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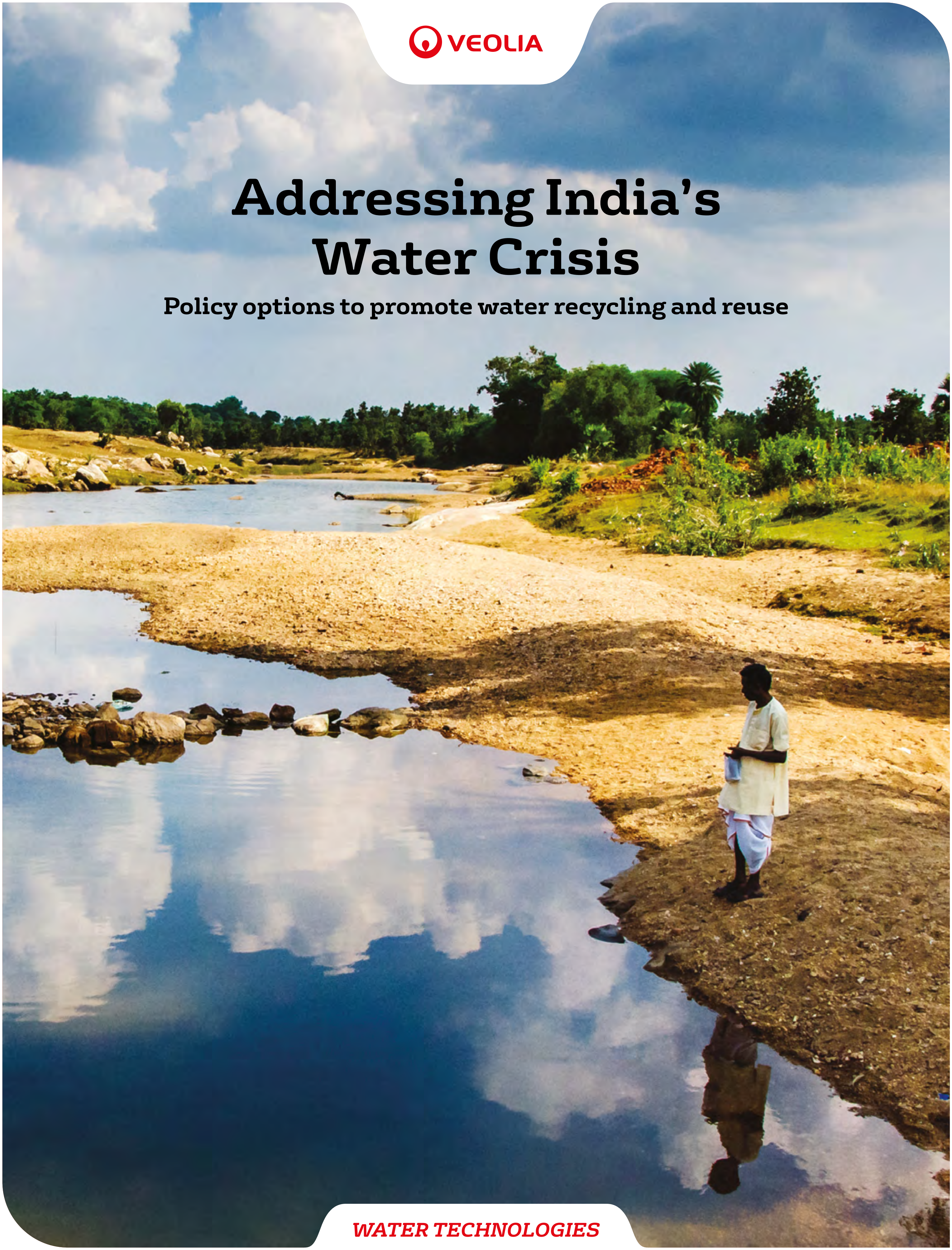
Addressing India's Water Crisis

Policy options to promote water recycling and reuse



WATER TECHNOLOGIES

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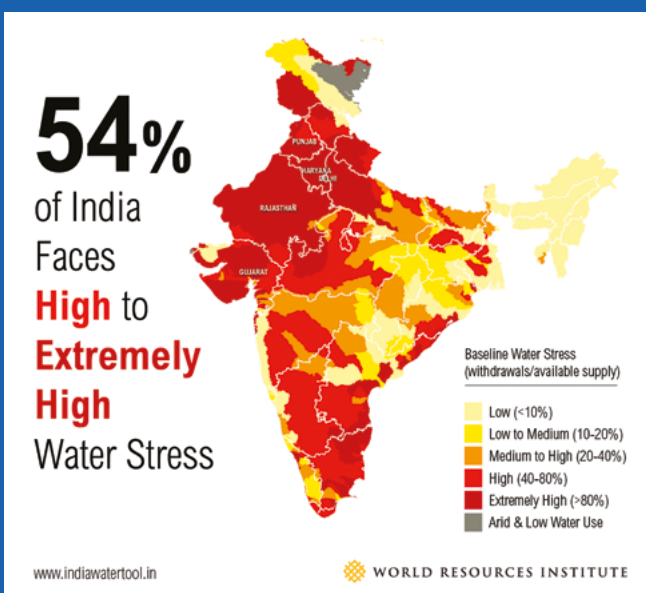
Executive Summary

This white paper summarizes India's water challenges, highlights the bold actions that the government is taking to address them, and provides a menu of policy options that the government can choose from as it evaluates ways to augment the impressive steps it has already taken.

India is experiencing the worst water crisis in its history with more than 600 million people facing acute water shortages.[1,2] Severe droughts have drained rivers, reservoirs, and aquifers across vast parts of India in recent years, pushing the nation's water systems to the brink.[3] At the same time, a booming population is placing unsustainable demands on the country's stressed water resources. Groundwater wells are declining and 21 major cities—including Delhi, Bangalore, and Hyderabad—are soon expected to run out of groundwater, affecting access for 100 million people.[4] Experts warn that India must act now to mitigate the impacts of this growing crisis.



World Resources Institute. 2015.

Despite the significant challenges, there is room for optimism, thanks to water management receiving increased policy attention over the past few years.[5] Flagship national missions and treated wastewater policies of several state governments - including Karnataka, Maharashtra, Gujarat, Jharkhand, Punjab and Haryana - demonstrate strong commitment at the national and sub-national levels to developing solutions to India's widespread water problems and ensuring safe, potable supplies for meeting the growing demands of residents, industries and agriculture.

This white paper provides a menu of policy options that the government can draw on as it evaluates ways to accelerate India's path toward water security. Based on India's unique water challenges and existing water management framework, Veolia believes water recycling and reuse holds vast potential for helping India address its water crisis and achieve a sustainable water future.

As India evaluates the optimal policies to enhance the resilience of its water resources, the examples in this white paper are intended to provide a range of options for increasing water recycling and reuse.

While policy needs can vary region to region based on local needs and specific challenges, most policy options fall into 4 main categories:

- Education and Outreach
- Removing Barriers
- Incentives
- Mandates, Regulations and Standards

By bringing together a varied collection of policy options and concrete examples from around the world into one resource, this white paper seeks to help the government of India make informed decisions and pull from proven solutions that can lead to a more resilient water future.

[1] NITI Aayog. Composite Water Management Index. June 2018.

[2] World Resources Institute.

[3] MIT Technology Review. India's water crisis is already here. Climate change will compound it. Apr 24, 2019.

[4] NITI Aayog. Composite Water Management Index. June 2018; World Bank.

[5] NITI Aayog. Composite Water Management Index. June 2018.

India's water crisis and a path to a sustainable future

India's Water Challenges

India's water challenges are multifaceted and diverse. Ranked as the world's 13th most water-stressed country by the World Resources Institute's Aqueduct Water Risk Atlas, both surface water and groundwater in India are highly exploited.[6] At the same time, precipitation occurs unevenly across the country. Nearly a third of India's geographical area is drought-prone whereas 12% is prone to floods.[7] Additionally, more than 80% of India's rainfall occurs during the monsoon months of June to September and often over very short periods, causing significant runoff.[8] As of 2018, India had experienced deficit monsoons in 13 of the previous 18 years.[9]

Overpopulation and Urban Migration

With approximately 1.37 billion people, India is the second most populous country in the world. However, India is projected to surpass China and become the most populous by 2027.[10] As India grows, its population is outstripping the available water supply. By 2030, the country's water supply is forecasted to be only half of demand.[11] India's population is also becoming increasingly concentrated in urban areas. Between 2018 and 2050, India's urban population is predicted to grow more than any other country, nearly doubling in size.[12] Migration to already-stressed urban centers is putting additional strains on overallocated freshwater resources.[13]

Dwindling Groundwater Supplies

India is heavily reliant on its aquifers to meet potable demand. Yet, drought and over extraction have significantly reduced groundwater levels across the country. Groundwater resources—which account for 40% of India's water supply—are being depleted at unsustainable rates.[14] At least a third of India's groundwater reserves are being pumped at much faster rates than they are being recharged by rainfall.[15]

A Central Ground Water Board assessment of 5,723 blocks (subdistricts) across India found that 28% were either overexploited (839), critical (226), or semi-critical (550).[16] India's groundwater crisis is partially driven by a poorly defined legal framework governing extraction, and is most acute in the agriculture sector where groundwater supplies 63% of total irrigation demand.[17,18]

Water Pollution

Water pollution is a significant factor contributing to India's water crisis. Nearly 70% of the country's water is contaminated and India is ranked 120th among 122 countries in a global water quality index.[19] Untreated urban and industrial wastewater—which is often discharged directly into surface waters—are the main sources of water pollution. Just 30% of wastewater undergoes any sort of treatment before being discharged and raw sewage

[6] Pandey, Kiran. India world's 13th most water-stressed country: WRI. Down To Earth. August 2019.
[7] Lahiry, Samar. Why India needs to change the way it manages water resources. Down To Earth. July 2017.
[8] Chakraborti et al. Water Shortage Challenges and a Way Forward in India. Journal AWWA. May 2019.
[9] Pandey, K. and Sengupta, R. India Had a Deficit Monsoon in 13 of the Last 18 Years. Down To Earth. October 2018.
[10] United Nations. World Population Prospects 2019: Highlights. June 2019.
[11] NITI Aayog. Composite Water Management Index. June 2018.
[12] United Nations. World Urbanization Prospects. 2018.
[13] Chakraborti et al. Water Shortage Challenges and a Way Forward in India. Journal AWWA. May 2019.
[14] NITI Aayog. Composite Water Management Index. June 2018.
[15] Schneider, K. Groundwater Scarcity, Pollution Set India on Perilous Course. Circle of Blue. December 2018.
[16] Central Ground Water Board. 2019
[17] NITI Aayog. Composite Water Management Index. June 2018.
[18] World Resources Institute.
[19] NITI Aayog. Composite Water Management Index. June 2018.

and industrial wastewater contaminated with metals and chemicals irrigate much of the nation's food.[20] Exacerbating India's water pollution problem are sporadic monsoons and soaring summer temperatures which serve as a catalyst to bacteria growth in water, further reducing the amount of safe water.[21]

Water Inefficiency in Agriculture

Agriculture is the primary source of livelihood for approximately 58% of India's population and water use for crop irrigation has been estimated at between 80% and 90% of the country's total usage.[22,23] However, for such a vast water consumer, the agricultural sector's use and distribution of water is inefficient, unsustainable, and inequitable.[24] Major irrigation networks in India operate at a mere 38% efficiency, contributing to rising water insecurity.[25]

Agriculture in India is misaligned and a major source of the country's water problems, contributing to depletion of groundwater tables at an alarming rate.[26] Paddy and sugarcane crops, which use more than 60% of the available irrigation water in India, are largely being cultivated in the most water scarce regions of the country, thus restricting irrigation water availability for other major crops of the region.[27] Reinforcing incentives for avoiding freshwater extraction and groundwater exploitation through water reuse could improve the irrigation water productivity in agriculture.

[20] Möller-Gulland, Jennifer. Toxic Water, Toxic Crops: India's Public Health Time Bomb. Circle of Blue. September 2018.
[21] Rajawat, Somya. Drought and Water Security in India. Future Directions International. June 2016.
[22] India Brand Equity Foundation. Agriculture in India: Information About Indian Agriculture & Its Importance. September 2019.
[23] NITI Aayog. Composite Water Management Index. June 2018.
[24] Dhawan, Vibha. Water and Agriculture in India: Background paper for the South Asia expert panel during the Global Forum for Food and Agriculture. 2017.
[25] Iyer, Parameswaran. Infrastructure and Investments in Water and Sanitation in India. June 2018.
[26] Saranga, Haritha. Misaligned agriculture: A major source of India's water problems. Forbes India. July 2018.
[27] Sharma, Bharat et al. Water Productivity Mapping of Major Indian Crops. 2018.

Actions by India to address water scarcity

The government of India recognizes the urgent need to address its water crisis and has taken important steps to enhance its governance of water. Recent actions reflect India's commitment to develop more effective approaches for managing its complex water resources. In fact, the Ministry of Jal Shakti (MoJS) has requested the National Mission for Clean Ganga (NMCG) to coordinate the process of formulating a Treated Wastewater Reuse policy. A policy working paper is being developed through expert consultation as the first step.

Jal Jeevan Mission

In August 2019, Prime Minister Narendra Modi addressed India's growing water crisis by announcing that Rs 3.5 lakh core will be spent in the next five years on the Jal Jeevan Mission to provide potable water to all rural households by 2024. The Jal Jeevan Mission (Har Ghar Jal) incorporates an integrated approach in rural water supply by including mandatory provisions for grey water treatment and reuse, along with water conservation. The program includes:

- Developing a piped water supply that would deliver 55 liters per capita per day under normal conditions;
- Building water conservation efforts at the local level;
- Regulating groundwater extraction;
- Rejuvenating water sources through local infrastructure (rainwater harvesting, groundwater recharge, management of household wastewater);
- Developing improved practices and policies for wastewater management; and
- Intensive afforestation.

Regions where groundwater availability has reached critical or overexploited levels will be prioritized. In regions with adequate water quality, piped water will be sourced and supplied at the village level. In regions with poor water quality, a truck water supply system will deliver water to village clusters.

Jal Shakti Abhiyan Water Conservation Campaign

Built on citizen participation and collaborative efforts on behalf of the central and state governments, the Jal Shakti Abhiyan water conservation campaign was carried out over two phases in 2019. Government of India officers, groundwater experts and scientists worked with state and district officials in India's most water-stressed districts to advance water conservation and water resource management by focusing on accelerated implementation of five intervention areas which included:

- Water conservation and rainwater harvesting;
- Renovation of traditional water bodies;
- Reuse/borewell recharge structures;
- Watershed development; and
- Intensive afforestation.

Establishing a Unified Ministry of Jal Shakti

Responding to the escalating water crisis, the government in May 2019 merged the Ministry of Water Resources, River Development and Ganga Rejuvenation and the Ministry of Drinking Water and Sanitation into the Ministry of Jal Shakti with the goal to manage water resources in a more integrated and holistic manner.

Swajal Scheme Project

Launched in 2018 by India's Ministry of Drinking Water and Sanitation, the Swajal Scheme is a community owned program that aims to provide clean drinking water in an integrated manner to people in rural areas. Funded mostly under the National Rural Drinking Water Program, the Swajal Scheme targets 115 rural districts in India to receive sustained water supply.[28,29]

National Water Quality Sub Mission

In 2015, the government of India formed the National Water Quality Sub Mission (NWQSM) to address contaminated drinking water sources and provide good quality drinking water in approximately 28,000 habitations impacted by groundwater contamination from arsenic, fluoride and other elements. The program aims to move India closer to international standards of water quality by 2020.

[28] Iyer, Parameswaran. Infrastructure and Investments in Water and Sanitation in India. June 2018.
[29] India Today. Government launches schemes to provide clean water to rural districts. June 2018.

Water recycling and reuse: The path to a more sustainable water future

Overview

India's urban population is projected to grow rapidly and generate mounting volumes of urban wastewater, driving the need for investments in wastewater systems to manage flows and protect downstream areas. With only 30% of wastewater treated before discharge (and a small amount reused), India has an immense opportunity to capitalize on projects that treat wastewater for recycling and reuse. Widespread water recycling and reuse offers a reliable, long-term water supply source for helping meet both potable and non-potable demand.

By reusing water, India can significantly increase the utility gained out of all available water and help bridge the supply-demand gap.[30] Reclaimed water could also represent a key supply for meeting the country's vast agricultural demand, reducing the strain on depleted groundwater resources. Further non-potable uses of reclaimed water include landscape watering, toilet flushing, fire protection, dust control, and air-conditioning. In industry, reclaimed water treated to higher qualities can be used for cooling applications, as boiler feedwater, or to help meet a variety of industrial process water needs. In addition, reclaimed water purified to drinking water standards can be used to recharge aquifers, and augment reservoirs and potable supplies.

When water recycling and reuse is deployed onsite or relatively near an end use, energy can be saved by avoiding the need to transport water over long distances. Furthermore, tailoring water quality to specific water uses reduces the energy needed to treat water.[31]

Energy Neutrality and Digital Water

As water recycling and reuse is implemented, forward-looking investments in resource recovery, energy efficiency and digital water should be considered to maximize the value and effectiveness of projects.

Measures to increase the energy efficiency of water recycling and reuse, and advance energy neutrality in the future, are especially vital to help mitigate India's rising energy demands. From 2011 to 2016, annual national electricity consumption grew by more than 25%, driven by industrial, domestic and agricultural needs.[32] Higher temperatures in future years will likely increase electricity demand due to higher air conditioning use, and hydropower production may be reduced because of decreased precipitation.[33]

At the same time, India faces mounting energy demand from the country's immense wastewater treatment needs, driven by the large amount of energy that is required to run conventional wastewater systems. Here the use of waste-to-energy technologies such as anaerobic digestion, convert organic wastes, municipal solid waste, and industrial effluent into biogas. This can be used for producing electricity and heat, as well as a green fuel (Bio CNG) in transportation, offering a viable option for addressing the energy demand. Technologies that recover water can work in close conjunction with those that recover nutrients and energy—helping facilities to become energy neutral. By producing renewable energy onsite, energy recovery solutions help reduce dependence on fossil fuels.

[30] NITI Aayog. Composite Water Management Index. June 2018.
[31] U.S. Environmental Protection Agency. Water Recycling and Reuse: The Environmental Benefits.
[32] Water Use in India's Power Generation: Impact of Renewables and Improved Cooling Technologies to 2030. World Resources Institute. January 2018.
[33] Chakraborti et al. Water Shortage Challenges and a Way Forward in India. Journal AWWA. May 2019.

Programs that incorporate robust resource recovery can transform treatment plants from large energy consumers into energy positive facilities. By harnessing resources from wastewater, Indian cities may be able to simultaneously gain a clean source of water, energy and improved sanitation.[34]

Similarly, India can leverage the benefits of digital water technologies to optimize water recycling and reuse as well as minimize non-revenue water (NRW) that is either lost through leakage, incorrect metering or theft. Average NRW in India has been estimated between 20% and nearly 32%.[35,36,37] Ageing and poorly constructed infrastructure are no doubt the major causes of NRW in India, although theft and corruption are playing an increasingly bigger role.[38]

Preventing NRW is integral to a sustainable, long-term water management strategy. By harnessing monitoring technologies including data and analytics, India can improve the performance of its water distribution systems. Such technologies collect and analyze data in real-time to detect flaws, reduce unplanned downtime, lower operating costs, and enable better decisions.

Digital water solutions include asset performance management (APM) tools that connect disparate data sources and use advanced analytics to turn data into actionable insights. By connecting APM technology to a wastewater treatment plant, plant operators can collect real-time data from multiple sources on operating conditions to diagnose potential problems and report on key performance indicators.

APM tools can also provide information on trends over time, helping operators discover opportunities to enhance operations and lower energy costs. As an example, APM can help reduce energy usage within a plant by monitoring and optimizing the cleaning and cycling process of membranes.

Further digital water solutions include “intelligent” pipeline technologies that provide advanced detection and control of water distribution networks, enabling rapid identification of hidden leaks and ranking of potential danger zones where high consequence failures are more likely to occur. By bringing together critical data sets, intelligent pipeline solutions deliver near real-time situational awareness of daily risk identification on pipeline assets, as well as the analytic capabilities to extract actionable, predictive data insights from pipeline data sets.

[34] Boggaram, Vittal and Goswami, Sahana. From Waste to Watts: How Sewage Could Help Fix India’s Water, Energy and Sanitation Woes. World Resources Institute. March 2017.
[35] Rajawat, Somya. Drought and Water Security in India. Future Directions International. June 2016.
[36] Asian Development Bank. Benchmarking and Data Book of Water Utilities in India. 2007.
[37] Ministry of Water Resources India. Report of the Working Group on Water Resources for the XI Five Year Plan (2007–2012). 2006.
[38] Rajawat, Somya. Drought and Water Security in India. Future Directions International. June 2016.

Policy options to encourage water recycling and reuse

Water recycling and reuse is most common in communities that face limited water supplies. These communities often combine aggressive water conservation measures with water recycling initiatives to address current, as well as future, water scarcity challenges.

The purpose of this white paper is to help the government of India think through its options for increasing recycling and reuse of water. The paper is built around a menu of policies being used in different locations around the world to advance water recycling and reuse including efforts to:

- provide more information on, and recognition of, water recycling and reuse efforts
- reduce or remove regulatory or cost barriers that prevent more water reuse or recycling
- Provide financial, regulatory or other incentives for water recycling and reuse
- Promote more water recycling and reuse through clear regulations and/or mandates

This menu offers a spectrum of policy options ranging from less intensive mechanisms, such as making information available, to more proactive, regulatory approaches that mandate water reuse. Examples of how these policies are being applied in communities around the world are included below each section. Since each community has unique water, economic, social and other needs, this menu is best seen as a tool to help spark discussion of what set of policies might work best in any particular situation or for any particular group of users.

1. Education and Outreach

Education and outreach are generally perceived as critical to not only advancing and encouraging water recycling and reuse, but for overcoming any public concerns about the safety and quality of recycled water.

Water reuse projects will have a higher rate of success if outreach can help the public understand that today's treatment technologies can purify water to any level of quality desired. In this regard, communication should emphasize that water purification technologies are proven to remove pathogens, viruses and other contaminants to produce reusable water that is safe for potable use.

Due to the importance of gaining public trust, most communities with a water recycling program also have active public education and community outreach programs. These programs are often supplemented by state and regional-level government campaigns.

Similar public education and outreach programs are also employed where renewable energy programs and digital water solutions are used. As with water recycling and reuse, these programs are often supplemented by broader governmental campaigns.

Local communities and governments raise awareness through many common techniques. Some of these techniques are highlighted here.

	Policy options Education and outreach	Reference examples
1.1	Create national awareness and commitment via a national water reuse plan.	Example 1.1
1.2	Recognize successful projects through awards and certification programs.	Example 1.2
1.3	Establish reporting programs requiring major water consumers to file annual 'water returns' that disclose information such as water consumption data, water utilization per unit produced, and effluent discharge data.	Example 1.3
1.4	Create programs for information dissemination, strategic communications, and educational outreach.	Example 1.4
1.5	Improve skillsets and capabilities through technical assistance, training and certification programs.	Example 1.5

Example 1.1

Create national awareness and commitment via a national water reuse plan

As India considers the most effective path forward with respect to achieving greater water recycling and reuse, a relevant example of a comprehensive water reuse plan organized at the national level is available from the U.S. Environmental Protection Agency (EPA). The EPA's National Water Reuse Action Plan (WRAP) is a coordinated and collaborative effort across the water user community to advance consideration of water reuse to ensure the security, sustainability, and resilience of the nation's water resources. The WRAP seeks to advance water reuse through actions that will help communities, policymakers, water resource planners and practitioners, and other stakeholders to match potential sources of water that can be provided at a quantity and quality needed for identified applications.

The WRAP: Collaborative Implementation (Version 1), released in February 2020, describes 37 actions with over 200 implementation milestones to support consideration of water reuse that can improve available freshwater portfolios. The actions represent initial momentum and serve as a catalyst for additional partnerships and subsequent actions to strengthen and diversify water resources.

Example 1.2

Establish recognition awards and certification programs

- The EPA recognizes public and private entities for water conservation and recycling efforts through its WaterSense Award.
- WateReuse California recognizes agencies, customers, and individuals that have demonstrated exceptional leadership in advancing water recycling in California. Winners are presented with awards each year at WateReuse California's annual conference.
- In April 2015, the Mayors of San Jose and Santa Clara, California each took sips of recycled water from the recently completed Silicon Valley Advanced Water Purification Center. The event's purpose was to showcase the safety of the water and to promote indirect potable reuse.
- Each year, Global Water Intelligence (GWI) presents the Global Water Awards, which acknowledge the most important achievements in the international water industry relating to several categories. One category is the Water Reuse Project of the Year which has recognized winning projects in Jeddah, Saudi Arabia; King County, Washington; and Big Spring, Texas. The Global Water Awards also recognize companies that adopt digital water solutions. For example, the "Water Performance Initiative of the Year" award recognizes the most significant commitment to improving long-term performance of water services to the public. Additionally, the "Water Technology Idol" award is presented to the early-stage company whose technology could change the future of the water market.[39]
- The American Biogas Council (ABC) presents its Biogas Industry Awards each year to recognize biogas projects and technology innovations that are exceptional examples for replication in future biogas projects.

[39] http://www.globalwaterawards.com/2015#WaterTechIdol

- The Water Industry Alliance of South Australia (WIA), a cluster of 150 water-related organizations focused on sharing South Australia's water expertise with the world and growing the region's water industry, hosts an annual Smart Water Awards to recognize excellence in this field. The WIA awards seven categories including smart water solutions for water treatment and reuse.[40]
- The Certified Water Efficiency Professional (CWEP) program presented by the Association of Energy Engineers is designed to help educate and qualify individuals in the water/energy management field on best-practices for improving water efficiency. By obtaining the CWEP certification, candidates gain industry and peer recognition by demonstrating their understanding of technical and operational water management principles.[41]

Example 1.3

Establish Reporting Programs

- Australia has been producing National Performance Reports on water management, including water reuse, for more than eight years.
- The Florida Department of Environmental Protection publishes an annual reuse inventory, which is one of the largest and most comprehensive databases of reuse systems in the world.
- CDP (headquartered in London, U.K.) runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts. The CDP water program responds to the ever-growing need to address the global water crisis by asking companies to disclose their impacts on climate change and, more specifically, their water management practices. The data that CDP collects helps influential decision makers to reduce risk, capitalize on opportunities and drive action towards a more sustainable world.

[40] https://www.waterindustry.com.au/Public/About_Us/Public/AboutUs/About_Us.aspx?hkey=a75a93b6-d5f7-43aa-bcd9-16d3f1b75f2b
[41] https://www.aeecenter.org/certifications/certifications/certified-water-efficiency-professional

Example 1.4

Promote information dissemination, strategic communications, and educational outreach

- Singapore's National Water Agency created the NEWater Visitor Centre to enhance public understanding of water treatment technologies and the benefits of water reuse as a supply option. Promoting an authentic learning experience, the Centre utilizes educational workshops and interactive displays for advancing a more holistic understanding of water treatment and reuse within the context of the water cycle.
- The British Columbia Government of Canada's Living Water Smart Program offers publicly accessible water data and mapping tools to find regional information about water, climate, and the environment. Residents may also find information about water use and rights in different regions. The program offers federal and provincial monitoring data about water quantity and quality.[42]
- The South Korean Government's Ministry of Land, Infrastructure, and Transportation organized the SMART Water Grid International Conference to gather professionals to present and discuss the latest technologies, methodologies, practices, and research advances in the development and implementation of a Smart Water Grid and its water management plans.[43]
- The Queensland State Government of Australia engaged in a robust public relations campaign to bolster support for the capacity of digital water solutions to reduce water usage and utility bills, leading to a 12-month trial for digital water meters in Queensland's Sunshine Coast. Residents can check their daily water usage, analyze consumption through a self-service dashboard, and receive electronic alerts of leaks from state-owned utility, Unitywater.[44]
- To merge the roles of innovator and end user, the District of Columbia Water and Sewer Authority—based in Washington D.C.—launched the DC Water Open Innovation Challenge which encourages employees to identify emerging technologies and upcoming regulatory changes, undertake scientific research, and ultimately make recommendations for new technologies or practices to be implemented.[45]
- The EPA launched the Combined Heat and Power (CHP) Partnership that seeks to reduce the environmental impact of power generation by promoting the use of CHP. The program works closely with energy users, the CHP industry, state and local governments, and other clean energy stakeholders to facilitate the development of new projects and promote their environmental and economic benefits.[46]
- To address the challenges of excess wastewater and a lack of freshwater in China, the government of the People's Republic of China (PRC) is teaming with the Asian Development Bank, private companies, and communities to find innovative and cost-effective ways to turn wastewater into clean, usable water. One example is the Wastewater Treatment and Reuse Project which supports a series of wastewater treatment projects for meeting reuse water quality across the PRC.[47]
- To build support and acceptance of direct potable reuse, the WateReuse Association in February 2015 launched a project titled, "Model Communication Plans for Increasing Awareness and Fostering Acceptance of Direct Potable Reuse." The project will help to develop communication plans at the state and community levels.

[42] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-planning-strategies/living-water-smart
[43] http://www.swgic.org/
[44] http://www.itnews.com.au/news/sunshine-coast-to-get-digital-water-meters-430616
[45] Chawaga, Peter. DC Water Develops Its Own Future With Open Innovation. Water Online. May 2016.
[46] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-planning-strategies/living-water-smart
[47] Asian Development Bank. Meeting the Wastewater Challenge in the People's Republic of China. October 2016.

Example 1.5

Improve Skillsets and Capabilities

- To support the use of alternate water sources in buildings, San Francisco Public Utilities (located in San Francisco, Calif., U.S.), along with the San Francisco Department of Building Inspection and the San Francisco Department of Public Health in March 2015 published the guidebook, "San Francisco's Non-potable Water Program."
- The United Nations, through its Institute for Water Education, runs the annual course "Advanced Water Treatment and Reuse" which is recognized across different European institutions of higher learning.
- In 2015, the U.S. Department of Energy, the EPA, and the National Science Foundation (NSF), hosted the Energy-Positive Water Resource Recovery Workshop to discuss barriers to the development and deployment of the water resource recovery facilities (WRRFs) of the future, which could effectively manage more diverse waste streams, generate fuel, produce water and fertilizer, and help communities recover other valuable resources.[48]
- Recognizing that intelligent metering has the potential to revolutionize customer engagement and management of urban water by utilities, researchers from Australia's Institute for Sustainable Futures at the University of Technology Sydney and the Centre for Infrastructure Engineering and Management at Griffith University released a paper that reviews the drivers, development, and global deployment of intelligent water metering. "Intelligent Metering for Urban Water: A Review" provides a summary of the knowledge base for researchers and industry practitioners to ensure that the technology fosters sustainable urban water management.[49]

[48] https://energy.gov/eere/bioenergy/energy-positive-water-resource-recovery-workshop-report
[49] Thomas M. Boyle, Damien Giurco, Pierre Mukheibir, Rodney Anthony Stewart. Intelligent Metering for Urban Water: A Review. Water — Open Access Journal. September 2013.

2. Removing barriers

Barriers to water recycling and reuse, energy neutrality, and digital water come in several forms and can include regulatory, technical, and financial obstacles. Additionally, a lack of collaboration and information sharing between organizations can be a barrier to the implementation of projects.

Multi-Stakeholder Platforms (MSPs) established under government leadership, together with strong private sector and civil society participation, are building stakeholder capacities in design and implementation of wastewater reuse programs at the state and city levels in Karnataka, Maharashtra and Uttar Pradesh.

Addressing barriers to water recycling and reuse

Regulations that are intended to protect the public or programs that provide services to the community may have the unintended effect of discouraging or even preventing voluntary water recycling and reuse. One of the largest barriers to water recycling and reuse are municipal, state, or regional water codes that do not recognize the use of recycled water. For example, water recycling and reuse is hindered when local regulations mandate that all water used in a community meet potable water standards.

Other requirements and actions that present barriers to water recycling and reuse include:

- Building and plumbing codes that prohibit the installation of the dual piping necessary for recycled water or grey water use.
- Regulations that impose stringent permitting and inspection requirements for recycled water regardless of the use or risk of human exposure; for example, imposing the same set of standards on a water recycling and reuse system in an industrial chemical manufacturing facility as for residential lawn irrigation.
- Actions that encourage (or do not discourage) potable water use, such as subsidizing construction of potable water systems or not imposing full cost pricing on potable water use.

	Policy options Removing barriers	Reference examples
2.1	Update building and plumbing codes to encourage dual plumbing necessary for wastewater reuse.	Example 2.1
2.2	Design adequate infrastructure, efficient collection and conveyance systems, and establish maintenance programs to facilitate and encourage wastewater recycling and reuse.	Example 2.2
2.3	Allow Urban Local Bodies (ULBs) and State Industrial Development Corporations (SIDCs) to assist and facilitate offtake agreements; expedite permits, easements, and right of ways; and encourage water recycling and reuse.	Example 2.3
2.4	Update outdated regulations and mandates based on newer reporting mechanisms.	Example 2.4
2.5	Incorporate digital water technologies into smart city initiatives to maximize the effectiveness of water recycling and reuse.	Example 2.5
2.6	Update bidding norms for government contracts with equal weight given to quality, technology, and bidder experience.	Example 2.6

Example 2.1

Update Dual Plumbing Codes

- In March of 2016, four international plumbing and building codes—the 2015 International Residential Code, 2015 International Plumbing Code, 2015 Uniform Plumbing Code and 2015 International Green Construction Code—adopted the NSF/ANSI 350 standard for water reuse systems, which establishes material, design, construction and performance requirements for onsite residential and commercial water reuse treatment systems.[50]
- Canada has been ramping up its implementation of reuse/reclaimed water regulations and codes. Canada's National Plumbing Code was updated in 2010 to include a grey water reuse standard; design and installation of non-potable water systems were added to Quebec's Construction Code in April 2014; British Columbia's 2012 Plumbing Code expanded permitting of grey and black water systems; and Alberta's Environment and Sustainable Resource Development (ESRD) Ministry is working to complete a policy directive to guide reuse applications (est. 2015).

Example 2.2

Design infrastructure, collection and conveyance systems, and maintenance programs to support wastewater reuse

- Policies that require wastewater infrastructure and collection and conveyance systems to be designed to support water recycling and reuse will help remove constrains to such projects.

Example 2.3

Allow ULBs and SIDCs to assist and expediate water reuse projects

- Policies that enable ULBs and SIDCs to streamline approval and permitting processes will work to accelerate the adoption of water recycling and reuse schemes.

Example 2.4

Update outdated regulations that restrict water reuse

- In France, the Decree Order of 2014 (Article R211-23 of the Code of the Environment) streamlined approvals for the use of treated wastewater for agricultural purposes.
- In 2012, the City of Irving, Texas petitioned the Texas Commission on Environmental Quality (TCEQ) to amend the definition of "Municipal Use" in §297.1(32) to allow indirect reuse of treated wastewater effluent for watering of parks, golf courses, and parkways as a municipal use. The CEQ in July 2013 adopted an amendment to the Texas Administrative Code as requested in the petition. In addition, the CEQ expanded authorized uses to include watering of other public or recreational spaces.
- In 2015, the International Standards Organization (ISO) released a new standard that applies to agricultural irrigation projects that use reclaimed wastewater. The ISO 16075 series contains guidelines for the development and execution of treated wastewater projects, including design, specifications, components, and performance.[51]

[50] http://www.nsf.org/newsroom/four-plumbing-and-building-codes-adopt-nsf-ansi-350-standard-for-water-reus
[51] https://www.iso.org/news/2015/11/Ref2023.html

Example 2.5

Incorporate digital water technologies with smart city initiatives

- In 2016, Dubai (United Arab Emirates) launched a five-year strategy called Smart Dubai 2021. One of the goals of Smart Dubai 2021 is to foster a clean environment by utilizing cutting-edge information and communications technology. Dubai's water, energy, sewerage, drainage, waste distribution networks, buildings, and traffic lights are monitored through Internet of Things (IoT) platforms. This not only allows Dubai to provide more reliable and better services but to also provide efficiencies. For example, outages in water supplies can be detected immediately and faster recovery is possible. Similarly, leaks in water networks and their locations are detected in a much more reliable manner to minimize loss.[52,53]
- In February 2019, the city of Markham in Ontario, Canada, partnered with Bell Canada and IBM on a smart city pilot project to monitor water flow and flooding. The Smart City Accelerator Research Program will utilize Bell Canada's broadband networks and IBM's data and analytics technology to track real-time data about the conditions of the city's water systems.[54]
- In South Korea's "Songdo" Smart City, a new city built on the peninsula off the coast of Seoul, the government has engaged in city-wide planning efforts to integrate water, energy, communications, and transportation systems. The wireless sensor networks used in Songdo are designed specifically to create smart cities. City authorities have equipped the water distribution system with sensors for leak detection, pipeline management and storm water management as well as water quality and asset performance management in water treatment.[55]
- In conjunction with the Israeli Smart City initiative in Jerusalem, the city's water utility, the Hagihon company, deployed over 2,000 remote sensors in its 1,200 km of pipes. Along with quality metrics that affect the integrity of the pipes, the sensors also monitor pressure through the network. In addition to identifying peak demands in real-time, and adjusting supply treatment accordingly, it also allows Hagihon to detect leaks in the piping system. The connected sensors on the distribution system quickly notice inaccuracies and loss of flow, allowing for timely inspection and repair.[56]

Example 2.6

Update Bidding Norms

- NITI Aayog will prepare a draft proposal that aims to change the lowest bidder norm for government contracts in India. Under the current 'lowest bidder' (L1) tendering norm—called the Least Cost Selection Method—the bidder quoting the lowest price wins the contract. The proposal will suggest alternatives to overcome deficiencies in the process which doesn't give enough weight to quality parameters. For example, while a water reuse project may be more expensive, the long-term sustainable benefits to the water program should be considered.[57]

[52] https://www.weforum.org/agenda/2017/05/how-digital-technology-is-transforming-dubai/
[53] Smart Cities World Forums. A total of 80.6% of Dubai's water meters are now smart. October 2018.
[54] Vincent, Donova. Markham launches new smart city pilot project to improve infrastructure, monitor water flow and flooding. Bewhere. February 2019.
[55] http://ec.europa.eu/eurostat/documents/42577/3222224/Digital+economy+outlook+2015/dbdec3c6-ca38-432c-82f2-1e330d9d6a24
[56] http://www.innovationendeavors.com/thoughts/israeli-internet-of-things
[57] Niti Aayog seeks to change lowest bidder norm for government contracts. The Times of India. March 2, 2020.

3. Incentives

Government incentives for encouraging water recycling and reuse, energy neutrality, and digital water can take many forms but are mostly economically driven. Examples of financial-based incentives—including private financing and direct and indirect methods—that are being employed to promote programs and projects are included here.

	Policy options Incentives	Reference examples
3.1	Provide financial incentives in the form of direct subsidies, grants, tax breaks, and reduced payments for recycling and reuse projects.	Example 3.1
3.2	Provide payments or other credits for the reintroduction of recovered water.	Example 3.2
3.3	Provide financial incentives to encourage energy neutrality and digital water technologies.	Example 3.3
3.4	Incorporate pricing that makes recycled water cheaper than potable water.	Example 3.4
3.5	Leverage public-private partnerships (PPPs) to encourage risk-sharing and introduce private sector expertise to the water utility sector.	Example 3.5

Incentives for water recycling and reuse

Communities often initiate economic incentives that encourage water recycling and reuse by making recycled water cheaper than potable water. Another approach is to tie water usage to conservation programs and exempt recycled water users from many of the community's conservation requirements. Other programs involve property rights and payments for the use of recycled water; pricing schemes that use higher rates for potable water; subsidies or grants for water recycling and reuse; and water recycling and reuse technologies and programs for government procurement of water recycling and reuse infrastructure.

Additionally, performance-linked Hybrid Annuity Models (HAM models) for water treatment infrastructure financing have found acceptability through reduced risk exposure to the exchequer and improved accountability.

HAM models are structured as part-upfront payment and part-annuity payments over the life/agreed term of the project. These annuity payments are linked to O&M performance indicators agreed in the contract.[58]

[58] 2030 Water Resources Group

Example 3.1

Provide financial incentives to encourage water recycling and reuse

- In 2016, the California State Water Resources Control Board authorized $960 Million in 1% financing for recycled water projects through the Clean Water State Revolving Fund.[59]
- In May 2017, the U.S. Bureau of Reclamation awarded over $23 million to communities in seven states for planning, designing and constructing water recycling and reuse projects through the Title XVI Water Reclamation and Reuse program.[60]
- In the U.S., the State of New Jersey provides tax incentives to industries that use reclaimed water for beneficial reuse. This includes a sales tax refund as well as a business tax credit of up to 50% for the cost of treatment and/or conveyance equipment purchased for industrial reuse of wastewater effluent.[61]
- In January 2020, the Telangana government of India announced the launch of Sanitation Hub, an incubator to promote startups and innovations in water, sanitation, sewage water management and wastewater recycling. A seed fund of Rs 25 crores will be earmarked for the initiative.[62]
- Austin, Texas's "Bucks for Business" Rebate Program offers up to $100,000 in rebates to industrial, commercial and institutional customers to help with costs for installing water-efficient equipment or process upgrades, which include condensate recovery projects that reuse the water produced by air conditioning systems.[63]
- The State Water Implementation Fund for Texas (SWIFT) was created by the Texas Legislature to provide affordable, ongoing state financial assistance for projects—including water recycling and reuse—in the state water plan. The program helps communities develop cost-effective water supplies by providing low-interest loans, extended repayment terms, deferral of loan repayments, and incremental repurchase terms. Through Fiscal Year 2019, SWIFT has committed over $8.3 billion for projects across Texas.[64]
- In October 2014, the State of Karnataka, India, launched its Industrial Policy 2014-2019. The policy supports subsidies of up to 75% of the cost of wastewater recycling and reuse by "small and medium manufacturing enterprises."
- In the United States, private industry has traditionally financed industrial water treatment and reuse systems through a combination of commercial loans and corporate bonds, while public water utilities have had access to government subsidized financing through the Clean Water State Revolving Fund (CWSRF). The 2014 Water Resources Reform and Development Act (WRRDA) allows private companies to obtain CWSRF loans to support onsite industrial water recycling and reuse projects and other privately-owned facilities that reuse or recycle wastewater, stormwater, or subsurface drainage water.
- There are also a number of other programs that can potentially finance publicly-owned water recycling and reuse activities in the U.S., including the Community Development Block Grant program through the Department of Housing and Urban Development, the Water & Waste Disposal Loan & Grant Program through the Department of Agriculture, and the WaterSMART program through the Bureau of Reclamation.
- In the U.S., Denver Water in Colorado offers a Cooling Tower Water Conservation Incentive Program to encourage cooling tower water conservation. This program pays cooling tower users $18.50 for every 1000 gallons of water saved over a one-year period. Customers can earn 50% of project costs up to $40,000. Projects must save at least 100,000 gallons per year to qualify.[65]
- The Beijing, China city government in 2013 made the decision to invest billions in upgrading its wastewater treatment and reuse capacities. It simultaneously implemented more competitive pricing and corporate financing for water recycling and reuse.

[59] http://www.waterboards.ca.gov/press_room/announcements/
[60] https://www.doi.gov/pressreleases/secretary-zinke-announces-236-million-water-reclamation-and-reuse-projects-and-studies
[61] http://www.nj.gov/dep/dwq/reuseff.htm
[62] Telangana Today. Sanitation Hub for Hyderabad. January 2020.
[63] https://www.austintexas.gov/sites/default/files/files/Water/Conservation/Rebates_and_Programs/BucksForBusinessRebate.pdf
[64] http://www.twdb.texas.gov/publications/shells/swift_info_sheet.pdf
[65] http://www.terlyn.com/denver-water-headquarters-denver-colorado/

Example 3.2

Provide Payments and Credits

- The Metropolitan Water District of Southern California, through the Local Resources Program (LRP), offers financial incentives for water recycling and reuse, groundwater recovery, or seawater desalination projects that replace an existing demand or prevent a new demand on Metropolitan's imported water deliveries either through direct replacement of potable water or increased regional groundwater production. The LRP provides three incentive payment structure options to choose from, which include sliding scale incentives up to $340/AF over 25 years, sliding scale incentives up to $475/AF over 15 years, or a fixed incentive up to $305/AF over 25 years.[66]
- The State of Florida implemented "substitution credits" which allow the use of reclaimed water to replace all or a portion of an existing permitted use of resource-limited surface water or groundwater.

Example 3.3

Provide financial incentives to encourage energy neutrality and digital water

- The United Kingdom offers the Renewable Heat Incentive (RHI) to encourage the installation of renewable heat generation equipment by helping businesses including public sector and non-profit organizations in England, Wales and Scotland meet the cost of installing renewable heat technologies. The RHI pays a set tariff for each kWh of renewable heat produced over 20 years and covers a range of project types including biomethane, biogas and CHP systems—which are often closely integrated with water recovery technologies in wastewater treatment plants to help make facilities energy neutral.[67]
- To address the increasing problems of municipal solid waste management, the Government of Vietnam issued a series of laws and regulations requiring immediate attention to the management and disposal of waste in an environmentally sustainable manner. Waste-to-energy was recognized as an effective method to reduce waste volume by 90% and to eliminate methane emissions. Despite this policy shift, market barriers still limit private sector participation in waste-to-energy. To help overcome these barriers, the Asian Development Bank (ADB) in February 2018 signed a $100 million loan facility agreement with China Everbright International Limited to facilitate a series of waste-to-energy plants in primary and secondary cities in the Mekong Delta.[68]
- PECO, a U.S. energy company based in southeastern Pennsylvania and part of Exelon Corporation, offers cash incentives for qualified CHP projects to encourage the development of CHP systems that concurrently produce electricity and useful thermal energy from a single fuel source and are often integrated at wastewater treatment and water reclamation plants to help make these facilities energy neutral. PECO's financial incentives include capacity incentives that are based on the operational capacity of the system and capped at 40% of the total project cost, as well as performance incentives that are based on net electric generation of the CHP system. The combination of both incentives is capped at $2,000,000, or 50% of the total project cost
- Administered by the Federation of Canadian Municipalities, the Green Municipal Fund is a revolving fund that supports grants, loans and loan guarantees to encourage investment in environmental municipal projects. The types of capital projects that can gain access to funding include those that feature energy efficiency and recovery. Projects that have received funding include a waste-to-energy transformation system, a feasibility study for a micro-sewer energy recovery system, an anaerobic digestion facility for the treatment and reclamation of residual organic matter waste, and a CHP system fueled by naturally produced landfill methane gas.[69]

[66] http://www.mwdh2o.com/PDF_About_Your_Water/2.4.3.1_Local_Resources_Program_Application.pdf
[67] http://www.energysavingtrust.org.uk/scotland/grants-loans/renewables/renewable-heat-incentive
[68] Asian Development Bank. ADB, China Everbright International Facilitate Clean Waste-to-Energy PPP in Vietnam. February 2018.
[69] https://fcm.ca/home/programs/green-municipal-fund/about-gmf.htm

- The Water Infrastructure Finance Authority of Arizona (WIFA) is a state agency authorized to finance the construction, rehabilitation and/or improvement of drinking water, wastewater, wastewater reclamation and other water quality facilities and projects. Since 2013, WIFA has helped many communities make digital water investments through low-cost financing and incentives, including offering borrowers below-market interest rates on loans.[70]
- The EPA's State-Revolving Fund (SRF) program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a wide-range of water quality infrastructure projects. States are increasingly using the program to finance adoption of digital water technology and management. The SRF program has a distinguished track record of promoting water conservation and water recycling and reuse in several U.S. states, including California, Texas, Oregon, Washington and Ohio.[71]

Example 3.4

Set pricing that makes recycled water cheaper than potable water

- In Durban, South Africa, high water tariffs have influenced market dynamics by making wastewater reuse more attractive and economically viable. Industrial users of recycled water pay 50% less than the cost of water from the conventional system. Approximately 23% of the city's treated wastewater is reused by local industries in production processes.[72]

Example 3.5

Leverage private-sector financing via PPPs

As a financing mechanism for the delivery of large, capital-intensive water recycling and reuse projects across India, the private sector can play a significant role. Governments and multi-lateral organizations recognize that private sector participation—when modeled correctly—can bridge the investment gap in the water infrastructure sector while improving water access and service delivery.[73] In addition to acting as a funding catalyst, PPP financing models—such as design-build (DB), build-own-operate (BOO), and design-build-operate (DBO)—offer the potential to harness the technical expertise and efficiencies of the private sector.

Traditionally, private sector participation in water and sanitation projects in India has been minuscule compared to those for electricity and roads, but that could change as cities look to increase the efficiency of their water distribution networks, ensure equitable distribution of water, and reduce leakages and theft.[74] Private sector participation in water service delivery is a key component of India's development agenda—specifically in urban areas—but it is essential that participation through water PPPs be designed to deliver water service that is affordable, accessible, adequate, and consistent with minimum drinking water quality standards.[75]

Although many water sector projects backed by international financial institutions (IFIs) have been unsatisfactorily operated with services below expectations, a changing political, institutional, and economic context driven by sustainable development goals and climate objectives have created an

[70] http://www.azwifa.gov/
[71] https://www.epa.gov/cwsrf
[72] Expanding Access to Clean Water. International Finance Corporation.
[73] Expanding Access to Clean Water. International Finance Corporation.
[74] Seetharaman, G. The private sector has transformed India's highways, airports. Can it do the same for water supply? The Economic Times. November 2018.
[75] Bharadwaj, Ananthi Shankar. Private Participation in India's Water Sector: Impact on Water Access and Service Quality Indicators. Thesis submitted to the Faculty of the Graduate School of Arts and Sciences of Georgetown University. April 2017.

environment where IFIs are now more focused on actual service delivery. To tackle shortcomings related to standard selection methods of IFIs in developing countries, the World Bank (WB), ADB, and Agence Francaise de Developpement (AFD) have been working together to develop DB and DBO standard bidding documents for the water sector that are designed to ensure the highest quality of service delivered at the best possible cost.

Focusing on sector and output-based procurement procedures, the WB, ADB and AFD identified an optimal path forward for procurement strategies that leverage the private sector. Encouraging priority enhancements in long-term contracts, the standard form of infrastructure financing in the water and waste sectors will be a long-term DBO contract, where the DB component would be secured by an IFI loan and the operations and management component by a partial risk guarantee.

- An Indian real estate developer formed a BOO partnership with Veolia for the design of a wastewater treatment and recycling system serving a 4,500-acre smart city development. The partnership transfers complete accountability to Veolia for developing and operating several decentralized wastewater treatment plants over the next 10 years.

4. Mandates, Regulations and Standards

Government mandates, regulations and standards for water recycling and reuse can incorporate different legislative approaches but are mostly intended to achieve a desired action. The common policy mandate structures stipulate that utilities treat wastewater to produce a supply of recycled water or require businesses and industry to reuse water in certain applications.

Wastewater treatment and water supply utilities

Most commonly, recycled water is provided by the community's wastewater treatment district or utility, as these organizations are best positioned to deliver high-quality recycled water. Not only do the districts have a large volume of wastewater, they often are the only ones with the capacity to carry out the level of treatment necessary to meet water quality standards.

Communities may require treatment districts to develop plans for the recycled water and/or to provide recycled water to certain types of users. Some local governments couple the wastewater treatment utility mandates with restrictions on the local water supply utility. These regulations typically restrict the use of potable water, forcing industrial water users to rely on recycled water and creating more customers for the local water reuse program.

	Policy options Mandates, regulations and standards	Reference examples
4.1	Advance wastewater recycling and reuse adoption through policies, regulations and plans organized at the national, state and city levels.	Example 4.1
4.2	Implement regulations that restrict the use of potable water for non-potable applications where recycled water is available.	Example 4.2
4.3	Mandate the use of recycled water in industry and for certain large-volume activities, and/or create "Fresh Water Free zones" based on distance.	Example 4.3
4.4	Mandate the inclusion of water recycling equipment and piping in residential and commercial development.	Example 4.4
4.5	Set minimum water reuse quality standards for different usages, including industrial, agriculture, and construction, as well as discharge to rivers and lakes.	Example 4.5
4.6	Mandate Zero Liquid Discharge (ZLD) for all industrial effluents.	Example 4.6

Example 4.1

Implement water reuse plans, regulations and policies at all government levels

- Korea passed the Promotion of and Support for Water Reuse Act in June 2010. The legislation requires, among other actions, the establishment of a comprehensive water reuse management plan in each jurisdiction.
- To increase the amount of water sourced locally and reduce reliance on imported water, the City of Los Angeles created a plan to recycle 100% of its wastewater by 2035. Currently, three of the City's four wastewater treatment plants are already at 100% recycling capacity. As such, Los Angeles's efforts will focus on the Hyperion Treatment Plant—the largest wastewater treatment facility in the western U.S. Improvements to Hyperion—which currently treats 81% of the City's wastewater and recycles 27%—will cost roughly $2 billion over the next 16 years to increase its recycling capacity to 100%. In doing so, the City's total amount of water supply that comes from recycling will increase from 2% to 35%.[76]
- China's 13th Five-Year Plan (2016-2020) set new targets for wastewater effluent quality, sludge management, and drinking water quality. The expenditure on environmental protection was $536 billion USD, of which $60 billion USD was allocated to urban wastewater systems. Water reuse was one of the Plan's major components with an estimated expenditure of over $3.5 billion USD.[77]
- China's State Council in April 2015 issued the Water Pollution Prevention and Control Action Plan—also known as the Water Ten Plan—which sets a series of aggressive water quality improvement targets for 2030. The Water Ten Plan incorporates a focus on industrial effluent management, wastewater treatment, water reuse, enhanced monitoring, and new enforcement mechanisms, and seeks to break down silos between government agencies to reduce water pollution, particularly from industries. The Water Ten Plan also prioritizes water scarce regions; Beijing, Hebei and Tianjin face stricter targets for municipal and industrial water as well as wastewater management and reuse.[78,79]
- In November 2019, India's Haryana government approved a policy to treat wastewater for non-potable purposes, aimed at alleviating stresses on ground and surface water resources.[80]
- The Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), located in the Southern Indian State of Tamil Nadu, formulated a set of service standards mandating accelerated wastewater reuse and zero liquid discharge. All stakeholders, including government authorities, the private sector, and citizens are mandated by a set of regulations and bylaws to ensure maximum reuse of water and wastewater to safe quality standards. The treatment standards created by the CMWSSB set specific water quality parameters to ensure industry do not need to repeat the treatment steps at their own facilities, thereby making it more cost-effective and efficient for end-users.[81]
- The Indian State Governments of Gujarat, Haryana, Maharashtra, Rajasthan, Chhattisgarh, Karnataka, and Madhya Pradesh have all either adopted, or are moving forward with, treated wastewater reuse policies that seek to reduce dependency on freshwater resources. The goal of policy is to reuse 70% of treated wastewater by 2025 and to achieve 100% reuse by 2030.[82,83]
- To address Australia's Millennium Drought, which lasted from 1997 until 2012, Australian governments issued several demand-side and supply-side measures to address their water crisis. Among the supply-side measures were major water reuse projects which specified the use of recycled water for various non-potable purposes to offset potable water demand. Reuse targets were established which drove investments in recycling.[84]
- In 2008, the Florida Legislature approved a law requiring all wastewater utilities in southeast Florida utilizing ocean outfalls for disposal of treated wastewater to reduce nutrient discharges by 2018, cease using the outfalls by 2025, and reuse 60% of the wastewater flows by 2025. The statute was amended in 2013 to provide greater flexibility to meet the reuse requirements.[85]

[76] LAMayor.org. Mayor Garcetti: Los Angeles Will Recycle 100% of City's Wastewater by 2035. February 2019.
[77] CIEPEC 2019. Fact Sheet: China Water Reuse Opportunities.
[78] CIEPEC 2019. Fact Sheet: China Water Reuse Opportunities.
[79] Chinawaterrisk.org. New 'Water Ten Plan' to Safeguard China's Waters. April 2015.
[80] Outlook India. Haryana approved treated wastewater policy for non-potable purposes. November 2019.
[81] The International Water Association. Wastewater Report 2018. The Reuse Opportunity.
[82] Fluence. India's Gujarat State Adopts Water Reuse Policy. July 5, 2018.
[83] DNA India. Policy for reusing waste water: Gujarat government. May 2018.
[84] Alliance for Water Efficiency, Institute for Sustainable Futures at the University of Technology Sydney, Pacific Institute. Managing Drought: Learning from Australia. March 2016.
[85] Miamidade.gov. Ocean Outfall Legislation Plan.

Example 4.2

Restrict potable water usage for non-potable applications if recycled water is available

- California's Water Code Section 13551 states that "A person or public agency, including a state agency, city, county, district, or any other political subdivision of the state, shall not use water from any source of quality suitable for potable domestic use for non-potable uses, including cemeteries, golf courses, parks, highway landscaped areas, and industrial and irrigation uses if suitable recycled water is available."

Example 4.3

Require the use of recycled water in industry and for certain large-volume activities

- Tariff Policy 2016, issued by India's Ministry of Power, mandates that all thermal power plants including existing plants located within 50 km radius of a municipality or local body sewage treatment plant use treated sewage water for cooling purposes.[86]
- In order to preserve freshwater supplies for the local municipality, a leading fertilizer company in India installed a sewage recycling plant in cooperation with civic authorities. The company treats it wastewater as "fit for purpose" and reuses it in a variety of industrial applications including cooling water makeup; thereby, reducing its freshwater demand from the municipality by 22.75MLD.
- In the Canadian oil sands in Alberta, Canada, Directive 081 sets water disposal limits and reporting requirements for thermal in situ oil sands schemes. The goal of the directive is to compel operators to minimize the use of high-quality nonsaline make-up water by recycling produced water efficiently and using alternative water sources where possible.[87]

Example 4.4

Mandate water recycling equipment and piping in new development

- In January 2009, China's Circular Economy Promotion Law went into effect. The law contains a chapter that refers to recycling and resource recovery. In that chapter, Article 31 states: "Enterprises shall develop a series water system and cycle water system to improve the water reuse rate. Enterprises shall use advanced technologies, processes and equipment to recycle wastewater generated in production."
- In February 2018, the Bangalore Water Supply and Sewerage Board amended the Bangalore Sewerage Regulations, mandating the establishment of sewage treatment plants and dual piping systems for certain buildings in unsewered areas where water is supplied by the Board. Buildings subject to the regulations include residential buildings with at least 20 apartment units or measuring 2,000 square meters; commercial buildings measuring at least 2,000 square meters; and educational institution buildings measuring at least 5,000 square meters.[88]
- The Hawaii state legislature passed an amendment that took effect on January 1, 2020 mandating that all new buildings are furnished with equipment that allows for the collection and future use of grey water.[89]
- Singapore's Handbook on Application for Water Supply (last updated in 2018) mandates that all new non-domestic development proposals with cooling towers and/or processes are required to provide a dedicated NEWater pipe system during planning and construction work stages to take in NEWater for such usage when it becomes available in the future. NEWater is a high-grade water produced by treating used water with advanced water purification and membrane technologies that achieves a quality exceeding EPA and World Health Organization (WHO) drinking water standards.[90]

[86] Mandatory use of treated sewage water by the Thermal Power Plants as per the provisions of the Tariff Policy 2016. Government of India, Ministry of Power. 2016.
[87] Alberta Energy Regulator. Directive 081. November 2019.
[88] Bangalore Water Supply and Sewerage Board. Establishment of Sewage Treatment Plants and Dual Piping System. February 2018.
[89] Sustainable Water. Hawaii Requires Water Reuse for New Buildings.
[90] Singapore's National Water Agency. Handbook on Application for Water Supply. 2018.

Example 4.5

Set Minimum Reuse Standards

- Several countries have instituted minimum water standards based on usage including China, Singapore and the United States (Texas). In 2011 the government of China set a BOD discharge standard for rivers and lakes to be < 6 mg/l. In 2009, Singapore adopted standards that regulate BOD to 1 – 5 mg/l for industries, and in Texas, USA, in 2012, the EPA set a BOD standard for industrial and agriculture use to be < 5 mg/l.[91,92]
- The Sulaibiya Wastewater Treatment and Reclamation Plant, located near Kuwait City, converts 600,000 m^3/day of municipal effluent wastewater into high quality reclaimed water that will be used for agriculture and non-potable industrial use, as well as to recharge the aquifer. To ensure a consistent quality, the plant adopted minimum wastewater reuse standards of 1 mg/l for BOD, < 1 mg/l for TSS, and 100 mg/l for TDS.[93]

Example 4.6

Mandate Zero Liquid Discharge (ZLD) Concept

- The Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), located in the Southern Indian State of Tamil Nadu, formulated a set of service standards mandating accelerated wastewater reuse and zero liquid discharge. All stakeholders, including government authorities, the private sector, and citizens are mandated by a set of regulations and bylaws to ensure maximum reuse of water and wastewater to safe quality standards. Industries and manufacturers are also mandated to achieve zero liquid discharge in their operations. Through a PPP model, CMWSSB treats wastewater to a standard and sells it to large industries in Chennai that further treat it to tertiary standards.[94]
- A leading agribusiness in Gujarat, India installed a complete wastewater treatment system to meet environmental regulations for Zero Liquid Discharge. The company is reusing 400 m^3/day with outcomes of Inlet TDS at 10,000 pm and RO permeate at TDS <500 ppm. The treated wastewater is being reused in industrial applications and as cooling tower makeup water.

[91] China Reclaimed Water Specifications: Rodrigues, Sasha. China Reclaimed Water Reuse Regulations. IWA.
[92] United States Environmental Protection Agency. 2012 Guidelines for Water Reuse. September 2012.
[93] https://www.water-technology.net/projects/sulaibiya/
[94] The International Water Association. Wastewater Report 2018. The Reuse Opportunity.

Case Studies

Based on India's unique water challenges, we believe the following case studies will prove inspiring.

Case Study #1

Veolia's UF and RO membranes support one of the world's largest membrane-based water reuse project in Kuwait

Background

Kuwait is located in the most water-scarce region of the world and is predicted by the World Resources Institute to be one of the most water-stressed countries by 2040. Kuwait has no permanent rivers or lakes and its limited groundwater supplies are deteriorating in quantity and quality due to continuous pumping that exceeds recharge rates.[95] To meet domestic and industrial freshwater needs, Kuwait relies primarily on desalination.

Challenge

With little natural water resources and one of the world's highest per capita consumptions of water, Kuwait faces mounting challenges in coping with water stress and meeting the rising water demands of a growing population. For enhancing the country's future water security, Kuwait identified the need to expand its water resources by developing new sources of water, thus creating more diversified supplies and reducing its dependency on desalination.

These drivers led to a focus on upgrading the nation's wastewater treatment capacity to produce reclaimed water for non-potable reuse, which would help alleviate pressures on fragile groundwater sources and more pristine desalinated water supplies.

Solution

To meet its wastewater treatment, recycling and reuse objectives as part of the country's long-term water security strategy, the Kuwaiti government in May 2001 awarded a 30-year concession to a consortium that includes Mohammed Abdulmohsin Al-Kharafi and Sons (The Kharafi Group) and Veolia to recover municipal wastewater from Kuwait City and the surrounding area.

The consortium was established to design, build, own, operate and maintain a 100 million gallons per day (MGD) (375,000 m^3/day) wastewater treatment and reclamation facility at Sulaibiya near Kuwait City. Completed in 2005, the Sulaibiya Wastewater Treatment and Reclamation Plant includes one of the world's largest membrane-based water reclamation facility.

Following preliminary treatment in Ardiya, effluent is piped 25 km (16 miles) to the Sulaibiya facility where it is first treated by a conventional biological wastewater treatment plant (WWTP), generating a secondary effluent that exceeds a typical secondary effluent quality. The secondary effluent is then conveyed to the water reclamation plant, where ultrafiltration (UF) is employed followed by reverse osmosis (RO) to produce purified water at a quality that is suitable for reuse. UF wastewater stream is diverted back upstream to the biological WWTP to achieve the highest possible overall water recovery.

UF membrane technology was selected for pretreatment of secondary effluent due to its ability to provide robust treatment, reduce plant chemical consumption, and guarantee that a low turbidity water could be fed to the RO. A higher quality RO feedwater also helps to extend the RO membrane life while lowering operating pressure and reducing the cleaning frequency for the RO system.

The water reclamation plant is designed to treat 112 MGD (425,000 m^3/day) of secondary effluent. Since the UF wastewater stream is recycled back to the biological treatment process, the UF system treats 100% of the flow

[95] Ismail, Haweya. Kuwait: Food and Water Security. Future Directions International. September 2015.

after biological treatment. As such, the feed to the RO system is also 100 MGD (375,000 m^3/day). The RO plant is designed for 85% water recovery, resulting in an expected production rate of 85 MGD (318,750 m^3/day).

Water Reclamation Plant Expansion

In 2009, the water reclamation plant underwent an expansion with additional capacity added to both the UF and RO plants. Two additional UF skids were installed, which increased UF gross production capacity by roughly 3.2 MGD (12,000 m^3/day), and 120 new RO pressure vessels were added to the RO plant, increasing the final production volume up to 9.2 MGD (350,000 m^3/day).

Water Reclamation Plant Optimization

Beginning in 2012, an optimization project based on scientific approach was initiated. A small-scale UF and RO plant was created to simulate the large-scale facility and analyze the process with respect to the plant's condition to revise parameters and arrive at the best practices. Ultimately the small-scale system led to replacing and upgrading the existing UF and RO membranes to improve the long-term performance and longevity of the water reclamation plant.

The previous UF pretreatment membranes were replaced with Veolia's ZeeWeed* 700B membranes—a pressurized hollow-fiber UF membrane that employs a blended polyethersulphone (PES), allowing the membrane to stay permanently hydrophilic and reduce the fouling tendency. The ZW700B features SevenBore* fiber technology, a design where each fiber incorporates seven bores to produce a mechanical strength that is 10 times higher compared to a single fiber. The robust design of the ZW700B enables performance in a wide pH range and makes the membrane virtually impervious to variable raw water quality. The RO plant's existing RO membranes were also replaced with Veolia's RO membranes.

One of the main reasons for switching to the ZW700B membrane was to eliminate small leaks which were occurring with the previous membrane, causing fouling trouble with the RO system. The SevenBore fiber technology design of the ZW700B prevents small leaks while also reducing the required cleaning intervals on the RO system.

Phase 2 Expansion

Due to rapid growth in Kuwait City, a phase 2 expansion project was awarded to the Kharafi Group and Veolia consortium. The phase 2 expansion includes utilizing Veolia's ZeeWeed 1000 UF membranes in combination with Veolia's state of the art, two-stage RO design to process an additional 60 MGD (225,000 m^3/day). With the completion of phase 2, the total treatment capacity of the Sulaibiya facility will be 160 MGD (600,000 m^3/day).

Results

The Sulaibiya facility demonstrates how water reuse can be employed as a strategy to address water scarcity. The world-class water reclamation project provides Kuwait with a reliable water source for the future—increasing the nation's water security by converting municipal wastewater into high quality reclaimed water which is recycled for non-potable reuse in agricultural irrigation and landscape watering.

The combination treatment of UF and RO removes bacteria and pathogens to a level which exceeds World Health Organization (WHO) potable water guidelines. Reclaimed water produced by the Sulaibiya facility is now completely supporting the entirety of Kuwait's dairy and vegetable growing operations. At the completion of phase 2, excess secondary quality water (brine) leftover from the RO plant will be reused for oil recovery and reinjected into Kuwait's oil fields for water flooding.

As a benchmark for water reuse in the Middle East, the Sulaibiya Wastewater Treatment and Reclamation Plant is a successful example of how an alternate source of water can be produced to help ease strains on valuable drinking water supplies.

Case Study #2:

Stringent discharge regulations compel water recycling and reuse at large Bahrain refinery

The Bahrain Petroleum Company (BAPCO) Sitra refinery, located near Bahrain's capital, Manama, is among the largest refineries in the Middle East, processing in excess of 250,000 barrels per day. Following its commitment to environmental protection, BAPCO decided to upgrade its existing wastewater treatment plant to improve the quality of its effluent and comply with stricter requirements using the best available technology. Membrane bioreactor (MBR) was the technology chosen for this project that treats 24,000 cubic meters per day of the refinery wastewater.

Prior to deciding on the technology, BAPCO conducted bench scale testing that gave a positive indication that the wastewater was biologically treatable. With this affirmation, pilot scale testing was conducted on site in order to increase the level of confidence and provide further insight into the solution. It showed that MBR was the ideal technology for BAPCO's highly saline wastewater that exhibited poor biomass flocculation and low filterability. The installed full size MBR consists of a four-stage biological treatment system followed by four membrane UF trains, each with ten ZeeWeed* 500d cassettes supplied by Veolia. During the performance test, results showed that the UF system was able not only to consistently meet the required treatment capacities, but also the required effluent parameters at all times. In fact, the effluent quality was significantly better than the guaranteed values.

Following the successful completion of the performance test, the UF system was put in operation and continued to consistently meet the treatment capacity on a daily basis as well as all effluent quality parameters including total suspended solids and turbidity, thus setting the stage for water recycling and reuse and increased sustainability in the refinery.

The treatment goals at the Sitra refinery are driven by strict discharge regulations set by the Bahrain Supreme Council for the Environment. The aim of the Council, established in late 2012, is to protect and develop the sustainability of Bahrain's environmental resources through practical implementation of Bahrain's environmental laws. It extends coverage to the water and wastewater sector through its Water Resources Council arm.

In the case of the BAPCO refinery, meeting the very stringent nitrogen and phosphorous wastewater discharge limits was especially challenging, along with addressing organic carbon and the biological treatment complications resulting from elevated temperatures. The latter was addressed by means of introducing a double stage cooling system to bring down the wastewater temperature from 48°C to 35°C. There was also the issue of spent caustic that was successfully addressed to promote recycling and reuse as a source of nutrients for the biomass. In recognition of the treatment put in place by the BAPCO refinery and its commitment to water sustainability in industry, the project was awarded a Distinction Award at the GWI Global Water Awards event in Paris, France in 2014.

Case Study #3:

Veolia helped one of India's leading chemical and fertilizer companies to get uninterrupted supply of process water by using treated sewage.

Challenge

The plant is situated in a highly populated city of India wherein the freshwater demand is very high. The intake water requirement was being met by the municipal corporation which supplies fresh water for industrial purpose. To conserve potable water for the growing population of the area, the customer decided to install a 22.5 MLD sewage recycle plant in cooperation with civic authorities. The primary objective was to recycle the existing sewage using advanced technology and reuse it for industrial application, thereby saving the freshwater resources.

Solution

Veolia helped the customer to install a state-of-the-art sewage recycling plant, which features ZeeWeed membrane bioreactor (MBR) and reverse osmosis (RO) technology.

The MBR treated effluent goes to the RO system for TDS removal. The ZeeWeed MBR produces high quality treated water meeting the reuse norms at lesser footprint than conventional processes.

Results

The customer is now getting high quality treated sewage consistently, which is being reused for cooling water makeup and other industrial process applications.

As a benchmark for water reuse in India, the sewage recycling plant is a successful example of how an alternate source of water can be produced to help ease strains on valuable drinking water supplies.

Case Study #4:

Beneficial water reuse at Delhi Gate Nallah and Sen Nursing Home Sewage Treatment Plants

Back in 1999, to help the region reduce pollution to the river Yamuna, Veolia designed and built two Sewage Treatment Plants (STP) for the Delhi Jal Board (DJB) in Delhi. With a combined capacity of 20MLD, the two plants were designed to capture the highly polluted wastewater flowing in the open drain (Delhi Gate Nalla) and treat it to such a high level to ensure only clean, treated effluent was discharged into the river course.

Keeping in mind that the plant was located in an important area like Gandhi Darshan and Rajghat Samadhi (major tourist areas), the DBJ and PPCL needed to be mindful of odour or smell nuisance, as well as land constraint at the existing sites.

As such, they selected Veolia state-of-the-art technology to meet both the odour and space requisites, while also meeting critical effluent quality parameters. These STPs treat sewage to the secondary level with output parameters of BOD < 10, COD < 25-30, and TSS < 10 mg/l, a standard which was better than prevailing discharge standards (BOD < 30 mg/l, TSS < 50 mg/l), at that point of time.

The process adopted is Physico-Chemical treatment in the DENSADEG* Clarifiers followed by high rate Biological Filters (BIOFOR*).

The clarifier design is an expression of an overall qualitative improvement in water clarification, which enables a high rate of clarification in a compact plant. The integrated sludge thickening helps avoid downstream thickening and the lamella separation with tubes at the top produce high-quality effluent.

The biofiltration process of BIOFOR enables a high rate of filtration and eliminates odours, while its diffused aeration prevents the presence of aerosols and saves energy.

In 2004, understanding that power plants are significant consumers of water and that India's policies encouraged the utilization of treated municipal wastewater for power generation, the DJB entered into an agreement with the Pragati Power Corporation Limited (PPCL), a subsidiary of Indraprastha Power Generation Corporation Limited, to supply treated effluent to the plant which could then be reused in critical applications.

The PPCL currently uses the treated effluent for its installed capacity of 330 MW Combined Cycle Power Plant, with major portions of the treated sewage going towards cooling needs. The remainder of the recycled water is further treated through Reverse Osmosis to make high quality demin water to feed the HRSG unit.

Between the two sewage treatment plants, the DJB has conserved freshwater supplies for more than 15 years, an amount equivalent to serving a population of 150,000 people per day.

Conclusion

India faces acute water scarcity and water pollution challenges, but with these challenges also come tremendous opportunity. As governments around the world grapple with similar issues, many are adopting water recycling and reuse to help meet future needs and foster more efficient water demand management. We believe the solutions and strategies presented in this paper can help India ensure a more sustainable water future.

This paper provides policy options in the following categories:

- Education and Outreach
- Removing Barriers
- Incentives
- Mandates, Regulations and Standards

Identifying appropriate policies depends on various factors. These include the time horizon for program implementation; governmental structures and processes to communicate and implement such programs; resources, including both funding and expertise; and degree of agreement from stakeholders and policymakers.

While the needs and circumstances of countries, regions, states, cities and local communities vary greatly, the menu of policy options presented in this white paper is specifically tailored to India's distinct regional conditions, unique water challenges, and the existing water management practices and technologies that are currently in place to meet water demand.

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