MAINSTREAMING GOVERNANCE ON WASTE WATER TREATMENT AND WATER RE-USE: LEARNINGS FROM INDIA AND THE EUROPEAN UNION

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AUTHOR

Gabriela Cuadrado Quesada *(IHE-Delft)*, **Lena Breitenmoser** *(FHNW)*, **Tineke Hooijmans** *(IHE-Delft)*, **Anshuman** *(TERI)*, **Nathaniel B. Dkhar** *(TERI)*, and **Paul Campling** *(VITO)*.

Contributors:

Giuliana Ferrero *(IHE-Delft)*, **Sonia Grover** *(TERI)*, **Mayuri Phukan** *(TERI)*, **Andraju Nagababu** *(TERI)*, **Anagha Krishnan** *(TERI)*, **Nitin Bassi** *(IRAP)*, **M Dinesh Kumar** *(IRAP)*, **Saurabh Kumar** *(IRAP)*
Herman De Schamphelaere *(Aquafin)*, and **Tara Saharan** *(TUDelft)*.

FOR MORE INFORMATION

Mr Anshuman
Water Resources Division, TERI, Darbari Seth Block
IHC Complex, Lodhi Road, New Delhi 110 003, India
Tel.: +91 11 2468 2100 or 2468 2111 | Fax: +91 11 2468 2144 or 2468 2145
Email: anshuman@teri.res.in | Web: www.teriin.org

1. BACKGROUND

India's water resources are severely overexploited and polluted. Discharge of untreated wastewater has resulted in contamination of 75% of all surface water bodies in India (CPHEEO, 2012). Over the years, the need for wastewater, treatment, recycle and reuse has been emphasised in several policies & programs. While attempts have been made at different scales with varying level of completion and success, however, owing to various bottlenecks related to technological adequacy and upscaling, policy convergence, lack of robust financial and incentive mechanisms, lack of adequate capacities & awareness amongst stakeholders etc., the interventions specially on wastewater recycle/reuse are yet to make a significant impact at a large scale in India. As India grows and urbanizes, meeting the ever-increasing water demand amidst water scarcity and pollution scenarios necessitates a major impetus on wastewater treatment & reuse through mainstreaming of various related policies & programs, and governance framework. This policy paper is derived out of the PAVITRA GANGA project (a joint India-EU project) that focuses to develop and pilot robust, cost-effective wastewater treatment and reuse technologies along with policy interventions to address some of the existing challenges and promote widescale wastewater treatment and reuse in India.

1.1 State of wastewater treatment and re-use in India

The total sewage generated by urban areas in the country was estimated to be about 61,948 million litres per day (MLD) (in 2015), as against the available installed sewage treatment capacity of only 23,277 MLD (i.e. about 37% of the sewage generated) (MoEF&CC 2018), illustrating a huge gap in sewage treatment, while also suggesting a significant volume (about 63%) of untreated/partially treated sewage finding way into water bodies & causing pollution. Figure 1 indicates the wastewater generation & treatment scenario in different classes of cities in India. The wastewater treatment infrastructure overall

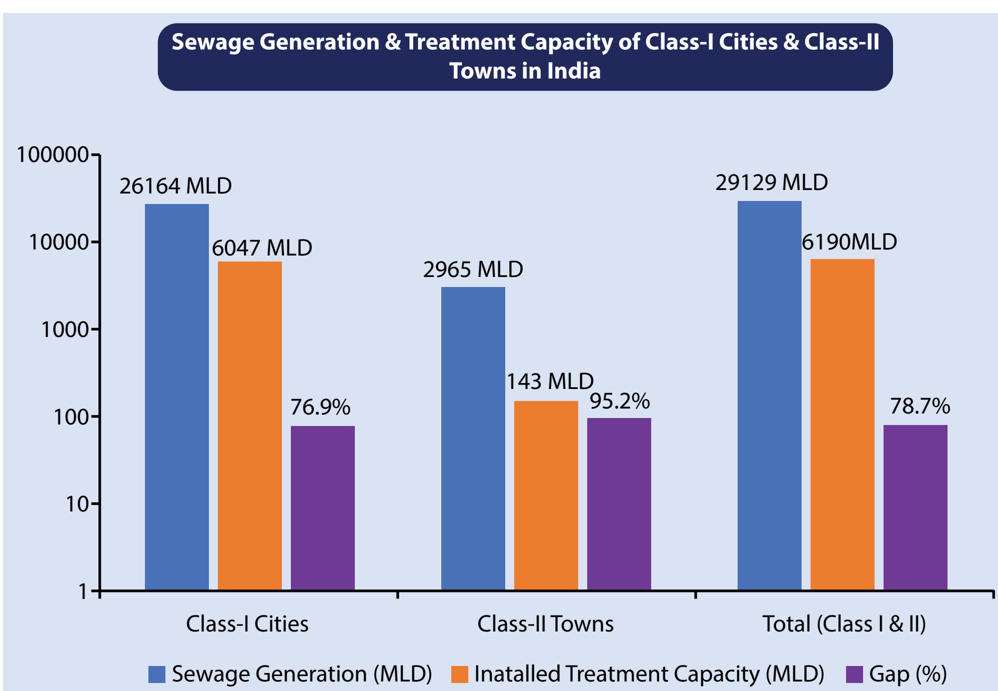

Figure 1: Sewage generation and treatment scenario of Class-I cities & Class-II towns of India
(Data Source: CPCB, 2017)

performs poorly due to frequent electricity break-downs, poor operation and maintenance, inadequate sewerage networks and technology designs not matching the wastewater characteristics (Never, 2016, CPCB 2007). Latest estimations by the Central Pollution Control Board (CPCB) show that 20% of Sewage Treatment Plants (STPs) are non-functional and about 39% of the STPs do not meet the discharge standards prescribed under the Environment (Protection) rules for discharge into streams (CPCB, 2017).

Moreover, untreated wastewater (in the absence of any other source of water) is widely used in agriculture for irrigation and as source of nutrients, which result in increased health risks and leads to water and soil pollution (Kaur et al. 2012). So far, the reuse of treated wastewater from centralized schemes is limited to a few places in India and restricted to agriculture and horticulture (Amerasinghe et al., 2013; WSP & IWMI, 2016) and some industries for cooling (PwC, 2016; Lahnsteiner et al., 2015). Two examples for these two reuse schemes are given in Chapter 3 of this policy brief, where enabling factors and barriers for water reuse are further discussed. Zero-liquid discharge (ZLD) guidelines were introduced for four industrial sectors (textile, distilleries, pulp and paper and tanneries) by CPCB in 2015 and promoted in nine states along the Ganga river basin (CPCB, 2015) setting the stage for increased on-site water reuse by industries in the near future.

Recent assessments of small-scale treatment systems showed that these fail to treat wastewater up to the desired water reuse standards (due to insufficient nutrient and pathogen removal) and that reuse of treated water is hampered by a lack of opportunities and demand in the vicinity (Ulrich et al., 2018). However, decentralised wastewater treatment solutions are commonly perceived as solutions for underdeveloped areas (e.g. peri-urban and rural settings) and have several advantages (e.g. less energy use, easier management of wastewater reuse, better adaptation to local conditions, better affordability, etc.) over centralised treatment systems (Starkl et al., 2013).

India's water crisis requires a paradigm shift of current water governance practices, moving from today's linear **'take-use-waste'** approach to a **circular water management** introducing appropriate pollution control and following the multi-barrier-principle of the WHO to safeguard environmental and public health. Proper access to safely managed sanitation remains a problem for millions of people in India, and untreated sewage introduces serious health risks for a large part of the population, making the SDG6 targets important focus points of policy as well as of technological and social innovation.

About this policy brief

The PAVITRA GANGA project was initiated to contribute to the Indian policies & programs and fulfilment of Sustainable Development Goal (SDG) 6, by unlocking the environmental and economic potential of municipal wastewater treatment and reuse solutions for urban and peri-urban areas in India. The core aim of this policy brief is to bring together the learnings from successful and unsuccessful case studies from India and EU with an analysis of the Indian and EU policy and regulatory frameworks. Together with relevant stakeholders from Central, State and local level for the two selected technology test sites (Delhi and Kanpur), it intends to formulate recommendations to support the existing and future policy and law reforms in India.

1.2 European shift from wastewater treatment to wastewater reuse

Europe is experiencing growing water stress, both in terms of water scarcity and deteriorating quality. Approximately half of the European countries, representing almost 70% of the population, are facing water stress issues. Some European countries such as Belgium and Spain are high (above 40%) on the water stress index[1], emphasizing the need to work on comprehensive governance of water resources, of which one is reuse of wastewater (see Figure 2).

[1] Water Stress is defined as the ratio (%) of a country's total water withdrawal to its total renewable freshwater resources

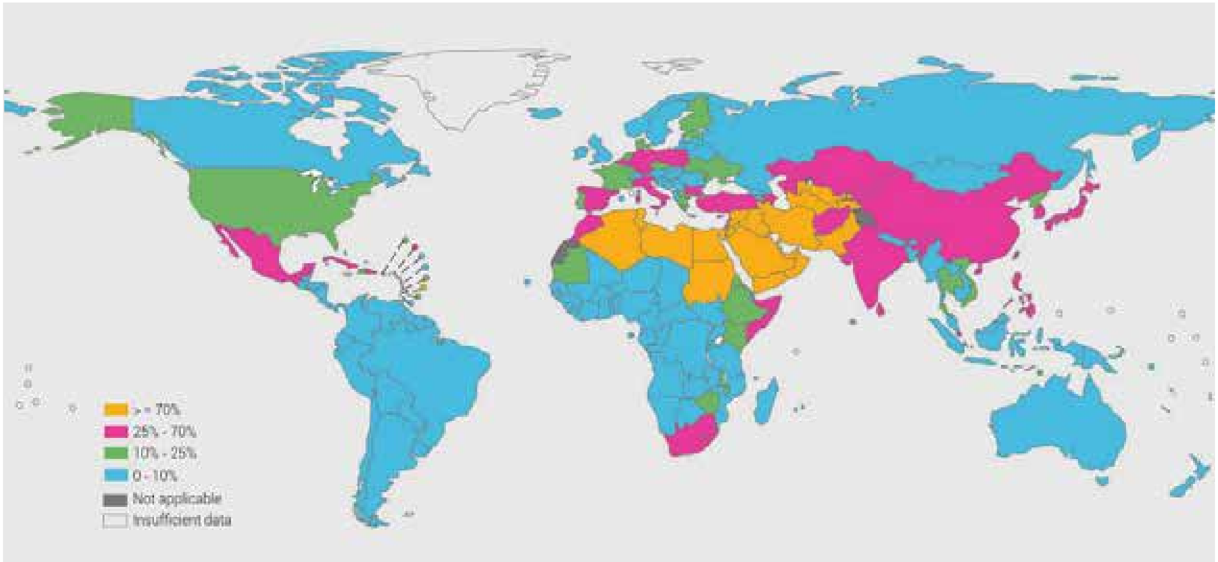

Figure 2: Level of Water Stress in Different Countries
(Source: United Nations (2018). Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation. New York.)

The EU has been tackling water pollution and scarcity for a long while now. Core policy instruments ~~in this sense~~ are the Urban Waste Water Treatment Directive (UWWTD, 91/271/EEC), the Water Framework Directive (WFD) (Directive/2000/60/EC) and the Groundwater Directive (Directive 2006/118/EC).

The UWWTD aims to protect the environment from discharges of urban wastewater, in particular by requiring that cities, towns and other population centres meet minimum wastewater collection and treatment standards by stipulated deadlines. Under the UWWTD, there have been billions of euros invested across Europe to collect and treat urban wastewater from agglomerations ≥ 2000 p.e. to remove harmful microorganisms, oxygen-consuming substances and nutrients (EC 2017). The WFD aims to protect surface and groundwater in EU river basins through specific milestones and operational steps to be undertaken by all EU countries. It establishes measures to prevent or limit the inputs of pollutants into surface and groundwater and thus mitigates the deterioration of water resources. The Groundwater Directive provided detailed regulations to prevent, control and address groundwater pollution and established groundwater quality standards.

Water reuse practices in EU Member States are mainly driven by the demand for additional water resources and evolve under quite diverse national legal regimes. Mostly agricultural uses are permitted but some countries also have quality standards for urban, industrial, recreational and environmental applications (Breitenmoser & Hochstrat, 2019). One of the factors preventing the uptake of water reuse include the lack of common environmental and health standards for water reuse across the EU, plus the potential obstacles to the free movement of agricultural products irrigated with reclaimed water (European Parliament 2020). Increasing efforts in recent years have been put to promote water reuse as a possible solution to water scarcity problems. In 2015, the European Commission presented the new circular economy package (EU 2015) with one of the actions to develop regulations on the 'minimum requirements for water reuse', expected to be adopted in 2020. The regulation aims to stimulate the uptake of water reuse by offering a sustainable, alternative water supply for agricultural irrigation.

2. POLICY AND REGULATORY LANDSCAPE SUBSUMING WASTEWATER TREATMENT AND REUSE IN INDIA

2.1 Key Policies at Central Level

2.1.1 The 2012 National Water Policy

The first National Water Policy was formulated in India in 1987 which was updated once in 2002 and again later in 2012 as the National Water Policy (NWP) (2012). The NWP prioritizes water allocation (drinking, irrigation, hydropower, navigation, industrial and other uses), conservation, conjunctive use etc. It emphasizes on water conservation, recycle reuse, water demand management, sectoral water use efficiency, provision of water supply and sanitation facilities and enhancing water availability. It stresses on river basin management approach, transboundary water management, IWRM as well as adaptation to climate change amongst others.

While some states have drafted a state water policy based on the central policy recommendation, weak enforcement, lacking monitoring mechanisms and unclear responsibilities as well as inter-sectoral conflicts among water related ministries hinder any significant impact on improving India's water management practices (Pandit & Biswas, 2019; Sharad K. Jain, 2019).

Though the objectives of the policy calls for recycle and reuse of water, the lack of clear frameworks/action plan to operationalise the policies and bring about transformational changes on ground is a recurring issue.

2.1.2 The Water (Prevention and Control of Pollution) Act 1974

The Water (Prevention and Control of Pollution) Act aims to prevent and control water pollution by establishing Central and State Pollution Control Boards (the CPCB and SPCBs) to monitor, provide guidelines and norms and enforce the regulations relating to the treatment and disposal of sewage and trade effluents. It makes it mandatory to establish and implement effluent discharge standards and introduced penalties for non-compliance in case of wastewater-discharging bodies thus compelling wastewater treatment as a desired practice in India. The CPCB develops water quality management plans involving amongst others setting water quality goals; monitoring water quality; controlling pollution; wastewater recycling and resource recovery, use of clean technologies, and setting wastewater discharge standards and charges for residual pollution (CPCB, 2008). The SPCBs plan comprehensive programme for prevention, control and abatement of water pollution and secures its execution at state level, as well as advises the State Government on water pollution.

Though, the Act details the function of various agencies to look at prevention and control of water pollution, it depends on 'end of the pipe' treatment systems and lacks emphasis on cleaner production. There is also a lack of provision for public participation, in matters related to water pollution.

2.1.3 The Environmental (Protection) Act 1986

The Environment (Protection) Act empowered the Central Government to make rules to regulate environmental pollution. Concerning water, the environmental rules prescribe standards for quality of surface water for various purposes (irrigation, domestic, industrial, recreation, etc.) and the effluent discharge standards, with permissible limits of concentration of various parameters in wastewater for discharge over different areas (inland surface, public sewers, land for irrigation and marine coastal areas, etc.).

In 2017, an amendment was made to the Environment (Protection) Act to specify the standards for the discharge (into water bodies and land) of the treated effluent from the sewage treatment plants (STPs). However, these standards were scrapped by the Order of the National

Green Tribunal (NGT), stating that the diluted and differential standards will affect the existing pollution load of water bodies and will further impact a large section of the population. The NGT in its 2019 order made the sewage discharge standards much more stringent and emphasized that the benefit of such standards is to achieve all purpose non-potable reuse quality effluent. It states that each STP is to be treated as a source of water for reuse and recycling, helping in mitigating drought/climate change in the country (NGT Order 2019).

2.2 Key Government Programs at Central Level

2.2.1 Programs to Clean River Ganga

The key flagship programs launched by the Government of India with an aim to clean River Ganga have been the Ganga Action Plan (GAP) launched in 1985 and the current flagship program of Namami Gange launched in 2014 (figure below).

GANGA ACTION PLAN - I	GANGA ACTION PLAN - II	GANGA ACTION PLAN - III
Focus on pollution abatement, interception & diversion (I&D) as well as treatment of domestic sewage, to prevent toxic and industrial chemical wastes from identified grossly polluting units from entering in to the river GAP phase-I involved a sanctioned cost of INR 462.04 crores of which about INR 433.3 crores was spent on 25 class-I towns in Uttar Pradesh, West Bengal and Bihar About 868.69 MLD of sewage treatment capacity was created	Involved laying sewers, construction of new sewage treatment plants and rehabilitation of existing sewerage systems amongst others activites Under GAP phase-II, about INR 3402.43 Crores (until February 2014) capacity was spent on for Ganga and its tributaries About 1757.23 MLD of sewage treatment capacity was created	Key activities of the Namami Gange are the creation of sewage treatment infrastructure, river front development, cleaning of river surface, conservation of bio-diversity and conservation of identified priority species, afforestation and public awareness. The program has an approved budget of INR 20000 crore Treatment capacity of about 328 MLD have been created until 2019

Despite creating considerable STP infrastructure, the Ganga Action Plan was not able to achieve its overall objectives due to multiple factors including inadequate institutional & policy framework between central, state and local Government bodies to implement schemes, inadequate technological designs, significant delays in project execution, lack of funds in urban local bodies (ULBs) for adequate O&M of STP infrastructure, improper mass awareness, weak monitoring network etc.

The Government of India's flagship Namami Gange programme (launched in 2014) is an ongoing program with a broader scope of effective abatement of pollution, conservation and rejuvenation of National River Ganga. Activities are underway for creating sewerage capacity of 1187.33 (MLD) including two projects based on Hybrid Annuity PPP Model at Haridwar & Varanasi.

2.2.2 Recent Government initiatives to improve wastewater treatment and management

The Government of India has recently initiated or renewed several programmes to improve un-sewered and sewered sanitation. Under these programmes, applicants from municipal and private sectors are offered grants, subsidies and loans for investments. An overview of these initiatives is provided in Table 1:

Table 1: Overview of Government initiatives to improve wastewater treatment

Initiative	Ministry	Period	What is financed	Available funds	Reference
Swacch Bharat (Clean India) Mission	MoHUA/ MoDWS	2014-2019	Toilet construction in households, communities and public spaces in all 4041 statuary towns	9 billion USD	http://swachhbharaturban.gov.in/
AMRUT Mission	MoHUA	2015-2023	Water supply and sewerage connections, wastewater treatment facilities and septage management; as well as storm drainage systems (500 cities)	7 billion USD	http://amrut.gov.in/content/
Smart City Initiative	MoHUA	2017-2023	Sanitation and wastewater treatment and management in 100 Indian cities	7 billion USD	http://smartcities.gov.in/content/

Source: MoHUA = Ministry of Housing and Urban Affairs, MoDWS= Ministry of Drinking Water and Sanitation

Though there are many policies and programs by the Government that endorses wastewater treatment and reuse, the availability of clear guidelines and specific standards with a defined implementation framework for wastewater reuse is lacking. There is the need to dovetail existing water and wastewater laws into a National Water Framework as an umbrella of general principles governing water issues by the national government, the state governments and the local governing bodies. This should lead the way for essential legislation on water and sanitation governance in the entire country. Such a framework should recognise the importance and mainstream the wastewater treatment and reuse in India.

3. ANALYSIS OF SUCCESSFUL AND UNSUCCESSFUL EXPERIENCES WITH WASTEWATER TREATMENT AND WATER REUSE TECHNOLOGIES IN INDIA AND EUROPE

Globally, the uptake of wastewater treatment and water reuse systems has been slow despite its various benefits in alleviating the increasing water scarcity in many areas. The past experiences on wastewater treatment and water reuse practices have demonstrated both the benefits and the challenges related to sustainable planning and operation of technologies planning of wastewater reuse. A review of various initiatives in India and the EU (case studies, Section 3.1) and stakeholder consultation (Section 3.2) provide an in-depth understanding of water governance factors (Section 3.3.) that successfully or unsuccessfully contributed to delivering improved wastewater treatment and water re-use systems. These form the base for policy recommendations towards enhancing water governance on wastewater treatment and water reuse in India.

3.1 Experiences from full-scale technology applications case studies

In total six case studies on agricultural and industrial water reuse in India and the EU were analysed to determine water governance factors influencing the planning and operation of wastewater treatment and reuse systems. Water governance factors comprise the political, legal, socio-economic and institutional systems in place to manage water resources. Short descriptions of four of the case studies are presented below, highlighting policy interventions, technological designs and the main enabling factors and barriers of water governance arrangements. Additional information and further analyses can be found on the Pavitra Ganga project website: https://pavitra-ganga.eu/en

Agricultural reuse

Case 1: Kanpur (Jajmau), India

Background: Kanpur city in Uttar Pradesh is situated on the banks of river Ganga. The estimated sewage generation of Kanpur city is about 339 MLD, while its industrial tannery cluster produces 26 MLD of highly polluted wastewater.

Policy intervention: The introduction of the Ganga Action Plan (GAP) aimed to improve the water quality by interception, diversion and treatment of domestic sewage and toxic and industrial chemical wastes from polluting tannery units.

Treatment technologies: Under GAP-I, three sewage treatment systems were commissioned at Jajmau, viz. a 130 MLD sewage treatment plans (STP) based on the activated sludge process; a 36 MLD combined effluent treatment plant (CETP) based on upflow anaerobic sludge blanket (UASB) as well as a 5 MLD pilot plant based on UASB. Treated effluents from STPs and CETP are now mixed and provided for irrigation through an irrigation canal.

Enabling factors and barriers: Technological design of the CETP did not take into account a long-term development of the area and hence increased volume of effluent against created treatment capacity, frequent electricity breakdowns, inter-institutional conflicts and lack of cost-recovery resulting in low quality irrigation water (exceeding standards for BOD, COD, Cr, Pb, Zn and Cu). The deterioration of the quality of the effluent caused a decrease in crop yields and led to the contamination of soil and groundwater (IWMI 2013).

To address the bottlenecks, several interventions have been recently initiated under the Namami Gange Program involving various stakeholders (viz. NMCG, Autralian AID, IIT Kanpur, VA Tech Wabag, UP Jal Nigam, Jajmau Tannery Effluent Treatment Association (JTETA) etc.) that includes diversion of major Sisamau drain to Jajmau STP (60 MLD) and Bingawan STP (80 MLD) to prevent direct discharge into Ganga river and creation of 20 MLD zero liquid discharge CETP to treat tannery effluent.

Agricultural reuse	**Case 2:** Barcelona, Spain	Background: The water supply source of the Barcelona Metropolitan Area viz. the Llobregat River was intensively exploited for urban, industrial and agricultural uses, resulting in water quantity deficits and water quality deterioration due to agricultural runoff and disposal of industrial and urban treated effluents in most of the areas supplied from the River. Policy intervention: Spanish water reuse guidelines were established in 2007 for different uses of treated wastewater including urban, agricultural irrigation, and recreational purposes including parameters such as suspended solids, turbidity, E.coli, and intestinal nematodes eggs. The national water reuse guidelines and competing freshwater demands fostered the development and implementation of different wastewater reuse technologies. Treatment technologies: Technology designs were driven by reuse purpose and wastewater characteristics ('fit-for-purpose treatment') and based on a participatory stakeholder dialogue to meet the particular water quality needs of each reuse purpose at additional costs and demand. The wastewater treatment plant of El Prat de Llobregat is an activated sludge system. About two-thirds of the secondary treated water is discharged into the Mediterranean Sea, while one-third undergoes, depending on demand, tertiary treatment for reuse, by coagulation-flocculation and lamella settling, filtration through a microscreen followed by UV disinfection. Oxygen is injected into the system to ensure a saturated dissolved oxygen concentration. A smaller part of the flow undergoes reverse osmosis (RO). Enabling factors and barriers: The close proximity of the farmers to the wastewater treatment system limited pumping costs of the treated water and provided farmers an economic incentive over freshwater sources for irrigation, especially during times of scarce freshwater supply. Another driver of success was the leadership and involvement of one single agency providing greater flexibility and ease for negotiating with farmers.
Industrial reuse	**Case 3:** Nagupr, India	**Background:** Nagpur city in Maharashtra has witnessed high demands for freshwater due to rapid population growth and economic development during the last decades. The Maharashtra Generation Company Limited (MahaGenCo) needed large volumes of cooling water (309 MLD) for expanding production capacity of its thermal power plant (TPP) against an allocated 205 MLD by the Irrigation Department of the Maharashtra Government (SANDRP 2014). As an alternative to freshwater, the use of treated sewage was explored to meet the additional water requirements. **Policy intervention:** In 2005 the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was launched to facilitate the development of infrastructure projects with water supply, sewerage and treatment. As a result, a Memorandum of Understanding (MoU) was signed in 2008 between Nagpur Municipal Council and MahaGenCo for the supply of 110 MLD treated sewage from Bhandewadi STP to be further used in the cooling towers of the thermal power plant located in Koradi (Ade, Daharwal, Mahajan & Rathod 2018). In order to complement the efforts achieved with the JNNURM, the state of Maharashtra adopted its wastewater reuse policy in 2017. **Treatment technologies:** Bhandewadi STP is a sequencing batch reactor system followed by chlorination and deep-bed multimedia filtration. The tertiary treated wastewater is of acceptable quality for further use as process water at the thermal power plant. **Enabling factors and barriers:** The strong contractual agreement backed by Government policies and regular monitoring of delivered water quality resulted in a sustainably operated treatment system. MahaGenCo experienced economic advantages over sourcing freshwater, while Nagpur Municipal Council was able to cover the O&M costs through the revenues by the industry.
	Case 4: Schilde, Belgium	**Background:** The potential role of treated wastewater reuse as an alternative source of water supply is being more and more acknowledged in Belgium, which ranks 23 out of 164 countries experiencing water scarcity (World Resources Institute 2019) **Policy intervention:** The 2003 Flemish Integral Water Policy Decree has been launched in response to the European Urban Waste Water Treatment Directive (UWWTD, 91/271/EEC), the Water Framework Directive (2000/60/EG) and the Groundwater Directive (2006/118/EC). **Treatment technologies:** The WWTP of Schilde, located in the province of Antwerp, was retrofitted with an MBR system. It runs in two treatment lanes, one with a conventional activated sludge system and the other with the MBR. The MBR lane is intended to meet more stringent water quality norms. MBR effluents further undergo nanofiltration and are used as source water for breweries. **Enabling factors and barriers:** The increasing freshwater demands and water stress combined with policy interventions and large investments in developing, implementing and operating wastewater treatment infrastructures are key enabling factors for successful water reuse systems in Belgium.

3.2 Experience from stakeholder workshops

Water sector reforms and development of effective policies and regulations require multi-stakeholder partnerships and regular stakeholder engagement to enhance acceptability and sustainability of identified interventions. Participatory stakeholder engagement is also fundamental to achieving the Sustainable Development Goals (SDGs) including amongst others, supporting and strengthening the participation of local communities in improving water and sanitation management (Goal 6.B), as well as- ensuring responsive, inclusive, participatory and representative decision making at all levels (Goal 16.7). A stakeholder engagement process was employed as an important pillar to elucidate the challenges on the ground, discuss feasible solutions from users' and managers' perspectives and also to validate the findings from the case study analyses (Section 3.1). Two stakeholder consultation workshops were held in New Delhi and Kanpur.

participants of the workshop in New Delhi stated that the high costs of transportation of treated sewage from STPs to reuse sites and low demand for treated wastewater are major constraints. Absence of guidelines with well-defined quality criteria and standards for reuse of treated wastewater for different purposes (agriculture, horticulture, landscaping etc.) are other barriers to wastewater reuse.

Opportunities of treated wastewater reuse for irrigation, forestry and other non-potable uses were reflected upon in both ~~the~~ workshops. The consensus was that the wastewater has to be treated to acceptable limits before any further reuse. Some participants of the workshops also mentioned that there should be public awareness regarding wastewater management and segregation of waste. Suggestions were made to shift from Public Private Partnership (PPP) models to Public, Private and Community Partnerships (PPCP). This would help improving wastewater management with the involvement of the community as a key stakeholder. The participants also highlighted that even though in

Stakeholders in Delhi workshop

- Ministry of Jal Shakti
- National Water Mission
- Central Pollution Central Board
- National Mission for Clean Ganga
- Delhi Jal Board
- Technology Providers
- Research Institutions
- Non-Governmental Organizations

Stakeholders in Kanpur workshop

- Uttar Pradesh Jal Nigam
- Uttar Pradesh Pollution Control Board
- National and State Mission for Clean Ganga
- Solidaridad Asia
- Researchers from CSIR Indian Institute of Toxicology Research, Lucknow
- Harcourt Butler Technical University Kanpur and IIT-Kanpur

The two stakeholder consultation workshops provided the opinions and views of diverse stakeholders on core challenges and opportunities of wastewater treatment and re-use in India. The stakeholders highlighted that key challenges faced by STPs in India are: (i) high load variations of incoming sewage; and (ii) complexity of the sewage composition which affects the treatment efficiency. Another key issue that was brought out in the workshops was the dearth of faecal sludge treatment systems to handle high volumes of sludge generated which can result in re-contamination. Further, operation, maintenance and pricing issues were also discussed as major barriers to wastewater management. The most cases rules and regulations are already in place, it is imperative that their enforcement and implementation is done effectively.

3.3 Lessons learnt from case studies and stakeholder consultation

The case studies and stakeholder consultation in India highlighted that the State Governments have been taking important steps to tackle - to some extent - the problems of water pollution and water scarcity. However, the lack of overarching and clearly-defined guidelines from the Central or State Governments, along with the lack of an established framework for safe and sustainable reuse of treated wastewater with clear incentive/ disincentive mechanisms still poses a major barrier towards sustainable wastewater treatment and water reuse systems. Further, the choice of technology to treat and recycle/reuse domestic wastewater has to be guided by the physical constraints as well as the intended use of the treated wastewater (fit-for purpose treatment).

The case studies from the EU show that there has been an increased utilisation of wastewater in recent years, for many different proposes including agriculture, industry and drinking, especially in water scare countries. The recent development of governance arrangements such as dedicated economic instruments and the set-up of water reuse guidelines are expected to foster water reuse in the EU in the years to come.

The table below summarizes the water governance factors that influence (positively + or negatively -) the development and implementation of wastewater treatment technology and water reuse systems in India and EU. Water scarcity and seasonal variations in freshwater availability, environmental concerns related to wastewater reuse, acceptability of treated wastewater by user communities, cost/benefits for wastewater treatment and reuse, water pricing systems and treated wastewater supply mechanisms are some of the factors driving the success or failure of a wastewater reuse initiative.

Water Governance Factors		
Enabling Factor/Barriers	**Europe**	**India**
Legislation/policies	(+) UWWTD compliance (agglomerations > 2000 p.e.) is above 80% (+) Non-compliance followed up by warnings then financial penalties → drives investments in wastewater treatment infrastructure	(+) Water Pollution (Prevention and Control of Pollution) Act 1974 in place (+) CPCB standards for STP and CETP effluents in place (incl. quality parameters for irrigation on landscape) (-) low rate of enforcement of pollution controls (-) Lack of 'umbrella directive' for integrated water resources management
	(+) WFD provides integrated water resources management framework for European river basins	(+) introduction of river protection plans (e.g. Ganga Action Plan; Namami Gange)/Government programs (e.g. JNNURM) enhancing municipal wastewater treatment infrastructure
	(+) EU Member States with individual water reuse norms legislations (e.g. Spain, Portugal)	(-) No India-wide regulation or norms on water reuse quality parameters (-/+) Indian states with individual water reuse legislation/norms (e.g. Maharashtra, Gujarat, Punjab)
		(+/-) zero-liquid discharge policy of CPCB (2015) for four industrial sectors in 9 Indian states in the Ganges river. However, ZLD is expensive, requires a lot of energy and produces a lot of solid waste
		(+) Tariff Policy 2016 mandate thermal power plants located within 50 km radius of STPs to use treated sewage water
New legislative initiatives/ revisions	(+) Circular economy package including legal instrument for minimum water quality requirements for agriculture (expected 2020)	(+) National Green Tribunal (NGT) has directed the Ministry of Environment and Forests and Climate Change (MoEFCC) to issue stricter norms for effluent discharge from sewage treatment plants (STPs)
Water scarcity issue/ Decreased water availability	(+) drives diversification to alternative water supplies, more local supply / semi-closed water cycles	
Wastewater treatment and reuse infrastructure	(+) Reuse purpose and wastewater characteristics decide on technology design (fit-for purpose treatment)	(-) Technology designs not matching resource context and not taking long term development plans of the area into account

<table>
<tr><th colspan="3">Water Governance Factors</th></tr>
<tr><th>Enabling Factor/Barriers</th><th>Europe</th><th>India</th></tr>
<tr><td></td><td>(+) technology design matching resource contexts</td><td>(-) Prescribed standard technologies in tender processes</td></tr>
<tr><td>Operation and maintenance</td><td></td><td>(-) Frequent electricity breakdowns
(-) Financial constraints</td></tr>
<tr><td></td><td></td><td>(+/-) skills and capacities of plant operators</td></tr>
<tr><td></td><td></td><td>(-) outdated O&M on installations</td></tr>
<tr><td>Cost recovery</td><td>(+) high cost recovery for water treatment in EU15 Member States
(-) low cost recovery for water treatment in EU 13 Member States</td><td>(-) in general low cost recovery for wastewater treatment
(-) Lack of rational pricing in water & wastewater management services affecting cost efficacy of interventions</td></tr>
<tr><td></td><td colspan="2">(+) economic incentive of using treated wastewater over freshwater systems, when freshwater is scarce (industrial reuse examples)
(-) difficult for low revenue applications such as agricultural irrigation</td></tr>
<tr><td>Public financing strategies for wastewater treatment and reuse</td><td>(+) ERDF Cohesion funds essential for EU 13 Member States to reach UWWTD compliance
(-) high investments needed for wastewater treatment and reuse
(+) fit-for-purpose treatment reduces capital expenditure</td><td>(+) Government support/initiatives (e.g. Swacch Bharat Mission, Namami Gange, AMRUT, JNNURM etc.)
(+) Promotion of PPP through financial models of BOOT, DBOOT etc. Recent launch of Hybrid Annuity Model (HAM) for PPP in wastewater treatment schemes
(+) Public private partnerships
(+) Creation of Viability Gap Funds (VGF) to support infrastructure projects</td></tr>
<tr><td></td><td colspan="2">(+/-) charges for wastewater services influenced by socio-cultural norms and political interests</td></tr>
<tr><td>Institutional arrangements</td><td>(+) public private partnership/clear allocation of roles and leadership</td><td>(-) Multiplicity of organizations/stakeholders with lacking collaborative efforts
(+) Creation of Special Purpose Vehicles (SPVs) to assist better execution of infrastructure projects on ground.</td></tr>
<tr><td>Acceptance</td><td colspan="2">(+/-) perceived risks by public/farmers related to treated wastewater quality and quality of waste-water irrigated products
(+) on-site treatment and reuse (industrial reuse)</td></tr>
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4. WAY FORWARD

Though the Indian Government has been taking important steps to create an enabling environment for tackling the issues of water pollution and water scarcity, there are still some challenges that impede advancement in wastewater sector. Based on lessons learnt from the policy and regulatory framework analysis (Section 1.2 and 2), the consultation workshops with stakeholders (Section 3.2) and the case studies' analysis (Section 3.1) from India and EU, the following recommendations are deduced to encourage and mainstream wastewater treatment and reuse in India:

1. Need for target-based regulations, defined national standards on water reuse quality and effective enforcement strategy.

Target-based regulations, defined national standards on reuse water quality, as well as water safety planning and risk mitigation measures are imperative interventions for enhancing water reuse in India. Guidelines and frameworks should not only include targets but also detail out the legislative, regulatory and financial measures needed to achieve them.

Further, regulations and guidelines need to be supported by effective monitoring, enforcement and follow-up strategies. Enforcement mechanisms for polluters need to be established in order to reduce the pressure on end-of-pipe treatment systems.

2. Policy and guiding frameworks need to establish detailed guidance on wastewater treatment and reuse technologies (fit-for-purpose treatment)

The choice of technology to treat and recycle wastewater has to be guided by the physical and socio-economic constraints as well as the intended uses of the treated wastewater (fit-for-purpose treatment). Decentralised systems should be promoted to facilitate and enhance reuse of wastewater in peri-urban and rural areas with openness to new technologies and configurations that allow for different degrees of treatment for different water uses. For this purpose, enhanced Government support and investments into research and development for innovative technologies for wastewater reuse is required. A robust implementation framework involving last mile connectivity of solutions will help in better upscaling and optimisation.

Reuse of wastewater is still in its nascent stage in India. Most State Governments lack a wastewater management and reuse policy and/or law. Only select states (Gujarat, Jharkhand, Karnataka, Haryana and Punjab) have formulated policies to improve wastewater treatment and encourage the reuse of water. However, there is limited capacity to enforce regulations that are already in place.

There is a requirement of clearly-defined guidelines from the Central or State Governments, along with an established framework for safe and sustainable reuse of treated wastewater. Regular and planned engagement of key stakeholders in policy formulations and implementation; and community mobilization, awareness and capacity building are important and collaborative action is needed to create demand for the end-products from the STPs.

3. Need of effective financing mechanisms (funds, taxes, tariffs) that permit sufficient cost-recovery for long-term operation and maintenance of wastewater treatment infrastructure.

Although public funds are available for treatment infrastructure, most utilities are unable to recover cost of treatment, especially for low cost applications such as agricultural irrigation. To boost industrial reuse, several industries and bulk water users will need to look towards wastewater as economically viable option to meet their water requirements. Thus, treated wastewater should be cost-competitive as compared to alternative options available to industries.

Circular economy initiatives to increase water reuse require robust business models that ensure cost recovery. Effective incentive and disincentive mechanisms for wastewater reuse with economic advantages for entities (e.g. exemptions in GST charges, incentives to recycle/reuse by-products etc.) will increase utilisation of treated wastewater.

Policies are needed to support more effective water- and wastewater-pricing systems that permit sufficient cost recovery, ensure adequate investments and support long-term operation and maintenance. The willingness to pay for water reuse is clearly linked to the non-availability of conventional water sources i.e., surface and or groundwater. Hence, adequate permitting systems need to be in place to control or prevent groundwater extraction, thus safeguarding long term supplies for drinking water.

4. Strengthening of institutional and monitoring capacity

Improvements are needed in the institutional framework for water supply, distribution, sewage, wastewater treatment and reuse at the national and state levels with clearly defined roles and responsibilities supported by adequate infrastructure, manpower and finances. State pollution control boards have limited human resources to monitor water quality, and limited organisational capabilities to pursue legal action against violators of pollution control (Kumar and Tortajada, 2020). Thus, capacity enhancement of the pollution control boards will enable in establishing a better pollution monitoring and prevention system.

The number of monitoring stations in water bodies are inadequate and many of them are not located in cities or immediately downstream of sources of pollution, due to which, a realistic picture of the extent of water pollution in the country does not surface (Kumar and Tortajada, 2020). Substantial investments in monitoring stations and monitoring capacity are needed to ensure total confidence for the end users such as farmers in the safety of using treated waste water.

As a way forward, it is fundamental to rethink water and sanitation governance in India and continue to design, implement and enforce robust policy and regulatory frameworks - taking inspiration from recent developments in water governance and best practices. The research and development of innovative, cost effective, and sustainable technologies and establishment of monitoring mechanisms have an important role to play in achieving this titanic task and PAVITRA GANGA aims to make a contribution to these endeavours.

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PAVITRA GANGA: A Joint India-EU initiative towards innovation in water technology

The potential role of treated wastewater reuse as an alternative source of water supply is well acknowledged and embedded within international, European and Indian strategies. UN Sustainable Development Goal on Water (SDG 6) specifically targets a substantial increase in recycling and safe reuse globally by 2030.

The PAVITRA GANGA project has as one of its key objectives to develop and pilot robust, cost-effective water treatment technologies for the Indian context with a focus on reuse. The project envisages to pilot test an array of innovative wastewater treatment technologies with a potential for application and upscaling that might have a significant impact on wastewater treatment in India and as such shall contribute to improving water quality and overall rejuvenation of the River Ganges. The novel technologies are that will be tested are the following:

- The Andicos™ technology (combined anaerobic treatment of organic waste and sewage), a modular treatment step that can be addition to existing treatment plants, and/or applied as a new stand-alone facility. It consists of filtration through membranes, the membrane concentrate is processed through a digester, producing biogas and a nutrient-rich digestate that can be used as a fertilizer. In case of water reuse the effluent can be treated by a CWplus designed to remove micro-pollutants and pathogens. Structured adsorbers can be used in case of river flow augmentation.
- The SFD-MBR, a self-forming dynamic membrane bioreactor, is based on integration of conventional activated sludge and 'non-membrane' surface filtration. It is robust, resilient and cost-effective compared to ultrafiltration membranes, offering a decentralised wastewater treatment solution that has both low energy and maintenance requirements, also making it suitable for small-scale applications and for installation in remote areas. In case of water reuse the effluent can be treated by CWplus or by structured adsorbers in case of river flow augmentation.
- The PAS, a photo activated sludge system, is a merger of the high rate algae ponds (HRAPs) and activated sludge systems, combining the advantages of simple natural systems making use of sunlight and technologically advanced activated sludge systems, suitable for small-scale applications and for installation in remote areas needing little maintenance.
- The structured adsorbers, low-cost inorganic granulated sorbent materials for chromium or phosphorous removal and recovery, show a high sorption capacity, fast kinetics and good mechanical and chemical stability, allowing for the recovery and reuse of the valuable metals and nutrients.
- CWplus, a modified constructed wetlands, combine vertical flow constructed wetlands composed of several layers consisting of gravel, sand, and sorbents planted with local vegetation. The sorbents are based on e.g. granular activated carbon for enhanced heavy metal removal.

All these technologies consider the Indian wastewater composition and allow for simple operation and maintenance procedures. The efficiency in removing bulk pollutants as well as micro-pollutants and pathogens shall be tested. Challenges with respect to health will remain a focus, therefore protocols shall be developed for designing water reuse safety plans to promote health and safety as well as to demonstrate an innovative, easy to use water quality and quantity monitoring platform to improve operation and maintenance. The success of the application of the technologies are strongly affected by water governance arrangements and stakeholder's engagement. The PAVITRA GANGA project and these technologies is being piloted at two pilot sites in India viz. Delhi (Barapullah) and Kanpur (Jajmau) which face significant challenges of pollution from domestic sewage and industrial effluents. The project also comprises key stakeholder engagements and analysis of policy & regulatory frameworks necessary for success of potential interventions.