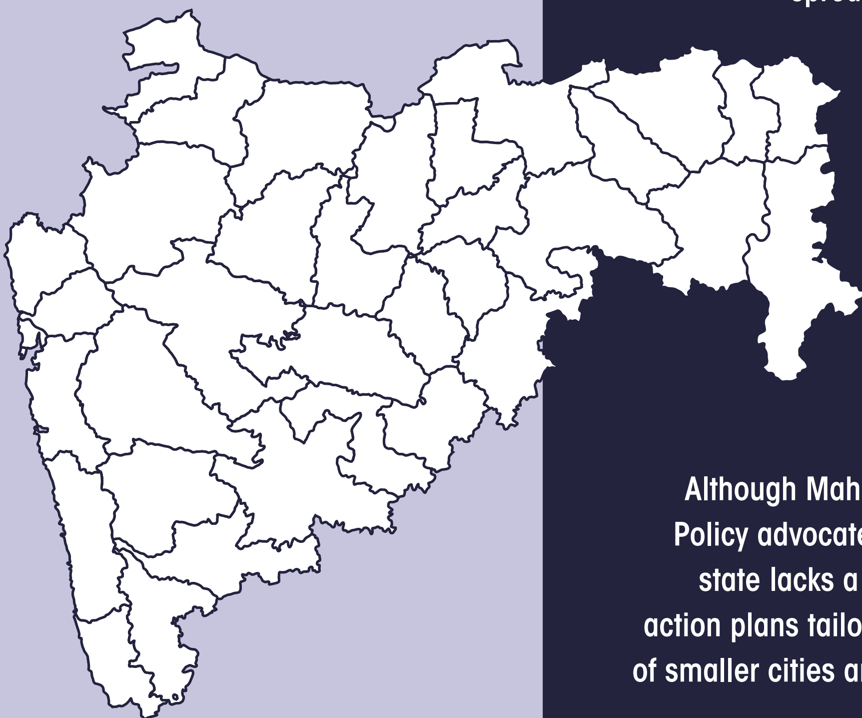
CMWSSB is undertaking PPP model-based tertiary treated water supply for industries. The cost incurred for tertiary treated water reuse is high and it automatically limits demand to the industrial sector that can pay for it. Secondary treated water reuse cost is much lower and should be promoted for addressing groundwater recharge through tanks/lakes and water bodies.

Currently, even lake revival is being done using tertiary treated water (Naspakkam project of CMWSSB). The ambition was to scale up to 260 MLD by 2024. This has not occurred within the expected timeframe.

A state policy that prioritizes groundwater recharge through tanks and lakes, with treated wastewater from STPs, guided by principles of equity and justice is needed for Tamil Nadu. If the state is able to treat and reuse treated water by even 20 per cent of its total sewage generation (3,938 MLD), as mandated by the Ministry of Urban Development, it could augment water supply for its cities.

The reuse potential from the centralized treatment facilities will be limited in the coastal cities of Tamil Nadu like Chennai owing to the natural slope and terrain. Therefore, it is advisable to promote decentralized treatment and reuse opportunities.

MAHARASHTRA



In Maharashtra, reuse of treated wastewater is concentrated in a few big cities, with limited spread to other parts of the state.

With 42.5% of Maharashtra's geographical area being water-stressed, there is a critical need to expand the reuse of treated wastewater, particularly in urban areas.

Although Maharashtra's 2016 State Water Policy advocates for wastewater reuse, the state lacks a clear action plan. Localized action plans tailored to the specific demands of smaller cities are needed to enhance water reuse practices.

TOTAL WASTEWATER/ SEWAGE GENERATED (MLD)
10,547

TOTAL WASTEWATER/ SEWAGE TREATMENT CAPACITY (MLD)
7,411

TOTAL OPERATIONAL CAPACITY OF STP (MLD)
4,304

TOTAL WASTEWATER/ SEWAGE TREATMENT BEING TREATED* (MLD)
4,317

TOTAL TREATMENT CAPACITY COMPLIES WITH THE DISCHARGE NORMS (MLD)
2,459

AMOUNT BEING REUSED (%)
17

* (and can be reused)

WATER AND WASTEWATER IN MAHARASHTRA: AN OVERVIEW

The population of Maharashtra is poised to reach 132 million by 2025, making it the second-largest state in India in terms of population, with an equally large urban population (45.2 per cent).[167] The geographical area of Maharashtra state is 308 lakh hectares and its cultivable area is 225 lakh hectares. Of this, 40 per cent of the area is drought prone and seven per cent is prone to floods.[168] The highly variable rainfall in Maharashtra ranges from 400 to 6000 mm and occurs within a four-month period between June to September, with the number of rainy days varying between 40 to 100.

The state is home to six river basin systems namely, Krishna, Godavari, Tapi, Narmada, Mahanadi and the west-flowing river basins (Konkan). The estimated average annual water availability is 164 km^3 of surface water and 20.5 km^3 of subsurface water. Marathwada and north Maharashtra regions have recorded the highest levels of groundwater depletion.

Out of the total area under irrigation, 28.75 lakh hectares or 71 per cent of the land is irrigated by groundwater. 85 per cent of the groundwater in the state is used for irrigation, 10 per cent for industrial use and only five per cent for domestic consumption.[169]

Maharashtra has 233 industrial areas and 23 thermal power stations all of which are highly water-intensive economical activities.

Maharashtra is facing a water emergency of unprecedented proportions. Due to years of drought, the rivers' currents have ebbed, the water in dams and reservoirs has depleted and the overexploitation of groundwater has raised concerns over the long-term availability of water. Tankers are the sole source of water in large parts of the state. The depletion of its water resources has resulted in delayed monsoons following a deficit year leading to groundwater depletion in 279 talukas, and reducing live storage to under 10 per cent in 13 major reservoirs.[170]

The total installed capacity of sewage treatment is 75 per cent of the total sewage generated in the state. As per latest report by state submitted to NGT[171] by the state, 10,547 MLD of sewage is generated in Maharashtra. There are 147 sewage treatment plants (STPs) in operation, with a combined treatment capacity of 7,411 MLD. Of this, 4,317 MLD capacity is being utilized currently for treating sewage, while 80 STPs have not been complying with the CPCB norms. There has been a proposal of an additional 90 STPs, with a combined capacity of 4,219.68 MLD, to fill the gap in sewage treatment *(see Figure: Sewage generation and treatment in Maharashtra).*

CURRENT POLICIES AND REGULATIONS

In addition to national policies concerning water resource conservation, Maharashtra has implemented its own specific policies and regulations aimed at conserving water resources.

The table below illustrates the main policies and their salient features.

Table 42: Policies supporting reuse of treated wastewater in Maharashtra

S.N.	Policy	Salient features
1.	Maharashtra Irrigation Act, 1976	To improve water management efficiency and enhance agricultural productivity through effective irrigation system management.
2.	Maharashtra Water Resources Regulation Authority Act, 2005	To regulate water resources within the state, the Maharashtra Water Resources Regulatory Authority (MWRRA) has been established.
3.	The Maharashtra Groundwater (Regulation for Drinking Water Purposes) Act, 2009	To regulate and facilitate sustainable, equitable and adequate supply of groundwater within the state, which empowers MWRRA to regulate groundwater resources of the state.
4.	Integrated State Water Plan	Ensuring efficient utilization and conservation of water resources in the state.
5.	Maharashtra's Wastewater Reuse Policy, 2017	To reuse 6,888 million litres of daily sewage generated across 71 urban areas by 2020 (India Water Portal, 2016). Priority reuse: • Thermal power plants (mandatorily within 50km; preferentially within 100 km) • Businesses or industries in Maharashtra Industrial Development Corporation (preferentially in 100km) • Railways or other bulk buyers • Agriculture • Non-potable to ULBs (as per Maharashtra Pollution Control Board)
	Maharashtra State Water Policy, 2019	This policy helps to ensure sustainable consumption and production patterns and protect, restore and promote the sustainable use of water. Emphasis should be laid on the collection and treatment of all sewage using cost-effective technological innovations. A minimum of 30 per cent of the recycled water shall be reused to reduce the fresh water demand in the next five years. Industries shall be encouraged to recycle and reuse water and follow the policy of 'zero effluent' in the final stages. The recycle and reuse of water after treatment of sewage water to specified standards be incentivized through a properly planned tariff system.
7.	Draft Maharashtra Water Resources Regulatory Authority Water Entitlement Transfer (WET) and Wastewater Reuse Certificates (WRC) Platform Regulations, 2019	To encourage wastewater recycling and reuse in water-intensive industrial and urban areas. The outcome of this intervention included the development of a policy promoting wastewater recycling, the creation of a transparent water accounting system, and the establishment of a repository for wastewater reuse certificates.

Source: Compiled by CSE

REUSE OF TREATED WATER

To enable the reuse of treated wastewater, the Water Resource Department, Government of Maharashtra, has prepared integrated State Water Plan, which includes recycling of treated sewage.[172] The reuse of treated water is of prime importance for Maharashtra, given its climate is predominantly semi-arid and groundwater sources are depleted. Not just used water, but its by-products can also be used for many residential, industrial and agricultural uses (World Bank, 2020).[173]

In Maharashtra, significant reuse is occurring primarily in industrial and thermal power plants, with agriculture and construction sectors also participating in water reuse initiatives.[174]

- Pune is reusing 400 MLD of treated wastewater for agriculture (lift irrigation scheme)
- 395 MLD sewage is recycled for industrial purposes
- 330 MLD is used for thermal power plants in Nagpur
- The local bodies will be encouraged to reuse treated sewage for various purposes including construction and gardening.

Water usage in thermal power plants

Thermal power plants use a large amount of water. A typical 500 kW plant requires 42 MLD, which could supply the needs of 420,000 people. Out of the total 42 MLD water, 72-78% is used for cooling and ash removal, 9-10% for service water, Ash HandIng Plant seal water, firefighting, and coal dust suppression, 3-4.5% for demineralized (D.M.) water, 1.25-1.5% for potable uses and 10-11% for various other purposes. These plants get their water from sources like groundwater, rivers, canals, or the sea, often using desalination to make it suitable for use.

To gain practical insights into the processes and potential reuse of treated wastewater from sewage treatment plants (STPs), visits were made to four STPs in Pune and Nagpur, the details of which have been mentioned in the table below.

Table 43: Details of visited STPs in Maharashtra

District	STP	Commissioned (year)	STP capacity (in MLD)	Technology	Reuse
Pune	Mundhwa	2009	45	SBR	Irrigation
	Kharadi	2012	40	SBR	Irrigation
Nagpur	Bhandewadi I	2016	130	SBR	Thermal power station
	Bhandewadi II	2018	200	SBR	Thermal power station

Source: CSE visit

PUNE

Pune, the second largest city in Maharashtra, and the ninth-largest city in the country, encompasses 5.10 per cent of the total geographical area of the state. Pune has been one of the fastest-growing cities in the Asia-Pacific region for some time. Between 1991 and 2001, the city grew by 40 per cent, increasing from 1.6 million to 2.5 million. The decadal growth rate of Pune for the last 40 years has been at least 40 per cent and it is estimated that the population will hit 5.6 million by 2031 if this trend continues.[175]

Pune holds significant importance in terms of economic and industrial growth. Over the years, Pune has witnessed remarkable economic development, with the manufacturing, automobile, and IT sectors emerging as key industries. The city also has the sixth highest per capita income in India.

Pune is crossed by many rivers and streams, which originate near the Sahyadris. The major rivers within the city limits include Mutha River, Mula River and Mula-Mutha River. The total length of the Mutha River within the city limits is approximately 10.40 km, Mula river is 22.37 km and Mula-Mutha River is 11.75 km. There are three important lakes in the city—the Pashan Lake (62.60 Ha), Katraj Lake (7.20 Ha) and Snake Park Lake (18.60 Ha).

The Pune Municipal Corporation (PMC) supplies water to the city from four storage reservoirs: Panshet, Varasgaon, Temghar, and Khadakwasla. These reservoirs are managed by the Irrigation Department of Maharashtra. These reservoirs have a combined storage capacity of 29.12 thousand million cubic feet (TMC). Katraj and Pashan lakes are not directly utilized for water supply by the PMC, they play a crucial role in recharging groundwater, which is then used by numerous city residents. The PMC procures water from the Irrigation Department, treats it for supply to Pune. The current water suppled is approximately 1,250 million litres per day (MLD).[176]

Approximately 92 per cent of Pune is covered by a sewerage network, which spans 2,200 kms within the Pune Municipal Corporation (PMC) limits. The total sewage generation in the city is 850 MLD.

Currently, there are 10 sewage treatment plants (STPs) with a combined capacity of 567 MLD capacity. However, one STP with a capacity of 90 MLD is non-functional, resulting in an actual sewage treatment capacity of 477 MLD.[177] 11 STPs with a total capacity of 396 MLD are under construction. Additionally, plans have been proposed for two more STPs with capacities of 93.5 MLD and 12 MLD to serve 11 newly added villages.[178]

Out of the nine existing STPs, only three have been designed according to NGT discharge standards of 10 BOD-10 TSS. The other six STPs are in the process of being upgraded to tertiary-level treatment targeting 5 BOD-5 TSS. The treated sewage is intended for reuse in railway applications.

Table 44: Status of STPs under Pune Municipal Corporation

STP	Installed capacity (MLD)	Status	Present capacity/ utilization	Compliance status
Erandwane	50	Operational	50	Non-compliant
Bopodi	18	Operational	18	Non-compliant
Tanjiwadi	17	Operational	17	Non-compliant
Bhairoba	130	Operational	130	Non-Compliant
Mundhawa	45	Operational	45	Non-Compliant
Vithalwadi	32	Operational	32	Non-Compliant
Baner	30	Operational	30	Non-Compliant
Kharadi	40	Operational	40	Non-compliant
New Naidu	115	Operational	115	Non-compliant
Old Naidu	90	Upgradation	0	Non-compliant

Source: NGT Monthly Progress Report, December, 2023

Reuse of treated wastewater

Due to insufficient treatment capacity, approximately 50 per cent of the untreated sewage is currently discharged directly into the Mula-Mutha river. The polluted waters of the Mula-Mutha rivers eventually merge into the Bhima River, adding to the overall flow into the Krishna River.

Under an agreement between the Pune Municipal Corporation (PMC) and the Water Resources Department (WRD) of the Government of Maharashtra, Pune receives an annual allocation of 11.5 thousand million cubic feet (TMC) of water. In return, Pune is obligated to discharge 6.5 TMC (504 MLD) of treated wastewater back to the Water Resource Department as per the data provided by the Pune Municipal Corporation (PMC).[179]

According to the Environment Status Report (2022–23) published by PMC, this demand has now increased to 14.5 TMC.[180] However, PMC lifts more than 18 TMC of water which is much more than its allocated quota. By 2047, the demand is projected to reach 30 TMC, representing an increase of nearly 66 per cent from the current demand.[181] In addition to the 18 TMC of water that PMC extracts, recent estimates from government-supported surveys and NGOs indicate that PMC also draws 3.5 TMC from groundwater annually.[182]

To address the water demand, the PMC has made the necessary amendments to the Building Control Rules. It is now mandatory for all housing schemes with more than 150 tenements to install sewage treatment plants (STPs) and reuse the treated sewage for purposes such as flushing and gardening.

In case of non-compliance, there will be penalties which will depend on the capacity of the STPs. STPs with a capacity of less than 300 KLD will be fined INR 2,500; those with a capacity between 300–500 KLD will be penalized up to INR 4,000; and those with a capacity beyond 500 KLD will be fined INR 5,000.[183]

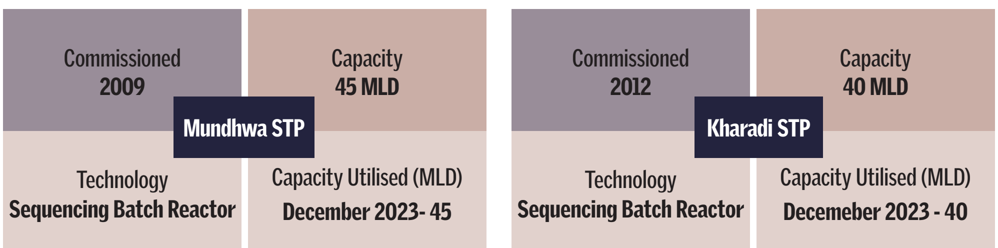
To conserve fresh and potable water and reduce groundwater wastage, the PMC has mandated construction sites to use treated greywater for all construction activities. Before receiving completion certificates for their projects, builders and real estate developers need to make sure that the STPs are operating properly. In case of non-compliance, notices are issued to defaulters seeking explanations. A total of 326 construction projects are underway in PMC areas and 128 of them are using treated water, while 208 are not using it.[184] (*see Table: Status of STPs under Pune Municipal Corporation*)

Pune is reusing 400 MLD of treated wastewater which is pumped from the rising main from Mula-Mutha river and directed into a canal. The Agriculture Department then distributes this water for irrigation purposes in farmland areas.

MUNDHWA AND KHARADI SEWAGE TREATMENT PLANTS: REUSE OF TREATED WATER FOR IRRIGATION AND CONSTRUCTION

Pune treats 477 MLD of wastewater through nine STPs. The treated wastewater from all nine STPs in the city is released into the Mula and Mutha rivers.[185] In 2015, PMC started reusing approximately 400 MLD of the treated water for irrigation, responding to the requirements of the irrigation department. The treated water is transferred to irrigation canals through a jackwell installation, where river water is lifted, effectively blending with treated water that has been diluted. This water is sent for irrigation purposes through a canal spanning 17.5 miles. A 3.5 km underground pipeline has been laid to facilitate efficient water transport to the irrigation canal. At the jackwell, there are eight pumps, with six currently operational and two kept on standby. Each pump has a capacity of 85 million litres per day (MLD).

Figure 38: Salient features of the Mundhwa and Kharadi STPs



The CSE team visited two STPs in Mundhwa and Kharadi to assess the reuse of treated water. Both facilities employ sequential batch reactor (SBR) technology and are operated and maintained by Vishwaraj Environment Pvt Ltd. The monthly operation and maintenance costs for STP Mundhwa and Kharadi is INR 0.15 million each and borne by the Pune Municipal Corporation (PMC).

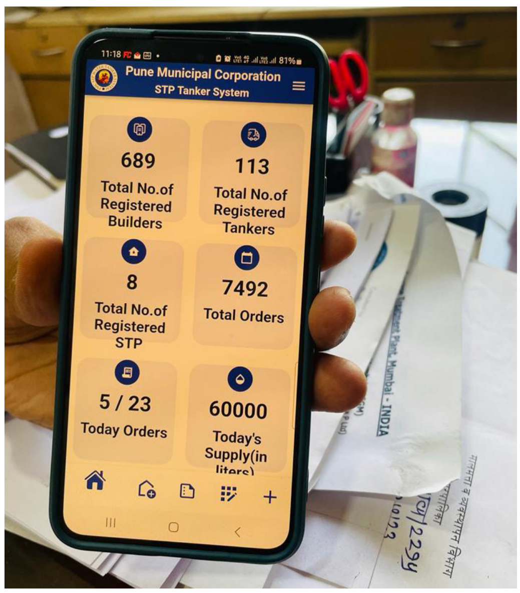
The treated wastewater is also used for construction and road cleaning through tankers. From STP Mundhawa, seven to eight tankers, each capable of holding 6000–8000 litres, are allocated daily for construction activities, provided at no charge. An additional two to three tankers serve municipal horticulture projects on a daily basis.

From STP Kharadi, 15–18 tankers are used for construction purposes daily, free of cost. Additionally, three to four tankers serve municipal horticulture projects. To streamline the process of recycling wastewater, the Pune Municipality has developed the STP Tanker app. A total of 147 tanker owners and 765 builders have registered on this app. The water is tested every fifteen days from an NABL-approved testing laboratory.

However, the water quality provided to the Irrigation Department for agricultural use does not meet the standards set by the Irrigation Department. Even after the treated water is discharged into the river, pollution

CSE team with operators of Mundhwa Jackwell

Tanker filling up the treated water from Kharadi STP for use in construction activity.



Mobile application developed by Pune Municipal Corporation to track the order and number of total tankers supplying water for construction purpose to registered builders.

issues in the river persist. The Irrigation Department has pointed out that one of the major reasons for the pollution of the Mula and Mutha rivers is the discharge of untreated domestic wastewater into the river due to inadequate sewerage systems.

Also, in 2023, the State Irrigation Department had asked the Pune Municipal Corporation (PMC) to pay INR 507 crores as a fine for polluting city rivers from 2018 till June 2022.[186]

NAGPUR

Nagpur is the largest city in central India. In 2021 it had a population of 2.96 million which is projected to grow to 3.59 million in 2031 and 4.33 million in 2041.[194] It is the thirteenth largest urban agglomeration in India and the third largest city in Maharashtra after Mumbai and Pune. The region is drained by rivers such as Kanhan and Pench in the center, Wardha in the west, and Wainganga in the east.

The Nagpur Municipal Corporation manages the water supply in the city, procuring approximately 670 MLD from various sources, including surface water and groundwater. Groundwater utilization is relatively low, at around 10 MLD, with the city primarily relying on three surface-water sources—Gorewada Lake, Kanhan River, and Pench Dam. The demand for water has substantially increased over the past decade due to population growth and economic development.

Koradi Thermal Power Station and Khaparkheda Thermal Power Station are the two major thermal power stations located near Nagpur and operated by MSPGCL. And there are five upcoming thermal power plants:[187]

a. Ideal Energy projects, Bela, Nagpur, Capacity 270MW
b. Lenexis Energy, Khursapar, Nagpur, Capacity 1320MW
c. Mantri Power Ltd, Bela, Nagpur, Capacity 540MW,
d. Vidarbha Industries Power, Butibori, Nagpur, Capacity 300MW
e. Abhijit MADC Nagpur Energy Pvt.Ltd, Khari Khurd, Nagpur, Capacity 271MW

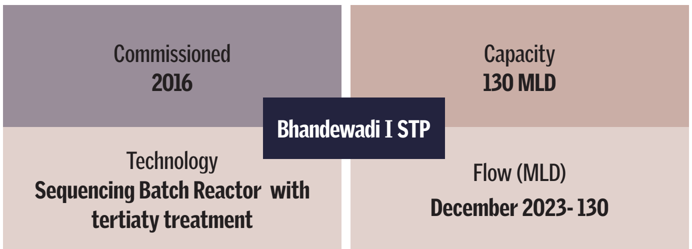
As per the data provided by Nagpur Municipal Corporation (NMC), Nagpur generates approximately 520 MLD sewage. 65 per cent of the households are connected to the sewer system. However, there are several gravity-based sewer lines that are connected to open nullahs (drains) and rivers. There are currently 12 existing STPs with a combined treatment capacity of 403.5 MLD. Untreated sewage is discharged into the Nag, Pioli, and Pora rivers, as well as their tributaries.

The central part of Nagpur town has a well-established sewerage network that is connected to the two Bhandewadi Sewage Treatment Plants (STP). These treatment plants have capacities of 130 MLD and 200 MLD, respectively, and are equipped with advanced tertiary treatment processes. Additionally, the Nagpur Municipal Corporation (NMC) has initiated the construction of smaller decentralized STPs at Mokshadham, Ghat Road (with a capacity of 5 MLD), and Mankapur Square (with a capacity of 5 MLD).

The total installed capacity is 403.5 MLD out of which 340 MLD (4 STPs) is being handled by Nagpur Municipal Corporation and 63 MLD (8 STPs) is being handled by Nagpur Improvement Trust.

BHANDEWADI I STP: CASE STUDY ON REUSE OF TREATED WATER FOR THERMAL POWER STATIONS

Figure 39: Salient features of the Bhandewadi I STP



This case study highlights the success of the reuse of treated water from Bhandewadi Sewage Project, managed by Nagpur Municipal Corporation (NMC), in collaboration with Maharashtra State Power Generation Company (MAHAGENCO). Started in 2015, the treated wastewater from the Bhandewadi STPs is utilized by Koradi thermal power plant.

Before this project, the Koradi thermal power plant, that has a capacity of 620 MW, used to draw 72 MLD water for its operations from the Kamptee-Khairy Pench project. Due to increasing power demand, MAHAGENCO opted to enhance the current capacity of the Koradi thermal power plant in 2008, increasing it from 660 MW to three units totalling 1,980 MW. This expansion project required 130 million litres of water daily. Due to the lack of additional water allocation from the existing Kamptee Khairee Pench project and acknowledging water scarcity in the Vidharbha Region, MAHAGENCO opted to pursue an alternative unconventional water source.

After a feasibility study, MAHAGENCO entered into a tripartite agreement with NMC and Nagpur Waste Water Management Private Limited (NWWMPL) to treat and reuse wastewater by installing a sewage treatment plant. NMC was responsible for the supply of raw sewage, NWWMPL was responsible for capital investment, construction and operation and maintenance, and MAHAGENCO was responsible for making payments against reusing treated water. The overall cost of the project was INR 195 crore (NMC INR 90 crore+ MAHAGENCO INR 105 crores).

The treatment model has five modules comprising a pumping station, SBR-based STP, tertiary treatment plant, treated water pumping station and 16.2 km transmission lines for transporting treated water to a thermal power plant.

A total of 320 MLD of treated water is used by thermal power stations for the Koradi 660 MW units, old Koradi units, and Khaperkheda units.

- The Koradi TPS utilizes overall 130 MLD treated wastewater.
- Out of the 200 MLD treated by the STP, 90 MLD is allocated to the Koradi TPS, 100 MLD to the Khaparkheda Thermal Power Station, and the remaining 10 MLD is discharged into the river.

For MAHAGENCO, the deal had several benefits. It helped them save money by using wastewater instead of freshwater to meet their water needs. The cost of treating and providing water through this arrangement amounted to approximately INR 3.4 per cubic meter. If they had obtained freshwater from another municipal or irrigation project, the cost would have been significantly higher, around INR 9.6 per cubic meter for recent projects[188] *(see Table 45: Financials of Bhandewadi I STP).*

Table 45: Financials of Bhandewadi I STP

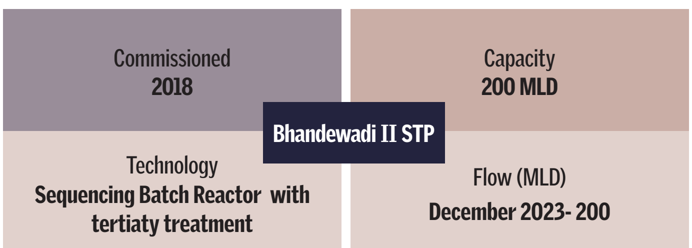
STP	Bhandewadi I
Capacity	130 MLD
Contribution	ULB share borne by MAHAGENCO
Total capital cost	INR 195 Cr
O&M	M/s SMS envocare
O&M cost	INR 24 lakh per annum
Cost per KLD	INR 11
Revenue to NMC	INR 17 crores per annum

Source: Maharashtra State Power Generati on Company (MAHAGENCO)

This case study represents an example of PPP where industries have benefitted by securing their rights on treated wastewater and ensured economical water supply for the operations of a thermal power plant. The municipality draws benefits from the revenue that comes from treated wastewater fees.

BHANDEWADI II STP: CASE STUDY ON THE REUSE OF TREATED WATER FOR THERMAL POWER STATIONS

Figure 40: Salient features of Bhandewadi STP



This 200 MLD project for the reuse of treated water was inaugurated in 2018. Phase 2, incorporating tertiary treatment, was commissioned in 2020. The project aims to supply the treated sewage to nearby thermal power plants (TPPs) for non-potable use.

The project was implemented in public-private-partnership (PPP) mode on a design-build-finance-operate-transfer basis. A consortium of three companies, that included Vishvaraj Infrastructure Limited (VIL), constructed the STP at a cost of INR 261 crores. As per agreement, VIL invested 100 per cent capital for the project, MAHAGENCO pays an annual royalty of INR 45 crore to NMC and NMC pays the contractor INR 60 crores per annum for the operation and maintenance of the STPs for over a span of 30 years.

As per the arrangement between VIL and NMC, VIL has the right to sell the secondary or tertiary treated wastewater to any non-potable user. Of the 200 MLD capacity, VIL is supplying 190 MLD of treated water to Maharashtra State Power Generation Company Limited and the remaining 10 MLD of treated wastewater is discharged into the river *(see Table 46: Financials of Bhandewadi II STP).*

Table 46: Financials of Bhandewadi II STP

STP	**Bhandewadi II**
Capacity	200 MLD
Contribution	Complete funding by VEL (Vishwaraj Environment Pvt. Ltd.)
Total capital cost	INR 261.72 crores
O&M	Vishwaraj Environment Pvt. Ltd
O&M cost	INR 60 Cr for 30 years
Cost per KLD	INR 2.03
Revenue to NMC	INR 45 crores per annum

Source: MAHAGENCO

Beyond Bhandewadi, Nagpur envisions further enhancements in wastewater management. The treated wastewater currently discharged into the river from two 5 MLD plants is scheduled for future reuse in the National Park Ghorewada, located 15 km away. The Forest Department is overseeing the construction of the transportation line for this purpose.

In another initiative, Indoor Stadium at Manakpur, which is four kilometres away from the 5 MLD STP is going to have treated water, with the Sports Authority undertaking the construction of the transportation line.

THE LEARNINGS

In Maharashtra, there are a total of 414 ULBs that generate 10,547 MLD of sewerage. There are 147 STPs in operation with a combined treatment capacity of 7,411 MLD. Currently 4,317 MLD capacity is being utilized for treating the sewage.[189] The two case studies (Pune and Nagpur) covered in the study accounts for 17 per cent reuse of the total treated water in the state.

Nearly 42.5 per cent of the geographical area is water stressed. There is a need to supplement the fresh water sources by exploring options of reuse of treated wastewater, particularly in the urban areas.

The state water policy of Maharashtra (2016) advocates for the reuse of treated wastewater as a part of water use efficiency and conservation. However, there is need for proper action plan defining the targets and timeline for the reuse of treated wastewater in various sectors which at this moment is missing.

The reuse of treated wastewater is primarily concentrated in three or four major cities such as Nagpur, Pune, Mumbai, etc., and has not been extensively adopted in other parts of the state. In cities where sewage generation is lower, treated water can be utilized for recharging shallow aquifers, thereby contributing to the augmentation of groundwater supply. It can also be used for the revival of waterbodies and lakes. Hence, each city should have their own action plan for the reuse of treated water while keeping local demand in mind.

Currently, the majority of treated wastewater in Mumbai is discharged into the sea after ensuring it meets the required quality standards. The reuse possibility is limited because of Mumbai's status as a coastal city. Due to its natural slope and terrain the infrastructural development of supplying treated water against the slope will be immensely challenging and cost-intensive. Hence, the sewerage operations department of Municipal Corporation of Greated Mumbai (MCGM) has adopted a programme to decentralize wastewater treatment.

The MCGM has made it mandatory for high-rise buildings to recycle and reuse wastewater, and to build a sewage treatment plant (STP). Additionally, they are working on creating "Grey Water Recycle Bye-laws" to support the recycling and reuse program.

Despite having provisions for the reuse of treated water in the state, as mentioned in the notification of the Maharashtra Water Resources Regulatory Authority, 2019,[190] the reuse of treated water has not been widely practiced in the state as it lacks a clear operational and implementation mechanism.

Maharashtra's State Water Policy also mandates penal action for the polluter of water resources and the Act states that the polluter-pays-principle should be followed for the preservation of water quality. Despite this, many STPs have not been compliant with the standards. For example, all the nine STPs in Pune have not been complying with the discharge standards. In total, 80 STPs have not been complying with the CPCB norms in the state.[191]

The PPP model in Nagpur for securing water for operating thermal power plants showcases how partnerships and initiatives can lead to the optimal utilization of resources. But these kinds of models may not be feasible for smaller ULBs/cities.

The major focus of reusing treated wastewater in the industry will require tertiary treated water which is capital-intensive and often hinders the scaling up of secondary treated water which is easier to uptake. The focus should be to be increase the uptake of secondary treated water by exploring demands to achieve the target at a faster pace.

Fisheries in Nasappakam treatment plant using tertiary water

ASSESSMENTS AND RECOMMENDATIONS

- The reuse of treated wastewater is increasingly recognized as a vital climate resilience resource amidst growing water scarcity and climate change impacts.

- Despite significant sewage generation, only 28% undergoes treatment, with a large proportion failing to meet reuse standards, underscoring the need for improved infrastructure and compliance.

- There is a need for prioritizing wastewater reuse based on equity, justice, and environmental considerations, rather than solely focusing on financial gains.

- Effective reuse requires robust state policies, public engagement, decentralized treatment infrastructure, and clear prioritization to ensure sustainable water management.

- Emphasizing local treatment and reuse strategies, particularly for drinking water security and groundwater recharge, is essential for achieving a circular water economy

Jajmau STP in Kanpur. The treated wastewater from this STP is chanelled into a nearby escape canal from where the water is tapped for agricultutre by the farmers using gravitational force.

The significance of reusing treated wastewater is being increasingly recognized across various stakeholders. This study assesses the existing status of the treatment and reuse of wastewater, and analyzes the challenges and potential associated with the it in seven states of India. It provides insights into the existing status, policies, standards, and reuse practices.

At a time when climate change is impacting the already unequal and inadequate distribution of water and wastewater management, the reuse of treated wastewater is an important climate resilience resource that must be planned and implemented well.

The study emphasizes the importance of prioritizing wastewater reuse based on principles of equity, justice, and considerations for environmental and biodiversity preservation. These aspects are crucial as they may be overshadowed by the enthusiasm to promote wastewater reuse for purposes that offer greater financial returns.

Of the total urban sewage generated in India, a mere 28 per cent (20,236 MLD) undergoes treatment, leaving a substantial 72 per cent untreated and allowed to flow into rivers, lakes and land.[192] The gap in the total sewage water generation and its treatment is highest in Uttar Pradesh, followed by Maharashtra, Karnataka, Rajasthan, Tamil Nadu, Delhi and Haryana. The primary challenge in the reuse of treated wastewater is ensuring that wastewater is effectively treated to meet appropriate quality standards before considering it for reuse, whether those standards are for reuse or disposal. Effective treatment of wastewater and its reuse (preferably for reuse standards) is required to achieve a circular economy of water and nutrient cycle.

The study highlights the urgency of prioritizing the reuse of treated wastewater for all cities—big or small. State-level reuse policies and strategies need to plan for and identify the potential and constraints in the reuse of treated wastewater.

Reuse will require identifying and prioritizing local treatment and reuse above everything. States need to define reuse priorties first, have extensive public outreach and consultation processes in place, develop the infrastructure for the conveyance of treated wastewater, establish financial models and programmes, and provide comprehensive guidelines.

Where large volumes of treated water are being released from centralized STPs, there will be a need to create infrastructure for the same for the conveyance of treated wastewater for use elsewhere.

The reuse of treated wastewater calls for a restructuring and improvement of Urban Water Utilities and Boards to enable efficient management, with a focus on safe groundwater recharge initiatives. It is essential to enhance institutional capacity for mapping urban aquifers, assessing their recharge and discharge potential, and conducting regular monitoring. A priority should be placed on recharging shallow urban aquifers to bolster the urban water supply.

CURRENT SCENARIO OF REUSE OF TREATED WASTEWATER IN STUDY AREAS

The study of the seven states' wastewater generation and reuse has been presented below. Based on secodary data assessment, Maharashtra has the highest volume of sewage water generation followed by Uttar Pradesh, Tamil Nadu, Delhi, Karnataka and Rajasthan.

The gap in total sewage water generation and treatment is the highest in Uttar Pradesh followed by Maharashtra, Karnataka, Rajasthan, Tamil Nadu, Delhi and Haryana *(see Table 47: Details on the sewage genration, treatment and reuse for the study area)*.

Based on an analysis of 35 case studies conducted in 16 cities across seven states in northern and southern India, study findings indicate that major reuse is happening in agriculture which is (40 per cent) based on CSE's visit to different STPs, followed by industry which is (20 per cent), lake revival/recharge (26 per cent), construction (5 per cent) and thermal power stations (6 per cent) and green belt development (3 per cent) *(see Table 48: Details on the visited STPs in seven states of India, and Map 13: Locations of visited STPs in seven states of India and Graph 11: Break-up of reuse in different sectors based on CSE analysis for visited STPs)*.

Table 47: Details on the sewage generation, treatment and reuse for the study area

State	Town	No. of STPs	Sewage generation (MLD)	Treatment capacity (MLD)	Actual utilization (MLD)	Gap in sewage generation and treatment (%)	Reuse of treated wastewater (%)
Haryana	154	180	1,655	1,965	1,373	17	15
Delhi*	0	37	3,600	3,033	2,587	28	49
Uttar Pradesh**	764	139	5,500	4,175	1,100	80	NA
Rajasthan	210	118	1,550	1,299	950	39	29
Karnataka	281	177	3,356	2,677	2,054	39	43
Tamil Nadu	528	104	3,938	2,350	1,093	28	17
Maharashtra	400	152	10,547	7,490	4,317	59	17

Source: CSE analysis

*In case of Delhi, out of the total treated wastewater (2568 MLD), 1,214 MLD is used for mandatory return flow. The remaining 1,354 MLD is used for various purposes. The percentage of reuse in Delhi is shown as high but the implementation on the ground is lagging behind the timeline.

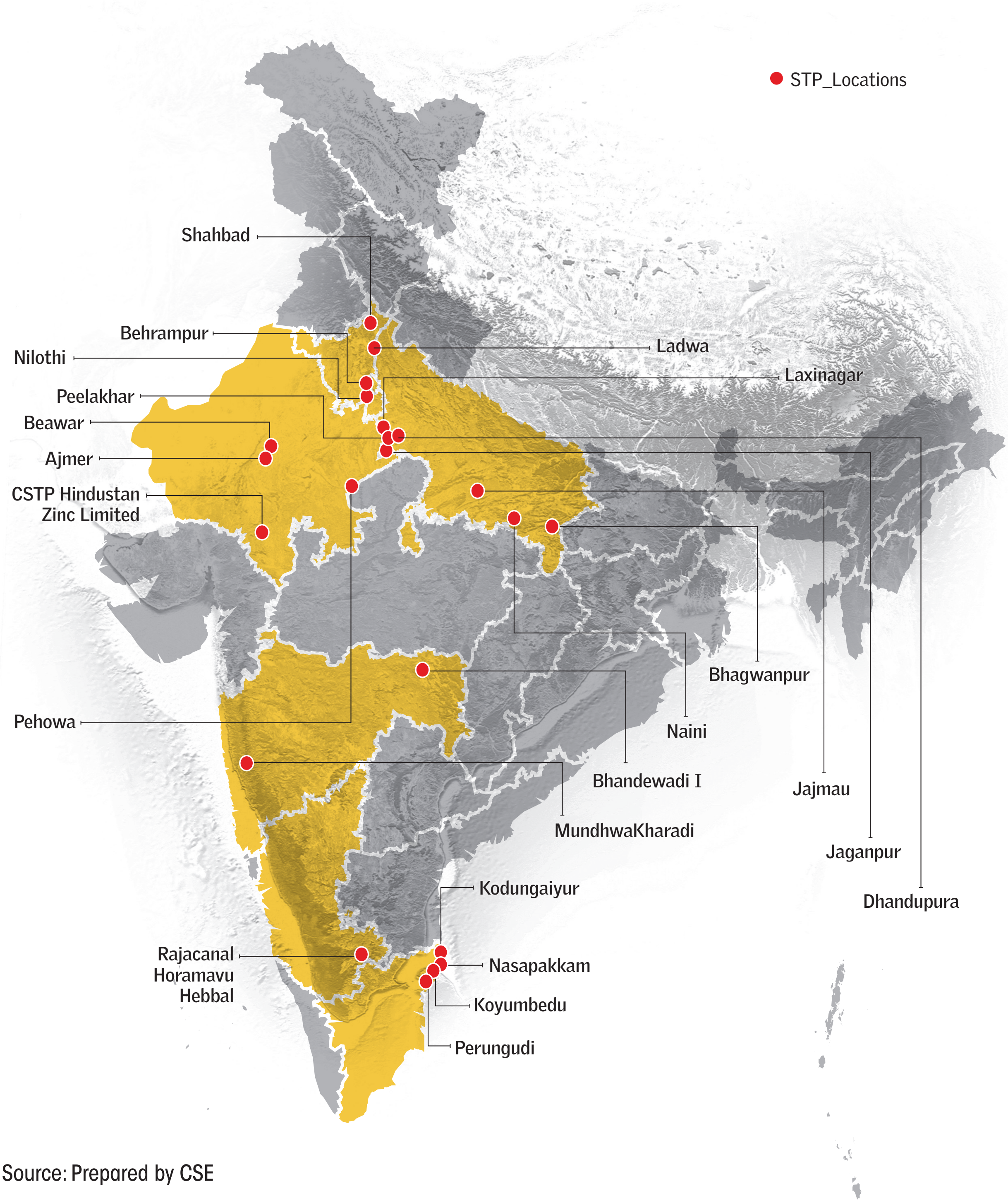
** Uttar Pradesh, no data on sector-wise or cumulative reuse of treated wastewater at the state level.

Table 48: Details on the visited STPs in seven states of India

State	STP	Reuse
Uttar Pradesh	Jajmau	Agriculture
	Bhagwanpur	Agriculture
	Naini	Agriculture
	Dhandupura	Agriculture
	Jaganpur	Agriculture
	Peelakhar	Agriculture
	Laxminagar	Agriculture
	Laxminagar	Industry
Haryana	Behrampur	Agriculture
	Behrampur	Industry
	Behrampur	Construction
	Behrampur	Lake recharge
	Behrampur	Park/Green Belt development
	Shahbad	Agriculture
	Ladwa	Agriculture
	Pehowa	Agriculture
Rajasthan	CSTP Hindustan Zinc Limited	Industry
	Anasagar STP	Lake recharge
	Beawar	Industry
	Beawar	Agriculture
Delhi	Nilothi	Lake recharge
	Pappan Kalan	Lake recharge
Tamil Nadu	Koyumbedu	Industry
	Kodungaiyur	Industry
	Nasapakkam	Lake recharge
	Perungudi	Lake recharge
Maharashtra	Mundhwa	Agriculture
	Kharadi	Construction
	Kharadi	Agriculture
	Bhandewadi I	Thermal power plant
	Bhandewadi II	Thermal power plant
Karnataka	Hebbal	Lake recharge
	Horamavu	Lake recharge
	Rajacanal	Lake recharge
	IT Park Industrial Area	Industry

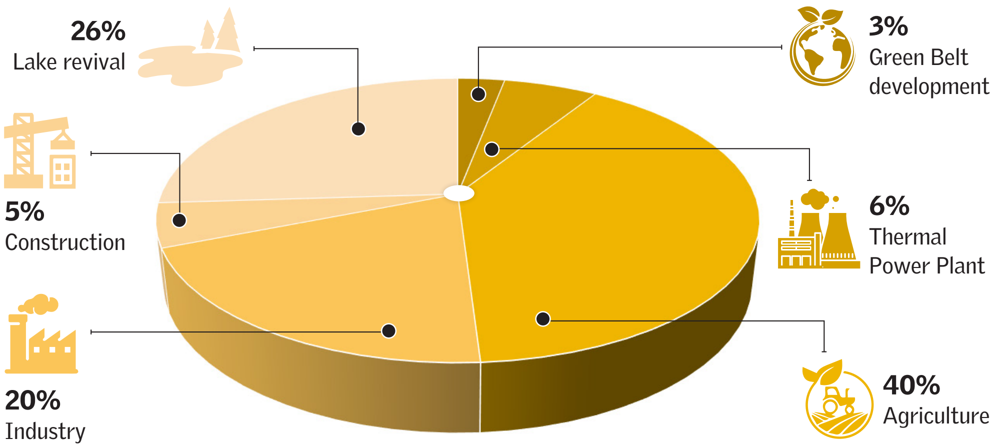
Source: Compiled by CSE

Map 13: Locations of visited STPs in seven states of India



Source: Prepared by CSE

Graph 11: Break-up of reuse in different sectors based on CSE analysis for visited STPs



Source: Based on CSE analysis

CONCLUSIONS DRAWN FROM THE STUDY

Treatment, compliance and monitoring

According to CPCB data, only 17 per cent of the total treated capacity complies with established treatment standards.[193] The significant disparity between sewage generation and treatment capacity, combined with a low percentage of treated water meeting compliance standards, presents a barrier to scaling up treated wastewater reuse initiatives.

As mentioned in the report, in Delhi, out of 37 STPs, 21 STPs have not been compliant with the norms laid out by the Delhi Pollution Control Committee (DPCC). In Maharashtra, 80 STPS out of 147 have not been meeting the norms of CPCB. In Pune alone, none of the STPs are complying with the standards.[194]

Therefore, state policies should incorporate clauses that mandate the involvement of appropriate provisions and institutions for monitoring treated water. These policies should also enforce compliance with performance criteria and require submission of annual reports to the designated authority.

Standards of reuse

During our study we found that the lack of standards pertaining to the reuse of treated water is a major hurdle towards widening the scope of its adoption. The standards prescribed by NGT and CPCB are for the discharge of treated water into waterbodies, not for reuse. The reuse of wastewater for different purposes requires varying levels of treatment depending on the intended use. However, the imposition of more rigorous norms for used water discharge faces challenges due to the considerable financial and economic burdens encountered by treatment plants.

Standards for reuse should be tailored to the specific purpose of use, and not on a one-size-fits-all approach. The extent and nature of treatment should be aligned with the intended reuse, fostering clarity in end-use standards.

The Haryana State Pollution Control Board has recently drafted standards for the discharge of treated wastewater from Sewage Treatment Plants (STPs) intended for various uses such as irrigation, industrial processes, construction activities, other non-potable uses, and groundwater recharge through lakes, ponds, water storage areas, natural or artificial depressions.[195]

Opportunities and challenges of expanding treated wastewater reuse

Despite the numerous benefits associated with wastewater reuse, our study reveals that its implementation is still not widespread throughout India. Only a limited number of states have made significant progress in promoting reuse practices, that too in big cities, while others have shown little to no advancement in this area.

In Haryana, out of the total sewage generation, Gurugram town accounts for approximately 50 per cent of the total treated water generated.[196] In Karnataka, out of the total treated wastewater in the state, 69 per cent is being reused only in in Bengaluru and nearby water-scarce districts for various purpose such as lake revival, industrial and irrigation.[197] Similarly, in Tamil Nadu, Chennai alone accounts for 58 per cent of the treated water reuse out of the total treated water reuse in state.[198]

State-level reuse strategies need to plan for and identify potential and constraints in the reuse of treated wastewater, create infrastructure for the same where possible.

Need for state policies developed through public engagement

Current reuse policies seem to have emerged as a default. The inability of state water utilities like Bangalore Water Supply and Sewerage Board (BWSSB) led to the enactment of regulations mandating apartment complexes above 50 units, and commercial and institutional buildings with more than 2,000 sq m to have an STP on-site. The ongoing water scarcity crisis in Bengaluru has led to the sale and reuse of treated water from decentralized institutional STPs (50 per cent of the treated wastewater from apartments for non-potable uses). Creating a wastewater market that could potentially meet 26 per cent of the city's water demand.[199]

States need to define reuse priorities first, have extensive public outreach and consultation processes in place, develop infrastructure for the conveyance of treated wastewater, establish financial models and programmes, and provide comprehensive guidelines. Polices need to be backed by bye-laws and notifications at the district/city-level and there should be effective monitoring of their implementation.

Defining reuse priorities and action plans—potential and constraints

State policy on reuse, when complemented by an action plan, has proven to be an effective strategy in enabling states to establish specific targets and goals for treated wastewater reuse. During our study, it became evident that states like Haryana and Delhi, which have implemented these action plans, are actively working towards their set targets, monitoring progress, and accelerating their efforts to achieve them within the specified timeframes.

Haryana has set the target for reuse at 80 per cent by 2030.[200] Similarly, the plan in Delhi follows a phased approach with specific targets, starting with 25 per cent of all sewage generated to be reused by 2017, and progressively increasing the reuse percentage to over 80 per cent by 2027, with the added objective of enhancing water availability.[201]

Reuse policies for both large metros and small to medium towns should prioritize the reuse of treated wastewater primarily for ensuring the drinking water security of residents, placing this above any other use. This needs to be explicitly defined in the state-level reuse policies and town-level reuse plans, and monitored rigorously every year with the engagement of civil society and the public at large.

In case of large coastal metro cities like Mumbai and Chennai, a major percentage of treated wastewater is discharged into the sea directly or through networks of local drain/rivers after assuring its quality and standard. Drainage and flood prevention are of priority in coastal areas, hence impounding groundwater has a constraint (although it is required for the prevention of salinity ingress). Reuse potential is limited in coastal areas due to its natural slope towards the sea. Transporting treated wastewater several hundred kilometers upstream for irrigation purposes would pose immense challenges and be highly cost-intensive.

Hence, the Sewerage Operations Department of Municipal Corporation of Greater Mumbai (MCGM) has taken up a programme to decentralize wastewater treatment. MCGM has made the recycle and reuse of wastewater compulsory for high-rise buildings and the construction of an STP mandatory for such buildings. Also, to promote recycle and reuse, the programme preparation of 'Grey Water Recycle Bye-laws' is in progress.

Need for an effective governance model

Policies must be implemented with an effective and transparent institutional setup to achieve equity and justice in the reuse of treated wastewater, prioritizing these goals over solely focusing on financial and operational efficiency.

In case of Haryana, the Integrated Water Resources Action Plan (IWRAP) and the reuse of treated water policy in Haryana are crucial initiatives that ensure the planned and timely execution of projects related to the reuse of treated water. Under IWRAP, all the major departments have prepared the month-wise, block-wise, district-wise and intervention-wise action plan for the next two years i.e. 2023–25. Additionally, the establishment of the Haryana Water Reuse Authority (HWRA) has provided significant momentum to the reuse of treated water in the state.

In Karnataka, Urban Local Bodies (ULBs) play a crucial role, with clearly defined responsibilities that include coordination with the dedicated Waste Water Reuse Resource Centre. This resource centre plays a vital role in capacity building, providing project assistance to ULBs through the preparation of integrated urban water resource management plans, and identifying viable wastewater reuse projects.

Prioritization based on equity, justice, environment and biodiversity

Water is above all a social good. Treated wastewater reuse must be guided by this perspective. Claims of treated wastewater reuse must be prioritized for meeting the most urgent requirements of drinking water supply augmentation, before considering agriculture or industrial demands. The large volumes of treated wastewater, especially in our large metros, should be prioritized for addressing equity and justice in water reuse, especially for underprivileged residents of unplanned and informal settlements, and for environmental and biodiversity considerations.

In Rajasthan, the reuse of treated water is practiced in industrial applications more commonly, mainly to secure their rights on treated water reuse in the absence of fresh water availability for water-intensive industries like cement, iron and zinc leading to a monopoly and privatization of the resource. Rajasthan being a dry state, other area-specific reuse options should be urgently explored and scaled up, such as lake revival and recharge of shallow aquifers, domestic water supply etc. The case study of Beawar town shows that the dry city is running out of water due to extraction by the cement industry. Keeping the pitfalls of monopolization and privatization in mind, the reuse of treated water should not be allowed for industry in the future.

The importance of lake rejuvenation for groundwater recharge, as well as for a climate-resilient blue-green infrastructure of cities, is gaining recognition. In Karnataka and states in southern India, where cascading tanks systems were a part of the water history of the region, the reuse of treated wastewater to revive and replenish lakes is a major initiative given the expanding urbanization and water stress. Groundwater recharge through lakes and water bodies' rejuvenation must be prioritized for the rest of the country as well, because groundwater dependence is high for peri-urban areas that host the majority of unplanned and dense urban settlements.

The Delhi Water Policy (Draft 2016) is perhaps the best example of water planning, as well as for the reuse of treated wastewater. It prioritizes water supply for domestic supply through lake revival for increasing groundwater recharge. Complete aquifer mapping has been done to identify potential recharge areas and areas that have been targeted for implementation. This kind of area-specific, planned approach needs to be adopted instead of looking at generic solutions for reuse.

CSE's study of the dense and unplanned settlement of Sangam Vihar has shown how the unplanned residential settlement with a population of a million receives only 45 litres of water per person per day. The same can be increased by planning lake recharge using treated wastewater from the nearby STPs, for any of the four large water bodies within a 15 kms radius. This will reduce dependence on long water supply pipelines, high pumping cost and distribution losses since Sangam Vihar is set in the very southern end of the city. The example of Seehineeru Lake in Devanhalli town in the peri-urban part of Bengaluru has shown how recycled water can recharge a lake and meet the water supply needs of the small town. In Tamil Nadu, the Nasapakkam project plays a crucial role in the Chennai Metropolitan Water Supply and Sewerage Board's (CMWSSB) water sustainability strategy. This initiative involves a 10 MLD tertiary treatment unit. Following tertiary treatment, the water is channelled into Porur Lake, where it is blended. Subsequently, the blended water undergoes treatment at a 6 MLD drinking water treatment plant in a 1:100 ratio and is then distributed to nearby settlements.

Local treatment and local reuse priority

Large sewage treatment plants are often located on the outskirts of cities due to significant land requirements. However, these plants face challenges in effectively reusing treated wastewater. For large STPs such as Bharwara in Lucknow, where substantial volumes of treated wastewater are discharged, there is limited opportunity for reuse due to the lack of demand centres nearby.

However, decentralized sewage treatment plants at the city-level offer a more suitable alternative as they require less space and can be established in various parts of the city, enabling reuse for different purposes.

The case studies of Delhi and Bangalore demonstrate the implementation of decentralized STPs located in different parts of the city. The treated water from these STPs is reused for various purposes, including lake recharge, recharge of shallow aquifers, industrial supply, and horticulture. In Delhi, the location of decentralized STPs at various locations in the city has proven to be an important element of strategic planning behind the City of Lakes programme. This programme involves constructing artificial lakes within STP premises, allowing natural percolation and groundwater recharge.

Bangalore's district has been split into three zones—KC Valley, HN Valley, and V Valley—aligned with the natural topography. Treatment plants (STPs) within each zone serve the reuse needs of that specific area only. Besides this, decentralized sewage treatment systems in the city are supplying treated used water for parks and gardens, and to an extent, the industries such as the STP with a capacity of 4 MLD located in Cubbon Park, wastewater after treatment is reused for horticulture in the same park.

This methodology eliminates the necessity for constructing extensive and often costly reuse infrastructure.

ANNEXURE

Annexure 1- Questionnaire and datasets used in the study

Questionnaire

Regulations and standards	1. What specific regulations and standards are in place governing the use of treated wastewater for agriculture? 2. How are these regulations and standards developed, and who are the stakeholders involved in the process? 3. How do you ensure stakeholders are aware of and comply with the regulations and standards for using treated wastewater in agriculture?
Health and safety	1. What specific measures are in place to ensure health and safety? 2. How do you assess and manage the potential health risks associated with the use of treated wastewater in various sectors? 3. Are there any specific guidelines or protocols for the safe handling, application and storage of treated wastewater in agricultural practices?
Monitoring	1. What are the key parameters and indicators that are monitored to ensure the safe and effective use of treated wastewater? 2. How frequently are monitoring activities conducted to assess the quality of treated wastewater? 3. What actions are taken if monitoring results indicate non-compliance with the established standards or guidelines for using treated wastewater?
Institutional framework	1. What is the existing institutional framework for the use of treated wastewater, and how are the responsibilities and roles of different stakeholders defined within this framework? 2. Are there specific government agencies or departments dedicated to overseeing and regulating the use of treated wastewater? 3. How do you ensure coordination and collaboration among different government agencies, regulatory bodies and certification agencies involved in the institutional framework?
Financial support/ Incentivization	1. What is the current financial structure in place to support the use of treated wastewater, and how are the costs and funding mechanisms allocated?
Planning	1. What are the key factors and considerations that influence the planning and implementation of treated wastewater reuse? 2. How do you ensure the efficient and effective distribution of treated wastewater to the targeted consumers? 3. How do you engage with stakeholders during the planning and implementation stages to understand their needs, preferences, and concerns?

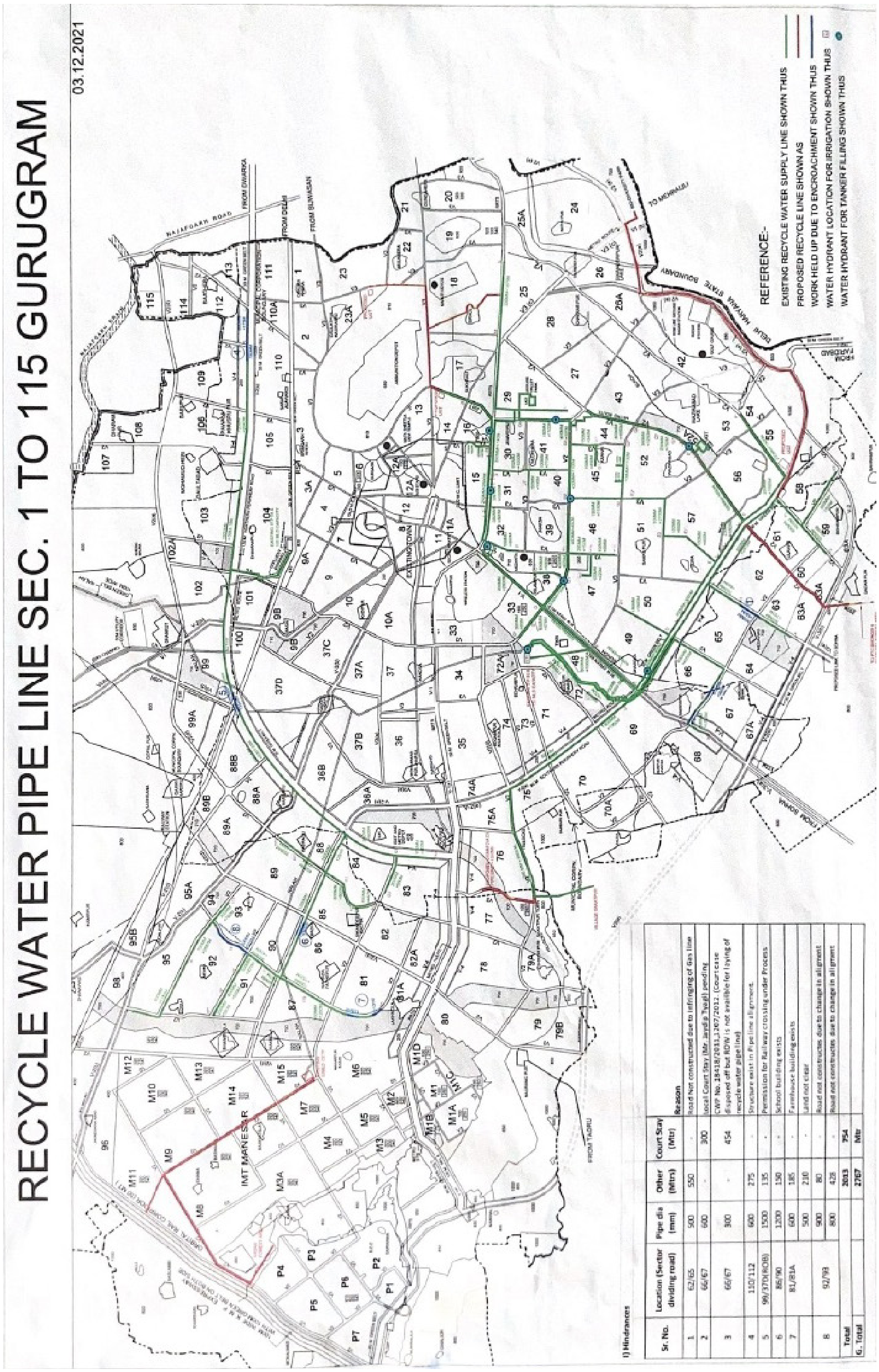
Questionnaire

Cost benefit analysis	1. How do you conduct a comprehensive cost-benefit analysis for the implementation of treated wastewater use? 2. What are the key cost components involved in the implementation, operation and maintenance? 3. How do you assess the economic benefits derived from using treated wastewater such as cost savings on freshwater resources or increased crop yields?
Conveyance mechanism	1. What are the key considerations when designing the conveyance system for treated wastewater from the source? 2. What are the challenges or limitations typically encountered during the conveyance of treated wastewater, and how are they addressed during the planning and implementation stages? 3. How do you ensure the efficient and effective transport of treated wastewater while minimizing losses, leaks or contamination risks? 4. Are there any guidelines or regulations in place for the design, construction, and maintenance of the conveyance infrastructure? 5. What measures or contingency plans are in place to address emergencies, such as leaks, spills, or natural disasters that may impact the conveyance of treated wastewater?
Operation and maintenance	1. How do you ensure the reliable and consistent supply of treated wastewater? 2. What are the measures that are in place to monitor and control the flow and distribution of treated wastewater to optimize water use efficiency and minimize wastage? 3. What maintenance procedures and schedules are followed for the infrastructure and equipment used in treated wastewater irrigation, such as pumps, filters, pipelines, and irrigation systems? 4. How is the performance of the treated wastewater reuse is evaluated and assessed, and what measures are taken to address any identified inefficiencies or malfunctions?
Outreach and capacity building	1. What strategies or approaches are employed to raise awareness among stakeholders about the benefits and best practices of using treated wastewater for agriculture? 2. How do you engage with local communities and farmers to ensure their participation and understanding of the treated wastewater use in agriculture initiatives? 3. How do you measure the impact and effectiveness of the outreach and capacity-building activities in promoting the adoption and sustainable use of treated wastewater in agriculture?

Data collection

Wastewater generation	Amount of wastewater generated daily or annually in the city. Breakdown of wastewater sources (industrial, residential, commercial). Seasonal variations in wastewater generation.
Infrastructure data	Detailed information on the existing wastewater treatment infrastructure, including the number, capacity of treatment plants and distribution. Operational efficiency and compliance with environmental standards.
Treatment processes and technologies	Technical specifications of the treatment processes and technologies employed in wastewater treatment plants.
Wastewater reuse projects	Information on existing projects that utilize treated wastewater for various purposes (e.g., irrigation, industrial processes, landscaping). Location and scale of these reuse initiatives.
Financial data	Budget allocations and expenditures related to treated wastewater reuse programs. Cost breakdowns for the construction, operation and maintenance of treatment facilities.
Economic model	Details on the economic model supporting treated wastewater reuse, including revenue streams and financial incentives for users. Information on any public-private-partnerships or collaborations.
Cost-benefit analysis	Cost of wastewater treatment and reuse projects. Economic benefits and savings associated with wastewater reuse. Return on investment (ROI) for different initiatives.
Monitoring and evaluation	Data on the monitoring of treated wastewater quality throughout the reuse process. Effluent quality after treatment, including parameters like biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), nutrient levels and pathogen concentrations.
Future plans and innovations	Information on future plans for expanding or improving treated wastewater reuse initiatives. Any ongoing or planned innovations.

Annexure 2: Master recycle water network map of Gurugram[211]



Annexure 3: Reuse of treated wastewater from different STPS in Karnataka

S. No.	STP	Total capacity utilized (MLD)	Capacity utilized (MLD)	Tread sewage reused (MLD)	Used for
1	Rajacanal	40	32.68	30.25	Irrigation and industrial
2	Rajacanal	40	40.51	40.18	Irrigation and industrial
3	Horamavu	20	16.57	14.96	Irrigation and industrial
4	Hebbal	100	86.54	84.5	Irrigation and industrial
5	K&C Valley	218	153.66	146.55	Lakes of Kolar
6	K&C Valley	30	31.41	30.27	Lakes of Kolar
7	Bellandur Amanikere	90	88.2	77.76	Lakes of Kolar
8	Jakkur	15	17.18	17.08	To KPTCL for power generation, remaining to Jakkuru lake
9	Sarakki	5	4.77	4.67	Proposal to recharge Sarakki lake
10	Lalbagh	1.5	1.23	1.17	Horticulture department
11	Cubbon Park	4	2.5	2.07	Horticulture
12	Yelhanka	10	9.97	1.76	Industrial
13	Yelemelle chetty	15	13.63	13.29	Lake
14	Chikkabanavar	5	4.88	4.59	Lake
15	Mailsandra	100	80.03	0.318	Horticulture
16	Kadugodi	6	5.22	5.2	Industry
17	Halasaru	2	1.93	1.89	Lake
18	Nagasandra	20	16.5	14.96	SWD
19	Nagasandra	20	14.57	14.96	SWD
20	Kadabeesanahalli	50	31.5	29.52	SWD
21	K R Puram	20	14.7	12.89	Lake
22	Doddabele	40	41.95	0.544	Other (For STP process and balance to downstream nalla)
23	Kengeri	60	56.3	2.15	Other (For STP process and balance to downstream nalla)
24	Doddabele	35	26.5	0.26	Other (For STP process and balance to downstream nalla)

25	K&C Valley	60	59.98	57.98	Lakes of Anekal
26	Hulimavu	10	8	9.33	Hulimavu Kere
27	Agaram	35	14.51	33.92	Agaram Kere
28	K&C Valley	150	148.2	146.11	Lakes of Kolar
29	KR Puram (New)	20	19.81	19.26	Vengaiana Kere
30	Chikka Beguru	5	4.24	4.19	Chikkabegur Kere
31	Hennur	1	0.5	0.48	To biodiversity park and SWD
32	Madiwala	4	2.08	1.99	Madiwala lake
33	V Valley	150	142.46		SWD
34	Hassan	10	10	2	Agriculture
35	Belur	5	2.4	0.4	Agriculture
36	Belur	0.3	0.3	0.3	Agriculture
37	Bannuru	3.8	1.7	1.5	Agriculture
38	Bannuru	0.15	0.06	0.05	Agriculture
39	Arasikere	12	6	6	Agriculture
40	Channarayapatna	4.6	4.6	1	Agriculture
41	Holenarasipura	3	3	0.5	Agriculture
42	Birur	2.64	0.3	0.15	Agriculture
43	Muddebihal	5.24	4	4	Treated sewage is discharged into nala for agriculture purpose
44	Tumkur	6	2.7	2.3	Agriculture
45	Mangaluru	43.5	27	27	Industry
46	Ballari	30	23	3	Industry
47	Kollegala	9	6	4	Agriculture
48	Chickmagalur	20	12	6	Agriculture
49	Basavana Bagewadi	0.25	0.2	0.2	Agriculture
50	Basavana Bagewadi	0.25	0.2	0.2	Agriculture
	Total	**1,537.23**	**1,340.47**	**883.65**	

Annexure 4: Water quality result - Seerineeru Lake, Devanhalli

Parameters	Desirable limits	Permissible limits	F2 (Cl after chlorination)	F1 (UV after uv treatment before chlorination)	Sump outlet traded water mixed with borewell water	FB1 filter borewell 1	FB2 to filter Borewell 2	Openwell water	Lake water
pH	6.5 - 8.5	No relaxation	8.4	8.7	7.3	6.8	6.8	7.6	8.4
EC			687	641	1,762	1,155	1,157	700	732
Total dissolved solids, mg/l	500	2,000	315	296	700	500	500	322	331
TSS			6	6	8	6	9	8	12
Turbidity	1	5	7	6	10	11	11	10	13
Fmg/l	1	1.5	0.6	1.2	2	1.1	1	1.2	1.1
Nitrates as NO3, mg/l	45	No relaxation	0.8	3.7	3.4	1.7	1.6	1.1	2.3
Nitrites			0	0.1	0	0.1	0.1	0.1	0.1
Sulphate as SO4, mg/l	200	400	17	18.7	39.5	56.4	5.5	16.7	18.4
Ammonia	0.5	No relaxation	0.1	0.6	0.1	0.1	0.1	0.1	0.2
Orthophosphates			0.01	0.01	0.01	0.01	0.01	0.01	0.02
COD			90	85	110	75	70	88	125
DO			8.2	8	7.8	7.9	7.9	7.9	7.3

** Test result dated 5, June 2023 conducted by Indian Institute of Science, Bengaluru.

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India's urban water crisis is escalating. Our reliance on sources, often hundreds of miles away, is becoming increasingly unsustainable. Major cities like Delhi, Bengaluru, Mumbai, Pune, Hyderabad and Chennai are staring at an impending water crisis. The solution to bridge the gap between water demand and supply lies not in finding more water but in reusing the treated water that we already have. This report is a call to action.

Based on a comprehensive analysis of 35 case studies across 16 cities in seven Indian states, the report assesses the current state of treated wastewater reuse in India. It examines existing policies, programs, and on-ground practices, providing valuable insights for policymakers and practitioners. It also highlights the critical importance of prioritizing treated wastewater reuse as a public good, particularly for irrigation and groundwater recharge, while ensuring equity and justice for underserved communities. It urges a critical revaluation of treated wastewater reuse from both a policy and practice standpoint. The urgency of water scarcity demands a fresh perspective on how we prioritize and utilize treated wastewater as a new and vital water resource. By promoting equity, fostering climate resilience, and advocating for sustainable water management practices, this report serves as a blueprint for building a robust framework for treated wastewater reuse across India.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phones: 91-11-40616000 Fax: 91-11-29955879
E-mail: cseindia@cseindia.org Website: www.cseindia.org