Governance of Small-Scale Sanitation in India

Institutional Analysis and Policy Recommendations

Small-Scale Sanitation Scaling-Up (4S) – Project Report Vol. II

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All publications from the 4S Project including this report can be downloaded from:
www.sandec.ch/4S

Related Journal Publication

The main research findings described in this study report are also published in a scientific paper (open access):

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Governance Arrangements for the Scaling Up of Small-Scale Wastewater Treatment and Reuse Systems – Lessons From India

ABOUT THE 4S PROJECT

The project *Small-Scale Sanitation Scaling-Up* (4S) is the first holistic assessment of small-scale sanitation systems in South Asia. The research project was carried out from 2016 to 2018 with the aim of developing evidence-based policy recommendations for the successful implementation of small-scale wastewater (sewage) treatment and reuse systems at scale. This was achieved based on the technical field evaluation of more than 300 sanitation units, as well as in-depth governance and financial analysis. 4S was implemented under the auspices of the Indian Ministry of Housing and Urban Affairs by the Swiss Federal Institute of Aquatic Science and Technology (Eawag), the Indian Institute of Technology Madras, BORDA (Germany), CDD Society (India), ENPHO (Nepal) and other partners.

What is Small-Scale Sanitation (SSS)?

An SSS system refers to a **sanitation system that collects and treats sewage at or near its point of generation, using a small-scale sewerage network and a small-scale sewage treatment plant** (SSTP). A complete SSS system also includes a **solution (on-site or off-site) for managing the sludge** generated at the SSTP. SSS systems are sometimes also known as decentralised or distributed sanitation systems. Depending on the context, an SSS system can be designed to enable local water reuse, as well as energy and/or nutrient recovery (see **Figure 1**). In 4S, an SSS system is defined as one that serves **10-1,000 households (or 50-5,000 person equivalents, i.e., treating about 5-700 KLD [=m³/day] of wastewater)**. SSS systems can be installed for clusters of buildings or individual buildings, as well as for special applications such as public toilets.

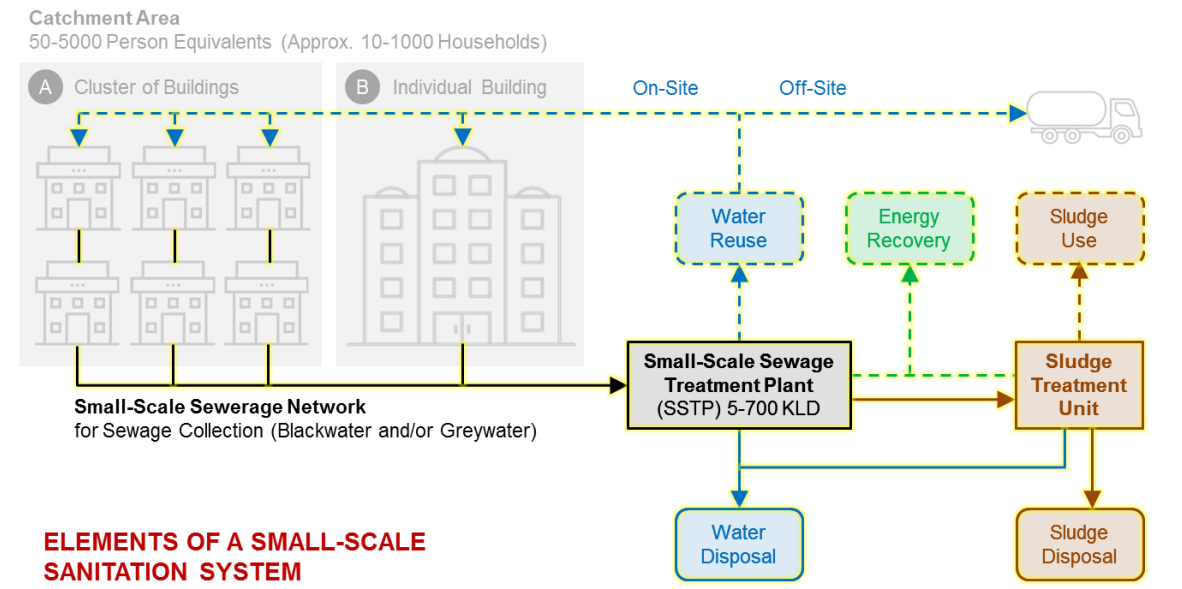


Figure 1: An SSS system is a sewer-based sanitation system that uses a small-scale sewage treatment plant inside or near the catchment area, and that can be designed for water reuse, as well as energy and/or nutrient recovery.

Why this Project? In increasingly urbanised South Asia, conventional approaches to water supply and sewerage are reaching their limits, manifested by water scarcity and slow progress of wastewater infrastructure provision. At the same time, the number of SSTPs is increasing rapidly, and water reuse becomes more and more important, especially in India. However, **there is currently a limited understanding of i) the specific role that SSS systems should best play in the future, ii) how good performance and cost-effectiveness can be ensured, and iii) how the ever-growing number of systems can be optimally regulated and managed**.

4S aimed to establish the current status of SSS, and what is needed for it to fulfil its potential for healthy and water-secure cities. By learning from the current challenges and opportunities, 4S aimed to help develop a roadmap towards an enabling environment for successful and thriving SSS at scale.

The 4S Approach

4S looked at SSS holistically, by integrating a mixed-method approach that combined actual sanitation system assessments with analyses at the governance level (see **Figure 2**). By doing this, the study considered all components that are needed for sanitation systems to achieve the desired performance:

- ✓ An enabling environment (see the six elements in **Figure 2**)
- ✓ The design and implementation as well as operation and maintenance (O&M) phases of a sanitation project
- ✓ Adequate technology and management schemes
- ✓ The planning, monitoring and evaluation cycle

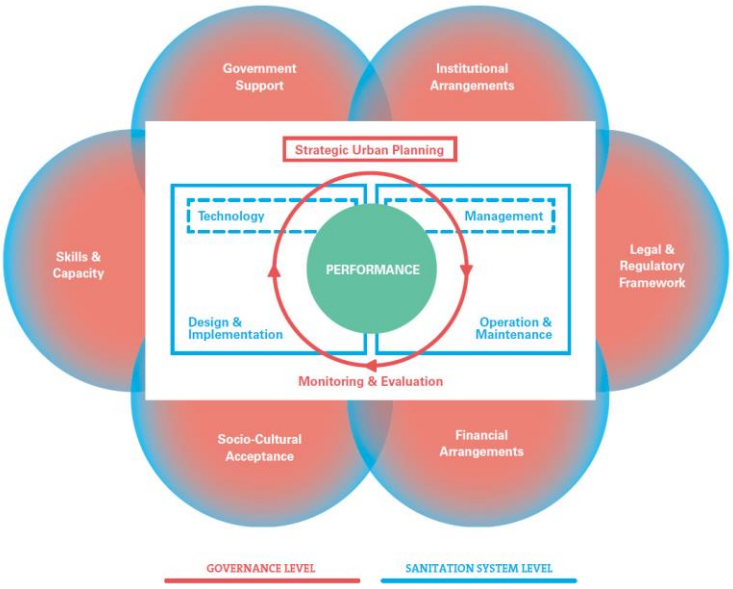


Figure 2: Diagram of the 4S analysis framework. The framework is based on the six elements of an enabling environment (Lüthi et al., 2011) and incorporates factors at the sanitation system level (blue) as well as at the governance level (red). Sanitation system performance (in the centre) is impacted by any of the depicted elements.

The 4S Project included the following study components:

I. **Technology, Implementation and Operation**:
   A. Desk-based **landscape study** of SSS in India, Nepal, Pakistan and Bangladesh
   B. **Basic assessment** of 279 systems in India and 30 in Nepal: site inspection and stakeholder interviews
   C. **In-depth performance analysis** of 35 systems in India and 5 in Nepal: sampling campaigns

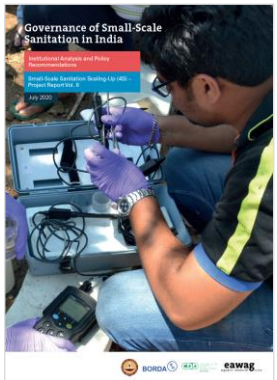
II. **Governance**: policy, institutional and stakeholder analysis

III. **Financial Sustainability**: financial analysis and study of life cycle cost

4S Publications

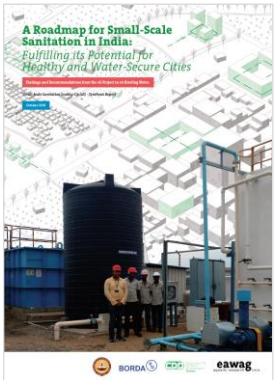
This report is one of four main publications from the 4S Project. All documents can be downloaded from www.sandec.ch/4S.

Vol. I: Technology, Implementation and Operation of Small-Scale Sanitation in India – Performance Analysis and Policy Recommendations



Vol. II: Governance of Small-Scale Sanitation in India – Institutional Analysis and Policy Recommendations

Vol. III: Financial Sustainability of Small-Scale Sanitation in India – Life Cycle Cost Analysis and Policy Recommendations



Synthesis Report: A Roadmap for Small-Scale Sanitation in India: Fulfilling its Potential for Healthy and Water-Secure Cities

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Abbreviations and Acronyms

ADB	Asian Development Bank
ADSIS	Association for Decentralised Sanitation Infrastructure and Services
AMC	Annual Maintenance Contract
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BBMP	Bruhat Bengaluru Mahanagara Palike *(municipal corporation)*
BDA	Bangalore Development Authority
BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
BWSSB	Bangalore Water Supply and Sewerage Board
CMA	City Managers' Association
CMDA	Chennai Metropolitan Development Authority
CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board *(under MoEFCC)*
CPHEEO	Central Public Health and Environmental Engineering Organisation *(under MoHUA)*
CPR	Centre for Policy Research
CRRT	Chennai River Restoration Trust
CSP	City Sanitation Plan
CTE	Consent to Establish *(sometimes called Consent for Establishment, CFE)*
CTO	Consent to Operate *(sometimes called Consent for Operation, CFO)*
DMA	Directorate of Municipal Administration
DMS	Data Management System
DoE	Department of Environment *(Tamil Nadu)*
DPCB	District Office of Pollution Control Board *(may be called "zonal" or "regional" PCB in some states, but for convenience this report refers to DPCB to denote area-specific sub-units of SPCBs)*
EIA	Environmental Impact Assessment
FAQ	Frequently Asked Questions
FC	Faecal Coliforms
FEE	Forest, Ecology & Environment Department *(Karnataka)*
FSSM	Faecal Sludge and Septage Management
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit *(German International Cooperation)*
IGBC	Indian Green Building Council
IWK	Indah Water Konsortium
JNNURM	Jawaharlal Nehru Urban Renewal Mission
KLCDA	Karnataka Lake Conservation and Development Authority
KLD	Kilolitres per Day [= m^3/day]
KSPCB	Karnataka State Pollution Control Board
KUDD	Karnataka State Urban Development Department
KUIDFC	Karnataka Urban Infrastructure Development and Finance Corporation

KUWSDB	Karnataka Urban Water Supply and Drainage Board
MAWS	Municipal Administration and Water Supply
MDU	Multi Dwelling Unit
MEP	Mechanical, Electrical and Plumbing
MLD	Million Litres per Day
MoEFCC	Ministry of Environment, Forest and Climate Change *(former MoEF)*
MoHUA	Ministry of Housing and Urban Affairs *(former MoUD)*
MoUD	Ministry of Urban Development *(now MoHUA)*
MoWR	Ministry of Water Resources, River Development and Ganga Rejuvenation *(merged with Ministry of Drinking Water and Sanitation to form the Ministry of Jal Shakti in May 2019)*
MSDE	Ministry of Skill Development and Entrepreneurship
NABL	National Accreditation Board for Testing and Calibration Laboratories
NGT	National Green Tribunal
NH_4-N	Ammoniacal Nitrogen
NIUA	National Institute of Urban Affairs
NUSP	National Urban Sanitation Policy
O&G	Oil and Grease
O&M	Operation and Maintenance
PCB	Pollution Control Board *(refers to SPCB)*
PE	Person Equivalent
PHE	Public Health Engineering
PPP	Public-Private Partnership
RWA	Resident Welfare Association *(Building Management Entity)*
SBM	Swachh Bharat Mission
SBR	Sequencing Batch Reactor
SEIAA	State Environmental Impact Assessment Authority
SHB	State Housing Board
SNA	Social Network Analysis
SPCB	State Pollution Control Board
SSS	Small-Scale Sanitation
SSTP	Small-Scale Sewage Treatment Plant
STP	Sewage Treatment Plant *(Synonym: Wastewater Treatment Plant)*
SUDD	State Urban Development Department
SUIDFC	State Urban Infrastructure Development and Finance Corporation
SWSDB	State Water Supply and Drainage Board
TN	Total Nitrogen
TNPCB	Tamil Nadu Pollution Control Board
TNUIFSL	Tamil Nadu Urban Infrastructure Financial Services Ltd.
TP	Total Phosphorus
TSS	Total Suspended Solids
TWAD Board	Tamil Nadu Water Supply and Drainage Board
ULB	Urban Local Body / City Municipal Corporation
WSSB	Water Supply and Sewerage Board *(parastatal utility in a few large cities)*
ZLD	Zero Liquid Discharge

Executive Summary

Small-scale sanitation (SSS) systems are making an increasingly important contribution to urban sanitation coverage in India, alongside large-scale sewage (wastewater) treatment plants (STPs) and the management of faecal sludge and septage from non-sewered sanitation systems. Such systems consist of small-scale sewerage networks and STPs. They represent a wastewater management solution for buildings and neighbourhoods in rapidly growing cities, especially where a connection to the centralised sewerage network is not feasible in the short to medium term. SSS systems can be implemented incrementally and flexibly, offering significant potential for cost-effective local wastewater treatment and reuse.

An impressive scaling-up process under an incomplete governance framework

With more than 20,000 SSS systems estimated to be operational today, India is one of the most advanced countries worldwide in the implementation of decentralised urban wastewater treatment solutions. Interestingly, the drive for SSS did not come from governmental agencies in charge of sanitation or urban planning; the initial impetus for this scaling-up process came from a regulation by the Ministry of Environment and Forests in 2006, requiring every large new building to have its own small-scale sewage treatment plant (SSTP). The resulting infrastructure is largely funded, implemented, owned and operated by private sector and civil society actors, with limited guidance and supervision from government agencies. None of the regulations stipulating the installation of SSTPs is accompanied with guidelines, incentives or monitoring strategies. So far, low government involvement, paired with the lack of integration of SSS policies in urban sanitation and water management plans, have resulted in a weak governance framework and a low awareness of the significant performance problems on the ground. The latter are described in the 4S Project Report Vol. I.

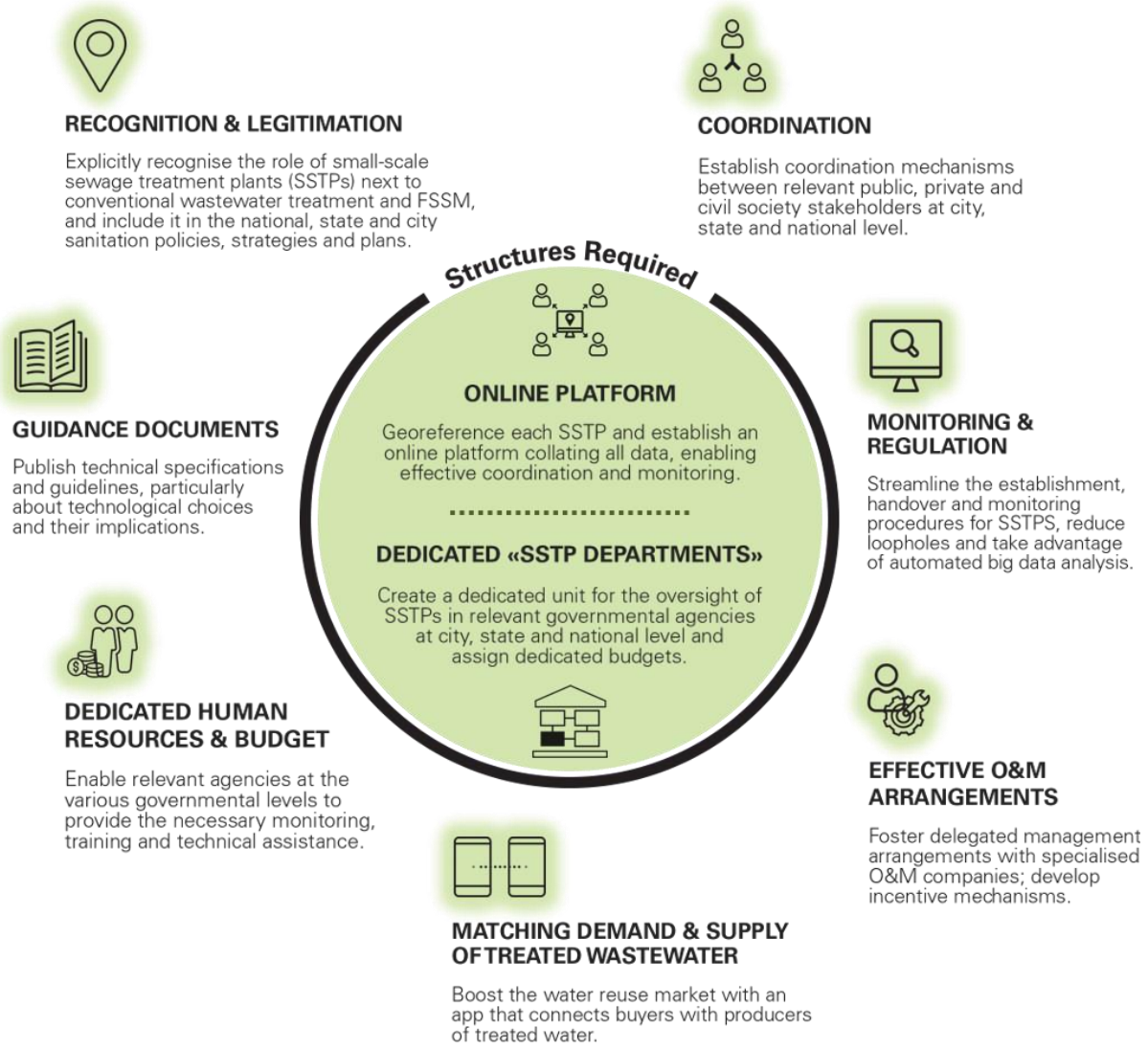
The main goal of the governance component of the 4S Project was to identify the gaps in the SSS governance arrangements in India, and to propose measures to the government stakeholders on how to shape the enabling conditions and support structures that will allow SSS systems to work at scale.

This research investigated the overall SSS governance framework at the national, state and city levels, and analysed the institutional arrangements for the implementation, operation and monitoring of SSTPs. It included a study of existing policies, laws and regulations around SSS, and an analysis of the stakeholders and their roles and responsibilities, with a focus on the states of Karnataka and Tamil Nadu. The research also included a review of relevant international experience. A mix of mainly qualitative methods was used, consisting of a literature review, semi-structured stakeholder interviews, social network analyses and a questionnaire-based assessment of 279 existing SSS systems.

The SSS governance framework did not develop at the same pace as the market-led implementation of SSTPs in India, and there are big differences between states. Accordingly, governmental bodies are not fully equipped to actively direct the scaling-up process and monitor the performance of systems. The analysis shows that weaknesses exist at all governance levels, from the governance arrangements at the national level to the details of implementation, operation and monitoring processes of SSTPs at the local level. Based on the analysis, the authors conclude that, from a governance perspective, the overall performance and success of SSS in India is impaired by the eight interlinked factors listed in the first column of the table below.

Priority actions for effective governance of small-scale sanitation in India

With the growing need for water reuse and the inability to quickly scale up centralised sanitation systems, SSS systems will play a critical role in urban areas. Government departments at all levels need to seize the opportunity and build on the on-going SSS scale-up process. In order to unlock the potential of SSS as a scalable solution for healthy and water-secure cities, the existing gaps in the governance framework need to be addressed systematically. Based on the evidence from this research, several priority actions for effective SSS governance are proposed, as illustrated in the figure below.



The table below provides an overview of the measures recommended to address each of the eight gaps identified in this study. Chapter 6 of this report describes the recommendations in detail, with short summaries at the end of each sub-chapter. These recommendations are a reflection of the results of this governance analysis and represent the most promising pathway towards effective governance and performance of SSS systems according to the authors' perspective.

Opening the discussion

To develop and implement reforms, the relevant stakeholders and sector experts should be brought together to discuss the following questions:

1. How to launch and fund the development of an online data management platform, as a key instrument for planning, monitoring and coordination? Would it be possible to create a committee with representatives from various stakeholder groups? Who should take the lead?
2. Which institutional embedment would make most sense for the proposed "SSTP departments" (SSS oversight and support units)?
3. How to build the required capacities for SSS implementation, O&M, management and governance?

Weakness	Recommendations
1) Lack of recognition of SSS by the governmental agencies responsible for urban sanitation planning (➲ section 5.1)	• Specify role and scope of SSS in national policies, state sanitation strategies and city sanitation plans (➲ sections 6.1.1 and 6.1.2) • MoHUA: develop technical specifications and guidelines so that funds can be channelled for SSS from national level down to ULBs and WSSBs (➲ section 6.1.1) • Create a unified database of SSTPs, with georeferenced data (➲ section 6.4.1) • Draw statistics on the contribution of SSS to urban sanitation coverage, and introduce an SSS category in the census (➲ section 6.4.1)
2) Lack of coordination between relevant governmental agencies (➲ section 5.2)	• Build an online platform with a unified database (➲ section 6.4.1) • Harmonise the role of SPCBs, WSSBs and ULBs (➲ section 6.3.2) • Ensure stakeholder participation in policy processes (➲ section 6.1.3)
3) Lack of dedicated budget and human resources (➲ section 5.3)	• Create dedicated SSS oversight and support units ("SSTP departments") at state and city levels to monitor SSS implementation and operation and to provide technical assistance if needed (➲ section 6.3.3) • Provide training to staff of SSS oversight and support units and SSTP operators through capacitated training centres (➲ section 6.5) • Develop a fair approach to optimise the private sector's role (➲ section 6.3.4)
4) Gaps in the establishment, handover and monitoring procedures (➲ section 5.4)	• Build an online platform, centralising all information for each SSTP (➲ sections 6.4.1 and 6.4.2) • Create dedicated SSS oversight and support units at state and city levels (➲ section 6.3.3) • Create mechanisms increasing the accountability of private players in technology selection and design (➲ section 6.1.6 and 6.3.4) • Support SPCBs in design clearance, e.g., through state level SSS oversight and support units (➲ sections 6.3.2 and 6.3.3) • Standardise handover between real estate developers and building management body (➲ section 6.3.1) • Automate verification procedures and prioritisation of field visits (➲ sections 6.4.1 and 6.4.3) • Streamline sample management, with results directly uploaded on the online platform by certified laboratories (➲ section 6.4.3)
5) Inadequate operation & maintenance (➲ section 5.5)	• Incentivise design-build-operate models (➲ section 6.3.4) • Develop financial incentives for building management bodies (e.g., property tax rebate) (➲ section 6.1.6) • Delegate management to specialised private service providers to oversee the O&M of several SSTPs, along with performance-based contracts (➲ sections 6.3.4 and 6.4.4) • Train and certify O&M service providers (➲ section 6.5.4) • Create an operator network to facilitate experience exchange and cross-fertilisation (➲ sections 6.3.4 and 6.5.4)
6) No specific effluent and reuse standards for SSTPs (➲ section 5.6)	• Review standards so that they can support the progress towards spatially and socially inclusive basic wastewater treatment coverage and water security (➲ section 6.2)
7) Insufficient integration of SSS in water reuse planning (➲ section 5.7)	• Specify role and scope of SSS in water reuse policies (➲ section 6.1.5) • Geo-reference all SSTPs (➲ sections 6.4.1 and 6.4.2) • Draw statistics on the contribution of SSS to water reuse (➲ section 6.4.1) • Develop an app to link supply and demand of treated wastewater (➲ section 6.1.7) • Increase level of centralisation (cluster of buildings or street) if water reuse is not possible at building level (➲ section 6.1.2 and 6.1.7)
8) Lack of key centralised governance structures, e.g., for data management, information and training (➲ section 5.8)	• Create dedicated SSS oversight and support units at state and city levels (➲ section 6.3.3) • Create an online platform, initiated at national level and developed in all states (➲ section 6.4.1) • Develop training programmes for SSS (➲ section 6.5) • Develop guidelines at national level for decision-support on SSS technology selection and O&M to foster informed decisions (➲ section 6.1.1)

1 Introduction

In 1992, the Indian Ministry of Environment and Forests stated: 'For a country like India, conventional [wastewater] treatment plants are costly. In fact, these are beyond the financial means of many small towns' (MoEF, 1992). That is still true today. Alternative sanitation systems are needed to achieve citywide inclusive sanitation [1], and for accelerating progress towards the ambitious Sustainable Development Goal 6.3 target of halving the proportion of untreated wastewater by 2030 (Andersson et al., 2018).

Investments in urban wastewater management and reuse can avoid many negative externalities, such as pollution and depletion of water bodies, public health issues and the unsustainability of tapping water from increasingly distant sources (Shah, 2016; WSP & IWMI, 2016). Small-scale sanitation (SSS) systems (see p. 3 for an explanation) have proven to be a viable alternative to conventional wastewater management systems for a variety of contexts, including large residential buildings, compounds, peri-urban areas, communities and small rural settlements (Gikas and Tchobanoglous, 2009; Larsen et al., 2016, 2013; Newman, 2001; Parkinson and Tayler, 2003; Singh et al., 2015; van de Meene et al., 2011; Wilderer and Schreff, 2000). SSS systems have the potential to complement large-scale plants in the non-sewered zones of cities, while significantly reducing the time needed for planning and implementation. Among the main advantages of small-scale wastewater treatment systems are their flexibility, modularity and cost-effectiveness (Libralato et al., 2012; Massoud et al., 2009), as well as their ability to produce water for local reuse (Gikas and Tchobanoglous, 2009; Larsen et al., 2016). SSS systems can be implemented in stages and dimensioned very close to the actual wastewater volume, reducing idle capacity costs (Maurer, 2009).

1.1 Small-scale sanitation in India: a scale-up process triggered by increasing water pollution and scarcity

Recognising that Indian cities grow faster than the pace at which the centralised water supply and sewerage networks can be extended, the Indian Ministry of Environment and Forests (MoEF – today MoEFCC), in charge of pollution control, instigated the implementation of small-scale sewage treatment plants (SSTPs) in 2006 (more details are given in section 3.2.2). This drive did not come from the governmental agencies in charge of sanitation or urban planning; the main rationale was environmental protection, i.e., pollution abatement and water saving through reuse. This policy move by MoEF was followed by adaptation and uptake to various extents at state and city levels, creating a boom in private sector SSS service providers. Thousands of units have been implemented since then throughout India, representing one of the biggest urban scaling-up processes of SSTPs worldwide. These plants are largely funded, implemented, owned and operated by private sector and civil society stakeholders – with limited government supervision. It is estimated that more than 20,000 SSTPs exist throughout India (see 4S Project Report Vol. I on technology, implementation and operation (Klinger et al., 2020)). In Bengaluru (Karnataka), SSS has an installed capacity to treat up to an estimated 10-20% of the city's sewage (Kuttuva et al., 2018; The Hindu Business Line, 2018). In view of increasing water scarcity and the high price of conventional centralised systems, scaling-up of SSS will accelerate in the years to come. Drangert and Sharatchandra (2017) demonstrate the key role that SSS systems have to play to ensure future urban water sustainability, citing the example of Bengaluru.

[1] Citywide inclusive sanitation (CWIS) encourages a mix of different sanitation systems to make sanitation sustainable and equitable (Narayan and Lüthi, 2020). See www.sandec.ch/cwis for further information.

1.2 Governance – indispensable foundation for successful SSS at scale

The successful scaling-up of SSS is not an easy process (Reymond et al., 2018). India is already far on the way. However, the performance and sustainability analysis component of the 4S study highlighted a relatively poor overall record in terms of performance and sustainability – see 4S Project Report Vol. I (Klinger et al., 2020). Other research has also found that many SSTPs are experiencing performance problems (Chatterjee et al., 2016; Starkl et al., 2018; Suneethi et al., 2015). To a large extent, this represents the impact on the ground of the current governance "ecosystem" (Klinger et al., 2020). Adjustments of the governance framework and of the institutions are necessary in order to reach a mature and well-functioning SSS sector in India.

In this report, "governance" refers to the rules, roles and relations that make sanitation systems work (UNDP-SIWI Water Governance Facility, 2016). It includes the formulation, establishment and implementation of sanitation policies, legislation and institutions, and clarification of the roles and responsibilities of government, civil society and the private sector in relation to sanitation systems and services (adapted from UNDP-SIWI Water Governance Facility, n.d.). As for "institutions", they are here defined according to the convention in institutional analyses in the social sciences to denote rules governing the behaviour of actors (Pahl-Wostl, 2009): "Institutions do not refer to organisations or physical structures. Formal and informal institutions refer to nature of processes of development, codification, communication and enforcement."

Needless to say, governance-rooted performance problems are not unique to SSS systems. The poor record of functionality of conventional large-scale wastewater management infrastructure reported in India and many low- and middle-income countries is a widespread issue, typically caused by an infrastructure-centred approach and institutional constraints (WaterAid, 2020). There are numerous barriers to progress in sanitation coverage and sustainable urban water management, but research has shown that the major barriers lie within the governance and policies, both in low- and middle-income countries (Lüthi et al., 2011; Medilanski et al., 2007; Reymond et al., 2018; Ross et al., 2014; Starkl et al., 2013; Tilley et al., 2014), and in high-income countries (Brown and Farrelly, 2009; Kiparsky et al., 2016; Mitchell et al., 2010). The complexity of governance in combination with weak institutions impairs urban service delivery (Boex et al., 2020).

Scaling up SSS entails more than replicating a large number of discrete projects (Eales et al., 2013); it requires innovative management models, institutional schemes and financing plans (Abeysuriya et al., 2007; Evans, 2013; Willetts et al., 2007). As for centralised large-scale sanitation and faecal sludge and septage management (FSSM), technology alone does not work (Reymond et al., 2016). The large-scale dissemination of on-site treatment solutions, such as SSTPs, depends on the successful organisation of innovation processes in three domains: (i) technological components and system integration, (ii) value chain formation and the development of new business models, and (iii) institutional innovations to create appropriate conditions under which these systems can reliably operate (Truffer et al., 2013).

Governance is critical to the success and sustainability of small-scale sewage treatment and reuse systems on the ground. An enabling environment must be in place around SSS, as illustrated in Figure 2 on p. 4, consisting in particular of

- government support: supportive and implemented policies and plans, legitimacy of SSS to the relevant government agencies;
- efficient and enforced laws and regulations;

- clear roles and responsibilities of the different governmental agencies, as well as coordination mechanisms;
- a robust monitoring scheme;
- capacity building structures to empower stakeholders at all levels;
- socio-cultural acceptance (this aspect is covered in the 4S Project Report Vol. I on technology, implementation and operation (Klinger et al., 2020));
- financial mechanisms that incentivise the different stakeholders (this aspect is covered in the 4S Project Report Vol. III on finance (Rajan et al., 2021)).

Weaknesses in these elements will inevitably affect the performance of scaled-up SSS. While national legislation and programs may provide important guidelines and incentives, the functioning of the sector and outcomes (i.e., actual improvements to the sanitation situation) crucially depend on how laws and regulations are implemented and enforced by public and private actors. Such implementation processes are rarely linear and straightforward, and are never controlled by one single stakeholder (Bardach, 1977; Hupe and Hill, 2016). Rather, implementation processes in complex policy issues require the involvement of, and collaboration between, many different public and private stakeholders, which aim at influencing the implementation process according to their interests. Therefore, to understand how policies are implemented, it is crucial to look at informal network governance structures, especially as there are considerable gaps and overlaps in institutional roles and responsibilities at the national, state and city levels in India (Cullet and Bhullar, 2015).

SSS has become a key component of citywide inclusive sanitation in India, alongside and complementary to centralised conventional systems and FSSM. However, whereas the governance framework for centralised systems is well established and the one for FSSM under quick development, the governance framework for SSS is still weak – despite the growing contribution of SSS to urban sanitation coverage, water reuse and environmental protection. This report analyses the concrete governance gaps and investigates how institutional innovations can create the conditions under which SSTPs can reliably perform. It sheds light on four related elements of the enabling environment: government support, institutional arrangements, legal and regulatory framework, and skills and capacity (➲ **Figure 3**).

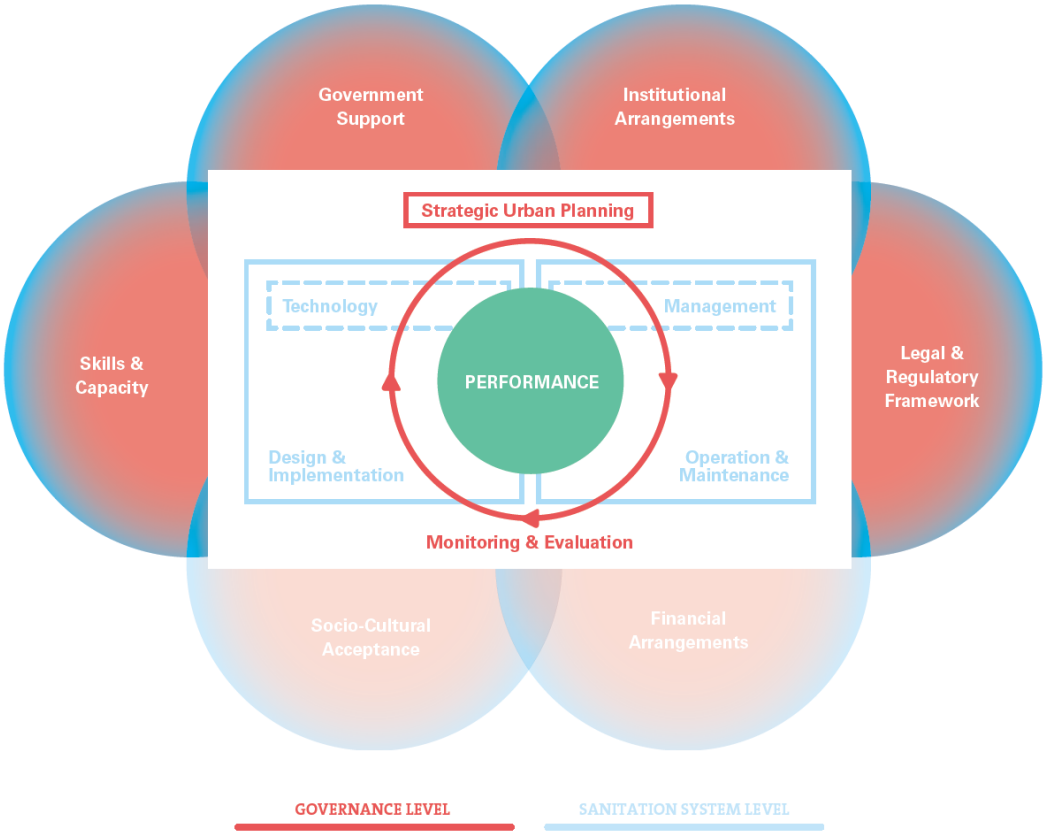


Figure 3: Diagram of the 4S analysis framework (see p. 4 for a detailed explanation). The framework is based on the six elements of an enabling environment (Lüthi et al., 2011). This governance analysis studies the aspects that are accentuated in the figure.

1.3 Purpose and objectives of this governance analysis

The main goal of the governance component of the 4S Project was to identify the gaps and shortcomings in the current SSS governance framework in India (with a focus on the states of Karnataka and Tamil Nadu, ➲ section 2.1), and to propose measures for the government to shape the enabling conditions and structures that will make SSS systems work at scale. This will enable

- **National government bodies** to make the necessary adaptations to the policy framework and to develop the required centralised governance structures, including databases, guidance documents and capacity building programmes.
- **State level agencies** to develop, implement and enforce pragmatic policies, strategies, legislation, monitoring processes, coordination mechanisms and support structures that ensure sustainable sanitation and water resources management.
- **Local authorities** to efficiently implement SSS strategies that meet their sanitation, water reuse and environmental protection priorities and foster liveable, healthy and water-secure cities and towns.
- **Private sector and civil society stakeholders** to design, implement, operate and maintain SSS systems that deliver a constant, affordable and premium quality water management service.
- **Decision-makers in other countries** to design effective strategies for the successful scaling-up of SSS, based on relevant lessons from India.

The **specific objectives** of the analyses documented in this report are

1. to thoroughly review the principal policies, laws and regulations for SSS in India, focusing on Karnataka and Tamil Nadu,
2. to get an in-depth understanding of the stakeholders and institutional arrangements for SSS through a systematic analysis of the roles, responsibilities, capacities and relations of different actors involved,
3. to compile relevant international experience,
4. to highlight the factors currently impairing the performance of SSS at scale, and
5. to derive evidence-based recommendations and propose priority actions for improving the governance of SSS in India, particularly in the areas of
   - policies and regulations,
   - management and monitoring,
   - capacity building, and
   - the roles and responsibilities of stakeholders at the national, state and city levels.

This report aims to answer the following main **research questions**:

1. What are the policies, laws and regulations that influence SSS in India (and particularly in Karnataka and Tamil Nadu), and how well are they implemented and enforced?
2. What are the current institutional arrangements for the planning, design, implementation, handover, operation, maintenance and monitoring of SSS systems?
3. What does the current stakeholder landscape look like (in terms of power, interest, roles, responsibilities, capacities and relationships)?
4. What are the key governance-related factors that currently impair the efficiency of SSS at scale?
5. Which measures can address the current shortcomings of SSS governance in India?

2 Methods

2.1 Overview of the approach

The governance issues were analysed both from the top (the national and state policy and regulatory level) and from the bottom (the impact on the ground, i.e., at the sanitation system level) (➲ Figure 3 on p. 18). The analysis looked at the overall SSS governance framework and at the governance arrangements along the project cycle of SSTP implementation, operation and monitoring. This approach allowed to obtain an understanding of the strengths and weaknesses of the current governance framework and how it materialises on the ground. It further allowed to identify the key factors impairing the efficiency of SSS at scale.

The governance framework for SSS differs in every state. While studying SSS all over India, the 4S Project had a focus on the states of Karnataka (and especially the city of Bengaluru) and Tamil Nadu (especially the city of Chennai). This focus was for two main reasons. Firstly, the two states are already well advanced in the scaling-up process of SSS. Karnataka, and particularly Bengaluru, has been a pioneer in the implementation of SSS policies. As the home to a large number of private sector service providers, Bengaluru is spearheading the development of the sector. Secondly, logistical reasons also contributed to the focus on the two states, as the research team was based in Bengaluru and Chennai.

Different examples from other states were also compiled to substantiate the discussion. **Table 1** gives an overview of the mixed-methods framework applied. The analysis steps, methods and data sources are further described in the following sections.

2.2 Analysis steps

The small-scale sanitation governance analysis conducted as part of 4S included the following steps of data collection, collation and analysis:

- **Review of the policies, laws and regulations** around SSS in India, with a focus on the states of Karnataka and Tamil Nadu (➲ chapter 3.2)
- **Analysis of stakeholders and institutional arrangements** for SSS in urban India, with a focus on Karnataka and Tamil Nadu (➲ chapter 3.3).

  The analysis of the institutional arrangements was carried out systematically along the project cycle of SSS systems, i.e., identifying the rules and procedures for

  1. the planning, design and implementation of SSS systems;
  2. the handover, operation and maintenance of SSS systems;
  3. the monitoring of SSS systems.

  Stakeholder analysis provides insights on the set of stakeholders involved in the governance of the SSS sector, especially their importance (interest), influence (power) and relationships. The following steps aimed to identify the allocation of responsibilities and to understand the challenges faced by the stakeholders in fulfilling these responsibilities:

  - Identification of public and private stakeholders at national level, in the states of Karnataka and Tamil Nadu, and in the cities of Bengaluru/Mysuru (Karnataka) and Chennai/Coimbatore (Tamil Nadu); identification of key

stakeholders, i.e., the most influential and important actors in the sector, through an analysis of power and interest (➲ **Box 1**)

- Analysis of the stakeholders' roles and responsibilities according to the existing institutional framework
- Assessment of stakeholder relationships and information exchange in the cities of Bengaluru/Mysuru (Karnataka) and Chennai/Coimbatore (Tamil Nadu)

- **Review of relevant international experience** (➲ chapter 4)
- **Formulation of conclusions and recommendations** for governance improvement based on the results (➲ chapters 5 and 6)

Table 1: Methodological framework of the 4S governance analysis. X indicates main method used in an analysis step, (X) indicates supplementary method.

	Methods and data sources				
Analysis steps	Desk-based literature review	Semi-structured stakeholder interviews	Social network analysis (SNA)	Consultations and informal discussions with sector experts and concerned citizens	Questionnaire-based assessment of 279 small-scale sanitation systems
Review of policies, laws and regulations around SSS in India (chapter 3.2)	X				
Analysis of stakeholders and institutional arrangements for SSS in urban India (chapter 3.3)					
Analysis of the institutional arrangements along the project cycle of SSS systems	X	X	(X)	(X)	(X)
Identification of stakeholders and key stakeholders at national, state and city level	X	X	(X)	(X)	
Analysis of the stakeholders' roles and responsibilities	X	X	(X)	(X)	
Assessment of stakeholder relationships and information exchange	(X)	(X)	X	(X)	
Review of relevant international experience (chapter 4)	X			X	

Box 1: Identifying key stakeholders amidst a complex landscape of actors

The SSS sector encompasses a wide range of public, semi-public and private actors at different levels. The agencies which are enforcing and monitoring sometimes differ from state to state, and even from one city to another, which can make the identification of the involved stakeholders quite complex.

In a first step, stakeholders were identified through a review of the documents such as policies, local development regulations, newspaper articles, as well as through expert consultations and interviews. Fischer et al. (2017), Ingold and Fischer (2014), Knoke (1993) and Knoke et al. (1996) propose a systematic strategy for identifying stakeholders in a policy sector, relying on three criteria: (i) "decisional criteria": those stakeholders that participate in important decision-making venues of the sector are identified; (ii) "positional criteria": those stakeholders that are in an institutional position to influence the policy sector are identified; (iii) "reputational criteria": those stakeholders that are identified by other stakeholders as being influential in the policy sector are identified. During interviews, respondents were asked to mention important stakeholders not identified at first (*snowball principle*). This strategy of relying on "crowd knowledge" ensures that the analysis captures the most important stakeholders.

This first "landscape study" resulted in a list of 29-32 stakeholders per city (➲ Table 3). Stakeholders are broadly categorised into:

- Governmental stakeholders (at national, state and city level)
- Private stakeholders
- Non-governmental organisations (NGOs)
- Citizen groups (e.g., Bangalore Apartments' Federation)

The first list of actors was then reduced to include key stakeholders only, based on the results of the stakeholder analysis (➲ section 3.3.4).

These steps allowed for a general and case-specific overview of the stakeholders involved in the governance of the SSS sector in India.

2.3 Methods and data sources

The methodology used consisted of a mix of mainly qualitative methods:

2.3.1 Desk-based literature review

Different secondary data sources were used to compile governance-related information:

- **Research journals, academic reports and Master theses:** Some academic research on governance aspects of SSS is available. However, the number of relevant studies is very limited.
- **Policy documents, legislations and acts:** Many of them are publicly accessible, but sometimes difficult to find. The website of the International Environmental Law Research Centre (IELRC[2]) proved to be a useful resource to access policies and building bye-laws pertaining to SSS. Cullet and Bhullar (2015) was a valuable book reference.
- **Other grey literature:** A lot of relevant information can be found in documents such as project reports, minutes and presentations of workshops organised by various agencies.
- **Newspaper articles:** The information pertaining to the regulatory framework and roles and responsibilities are not well documented in easily accessible sources. Key information related to discharge standards and amendments made to the existing policies are shared through daily newspapers. Newspapers are also useful to study the reactions of concerned citizens towards the policies.

[2] www.ielrc.org

2.3.2 Semi-structured stakeholder interviews

Semi-structured qualitative stakeholder interviews aim to obtain a general understanding of the situation. These interviews were conducted by the project team in different local languages and were not recorded, as many stakeholders, especially government stakeholders, are afraid that truthful answers could be used against them. For that reason, focus was given on trust building and informality. Key information was then extracted and compiled. See Appendix 1 for the list of interviewed stakeholders and Appendix 2 for the interview questionnaires.

Overall, a total of 35 key informants shared information through semi-structured interviews. They represented different groups of stakeholders, as summarised in **Table 2**. A majority of the interviews was conducted with government stakeholders at state level and with private sector stakeholders. This reflects the fact that sanitation is a state subject and that SSS is predominantly implemented and operated by the private sector.

Table 2: Number of interviewees per stakeholder group

Stakeholder group	Number of interviewees
Governmental agencies at national level	2
Governmental agencies at state level	14
Governmental agencies at city level	4
Private sector	11
NGO	4

2.3.3 Social network analysis (SNA)

Social network analysis (SNA) was used as a systematic method to describe and analyse the web of relations between various stakeholders (Lienert et al., 2013; Victor et al., 2017; Wasserman and Faust, 1994) and to understand the informal dynamics fostering or hindering the SSS sector. SNA allows for a quantitative analysis and comparison of network structures across cases and for the identification of the most central stakeholders in the network. It also provides useful visual representations of stakeholder relations in network graphs (or sociograms). The combination of SNA with stakeholder analysis can generate fine-grained insights and a more complete understanding of stakeholder interactions (Lienert et al., 2013).

Data for the network analysis stems from a structured written questionnaire (➲ Appendix 3) asking all respondents to mention their relations with the other key stakeholders. It is complemented with information from semi-structured interviews (➲ section 2.3.2) and an analysis of the relevant literature, and validated with expert consultations (see further below).

In order to visualise the differences between and within the states of Karnataka and Tamil Nadu, the SNA was conducted for a mega[3] city and a secondary[4] city in each state, namely Bengaluru and Mysuru in Karnataka, and Chennai and Coimbatore in Tamil Nadu.

[3] Mega cities are defined as urban agglomerations with a population of more than ten million (UN DESA, 2016).
[4] Secondary cities are here defined as cities with a population of more than one million and in the top five in the economic hierarchy of the state (Narayan et al., 2020).

For the four cities, the information exchange networks were analysed, integrating aspects of technical information exchange as well as of administrative information exchange. Technical information is defined here as information on the technical aspects of SSS systems (for example information on technologies and their implications), while administrative information represents the sharing of new requirements, legal frameworks, and guidelines (for example new requirements for the construction of SSS systems) (Fischer et al., 2017).

Table 3 gives an overview of the number of stakeholders identified for the four cities, and how many of them were identified as key stakeholders (➲ Box 1 on p. 22 and section 3.3.4). It then shows the number of stakeholders interviewed (the key ones, with a few exceptions), and the respective numbers of written SNA questionnaires received (and response rates) after these interviews. In total, for the four cities, 27 key stakeholders were interviewed (column e), and 14 SNA surveys were received (column f) from key stakeholders. The numbers in the table are higher in total because responses from national and state level actors are applicable for all four cities, or both cities per state. The list of stakeholders is provided in Appendix 1.

Table 3: Number of identified actors and response rates of interviews and SNA questionnaires

State (a)	City (b)	Nr. of stakeholders (c)	Nr. of key stakeholders (d)	Nr. of stakeholders interviewed (e)	Nr. of questionnaire responses (f)	Written SNA questionnaire response rates (g)=(f)/(d)
Karnataka	Bengaluru	33	14	15	7	50 %
	Mysuru	32	13	15	6	46 %
Tamil Nadu	Chennai	31	13	16	4	31 %
	Coimbatore	29	11	12	3	27 %

The survey response rates were relatively low (column g of Table 3), which is a common problem in SNA, for various reasons, such as: potential respondents may not feel competent to fill the survey, not be interested to do so, not have time, or may not want information about their organisation to appear in studies (Narayan et al., 2020). Such incomplete network data can lead to unreliable estimates of network level statistics, which in turn distort the sociogram and ultimately cause incorrect conclusions (Burt, 1987). To overcome the low response rates and complement the available information, a novel validation method was developed and applied by Narayan et al. (2020) based on this case. This validation method uses available expertise from informants with high case knowledge and shared relationships with the network. It relies on information from internal (directly involved) and external (unbiased) experts. The novel validation method helped to improve, consolidate and confirm the findings from the SNA with a reasonable additional effort.

2.3.4 Consultations and informal discussions with sector experts and concerned stakeholders

As a means of substantiating fragmentary information and validating findings and conclusions, the personal communication with experts was helpful (e.g., for chapter 4).

During the project period, numerous workshops, brainstorming meetings, dissemination events and conferences on the subject of SSS took place, organised either through the 4S project or other stakeholders. The participation in such events allowed interacting with the entire range of government, private sector and civil society stakeholders and helped complementing the understanding of governance issues.

2.3.5 Questionnaire-based assessment of 279 small-scale sanitation systems

During the 4S field data collection phase, 279 existing SSS systems were visited for site inspection and stakeholder interviews. As part of this questionnaire-based data collection, governance-related information was gathered in order to understand the implications of policies and the enforcement of regulations on the ground. See 4S Project Report Vol. I on technology, implementation and operation (Klinger et al., 2020) for further details.

2.4 Limitations

This study aims to pinpoint the main shortcomings in the institutional framework around small-scale sanitation and formulate recommendations. The policy, legal and regulatory framework in India is complex and dynamic, with differing regulations from state to state and sometimes from city to city. This study is an attempt to understand at best the situation through a deeper analysis of the states of Karnataka and Tamil Nadu. The focus on these states is justified as they are most advanced in SSS implementation (highest numbers of units) and therefore function as ideal cases to understand the challenges of the scale-up process. Such challenges are not (yet) apparent in other states that do not implement SSS policies to the same extent. Although this approach gives a good overview of what the challenges can be and what is needed for an efficient governance framework around SSS, it is clear that this view is partial, and cannot fully represent what is happening all around India. For that, an analysis of the framework in each state in view of this report's findings would be required.

It has been observed that some regulations pertaining to SSS and effluent discharge standards are under constant revision. Some policies and regulations mentioned in this report may, therefore, become outdated quickly (this report reflects the status in 2020). The analysis of the policies, laws and regulations was done to substantiate the recommendations, which are by themselves not dependent on minor policy variations. For the reader, a focus on the recommendations is, therefore, most important.

Some constraints reduced the extent of this study. In particular, the social network analysis, aiming at analysing the formal and informal relationships between stakeholders, led to less results than expected because of the difficulty to access stakeholders, have a complete interview and get answers in the written survey. An in-depth comparison between mega cities and smaller towns was not possible for that reason. Besides, the very large number of factors influencing the performance of small-scale systems did not allow establishing the links between the policy framework in a specific state or city and the actual performance of the SSS systems.

3 Governance of small-scale sanitation in urban India: an analysis

This chapter analyses how well the different governance-related functions required for an enabling environment for small-scale sanitation are fulfilled in India, with a focus on the states of Karnataka and Tamil Nadu. It draws a panorama of SSS governance in India by looking at i) the related policies, laws and regulations, and ii) the stakeholders and relevant institutional arrangements, including current roles and responsibilities. It also highlights the framework differences between large-scale (conventional) and small-scale sanitation systems.

3.1 Overview of the institutional framework for urban wastewater management in India

Figure 4 maps the different government stakeholders that are relevant for urban wastewater management in India at national, state and city level, as described in the following paragraphs.

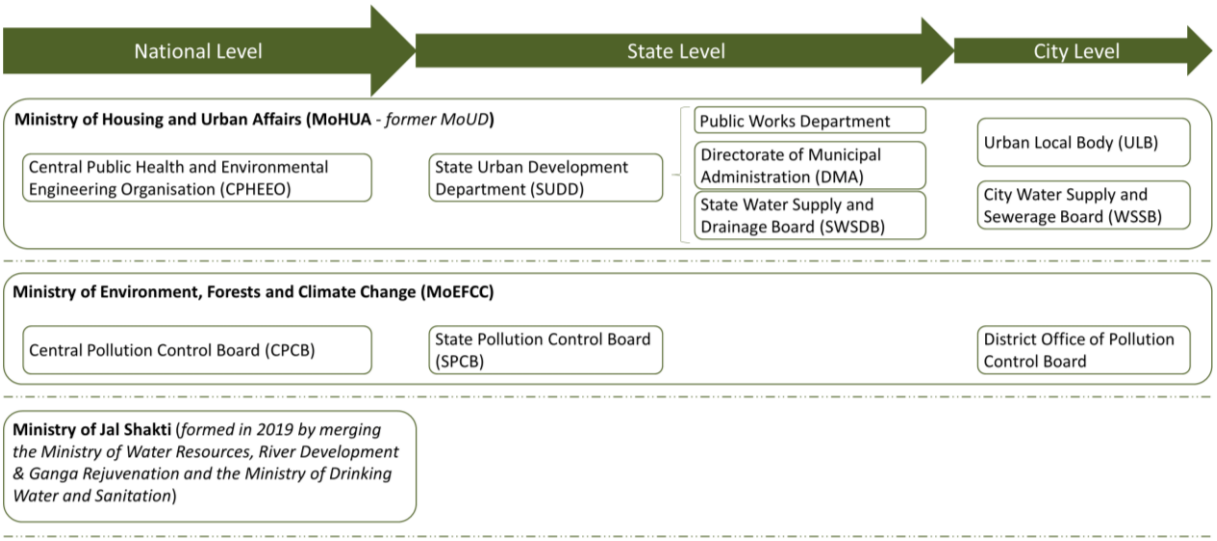


Figure 4: Government agencies responsible for urban wastewater management in India (in May 2019)

In the Constitution of India, the responsibility for urban sanitation is delegated to the states, under purview of the Ministry of Housing and Urban Affairs (MoHUA, formerly MoUD) at national level. Constitutionally, MoHUA's role is confined to advocate policies, design guidelines and standards, clearly demarcating sanitation as a state subject (Bhullar, 2013). The Central Public Health and Environmental Engineering Organisation (CPHEEO) is a technical wing of the MoHUA. "The organisation not only supports the Ministry in policy formulation but also handholds states by way of technical advice, guidelines, scrutiny and appraisal of schemes and propagation of new technologies in the field of water supply and sanitation including municipal solid waste management. [...] It acts as an advisory body at central level to advise the concerned state agencies and Urban Local Bodies (ULBs) in implementation, operation and maintenance of urban water supply, sanitation and solid waste management projects and helps to adopt latest technologies in these sub sectors." (CPHEEO, 2020).

State governments are vested with powers to legislate on sanitation either directly or indirectly. With the enactment of the 74th amendment of the Constitution of India in 1993, ULBs, which are in charge of approving new buildings, are vested with the responsibility for devising and implementing sanitation strategies. In a few metropolitan [5] cities, parastatal agencies (Water Supply and Sewerage Boards – WSSB, which act as utilities) are responsible for water supply and wastewater management services. Such bodies are partly or wholly owned or controlled by state government (Bhullar, 2013). Where a WSSB exists, it takes over the responsibility for sanitation from the ULB. In that case, the ULB's role is limited to devising building regulations, which can encourage small-scale sanitation.

In practice, Urban Local Bodies and WSSBs (in metro cities) do not have sufficient institutional and financial capacities to build, operate and maintain wastewater management infrastructure with citywide coverage and full cost recovery (HPEC, 2011; Planning Commission, 2011). To tackle the gaps in provision of sewage collection and treatment services, State Water Supply and Drainage Boards (SWSDBs) were formed at state level to support ULBs in planning, designing and implementing water supply and wastewater management infrastructure. These boards draw funds from national and state governments. They can build treatment plants and then hand them over to ULBs for operation and maintenance. Similarly, parastatal agencies also rely on state government or donor agencies for financial resources to construct large-scale wastewater management infrastructure.

The Ministry of Environment, Forest and Climate Change (MoEFCC) is in charge of planning, promoting and coordinating environmental and forestry policies and programmes in the country, including those aiming to prevent and control environmental pollution. Of particular importance for the wastewater sector is MoEFCC's responsibility for setting environmental standards (especially the discharge standards for treated wastewater).

The Central Pollution Control Board (CPCB) is a body within the MoEFCC which was constituted under the Water Act in 1974 with the objective to prevent, control and abate environmental pollution. The CPCB offers technical services to the Ministry. One of its mandates as per the Water Act is to "collect, compile and publish technical and statistical data relating to water pollution and the measures devised for its effective prevention and control and prepare manuals, codes or guides relating to treatment and disposal of sewage and trade effluents and disseminate information connected therewith".

At state level, State Pollution Control Boards (SPCBs) are responsible for the implementation of legislations related to environmental pollution (➲ **Box 2**). SPCBs are empowered to lay down effluent standards at state level. While all the sewage treatment plants in India should adhere to the standards issued by the MoEFCC, SPCBs are provided freedom to define more stringent regulations for the state. SPCBs are responsible for monitoring the performance of all wastewater discharging entities (i.e., buildings, industries, large and small-scale sanitation systems).

[5] Metropolitan (or metro) cities in India include Mumbai, Delhi, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad and Pune.

Box 2: State Pollution Control Board (SPCB) functions and powers with relevance for small-scale sanitation, as defined in the Water (Prevention and Control of Pollution) Act, 1974

The Water (Prevention and Control of Pollution) Act (No. 6 of 1974, dated 23 March 1974, as amended to date) defines the responsibilities and powers of SPCBs and stipulates that any sewage treatment and disposal system requires SPCB consent before being established:

17. Functions of State Board[6]
"Subject to the provisions of this Act, the functions of a State Board shall be [...]
(e) to collaborate with the Central Board in organising the ***training of persons engaged or to be engaged in programmes relating to prevention, control or abatement of water pollution*** *and to organise mass education programmes relating thereto;*
(f) to ***inspect sewage*** *or trade effluents,* ***works and plants for the treatment of sewage*** *and trade effluents and to* ***review plans, specifications or other data relating to plants*** *set up for the treatment of water, works for the purification thereof and the system for the disposal of sewage or trade effluents or in connection with the grant of any consent as required by this Act;*
(g) to ***lay down, modify or annul effluent standards*** *for the sewage and trade effluents and for the quality of receiving waters [...];*
(h) to ***evolve economical and reliable methods of treatment of sewage*** *and trade effluents [...];*
(i) to ***evolve methods of utilisation of sewage*** *[...] in agriculture;*
(j) to ***evolve efficient methods of disposal of sewage*** *[...] on land [...]*
(l) to make, vary or revoke any ***order*** *[...]* ***requiring any person concerned to construct new systems for the disposal of sewage*** *[...] or to* ***modify, alter or extend any such existing system*** *[...]."*

20. Power to obtain information
"(3) [...] a State Board may [...] give directions requiring any person in charge of any establishment where any industry, operation or process, or treatment and disposal system is carried on, to ***furnish to it information regarding the construction, installation or operation of such establishment*** *[...]."*

25. Restrictions on new outlets and new discharges
"[...] no person shall, without the previous ***consent of the State Board*** *(a) establish or take any steps* ***to establish*** *any industry, operation or process, or* ***any treatment and disposal system*** *or any extension or addition thereto, which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land [...]; or (b) bring into use any new or altered outlet for the discharge of sewage; or (c) begin to make any new discharge of sewage."*

33A. Power to give directions
"[...] a Board may, in the exercise of its powers and performance of its functions under this Act, ***issue any directions*** *in writing to any person, officer or authority, and such person, officer or authority shall be bound to comply with such directions. [...] the power to issue directions under this section* ***includes the power to direct*** *(a) the* ***closure, prohibition or regulation of any industry, operation or process****; or (b) the storage or regulation of* ***supply of electricity, water or any other service****."*

The Ministry of Jal Shakti (formed in 2019 by merging the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR) and the Ministry of Drinking Water and Sanitation) only plays a minor role in urban sanitation, namely through the National Mission for Clean Ganga (formerly under MoWR). Under this mission, the implementation of wastewater treatment infrastructure in the Ganga basin is one focus, e.g., as a pillar of the "Namami Gange" programme.

[6] Refers to State Pollution Control Board

3.2 Policies, laws and regulations for SSS in India

A number of sanitation policies were developed at national level during the last decades, which mainly addressed toilet coverage and large-scale sewer-based treatment systems in the country. It is only when the Ministry of Environment and Forests (today MoEFCC) decided to address the water-related environmental impact of large construction projects that small-scale, building-level wastewater treatment and reuse entered the scene. The corresponding regulations on building development prescribed by the Ministry and subsequently also by state and city level governmental agencies resulted in the installation of thousands of SSS systems in urban India (➲ section 3.2.2). However, small-scale sanitation is still not well integrated into the sanitation planning landscape.

In what follows, the major sanitation policies are presented, as well as the current policy and regulatory framework influencing SSS.

3.2.1 National urban sanitation programmes and policies

National-level sanitation policies and funding schemes influence – and to some extent determine – the type of wastewater infrastructure implemented in the country. Historically, programmes and investments in urban sanitation have always been routed to construction of large-scale sewage treatment systems, and to some extent community toilets and septic tanks in slums and low-income communities. MoHUA is the principal policy-making agency in the field of urban sanitation and also largest funder of the sector (Wankhade, 2015).

The following paragraphs describe the different sanitation programmes and policies since 2005.

Jawaharlal Nehru Urban Renewal Mission (JNNURM) funding scheme – 2005-2014

MoHUA (at that time still MoUD) launched JNNURM, targeting 65 selected cities to infuse capital for infrastructure development. A large portion of the investments in urban sanitation in the last decade was directed to centralised networked systems in these cities (Wankhade, 2015).

National Urban Sanitation Policy (NUSP) – 2008

The National Urban Sanitation Policy (MoUD, 2008) encourages cities to prepare city sanitation plans (CSP) encompassing the assessment of the existing sanitation situation, recommendations for sanitation improvement and corresponding financial plans. With regard to SSS, the policy only includes four relevant statements:

- A CSP must include (among many other aspects) the discussion of the use of decentralised wastewater treatment technologies.
- Wastewater reuse for non-potable applications should be implemented wherever possible.
- The proportion of treated wastewater that is reused is defined as one of the indicators for the rating of cities with regard to their performance in sanitation improvements. A reuse of 20% or more is needed for the maximum score in this indicator.
- States are recommended to set standards for environmental outcomes in their sanitation strategies, considering the use of low energy intensive onsite/decentralised wastewater treatment technologies.

JNNURM funding was largely available for large-scale network-based solutions. This is one factor which led CSPs to prioritise conventional wastewater treatment systems. There are a few exceptions where SSS was mentioned as a solution. However, the traditional approach of CSPs did not encourage cities to integrate SSS. Even existing SSS systems were hardly taken into account while drafting CSPs in a majority of the cities (➲ example of Goa in **Box 3**).

In 2014, the number of CSPs reached 165 in the entire country (Dasgupta and George, 2014). At the time of writing, the NUSP was under revision with the MoHUA.

Box 3: Case study – The absence of SSS in the CSP of Panaji, Goa

There are at least 170 small-scale systems in Goa (1.8 million inhabitants) (Singh et al., 2016), and a fair number of systems exist in Panaji, the state's capital. However, the CSP report of Panaji does not take these systems into consideration (CCP, 2015). At the same time, the report refers to solutions oriented towards septage management.

Smart Cities Mission and Atal Mission for Rejuvenation and Urban Transformation (AMRUT) – 2015

Smart Cities and AMRUT were announced in 2015 as the new urban infrastructure development schemes (succeeding JNNURM) to be implemented in selected cities. Under these initiatives, septage/faecal sludge management (i.e., non-sewered solutions) are receiving increased attention, besides large-scale sewage treatment plants which are still the preferred option in most cities. There are a few instances of setting up SSTPs near urban water bodies to treat inflowing wastewater, such as under a Smart Cities project in Coimbatore (CDD Society, 2020).

National Policy on Faecal Sludge and Septage Management (FSSM) – 2017

With the large investments in sanitation through the Swachh Bharat Mission and AMRUT, FSSM gained a lot of attention in India over the last few years. Significant efforts are being made to ensure adequate collection, transport and treatment of faecal sludge and septage. As part of these efforts, a national FSSM policy was released in 2017 (MoUD, 2017). The principal objective of this policy is to address the gaps in FSSM by setting the context, priorities and directions for the nationwide implementation of FSSM services through diverse stakeholders. Only on-site sanitation facilities fall under the purview of this policy; it does not cover networked/conventional wastewater management systems. However, it aims to address synergies between FSSM and sewer-based systems, e.g., co-treatment of faecal sludge at sewage treatment plants.

Swachh Bharat Mission (Urban): SBM Water Plus Protocol – 2019

The Swachh Bharat Mission aimed to fulfil the objective of open defecation free (ODF) cities by 2 October 2019. SBM (Urban) also had a limited focus on the correct operation and maintenance of toilet facilities (referred to as ODF+) and effective faecal sludge and septage management (ODF++). Recognising that further efforts are needed to move towards sustainable urban (waste)water management, MoHUA announced the SBM Water Plus Protocol in 2019. Cities can get Water Plus certification if all their wastewater is treated, and parts of it reused. The protocol includes the following aspects that are relevant in view of SSS (MoHUA, 2019):

- All wastewater from households, commercial establishments etc. to be treated (no untreated wastewater discharged into the open environment)
- Adequate capacity of sewage treatment facilities to be ensured (100 litres per person connected to sewer, "through decentralised or centralised treatment plants")
- At city level, at least 10% of wastewater to be reused after treatment (horticulture, agriculture, industrial use, road cleaning etc.)
- Operation and maintenance costs to be recovered through dedicated revenue streams (including from reuse/recycling of treated water)

With this explicit mention of decentralised treatment systems and reuse, it is clear that any city aiming for SBM Water Plus certification will not get around a detailed consideration of the current and potential role of SSS systems.

3.2.2 The triggers of SSS: environmental regulations and water reuse policies

The national trigger

As shown above, a significant policy push for small-scale sanitation is lacking on the part of urban sanitation programmes and policies from the central government. Nonetheless, it is estimated that there are now more than 20,000 SSS systems in India (see 4S Project Report Vol. I (Klinger et al., 2020)). The initial impetus for this considerable development came from the Ministry of Environment and Forests (MoEF, today called MoEFCC). Recognising that Indian cities grew faster than the pace at which centralised water supply and wastewater management systems could be extended, the MoEF prescribed SSS systems for new large residential, institutional and commercial buildings in 2004 through an amendment to the Environmental Impact Assessment (EIA) notification (MoEF, 2004). The Ministry further amended the EIA notification in 2006, prescribing SSTPs for buildings with a total built-up area larger than 20,000 m^2 throughout the country (MoEF, 2006). The key rationale behind is that large buildings tend to have a greater environmental impact, and mandating SSS was a mitigating measure, with the benefit of reduced pollution and lower water consumption due to reuse. At the same time, it is a move to hand over the responsibility for sewage treatment from public service providers to the polluters, resulting in considerable wastewater management assets that are built, owned and operated by the private sector.

State and city level triggers and related challenges

Besides the national trigger, there were also various initiatives with a similar rationale in several states and cities which led to the widespread implementation of SSS systems, as highlighted in the following paragraphs. The fact that SSS policies were not implemented everywhere in India with the same emphasis and rigour is reflected in the number of SSTPs found across the country today (this may also have to do with sanitation being a state subject, ➲ section 3.1). In some cities there are now thousands of units, while in others there are hardly any records (Klinger et al., 2020).

Karnataka was one of the SSS pioneer states. Already in 2004, the Karnataka State Pollution Control Board (KSPCB) introduced the requirement of SSTPs in new residential buildings with more than 50 apartments or a built-up area of more than 5,000 m^2, and 2,000 m^2 for commercial establishments (Evans et al., 2014; Kuttuva et al., 2018). Other states and cities also started demanding SSS systems for buildings much smaller than stipulated in the 2006 EIA notification, e.g., through building development regulations or bye-laws. In some cases, including Tamil Nadu and Andhra Pradesh, it was the State Urban Development Department (under MoHUA) which introduced SSS, but clearly mentioning

that design clearance has to be obtained from the respective State Pollution Control Boards (SPCB – under MoEFCC). In a few other cases, e.g., in the cities of Hyderabad and Pimpri-Chinchwad, the Urban Local Bodies prescribed SSTPs with a similar design clearance clause. In several locations including Navi Mumbai, Nanded and Jammu, SSS is introduced through greywater[7] recycling policies drafted in bye-laws (IELRC, 2011, 2010a, 2010b)[8]. Interestingly, these water-saving oriented bye-laws explicitly entrust the ULB with enforcement and monitoring responsibilities. For Nanded and Navi Mumbai, the draft policies also envisaged to incentivise greywater reuse through water and sewerage tax rebates.

Local regulations for SSS were, thus, introduced by different governmental agencies in different ways.

The initiatives adopted at state and city level prescribe different conditions and thresholds for the implementation of SSS, often significantly stricter when compared to EIA 2006. The criteria can include the number of apartments (in residential buildings), the number of rooms (in hotels) and the total built-up area (➲ examples in **Table 4**).

Table 4: Examples of thresholds for the establishment of SSS in different states and cities (not necessarily reflecting the latest and/or enforced status)

	States			Cities			
	Tamil Nadu	**Goa**	**Andhra Pradesh**	**Pune**	**Bengaluru**	**New Delhi**	**Hyderabad**
Sources	(CMDA, 2016)	(Herald Goa, 2013; The Times of India, 2016)	(MA&UD Department, 2015)	(Barringer, 2014; Pune Municipal Corporation, 2013)	(BWSSB, 2017)	(DPCC, 2013)	(Deccan Chronicle, 2017; Telangana Today, 2018, 2017)
Residential buildings (number of apartments)	> 50 *(only if no sewer exists)*	> 40	> 100	> 80 *(Pune)*	> 20 *(new buildings)* > 50 *(existing buildings[1])*	NAV*	NAP*
Residential buildings (area in m²)	NAP	NAV	NAP	> 4,000 *(Pimpri-Chinchwad)*	> 2,000 *(new)* > 5,000 *(existing)*	NAV	> 10,000
Commercial buildings (area in m²) or hotels	> 2,500 *(only if no sewer exists)*	Hotels > 24 bedrooms	NAV	NAV	> 2,000 *(new and existing)*	Hotels 3* and above; other hotels dep. on sewer connection, use of kitchen / laundry; restaurants > 36 seats; banquet halls > 100 m²	> 10,000
Institutional buildings (area in m²)	NAV	NAV	NAV	NAV	> 5,000 *(new)* > 10,000 *(existing)*	NAV	> 10,000

*NAV: Not available from sources cited; NAP: Not applicable according to sources cited; [1] i.e., constructed before enforcement of the BWSSB notification dated 26/04/2017

[7] Greywater is the total amount of water generated from washing food, clothes and dishware as well as from bathing, but not from toilets.

[8] The bye-laws for Nanded and Navi Mumbai available to the authors were only drafts. Hence, it is not clear if they are effective and in force.

No guidelines exist for setting thresholds and for defining SSS strategies, which explains why thresholds can differ considerably between states/cities, despite similar rationales. For instance (among other relevant aspects), it is not well understood what the minimum conditions are (including but not limited to STP capacity, water tariff and O&M personnel requirement) at which economies of scale allow for financially sustainable operations. The 4S Project Report Vol. III on finance (Rajan et al., 2021) sheds more light on this issue.

There are also no guidelines or suggestions provided to Urban Local Bodies on how cities can integrate SSS into their main sanitation plans. Although it concerns sanitation and sanitation coverage, there is no ownership on the part of WSSBs and other stakeholders in charge of sanitation planning. One reason for this is that the majority of SSTPs are privately built, owned and operated, with minimal involvement of public actors (➲ section 3.3.1). Another one is that SSS is mostly driven by MoEFCC and the SPCBs, and not by the agencies in charge of sanitation.

It is remarkable that none of the policies making the installation of SSTPs a requirement is accompanied with any guidance or incentives for the successful operation and management of systems. The management of the sewage sludge generated is also never considered, apart from a mention in two recent MoEFCC notifications (MoEFCC, 2018, 2016)[9] and a guidance note from Hyderabad (➲ Box 7 on p. 46).

The lack of understanding of the financial and practical implications of building-level STPs became apparent in Bengaluru, where policies changed several times based on a trial-and-error approach, with significant resistance on the part of concerned residents (➲ **Box 4**).

Box 4: A case study in unrealistic policies

In Bengaluru, the Bangalore Water Supply and Sewerage Board (BWSSB) has the mandate to provide water supply, sewerage and sewage treatment services. BWSSB is operating the existing large-scale STPs, with plans to realise the extension of the sewerage system and numerous new STPs to ensure full sanitation coverage of the city. As the SSS drive in Karnataka initially came from the Pollution Control Board, BWSSB historically had no involvement in this field. Interestingly, BWSSB took two unadept actions with regard to SSS systems in recent years:

1. In 2015, BWSSB issued a circular requiring all SSTP owners to use “external additives like microorganisms for bio culturing to accelerate the treatment”, as well as ”a single low-cost probe equipped with GPRS communication for obtaining instantaneous online general performance of treatment” (BWSSB, 2015). The circular explicitly mentioned three approved vendors where these products were to be sourced. However, the circular was withdrawn within a month, as it was questioned even within BWSSB (Citizen Matters, 2015a).
2. In 2016, a notification from the Karnataka Forest, Ecology & Environment Secretariat directed all concerned building, planning and regulatory authorities in the state to ensure that all residential buildings with 20 units and above, or a total built-up area of 2,000 m^2 and above, install SSTPs and ensure reuse of treated water – even where sewerage systems exist (GoK FEE, 2016). In the following, BWSSB announced that even existing buildings with 20 or more apartments will have to implement SSTPs and dual plumbing systems. Anyone failing to do so would have to pay significantly increased water and sanitary charges (BWSSB, 2016). This idea did not consider practical aspects like availability of sufficient space for a treatment facility, technical feasibility, high associated costs, monitoring, energy consumption, or reduced flow in existing sewers and treatment plants. This unrealistic policy created an outcry among the residential community (Narasimhan and Durai, 2017) and huge criticism in the media. In 2017, BWSSB consequently had to relax the regulation for existing buildings from 20 apartments to 50 (or built-up area above 5,000 m^2) and to extend the timeline to one year (BWSSB, 2017).

[9] By the end of 2018, the 2016 notification was overruled and the 2018 notification was sub-judice.

This case study reveals several important shortcomings:

- **The lack of integration of SSS in sanitation planning:** BWSSB on the one hand has a clear mandate and full-fledged plans to develop sewerage and treatment coverage for the entire city. On the other hand, it directs all big buildings to suddenly have their own treatment and reuse systems. This would create two overlapping, parallel systems. Residents are charged sewerage fees but asked to build and operate STPs at their own cost. The role of SSS from a water supply and sanitation service perspective was never defined.
- **Unclear responsibilities:** the role of various authorities with respect to SSS policy making and enforcement was never defined.
- **Lack of consultation and coordination between stakeholders:** policies are determined and released without coordination between state and city level authorities, and without any public consultation, feasibility analysis and strategic planning. Stakeholders which are "far away" from the subject's ground realities (such as BWSSB which was previously not at all involved in SSS) fail to develop pragmatic policies themselves without seeking external support and consultation.

Water reuse policies can further trigger SSS

Some states and cities proactively developed policies to bring reuse concepts closer to the ground. As early as 2003, in a situation of drinking water shortage, Karnataka issued a government order for Bengaluru, making it mandatory to use tertiary treated water for non-potable purposes, with penal provisions in case of non-compliance. The order clearly states that the Bangalore Water Supply and Sewerage Board (BWSSB) shall not provide potable water supply for activities including gardening, vehicle cleaning and construction (GoK, 2003).

In April 2015, the CPCB issued the following remarkable directions to all State PCBs (along with new discharge standards and other directions): *"SPCB shall issue directions to all municipalities and other concerned authorities in the State/Union Territory responsible for treatment and disposal of sewage to the following effect: [...] (III) Secondary treated sewage should be mandatorily sold[10] for use for non-potable purposes such as industrial processes, railways and bus cleaning, flushing of toilets through dual piping, horticulture and irrigation. No potable water to be allowed for such activities. [...] (IV) Dual piping system should be enforced in new housing constructions for use of treated sewage for flushing purpose."* (CPCB, 2015a, 2015b). The directions aim to enforce dual piping for new housing but do not mention i) a minimum size of the housing above which to enforce it, and ii) the requirement of SSTPs.

In December 2015, the Karnataka State PCB communicated these directions in the same wording to BWSSB and all ULBs, adding that local bodies shall enforce the dual piping rule (KSPCB, 2015). The actual impact of these policies on the ground is not clear; enforcement is difficult and appears not to be done in a strict manner.

Often the local policies also specify whether or not excess amounts of treated water from SSTPs can be discharged to a sewer network (if existing) or storm drain. In some cases, it is reported that authorities require "zero liquid discharge (ZLD)", i.e., that all water is reused and no water leaves the property. The rationale behind such policies may be that discharge permission disincentivises proper treatment of the wastewater. ZLD reportedly seems to be required in Kerala, as stated by representatives of multiple private companies interviewed. A newspaper article says, however, that the state norms demand 80% reuse (The Hindu, 2012), which would still be difficult to achieve in practice (see also 4S Project

[10] At least at the national level it seems that there are no restrictions for the sale of treated wastewater from SSTPs. However, it is also not clearly regulated in terms of quality assurance, monitoring, liability etc.

Report Vol. I on technology, implementation and operation (Klinger et al., 2020)). It is not clear whether or not a ZLD policy also applies in Bengaluru/Karnataka, de jure banning the discharge of treated wastewater into stormwater drains. Several sources mention it (Evans et al., 2014; Kuttuva et al., 2018), but there is no official document confirming it and available information and opinions on past and current actual practice are conflicting. It is also not clear whether or not ZLD implies that it is not allowed to sell treated water.

More pragmatically, the Andhra Pradesh state sanitation strategy suggests to enforce that larger industries, commercial establishments and apartment complexes meet at least 20% of their non-potable water requirements from reclaimed water (SLSC, 2016).

In Pune, water reuse in buildings with SSS systems is enforced by providing only a limited amount of water that is just sufficient for domestic consumption. This forces users to use treated wastewater for gardening, cooling and toilet flushing (Barringer, 2014).

In 2017, Karnataka's Urban Development Department (KUDD) promoted a new urban wastewater reuse policy, to be implemented by a committee composed of representatives from the wastewater, industries and agriculture sectors. The overall goal of this policy is to establish an enabling environment for the reuse of municipal wastewater to maximize efficient resource use, protect the environment, address water scarcity, and enhance economic output (KUDD, 2017). In particular, this policy initiated the development of a "Wastewater Reuse Resource Centre" within the Urban Development Department, aimed at awareness and capacity building (i.e., being an information centre) as well as project assistance. The new policy explicitly encourages decentralised treatment and reuse practices. It also states that "The ULBs will explore Public Private Partnerships (PPPs) as a possible option for implementation of wastewater reuse projects, focussing on bringing in private sector expertise for sustainable operations and maintenance of wastewater assets, with balanced risk allocation, and performance-based remuneration." The effects of this policy on the ground are still to be seen, but it shows how dynamic the development of wastewater policies and regulations is in India.

A first draft of a National Policy on the Safe Reuse of Treated Wastewater was circulated in October 2020, covering non-potable urban and rural reuse of treated used water (including water from SSS systems). When released, this new policy is expected to become a relevant resource for the sector, contributing to an enabling environment for reuse-oriented SSS systems.

3.2.3 Other initiatives promoting SSS and urban water reuse in India

Outside the mainstream sanitation and environment policies, the promotion of SSS has happened in various ways, including Government-led initiatives in a few states and cities (➲ examples in **Box 5** on p. 37).

The significance of SSS has been reiterated in different documents, such as 'model building bye-laws' or policies and policy guiding documents. None of the measures suggested in these documents are binding, leaving enforcement and application to the willingness of Urban Local Bodies. The main documents and initiatives are the following:

1. *Model Building Bye-laws by Town and Country Planning Organisation, a governmental agency under MoHUA – 2004 [revision 2016] (TCPO, 2016, 2004):*

   Two statements in these model building bye-laws suggest the inclusion of greywater recycling systems and small-scale wastewater treatment plants in new buildings:

- For residential plots more than 2,000 m^2 and non-residential plots more than one hectare in size, a separate piping system for greywater shall be provided to facilitate reuse for gardening and washing purposes.
- All buildings having a minimum discharge of 10,000 litres/day and above shall incorporate a wastewater recycling system. The recycled water should be used for horticultural purposes.

It is unclear whether these model building bye-laws have really influenced cities to include the clauses on SSS systems into their building regulations. Shah (2016) states that the city of Nanded in Maharashtra adopted the 2,000 m^2 rule in 2010, incentivised with water and sewage tax rebates.

2. *JNNURM optional reform: Bye-laws for reuse of water – 2005 onwards (Wankhade, 2013):*

   An optional reform under JNNURM, linked with financial assistance, led at least 46 cities to adopt bye-laws on reuse of water. However, there were challenges in the implementation of related dual piping systems (Planning Commission, 2011). Unfortunately, a better documentation of these cases could not be found.

3. *Creation of a Centre of Excellence in Decentralised Wastewater Management – 2009 (Philip et al., 2012):*

   MoHUA (at that time still MoUD) funded the creation of a centre of excellence in the area of decentralised wastewater management, in the Department of Civil Engineering at the Indian Institute of Technology (IIT) Madras. The scope of the project included: (i) preparation of detailed implementation plan in identified cities in case of decentralised wastewater management, (ii) helping ULBs in the implementation of the plans, and (iii) documentation and dissemination of the concepts and findings. The centre worked extensively with ULBs in Guntur (Andhra Pradesh) and Tiruchirapalli (Tamil Nadu) in this regard (Philip et al., 2012). The centre also prepared guidelines on decentralised wastewater management in 2012 (➲ section 3.2.4 below).

4. *Policies and policy guiding documents: National Mission on Sustainable Habitat – 2010* (MoUD, 2010a)*; National Water Policy – 2012 (MoWR, 2012):*

   While still not widely implemented, wastewater reuse is mentioned in several key policy documents (including the NUSP, ➲ section 3.2.1). Both documents listed here encourage small-scale treatment systems at building level and wastewater recycling to reduce the dependency on primary drinking water supplies. The National Water Policy states that i) reuse should be incentivised through a properly planned tariff system, ii) SSTPS that are less water intensive should be incentivised, and iii) reuse for flushing should be encouraged.

5. *Voluntary initiatives – Green Rating for Integrated Habitat Assessment (GRIHA) and Leadership in Energy and Environmental Design (LEED)*

   GRIHA and LEED are independent sustainability rating systems that provide rating to buildings with sustainability elements (rainwater harvesting pits, wastewater treatment system and reuse, etc.). These rating platforms serve as branding/labelling tools for the real estate companies and at times influence the preference of buyers. Both rating systems are encouraging SSTPs. In 2016, there

were 650 LEED certified buildings with SSS systems in the country (N. Akkina, personal communication, November 23, 2016).

6. *Financial incentives for SSTPs and water reuse*

While in most places financial incentives for the installation and/or correct operation and maintenance of SSS systems do not exist, the example of Pune is a noteworthy exception: as announced in 2010, the city grants a 10% reduction in property tax for buildings that have "green" elements such as sewage treatment, water recycling or rainwater harvesting (The Indian Express, 2010).

Box 5: Case studies – State and city governments funding and/or implementing SSS projects

Some state and local governments promoted and implemented small-scale wastewater treatment plants or greywater recycling systems on their own initiative, as illustrated by the following two case studies:

3. Emergency Tsunami Reconstruction Project – Tamil Nadu

As part of a World Bank assisted scheme under the Emergency Tsunami Reconstruction Project following the 2004 Indian Ocean tsunami, the Government of Tamil Nadu, through the Tamil Nadu Water Supply and Drainage (TWAD) Board, implemented 73 small-scale sanitation projects for resettled coastal communities with 17-1,100 houses (Government of Tamil Nadu, 2007). The planned settlements were scattered and, thus, difficult to serve through large, conventional wastewater treatment plants. This led the TWAD Board to opt for small-scale sanitation systems. Three very different treatment technologies were selected and installed in the various locations (Decentralised Wastewater Treatment Systems, Moving Bed Biofilm Reactors and Single-Pass Intermittent Sand Filters).

Several sanitation systems implemented under the tsunami reconstruction scheme were visited as part of the technical analysis of the 4S Project (Klinger et al., 2020). Considerable problems were observed, ranging from non-operational to poorly performing and dilapidated systems. Tsunami reconstruction project funding was purely infrastructure-centred; no organisational and financial provisions were made for correct handover (to Urban Local Bodies), operation and maintenance to ensure long-term performance. It is assumed that this is the principal reason for the failures.

4. New Delhi promoting SSS systems

In 2015, the Delhi Jal Board, a public agency responsible for providing water supply and sewerage services throughout the city, launched six SSS projects on a pilot basis in residential neighbourhoods along with the dual-plumbing systems to supply treated water for non-drinking purposes. Overall, these projects were estimated to benefit 50,000 people. In the press release, the Delhi Jal Board stated that "it is believed that adopting a decentralized model can help in getting [the extension of sewerage services] done much faster and at a lesser cost" (DJB, 2015).

In March 2016, the New Delhi Municipal Council (NDMC) had decided to build small-scale systems between 100 and 500 KLD at ten locations in Central Delhi (Hindustan Times, 2016). The systems are reuse-focused, treating water from sewer mains or drains, primarily for horticultural reuse in parks, using Soil Biotechnology and Membrane Bioreactors. An interesting Public Private Partnership approach is adopted, based on a design-build-operate model: NDMC guarantees to buy the treated water for approx. 30-37 Rs/m^3 (depending on system scale) during 12 years from the company that installs, operates and maintains the system (Alley and Maurya, 2017; Rath et al., 2020). Further details on this and other financing models is provided in the 4S Project Report Vol. III on finance (Rajan et al., 2021).

Four months later, the NDMC planned to construct SSS systems based on Phytorid technology (using planted filters) in 12 municipal schools. Treated water was intended to be reused for horticulture in nearby green areas (Hindustan Times, 2016).

In September 2017, the Delhi Jal Board announced plans to implement small-scale wastewater treatment plants in unauthorized neighbourhoods, villages and other areas, with the aim to address the sanitation crisis and produce recycled water. 600 potential sites for treatment plants were identified. The intention was to reuse the treated water for different purposes, like water body recharge, horticulture and other non-potable uses (The Financial Express, 2017).

3.2.4 Design standards, technical specifications and guidelines for SSS

SSS systems often use the same wastewater treatment technologies as the conventional large-scale systems. However, there are several technical differences that need to be considered in the design:

- Technology choice: certain technologies are not suitable for SSTPs, while other processes are exclusively used in small systems
- Small systems typically require special design features or components, such as equalisation tanks or storage tanks for treated water.
- The requirements for the reticulation system (piping) are also different
- Site-specific requirements need to be considered (wastewater characteristics and feed fluctuations, noise and odour control, safety, head space for indoor systems, sludge management etc.)
- User manuals should fulfil certain minimum requirements

The 4S landscape study found that there is currently a lack of comprehensive technology choice criteria and guidelines, technical specifications and design standards for SSS systems (see 4S Project Report Vol. I on technology (Klinger et al., 2020)). Four relevant existing documents are highlighted here:

- **Guidelines for decentralised wastewater management** (Philip et al., 2012): These guidelines were prepared by the Centre of Excellence in Decentralised Wastewater Management (➲ section 3.2.3) and are dealing with technical details of SSS. The purpose of these concise guidelines is to provide decision-makers with information on essential aspects of decentralised wastewater management. The document is a helpful introductory resource on the subject. However, more detailed and up-to-date guidelines are needed (➲ section 6.1.1), systematically considering all implications of all technology families, based on latest development and research (including 4S).
- **The STP Guide – Design, Operation and Maintenance** (Kodavasal, 2011a): In 2011 the Karnataka State Pollution Control Board published an "STP Guide" with the aim to provide private players and managers with a reference for design and O&M of small-scale plants, and KSPCB officials with a guidance for design approval, inspections and checking (Kodavasal, 2011a). Besides useful general considerations for SSTPs, the guide includes comprehensive technical details of activated sludge plants (extended aeration design), along with an engineering checklist and an operational checklist. Similar engineering references are also needed for the other common SSTP technologies, but currently unavailable (see also 4S Project Report Vol. I (Klinger et al., 2020)).
- **Guidance notes for SSTPs as part of the Environmental Building Guidelines for Greater Hyderabad** (TERI and TVPL, 2010a, 2010b, 2010c, 2010d): In view of the increased number of SSTPs in the Greater Hyderabad area, four guidance notes were drafted in 2010. They cover appropriate treatment options, O&M, disposal of excess treated water and sludge management. These guidance notes aim to support stakeholders involved in the implementation and operation of SSTPs in their design and management decisions. They also delineate a monitoring framework to ensure performance. It is not clear whether the procedures described in the guidelines have been adopted by the authorities. However, some of the proposed concepts are interesting and could be enforced for improving SSS implementation, operation and monitoring procedures also in other cities (➲ Box 7 on p. 46).

- **CPHEEO Manual on Sewerage and Sewage Treatment Systems** (CPHEEO, 2013a, 2013b, 2013c): This extremely detailed manual consisting of three parts is the number one reference for wastewater engineering in India. However, it is largely focused on conventional, large-scale systems. The chapters on small-scale (decentralised) systems only provide a very limited level of detail without an accurate consideration of SSTPs and their requirements. **Box 6** discusses the relevance of the manual for the SSS sector.

Box 6: The CPHEEO Manual on Sewerage and Sewage Treatment Systems and its relevance for small-scale sanitation

In 2013 the Central Public Health and Environmental Engineering Organization published a comprehensive wastewater manual, consisting of three parts:

- **Part A: Engineering** (third edition, revised and updated, 779 p.) (CPHEEO, 2013a)
- **Part B: Operation and Maintenance** (first edition, 414 p.) (CPHEEO, 2013b)
- **Part C: Management** (first edition, 255 p.) (CPHEEO, 2013c)

Part A is an exhaustive technical manual on sewerage and sewage treatment. It includes detailed chapters on project planning, design and construction of sewers, sewage pumping mains, pumping stations, sewage treatment facilities, sludge treatment facilities, recycling and reuse, decentralised sewerage, on-site sanitation and city sanitation plans. Of relevance for SSS are the chapters on recycling and reuse, decentralised sewerage and on-site sanitation. However, these chapters only provide a very limited level of detail without an accurate consideration of SSTPs and their technology choice and detailed design requirements.

Part B provides chapters on the operation and maintenance of sewer systems, pumping stations, sewage treatment facilities, sludge treatment facilities, electrical and instrumentation facilities, monitoring of water quality, environmental conservation, occupational health hazards and safety measures and on-site systems. There is a lot of relevant content that should be considered for the O&M of SSS systems. However, a chapter highlighting O&M aspects that are relevant specifically for small systems and their design features, components and requirements is currently missing.

Part C has chapters on legal framework and policies, institutional aspects and capacity building, financing and financial management, budget estimates for O&M, public private partnership, community awareness and participation, asset management, management information systems and potential disasters. The document does not include anything specific to the SSS sector. However, the key recommendations from the 4S governance component are in alignment with Part C on management, as highlighted in several instances in this report.

While Part A is a widely known and cited reference, it appears that Parts B and C are lesser known (they only exist since 2013). It is important that these excellent documents are operationalised, i.e., disseminated and implemented on the ground, especially with regard to SSS.

3.2.5 Standards for discharge and reuse of treated water

Evolution of wastewater treatment standards in India

Indian national effluent discharge standards are applicable for any STP, regardless of its size. Accordingly, SSTPs are also expected to comply. **Table 5** summarises the evolution of standards in India. The differential standards for discharge and reuse from 1986 have been partly replaced by a single set of stricter national standards, along with encouragements for reuse.

State PCBs may stipulate stricter discharge limits; already in 2011 Karnataka introduced more stringent standards for urban reuse regarding BOD (10 mg/L), turbidity (2 NTU) and

E. coli (<1 CFU/100 mL) (Kodavasal, 2011b; Simha, 2013)[11]. Possibly because of frequent updates and the complexity inherent to the subject, press commentaries, as well as official texts, reveal a lack of clarity about the limits that are currently valid for all parameters.

Until 2015, national standards focused on indicators for organics and solids reduction without imposing strict requirements on nutrient removal. Draft standards published in 2015 first suggested the introduction of stringent TN and NH_4-N discharge limits, which, due to the impracticality related to costly technology requirements, were not included in the 2017 amendment (The Hindu, 2017). This 2017 amendment was challenged in 2019 before the National Green Tribunal (NGT). The NGT convened an expert committee to review the standards and subsequently ordered thresholds similar to those already proposed in 2015, with an additional limit for TP to control eutrophication (NGT, 2019). However, as made evident by the wording of the 2019 NGT order, these thresholds were crafted only considering large-scale conventional STPs operating under optimal circumstances – not taking into account the realities under which smaller systems operate.

Table 5: Evolution of the national discharge standards prescribed by the Ministry of Environment, Forests and Climate Change (MoEFCC). Grey font indicates standards not (yet) officially notified by the MoEFCC through the official Gazette (see corresponding table footnotes).

Version	**1986**[i)]				2015[ii)]	**2017**[iii)]		2019[iv)]
Source	(MoEF, 1986)				(MoEFCC, 2015)	(MoEFCC, 2017)		(NGT, 2019)
Applicability	Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	STP effluent discharge in water resources & land disposal	Metro cities[v)] & major state capitals	Other areas	STP effluent discharge in water resources & land disposal
BOD [mg/L]	30	350	100	100	10	20	30	10
COD [mg/L]	250	NS	NS	250	50	NS	NS	50
TSS [mg/L]	100	600	200	100	20	50	100	20
NH_4-N [mg/L]	50[vi)]	50	NS	50[vi)]	5	NS	NS	NS
TN [mg/L]	100 $_{(TKN)}$[vi)]	NS	NS	100 $_{(TKN)}$[vi)]	10	NS	NS	10
TP [mg/L]	NS[vi)]	NS	NS	NS	NS	NS	NS	1[vii)]
FC [MPN/100 mL]	NS	NS	NS	NS	100[viii)]	1,000[viii)]	1,000[viii)]	100 (Desirable) 230 (Permissible)
pH	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	5.5-9.0

BOD: Biochemical Oxygen Demand; COD: Chemical Oxygen Demand; TSS: Total Suspended Solids; NH_4-N: Ammoniacal Nitrogen; TN: Total Nitrogen; TP: Total Phosphorus; FC: Faecal Coliforms; NS: Not Specified

[i)] Not all 39 parameters of the 1986 standards are shown here; [ii)] These are draft standards that would have come into force on the date of their publication in the official Gazette of India (MoEFCC, 2015), which never happened. [iii)] STP effluent discharge (any disposal mode incl. reuse, some exceptions for marine outfalls); [iv)] Order of the NGT, 30 April 2019 (NGT, 2019). These standards have not yet been officially notified by the MoEFCC at the time of writing, indicating that they may still be disputed. [v)] Mumbai, Delhi, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad and Pune; [vi)] Standards for NH_3-N, NO_3-N and PO_4-P apply; [vii)] For discharge into ponds, lakes; [viii)] Not applicable for industrial reuse

[11] After having been more stringent than the national standards for a while, Karnataka later formally adopted the less strict set of 2017 national standards (KSPCB, 2018).

Stakeholder participation in standard setting

As observed by Schellenberg et al. (2020), the process of standard setting has not included a proper consensus phase with participation of the key stakeholders. The lack of participation of private sector and civil society stakeholders (such as SSS technology providers or apartment owner associations) in standard setting was also highlighted in the interviews and the social network analysis conducted as part of 4S.

The symptoms are exemplarily illustrated in the stringent 2015 draft standards which were prematurely applied in the states (CPCB, 2015a, 2015b; KSPCB, 2015) but never formally put into force due to their disputed feasibility (The Hindu, 2017). The consequence was a lack of clarity and lack of acceptance on the part of various stakeholders during two years.

Performance of SSS systems in India with regard to current standards

As part of the 4S Project, a detailed performance analysis was carried out for 35 SSS systems covering seven technology families commonly implemented in India (➲ **Figure 5**). The results show that all technology families, even high-tech systems, struggle to consistently reach all currently valid/proposed thresholds – especially when considering that some system selection criteria introduced a bias towards well-operating plants (see 4S Project Report Vol. I on technology (Klinger et al., 2020) for details).

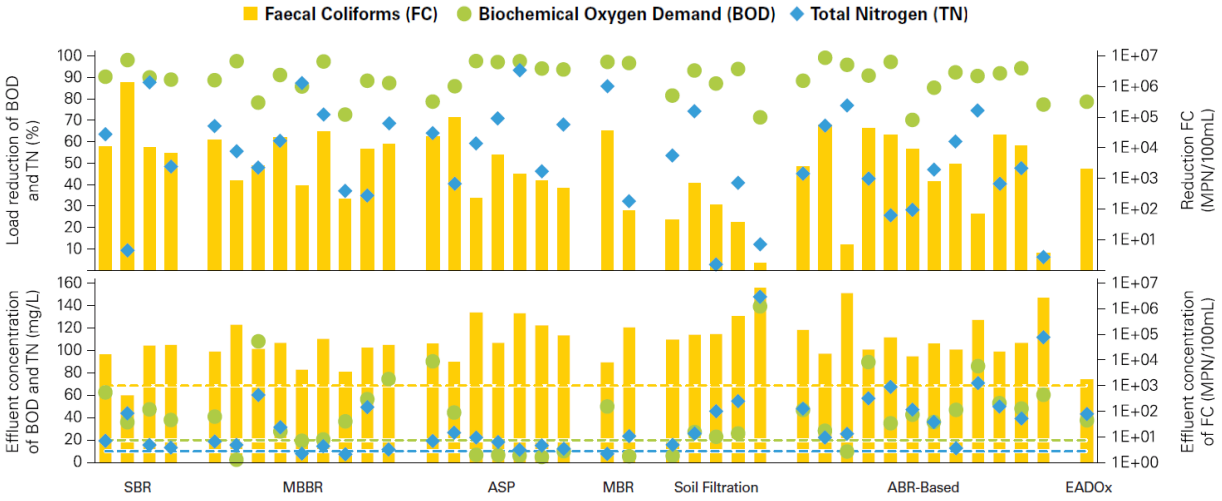


Figure 5: Average removal rates and effluent concentrations for key water quality parameters of 40 sampled SSS systems (35 in India and 5 in Nepal, 3 rounds of 24-h composite sampling), grouped by technology families. The dashed yellow and green lines indicate the 2017 discharge standards (metro cities) for FC and BOD, respectively. The blue line indicates the TN limit as directed by the 2019 NGT order.

Organic constituents and suspended solids: Good effluent quality can be achieved by combining measures to ensure proper O&M of systems with an efficient monitoring framework. The 2017 CPCB standards on BOD and TSS are technically achievable by all technology types assessed, if designed, operated and maintained correctly. Lower thresholds, such as those in the 2019 NGT order, are not reached by the majority of systems.

Nutrients: NH_4-N effluent concentrations of most systems of all technology families meet the 1986 discharge standard of 50 mg/L. However, the discussed standard value of 5 mg/L is not reached by the large majority of systems. None of the investigated systems include the highly technology and maintenance dependent denitrification or phosphorus removal

steps. Thresholds stipulated by the NGT order for TN and TP are, therefore, not met by almost the totality of the investigated systems.

Microbial quality: FC concentrations were greater – often by several orders of magnitude – than the 2017 limit in all effluents investigated, even when the systems included disinfection steps. Achieving even stricter standards, such as directed by the 2019 NGT order, will not be realistically feasible, unless a systematic effort is made to ensure low effluent organic matter and ammonium, and improved design and operation of disinfection units.

3.3 Stakeholders and institutional arrangements for SSS in urban India

As explained in the previous section, most SSS systems in India are the result of environmental protection and water reuse regulations, and not that of urban sanitation policies. With regard to the overall institutional framework for urban sanitation, a different set of stakeholders is therefore involved in SSS, with different rules governing their behaviour. In other words, SSS has its own "stakeholder ecosystem", with their own institutional arrangements that need to be understood.

Based on the review of policies, laws and regulations, **Figure 6** shows that this situation results in a stakeholder map that is pretty different between the large-scale and small-scale sanitation sectors. As illustrated in the figure, the governmental stakeholders responsible for the main policies, funding and implementation differ widely. On the one hand, with large-scale sanitation, MoHUA and its state and local level line agencies have a clear responsibility. On the other hand, the policy drive for SSS is clearly on the side of MoEFCC, while its funding and implementation (including operation) is almost fully delegated to the private sector and civil society. This highlights the fact that MoHUA drives investment towards conventional wastewater management systems (and FSSM since a few years). MoHUA and its line agencies are quasi absent of the small-scale sanitation setup, with the responsibilities shared between MoEFCC, its line agencies and the private real estate sector.

This section presents the results of a stakeholder analysis and explains the roles and responsibilities of key stakeholders for SSS, the institutional arrangements and relationships between them, and who does what in the process of establishing, operating or monitoring a small-scale sewage treatment plant.

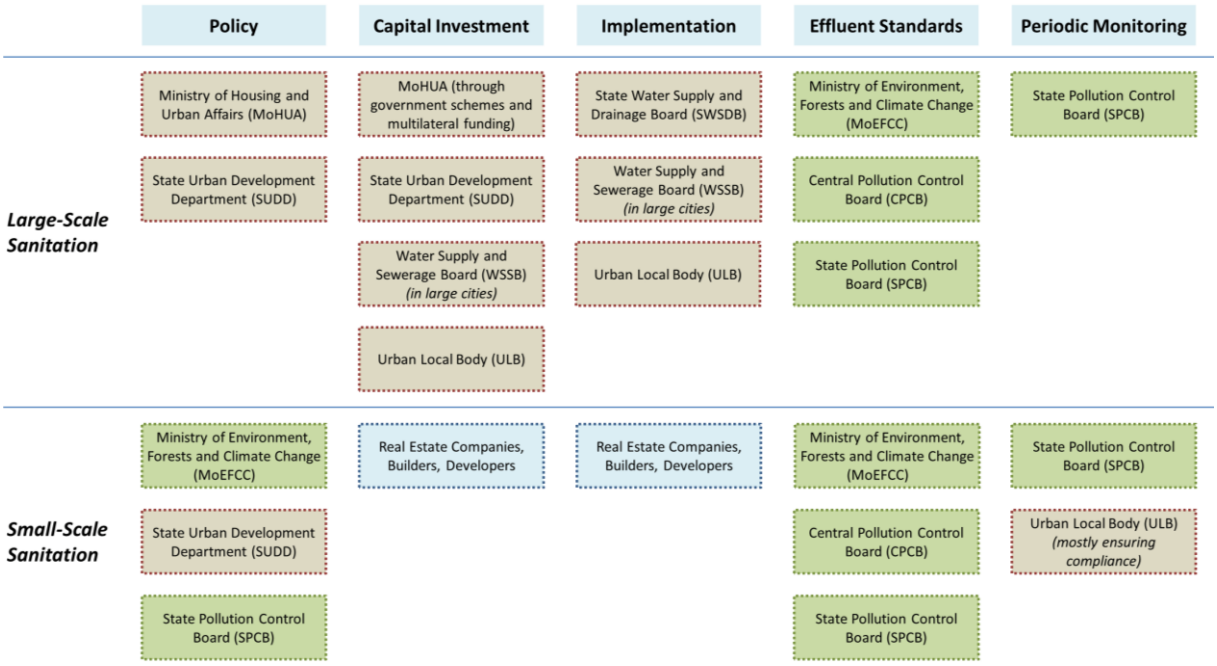


Figure 6: Comparison of responsibilities in the large-scale and small-scale sanitation sectors; the governmental agencies highlighted in brown fall under MoHUA and the ones in green under MoEFCC.

3.3.1 Institutional arrangements for the planning, design and implementation of SSS systems

There is an established formal setup to build SSTPs, which involves a variety of stakeholders. However, it may vary by location and context. The general process can be broken down into (i) preliminary approval of the design, together with the building approval[12], (ii) implementation and (iii) post-implementation check.

SSS systems are integral components of new construction projects (residential, commercial, institutional, etc.) falling under the regulations described in section 3.2.2, which differ in each state and city. There are two types of consents required for SSS systems: the **Consent to Establish** (CTE, to be obtained at the end of the design phase) and the **Consent to Operate** (CTO, to be obtained at the end of the implementation phase, before the commissioning of the plant, and to be renewed at a defined frequency)[13].

Figure 7 illustrates the current institutional arrangements for the planning, design and implementation of SSS systems in Karnataka (and the institutional arrangements for handover, O&M and monitoring).

[12] Not only the Consent to Establish but also the authorisation for the construction of a building itself (given by the ULB/Planning Department) may require the plan for an SSTP.
[13] Depending on the state, they may also be called Consent for Establishment (CFE) and Consent for Operation (CFO). It seems that some states do not issue CTOs for SSTPs (it is not clear whether they do not formally require it or whether they neglect it due to capacity constraints to do the follow-up with thousands of installations).

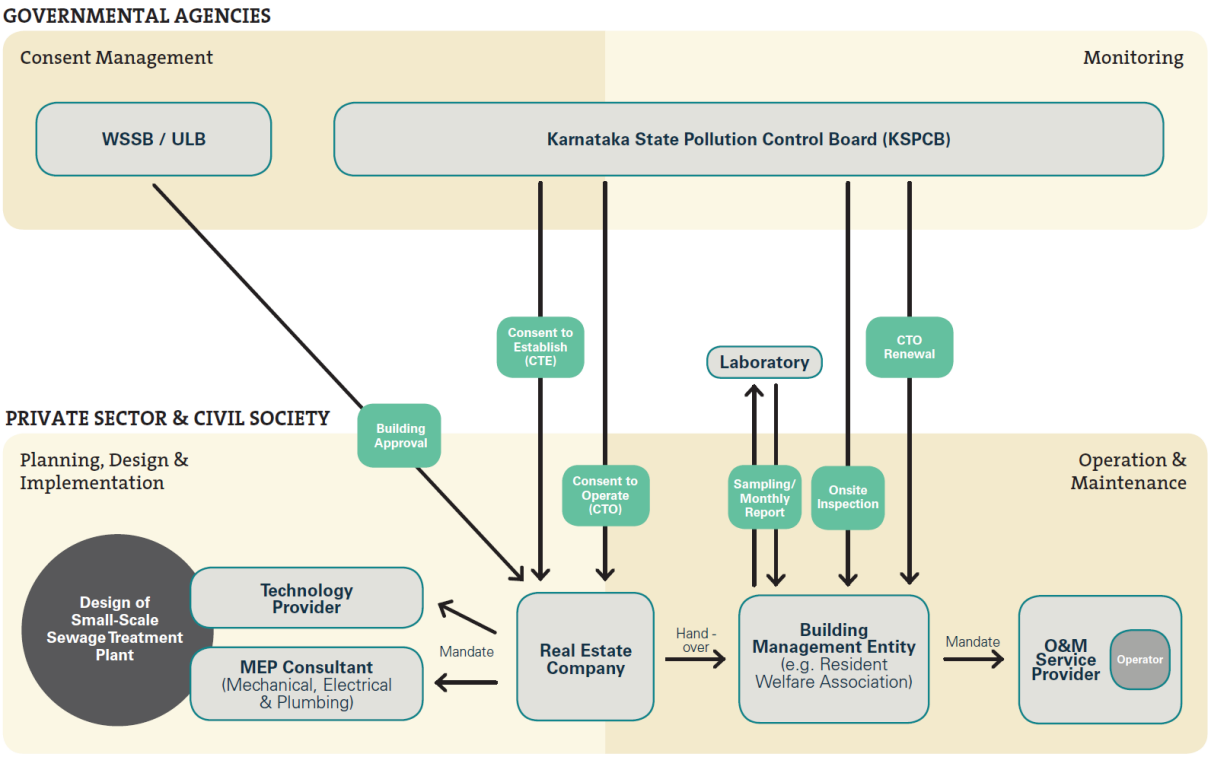


Figure 7: Stakeholders, procedures and governance arrangements through the life cycle of a small-scale wastewater treatment system in Karnataka.

The establishment of an SSS system first requires a Consent to Establish. Depending on the size of the construction project, the CTE is integrated in the environment impact assessment / environmental clearance and permissions are issued by different agencies (small projects: ULBs/SPCBs; medium projects: State Environmental Impact Assessment Authority (SEIAA); large township and area development projects: MoEFCC via Expert Appraisal Committee). Several recent amendments to the 2006 EIA notification (➲ section 3.2.2) were sub-judice at the time of writing (MoEFCC, 2019), including one that delegates the power to ensure the compliance of the environmental conditions of construction projects between 20,000-50,000 m^2 to ULBs (MoEFCC, 2018). Hence, the size limit is currently not clear. At least buildings with a built-up area up to 20,000 m^2 (if not higher by now) require permission from ULBs and/or State Pollution Control Boards as per the locally applicable building bye-laws. In that case, the SPCB is responsible for granting the CTE.

At the beginning of a project, real estate developers (builders) typically appoint consultants (Mechanical, Electrical and Plumbing (MEP) consultants, less commonly also Public Health Engineering (PHE) consultants) and/or SSS technology providers (designers, vendors) for the design of the system[14]. Consultants typically provide the macro-level specifications for the STP (input-output parameters, space allocation, sizing) and choose the technology. There are hundreds of private sector players providing the entire range of services from consultancy, design, equipment manufacturing, installation, O&M and

[14] Large construction projects which fall under SEIAA/MoEFCC supervision are required to work with certified environmental consultants to prepare environmental impact assessments and environment clearance reports. A certified consultant is required to submit status reports throughout the construction period of a building, which also includes the implementation status of SSS systems. These large projects no longer require a CTE.

turnkey solutions on the Indian market (see 4S Project Report Vol. I (Klinger et al., 2020)). There is currently no regulatory requirement for formal training for STP consultants and engineers.

A CTE is granted by the SPCB upon checking of the SSTP design. A meticulous design review and approval, however, appears not to be common practice in most cases. First, PCBs do not have the necessary human resource capacity and expertise for such detailed scrutiny (Sahu, 2013), and second, design standards and checklists are not available to guide the process (➲ section 3.2.4). This is exemplified by the Tamil Nadu PCB which seems to have taken steps to get design approval support by two academic institutes in Chennai (H.C. Sharatchandra, personal communication, 2016).

Once a construction project is implemented (including SSTP), the authorities carry out an inspection. The SPCB are responsible for validating that the SSS system is correctly implemented according to the design, before issuing the Consent to Operate. A study by Kuttuva et al. (2018) in Bengaluru, however, found several operational SSTPS which did not have a CTO.

Besides the SPCB's validation, utilities like water supply and electricity are provided only if buildings are constructed as per the approved plan. Inspectors from the ULB (small and medium towns) or Water Supply and Sewerage Board in large cities also carry out inspections. After completing the inspection of the building, a certificate is issued (such as a no objection certificate, completion certificate or finally occupancy certificate).

Inspections are mainly focussed on setbacks[15], height of the building and presence of the SSS system. There are no defined guidelines or checklists for the post-implementation validation of SSS systems for any available technology[16]. ULBs may not have the technical expertise to determine whether the provided SSTP is adequate in terms of capacity and design. Therefore, poor quality, sub-standard or under-capacity systems can get approved where the developer is trying to save money.

A noteworthy proposal made for Hyderabad went beyond these basic procedures (➲ **Box 7**). It included guidance notes for appropriate technology choice, and suggested further conditions to be fulfilled for obtaining the occupancy certificate (e.g., STP maintenance contract, O&M manual, safe disposal for treated water and sludge).

[15] Refers to the distance between the plot boundary (compound wall) and the building.
[16] One noteworthy exception is the KSPCB STP Guide which provides great detail for the activated sludge technology (extended aeration design, ➲ details in section 3.2.4).

Box 7: Guidance notes for SSTP regulation in Greater Hyderabad

In view of the increased number of SSTPs in the Greater Hyderabad area, four guidance notes were drafted in 2010 as part of the Environmental Building Guidelines for Greater Hyderabad (EBGH):

- Guidance note 1: Appropriate treatment options (TERI and TVPL, 2010a)
- Guidance note 2: Operation and maintenance (TERI and TVPL, 2010b)
- Guidance note 3: Disposal of excess treated water (TERI and TVPL, 2010c)
- Guidance note 4: Treatment and disposal of sludge (TERI and TVPL, 2010d)

These guidance notes support stakeholders involved in the implementation and operation of SSTPs in their design and management decisions. They also delineate a monitoring framework to ensure performance. It is not clear whether the procedures described in the guidelines have been adopted by the authorities. However, some of the proposed concepts are interesting and could be enforced for improving SSS implementation, operation and monitoring procedures also in other cities:

Guidance note 1: Appropriate treatment options

- Water calculator to estimate wastewater quantities and reusable grey-/blackwater
- Description of conditions making a greywater or wastewater treatment system and dual plumbing mandatory
- Decision support for appropriate treatment options according to context, wastewater quantity, site area and reuse options. Basic description of treatment options including pros and cons and some information on cost, space and power requirements.

Guidance note 2: Operation and maintenance

- The document states that for any new building with SSTP the following documents are to be provided when applying for the occupancy certificate:
  - Annual Maintenance Contract (AMC) for O&M between owner and certified service provider (preferably the same company which installed the system). N.B.: The guidance notes do not give any details about certification mechanisms. However, a list of 94 STP vendors was provided on the website of the Hyderabad Metropolitan Development Authority.
  - Supporting documents including the details of the installed system (the guidance note provides a checklist of O&M compliance to prepare this)
  - An O&M manual (the guidance note provides a checklist of components for this manual)
  - Documentation of reuse options
- Existing buildings should provide copies of AMC renewal, monthly quality reports and annual reports of compliance to the authorities.
- Further, the document states that at least one trained operational staff should operate the system (without giving any details about training).

Guidance note 3: Disposal of excess treated water

- This document specifies how much unused treated water can be discharged outside site limits. It also describes the allowed discharge options and respective water quality requirements.
- The document states that any building with SSTP seeking water connection from the utility should provide documentation of the quantity of treated water, types of reuse, quantity of water disposed of outside site limits and details of the disposal method. This includes a compliance certificate by a certified inspector to confirm safe disposal of treated water.

Guidance note 4: Treatment and disposal of sludge

- Recognising that “sewage sludge is frequently deposited in uncontrolled storage places or on the sites of the STPs”, this document aims to regulate the correct sewage sludge treatment and disposal.
- It describes permissible methods for sludge treatment and states that a service contract must be signed with a certified/accredited sludge disposal company (preferably the same as for the AMC).
- The guidance note states that any building with SSTP seeking water connection from the utility should provide a sludge management plan, including sludge generated per day, sludge handling method, disposal facility, sludge analysis results.

Such detailed concepts in combination with an online data management platform (➲ section 6.4.1) would help fostering best practice on the part of private stakeholders and improve SSS governance.

3.3.2 Institutional arrangements for the handover, operation and maintenance of SSS systems

Once the Consent to Operate is obtained from the respective State Pollution Control Board, the system can start its operation. A crucial phase is the **handover** of the SSTP from the builder/designer to building owners. As found in the 4S performance analysis, this process often does not get the necessary attention, resulting in the lack of user manuals and an insufficient understanding of the system's implications on the part of the owners (see 4S Project Report Vol. I (Klinger et al., 2020)).

In the residential context, real estate companies (builders, developers), as per the Real Estate (Regulation and Development) Act (MoLJ, 2016), are responsible for providing and maintaining the essential services of a building until a formal resident welfare association (RWA) is formed. Hence, they also have initial responsibility for **operation and maintenance** of the SSTPs. Later, the RWA has to take over; this can be several years after the commissioning of the SSTP but typically happens after 1-2 years. The Real Estate Act also includes a five-year warranty clause on "structural defect or any other defect in workmanship, quality or provision of services".

A variety of different **management schemes** (O&M arrangements) exists, which can involve various stakeholders:

- Self-managed:
  - *O&M by in-house caretaker:* when taking over from the builder, the RWA manages on their own with the available local staff (mostly unskilled, often part-time). This is only suitable where the system is highly automated and/or requiring minimal intervention.
  - *O&M by in-house O&M staff:* dedicated full-time O&M team (typically three operators working in shifts) are hired to run the system.
- Professionally managed:
  - *O&M by system designer / real estate company:* the installer or builder keeps the responsibility for O&M against a fee.
  - *O&M by independent service provider:* O&M tasks are outsourced to a third-party private player based on an annual maintenance contract. This can be a specialised O&M service provider or a facility management company. The latter would also take care of other services (security, landscaping, electrical, plumbing, elevators, etc.).
- NGO- or community-managed: this is less common but found in community SSS projects, such as slum sanitation improvement or community toilet systems.
- Government-managed: this is rare but sometimes found in public toilet systems or government funded projects.

Desludging is typically not included in an O&M package and organised separately on demand.

According to the findings of the 4S Project, more than 50% of the systems in the residential, institutional and commercial contexts are self-managed. Outsourced, professional management models are also very common, but slightly less popular (found in about one third of the middle to high income residential cases studied), probably mainly because of the higher cost (see 4S Project Report Vol. I (Klinger et al., 2020)). The different types of management arrangements and their implications are described in more detail in the 4S Project Report Vol. III on finance (Rajan et al., 2021).

Private actors play a key role in operating and maintaining systems. The SSS private sector itself is facing a number of challenges. In Bengaluru this has led to the formation of the Association for Decentralised Sanitation Infrastructure and Services (ADSIS) in 2015, with the aim to bring together industry players to collaborate and give the sector a voice (➲ **Box 8**).

The number of operating staff needed for SSTPs as well as their required skills differ depending on technology, level of automation and size of the system. Typically, three operators are working round the clock, in shifts of eight hours, ideally with one skilled supervisor. However, there are also fully automated or non-mechanised systems where only a caretaker is needed for a daily or weekly check and small maintenance tasks. Big challenges are the low level of skills of operators as well as the low job perception and pay scale, leading to high attrition (see 4S Project Report Vol. I on technology, implementation and operation (Klinger et al., 2020)). The ADSIS states on its website: *"Generally there is a wide disinterest among the operators even when they are trained. This disinterest comes from the limited scope for career growth for the STP operators. There is a need for dedicated and skilled operators with a facility to upgrade their existing skills so that they can improve their prospects. Usually only those in desperate need of money work in the sector as there are social stigmas attached to it."* There is currently no regulatory requirement for formal training for STP operators and training programmes do not exist yet. The ADSIS, therefore, started conducting its own trainings in 2016. Insufficient training and skills also applies to SSTP managers, as described in the 4S Project Report Vol. I (Klinger et al., 2020). Operator and manager capacity development are further discussed in sections 6.5.4 and 6.5.5, respectively.

The current institutional arrangements for the handover, operation and maintenance of SSS systems for Karnataka are illustrated in Figure 7 on p. 44.

Box 8: The Association for Decentralised Sanitation Infrastructure and Services (ADSIS): bringing together industry players to collectively address challenges and give the sector a voice

ADSIS was set up in 2015 as the first organisation in India that brings together SSS service providers. It aims to create a progressive business environment for the SSS sector, pursuing the following primary goals with a collaborative approach (Tsephel et al., 2017):

- Establish standards and service level benchmarks for the sector
- Present operating challenges to authorities and enable collective representation for better policies that will improve the quality of products and services delivered
- Set training requirements to establish minimum qualifications of technical operators; design and deliver training programmes
- Facilitate sharing of experiences and learning amongst service providers
- Serve as a repository of information and resources for service providers, operators, suppliers, government entities and the general public

The association's organisation as a formal body registered under the Karnataka Societies Registration Act (1960) gives it standing with the Government and legal stature. Such an industry body and institutionalised forum also has the potential of self-regulation to weed out unethical or incompetent players (Tsephel et al., 2017).

ADSIS started with 17 founding members in Bengaluru, establishing a secretariat and management committee. In 2016, 40 new members were enrolled. Since then, enquiries came in from Nagpur, Hyderabad and Mumbai to start local chapters and interaction with government agencies took place. On 25 May 2016, ADSIS conducted its first training for operators of activated sludge STPs.

More information on the ADSIS website: **www.totalsan.com**

3.3.3 Institutional arrangements for the monitoring of SSS systems

Monitoring refers to the assessment of the compliance of the existing systems and database management at national, state and city levels. As described in section 3.1 and Box 2 on p. 28, the State Pollution Control Boards are responsible for monitoring of all STPs, as well as for consent management (granting CTEs and CTOs). In practice, however, it seems that this is not always clear for all sector agencies – see case studies of Chennai (➲ **Box 9**) and Hyderabad (Deccan Chronicle, 2015).

To carry out the monitoring, SPCBs need to maintain a database of all planned and existing systems in the state, including consents, their validity, as well as performance records. In practice, however, SPCBs are struggling to keep up with the pace of implementation and up-to-date, comprehensive, geo-referenced inventories do not exist. In the case of Bengaluru, KSPCB is largely involved in database management, yet more than two-thirds of systems appear not to be under their radar (4S estimations, see Klinger et al. (2020)). In Mysuru and Chennai, no single institution was found to have the full list of systems either. The lack of a database also appears to be a problem in Hyderabad (Deccan Chronicle, 2015). As part of 4S, the SPCBs of ten states expected to have large numbers of SSS systems were approached in 2016 with a so-called "Right to Information" (RTI) petition[17]. The responses from these states revealed that electronic databases of systems were unavailable. Only a few very fragmentary paper lists could be collected. It has to be assumed that a lot of information is filed on paper, in different offices and, thus, hard to find and access. Since SEIAAs and the MoEFCC are involved in environmental clearance for large construction projects (➲ section 3.3.1), parts of the information are in their hands. Therefore, the information on the existing SSS systems of each state is spread in different incomplete and partly overlapping databases of different agencies. This means that SPCBs currently do not have the full overview of what they have to monitor in their jurisdiction.

The SPCB (with support from the ULB in some cases, ➲ section 3.2.2) is supposed to inspect the performance of the systems periodically. The stipulated frequency of monitoring varies within and between states, typically ranging from 1 to 3 times a year. In addition, system owners must regularly get grab samples of treated water analysed by NABL[18]-accredited laboratories (typically monthly or quarterly, also depending on the location), and send the report to the SPCB. If a treatment plant is found to be poorly performing or non-functional, the system owner is issued a so-called 'Show Cause Notice', asking for a justification why sanctions should not be imposed. System owners are given a defined period of time to rectify the plant and submit satisfactory treated water sample analysis results to the authority.

SPCBs are also in charge of renewing the CTOs. A CTO has to be renewed every 1-5 years, depending on the building category. SSTP owners applying for consent renewal also have to submit the lab report from the latest effluent grab sample analysis.

The monitoring role for SSS is challenging for SPCBs, whose dedicated staff and financial resources have not been adapted to the rapid increase in SSS systems (Sahu, 2013). Interviews with government stakeholders confirmed that SSS policies have not been matched by the resources necessary to monitor implementation and operation of the installations. Therefore, capacity-constrained PCBs often focus their random checks on

[17] https://rti.gov.in/
[18] National Accreditation Board for Testing and Calibration Laboratories, https://nabl-india.org/

the major pollution "hotspots" (e.g., industries, sensitive water bodies). Section 5.4 describes the identified weaknesses related to monitoring in greater detail.

The institutional arrangements for the monitoring of SSS systems for Karnataka are illustrated in Figure 7 on p. 44.

Box 9: Case study – monitoring gaps in Chennai

This rather anecdotal case study is based on interviews with government stakeholders in Chennai, conducted during the 4S project. Interviewees preferred to stay anonymous.

In Tamil Nadu, the State Urban Development Department enforced building bye-laws requiring the installation of SSS systems. The bye-laws clearly state that the design clearance (i.e., CTE) for systems has to be obtained from the Tamil Nadu Pollution Control Board (TNPCB) and, in Chennai, also by the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) in the form of a no objection certificate for building construction. However, nothing is mentioned about the responsibility for long-term monitoring.

A TNPCB representative denied the responsibility for monitoring systems which do not require environment clearance and environmental impact assessment (i.e., with built-up area below 20,000 m^2), adding that even systems for bigger buildings are rarely inspected. In addition, the TNPCB representative claimed that the Chennai Metropolitan Development Authority (CMDA) is responsible for the systems implemented in small projects (<20,000 m^2), but a CMDA representative stated that its authority is limited to building plan approvals.

In brief, none of the agencies feel responsible for monitoring. This highlights that the responsibilities should be well defined, also in policies and building bye-laws, to avoid gaps and overlaps. In addition, new directives need to be accompanied by proper funding and staff increase for monitoring.

3.3.4 Key stakeholders at state and city level: power and/or interest in SSS

As shown in Figure 6 on p. 43 and described in sections 3.3.1-3.3.3, quite a large number of stakeholders are involved in SSS. Depending on the state and city and its specific institutional arrangements, different stakeholders may have an impact on the way SSS scales up, or may be impacted by the policies, laws and regulations that are developed by others.

In order to better understand the stakeholder landscape at the state and city levels, a stakeholder analysis was carried out. This study focussed on the states of Karnataka and Tamil Nadu, and two cities in each state: Bengaluru (KA), Mysuru (KA), Chennai (TN) and Coimbatore (TN). All stakeholders were compiled, resulting in a list of 29-33 stakeholders per city potentially relevant for SSS (➲ **Table 6** and Table 3 on p. 24).

Table 6: List of stakeholders potentially relevant for small-scale sanitation in Karnataka and Tamil Nadu, identified in the 4S landscape study

Category	Organisation	Abbreviation
Governmental stakeholders at national level	Bureau of Indian Standards	BIS
	Central Pollution Control Board *(under MoEFCC*)*	CPCB
	Central Public Health and Environmental Engineering Organisation (CPHEEO) *(under MoHUA)*	CPHEEO
	Ministry of Skill Development and Entrepreneurship	MSDE
	Ministry of Water Resources, River Development and Ganga Rejuvenation (Ministry of Jal Shakti from May 2019 onward)	MoWR
Governmental stakeholders at state level	City Managers' Association	CMA
	Directorate of Municipal Administration *(Karnataka only)*	DMA
	Department of Environment (TN) / Forest, Ecology and Environment Department (KA)	DoE / FEE
	Karnataka Lake Conservation and Development Authority *(Karnataka only)*	KLCDA
	Municipal Administration and Water Supply *(Tamil Nadu only)*	MAWS
	State Environmental Impact Assessment Authority	SEIAA
	State Housing Board	SHB
	State Pollution Control Board	SPCB
	State Urban Development Department	SUDD
	State Urban Infrastructure Development and Finance Corporation	SUIDFC
	State (Urban) Water Supply and Drainage Board	SWSDB
Governmental stakeholders at city level	Chennai River Restoration Trust *(Chennai only)*	CRRT
	District Office of Pollution Control Board	DPCB
	Urban Local Body (City Municipal Corporation / Urban Development Authority)	ULB
	Water Supply and Sewerage Board	WSSB
NGOs and academic institutes	Asian Development Bank	ADB
	Centre for Policy Research	CPR
	German International Cooperation	GIZ
	Indian Green Building Council	IGBC
	National Institute of Urban Affairs	NIUA
	World Bank	
Private players	Architects	
	Buyers of Treated Wastewater	
	Certified Environmental Consultants	
	Laboratories	
	Mechanical, Electrical and Plumbing Consultants	MEP Consultants
	O&M Service Providers	
	Public Health Engineering Consultants	PHE Consultants
	Real Estate Companies, Builders, Developers	
	STP Technology Providers (Designers, Vendors & Associations)	
Owners and users of SSTPs	Apartment Owner Associations (e.g., Bangalore Apartments' Federation – BAF)	
	Resident Welfare Associations / Building Management Entities	RWA

* *The Expert Appraisal Committee (EAC) is another National Government stakeholder under MoEFCC, responsible for review and recommending environmental clearance of construction projects above a certain size, and in areas where there is no SEIAA. The EAC was not included in the present stakeholder analysis.*

The identified stakeholders were analysed in terms of their influence (or *power*) and importance (or *interest*) in SSS. *Power* refers to the ability of a stakeholder to make decisions and to influence the system, independent of its formal role. *Interest* refers to an actor's involvement in the sector, based on its responsibility (Ackermann and Eden, 2011). Stakeholders with significant power and/or interest in the SSS sector are considered to be *key stakeholders*.

Based on data from literature, the semi-structured interviews, and results of the written questionnaire for the social network analysis (➲ methods section 2.3), a power-interest matrix was drawn (**Figure 8**). As the general power-interest situation was found to be similar in Karnataka and Tamil Nadu, the figure compiles all actors from the two states. However, in a specific city, fewer stakeholders would be relevant, and minor local power-interest differences might apply. The horizontal axis represents the interest that each stakeholder has in the SSS sector and in being part of decision-making on SSS governance (Lienert et al., 2013; Reymond, 2014). The vertical axis represents the power (or influence) that each stakeholder exerts on the SSS sector.

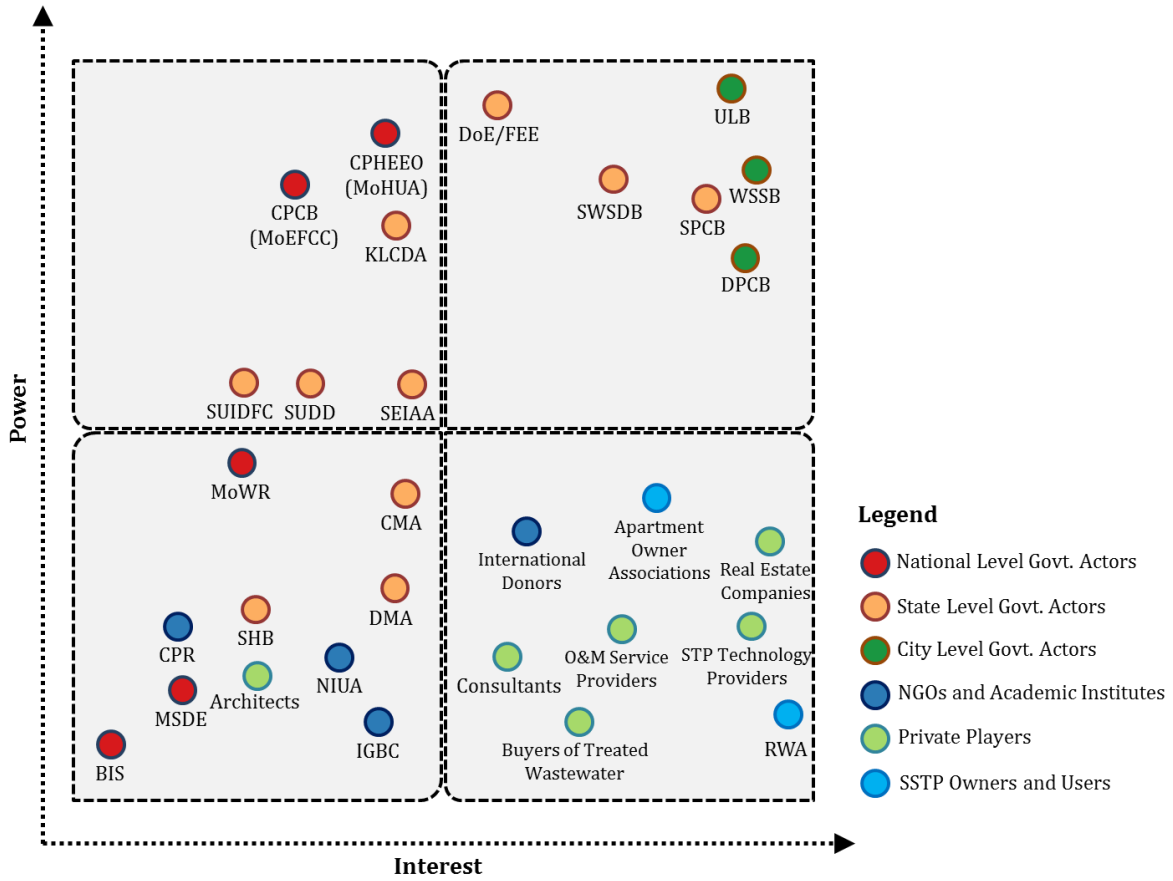


Figure 8: General power-interest matrix of the stakeholders linked to small-scale sanitation at the local level in Karnataka and Tamil Nadu (see Table 6 for abbreviations)

The power-interest matrix helps identify the key stakeholders (all but those in the bottom left corner), to highlight issues in the institutional arrangements, and to identify how to better involve stakeholders in the sector (Reymond and Bassan, 2014). A short guidance on how to read such a matrix and the characteristics of the four groups it delineates is given in Appendix 4.

The number of key stakeholders amounts to 14 in Bengaluru, 13 in Chennai and Mysuru, and 11 in Coimbatore (which means that the number of key stakeholders for each city is less than what the figure shows, as there are key stakeholders found only in Bengaluru or Chennai, for example – see also ➲ Table 3 on p. 24).

Key stakeholders either have high power (top left corner), high interest (bottom right corner), or both (top right corner). Stakeholders in the top left corner (high power, low interest) are exclusively government stakeholders at national and state levels, while stakeholders in the top right corner (high power, high interest) are primarily local government actors (including urban local bodies – ULBs) and state level actors. The relatively bigger interest of the latter compared to national stakeholders is due to the Indian Constitution stating that water supply and sanitation are state responsibilities and that states can further assign the responsibilities and powers to ULBs for effective self-governance. In addition, ULBs possess power to develop and implement regulations related to sanitation. However, relevant state and national level actors have a very significant power to influence the SSS sector. For example, as shown in the previous chapters, MoHUA has a huge influence on what is implemented, through its investment strategies (➲ section 3.2.1) and through its design policies and standards (➲ section 3.2.4). However, the absence of SSS in the latter reflects a lack of interest in SSS in general, and most initiatives on the ground are led by state or city level stakeholders.

Actors with high interest and low power are located in the bottom right corner. This cluster is primarily dominated by private stakeholders (such as STP technology providers and O&M service providers), together with international organizations and SSTP owners'/users' associations. Although stakeholders in this group are strongly interested in SSS and impacted by governmental decision-making, they are not directly involved or consulted when policies, laws or regulations impacting on SSS are developed. This partly explains the development of policies which are not always realistic, causing popular outrage among users and other concerned stakeholders (➲ example of Bengaluru in Box 4 on p. 33). Although these actors are the first to be impacted by SSS policies, they hardly have a voice, and need to be empowered (➲ sections 6.1.3 and 6.3.4).

Stakeholders in the bottom-left corner have a low power and low influence. They are no key stakeholders, but should be kept informed about the developments in the sector.

3.3.5 Roles and responsibilities of key government agencies

The main differences in key responsibilities between large-scale and small-scale sanitation have been illustrated in Figure 6 on p. 43 in the introduction of this chapter. Here, a more nuanced analysis of the government stakeholders' formal roles and responsibilities for SSS is presented. This and subsequent analyses rely on the smaller set of key stakeholders.

Table 7 shows the formal responsibilities of the main key stakeholders in the sanitation sector in general (see also ➲ section 3.1), and in the SSS sub-sector in particular. The last column shows which competencies the different governmental agencies have regarding SSS; this does not mean that they always use these competencies and fulfil their role in this regard.

The advantage that ULBs (and/or WSSBs) have over PCBs is that they have the power to impose fines in case of non-compliance (PCBs also have the power to issue directions to suspend power and water supplies). They could also grant performance-based incentives or rewards for well-managed systems. For further information on financial incentives, see ➲ section 6.1.6 and 4S Project Report Vol. III on finance (Rajan et al., 2021). ➲ Section 6.3.2 provides a more detailed discussion of the roles of SPCBs, WSSBs and ULBs, especially with regard to their harmonisation and coordination.

Table 7: Formal responsibilities and competencies of the main key governmental stakeholders at the national, state and city levels (based on findings from Karnataka and Tamil Nadu).

	Stakeholder	Responsibilities related to sanitation	Competencies for small-scale sanitation *(not always fulfilled)*
National level	**Central Public Health and Environmental Engineering Organisation (CPHEEO)** ***(Ministry of Housing and Urban Affairs)***	• Draft sanitation policies and guidelines • Channel investments to states/ULBs for the implementation of wastewater infrastructure, technical advice	• Provide technical guidance to state level authorities and local authorities in implementing SSS systems and regulatory framework
	Central Pollution Control Board (CPCB) ***(Ministry of Environment, Forest and Climate Change)***	• Collect, compile and publish technical and statistical data relating to water pollution control • Prepare manuals, codes or guides relating to treatment and disposal of sewage • Develop treated water quality standards and guidelines • Offer technical assistance and guidance to SPCBs • Introduce legislations and policies to protect the environment from wastewater contamination	• Provide technical assistance and guidance to SPCBs regarding SSS monitoring • Collect data related to SSS performance from city/district/state level PCBs • Can develop SSS specific effluent discharge standards • Can prepare manuals, codes or guides relating to SSS
State level	**State Urban Development Department (SUDD)**	• Responsible for sector policies, regulation, funding through budgetary support, sector coordination and monitoring	• Can influence urban local bodies through budget allocation in order to encourage SSS
	State Water Supply and Drainage Board (SWSDB)	• Design and implement sewerage schemes in urban areas (particularly in small and medium towns).	• Can influence the choice and scale of sewage treatment plant installed
	State Pollution Control Board (SPCB)	• Enforce treated water quality standards • Can adapt the national standards towards more stringency • Monitor the performance of sewage treatment infrastructure (large-scale and small-scale sanitation systems)	• Review plans, specifications or other data relating to plants • Organise training and mass education programmes • Can issue directions to close SSTPs or suspend power and water supplies • Can develop effluent discharge standards for SSS systems within CPCB standards

		• Issue consents to establish (CTE) and to operate (CTO) STPs	• Can "evolve economical and reliable methods of treatment/utilisation of sewage"
	State Environmental Impact Assessment Authority (SEIAA)	• Validate and inspect the design of SSS systems (as part of the environmental clearance for projects defined under EIA notification such as commercial mall and area development projects.)	
City level	**Urban Local Body (ULB)** ***(City Municipal Corporation / Urban Development Authority)***	• Responsible for water supply and sewerage infrastructure and services within jurisdiction (big cities may have WSSBs responsible for the same task)	• Can include policies related to SSS into municipal acts, develop regulations and enforce them • Can provide performance-based incentives, can impose fines or cut supplies in case of non-compliance
	Water Supply and Sewerage Board (WSSB) *(parastatal agency at city level)*	• Design, implement, and maintain water supply and sewerage infrastructure and services within jurisdiction	• Can advise ULBs on inclusion of SSS in building bye-laws • Can provide performance-based incentives, can impose fines or cut supplies in case of non-compliance
	District Office of Pollution Control Board (DPCB)	• Enforce and monitor wastewater treatment plant performance in small and medium cities, in alignment with SPCB	• Monitor the performance of SSS systems in small and medium cities, in alignment with SPCB

3.3.6 Stakeholder relationships and information exchange

The formal roles and responsibilities do not explain entirely how a sector works, as agencies may not be in a position to fulfil the roles and responsibilities assigned to them, or because of governance issues due to interagency and interpersonal shortcomings. This is reflected in particular in the relationships between stakeholders, and their degree of participation and communication.

A constructive involvement and good communication of the key stakeholders is important for efficient governance. Social network analysis (SNA, ➲ methods section 2.3.3) was used to describe and analyse the web of relations between various stakeholders and to understand the formal and informal dynamics fostering or hindering the SSS sector.

The information exchange networks were analysed for Bengaluru, Chennai, Mysuru and Coimbatore (➲ methods section 2.3.3). **Figure 9** shows the resulting network graph for Bengaluru as an illustrative example of a stakeholder network. The respective network graphs for Chennai, Mysuru and Coimbatore are presented in Appendix 5.

The network graphs give an intuitive graphical representation of how stakeholders are connected and how they interact. The graphs illustrate that the constellation of actors can differ quite considerably between cities, even within states, and particularly between mega cities (which have a utility, i.e., Water Supply and Sewerage Boards) and secondary cities. The SNA highlights the central position of the utilities (BWSSB and CMWSSB) in Bengaluru and Chennai. In the cities of Mysuru and Coimbatore (where there is no WSSB), the municipal corporation is the most central agency, with the SWSDB playing a bigger role. These stakeholders are the most central stakeholders in terms of information exchange, i.e., they have the most information exchange relations to other stakeholders and are, therefore, key in terms of organising (and re-organising) the sector.

A separate publication on this SNA (Narayan et al., 2020) provides a more detailed discussion, including an attempt to relate the SNA measures to the differences between mega and secondary cities.

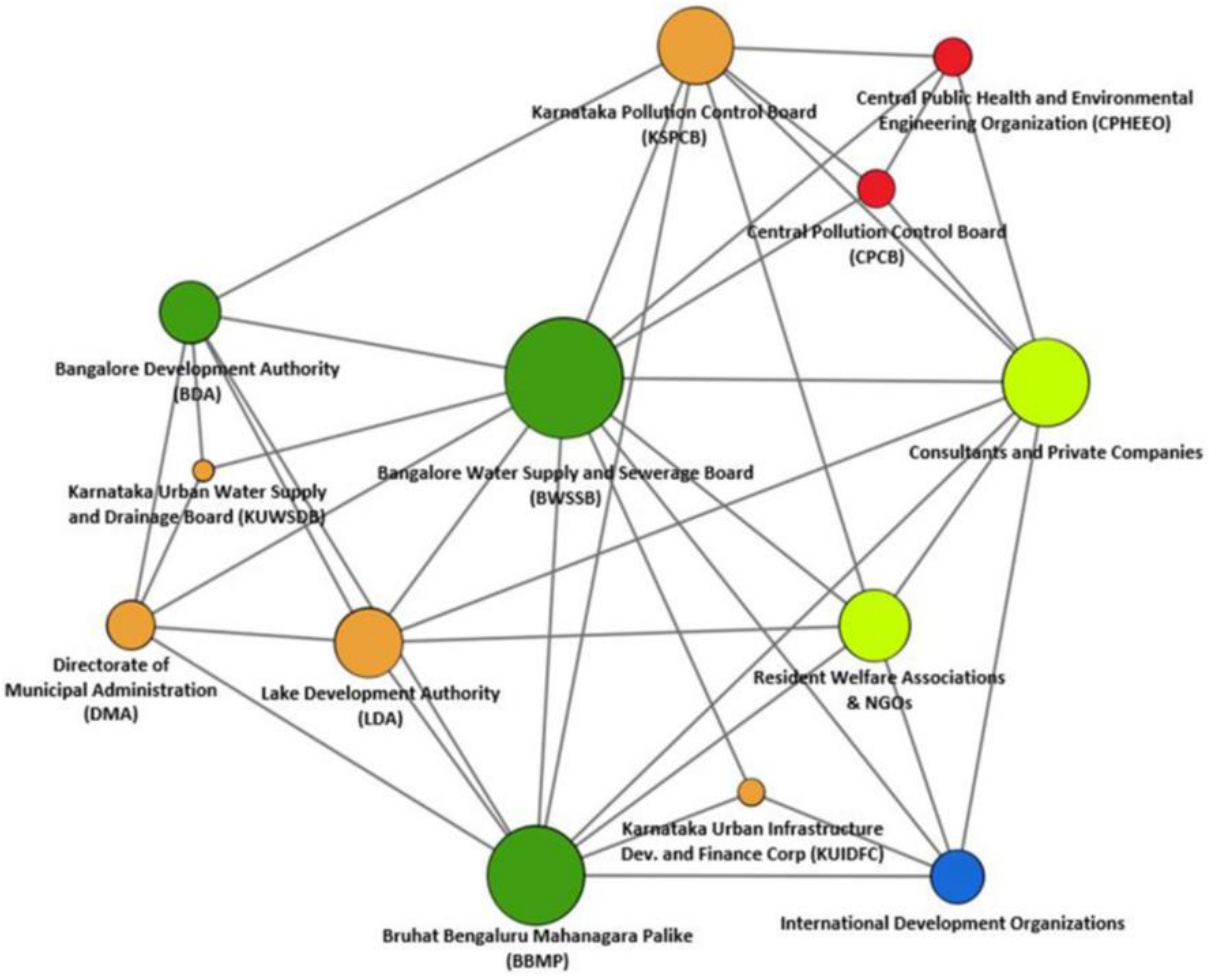


Figure 9: Network graph for Bengaluru, illustrating how SSS stakeholders at city, state and national levels exchange among themselves. Colours of stakeholders are as in Figure 8 on p. 52; sizes of nodes are relative to outdegree centrality, i.e., the number of connections mentioned by each stakeholder. Figure source: Narayan et al. (2020).

4 Learning from the international experience

SSS also developed at a significant scale in several other countries, facing challenges that are similar to those in India. This chapter presents relevant international cases and related lessons that might be helpful for developing the SSS governance arrangements in India.

4.1 SSS governance in Malaysia

In the 1970s and 80s, Malaysia experienced a scaling-up process of SSS similar to the one in India, with common issues. Useful lessons can be drawn from the measures taken by the Malaysian government to solve the problems and improve the sector. This case study provides details of the historical developments of SSS in Malaysia, and how the government incrementally improved the sector by learning from failures and adapting the institutional arrangements. A brief summary of the key lessons with relevance for India is provided in ➲ **Box 10**. The authors would like to thank Dorai Narayana (Specialist Consultant, Malaysia) for providing information and reviewing this case study.

Box 10: Summary of the lessons from the Malaysian experience of SSS governance

Lessons from the Malaysian experience

- At the beginning of the scaling-up process, the local authorities' lack of capacity and knowledge to operate and maintain small-scale systems resulted in a huge number of deficient plants. In order to solve the issue of poorly performing small-scale wastewater treatment plants, the Malaysian government decided to centralise operation and maintenance by entrusting it to a dedicated private utility.
- Development of a consolidated SSS database as a first step by the newly created utility, and categorisation of existing systems according to their status.
- Pragmatic approach to legacy system upgrade:
  - Stage-wise refurbishment, starting with measures to ensure safety and operability
  - Creation of a new set of discharge standards based on the age of systems and design standards used, with a timeframe to upgrade to the new requirements.
- O&M by the utility induces a number of economies of scale (e.g., equipment, human resources, trainings).
- Capacity building is centralised by the utility, which has a training centre where operators and managers get training and accreditation internally or by relevant government agencies.
- Engineers and contractors need to be registered to implement SSS systems.
- Most small-scale facilities are unmanned, and operations are carried out on maintenance visitation basis, with frequencies determined based on size and complexity of systems. Some are also equipped with electronic monitoring systems for fault detection.
- Most water quality monitoring is done by the utility itself, which has accredited laboratories nationwide. This happens under the control of the regulator, the Department of Environment (equivalent to PCBs in India). All monitoring results are geo-referenced and uploaded to an online platform.
- There is a move towards soft monitoring methods such as measuring operational parameters and interviewing operators. The license of operators can be cancelled.
- Water reuse is not a priority in Malaysia because of the abundance of water, and there is less of an incentive to keep SSS systems if neighbours are not happy and if a connection to a large-scale system is possible.

4.1.1 The introduction and centralisation of small-scale sanitation

In the 1970s, the Malaysian government started a "National Sewerage Development Program" to develop sanitation infrastructure in major cities with the aim to introduce modern sewerage systems in urban areas. However, due to the deficiencies of existing financing structures and the inability of the local government to gather sufficient resources, these master plans were implemented only in a few cities like Kuala Lumpur, Penang, Butterworth, and Kota Kinabalu. Sewerage services and network development were fully entrusted to local governments, which did not resolve the matter of insufficient funds. Additionally, it brought to the fore the deficiencies of resources, capacity and knowledge of the local governments to undertake such tasks.

During the 1970s, the Ministry of Health and Local Development in Malaysia introduced a regulation that obliged new real estate developments with 30 or more housing units to be connected to a small-scale sanitation system. It was, however, not accompanied by a robust regulatory framework for technology selection, quality control of systems, and long-term monitoring. Imhoff tanks (for 30-100 housing units) and oxidation ponds (>100 housing units) were the preferred technologies, considering the limitations of local authorities to manage sophisticated systems. With rising establishment and land costs, some developers looked for cheaper, but not necessarily appropriate, options. Many also failed to carry out proper maintenance of these systems due to shortage of manpower and lack of expertise (JICA, 1999). The local authorities' lack of capacity and knowledge to operate and maintain small-scale systems resulted in a huge number of deficient systems. Besides, the local authorities hardly had consolidated information on the existing systems.

In 1993, the government decided to take over and centralise the sewerage services considering the environmental damage being caused due to poorly functioning wastewater systems and ill-equipped local authorities. The sector was privatised under a 28-year concession agreement with Indah Water Konsortium (IWK). The Sewerage Service Department (SSD) was organized under the control of the Ministry of Housing and Local Government (currently under the Ministry of Energy, Green Technology, and Water) to regulate and monitor sewerage services entrusted to IWK.

4.1.2 A unified database and stage-wise upgrading process

The unavailability of a consolidated database of the existing SSS systems led IWK to prepare a catalogue of the existing systems. A majority of the identified systems were proven to be semi-functional or defective, owing to different reasons. In order to rectify the systems, IWK adopted a stage-wise refurbishing process. After identifying all the systems, IWK categorised the refurbishing process based on the level of damage incurred to the systems. The Malaysian government provided soft loans to carry out the refurbishment process. The three following stages were followed:

- *Stage I:* Raising the safety standards of systems (carrying out civil rectification works) and aesthetics
- *Stage II:* Provision of electricity, revamping / replacing electrical and mechanical equipment
- *Stage III:* Refurbishing the systems (revamping the entire system) to meet treated water quality standards

In the first stage, the objective was to enhance the safety standards of systems by carrying out civil works, and make them operable, remove nuisance and improve aesthetics. In the

next stage, the missing / non-functional components were repaired / replaced according to the original design intent irrespective of the design shortcomings if any. A sizeable number of systems had inherent design faults, and thus required refurbishment / upgrading of the entire system. In a few cases, the process of revamping was impossible since many systems were designed only to reach the formerly applicable standards. Consequently, IWK negotiated with the Department of Environment under the Ministry of Natural Resources and Environment to create a new set of standards based on the operational age of systems, as shown in **Table 8**. The older facilities (legacy systems, ➲ definition in Box 20 on p. 114) would be gradually upgraded to meet the new standards. IWK controls more than 8,000 systems.

Table 8: Malaysian effluent discharge standards 2009 (DOE, 2009)

	T [°C]	pH [-]	BOD [mg/L]	COD [mg/L]	SS [mg/L]	NH_3-N [mg/L]	NO_3-N [mg/L]	P [mg/L]	O&G [mg/L]
Category 1: New STPs (after 2009), Rivers									
Standard A*	40	6-9	20	120	50	10	20	-	5
Standard B**	40	5.5-9	50	200	100	20	50	-	10
Category 2: STPs designed from 1999 to 2009									
Standard A	-	-	20	120	50	50	-	-	20
Standard B	-	-	50	200	100	50	-	-	20
Category 3: STPs designed prior to 1999									
Communal Septic Tank	-	-	200	-	180	-	-	-	-
Imhoff Tank	-	-	175	-	150	100	-	-	-
Oxidation Pond	-	-	120	360	150	70	-	-	-
Aerated Lagoon	-	-	100	300	120	80	-	-	-
Mechanised STP (Std A)	-	-	60	180	100	60	-	-	20
Mechanised STP (Std B)	-	-	60	240	120	60	-	-	20

* Upstream of drinking water intake ** Downstream of drinking water intake

4.1.3 Process of establishment, O&M and monitoring of small-scale systems

Today, real estate developers build systems wherever centralised sewerage systems do not exist. The systems are handed over to Indah Water to be operated and maintained as soon as they are completed. There is a one-year defects liability period. For some self-contained large development projects, for example condominium blocks, hospitals or factories, where there is a single owner / maintenance entity, long-term O&M can be carried out by the owner / maintenance entity, by appointing a licenced operator – thus an example of delegated management.

Only a qualified engineer registered under the 'Board of Engineers' is authorized to provide the design of the system. Only systems approved by the regulator can be installed (based on detailed guidelines, ➲ 4.1.6), and only by registered contractors. All new systems are subject to approval at planning, design and construction stages by IWK (which acts as agent of the regulator, i.e., as a certifying agency). Buildings can only receive the occupancy certificate if the completion of their STP is approved by IWK. This serves as a quality control measure. New technologies must be successfully piloted and validated before entering the market.

Indah Water has a training centre where operators are trained on all required O&M tasks and get an accreditation from the Department of Environment. Certified operators carry out the O&M of the systems. Operational teams depending on the size and complexity of

the facilities are assigned by IWK to operate the systems. Some routine and specialised tasks (e.g., sewer cleaning and blockage clearing, pump maintenance, sludge removal, grass cutting or screen cleaning) may be outsourced by IWK to other private contractors. Small facilities are unmanned, and operations are carried out on maintenance visitation basis, with frequencies determined based on size and complexity of systems. Some facilities have remote sensors to detect mechanical and electrical faults, high water level in sumps, and security breaches.

Most effluent monitoring is done by IWK, which has three accredited laboratories nationwide. Monitoring costs are part of the operating costs of the company, and supposed to be covered by the tariffs. The monitoring body (Department of Environment) also carries out periodic effluent monitoring of the systems, which is becoming increasingly difficult due to the large numbers involved. Both monitoring programmes are coordinated. The number of samples and parameters to be taken by IWK are specified by the Department of Environment, and the data is submitted online, with geo-referencing.

About 10% of the samples do not meet the prescribed standards at any point in time, as local factors such as power outages, theft of components such as pumps and motors, equipment breakdowns or illegal discharges to sewers largely influence the performance of systems. If a plant fails to comply with the standards, actions can be taken including fine, court actions leading to fine and jail. The license of the operator can also be cancelled. The penalty is proportionate to the environmental pollution and seriousness of impact. As sampling alone is not fully satisfactory, there are discussions to introduce soft monitoring methods such as measuring operational parameters and interviewing on-site operators about the operational tasks, which provide a good overview of the performance of the system.

4.1.4 Building SSS for clusters of adjacent buildings

According to a regulation, if new developments are coming up adjacently, a common SSS system can be built within the premises of any new project. Real estate developers were extremely reluctant to provide land for the system, and therefore, the regulation did not witness major success rate, with one or two exceptions. Even with economies of scale and the O&M provided by IWK, allocating land for wastewater treatment within a development is perceived as disadvantageous by the real estate developers. Moreover, the adjacent developers are often competitors, and talking to each other is not easy.

4.1.5 Opposition to SSS

In many cases where SSS systems have been built for communities, the proximity of the facilities caused complaints from adjacent residents, and generated demands for facility relocation. Even in the case of Kuala Lumpur, the centralised STP which used to be in an isolated location is now surrounded by high-rise apartments, and there is an increasing demand that the government relocate the facility (“Not In My BackYard” or “NIMBY” syndrome). The government is undertaking a huge “rationalisation” scheme in Kuala Lumpur and adjacent areas to close down small-scale community sewerage systems and linking them to large centralised facilities. This is partly driven by cost efficiencies but also community pressure to remove local STPs. It is to be noted that water reuse is not a priority in Malaysia due to the abundance of natural water resources and low water prices.

4.1.6 References and Further Reading

- **Malaysian Environmental Quality (Sewage) Regulations 2009** (DOE, 2009), URL: https://www.doe.gov.my/portalv1/wp-content/uploads/2015/01/Environmental_Quality_Sewage_Regulations_2009_-_P.U.A_432-2009.pdf (last accessed: 24.09.2020)
- **Malaysian Sewerage Industry Guidelines**, URL: http://www.span.gov.my/article/view/malaysian-sewerage-industry-guidelines-msig (last accessed: 24.09.2020)
  - Especially Volume 4 dedicated to STPs (SPAN, 2009):
    - http://www.span.gov.my/document/upload/Rtbh9zHKMuYxK0v7kqMNPPmI8EMIcS1y.pdf (last accessed: 24.09.2020)
    - http://www.span.gov.my/document/upload/4AVyKdAVa44RLt5LGXHsMjNCH4cvnYKv.pdf (last accessed: 24.09.2020)
- **Privatisation of Water, Sanitation and Environment-Related Services in Malaysia** (JICA, 1999), URL: http://open_jicareport.jica.go.jp/pdf/11557659.pdf (last accessed: 24.09.2020)
- **Integrity in Sanitation Access and Service Delivery: A Case Study of Malaysia's Sanitation Sector** (Narayana, 2020)**,** URL: https://www.adb.org/publications/integrity-sanitation-access-service-delivery-malaysia-sanitation-sector (last accessed: 3.12.2020)

4.2 Scaling-up of small-scale wastewater treatment plants in Beijing, China

China experienced a scaling-up of small-scale wastewater treatment plants, but with different institutional processes and path creation dynamics than in India. The governmental agencies in Beijing and other major cities requested private companies to implement SSS solutions, allowing for a pragmatic initial trial-and-error process. Driven by increasingly pressing water scarcities in Beijing, small-scale wastewater treatment and reuse systems had already been implemented in hotels in the nineties, and this measure incentivised the private companies to also experiment in the residential context. Starting from 2003, the installation of SSS systems became mandatory in new, large residential construction projects in Beijing.

SSS in residential buildings faced a number of failures, especially related to O&M. This notwithstanding, an additional market segment was triggered in an environmental protection zone surrounding the city's major drinking water reservoir. Learning from the failures in residential buildings, a comprehensive O&M system was developed with engineers permanently repairing distributed systems. The city government of Beijing commissioned a private company through a public-private partnership (PPP) to build and manage a few hundred small-scale wastewater treatment plants in the peri-urban area. This move allowed for a consistent quality of treated water and much higher service quality.

As in the examples of the Bellandur Lake in Bengaluru and the Ganga in northern India, it shows the important role of the protection of key natural resources in triggering institutional change.

This case study was compiled from Binz et al. (2015) and validated with C. Binz (personal communication, 2019).

4.3 Code of practice for wastewater treatment systems for single houses in Ireland

While this case study is from a very different context (rural, single-household systems), it presents a good example of a code of practice for decentralised sewage treatment plants. The Irish Environmental Protection Agency published a code of practice to provide guidance on design, operation and maintenance of such systems. The code of practice establishes an overall framework of best practice for wastewater management in unsewered rural areas and intends to assist stakeholders such as authorities, developers, system manufacturers, system designers, installers and operators to deal with various systems. The code of practice provides

- a method for site assessments to determine local environmental requirements and the suitability for an on-site sewage treatment plant, including a site characterisation form;
- decision-making support for technology choice;
- information on design and installation of different systems;
- the requirements for operation and maintenance.

Such a code of practice sets standards and helps informing a wide range of stakeholders on current best practice. It also makes technology selection more transparent.

Source and download of the code of practice: Code of Practice: Wastewater Treatment Systems for Single Houses (EPA, 2020), URL: https://www.epa.ie/pubs/advice/water/wastewater/code%20of%20practice%20for%20single%20houses/ (last accessed: 3.12.2020)

4.4 Governance of almost 30,000 SSTPs in Austria: a framework for design, operation and monitoring

Austria has approximately 27,500 small-scale STPs with a design size less than 50 person equivalents (PE). A majority of these plants are of the conventional activated sludge, sequencing batch reactor or vertical flow constructed wetland technologies (Langergraber et al., 2018). The case of Austria is very different from the case of India (SSS systems used in rural areas, mostly for single houses, and there is no reuse). Nonetheless, it has several interesting features that can be of interest for the governance of SSS in India (Langergraber et al., 2018):

- Austria has two **design standards for SSTPs** – one for mechanised systems (such as activated sludge and SBR) and one for constructed wetlands. These design guidelines consider the specific Austrian performance requirements. The standard for treatment wetlands was released in 1997 and revised in 2009, and the standard for mechanised systems was released in 2001 and revised in 2012. It is important to keep such design standards updated, based on local experiences and technological advancements.
- For systems designed according to these standards the **process to get a permit to operate is simplified**. This helped streamlining and accelerating the implementation process of small wastewater treatment plants.
- Since the year 2000, the Austrian Water and Waste Association partners with BOKU University to offer **training courses for operators** and other special courses on the subject. For systems <50 PE a 1.5-day course is available, while for larger systems a special course has been designed. For the former, operator trainings take place more

than ten times a year in different parts of the country. They cover the following contents:

  - Theoretical knowledge on biological wastewater treatment, incl. wastewater composition, processes in treatment plants and different technologies
  - Basics on O&M requirements, incl. technology-specific aspects
  - Practical introduction to wastewater sampling and analysis, incl. the tests required in self-monitoring
  - Field visits to different systems of various technologies
  - Fundamentals of the legal and regulatory requirements and processes
- Most **authorities require that owners have a maintenance contract with an O&M company and/or that the owners/operators pass the training course**.
- The monitoring approach combines **self-monitoring and external monitoring**. Self-monitoring by the owner/operator includes weekly routine checks and weekly/monthly (depending on size) sampling and analysis of basic parameters (temperature, pH, ammoniacal nitrogen, settleable solids, sludge volume). All observations have to be recorded in a logbook. External monitoring takes place annually or biannually, depending on the size of the plant. This includes more detailed sampling (BOD_5 and COD), and an **evaluation of the operational logbook**.

4.5 Japan's governance framework enables the successful addition of 120,000 new SSTPs every year

Japan's SSTP system called "Johkasou" successfully complements sewer-based large-scale wastewater management systems. The case study is nicely summarised in this video by the Asian Development Bank Institute: https://www.adb.org/news/videos/spotlight-japan-johkasou-sanitation-system (last accessed: 05.03.2021)

Relevant highlights:

- "Johkasou" systems provide high quality wastewater treatment services for residential and commercial buildings
- Systems are implemented, operated and maintained by the private sector, but with considerable government supervision and support, namely in the form of
  - subsidy schemes and public-private partnerships
  - government approval of manufacturers, vendors, certified installers
  - registration of approved O&M and desludging companies
  - mandatory trainings and examination of O&M personnel at designated training facilities; certification
  - (semi-)centralised night soil treatment facilities to manage SSTP sludge (yearly scheduled desludging) (MoE, 2013)
  - annual inspections, incl. water quality sampling and document inspection (MoE, 2013)

4.6 International examples of effluent standards for SSS systems

Table 9 contains a selection of international examples of standards for SSS systems.

Table 9: International examples of effluent standards for SSS systems

	EU 1991	Germany 2004	Jordan 2016	Malaysia 2009	Philippines 2016
Source	(EU, 1991)	(BMU, 2004)	(MoWI, 2016)	(DOE, 2009)	(DENR, 2016)
Applicability	Surface waters; 2,000-10,000 PE	Surface waters; < 1,000 PE / < 5,000 PE	Surface waters; < 5,000 PE	Various system categories[i)]	Various surface water categories, any system size
BOD [mg/L]	25	40 / 25	NS	20-200[i)]	20-120[ii)]
COD [mg/L]	125	150 / 110	150	120-360[i)]	60-200[ii)]
TSS [mg/L]	60	NS	60	50-180[i)]	70-150[ii)]
NH_4-N [mg/L]	NS	NS	NS	10-100[i)]	NS[iii)]
TN [mg/L]	NS	NS	70	NS[i)]	NS[iii)]
TP [mg/L]	NS	NS	NS	NS[i)]	NS[iii)]
FC [MPN/100 mL]	NS	NS	1,000 (*E. coli*)	NS[i)]	4-800[ii)]
pH	NS	NS	6.0-9.0	5.5/6.0-9.0	5.5-9.5

BOD: Biochemical Oxygen Demand; COD: Chemical Oxygen Demand; TSS: Total Suspended Solids; NH_4-N: Ammoniacal Nitrogen; TN: Total Nitrogen; TP: Total Phosphorus; FC: Faecal Coliforms; NS: Not Specified

[i)] Range of discharge limits for system categories based on downstream freshwater use, age of system and technology type, ➲ Table 8 on p. 59; [ii)] Range of discharge limits to surface waters depending on freshwater use of water body;
[iii)] Standards for NH_3-N, NO_3-N and PO_4-P apply;

The examples represent technologically advanced countries, countries affected by severe water shortages and high population density, as well as countries with large socio-economic disparity. They showcase alternative approaches of standard setting relevant to the Indian scenario:

- **Differentiation between discharge and reuse:** The standards of the European Union (EU), the Philippines and Jordan distinguish between effluent discharge to aquatic environments and reuse. Discharge standards are typically less stringent than reuse standards concerning pathogen levels, but can be stricter for nutrients. This allows to implement technologies adapted to reuse or discharge possibilities and risks, accounting for local maintenance capacities and available budgets. Sometimes, reuse standards are linked to irrigation methods and crops (Schellenberg et al., 2020).
- **Relaxed discharge standards for small systems:** Standards valid in the EU and Jordan stipulate discharge levels depending on system size, with SSS systems typically being subject to relaxed organic limits and exempt from nutrient and pathogen removal requirements. There are various rationales for such legislation: in some cases, it is because small systems pose lower pollution risks, as they discharge lower loads and typically operate in sparsely populated rural areas. Also, because of higher flow and concentration fluctuations, raw wastewater treated by SSTPs is much more

challenging than in large systems. Acknowledging related techno-economic constraints, higher limits may be tolerated.

- **Graded standards depending on quality and/or use of receiving water bodies:** Regulations of the EU, the Philippines and Malaysia stipulate tightened standards for discharge to vulnerable ecosystems and in case of elevated public health risks. This guides the investments in improved treatment where needed most. Depending on their exact formulation, such regulations may require knowledge of the current state of the natural systems.
- **Compliance based on removal efficiency:** EU discharge standards define removal efficiencies above which STPs are deemed compliant even if concentrations exceed the limits. This adequately considers systems treating concentrated wastewater, but requires the estimating of average feed concentrations, thereby increasing monitoring requirements. Regulators in the Philippines took a different approach and defined higher concentration limits for systems treating highly concentrated sewage.
- **Tolerance to exceed limits:** It is common practice that regulators allow for a certain number of effluent samples per year to exceed the stipulated limits (e.g., EU). This accounts for the intrinsically fluctuating characteristics of STP effluents. It is only applicable where regular, relatively frequent sampling is possible.
- **Technology-specific standards:** In certain cases, the standards of the EU and Malaysia vary depending on the treatment technology. The EU, for example, has slightly adapted limits for treatment ponds, which typically discharge higher levels of environmentally benign organic solids than other systems. This allows for the implementation of proven technologies where reasonable.
- **Relaxed standards for older systems:** In the light of existing challenges and constraints in Malaysia, the country's regulators divided STPs into age categories with more relaxed standards for older systems (➲ section 4.1.2). This legalised a gradual refurbishing process towards improved treatment adapted to the country's capacity to implement and operate systems of various technology levels.

5 Conclusions: factors impairing the efficiency of SSS at scale

India presents a set of conditions for small-scale sewage treatment and reuse systems to take a very significant role in increasing sanitation coverage and water security: fast urban growth, large middle- and high-income housing areas, water scarcity and an urgent need for water reuse. Accordingly, there is an enormous opportunity and potential for SSS solutions for the water as well as the sanitation sector.

The political drive for sanitation improvement is there, and India is already far on the way with SSS. The analysis shows, however, that the corresponding governance framework did not develop at the same pace as the implementation of SSTPs. The market growth happened much faster than the development of monitoring and support mechanisms, with big differences between states.

Within the broad governance framework for urban wastewater management, the framework for SSS is not yet fully set. As seen in chapter 3, there have been a number of policies and initiatives fostering SSS. While these SSS policies are meaningful and laudable, the necessary enabling environment didn't come along with them. Most SSS-related regulations give indications on what should be done, without any provisions on the "how", and without preceding stakeholder consultations to consider practical implications on the ground. A fully structured, robust governance framework bridging the scopes of interest of MoHUA, MoEFCC and their respective line agencies is still missing. Accordingly, the governmental bodies are not fully equipped to actively direct the scaling-up process and monitor the performance of systems. These gaps have resulted in the sub-optimal implementation of otherwise progressive regulations for urban water reuse.

The assessment of 279 SSS systems in India showed that a large number of SSTPs do not perform according to their technical design, failing to comply with discharge standards (see 4S Project Report Vol. I on technology, implementation and operation (Klinger et al., 2020)). This provides evidence that the current governance framework for SSS does not offer the necessary incentives and enabling environment to guarantee wide-spread system performance at scale. The governance analysis shows that weaknesses exist at all governance levels, from the government arrangements at national level to the details of the implementation and operation processes of SSTPs. Based on the analysis, the authors conclude that, from a governance perspective, the overall performance and success of SSS in India is impaired by a number of interlinked factors (➲ **Box 11**). These factors represent the major bottlenecks for the sustainable scaling-up of SSS in India. The following sub-sections describe the conclusions for each of these aspects.

With the growing need for water reuse, SSS systems are here to stay in urban areas. Government departments at all levels need to seize the opportunity and take control of the on-going SSS scale-up process. The key weaknesses in the governance framework pointed out in the following sections need to be addressed in a collaborative and systematic effort.

Box 11: Factors impairing the performance of SSS at scale in India

1) Lack of recognition of SSS by the governmental agencies responsible for urban sanitation planning
2) Lack of coordination between relevant governmental agencies
3) Lack of dedicated budget and human resources
4) Gaps in the establishment, handover and monitoring procedures
5) Inadequate operation and maintenance
6) No specific effluent and reuse standards for SSTPs
7) Insufficient integration of SSS in water reuse planning
8) Lack of key centralised governance structures, e.g., for data management, information and training

5.1 Lack of recognition of SSS

The study highlights that although more than 20,000 SSTPs were built in India, with an on-going increase, the authorities in charge of sanitation planning (MoHUA and line agencies) are unaware of the number, location and functional status of these privately owned and operated systems (Deccan Chronicle, 2015; Klinger et al., 2020). SPCBs and SEIAAs are the only agencies which possess some databases, but these are neither harmonised nor digitised. As a consequence, SSS is still not on the "sanitation map" alongside conventional centralised wastewater management and faecal sludge and septage management (FSSM).

The analysis shows that it is because the drive for SSTPs did not come from the governmental agencies in charge of the wastewater sector (i.e., MoHUA and line agencies at state and city levels), but from MoEFCC and line agencies, based on an environment protection and water saving rationale. Another reason is the general low awareness of SSS as a real solution for urban sanitation. This was observed in the interviews conducted as part of the social network analysis in this study: when talking about sanitation, many government officials only had public sewerage and wastewater treatment infrastructure in mind, with STPs above 1 MLD capacity. The existence and growing significance of SSTPs has often not been on their radar.

Even if government agencies are aware of SSTPs, they are often risk averse and reluctant to go beyond "business-as-usual" and to take up responsibilities for new solutions that seem to demand important budget and human resources (Reymond et al., 2018). Also, ULBs lack sufficient knowledge on emerging alternative solutions. Despite the growing contribution of SSS to sanitation coverage, the WSSBs and ULBs, which are the governmental bodies in charge of sanitation planning at local level, do not show ownership for small-scale systems, and they do not yet integrate them in their sanitation masterplans. The main responsibility, as well as most of the existing information regarding SSS, are in the hands of the SPCBs, although they are only in charge of authorisation and monitoring and not sanitation planning per se. There are attempts to involve the ULBs in monitoring of SSS, but this was not enforced at the time of the study. For time being, the stakeholders and regulatory framework for SSS are insufficiently coupled with the institutional framework for urban water and wastewater management.

None of the SSS policies introduced so far was accompanied with technical, regulatory and/or financial support to promote sustainable SSS facilities (➲ section 3.2.2). While SSS is fostered in several documents, there is overall little policy encouragement for governmental agencies to implement SSTPs themselves or to get involved otherwise. SSS

is currently delegated to the private sector, with little direction from the government, neither in programming, nor in implementation or monitoring. A case in point is the poor management and regulation of the sewage sludge produced in SSTPs. As shown in section 3.2.2, the issue of sludge management has so far been totally overlooked by policy makers and regulators. The 4S performance analysis highlighted that this leads to considerable problems on the ground, such as uncontrolled disposal of sludge in the environment (see 4S Project Report Vol. I (Klinger et al., 2020)).

Sanitation planning stakeholders, thus, currently do not concretely consider SSS as a sanitation option alongside centralised systems and FSSM – despite its increasing contribution to sanitation coverage in big cities. SSS is currently disconnected from the greater urban sanitation policy landscape or strategy. At the national level, current sanitation policies focus on large-scale centralised systems and FSSM, without defining the role and scope for SSS. Until now, national programmes and policies have clearly not properly considered SSS systems as an option for urban sanitation (➲ section 3.2.1). This is also reflected in the census of India, which collects information only on household connectivity to "sewer network", "septic tank" and "others", without considering on-site SSTPs.

Each state develops its own state sanitation strategy to achieve the policy goals set out in the National Urban Sanitation Policy. Only few of the currently existing state sanitation strategies mention SSS. Interestingly, SSS is not mentioned in the sanitation strategies of Karnataka and Tamil Nadu, despite the large number of systems implemented and a relevant contribution to sanitation coverage. This highlights the lack of awareness from MoHUA line agencies and the lack of communication between stakeholders. In city sanitation plans (CSPs) as well, decentralised wastewater treatment approaches only rarely find an explicit consideration.

MoHUA largely influences the policy framework of urban sanitation at the state and ULB level through policy statements and investment linked to reforms in the urban sanitation sector, and thus to specific types of projects and wastewater management systems. MoHUA proposes different funding schemes for sanitation, and channels resources accordingly. This directly influences state governments' allocation of funds for sanitation projects. The problem for SSS is that it is not included in these investment schemes, which may prevent local public investment in SSS, even if it is part of state level strategies.

Another parameter that prevents governmental SSS projects is that sewage infrastructure projects are tendered/approved on the basis of technical specifications issued by the CPHEEO. At present, such technical specifications are available only for conventional sanitation solutions, and not for SSS systems which may use different technologies and system components (e.g., reuse system, or equalisation tank) (➲ section 3.2.4).

This lack of specifications combined with the focus of MoHUA and its policies on large-scale centralised systems results in the governmental bodies responsible for wastewater management at state and city level to focus solely either on conventional systems, or, since recently, on FSSM. In small and medium towns, the State Water Supply and Drainage Boards, a line agency of MoHUA, are responsible for designing and implementing wastewater management systems. These boards opt for conventional systems, as this is what the funding from national level is earmarked for. Existing city development plans and city sanitation plans (wherever available) are referred to when planning the infrastructure. Since most of the CSPs do not refer to SSS systems anywhere, SSS never reaches the table of discussion, which highlights again the low awareness of SSS in government bodies.

A disadvantage of the current policy framework (every new large construction project includes its own sewage treatment plant; little government involvement) is that it does not allow for a coordinated decision on the appropriate level of (de)centralisation based on economies of scale and optimised water reuse planning. This contributes to the current situation in which many SSTPs have high per capita operational costs and produce high quality treated water for which there is no immediate reuse (and sometimes even discharge) possibility.

Only with a better recognition of the role and potential of SSS for urban sanitation in Indian cities can some of its current key challenges be overcome.

5.2 Lack of coordination between relevant governmental agencies

SPCBs, ULBs and/or WSSBs (in the case of large cities) are the government agencies that are most concerned with SSS. Building bye-laws or development regulations may specify the responsibilities of governmental agencies in the implementation phase of SSTPs (design clearance, approving the construction, etc.), and sometimes also monitoring responsibility. As per the Water Act, the formal link of SSS with SPCBs is the requirement of a Consent to Establish and a Consent to Operate an SSS system. SPCBs are also responsible for monitoring. However, stakeholders are sometimes not aware of which agency is liable for long-term monitoring of the systems, or they do not agree to assume this role. The cases of Chennai and Hyderabad illustrate this issue (➲ section 3.3.3). While SPCBs have a clear official role to play since the early days of SSS in India, the involvement of WSSBs and ULBs in SSS is slowly rising. In Bengaluru, the KSPCB spearheaded the SSS policy for about a decade, while the massive scaling-up process received no consideration by the city's WSSB – despite its central position in the stakeholder network (➲ section 3.3.6). It was only in 2015 that BWSSB got involved by issuing stricter SSS policies, without discussing the modalities for the long-term monitoring of these new systems with KSPCB (➲ Box 4 on p. 33). In Chennai, CMWSSB has also been promoting SSS, but monitoring responsibilities were left unclear (➲ Box 9 on p. 50). It would be a natural role for WSSBs and ULBs to deal more with SSS as they deal with conventional wastewater systems and FSSM (➲ sections 6.1.1 and 6.1.2). If these stakeholders become more involved in the future, a coordination effort clearly has to be made (➲ section 6.3.2).

The current lack of consultation and coordination between stakeholders becomes manifest mainly in three different domains: databases, policies and planning.

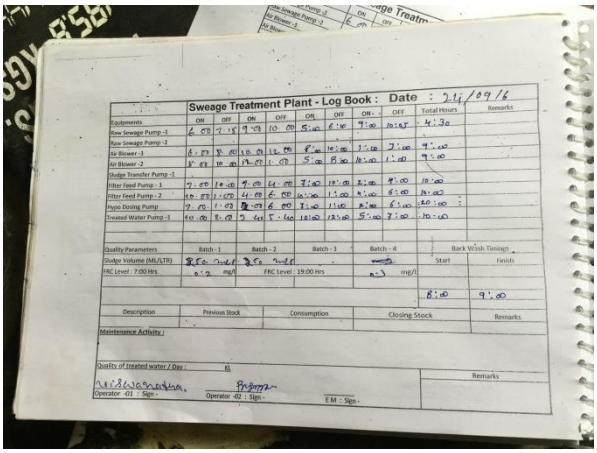


Figure 10: Today, a lot of information on SSTPs is still being stored on paper. This hampers the localisation of plants and effective performance monitoring (Photo: Shrikant Reddy).

1. Databases

Presently, Indian states and cities do not have comprehensive electronic databases of SSTPs (unified across states and, more importantly, among their own governmental agencies). A lot of information is still being stored on paper (e.g., sampling results). A major issue is that at city/town and state levels, there is no uniform process of recording SSS systems. As approvals are provided by different governmental agencies for different categories of buildings (➲ section 3.3.1), the responsibility for database management is not just with one single institution (➲ section 3.3.3). This means that different agencies have different, incomplete

databases, partly overlapping, but that there is not one single, unified and comprehensive database for SSS.

As long as SPCBs do not have the full overview of what they have to monitor (in the form of an electronic, geo-referenced and curated, up-to-date database), proper monitoring of SSTPs is impossible. Good databases would also be the basis for further urban planning, including the development of efficient water reuse strategies and assessment of the sanitation coverage (➲ section 6.4.1).

2. Policies

Policies are not coordinated, as highlighted by the lack of recognition of SSS by MoHUA and line agencies and their investment strategies. For instance, MoEFCC's 2006 EIA notification amendment which triggered SSTPs at national level (➲ section 3.2.2), was not developed in consultation with MoHUA and the State PCBs.

Unfortunately, consultation with stakeholders is currently rarely the case when policies are developed, and several regulations turned out to be unrealistic, causing popular outrage (as illustrated in Box 4 on p. 33 for the case of Bengaluru where an SSS policy was issued without taking into account the reality on the ground, generating an outcry from apartment owners). Insufficient participation of private sector and civil society stakeholders is also a problem in standard setting, as described in section 3.2.5.

At the time of writing, policies keep changing in a reactive rather than a proactive manner, i.e., based on a trial-and-error approach and not evidence-based. This may result in policies that are not connected with the reality. For instance, retrospective implementation of SSTPs for existing buildings is often not realistically possible due to space constraints and the infeasibility of structural modifications.

3. Urban sanitation planning

Urban sanitation planning is also weakly coordinated, which sometimes results in double investment, such as in cases where an SSTP is mandated in a building that will be shortly connected to the main sewer network. The case study of Bengaluru illustrates the lack of coordination between centralised sewerage and SSS policies and related planning practice (➲ **Box 12**). It also shows how important it is that MoHUA and line agencies integrate SSS as a long-term and integral part of their sanitation planning strategy. SSS policies need to be coordinated with the sewerage strategies of the city, defining clear zones for each of them, to avoid overlap and, thus, double investments.

Under the current policy framework, the implementation of SSS is disconnected from cities' sanitation or water management strategies. It is almost entirely private sector driven, leading to separate SSTPs for each building/construction project. This setup makes it difficult to increase government involvement for improved (small-scale) sanitation planning and decision-making (optimal sizing and siting of systems at ward/neighbourhood level, in terms of cost-effectiveness, reuse etc.).

Eventually, the lack of coordination between governmental agencies also contributes to a poor overall enforcement of related laws and regulations.

Box 12: Case study – lack of coordination between centralised sewerage and SSS policies and planning in Bengaluru

On the one hand, the Bangalore Water Supply and Sewerage Board (BWSSB) is vigorously pushing the idea of small-scale sanitation systems, and on the other hand, ambitiously planning to install large-scale sewage treatment plants to cover the entire city. Currently, existing public sewage treatment plants can treat 1068 MLD, whereas further planned infrastructure is expected to increase the total capacity to 1,724 MLD (BWSSB, 2021). Despite the goal to cover the city with networked systems, BWSSB is pushing the installation of SSS systems in a punitive manner, even in existing buildings (➲ Box 4 on p. 33), and in zones where an extension of the service by large-scale systems is already planned.

The promotion of small-scale wastewater treatment and reuse systems make a lot of sense in a water-stressed city like Bengaluru. However, a lack of coordination within and between water and wastewater organisations and policies can lead to inefficiencies and ineffectiveness of investments and, thus, slow down the progress towards service level, water security and environmental protection goals.

5.3 Lack of dedicated budget and human resources

The policies devised by the central and state governments were successful in enforcing the implementation of SSS in certain building categories. The government stakeholders in charge, however, were not prepared for the oversight of a large number of distributed systems. Similar to the situation in other emerging economies (Binz and Truffer, 2017), SSS systems, thus, got successfully installed, yet without the creation of an actor network, financial infrastructure and institutional arrangements that would be able to effectively monitor the spatially dispersed plants and enforce regulation.

This is of particular relevance for the SPCBs. As their capacity has not kept up with the rapid expansion of the sector in recent years, they rarely have the financial and human resources to be able to carry out the inspection role appropriately (➲ section 3.3.3). SPCBs with resource and capacity constraints have to prioritise their work based on the classification of polluters, focusing most of their attention on pollution hotspots and larger industries. As a consequence, small domestic pollution sources, such as SSS systems, are largely waved through without checking, even though their totality has an important overall pollution significance.

The authors assume that the general lack of budget and human resources dedicated to SSS is a main cause for the following shortcomings, highlighted during the interviews of experts and own observations:

- Insufficient understanding of the financial and practical implications of building-level SSTPs, entailing a trial-and-error approach in policy revisions (➲ section 5.2)
- Lack of technical support for planning, operation and maintenance of such systems from the responsible government agencies to the private sector
- Lack of capacity building and training, both for government workers and private service providers
- Inadequate monitoring mechanisms due to lack of funds and staff but also lack of coordination between governmental agencies. A systematic monitoring and regular on-site inspections of SSTPs are currently not possible.
- Weak/non-systematic enforcement of laws and regulations and insufficient penalisation

5.4 Gaps in the establishment, handover and monitoring procedures

The procedures to establish, commission and monitor private SSTPs were systematically analysed for the case of Karnataka, through desk-based research and discussion with experts (➲ sections 3.3.1-3.3.3). The study highlights the main weaknesses along these procedures. **Figure 11** illustrates these weaknesses by representing the different interactions between the government agencies and the private sector in Karnataka. The private sector is responsible for planning, design, implementation and O&M, whereas the main roles of the government agencies are consent issuance and monitoring. The numbers in the following list refer to the number tags in Figure 11, placed at the relevant location on the stakeholder and processes map:

1. ***Technology selection which is not based on long-term sustainability and life cycle cost of the future treatment plant:*** the stakeholders in charge of technology selection are usually not the ones who will operate the plant in the long-term (real estate developers vs. building management entities) (Klinger et al., 2020). Today, developers, STP designers and consultants do not have to account for the technologies they choose and systems they compile. Capital costs are typically the main selection criteria, and not O&M cost, although the latter vary enormously between systems: the 4S financial analysis found that the O&M and capital maintenance costs of a system amount to 2-12 times the capital cost over a 10-year lifetime, depending on technology and size (see 4S Project Report Vol. III on finance (Rajan et al., 2021)). However, life cycle costs and management implications are normally not taken into consideration. Besides, there is insufficient knowledge of the different options and the implications of choices, and relevant governmental bodies neither provide guidance nor control. The absence of a defined set of decision-making criteria leads to low transparency in the technology choice process.
2. ***Unqualified consultants:*** lack of expertise, experience and accountability for design and implementation on the side of consultants, such as mechanical, electrical and plumbing (MEP) consultants, resulting in low-quality installations and failures in the long-term operation of systems (Rajan et al., 2021).
3. ***Consent to Establish:*** lack of rigour in design evaluation, mainly linked to a lack of capacities, guiding documents and technical standards.
4. ***Consent to Operate:*** lack of capacities at SPCBs and ULBs to carry out an effective inspection of the infrastructure and to manage consents diligently.
5. ***Handover:*** absence of a formal transfer process between (most often) the real estate company and the building management entity (e.g., RWA). The newly constituted building management entity was not involved in technology decisions, is not well prepared to assume its new operational responsibilities, and the relevant training and documentation (e.g., O&M manual) is often lacking. Currently, RWAs often find themselves left alone with sanitation systems they do not master, or which are not adapted (see 4S Report Vol. I (Klinger et al., 2020) for a more detailed analysis of handover and training issues).
6. ***Sampling and reporting:*** the building management entity regularly takes samples and sends them to a NABL-certified laboratory. The laboratory sends the results back to the building management entity, which then submits them to the SPCB. This results in a high risk of data manipulation during one of the different steps of the process.

7. ***Inexistence of a unified, geo-referenced data management system with an online portal for SSTPs*** *(see also ➲ sections 3.3.3 and 5.2)**:*** this results in a difficulty for the PCB and other agencies involved to track the SSTPs.
8. ***Lack of financial and human resources for the SPCB to carry out sufficient on-site inspections*** *(see also ➲ section 3.3.3 and 5.3).*

Although the establishment, handover and monitoring procedures bear the features of a so-called hierarchical governance approach, a lot of freedom is left with the private sector. This is because of the lack of SSS-specific guidance, competency, resources, as well as clear and enforced legal and regulatory frameworks. The authors argue that in such a weak hierarchical governance framework, market governance dominates *de facto* (see Reymond et al. (2020) for a more detailed description of the various governance frameworks). The market grew with very little restriction from the government, and the lack of capacities and enforcement of the latter enables the different private stakeholders to easily work around the regulations.

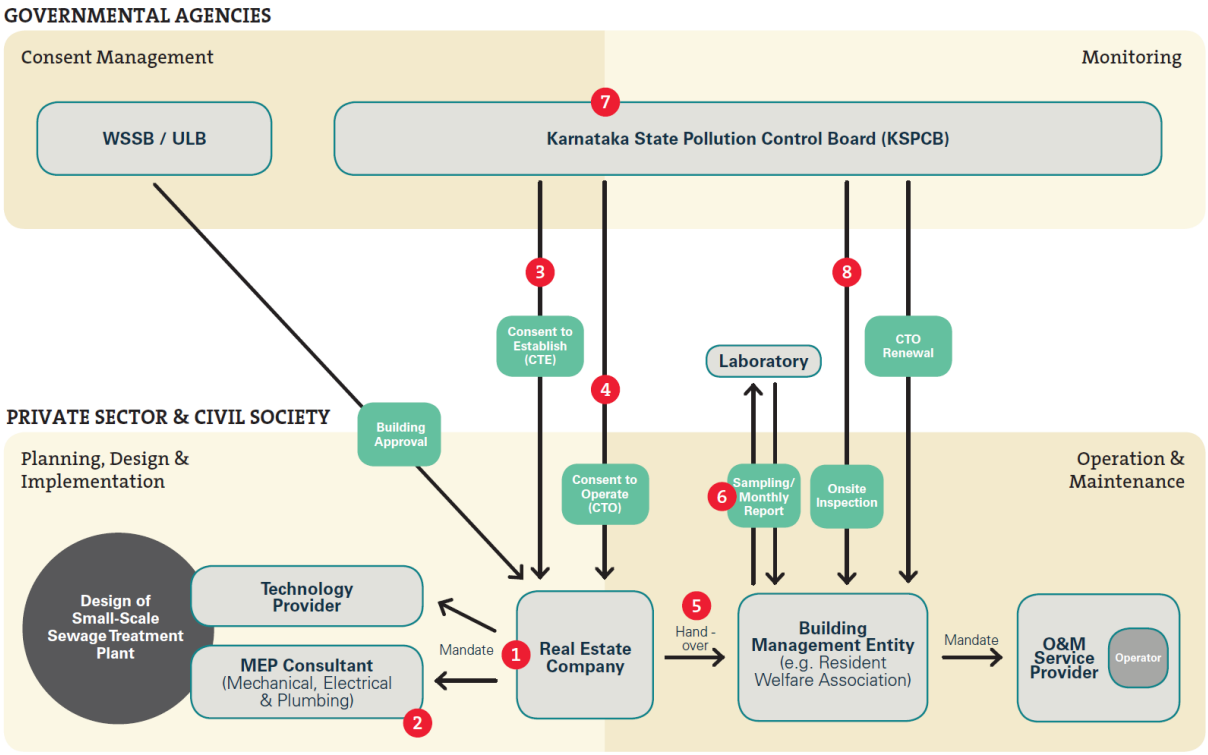


Figure 11: Stakeholders, procedures and governance arrangements through the life cycle of a small-scale wastewater treatment system in Karnataka. The red numbers refer to the main weaknesses explained in the text.

Ways to address these gaps and to optimise the processes are proposed in the recommendations chapter (➲ section 6.3.1 and Figure 16 on p. 98).

5.5 Inadequate operation and maintenance

SSS in India started with a government move that transferred the responsibility for wastewater management from public service providers to the polluters in case of large construction projects (➲ section 3.2.2), but without equipping the private sector with the necessary guidance, incentives and other support structures. Against this background, it is not astonishing that the assessment of 279 SSTPs found that many systems were not properly operated (see 4S Project Report Vol. I (Klinger et al., 2020)). The private sector plays a key role in the O&M of SSTPs. O&M is under the responsibility of the real estate developer or the building management entity, and different O&M arrangements exist (➲ section 3.3.2). As the following paragraphs show, reasons for poor O&M are manifold.

The field survey questionnaire to SSTP operators about their education and training levels showed that they often neither have the required skills nor the understanding of the treatment processes at stake (Klinger et al., 2020). This is also confirmed by the findings from Suneethi et al. (2015), Chatterjee et al. (2016) and Davis et al. (2019). The latter highlight that the lack of technical support, lack of clear O&M plans and insufficient O&M funds are major failure factors for SSS in India. There is currently no regulatory requirement for formal training of operators. Therefore, no licencing/certification mechanisms or trainings are available. The operators are often left alone and the low job perception, low pay scale and lacking career perspectives (➲ section 3.3.2) lead to low motivation and high operator turnover, posing an additional risk to stable O&M.

As life cycle costs are hardly considered in the technology choice process (➲ section 5.4), many SSTP owners find themselves confronted with a system that is expensive to operate. Accordingly, SSTPs are often not operated towards performance, but cost reduction: the O&M service provider or building management entity may run the treatment plant in order to reduce the energy costs (at least 40% of the systems were found to be run intermittently). This can be detrimental to the treatment performance (Chatterjee et al., 2016; Klinger et al., 2020). There is insufficient motivation to properly operate plants. In some cases, water reuse may play as an incentive, especially where treated wastewater is used for toilet flushing (Klinger et al., 2020). The 4S Project Report Vol. III on finance (Rajan et al., 2021) provides a more detailed discussion of the aspects related to financial sustainability of SSTPs.

The review of regulations shows that they do not state how the systems should be operated. None of the policies making the installation of SSTPs a requirement is accompanied with any guidance or incentives for the successful operation and management of systems. Guidelines for the O&M of wastewater treatment systems are developed by line agencies of MoHUA, but it was not done for SSS due to the lack of institutional ownership (➲ sections 5.1 and 5.2). The lack of proper monitoring from the relevant government agencies leaves a poor O&M by the responsible private or civil society stakeholders largely without consequence.

Whatever O&M arrangement (management scheme, ➲ section 3.3.2) is in place, in the residential sector there is a lack of capacity and motivation of building owners to make informed decisions and hold contracted service providers accountable (Klinger et al., 2020). Beyond SSTP management, there is an urgent need for formal trainings to build capacity for professional property managers, also called multi dwelling unit (MDU) managers (Citizen Matters, 2015b). Another challenge is that although the Real Estate Act includes a five-year warranty clause on “structural defect or any other defect in workmanship, quality or provision of services” (MoLJ, 2016), it is often hard to say in practice whether a performance problem originates in a design issue or poor O&M

(Klinger et al., 2020). The supplier of equipment is often blamed for failures. Therefore, it is advantageous in terms of liability if the technology provider (designer) of the system is also in charge of O&M (design-build-operate contracts; ➲ section 6.3.4). This study did not allow showing clearly if one management arrangement leads to better treatment performance outcomes than others.

5.6 No specific effluent and reuse standards for SSTPs

Current water quality standards do not account for SSS systems and should be reviewed

This study indicates a mismatch between discharge standards, reuse expectations, O&M realities and the techno-economic possibilities of existing SSS technologies. 2019 standards were proposed only with optimally performing large-scale STPs in mind, not SSS systems operating under field conditions (➲ section 3.2.5). They are relatively strict when compared to many international examples of standards applicable to small STPs (➲ section 4.6).

This study further shows that the 2017 discharge limits can in principle be reached by SSS systems of all investigated technology families. However, there are several important reservations. Firstly, O&M was often found to be inadequate, which certainly limited the treatment efficiency of many of the plants investigated (see also ➲ section 5.5). Also, systems with high feed concentrations (typical for low-income communities and public toilets) were found to have difficulties in reaching standards even when operating at high removal rates. Further, the stipulated pathogen levels were practically never reached. A systematic, scientifically backed effort is needed to improve performance (reduced effluent organic matter and ammonium, improved design and operation of disinfection units).

Tightening the standards (especially for nutrients, such as proposed first in 2015 and more recently by the National Green Tribunal order) will push most SSS system operations towards illegality and, thus, ignore their increasing significance to urban water management. Strict TN and TP discharge limits would be particularly problematic for existing SSTPs since they do not include the capital, technology and maintenance intensive denitrification and phosphorus removal steps.

This study, therefore, concludes that current standards should be reviewed, along with efforts to improve technical performance.

Unrealistically high standards are counterproductive

In a context where many existing systems are struggling to even be operated correctly and to be sufficiently funded for basic maintenance, it is an illusion to enforce stringent water quality standards. Re-engineering or revamping is not only expensive, it is often very difficult or infeasible, especially in space-constrained contexts such as urban housing areas.

Another key challenge is that high standards result in energy-consuming technologies. Not only do they increase the financial burden on the users, sometimes beyond the affordability threshold, but they may also face technical challenges in case of intermittent electricity supply.

The interviews of experts showed that the introduction of differentiated standards for different reuse purposes is debated. On the one hand, such a measure can provide incentives to SSTP owners, but on the other hand, it is difficult to monitor and enforce,

and may lead to new loopholes. Besides, tightening standards may overtask the government agencies in charge (Starkl et al., 2018).

Standards that are too difficult to meet combined with a weak monitoring framework (➲ section 5.4) leads SSTP owners to focus on circumventing the monitoring system in place rather than investing in improving the performance of their plant.

Pragmatic standards are more effective

Pragmatic standards with efficient enforcement are usually more effective than standards impossible to reach by the majority of systems (Schellenberg et al., 2020). Standards can, for example, be differentiated according to system size/load, context, end use or quality of receiving water body (➲ examples in section 4.6). In Malaysia (➲ case study in section 4.1), the government addressed the issue of incremental upgrading of the systems through the creation of a set of differentiated discharge standards based on the age of systems and design standards used, with a timeframe to upgrade to the new standards (➲ Table 8 on p. 59 and section 6.4.2).

Participation is needed to devise pragmatic and widely accepted standards

The analysis shows that the civil society and private sector are currently not involved in the development of standards. These stakeholders can at best influence standards retroactively at state level through collective action. Since government stakeholders have had a very limited involvement in SSS so far, they would benefit from the inclusion of field experience to define realistic standards. A more participatory standard setting process with a consensus phase would also foster acceptance.

5.7 Insufficient integration of SSS in water reuse planning

Water reuse policies can trigger SSS (Larsen et al., 2013), which also happened in India (➲ sections 3.2.2 and 3.2.3). The present study shows that the reuse of treated wastewater from SSS is widely practiced in Bengaluru and the other surveyed cities. While it is hard to quantify the actual amount of water reused, the field survey showed that more than 75% of the studied 279 systems reused at least parts of the treated water for irrigation, toilet flushing and sometimes other uses (Klinger et al., 2020).

A significant amount of the treated water, typically in the range of 25-70% (Drangert and Sharatchandra, 2017; Evans et al., 2014; Kodavasal, 2011b; Kuttuva et al., 2018; Shankar and Yathish, 2013), currently cannot be reused due to a lack of local reuse opportunities (there must be an effluent somewhere if the soil does not have the capacity to infiltrate everything, especially during monsoon months). Enforcing zero liquid discharge policies and forbidding the disposal of treated effluent into the drainage system is, therefore, counter-productive. The study shows that, in practice, most excess treated wastewater is discharged into storm drains (even where it is illegal), because of a lack of alternatives.

SSS, through its distributed nature, fosters the on-site or neighbourhood-level reuse of treated wastewater. Thus, it plays a crucial role in fulfilling water reuse strategies, but its potential role and advantages compared to conventional sewer-based systems are not fully taken into account by the responsible government agencies. Overall, there is a “lack of an integrated approach to urban water resource management”, as stated also in Karnataka’s recent “Policy for Urban Wastewater Reuse” (KUDD, 2017). The same policy further explicates that “water and wastewater initiatives are currently planned in a

piecemeal manner, with little consideration of efficient resource use in the full water loop, or circular economy principles".

For now, SSS remains mostly driven by MoEFCC and the SPCBs and implemented by the private sector – pretty much disconnected from local sanitation and water management stakeholders and their strategies. Even where good water reuse policies exist (e.g., requiring the use of treated wastewater on construction sites), there is presently an insufficient coordination and regulation to link producers and potential users of reclaimed water. Therefore, much of the water which cannot be reused on-site is wasted. Section 6.1.7 provides recommendations for increasing water reuse, including through the use of information technology to link producers and consumers of treated water.

5.8 Lack of key centralised governance structures

The findings suggest that the growing number of decentralised SSTPs requires centralised governance arrangements. Particularly in a multi-level governance framework as in India (national, state and city level), such arrangements are important to ensure economies of scale, e.g., in terms of information technologies development and knowledge management. A higher degree of centralisation of key activities would benefit the performance of the sector, especially for O&M and training. A robust, standardised monitoring and data management framework would allow sector learning and optimisation.

According to the analysis, there is currently no organisational structure equipped with dedicated expertise and budget to carry out SSS governance tasks and act as interlocutor for the various implementing stakeholders. None of the government agencies at local, state or national level were found to have experts or expert groups specifically tasked with oversight, coordination, technical support, knowledge management, training and information transfer activities relating to SSS.

The large number of SSTPs allows economies of scale in terms of management, O&M and capacity building. The study shows that the potential for economies of scale at government and private sector levels is hardly exploited. Numerous private sector stakeholders are competing for technology provision and O&M service provision (Klinger et al., 2020). Despite the high number of units, the management schemes (O&M arrangements, ➲ section 3.3.2) are very diverse and scattered, with hardly any monitoring. Operators are left alone, without a network to rely on. The observed market governance approach lacks centralised coordination around urban development plans, linked with monitoring and enforcement to ensure performance meets standards. Besides, training programmes for operators and municipal sanitation officers are lacking. This results in the observed shortcomings not being addressed, the best practice not incentivized, and the absence of an information sharing platform. In short, the inexistence of centralised governance structures leads to various inefficiencies throughout the SSS sector, slowing down its development.

6 Recommendations: measures to improve the governance and performance of small-scale sanitation in India

How to create the enabling conditions under which SSS systems can reliably operate? Building on the conclusions of the analysis, this chapter discusses the possibilities to address the shortcomings and close the gaps of the current governance framework. **Table 10** on the next page summarises the main suggested measures to address the eight weaknesses identified in the previous chapter.

The recommendations described in this chapter reflect the ideas for SSS sector improvement that have emerged in the light of the findings of this governance analysis and in discussions with numerous stakeholders and sector experts since the beginning of the 4S project in 2016. Needless to say, there is not just one 'right' solution and not all possible options with all their advantages and disadvantages could be discussed in this report. There may be additional ways to improve the governance framework that may be more appropriate for a given local or state-specific context.

Ideally, these recommendations can form the basis for discussion among stakeholders at national, state and city levels to facilitate concrete decisions on the way forward.

Each sub-chapter ends with a summary of the recommendations presented, along with important open questions to initiate discussions.

Table 10: Weaknesses in the governance framework and measures recommended by the authors

Weakness	Recommendations
1) Lack of recognition of SSS by the governmental agencies responsible for urban sanitation planning (➲ section 5.1)	• Specify role and scope of SSS in national policies, state sanitation strategies and city sanitation plans (➲ sections 6.1.1 and 6.1.2) • MoHUA: develop technical specifications and guidelines so that funds can be channelled for SSS from national level down to ULBs and WSSBs (➲ section 6.1.1) • Create a unified database of SSTPs, with georeferenced data (➲ section 6.4.1) • Draw statistics on the contribution of SSS to urban sanitation coverage, and introduce an SSS category in the census (➲ section 6.4.1)
2) Lack of coordination between relevant governmental agencies (➲ section 5.2)	• Build an online platform with a unified database (➲ section 6.4.1) • Harmonise the role of SPCBs, WSSBs and ULBs (➲ section 6.3.2) • Ensure stakeholder participation in policy processes (➲ section 6.1.3)
3) Lack of dedicated budget and human resources (➲ section 5.3)	• Create dedicated SSS oversight and support units ("SSTP departments") at state and city levels to monitor SSS implementation and operation and to provide technical assistance if needed (➲ section 6.3.3) • Provide training to staff of SSS oversight and support units and SSTP operators through capacitated training centres (➲ section 6.5) • Develop a fair approach to optimise the private sector's role (➲ section 6.3.4)
4) Gaps in the establishment, handover and monitoring procedures (➲ section 5.4)	• Build an online platform, centralising all information for each SSTP (➲ sections 6.4.1 and 6.4.2) • Create dedicated SSS oversight and support units at state and city levels (➲ section 6.3.3) • Create mechanisms increasing the accountability of private players in technology selection and design (➲ section 6.1.6 and 6.3.4) • Support SPCBs in design clearance, e.g., through state level SSS oversight and support units (➲ sections 6.3.2 and 6.3.3) • Standardise handover between real estate developers and building management body (➲ section 6.3.1) • Automate verification procedures and prioritisation of field visits (➲ sections 6.4.1 and 6.4.3) • Streamline sample management, with results directly uploaded on the online platform by certified laboratories (➲ section 6.4.3)
5) Inadequate operation & maintenance (➲ section 5.5)	• Incentivise design-build-operate models (➲ section 6.3.4) • Develop financial incentives for building management bodies (e.g., property tax rebate) (➲ section 6.1.6) • Delegate management to specialised private service providers to oversee the O&M of several SSTPs, along with performance-based contracts (➲ sections 6.3.4 and 6.4.4) • Train and certify O&M service providers (➲ section 6.5.4) • Create an operator network to facilitate experience exchange and cross-fertilisation (➲ sections 6.3.4 and 6.5.4)
6) No specific effluent and reuse standards for SSTPs (➲ section 5.6)	• Review standards so that they can support the progress towards spatially and socially inclusive basic wastewater treatment coverage and water security (➲ section 6.2)
7) Insufficient integration of SSS in water reuse planning (➲ section 5.7)	• Specify role and scope of SSS in water reuse policies (➲ section 6.1.5) • Geo-reference all SSTPs (➲ sections 6.4.1 and 6.4.2) • Draw statistics on the contribution of SSS to water reuse (➲ section 6.4.1) • Develop an app to link supply and demand of treated wastewater (➲ section 6.1.7) • Increase level of centralisation (cluster of buildings or street) if water reuse is not possible at building level (➲ section 6.1.2 and 6.1.7)
8) Lack of key centralised governance structures, e.g., for data management, information and training (➲ section 5.8)	• Create dedicated SSS oversight and support units at state and city levels (➲ section 6.3.3) • Create an online platform, initiated at national level and developed in all states (➲ section 6.4.1) • Develop training programmes for SSS (➲ section 6.5) • Develop guidelines at national level for decision-support on SSS technology selection and O&M to foster informed decisions (➲ section 6.1.1)

6.1 Policy framework: filling the gaps at national, state and city level

6.1.1 Integrating SSS in MoHUA's policies

It is quite remarkable and laudable how FSSM has gained the attention it deserves within a very short time-frame, and how it now has a dedicated national policy. Similarly, it can be argued that SSS (as the third important urban sanitation pillar besides non-sewered sanitation with FSSM and conventional large-scale wastewater systems, ➲ section 6.1.2) would also require a strong policy position and increased guidance and awareness at national, state and local levels.

At the national level, the MoHUA is in the position to lead the development of a clear policy framework for SSS. It can also offer support for effective implementation of policies. Technical specifications and design standards need to be developed, so that funds can be channelled from the national level down to cities. Guidelines for the design and implementation of SSTPs are needed, considering the SSS specificities and the wide variety of technologies now on the market.

It is recommended that the MoHUA:

1. **Clearly recognises SSS as a long-term alternative** alongside centralised sewerage and FSSM, as part of its drive to end unsafe urban sanitation practices and increase water security through reuse. The potential of SSS systems for greywater management (to complement on-site sanitation and FSSM services) also needs to be recognised. In short, **MoHUA needs to put SSS on the sanitation map** (➲ section 6.1.2). Full recognition of SSS by MoHUA and line agencies would quickly allow the implementation of the measures proposed in this report, and to overcome the identified weaknesses in the governance framework, including the need for capacity building (➲ section 6.5).
2. **Prepares, through its CPHEEO[19], up-to-date guidelines and technical specifications** for SSS system design and operation:
   - An SSS technology guide would help stakeholders to make more informed decisions (➲ **Box 13**).
   - The 2013 CPHEEO Manual on Sewerage and Sewage Treatment should be amended/supplemented for SSS based on state-of-the-art knowledge, particularly the chapters on decentralised sanitation (Chapter 9) and reuse (Chapter 7) of Part A (CPHEEO, 2013a).
   - Technical specifications for SSS are needed to enable such systems to be implemented with public funding: tenders as well as proposals from ULBs to MoHUA are required to be based on technical specifications. These are currently only available for the conventional technologies used at large scale. Ireland, through its code of practice (➲ section 4.3), and Austria, through its design standards (➲ section 4.4), went a commendable way to streamline SSS implementation.
   - An expert committee can be formed with the responsibility of updating relevant documents every five years, based on recent technological developments.
3. **Opens funding to SSS**. Since MoHUA is the largest funder of urban sanitation infrastructure in the country, there is a potential to open investment lines for SSS.

[19] There is an overlap with the CPCB's mandate (according to the Water Act) to "prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents". Therefore, good coordination is essential. A more detailed discussion of how to deal with this overlap is provided in section 6.5.1.

MoHUA can adopt a similar incentive approach to that of MoEFCC for industrial wastewater treatment, where 50% of the capital expenditure was funded under the Common Effluent Treatment Plant (CETP) financial assistance scheme (25% subsidy from central government, 25% from state government) (CPCB, 2005).

Box 13: The need for a small-scale sanitation technology guide

Why a small-scale sanitation technology guide?

- Small-scale wastewater treatment and reuse systems have **specific technical requirements** that are different to conventional, large-scale systems (➲ section 3.2.4).
- Most stakeholders (even from the private sector) are **not aware of all the available SSS technology options** and their respective risks and benefits (➲ sections 3.3.1, 5.1 and 5.4).
- There is currently an **insufficient understanding and/or consideration of the implications of various technologies** (especially life cycle costs and management, operation and maintenance implications). Capital costs and footprint are often the only selection criteria (➲ section 5.4).
- A technology guide with factsheets* and a defined set of decision-making criteria **would lead to**
  - a clear **overview of alternatives** and a better **understanding of the implications of choices**,
  - **improved consideration of all relevant aspects** (technology and site-specific),
  - **easier and more informed decisions**: step-by-step to the appropriate technology,
  - **increased transparency** in the technology choice process, and eventually
  - the implementation of **context-appropriate infrastructure**

** Factsheets of all major SSS technology families should provide an overview of the following technology-specific information: technology description; advantages and disadvantages; typical performance data; engineering and design considerations; considerations for planning, implementation, start-up and handover; information on O&M and management requirements and tasks; financial considerations (capital cost, O&M cost); social considerations (user behaviour and acceptance); recommended applications; appropriateness checklist*

Currently, the funding and implementation of SSS is fully left to the private sector. This leads to the selection of the least capital cost systems instead of the most appropriate ones, especially as monitoring is weak and design-build-operate arrangements are rare. If SSS is recognized by MoHUA and funding can be channelled from national to state and city levels, then state governments and ULBs will start promoting and incentivising SSS systems. Not only can they provide incentives for better systems (➲ section 6.1.6), but they can also foster decentralised treatment plants for several buildings or at street level, according to water reuse objectives (➲ Table 11 on p. 84). Overall, a stronger involvement from ULBs and WSSBs will lead to better sanitation planning and more efficient collaboration with PCBs (➲ section 6.3.2). Capacity building on how to integrate SSS systems with large-scale systems is essential for state level agencies and ULBs (➲ section 6.5.2). Here again, MoHUA has an important role to play (➲ section 6.5.1).

The National Urban Sanitation Policy is currently under revision. This is a huge opportunity to consider the role of SSS in urban sanitation and give it the adequate attention and recognition at the strategic level.

6.1.2 Defining the scope for SSS in urban India

In a majority of Indian cities and towns, the current shortage of water and funds does not allow the connection of the whole urban area to a centralised sewer network. The approval and implementation process of a centralised STP and corresponding sewerage network typically takes 2-5 years (CPHEEO, 2013c), and in some cases even longer. FSSM cannot provide an immediate and sustainable solution for all non-sewered areas, especially for buildings with an important wastewater generation. SSS systems have the potential to complement large-scale plants in the non-sewered zones of the city, while significantly reducing the time needed for planning and implementation.

With its specific advantages and enormous potential for sustainable urban water management, SSS is clearly emerging as the third important sanitation approach in the urban context, besides conventional large-scale wastewater systems and non-sewered sanitation with FSSM. In an effort to achieve citywide urban sanitation coverage in India, SSS needs to be leveraged to help filling the gaps between centralised sewer-based systems and on-site sanitation (➲ **Figure 12** and **Figure 13**).

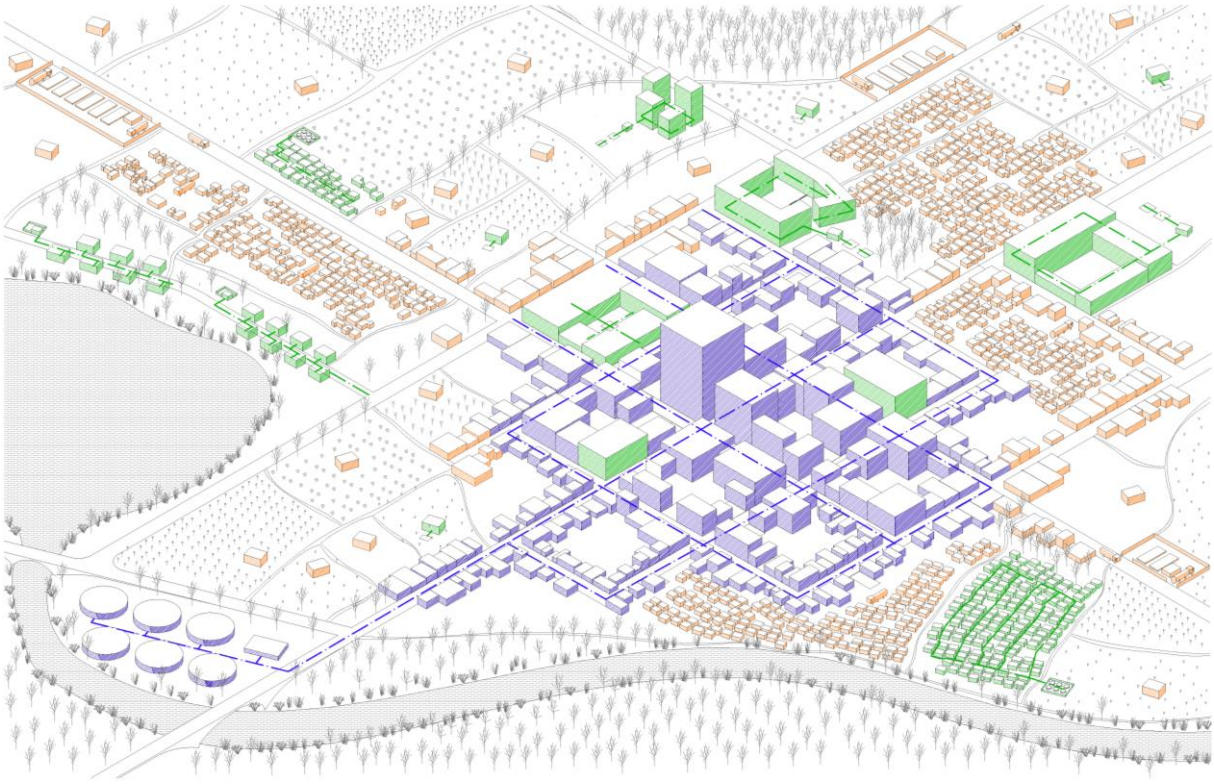


Figure 12: Full urban sanitation coverage can be achieved by combining three approaches: 1) conventional large-scale sewerage with treatment (purple), typically serving dense central areas; 2) non-sewered sanitation with safe conveyance and treatment (FSSM) (orange), typical for the lower-density urban fringe and unplanned areas; 3) small-scale sanitation (green), typical for large buildings, campuses or entire dense neighbourhoods, particularly outside of the sewered area. (Illustration: Marta Fernández Cortés)

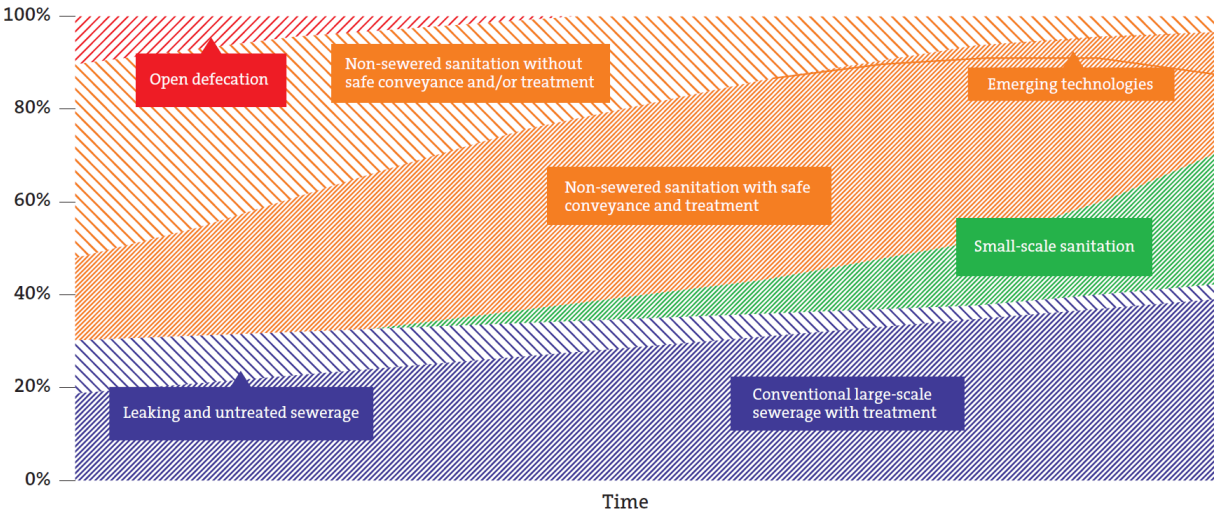


Figure 13: In any developing urban context, the share of each of the three approaches (colours as in Figure 12) is in constant transformation, depending on **a)** urban development dynamics (e.g., growth rate) and the proportion of unimproved sanitation, **b)** the defined scope of each approach, **c)** the speed of implementation of plans and policies, **d)** technological developments and **e)** changing priorities, such as water reuse. In metro cities, SSS already contributes a significant portion to the urban sanitation coverage (e.g., installed capacity of up to 10-20% in Bengaluru (Kuttuva et al., 2018; The Hindu Business Line, 2018)). Figure adapted from WHO (2018).

For all three approaches, the appropriate use needs to be identified and defined at city level. Therefore, coordination and leadership by government are important for policy, planning, regulation, monitoring etc. **Box 14** lists situations in which the implementation of SSS is typically meaningful.

Box 14: Application cases for small-scale sanitation systems

Where does it make sense to implement small-scale wastewater treatment and reuse systems?

- *From an urban sanitation planning perspective:* where a conventional sewerage system is unavailable in the foreseeable future and where non-sewered sanitation with FSSM is unsuitable
- *From a service delivery perspective:* where good infrastructure and services are not existent or under development yet (avoiding overlap)
- *From a technical perspective:* where the wastewater production is too low for conventional sewerage (water supply limited, not enough drinking water for flushing) and too high for non-sewered sanitation with FSSM
- *From a sustainable integrated urban water resources management perspective:* where urban water reuse is a necessity
- *From an end-user perspective:* where urban water reuse is locally beneficial (resource recovery to complement the existing water sources)
- *From a financial perspective:* where it is cheaper / affordable (this is often a leading argument, but it requires context-specific calculations – including life cycle cost, water supply cost and who pays for what). See 4S Project Report Vol. III on finance for a more detailed analysis (Rajan et al., 2021).
- *From a governance perspective:* only where the necessary governance and management structures exist or are being / can be developed

This list is not exhaustive but the variety of perspectives highlights the **importance of stakeholder participation** in decision-making processes (➲ section 6.1.3).

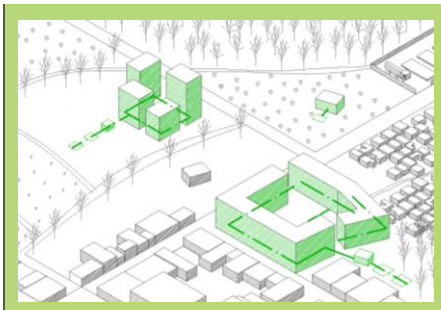
Currently, SSTPs are predominantly being implemented at the **building or campus level**, often making it impossible to fully reuse the treated water and resulting in high per capita cost due to small system sizes. With this model, the urban water and sewerage authorities are little involved in planning, as the responsibility and ownership are with the private sector.

The option of **street, neighbourhood or ward level SSS systems** also needs to be considered, as it would have significant financial benefits and would allow for increased reuse (➲ section 6.1.7). However, this option also means more engagement from the government authorities, both in terms of land provision and management.

Table 11 compares the implications of the two models of SSS implementation. When considering both models for implementation, it is crucial to

- ensure equity in the users' financial contribution and responsibility,
- keep in mind that any system size in the continuum from the micro-STP to the large-scale STP is possible and meaningful under certain circumstances. There is no clear boundary between small-scale and large-scale, or decentralised and centralised sewer-based sanitation systems.

Table 11: Comparison of two models of SSS implementation

	 **Building/Campus level system**	 **Neighbourhood level system**
	• Closed, single-owner • Predominant model in India	• Open, public spaces with small-scale sewerage networks
Advantages	• No infrastructure cost for the government • Clear ownership and management responsibility	• Reduced per capita cost • Can facilitate water reuse
Disadvantages	• High per capita cost • Limited reuse options • Risk of noise and smell nuisance	• More stakeholders involved • Need for innovative investment, O&M, management and cost-recovery arrangements

As many states are yet to prepare their **state sanitation strategy**, the potential of SSS should be strongly advocated so that state governments allocate funds for it.

SSS policies need to be coordinated closely with the sewerage strategies of the cities, to define coverage areas and avoid overlap. At city level, SSS should receive more attention in **city sanitation plans**, as well as in **Smart City and AMRUT plans**. SSS is also relevant to

cost-effective sanitation upgrading in **small towns** (population <100,000). For the latter, **Box 15** outlines some points that should be considered.

Cities should produce and maintain sanitation maps of sewers, SSTPs and FSSM infrastructure, along with their functional status. This will promote the zoning of areas to be served by SSS, considering the availability of funds and space, life cycle costs, management constraints and the reuse strategy. Unfortunately, such zoning is hardly ever done yet.

Particularly at city and town level, advocacy, awareness-raising and capacity building on SSS (➲ section 6.5) are needed from the national authorities, including MoHUA.

Box 15: Small-scale sanitation for small towns?

- Currently hardly any SSTPs installed in small towns (population < 100,000)
- Enormous potential for neighbourhood level SSTPs (need for wastewater treatment and water reuse)
- Start by learning from the big cities, i.e.: «blaze the trail» first: develop robust management and governance structures (SSS oversight and support units, data management system with online platform, guidelines, training)
- Start with a pilot town and state, grow experience and expertise
- Include SSS in local sanitation plans, alongside conventional STPs and non-networked on-site sanitation
- Involve the private sector (PPP) (➲ section 6.3.4)
- Create incentives (➲ section 6.1.6)
- Due to weaker capacities, centralised support structures such as SSS oversight and support units (➲ section 6.3.3) and an online data management platform (➲ section 6.4.1) are even more important in small towns

6.1.3 Devising pragmatic SSS regulations and filling policy gaps with the participation of stakeholders

As discussed in the previous section, the use of SSS should be optimised in the context of the portfolio of water supply and sanitation solutions that work together to achieve the overall goal. Hence, each introduction or modification of a policy, standard, regulation etc. should be a vehicle towards appropriate use of SSS and, eventually, urban sanitation coverage and water security.

The development of progressive SSS and water reuse policies needs to base itself on a good understanding of the situation and the implications on the users. The rationale behind decisions should be transparent and the pros and cons well balanced. In general, policy documents should have a revision cycle, based on a regular evaluation of their outcomes.

To that aim, consultation of the key stakeholders, especially representatives of the SSTP owners and users, should be the norm when drafting a new policy. All the practical expertise regarding SSS is currently with private and civil society stakeholders. Since government stakeholders had very limited involvement in SSS so far, they would benefit from the inclusion of field experience to define realistic policies. Information flows with civil society organisations, such as building owner organisations, need to be strengthened.

Participation can help avoiding pitfalls like the one of Bengaluru highlighted in case study Box 4 on p. 33.

Enforcing an SSS policy retrospectively for existing buildings is often not realistic, and such a policy should at least envisage the option of installing SSTPs that serve several buildings together. Integration into the overall urban wastewater management planning would allow for optimised strategies in terms of implementation, but also in terms of operation and water reuse.

Pragmatism and consultation of stakeholders also applies to the way one deals with treated water that cannot be reused on-site (➲ section 6.1.5), with existing (legacy) systems (➲ section 6.4.2) and with discharge standards (➲ sections 5.6 and 6.2.1).

6.1.4 Addressing the issue of SSTP sludge management

An important regulatory gap that has been identified concerns the management of sewage sludge from SSTPs (➲ sections 3.2.2 and 5.1). The issue of solids management should be addressed strategically by either ensuring appropriate on-site treatment or, as in Japan (➲ section 4.5), by providing (semi-)centralised off-site sludge treatment facilities. Any newly planned treatment infrastructure for sewage sludge, faecal sludge or septage should account for the capacity to receive the sludge from existing and future SSTPs nearby.

6.1.5 Promoting water reuse through realistic and flexible policies

Wastewater reuse policies foster SSS, as decentralised wastewater management allows for more efficient and diverse reuse than centralised large-scale systems (➲ **Box 16**). SSS allows for a maximal on-site water reuse: urban recycling (e.g., in toilet flushing) compared to agricultural reuse actually allows reusing water multiple times, making it a seemingly limitless source (Drangert and Sharatchandra, 2017).

Box 16: The many possibilities of urban water reuse

After treatment, used water can be a valuable resource for numerous urban applications, thereby relieving the pressure on limited freshwater sources:

- Toilet flushing
- Floor cleaning
- Urban gardening
- Vehicle washing (incl. buses, railways, metros)
- Groundwater recharge
- Horticulture and landscaping (incl. golf courses, public parks and roadway median strips)
- Lakes and aquatic biotopes
- Aquaculture
- Construction
- Industry (cooling towers, process water)
- Road washing and cooling
- Fire fighting
- Sewer flushing


Photo: Rama, Wikimedia Commons[20]


Photo: Sachin A. P.


Photo: Rohan Sunny


Photo: Lukas Ulrich


Photo: Rohan Sunny

[20] https://commons.wikimedia.org/wiki/File:Toilettes_mg_3872b.jpg

100% reuse (or "zero liquid discharge") is usually unrealistic (➲ section 5.7). However, the better the reuse is implemented (including indirect reuse through groundwater recharge), the more independent a city can become from costly and energy intensive remote water sources (WSP & IWMI, 2016). Drangert and Sharatchandra (2017) demonstrate that the use of recycled water as a third water source next to rainwater and groundwater, along with demand management measures, can allow the city of Bengaluru to be completely independent of Cauvery and other river water supplies even with a population of 20 million in 2050, while still recharging groundwater. Technically optimised and well-managed groundwater recharge with treated SSTP water will become more important in the future. This should therefore also be considered at the policy level for ensuring sustainable urban water supply.

To achieve real impact, it is important that wastewater reuse policies are

- designed with the involvement of all relevant stakeholders, including the private sector and city level government actors who can ensure alignment with local water supply, sanitation and reuse strategies;
- carefully developed and practical, based on a good understanding of the local situation. Reuse opportunities, space for SSTPs, the feasibility of retrofitting dual plumbing and cost implications are crucial aspects to consider when drafting effective and realistic policies.

The analysis of existing policies showed that several were too strict or unrealistic, and drafted with insufficient stakeholder consultation (➲ sections 3.2.2, 5.2 and 5.7). The retrospective modification of the sanitation system in existing buildings or zero liquid discharge are examples of policies whose implementation is impossible in many cases. This may be because of its cost or complexity, or because reuse is not feasible on-site. Wastewater reuse policies should, thus, be flexible enough and realistically implementable and enforceable. For instance, alternative discharge or reuse options (such as in the drainage system) should be allowed if the treated water cannot be reused 100% on-site and if the discharge standards are met. Financial incentives may be considered to encourage building owners to reuse a maximum amount of water (➲ section 6.1.6).

The new urban wastewater reuse policy of the Government of Karnataka (KUDD, 2017) seems promising. The document identifies the key current policy constraints for wastewater reuse in India:

- Lack of an integrated approach to urban water resource management
- Poor awareness
- Viability of urban wastewater treatment facilities
- Lack of clear guidelines and framework
- Institutional coordination, especially between urban planning, agriculture, industries and power

The explicit drive to start by creating the enabling environment for wastewater reuse is encouraging and positive, as is the multi-stakeholder committee bringing together the urban planning, wastewater, industries and agriculture sectors, in charge of piloting this initiative. This committee could be a good anchorage point for the SSS related recommendations proposed by the 4S Project, which are in agreement regarding optimising on-site reuse, bridging demand and supply, and fostering public-private partnerships.

6.1.6 Incentivising sustainable SSTPs and water reuse

Incentives are seen as a powerful and cost-effective governance mechanism to boost SSS system performance and water reuse. The relevant government bodies should introduce and promote incentives at various levels:

- **Incentives for affordable quality systems:** Purchasing decisions should be made based on life cycle costs, not just capital costs. To improve O&M, special funds should be earmarked by developers to cover all costs over a defined period (e.g., ten years). More sustainable systems could also be achieved by giving builders and technology providers more responsibility in O&M (e.g., build-operate modalities, ➲ section 6.3.4).
- **Incentives for good performance:** Well-designed and operated SSTPs should benefit from lower development charges, property taxes or water rates as they save substantial money and work for the government. Such benefits could be granted to SSS systems which prove that they fulfil the key requirements for long-term performance, or critical success factors (➲ section 6.4.3 and 4S Project Report Vol. I (Klinger et al., 2020)), or to systems with features that go beyond the minimum requirements (e.g., data loggers for real-time monitoring installed or certified operators). Another option are performance-based contracts between owners and operators (➲ section 6.3.4). A star rating scheme could also be introduced, and firms or SSTP projects that show particularly good operational performance could be awarded with a state level prize.
- **Incentives related to reuse:** Reuse policies should foster the type(s) of reuse that make(s) most sense for each building or cluster of buildings (➲ Box 16 on p. 86). Wherever the production of treated water for non-potable purposes costs less than the primary water source (especially if a significant amount is supplied by tankers), it incentivises reuse (Rajan et al., 2021). Clearly, water reuse also provides an incentive for the operators to reach the required water quality and end-user satisfaction. Besides, financial incentives can be introduced: treated water can be sold to construction sites (➲ section 6.1.7), and the government could provide tax reduction to the buildings achieving a certain percentage of reuse (for example property tax rebate, as already practiced for green buildings in Pune (Barringer, 2014)).
- **Whistle-blower incentives:** Incentives should be created for the reporting of improper practices to regulating bodies (e.g., through citizen watch groups). A public grievance portal or hotline could be established, where obvious malfunctions could be reported (related to odour, strange water colour, leakages, etc.). This could also be part of the proposed online portal (➲ Figure 18 on p. 111).

For further recommendations on financial aspects, including more information on financial incentives, see 4S Project Report Vol. III on finance (Rajan et al., 2021).

6.1.7 Matching demand and supply of treated wastewater

There are many non-potable water usages for which it makes sense to use treated wastewater, especially in water-stressed areas (➲ Box 16 on p. 86). According to a 2015 CPCB direction to all State PCBs, *"secondary treated sewage should be mandatorily sold for use for non-potable purposes such as industrial processes, railways and bus cleaning, flushing of toilets through dual piping, horticulture and irrigation. No potable water to be allowed for such activities."* (CPCB, 2015a, 2015b). This remarkable direction was further communicated to all ULBs (e.g., KSPCB, 2015).

Such reuse policies can only work if the intended on-site reuse is feasible (e.g., presence of reuse opportunities like sufficient garden areas, feasibility of dual plumbing) or if there is an organised market for treated wastewater. Currently, both are often missing and should be a priority action line for the responsible government agencies.

Two measures could be taken to better align supply and demand of treated wastewater:

1. **A web-based treated water marketplace, potentially offering an Uber-like service with smartphone app**, based on geo-referenced suppliers.

   Creating a local market for reclaimed water is essential, as transporting treated wastewater over longer distances is financially unviable. This implies the geo-referencing of treated wastewater producers, so that they can be linked with potential consumers (especially contractors on construction sites). Such a service would allow for minimised transport distances and, thus, make reuse financially interesting. This also implies that an efficient monitoring mechanism is in place to guarantee that the quality of the treated effluent matches the needs of the intended reuse, and to create trust from the buyers. As users require a certain water quality, operators would be incentivised to maintain a consistent treatment performance.

   The current gap between supply and demand for treated water opens up a potential market opportunity for a service like Uber or Ola, allowing users of treated water to identify suppliers. Owners of SSTPs could sell excess water to other users including municipality (for watering of public parks, groundwater recharge, road washing, etc.), farmers, construction or industry. A mobile smartphone application which links buyers and sellers of treated wastewater in a city could be beneficial in situations with dynamic water demands, such as on construction sites, and for water truck drivers. Local reuse potentials need to be very well understood in order to design the app properly. A treated water marketplace could possibly also be developed in conjunction with the proposed online data management platform for SSS (➲ section 6.4.1).

   A few years ago, the Bengaluru-based Association for Decentralised Sanitation Infrastructure and Service Providers (ADSIS, ➲ Box 8 on p. 48) intended to create an online web platform to connect buyers and sellers of treated wastewater. Unfortunately, this platform has not witnessed much success in connecting the producers and consumers of reclaimed water yet, as it did not allow the transport and cost optimisation that a geo-referenced service like Uber would facilitate.

   The Government of Tamil Nadu is already considering the implementation of a “water exchange web portal” for its industries and large-scale STPs (➲ **Box 17**). It would make sense to design this platform for the totality of all producers of treated water, including the several hundred SSTPs in the state.

   Internet-based market services can only work if there is a demand for treated water. Ultimately, fostering the market for reuse would help enhancing the treatment performance and financial viability of systems, and contribute to liveable cities. Respective government actors have to explicitly allow the sale of treated water and create a legal basis. Today, this is not very clear everywhere, especially where zero liquid discharge policies are in place (➲ section 3.2.2).

Box 17: Water exchange web portal and integrated water data platform proposed by the Government of Tamil Nadu

In its effort to optimise the reuse of treated wastewater, the Government of Tamil Nadu drafted a *Treated Waste Water Reuse Policy* (Government of Tamil Nadu, n.d.). The policy envisages the setting up of an **online integrated water data platform** and, as part of this, a **water exchange web portal**. The document announces several interesting features of the platform:

- "The water exchange portal shall serve as a platform for ULBs / CMWSSB to announce the available quantity and quality of treated waste water."
- "The online integrated water data platform can be accessed by the ULBs / CMWSSB, treated waste water end users and regulatory bodies."
- "The platform shall display data from online sensors fitted with latest communication modules which shall be installed in all advanced treatment facilities and networks. It shall additionally be equipped with data analytics capabilities."
- "The platform shall serve as a single window interface to monitor treated waste water quality and consumption pattern of any beneficiaries or end users and for overall asset management with predictive maintenance alert capabilities."
- "The platform shall also serve to monitor different stages of project completion and have a database of industrial, agricultural & ground water recharge demand met by treated waste water."

It has to be noted that the policy focuses on larger producers of treated water, such as industries and bigger STPs. However, the suggested online structures would also be interesting for SSS systems (as further discussed in section 6.4.1).

2. **Adapting the degree of decentralisation** to the reuse opportunities.

   Another option is to adjust the level of decentralisation of the wastewater treatment plants. If a fully decentralised on-site reuse of treated water at building level is not possible (for example, because there is no garden), it may be feasible at street or neighbourhood level (➲ section 6.1.2). In that case, a common SSS system ("CSTPs") for several buildings should be considered. Common treatment plants are already widespread for industrial effluent treatment and reuse (common effluent treatment plants – CETPs).

   Higher level of physical centralisation of SSTPs (i.e., one plant for a cluster of buildings) can lead to economies of scale and optimised water reuse; delegated O&M to an external company would facilitate such a concept (➲ section 6.4.4).

With these measures, municipalities and State governments can build a significant supply of treated water within a short period of time, focusing on urban areas that are most water-stressed (and where privately supplied water is most expensive). This will contribute to urban agriculture, greening, public health, quality of living and, eventually, long-term urban water security.

6.1.8 Summary of recommendations: a policy framework at national, state and city levels

- An **integrated urban water management approach** should be adopted that is multi-stakeholder and multi-sector oriented; the new urban wastewater reuse policy of the Government of Karnataka (KUDD, 2017) is a good example and could be adapted and adjusted to local conditions in other states.
- It is recommended that MoHUA **explicitly recognises SSS** as a long-term sanitation option alongside and complementary to centralised sewerage and on-site sanitation with FSSM. With its enormous potential to contribute to urban water security, SSS should not be seen as a transitory solution on the way to citywide centralised sewerage networks.
- At the national level, MoHUA should spearhead the **development of a clear policy framework** for SSS. The National Urban Sanitation Policy is currently under revision. This is a huge opportunity to consider the role of SSS in urban sanitation and give it adequate attention and recognition at the strategic level.
- In particular, **technical specifications** and **guidelines** need to be developed, so that funds can be channelled for SSS from the national level down to ULBs and WSSBs.
- There is a need for **guidance and capacity building** for state level agencies and ULBs **on how to integrate SSS systems alongside large-scale systems and FSSM**. MoHUA has an important role to play here.
- The role and scope of SSS should be explicitly detailed in the **state sanitation strategies** and **city sanitation plans**. Failing to do that leads to uncertainty and misplaced investments.
- Cities should have a **clear mapping** of what will be served by centralised sewerage in the mid-term, and what should be served by SSS and on-site sanitation with FSSM. SSS policies need to be coordinated with the sewerage strategies of cities, to define zones for each and to avoid overlaps and double investments.
- Such **zoning** should be based on the optimal scale of sanitation systems, which would consider the availability of funds and space, life cycle costs, management constraints and the wastewater reuse strategy.
- **To increase reuse, flexibility must be given** to the scale and location of the small-scale treatment plant (e.g., **building, cluster of buildings or street level**). Maximal reuse is often not possible with SSTPs at the building level.
- **Zero liquid discharge policies** demanding 100% on-site reuse are usually unrealistic and **should be avoided**. The **issue of discharging excess amounts of treated wastewater into stormwater drains should be pragmatically addressed**, as it is unavoidable in many cases. City level SSS policies should specify that buildings can be allowed to discharge treated wastewater if they can prove that more reuse is not an option and if the discharge standards are met.
- A **web-based treated water marketplace could be developed to link buyers and sellers of treated wastewater in a city**, potentially offering an Uber-like service. The treated wastewater market needs to be boosted by the authorities, as transport costs are a limitation to its expansion. This, however, also calls for better effluent quality control on the part of the authorities, to create trust among the buyers.
- The development of progressive SSS and water reuse policies **needs to base itself on a good understanding of the situation** and the implications for the users. Reuse opportunities,

availability of space for the treatment facility, the feasibility of installing dual plumbing systems in existing buildings and costs are crucial aspects to take into account.

- To that aim, **consultation of the key stakeholders**, especially representatives of the SSTP owners and users, as well as in the private sector, should be the norm when drafting a new policy. Since government stakeholders had very limited involvement in SSS so far, they would benefit from the inclusion of field experience to better be able to define realistic policies.
- **Policy documents should have a revision cycle**, based on a regular evaluation of their outcomes.
- The relevant **government bodies should introduce and promote incentives** at various levels:
  - **Incentives for affordable quality systems:** Purchasing decisions should be made based on life cycle costs, not just capital costs. To improve O&M, special funds should be earmarked by developers to cover all costs over a defined period. More sustainable systems could also be achieved by giving builders and technology providers more responsibility in O&M (e.g., build-operate modalities).
  - **Incentives for good performance:** Well-designed and operated SSTPs should benefit from lower development charges, property taxes or water rates as they save substantial money and work for the government.
  - **Incentives related to reuse:** Reuse policies should be incentive-based, and foster the type(s) of reuse that make(s) most sense for each building or cluster of buildings. Financial incentives should be introduced, for example, property tax rebates for buildings achieving a certain percentage of reuse.
  - **Whistle-blower incentives:** Incentives should be created for the reporting of improper practices to regulating bodies.
- The current **issue of solids management from SSS systems should be addressed strategically** by either ensuring appropriate on-site treatment or by providing (semi-)centralised off-site sludge treatment facilities.
- **Enforcement mechanisms** for the reuse of treated wastewater should be developed, especially where related policies already exist.

Open questions:

- *Is MoHUA planning to engage with SSS more closely?*
- *Which actions should be prioritised?*
- *How to concretely draft effective, locally appropriate reuse policies? Which incentive mechanisms should be put in place to ensure SSTP performance and water reuse?*
- *How to reliably ensure the quality of treated water to be sold on the market?*
- *Who should spearhead the development of a service or app to link buyers and sellers of treated water?*
- *How to build the required capacities? (This is discussed in ➲ section 6.5)*

6.2 Discharge and reuse standards: optimising outcomes by promoting technically feasible and economically reasonable solutions

Discharge and reuse standards should be seen as crucial mechanisms to shape the development of the wastewater sector. If they are too relaxed, the desired environmental and health outcomes may not be achieved. If they are too stringent, they may present a roadblock that hinders overall progress due to technical and economic hurdles, thereby inducing the misuse of loopholes and illegal practices. The parameters and thresholds determined in the standards strongly influence the systems that are built. For standards to be effective, their implementation needs to be technically feasible and economically reasonable (Schellenberg et al., 2020).

This is of particular relevance for SSS systems. This section provides recommendations for the future setting of standards.

6.2.1 Eight recommendations for future standard setting

Standards have to be fine-tuned to support the progress towards spatially and socially inclusive basic wastewater treatment coverage and water security. Thereby, risks, benefits and feasibility have to be balanced for different reuse and disposal options. Standards should promote the implementation of SSS systems that reduce environmental burdens and public health risks to acceptable levels. A pragmatic trade-off has to be found between the level of treatment, energy consumption, cost and other factors, while considering the capabilities of available technologies under existing local conditions.

Based on the lessons of this study (➲ sections 3.2.5 and 5.6) and from other countries (➲ section 4.6), the following recommendations are proposed:

1. Differentiate between discharge and reuse:
Treatment requirements depend on the specific environmental and human health exposure scenarios (Schellenberg et al., 2020). Therefore, it is strongly advised that legislation differentiates between discharge to aquatic environments and reuse. This would allow for the use of various technology levels adapted to local conditions. For reuse standards, it is advisable to set levels depending on reuse type, following a risk-based approach (Schellenberg et al., 2020). Reuse for irrigation and toilet flushing, for instance, does not require nutrient removal and should be encouraged.

Figure 14: Reuse for irrigation and toilet flushing does not require nutrient removal and should be encouraged (Photo: Rohan Sunny).

2. Account for small systems and their operating environments:
Not only the benchmark best available technology performance under ideal conditions should be considered, but also the operating conditions of SSS systems. The latter are challenging under all circumstances (high variations of wastewater characteristics), but especially in low-income communities and water-scarce areas (concentrated influent). Standards should not discourage investments in such areas.

3. Anticipate the practical and economic implications of parameters and thresholds:
Standards should promote feasible and affordable solutions that can be correctly implemented, operated and maintained. This requires the careful anticipation of all technical, financial, managerial and monitoring implications of decisions, such as power supply requirements, technology restrictions, life cycle cost, operator training needs and management complexity.

4. Make pragmatic arrangements for existing systems:
Retrospective upgrades may be feasible for large treatment plants, but may not be realistically possible for SSTPs (due to space constraints and the infeasibility of structural modifications). Legislation needs to consider the status of the existing "fleet" of systems (classification according to age, current status, risks to the environment and public health, etc., ➲ section 6.4.2). Gradual refurbishing strategies must be aligned with practical considerations (feasibility, time requirements and licence to contravene).

5. Allow for participation and consensus finding:
Most SSS expertise currently lies with private and civil society stakeholders. Standard setting should, therefore, occur in a participatory process with decisions based on balanced and transparently communicated rationales (Schellenberg et al., 2020).

6. Complement legislative texts with the necessary monitoring details:
These should include frequency, methodology and the yearly number of permissible limit breaches.

Figure 15: Due to space constraints and the infeasibility of structural modifications, retrospective upgrades may not be realistically possible for SSTPs (Photo: Shreyas Kumar).

7. Align standards with financial and governance mechanisms for performance improvement:
Governance arrangements (e.g., design standards, used water market, operator training, consent renewal and monitoring capacity) and financial incentives should further guide the implementation of technology options and reuse practices.

8. Schedule regular and gradual standard revisions:
This should take the latest evidence on technical, practical and economic feasibility and performance into consideration and would require systematic data collection, analysis and evaluation.

6.2.2 Summary of recommendations: effluent standards for SSS systems

- Based on the findings of this study (➲ section 5.6), **the revision of the current Indian national wastewater discharge and reuse standards should be a priority**.
- Discharge and reuse **standards should be seen as crucial mechanisms to shape the development of the wastewater sector**. If they are too relaxed, the desired environmental and health outcomes may not be achieved. If they are too stringent, they may present a roadblock that hinders overall progress due to technical and economic hurdles, thereby inducing the misuse of loopholes and illegal practices.
- Standards have to be fine-tuned to **support the progress towards spatially and socially inclusive basic wastewater treatment coverage and water security**. Thereby, **risks, benefits and feasibility have to be balanced** for different reuse and disposal options. **Standards should promote the implementation of SSS systems that reduce environmental burdens and public health risks to acceptable levels**. A pragmatic trade-off has to be found between the level of treatment, energy consumption, cost and other factors, while considering the capabilities of available technologies under existing local conditions.
- Standards should be reviewed as part of an appropriate legislative framework adapted to SSS system operations and aligned with performance optimisation strategies. **Reintroducing differential standards for discharge and reuse** and giving **sufficient time to their gradual implementation** would allow for the use of appropriate technology levels adapted to local conditions.
- Based on the lessons of this study and from other countries, **eight concrete recommendations are proposed for future standard setting** (details in ➲ section 6.2.1):
  1. Differentiate between discharge and reuse
  2. Account for small systems and their operating environments
  3. Anticipate the practical and economic implications of parameters and thresholds
  4. Make pragmatic arrangements for existing systems
  5. Allow for participation and consensus finding
  6. Complement legislative texts with the necessary monitoring details
  7. Align standards with financial and governance mechanisms for performance improvement
  8. Schedule regular and gradual standard revisions

Open questions:

- *How many reuse purposes should be defined in the standards, to keep monitoring and enforcement feasible and reliable?*
- *Should discharge limits be less stringent for SSS systems than for large STPs (as practiced, for instance, in the EU and Jordan, ➲ section 4.6)? If so, what could be meaningful size categories?*

6.3 Institutional arrangements: clarifying roles and responsibilities, improving coordination

As described in sections 5.1 and 5.2, the fragmented institutional arrangements are a major roadblock for the provision of sustainable SSS services. ULBs (and in metro cities WSSBs) are entrusted with all the tasks of urban / water infrastructure planning and development. Therefore, they should play an influential role in the oversight of SSS systems. However, SSS has so far been driven by MoEFCC and line agencies and implemented by the private sector and civil society, with very little ownership from MoHUA and the main sanitation planning stakeholders, especially the ULBs and WSSBs. The responsibilities are not clearly allocated, which often leads governmental agencies to blame each other in case of issues.

Current gaps in the establishment, handover and monitoring processes of SSS need to be addressed. Clearer roles and responsibilities and, above all, better coordination between the stakeholders are crucial. SSS needs to be better embedded within governmental agencies, which could be achieved through the creation of dedicated SSS oversight and support units (➲ section 6.3.3). A unified and harmonised online data management platform (➲ section 6.4.1) as well as capacity building (➲ section 6.5) would also be required on this way.

The following sections discuss how the current institutional arrangements could be optimised, and how the work of the different governmental agencies could be facilitated and coordinated.

6.3.1 Addressing gaps in the establishment, handover and monitoring procedures

The study identified that inadequate institutional arrangements are among the main causes for poorly designed, operated and managed SSTPs that don't function well or even fail. Section 5.4 pinpoints the major identified weaknesses on the example of Karnataka.

The following main improvements are proposed to address the gaps in the establishment, handover and monitoring procedures (for details see the corresponding report sections):

- Elaboration of an **SSS technology choice guide, technical standards and checklists** (➲ section 6.1.1). This would
  - facilitate decision-making and lead to more informed and more transparent technology selection, through the consideration of life cycle cost and other sustainability criteria;
  - standardise design evaluation and approval procedures as well as post-implementation inspections;
  - provide a useful resource for capacity building programmes.
- **Optimised allocation of responsibilities** throughout the process, to better use the expertise and resources, and to avoid fragmentation of responsibilities as much as possible (➲ section 6.3.2).
- Creation of **dedicated SSS oversight and support units** at state and city level (➲ section 6.3.3); development of the necessary capacity (➲ section 6.5.2).
  - State level unit (ideally within the SUDD)
  - City level units (ideally within the WSSB , where existing, or ULB)
- Development of an improved monitoring scheme, based on a **centralised data management system with an online platform** (➲ section 6.4.1).
- Streamlining of the **sampling procedure** for monitoring (➲ section 6.4.3).

- **Training and certification of operators** and other stakeholders (➲ section 6.5.4)
- Improvement of **procedures for SSTP handover:**
  - The recent Real Estate (Regulation and Development) Act (MoLJ, 2016) has the potential to improve the situation, as it includes a 5-year warranty clause on "structural defect or any other defect in workmanship, quality or provision of services". However, sanitation is a minor part of the Act as its primary intent is to secure fair trade and protect buyers. Consequently, it would be important to add appropriate provisions to prescribe a reasonable minimum period (e.g., 5 years) for the real estate developer to also be responsible for O&M before handing it over to RWAs. The liability for performance should be clear throughout the system lifetime.
  - Post-implementation inspections should be more comprehensive and rigorous, following clear checklists. Similar to what was proposed in Hyderabad (➲ Box 7 on p. 46), requirements for SSTP commissioning should include the submission of relevant project details (e.g., design specifications of SSTP as built, annual maintenance contract, O&M handbook, reuse & discharge options for treated water, sludge management provisions). Finally, capacities need to be developed in the relevant government agencies (➲ section 6.5.2).
  - A clear, standardised procedure for the handover of plants from technology providers to end-users and long-term owners of systems is also required. Systematic transfer of information, with minimum requirements of technology-specific design details, user-friendly and comprehensive O&M handbooks etc. should take place to ensure proper operation after designers and builders are no longer involved.
  - Trainings should also be offered to building management entities, in order to enhance their capacities (➲ section 6.5.5).
- **More frequent CTO renewal:** consents to operate are currently issued for 1-5 years (➲ section 3.3.3). An increased frequency would give the monitoring agency more control, but would require more capacities for inspections and consent review (➲ section 6.5.2). Therefore, a consent validity of 1-2 years would be a reasonable trade-off.

Figure 16 illustrates the main proposals, and is to be compared with the current situation (Karnataka) displayed in Figure 11 on p. 73. The suggested improvements to the institutional arrangements are highlighted in red.

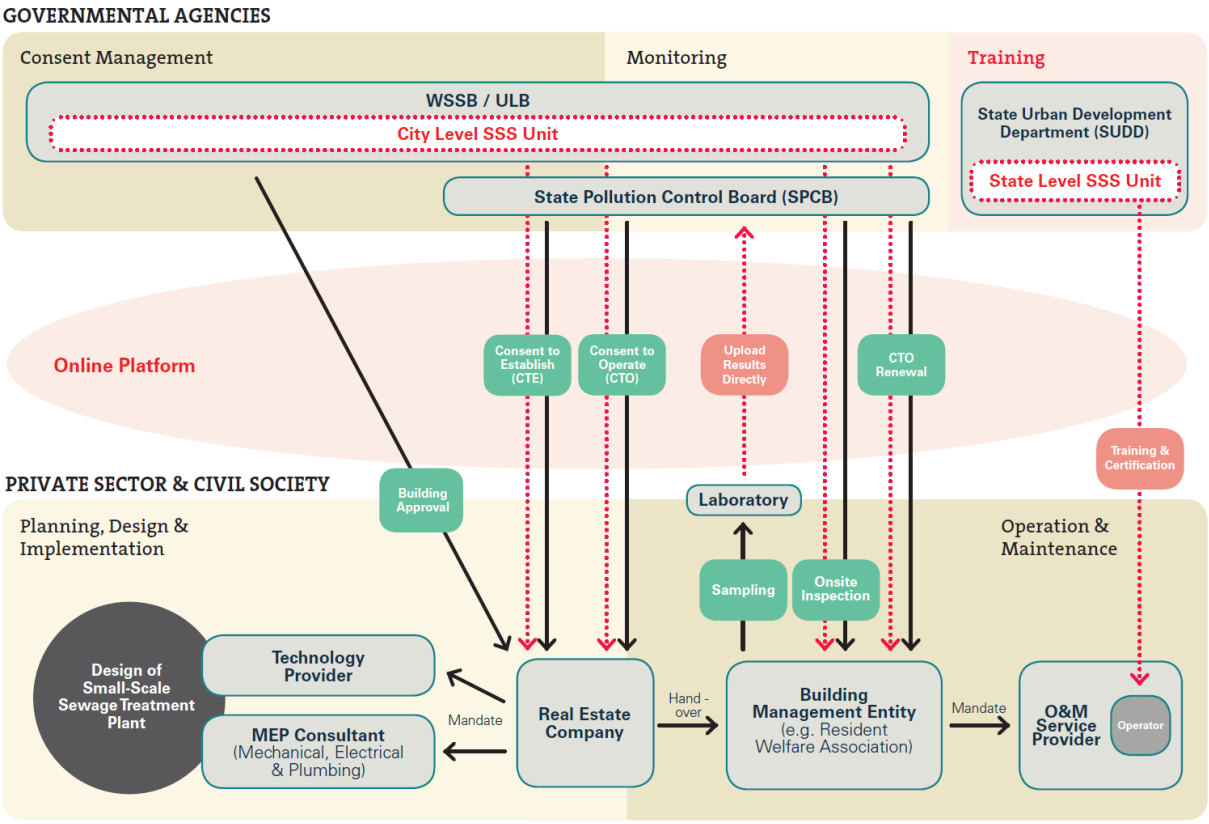


Figure 16: New governance arrangements and streamlined procedures proposed by the authors (in red colour)

6.3.2 Harmonising the role of SPCBs, WSSBs and ULBs

The analysis of the current institutional framework suggests to strengthen the role of the agencies currently in charge of planning and implementing urban water and wastewater management systems, and to extend their responsibilities over SSS. These agencies have more expertise regarding wastewater treatment and an overview of how each SSS system can fit into the overall urban sanitation management strategy. At the same time, the involvement of SPCBs should focus on a strong monitoring role.

In metropolitan cities with dedicated Water Supply and Sewerage Boards (WSSB), it is recommended that the latter take up the oversight responsibility for SSS systems, which needs to be defined explicitly. This is also justified by their central position in terms of information exchange (➲ section 3.3.6). In the cities without a WSSB, it is recommended that the ULBs take on the oversight responsibility. The CPHEEO Manual on Sewerage and Sewage Treatment Systems (Part C on Management) emphasises the clear ULB responsibility for sanitation, as envisaged in the 74th Constitutional Amendment, 1993. The manual highlights that *"ULBs will need to be responsible for asset creation and managing systems including service delivery. In this context, ULBs may bring in public, private and community agencies / groups to provide services on its behalf. [...] The State government will be responsible for monitoring and evaluation of its cities' performance, and hence needs to devise data collection and reporting systems"* (CPHEEO, 2013c). A 2018 MoEFCC notification takes the same line and recognises the importance of a bigger involvement of ULBs (MoEFCC, 2018). It states that for construction projects with built-up area of 20,000-50,000 m^2, the Central Government delegates the power to ensure the

compliance of environmental conditions (explicitly including SSTPs) to local bodies (such as municipalities, development authorities or district Panchayats), before granting the occupation/completion certificate. The notification was, however, sub-judice at the time of writing (MoEFCC, 2019).

On the whole, there are several strong arguments in favour of a more prominent role of WSSBs and ULBs in SSS:

1. All water and wastewater management under one roof – from the smallest to the largest systems
2. Inclusion of SSS in the urban planning process
3. Full overview of sanitation, and zoning for centralised sewer network, SSTPs and FSSM
4. Optimisation of water reuse policies, coordinated with the other urban services
5. Linking SSS to existing building databases and GIS

Table 12 presents the strengths, weaknesses, opportunities and threats of ULBs/WSSBs and PCBs. It sheds more light on why ULBs and WSSBs should take a stronger role in SSS, and what this role could include. Table 14 on p. 107 provides the big picture of the proposed role distribution of key government stakeholders at the national, state and local level.

If responsibilities are delegated to WSSBs or ULBs (depending on the specific situation of each city), it is recommended that the agency in charge creates a dedicated oversight and support unit for SSS (➲ section 6.3.3) within their existing wastewater treatment division. The new responsibilities should be accompanied by adequate technical, human and financial resources in order to carry out all the tasks efficiently. The development of an online data management platform (➲ section 6.4.1) would support the process of role harmonisation, as it would facilitate coordination between the oversight and planning agencies (ULBs/WSSBs) and the monitoring agency (SPCB).

The responsibilities should be formalised in the Water Supply and Sewerage Board acts (normally issued by the state urban development department), or in the municipal acts, respectively. **Box 18** on p. 101 exemplarily outlines the role that the Bangalore Water Supply and Sewerage Board could potentially play.

In many cities, especially the small and medium ones, ULBs lack awareness about SSS. Howsoever the responsibilities are allocated, capacity building and human resource strengthening (➲ section 6.5.2) are needed on all sides, if SSS is to be properly taken care of (see also ➲ Table 12). In cities with staff shortages, delegating tasks to a private company could also be considered as a medium-term measure (➲ section 6.4.4).

In Malaysia, a similar setup was adopted for the management of SSS systems, with the private utility being in charge of the whole life cycle of SSS. Most monitoring tasks are also delegated to the utility, under the supervision of the PCB equivalent agency (➲ case study in section 4.1).

To develop locally appropriate reforms, the relevant government stakeholders should be brought together. Crucial discussion points include:

- What are the governance needs, and which agency would be best placed to carry out related tasks?
- What financial arrangements are needed between government agencies to allow for efficient and financially sustainable SSS governance?
- Through which tools and arrangements can the coordination be strengthened?

Table 12: Strengths, weaknesses, opportunities and threats of PCBs and ULBs/WSSBs and their recommended role

	Urban Local Bodies / Water Supply and Sewerage Boards	State Pollution Control Boards
Strengths / opportunities	• Principal water and sanitation service provider; expertise in wastewater management (especially WSSBs) • Present everywhere • Central position (➲ section 3.3.6) • Potential to optimise wastewater treatment and reuse infrastructure, esp. spatial distribution between centralised sewered / SSS / FSSM (➲ section 6.1.2) • Access to funds from state and national government • ULBs are in charge of approving new buildings in the first place • ULBs can include policies related to SSS into municipal acts and building bye-laws • ULBs (and/or WSSBs) have the power to impose fines and to cut power and water supplies in case of non-compliance • ULBs (and/or WSSBs) can also grant performance-based incentives or rewards for well-managed systems	• Presently the agency most involved with SSS • Consent management and monitoring role established in the Water Act (➲ Box 2 on p. 28) • Capacity building function • Technology evaluation function ("evolve economical and reliable methods of treatment/utilisation of sewage") • Can issue directions to close SSTPs or suspend power and water supplies • Possess databases of SSS systems (although fragmentary) • Possess performance records (although not systematically documented in a digital repository)
Weaknesses / threats	• Lack of adequate human resource capacities • ULBs may lack technical expertise in wastewater management • At present hardly involved with SSS • Have little experience with SSS • Do not possess SSS databases • Poor coordination with SPCBs	• Established setup to carry out performance monitoring, but weak enforcement • Need to be financially self-reliant • Lack of adequate human resource and financial capacities (➲ sections 3.3.3, 5.3 and 5.4) • Lack compelling power in case of non-compliance (cannot impose fines directly) • Weak presence in medium and small towns • Not in a position to give incentives / subsidies • No mandate for sanitation and water resources management
Recommended role	• SSS oversight at city level, linked to building databases and GIS • Data analysis at city level • Holistic urban water management and sanitation planning, including SSS • Defining scope of SSS and devising pragmatic SSS policies and strategies at city level • Setting up incentives (➲ section 6.1.6) • Implementation of neighbourhood-level SSTPs where appropriate (➲ section 6.1.2) • Technical support to SSS owners and operators (hotline) *All these tasks ideally supported by a city level SSS oversight and support unit hosted within ULB / WSSB (➲ section 6.3.3)*	• Consent management (➲ section 6.3.1)* • Performance monitoring (➲ sections 6.3.1 and 6.4.3) • Standard setting at state level (➲ section 6.2.1) ** design clearance ideally supported by experts from the proposed state level SSS oversight and support unit hosted within SUDD (➲ section 6.3.3)*

Box 18: Potential role for the Bangalore Water Supply and Sewerage Board (BWSSB)

In Bengaluru, the plans of every new building have to be submitted to BBMP (Urban Local Body) and BWSSB. The building plans contain information on the SSS system, where applicable, and BWSSB provides the "no objection certificate" for the construction of the building. BWSSB, thus, has the basic information about the SSS system. However, the design of the system needs to be submitted to KSPCB in order to get the Consent to Establish (CTE).

It is recommended that BWSSB, in its quality of governmental body specialised in wastewater management, takes over the responsibility for SSS oversight and data analysis at the city level, through a dedicated SSS oversight and support unit (forming a "cell" or "department" of BWSSB). BWSSB's tasks should include the definition of the scope of SSS and corresponding policies at city level, as well as the provision of incentives for well-performing SSTPs and optimal water reuse.

KSPCB should get advisory support for design clearance by a state level SSS oversight and support unit (umbrella organisation for the city level SSS oversight and support units, ➲ section 6.3.3), proposed to be formed within the KUDD (aligned with the urban wastewater reuse policy, ➲ section 3.2.2 and 6.1.5). Such a unit could furnish its engineering opinion in the form of an expert report / approval certificate based on which the KSPCB would issue or reject consents.

This setup would allow concentrating the data in one single database: with a bigger involvement of BWSSB, database management would be improved, as BWSSB has information on most buildings, whereas KSPCB only focuses on a few categories of buildings. Besides, BWSSB possesses all the information (by and large) regarding water consumption (incl. boreholes) by buildings constructed within the city, allowing an optimisation of water reuse strategies.

The question is whether BWSSB is willing to take this increased responsibility or not. The potential benefits for BWSSB are clear:

- The improved management of existing SSS systems and increased water reuse reduce the need for centralised service provision (primary water supply and sewerage) and, accordingly, yield considerable cost savings in terms of infrastructure and operational cost.
- Improved zonal allocation, overall coordination and planning of SSS and other services would reduce BWSSB's investment needs for sewerage and STP capacity extensions, avoiding service overlaps, double investment and thereby also saving enormous amounts of funds.

6.3.3 Embedding SSS within governmental agencies: the case for SSS oversight and support units (or "SSTP departments")

The creation of dedicated governmental SSS expert units[21] would allow oversight of the growing number of SSS systems. Such units should consist of trained professionals and be created at state level, and in places with significant or growing numbers of SSTPs also at city level. They could be mandated to administer the proposed data management system and online platform (➲ section 6.4.1), develop and run capacity building programmes for SSS practitioners (➲ section 6.5), and support optimisation strategies for the state/city based on data analysis. Thus, SSS oversight and support units would be the main interlocutors for stakeholders involved in SSS and would ensure information transfer. **Table 13** lists the potential roles of state level SSS units and city level sub-units.

[21] These SSS oversight and support units should be established as "SSS expert units", "departments" or "cells" within existing governmental agencies. **There needs to be agreement on a suitable name for these units.**

Table 13: Suggested role of state and city level SSS oversight and support units

State Level SSS Oversight and Support Unit	City Level SSS Oversight and Support Unit*
• Technical support to WSSBs / ULBs and city level SSS oversight and support units • Overall administration of the data management system • Data analysis at state level and development of policy recommendations • Performance evaluation and benchmarking[22] of SSS technologies in use • Capacity building for government, private sector and NGO stakeholders • Support to PCBs in SSTP design reviews (possibly via city level unit) • Scientific exchange with academia • Fulfilment of functions of city level units where they have not yet been established	• SSS management at city level • Data analysis at city level • Support to WSSB / ULB in urban water management and sanitation planning • Technical support to SSS owners and operators with a focus on O&M (hotline) • Coordination and exchange with state level SSS oversight and support unit

* in places with significant or growing numbers of SSTPs

ULBs (and/or WSSBs) are responsible for urban sanitation and water management planning at city level. ULBs are also the ones who approve new building plans. ULBs and WSSBs could potentially grant performance-based incentives or rewards for well-managed SSTPs (e.g., property tax rebates). This setup justifies having the proposed city level SSS oversight and support units embedded in ULBs (or WSSBs), rather than in PCBs or elsewhere. As per the Water Act, however, PCBs are the ones responsible for performance monitoring. This sharing of roles underlines the need for an online platform, which would enable ULBs, SSS units, PCBs and other stakeholders to coordinate their work.

The proposed state level SSS oversight and support units could form an umbrella organisation for the city level SSS units and take on coordinating, planning, capacity building and advisory functions for the sector. This would concentrate related expertise and guarantee uniformity and economies of scale. The state level units could be entrusted to oversee and coordinate the data management system and online platform at the state level.

The state level SSS oversight and support units would be best placed within state urban development departments (SUDDs), which play a critical role in supervising urban planning. The Karnataka State Urban Development Department recently launched a policy for urban wastewater reuse (➲ sections 3.2.2 and 6.1.5). This exemplarily underpins the recommendation to anchor SSS oversight and support units and data management systems within SUDDs, as these departments would benefit greatly from such new structures in their efforts to improve the management of urban water resources and related infrastructure[23].

Figure 16 on p. 98 illustrates the embedment of the proposed state and city level SSS oversight and support units within the overall SSS governance framework. Figure 18 on p. 111 shows the units' positioning in relation to the proposed data management system

[22] This should be well aligned with the MoHUA's service level benchmarking initiative for urban services (see MoUD, 2010b, n.d.).
[23] Depending on the state, different departments such as Public Health Engineering Departments may also be relevant to support/host a state level SSS oversight and support unit.

and online platform. Figure 21 on p. 126 illustrates the role of the SSS oversight and support units in training and capacity development.

Centralised structures are also needed for the governance and regulation of on-site sanitation infrastructure such as pits and septic tanks (Dasgupta et al., 2019), and specialised oversight and support units would also make sense for this segment. Structural reforms in both areas should be aligned and integrated well, also at policy level (➲ sections 6.1.1 and 6.1.2).

In order to coordinate the setting up of new structures such as oversight and support units or online data management systems at every state concerned, a national initiative or committee at the concerned Ministry (i.e., MoHUA) would be needed, with corresponding funding.

6.3.4 Optimising the role of the private sector

In India, SSS has been funded, implemented and operated largely by the private sector. Therefore, all the practical expertise regarding SSS is currently with the private and civil society stakeholders. The private sector delivers an indispensable service which would otherwise be the responsibility of public service providers. It is clear that the government could not deliver this service alone due to lacking financial and human resource capacities. On the other hand, leaving it entirely to the private sector with limited government control and leadership, also doesn't deliver satisfactory performance. Hence, the engagement of the private sector needs to be established within well-defined responsibilities and clear rules.

Part C of the CPHEEO Manual on Sewerage and Sewage Treatment Systems (CPHEEO, 2013c) already recognises this. It includes the following recommendations:

> *"Public private partnership: There is a need to promote a healthy competition in the sewerage and sanitation services being provided by the ULBs and the private sector. The manpower cost is rising steeply in the local bodies and efficiency levels are declining. There is, therefore, a need to induct private sector to provide sewerage and sanitation services in un-served and under-served areas in a cost effective and efficient manner. This will reduce the costs and promote an element of healthy competition between public and private sector."*
>
> *"Private sector participation (PSP): The ULBs may promote PSP. As a policy, they may decide to set up treatment facilities with PSP on suitable terms and conditions for which standard concession agreements/formats may be drawn up with legal assistance to ensure protection of the interest of ULBs."*

With regard to SSS, a fair approach is needed to optimise the role of the private sector. It is recommended to do this in several ways:

- **Ensure private sector consultation in policy making**. The stakeholder analysis shows that private players have little influence on the policy process, although they are key stakeholders with a very high interest in SSS and a lot of expertise. The private sector needs to be involved when developing and piloting new regulations and innovative concepts for the sector (➲ section 6.1.3).
- **Cultivate an enabling environment for private sector stakeholders** to deliver good services. This should include

  - the right incentives for sustainable services (➲ section 6.1.6),
  - capacity building programmes for private players and civil society stakeholders (with the involvement of experienced private sector experts, ➲ section 6.5),
  - initiatives to increase the status and incentives for O&M personnel, such as operator networks or certification (➲ section 6.5.4),
  - the promotion of industry associations or professional networks, such as the Association for Decentralised Sanitation Infrastructure and Services (ADSIS, ➲ Box 8 on p. 48). Such an association can also support self-regulation and help take action against players who do not follow prescribed rules and processes. It can also protect private sector stakeholders against undue pressure from customers, real-estate developers or government bodies.
  - mechanisms to foster the good companies in the market and to eliminate unprofessional and dubious players and practices. This should include effective sanctions or penalties if needed. In the real estate sector, all real estate agents need to be registered with the state level Real Estate Regulatory Authority (RERA) (MoLJ, 2016). Their registration can be suspended or revoked by the authority in case of failure to comply with the rules. A registration of companies and consultants in SSS implementation and O&M could also be introduced (similar to Malaysia and Japan, ➲ sections 4.1.3 and 4.5), ideally linked with the proposed data management system (➲ section 6.4.1).

- **Promote innovative contractual arrangements** to increase accountability and performance.
  - Increase service provider accountability through design-build-operate contracts, also in public-private partnerships (see 4S Project Report Vol. III on finance (Rajan et al., 2021)).
  - Explore the option of performance-based contracts between owners and operators. Performance-focused contracting which links performance to payments may improve the efficiency and increase the life expectancy of SSS systems. Using a strong system of checks, the quality of the O&M service and performance are regularly assessed. The monitoring framework should include a clear list of operational and performance parameters, including the O&M tasks that need to be fulfilled, staff presence, run-time, energy usage, effluent quality and quantity, safe sludge management etc. As performance-based contracting is a new concept in the SSS sector, it first needs to be tested in the field. The proposal of performance-based contracts is described in more detail in the 4S Synthesis Report (Ulrich et al., 2021).
  - Conduct further research to compare the performance of various contractual and management arrangements.
- **Foster delegated management arrangements** with specialised O&M companies. Companies providing O&M services to a larger number of SSS systems need less staff and can access higher skills. A higher level of professionalism has the potential to increase the overall performance of SSS systems (➲ section 6.4.4).
- **Explore the delegation of monitoring tasks to private players:** in cities where the SPCB does not have the capacity to properly monitor all SSTPs, this task could be delegated to a private firm, under the supervision of the SPCB. (➲ section 6.4.4).
- **Boost the water reuse market** with an app that connects buyers with producers of treated water (➲ section 6.1.7).

6.3.5 Summary of recommendations: institutional arrangements

- To achieve a concentration of skills and to better embed SSS within governmental agencies, **dedicated SSS oversight and support units (or "SSTP departments") should be created at the state level**, and in places with significant or growing numbers of SSTPs also **at the city level**. According to the analysis, the state level units should ideally be hosted within the SUDD, and the city level units within WSSBs (where existing) or ULBs.
- Such units should consist of trained professionals. They could be empowered to **administer the proposed data management system and online platform** (➲ section 6.4.1), **develop and run capacity building programmes** for SSS practitioners (➲ section 6.5), and **devise optimisation strategies** based on data analysis.
- In order to coordinate the setting up of new structures, such as SSS oversight and support units or online data management systems at every state concerned, a **national initiative or committee at the respective Ministry** (i.e., MoHUA) would be needed, with corresponding funding.
- The **roles and responsibilities of SSS governance at the national, state and local levels should be carefully reviewed** and communicated. Based on this governance analysis,
- **Table** 14 below summarises the proposed distribution of responsibilities among the main governmental agencies at the different levels.
- ULBs (and in metro cities WSSBs) are entrusted with all the tasks of urban / water infrastructure planning and development. Therefore, they should play an increased role in the oversight of SSS systems. It is recommended that **WSSBs/ULBs take over the oversight and planning responsibilities for SSS**, supported by the proposed state level SSS oversight and support unit where needed. This would **foster the necessary improvement of wastewater infrastructure planning and investments**, as it would clarify the scope of SSS alongside centralised systems and FSSM. It would also **facilitate the implementation of pragmatic water reuse policies**.
- **SPCBs would remain the main agency in charge of consent management and long-term monitoring and enforcement**. In the medium to long term, the state level SSS unit could provide support to SPCBs in design reviews.
- To improve SSS oversight, a **good coordination should be guaranteed between WSSBs/ULBs and SPCBs**, from planning to implementation and monitoring. The development of an **online data management platform** (➲ section 6.4.1)**,** to be used by all agencies, would foster coordination between the oversight and planning agencies (WSSBs/ULBs) and the monitoring agency (SPCB).
- The **procedures for SSTP handover should be improved**. Post-implementation inspections should be more comprehensive and rigorous and follow clear checklists. A clear, standardised procedure for the handover of plants from technology providers to end-users and long-term owners of systems is also required.
- **Improved sampling and monitoring procedures** need to be developed (➲ section 6.4.3). A **reasonably increased CTO renewal frequency** would give the monitoring agency more control (but would require more SPCB capacities for inspections and consent review).
- An **enabling environment should be cultivated for private sector stakeholders** to deliver good services. Mechanisms should be introduced to foster good companies in the market and to eliminate unprofessional and dubious players and practices. This should include:
  - the right incentives (➲ section 6.1.6), but also effective sanctions or penalties;
  - the registration of companies and consultants in SSS implementation and O&M;

  - innovative contractual arrangements to increase accountability and performance (including design-build-operate contracts and performance-based contracts);
  - capacity building, especially for operators.

- **Delegated management arrangements** with specialised O&M companies should be fostered. Companies providing O&M services to a larger number of SSS systems need less staff and can access higher skills. A higher level of professionalism has the potential to increase the overall performance of SSS systems (➲ section 6.4.4).
- All the governmental agencies that are key for SSS governance are short-staffed. **Enhancing the institutional capacities and offering capacity building on SSS should be a priority** and go on par with the implementation and enforcement of SSS policies (➲ section 6.5).
- In cities with staff shortages, **delegating tasks to a private company** could also be considered as a medium-term measure (➲ section 6.4.4).
- The whole system would also benefit from **intermediary actors who would act as knowledge brokers and take over some coordination, training and knowledge transfer functions**. A **committee with representatives from various stakeholders**, such as the one formed in Karnataka in 2017 to implement the state's urban wastewater reuse policy (➲ section 3.2.2), has the potential to play the role of such an intermediary – a role that is essential for a robust governance framework. Such pioneering initiatives, involving representatives of the relevant government agencies, private sector and civil society can provide the required fertile soil on which promising governance innovations can grow, if they can remain autonomous and informal enough (Pahl-Wostl, 2009).

Open questions:

- *How to coordinate and fund the setting up of new structures, such as SSS oversight and support units or online data management systems, at the national level? Would it be possible to create a committee with representatives of various stakeholder groups?*
- *Which institutional embedment for the proposed SSS oversight and support units? Lead by SUDDs at state level? How and where to start?*
- *Which agency to be in charge of the proposed online data management platform?*
- *How feasible is it for WSSBs and ULBs to take over the local SSS oversight?*
- *What are the most successful O&M management schemes and contractual arrangements?*
- *What financial arrangements are needed between government departments to allow for efficient and financially sustainable SSS governance? How to increase the financial capacities of PCBs?*
- *How to build the required capacities? (This is discussed in ➲ section 6.5)*

Table 14: Proposed national, state and city level distribution of government responsibilities related to small-scale sanitation

	Stakeholder	Proposed distribution of responsibilities
National level	**Ministry of Housing and Urban Affairs – MoHUA** *(through the Central Public Health and Environmental Engineering Organisation - CPHEEO)*	• Develop a policy framework for SSS and promote SSS in national sanitation policies (NUSP, etc.) (➲ section 6.1.1) • Create guidelines for SSS, including a technology guide and corresponding technical specifications (➲ section 6.1.1) • Channel funds for SSS to states and ULBs (➲ section 6.1.1) • Coordinate the setting up of SSS oversight and support units at state/city level (➲ section 6.3.3) • MoHUA, CPCB or both: initiate the development of a centralised online data management platform that includes all STPs in the country (➲ section 6.4.1) • Lead the development of SSS capacity building strategies (➲ section 6.5.1)
	Central Pollution Control Board – CPCB *(under MoEFCC)*	• MoHUA, CPCB or both: initiate the development of a centralised online data management platform that includes all STPs in the country (➲ section 6.4.1) • Review standards so that they can support the progress towards spatially and socially inclusive basic wastewater treatment coverage and water security (➲ section 6.2) • Support the development of SSS capacity building strategies (➲ section 6.5.1)
State level[24]	**State Urban Development Department – SUDD** *(under MoHUA)*	• Develop state level policy frameworks for SSS and urban water reuse • Channel funds for SSS systems • Host state level SSS oversight and support unit (➲ section 6.3.3) and support its activities, including data management system administration and data analysis, technology evaluation and benchmarking, capacity building, as well as design review and design clearance support to the SPCB
	State Water Supply and Drainage Board – SWSDB *(under MoHUA)*	• Provide clear guidance and advise ULBs on where to implement SSS, centralised sewerage and FSSM (➲ section 6.1.2) • Support ULBs in planning, designing and implementing neighbourhood level SSS systems where appropriate (➲ Table 11 on p. 84)
	State Pollution Control Board – SPCB	• Consent management (➲ section 6.3.2) • Performance monitoring (➲ section 6.4.3) • Setting standards at the state level (➲ section 6.2)

City level	**Water Supply and Sewerage Board – WSSB** *(where existent)*
	Urban Local Body – ULB *(responsible in cities without dedicated WSSB)*
		• Host city level SSS oversight and support unit (➲ section 6.3.3) to support the following tasks:
		  ○ Take on oversight and planning responsibilities for SSS, i.e., keep the list of SSS systems in the city, analyse data (➲ section 6.3.2)
		  ○ Devise SSS and reuse policies and strategies at the city level and decide on its scope alongside centralised sewerage and FSSM
		  ○ Introduce the right incentives (➲ section 6.1.6)
		  ○ Implement neighbourhood-level SSTPs where appropriate (➲ section 6.1.2 and Table 11 on p. 84)
		  ○ Provide technical support to SSS owners and operators (hotline)

[24] Depending on the state and its structures, different departments such as Public Health Engineering (PHE) Departments may also be relevant and should be involved.

6.4 Management and monitoring: online data management platform and optimised processes

The day-to-day management of SSS systems is currently in the hands of the private sector and civil society stakeholders responsible for O&M. While this doesn't need to change, there are **SSS management** responsibilities that government stakeholders need to assume, such as database management, sanitation and water reuse planning, coordination, monitoring and evaluation, and improving partnerships with the private sector.

A unified online platform, which all relevant stakeholders could use for their own purposes, would facilitate information exchange among actors involved in SSS management. It would support the improvement of planning processes, sector coordination, harmonisation between the different states and cities, accountability and monitoring.

Monitoring is the systematic process of collecting, analysing and using information to track progress or assess compliance to guide management decisions. In the case of performance monitoring of SSTPs, the focus is on ensuring compliance with the law (e.g., through the enforcement of environmental discharge standards). However, well designed monitoring systems can also help decision-making in urban water and sanitation planning and foster design improvements. Performance monitoring can, thus, lead to savings of water, energy, spare parts and eventually money, as it allows for a constant improvement of the performance of individual plants and the sector as a whole.

6.4.1 Developing a unified data management system (DMS) with an online platform for long-term coordination and learning

The findings suggest that the inexistence or fragmentariness of electronic databases hamper enforcement efforts. Data needs to be accessible and usable. Considering the current situation, the priority should be to identify and complete the existing databases and merge them into one single DMS with an online portal. **Box 19** explains why an online data management platform would be important.

Box 19: The need for a centralised online data management platform

Why a centralised online data management platform?

- To facilitate the merging and completing of existing databases and to standardise data collection
- To foster coordination and harmonisation between the governmental agencies concerned with SSS
- To make SSS administration, monitoring and follow-up less time-consuming and more efficient (prioritisation of monitoring visits based on automated verification procedures)
- To boost sector accountability, especially by reducing loopholes in the monitoring process (e.g., through direct upload of sample analysis results by accredited laboratories)
- To allow for simplified data analysis, statistics and learning by all stakeholders concerned, inducing optimised management and performance
- To enable monitoring of the contribution of SSS to the progress of sanitation coverage and water reuse at city, state and national levels
- To allow for better integration of SSS in citywide urban sanitation planning, as well as water reuse planning, through geo-localisation and mapping of the SSTPs

An online platform would be a win-win for all stakeholders – from sanitation system owners to ULBs, WSSBs and SPCBs. It would allow all SSS management activities to be streamlined and to gain in efficiency, and reduce the bureaucratic burden. In fact, as shown in **Figure 17**, it could be the trigger of a virtuous circle to boost the performance of SSS systems at scale. **Table 15** lists the expected benefits of such a platform for various stakeholders.

Figure 17: The introduction of an SSTP data management system with an online platform could be the critical catalyser of a virtuous circle to boost SSS sector performance at scale.

Table 15: Potential benefits of an online data management platform for various stakeholders

Stakeholder	Benefits
SSTP Owners / Managers	• Can organise consent applications and renewals online • Can access a user forum with FAQs to exchange information on problems and challenges • Can access reference materials, such as technology guides and benchmarks • Can access SSTP design data, user manuals and performance history online to make informed decisions • Can find buyer(s) for excess treated water via online marketplace (service similar to Ola/Uber could be developed) • Can receive updates and reminders via email or SMS (for example for effluent sampling)
Citizens Water Users	• Can easily report grievances, such as inadequate sewage discharge or nuisance • Can buy treated water available nearby
Accredited Laboratories	• Can directly upload test results in electronic form
Water Supply and Sewerage Boards (WSSBs) Urban Local Bodies (ULBs)	• Can access data for building plan and occupancy certificate approvals • Have an overview of small-scale sewage treatment and water reuse systems in the city, through mapping and statistics • Can understand performance of existing SSTPs and devise optimisation measures • Can award incentives and impose penalties • Can avoid double investments (i.e., overlapping small-scale and centralised systems) • Can use data for urban water management and sanitation planning (including management of sludge from SSS and on-site sanitation systems)
Pollution Control Boards (PCBs)	• Have easy access to all records on each SSTP • Minimise paperwork for consent management • Can efficiently collaborate with other stakeholders (such as external experts assisting with SSTP design reviews in the approval process) • Can set up automated plausibility checks (validation) of incoming data and identification of non-compliance; computer-aided prioritisation of systems for physical inspection (based on alerts, citizen reports) • Can efficiently use the limited human and financial resources that are available for monitoring • Can easily upload test results from in-house laboratories • Can easily disseminate updates, e.g., about new regulations • Can do evidence-based review of discharge and reuse standards • In the long run, real-time online monitoring of SSTP operation and/or performance could be established through online SSTP logbooks and supervisory control and data acquisition (SCADA) systems
Ministry of Environment, Forests and Climate Change (MoEFCC) State Environmental Impact Assessment Authorities (SEIAAs)	• Have a user-friendly inventory of all projects under their approval (construction projects requiring environmental impact assessment / environmental clearance) • Can access relevant data
Ministry of Housing and Urban Affairs (MoHUA) State Urban Development Departments (SUDDs) State Water Supply and Drainage Boards (SWSDBs)	• Get state/national level overview on SSS landscape, status and performance, and can easily generate reports and statistics • Can use data for informed strategy development, policy making and capacity building • Can compare performance results from different types and sizes of systems as well as different management schemes • Can disseminate guidance documents and training offerings for various stakeholders

Functions and architecture of the proposed DMS and online platform

The DMS should be accessible online by all concerned governmental agencies, according to their needs (monitoring, urban wastewater management planning, water reuse planning, etc.), as illustrated in Figure 16 (p. 98) and **Figure 18** below. Figure 16 shows the position of the proposed online platform within the institutional framework, while Figure 18 illustrates the suggested functions of the proposed platform, and how different stakeholders could interact with it.

The centralised DMS should contain a file for each SSTP with at least the following information:

- ✓ **System specifications**, including unique ID for each SSTP, address, geographic coordinates and key design information
- ✓ **Authorisation documents**, including consent to establish (CTE), consent to operate (CTO), consent validity and applicable discharge standards (depending on the age of the system)
- ✓ **Performance history**, including water sample analysis reports, inspection results, operational data (e.g., electricity consumption) and status information

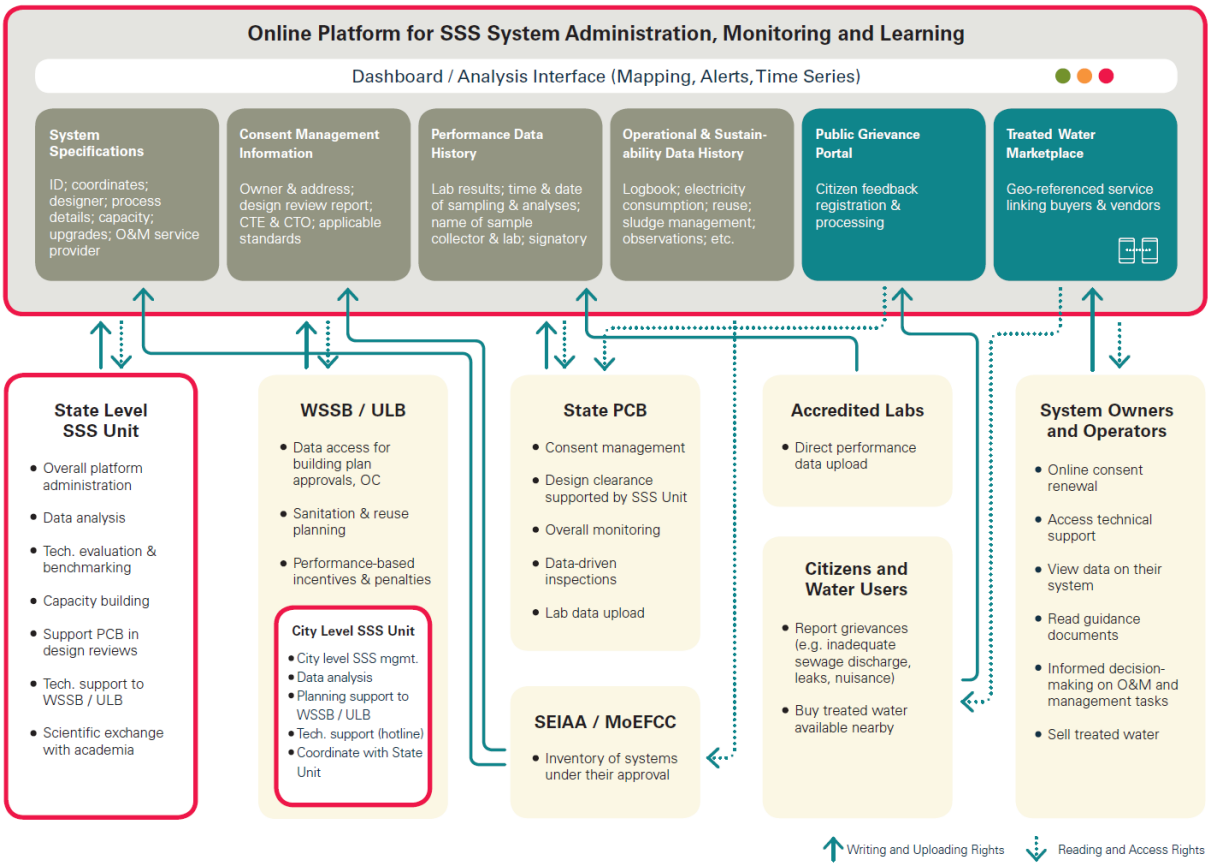


Figure 18: Suggested online platform for SSS data management, and how different stakeholders could interact with it. The newly proposed governance structures are highlighted with red rounded rectangles.

The online platform should offer the following **main functions**:

1. A **map** displaying all the SSTPs. Such a map can serve as a basis for monitoring, desludging services, water reuse optimisation, linking treated wastewater buyers and sellers (i.e., a treated water marketplace, ➲ section 6.1.7), or environmental pollution reduction. This can also be merged with existing urban water and wastewater management plans.
2. **Data upload and access** by authorised stakeholders, based on the unique ID of each file (e.g., direct upload of water sample analysis results by certified laboratories, CTO renewal by PCB etc.).
3. **Analysis functions** with automated and visualised statistics to support monitoring, e.g.:
   - Highlight and map SSTPs with substandard performance, missing or inconsistent data or reported public grievance which should be inspected in priority.
   - Highlight discrepancies in lab results, such as sudden changes or contradicting values, potentially allowing the identification of data manipulation and unreliable laboratories. For example, if values of different parameters are not aligned (e.g., ratio between two correlating parameters), a notification or visual sign (e.g., red light) would highlight it. The temporal evolution of the results over a period of time can also be checked: if big differences are observed, or, on the contrary, always exactly the same results, the software would automatically make the monitoring agency aware of it.
   - Average the performance of different types of systems (technology families), potentially allowing to scrutinise underperforming brands or providers.
   - Inform about overall performance of SSS systems for the definition of appropriate discharge standards (➲ section 6.2).
4. **Dissemination** of guidelines and best practice, course offers and training materials, FAQ and user forum.

The user interface should also be available on a smartphone app.

Possible modalities for the creation of an online platform

In order to coordinate the setting up of a unified online portal for states and cities concerned (i.e., where the number of SSTPs is already important or expected to grow), a national initiative or committee at the concerned Ministry (i.e., MoHUA) would be needed, with corresponding funding. The SPCBs, represented by the Central Pollution Control Board at the MoEFCC, would also have to be closely involved in the database development and funding. It could, therefore, be worth to create an inter-ministerial committee for the piloting of a new online data management portal.

The DMS should be linked or integrated with relevant existing data platforms and online structures at city and/or state level, such as GIS, consent management systems at SPCBs and RERA[25] databases. Its development could benefit from other e-Governance drives in India (including the Digital India programme). The National e-Governance Division at the Ministry of Electronics and Information Technology has the mandate to support such

[25] The platform could be linked with the state level web portals established through the Real Estate (Regulation and Development) Act (MoLJ, 2016), which contain the details of all construction projects. Each project, but also each real estate agent needs to be registered with the Real Estate Regulatory Authority (RERA).

initiatives and, thus, could be instrumental in supporting and coordinating the development of a new online platform.

While the platform development should be initiated and coordinated at national level (top-down), the inventory of SSS systems (i.e., the database filling) should take place bottom-up, from city to state and national level, following a structured approach.

The crucial role of SSS oversight and support units

For a new, centralised DMS to be successful in the long term, it is important that the overall responsibility for data curation is clear. This role could be given to dedicated SSS oversight and support units, embedded in the relevant governmental bodies of cities and states (➲ section 6.3.3). These SSS units could also take up a range of responsibilities to increase the sustainability of the sector, as shown in Table 13 on p. 102.

For further consideration

- There are other scenarios on how an online platform for SSS could be established (e.g., under the auspices of the Central Pollution Control Board). A careful consideration of advantages, disadvantages and potential financing modalities of the different options has to be made, with consultation of all stakeholders concerned.
- It has to be ensured that the agency in charge has sufficient long-term capacity and digital literacy to run the DMS and online platform. Different management options should be evaluated, e.g., having a mandated private company do delegated database management (➲ section 6.4.4), as practiced in Malaysia (➲ section 4.1).

Figure 19: A centralised data management system with an online platform would allow for the mapping of SSTPs and, thus, better integration of SSS in urban sanitation plans and water reuse strategies (Photo: Rohan Sunny).

- There needs to be agreement on the merging of the various existing databases to create a state-based (and eventually national) DMS. All the systems with at least one formal link to a governmental agency could be recorded in one central database. The first formal documentation of SSTPs happens during the approval of building plans by ULBs/planning departments. Systems approved by PCBs, SEIAA and MoEFCC (➲ section 3.3.1) are all inventoried in separate databases, with the approvals uploaded on their respective websites. Currently, existing data is in different formats, and often not yet digitised. It is recommended to investigate the optimal way to digitise this information, while giving a unique ID for each SSTP (e.g., property tax number) and geo-referencing it. The latter is necessary to identify database overlap, ensure follow-up and allow for mapping, thus creating a robust basis for planning and monitoring.
- Depending on the location, it has to be assumed that a considerable number of SSTPs are not recorded in any database (➲ section 3.3.3). It is crucial to trace and map these so-called legacy systems in order to capture them in the database (➲ section 6.4.2).
- The Government of Tamil Nadu already proposed the setting up of an online integrated water data platform to optimise water reuse in the state (➲ Box 17 on p. 90). This highlights the need for electronic management information systems also from other

angles of the water sector. Structures are also needed for the governance and regulation of on-site sanitation infrastructure (Dasgupta et al., 2019), including a database for the several hundred faecal sludge treatment plants currently being implemented in India. To promote integrated management and create synergies, it is important that structural reforms for SSS governance are not isolated but well aligned with other needs of the water and sanitation sector (➲ sections 6.1.1 and 6.1.2).

- Once the platform is set, the different authorised agencies can start uploading data, and accessing it for analyses and planning. There needs to be a clear allocation of the roles and responsibilities for data collection and use at the various levels of government (national, state and ULB). All the recorded details on the functional status of the systems should be accessible by the line agencies of MoEFCC and MoHUA. Collected in each city, the data can then be aggregated and analysed at the state and national levels as well. Volumes of wastewater treated via SSS can then be assessed at city, state and national level.
- In parallel to the aggregation of SSTP databases, the sanitation statistics in the census of India should explicitly include "connection to an SSTP" as one option in addition to "connection to centralised sewer network", "septic tank" and "others". Even if this does not go into details, it would provide an evaluation of the number of SSS systems that could be compared with what is captured in existing databases (and in the future possibly in the proposed centralised DMS).
- The development of the online data management platform could first be piloted in one pioneer state before being scaled up to the rest of the country. The same applies for the SSS oversight and support units. This "strategic niche management" approach (Caniëls and Romijn, 2008; Hegger et al., 2007; Mitchell et al., 2010) may allow a much quicker development and validation of such a tool, and make it more robust.

6.4.2 Dealing with legacy systems

All existing SSS systems other than those known to conform to the requirements valid at a point in time can be called *legacy systems*. **Box 20** provides a more fine-grained explanation of the term. Whenever a reform is made in the SSS governance framework (e.g., a new regulation), it may affect existing systems and/or new ones built after the effective date of the reform. Since it may not be realistic to expect existing systems to comply with stricter or supplemental requirements, any governance-related reform needs to base itself on a good understanding of the initial situation and the implications on the users. To that aim, consultation of the key stakeholders, especially representatives of the SSTP owners and users, and private players, is needed (➲ section 6.1.3).

Box 20: Definition of legacy systems

What are "legacy systems"?

Legacy systems are here defined as existing SSS systems that were not implemented as per the currently valid rules and regulations and that may therefore not fulfil the state-of-the-art requirements. This includes:

- Systems that were designed to meet less strict discharge standards, according to requirements at the time of implementation
- Systems that are in poor condition or have a deficient performance as a result of poor practice, i.e., installations that were poorly designed, implemented and/or operated under a weak governance framework and/or with weak enforcement
- Systems that are not or insufficiently documented in existing databases, and for which there is not enough information about their condition and/or performance

It is too ambitious to expect effluent compliance from all existing legacy systems in the short term. For instance, if current standards (➲ section 3.2.5) for nitrogen parameters are to be fulfilled, systems must account for this in their process design (see 4S Project Report Vol. I (Klinger et al., 2020)). While this could be implemented for newly planned SSTPs in the higher capacity size range, it will be necessary to lower the bar for existing and smaller systems (➲ section 5.6).

A staged approach is therefore needed, focusing on a) impactful and easy to achieve steps ("small wins"), and b) the prioritised refurbishment of the most problematic plants.

Legacy systems should receive separate attention and the approach is recommended to include the following four steps:

1. **Identification and mapping of systems that are not in any SSTP database**
   Depending on the location, it has to be assumed that there is a significant number of systems which are not in the database of any agency (➲ section 3.3.3). Their geo-referenced documentation may not be easy, but an attempt should be made as follows:
   - *Systems for which a consent to establish (CTE) was granted, but no consent to operate (CTO):* tracking through validation of PCB's list of CTEs.
   - *Systems which neither have CTE nor CTO:* The monitoring agency can give a 3-6 months period for system owners to legalise their SSTPs. Incentives have to be provided to encourage plant owners to declare themselves (e.g., impunity, initial CTO free of charge, waiver of STP energy charges for one year, benefits of the online platform and support system etc.).
2. **Status assessment of all existing systems and filling data gaps**
   Besides effluent sampling, this requires a systematic, qualitative inspection by trained experts (➲ section 6.4.3, see also 4S Project Report Vol. I for more specific recommendations (Klinger et al., 2020)).
3. **Categorisation according to ability to perform and upgrading needs**
   Legacy systems need to be classified according to their status and need for action (condition and operational readiness of infrastructure components and equipment, adequate system loading, safety and health risks, aesthetics, design weaknesses and ability to achieve treatment performance).
4. **Definition of realistic minimum requirements and feasible upgrading strategies**
   This includes the setting of time-bound objectives for each category and each performance parameter (infrastructure condition, safety, loading, operation, effluent quality etc.), and defining the contribution of various stakeholders. Eventually, this will allow achieving safety, operability, minimum performance, effectiveness and efficiency (in that order) in stages. See also ➲ section 6.2 for recommendations on discharge standards.

In an effort to improve water supply and sanitation, it should be a priority for service providers in the big cities to take advantage of the existing, currently underutilised sewage treatment and reuse assets at building and campus level. With a minimal increase in public spending, this infrastructure can be enabled to deliver a good service. Small, strategic investments that support SSTP owners and fortify an enabling environment are sufficient, and much cheaper when compared to the cost of building new sanitation infrastructure.

Cities (ideally through SSS oversight and support units) could support the process of legacy SSTP improvement by subsidising voluntary "check-ups" by government-approved local companies. Trained experts would assess the optimisation potential of the infrastructure

and its operations. SSTP owners should be encouraged to access this service by being charged only a fraction (e.g., one third) of its cost[26].

Malaysia followed a pragmatic approach to legacy system upgrade (➲ section 4.1 provides a more detailed description):

- Preparation of a catalogue of existing systems and status assessment
- Stage-wise refurbishment, starting with measures to ensure safety and operability
- Creation of a new set of discharge standards based on the age of systems and design standards used, with a timeframe to upgrade to the new requirements

The gradual step-by-step improvement of existing plants will eventually also result in considerable freshwater savings for a city.

6.4.3 Improving effluent quality monitoring

The State Pollution Control Boards have a clear regulatory role and must stay ahead of the curve to ensure public health and environmental protection objectives in India's rapidly evolving urban sanitation sector. However, the on-going performance of SSTPs is largely unknown at national, state and municipal levels and the current monitoring scheme for water quality is prone to irregularities, as pinpointed in sections 3.3.3 and 5.4. Samples are often taken by the SSTP owners themselves and sent to an accredited laboratory, which then send the results back to the operator. Thereafter, the operator is supposed to submit the results to the SPCB at a given frequency. This back and forth leaves a lot of room for tampering.

Two main measures should be taken:

1. **Direct uploading of lab results** to the database by the laboratory, via a unique identification code of each installation. This measure would be made possible through the development of an online data management platform (➲ Figure 16 on p. 98 and Figure 18 on p. 111). Direct upload into a database would allow automatic alerts in case of non-compliance, but also automatic checks for fake results. Malaysia already practices a direct upload of monitoring results to an online platform (➲ section 4.1.3).
2. **Increased and/or prioritised sampling by the authorities**. More sampling by SPCB inspectors would allow a standardised sampling procedure. However, human resource and financial constraints are currently limiting factors. Therefore, the immediate focus should be to prioritise monitoring visits of problematic SSTPs (e.g., in case of suspected fake results, repeated limit breaches, or public grievance reports). This would also be made possible through an online data management portal which would allow SPCBs to map the SSTPs with substandard performance or inconsistent data and prioritise inspections according to alert levels (➲ section 6.4.1).

For both measures, the precondition would be a complete and useable database of all existing systems. The development of human resources to manage databases and analyse any data collected also needs to be prioritised (➲ section 6.5.2).

[26] A similar mechanism exists in some Swiss municipalities for the optimisation of heating systems in residential buildings.

Figure 20: Inspecting a treated water sample of a small-scale sewage treatment plant in Nagpur, Maharashtra (Photo: Rohan Sunny).

For further consideration

- To support prioritised inspections, a **public grievance portal** or hotline could be established, where end-users/citizens can report systems with obvious malfunctions (related to odour, strange water colour, leakages, etc.). This could also be part of the proposed online portal (➲ Figure 18 on p. 111).
- Site visits should be **randomly allocated** to inspectors/auditors. Unannounced site visits should not only be scheduled during office hours.
- The use of tamper-proof sampling bottles and pre-printed bar-coded labels can **prevent post-collection tampering**. Certain simple tests (e.g., conductivity) can be done and uploaded real-time at the SSTP so that the data can be corroborated with the final tests to ensure a match.
- The **reliability of laboratories can also be checked** by randomly submitting samples to multiple laboratories for cross-checking.
- In cities where the SPCB does not have the capacity to monitor all SSTPs, this **task could be delegated to a private firm**, under the supervision of the SPCB (➲ section 6.4.4). In Malaysia, such a delegated monitoring approach is already implemented (➲ section 4.1.3).
- In the future, **online (real-time) monitoring** devices could reduce the need for on-site sampling.
    - Already today, operational parameters, such as electricity consumption, can be monitored electronically with energy meters at each system. Remote sensors can be used to detect mechanical and electrical faults or high water levels in sumps. Sophisticated plants use supervisory control and data acquisition (SCADA) systems. At least, the installation of mandatory electricity meters for SSTPs should be considered.

- In addition, probes for constant measurements are available for a few basic performance parameters (e.g., dissolved oxygen, pH, conductivity). The data collected could help inspectors to identify systems to visit in priority. As for now, online monitoring devices are expensive, potentially unreliable and there is a risk of misuse and manipulation of the instruments. However, development of simpler and cheaper remote monitoring devices is in progress and should be followed up.
- Concerned authorities should also monitor market developments in the fields of wastewater flow telemetry and regularly reassess the feasibility of making it mandatory to install flow meters at new systems (see 4S Project Report Vol. I (Klinger et al., 2020), p. 71, for more information on flow measurement).
- Offline data loggers focusing on operational parameters are a feasible option used by some private players already today, also to fully automate their systems and eliminate the need for full-time operator presence. Data logging can also help implementing companies to protect themselves from accusations by operators.

- **A holistic and problem-oriented monitoring approach should be developed.**
  - Current assessments rely on unrepresentative and costly grab samples. Many a sustainability issue of SSS systems and related failure risks cannot be identified even by the most precise sampling results (see 4S Project Report Vol. I). The analysis of wastewater grab samples for monitoring should be complemented with further quantitative and qualitative parameters.
  - In addition to the treated water quality, aspects like adequate loading, resource recovery (water and potentially nutrients and energy) and solids management are important indicators of a fully functional SSS system. Their inclusion in performance assessments will facilitate to monitor and address the corresponding challenges, especially those around underloading, water reuse and sludge management.
  - Monitoring the fulfilment of the conditions for performance (so called critical success factors, see sections 2.4.2 and 4.1.4 in 4S Project Report Vol. I) will provide a more holistic understanding of each system and help pinpointing sustainability risks. If institutionalised, such monitoring can also be used to constantly assess the impact of measures taken to improve the SSS sector, or to reward owners of model SSTPs with property tax rebates etc.
  - Collection of qualitative monitoring data should be facilitated with simplified questionnaires and checklists, considering the specific conditions, requirements and challenges of different application contexts and technologies.
  - In addition to other specifications (➲ section 6.1.1), all SSTPs should have certain clearly defined testing equipment for continuous monitoring of basic parameters, commensurate to the plant size.
  - The documentation of O&M activities and financial details should be mandatory. This would allow for the traceability of the systems' operation and upkeep. As in Austria (➲ section 4.4), the analysis of logbook information should also become part of the monitoring procedures. In the long term, online logbooks should be established for all systems.
  - A monitoring tool should be developed which can visualise an SSS system's current fulfilment of all critical success factors and performance objectives at a glance, for instance with scorecards. This would not only be of use for monitoring agencies but also for system owners. It would raise awareness of all the relevant aspects of a sanitation system, beyond the effluent quality of the SSTP itself.

- A comprehensive monitoring framework would provide datasets for further scientific analyses of cause-effect relationships. It could support the constant improvement of the SSS sector.
- The 4S Project Report Vol. I on technology, implementation and operation (Klinger et al., 2020) provides more detailed recommendations regarding the development of a holistic monitoring approach.

6.4.4 Fostering delegated management and monitoring

According to the analysis, insufficient financial and human resource capacities for SSS governance are among the biggest challenges for all key government stakeholders (➲ section 5.3 and Table 12 on p. 100). Since most SSS systems are currently funded, implemented, owned and operated by private sector stakeholders, there is a big opportunity for the government to delegate management and monitoring tasks to skilled private companies with the relevant expertise. The following activities – largely ULB/WSSB or SPCB responsibility – could be delegated to private firms:

Management tasks:

- Operation and maintenance of SSS systems
  - Already today, most systems are operated by private sector and civil society actors, through various management schemes (➲ section 3.3.2).
  - However, to increase performance, innovative contractual arrangements (➲ section 6.3.4) and a higher level of centralisation in O&M services (➲ **Box 21**) should be explored. This is also relevant for the government if more publicly funded SSS systems are built at neighbourhood scale in the future (➲ section 6.1.2 and Table 11 on p. 84).
- Tasks of the proposed SSS oversight and support units (➲ Table 13 on p. 102): taking into account the acute current staff shortage, delegating part of the responsibility of SSS oversight and support units to a private company may be considered in some cases, under the supervision of the corresponding government entity. This could include:
  - Development and/or management of the SSS data management system with an online platform (➲ section 6.4.1)
  - Development of an app that connects buyers with producers of treated water (➲ section 6.1.7)
  - Capacity building (➲ section 6.5)

Monitoring tasks:

- Inspection visits and effluent sampling (➲ section 6.4.3): in cities where the SPCB does not have the capacity to properly monitor all SSTPs, this task could be delegated to a private firm, under the supervision of the SPCB.
- Laboratory analyses: SPCBs also have their in-house laboratories but the analysis of most water samples is already delegated to the private sector through NABL-accredited laboratories. Ideally, the SPCB should pay for the tests, so the private laboratory sees the SPCB as the customer and not the owner of the SSTP who has to be served.

Box 21: Centralising O&M of decentralised systems

Benefits of centralisation

Decentralised (small-scale) sanitation systems can benefit from centralised structures (➲ section 5.8). Centralisation can generate economies of scale, which also applies to key activities of public and private sector stakeholders, including database management, technical support, capacity building and O&M. Thereby, centralisation can result in several benefits, including:

- Standardised processes
- Concentrated expertise
- Increased learning
- Higher efficiencies

Fostering a higher centralisation of O&M services

These benefits are particularly relevant for the O&M of SSS systems. Specialised companies providing O&M services to a larger number of SSS systems need less staff and can access higher skills. A higher level of professionalism has the potential to increase the overall performance of SSS systems. It is recommended to provide a supervisor (backstopping engineer) for each system to support O&M personnel and SSTP management entities in troubleshooting and taking performance-related decisions. Trained supervisors who understand the wastewater treatment processes can supervise multiple plants, compare performance to other references and make improvements. At least for the first five years, backstopping engineers should be deployed by the company which designed the system.

A higher degree of O&M centralisation can be achieved with fully automated, unmanned systems which do not require 24x7 operator presence. Such systems are already implemented by a few companies in India, as the necessary telemetry and remote-control technology is becoming more and more available and affordable. Fully automated processes enable the supervision of multiple plants by one professional operator – increasing the level of professionalism at a reduced overall staff cost. Malaysia is an example with large numbers of unmanned systems where operations are carried out on maintenance visitation basis (➲ section 4.1.3).

A higher level of physical centralisation of SSTPs (i.e., one plant for a cluster of buildings, ➲ Table 11 on p. 84) can lead to further economies of scale and optimised water reuse. Such projects at neighbourhood level would require government coordination. Centralised, delegated O&M through a specialised company becomes particularly interesting for a city which considers to implement a number of neighbourhood level SSTPs.

For further consideration

In Malaysia, the government reacted to the low performance of SSS with a centralisation of O&M in a private utility, representing an example of fully centralised and delegated management (➲ section 4.1). Monitoring is also delegated to the same utility, under supervision of the governmental body equivalent to the Indian PCB.

The city government of Beijing also responded to the poor performance of SSS systems in residential buildings by commissioning a private company through a PPP to build and manage a few hundred SSTPs. This move allowed for a consistent quality of treated water and much higher service quality (➲ section 4.2).

India could benefit from such centralisation of expertise and more delegation of management and monitoring responsibilities where the agency currently in charge cannot cope. The big open question is how to finance delegated management or monitoring schemes. Business models should be investigated to ensure the financial sustainability of delegated activities.

6.4.5 Summary of recommendations: management and monitoring

- Priority should be given to identify and complete the existing databases and to merge them into **one single data management system (DMS) with an online portal** that is accessible to all concerned governmental agencies according to their needs.

- A unified, centralised DMS with an online portal would provide a powerful and cost-effective **management information system for the administration and supervision of SSS systems**. Besides facilitating partially automated performance monitoring and enabling sector learning and benchmarking, it would also be beneficial for urban sanitation and water reuse planning. An online platform would be a **win-win for all stakeholders – from sanitation system owners to ULBs, WSSBs and SPCBs.** It would allow all SSS management activities to be streamlined and to gain in efficiency.

- The DMS should contain a **file for each SSTP** with system specifications (**including ID and geographic coordinates**), authorisation documents and the performance history. It should offer **mapping and analysis functions**, with automated and visualised statistics to support monitoring.

- In order to coordinate the setting up of a unified online portal for states and cities concerned, a **national initiative or committee** at the respective Ministry (i.e., MoHUA) would be needed, with corresponding funding. The SPCBs, represented by the Central Pollution Control Board at the MoEFCC, would also have to be closely involved in the database development and funding. It would, therefore, be worth creating an inter-ministerial committee for the piloting of a new online data management portal.

- Collected in each city, the **data can then be aggregated and analysed at the state and national levels** as well. The volumes of wastewater treated via SSS can then be assessed at city, state and national levels. In parallel to the aggregation of SSTP databases, the sanitation statistics in the **census of India should explicitly include "connection to an SSTP" as an option** next to "connection to centralised sewer network", "septic tank" and "others".

- For a new, centralised DMS to be successful in the long term, it is **important that the overall responsibility for data curation is clear**. This role could be given to **dedicated SSS oversight and support units**, embedded in the relevant governmental bodies of cities and states (➲ section 6.3.3).

- The development of the online data management platform could first be **piloted in one pioneer state** before being scaled up to the rest of the country. The same applies for the proposed SSS oversight and support units. This approach may allow for a much quicker development and validation of such a tool, and make it more robust.

- The DMS **should be linked or integrated with relevant existing data platforms and online structures** at city and/or state levels, such as GIS, consent management systems at SPCBs and RERA databases. To promote integrated management and create synergies, it is **important that structural reforms for SSS governance are not done in isolation, but in alignment with other needs of the water and sanitation sectors**.

- So-called **legacy systems** (➲ Box 20 on p. 114) **should get separate attention** compared to everything that is built from now on. An approach for dealing with these systems should include the following **four steps**:
  1. Identification and mapping of systems that are not in any SSTP database
  2. Status assessment of all existing systems and filling data gaps
  3. Categorisation according to ability to perform and upgrading needs
  4. Definition of realistic minimum requirements and feasible upgrading strategies. This includes the setting of time-bound objectives for each category and each performance parameter (infrastructure condition, safety, loading, operation, effluent quality, etc.).

- To **improve effluent quality monitoring**, two main measures should be taken:
  1. **Direct uploading of lab results** to the DMS by the private laboratory. Besides increasing accountability, this would allow automatic alerts in case of non-compliance, and also automatic checks for fake results.
  2. **Increased and/or prioritised sampling by the authorities**. More sampling by SPCB inspectors would allow for a standardised sampling procedure. However, human resource and financial constraints are currently limiting factors to this. Therefore, the immediate focus should be to prioritise monitoring visits of problematic SSTPs (e.g., in case of suspected fake results, repeated limit breaches, or public grievance reports). This would also be made possible through a DMS, which would allow SPCBs to map the SSTPs with substandard performance or inconsistent data and prioritise inspections according to alert levels.

- **In the future, online (real-time) monitoring devices could reduce the need for on-site sampling**. Already today, operational parameters, such as electricity consumption, can be monitored electronically with energy meters at each system. Remote sensors can be used to detect mechanical and electrical faults or high water levels in sumps. At least, the **installation of mandatory electricity meters for SSTPs should be considered**. As for now, **online monitoring devices are expensive, potentially unreliable and there is a risk of misuse and manipulation** of the instruments. However, development of simpler and cheaper remote monitoring devices is in progress and **should be followed up**.

- A **holistic and problem-oriented monitoring approach should be developed**. The analysis of unreliable wastewater grab samples for monitoring should be complemented with further quantitative and qualitative parameters. Next to the treated water quality, such aspects as adequate loading, resource recovery and solids management are important indicators of a fully functional SSS system.

- The **documentation of O&M activities and financial details should be mandatory**. This would allow for the traceability of the systems' operation and upkeep. The **analysis of logbook information should also become part of the monitoring procedures**. In the long term, online logbooks should be established for all systems.

- **Delegated management and monitoring approaches should be fostered**.
  - **Management tasks:** to increase performance, innovative contractual arrangements (➲ section 6.3.4) and a higher level of centralisation in O&M services should be explored. This is also relevant for the government if more publicly funded systems are built at the neighbourhood scale in the future (➲ section 6.1.2 and Table 11 on p. 84).
  - **Monitoring tasks:** in cities where the SPCB does not have the capacity to properly monitor all SSTPs, inspection visits and effluent sampling could be delegated to a private firm, under the supervision of the SPCB.

Open questions:

- *Who should take the lead in developing an SSS data management system (DMS) with an online platform? MoHUA, CPCB or an inter-ministerial committee? What could be possible financing modalities?*
- *Who should host it?*
- *How to merge the various existing databases into a state-based (and eventually national) DMS? How to best integrate it with existing online structures and align it with other needs in the sector?*
- *How to trace and geo-reference all existing SSTPs, including the legacy systems that are currently not documented in any database?*
- *Which management modalities should be fostered for operation and maintenance, and how to incentivise this?*
- *For which management or monitoring-related governance task would delegation to the private sector make sense?*
- *How to finance delegated management or monitoring schemes? What business models could ensure the financial sustainability of delegated activities?*
- *How to build the required capacities? (This is discussed in ➲ section 6.5)*

6.5 Capacity building: ensuring know-how, skills and human resources for the SSS sector

The implementation of any of the recommendations in this report depends on capacity, whereby two aspects are important: firstly, *sufficient manpower* that can be deputed and assigned to the tasks, and secondly, the actual *SSS-specific know-how and skills* of professionals that qualify them to do a good job.

Skills in SSS are rare, and it is important to concentrate them. Enhancing capacities for implementation, O&M, management and governance should be a top priority and go on par with the implementation and enforcement of SSS policy.

6.5.1 Organising capacity building with centralised coordination

Where to start?

Professionalisation of the entire SSS sector is crucial, encompassing the implementation, operation and management of SSS systems and – importantly – the overall governance. In any of these areas, capacity building needs centralised coordination. The concentration of related expertise at the state and national level offers an enormous potential for economies of scale, allowing for easy reinforcement and multiplication of capacity (➲ section 5.8). Malaysia successfully took the path of centralised management and capacity building after a long period of trial and error with decentralised systems (➲ section 4.1).

Governmental agencies can initiate and/or support the creation of training centres and curricula about SSS, ideally using synergies from relevant existing programmes like the National Skill Development Mission[27]. Part C (Management) of CPHEEO's Manual on Sewerage and Sewage Treatment Systems (CPHEEO, 2013c) already provides a lot of useful information regarding capacity building for urban sanitation (Chapter 3). The following sections aim to complement this information by providing additional recommendations that are necessary due to the specifics of the SSS sub-sector.

Whom to organise capacity building for SSS?

At the central level in India, various stakeholders already have a mandate related to capacity building (➲ more details in section 3.1):

- *The Central Pollution Control Board (CPCB) as per the Water Act*

  "**plan and organise the training** of persons engaged or to be engaged in programmes for the prevention, control or abatement of water pollution"; "collect, compile and publish technical and statistical data relating to water pollution and the measures devised for its effective prevention and control and **prepare manuals, codes or guides** relating to treatment and disposal of sewage and trade effluents and disseminate information connected therewith"

- *State Pollution Control Boards (SPCBs) as per the Water Act*

  "**collaborate with the Central Board in organising the training** of persons engaged or to be engaged in programmes relating to prevention, control or abatement of water pollution and to **organise mass education programmes** relating thereto."; "to **evolve economical and reliable methods of treatment of sewage** and trade effluents" (➲ Box 2 on p. 28).

[27] Alternative name: National Skill India Mission; https://nationalskillindiamission.in/

- *The Central Public Health and Environmental Engineering Organisation (CPHEEO)*

  "handholds states by way of **technical advice, guidelines**, scrutiny and appraisal of schemes and **propagation of new technologies**"; "Promote & co-ordinate **development of human resources** in the field of Public Health Engineering including imparting **training programs** for the in-service personnel." (CPHEEO, 2020)

- *Sanitation Capacity Building Platform (SCBP)*

  "an initiative of the National Institute of Urban Affairs (NIUA) for addressing urban sanitation challenges in India. […] The Platform lends **support to the Ministry of Housing and Urban Affairs (MoHUA)**, […] by focusing on urban sanitation and supporting states and cities to move beyond the open defecation free (ODF) status by addressing safe disposal and treatment of faecal sludge and septage. […] SCBP's core is **capacity building for Non-Sewered Sanitation and Integrated Wastewater Management**. From 2015 onwards, the Platform has **produced a portfolio of training modules [and] research reports** […]." (NIUA, 2021)

From this list, three important observations emerge:

1. A training mandate is naturally linked with a mandate to evaluate technologies and best practice and to develop knowledge products, such as manuals and guides. This makes sense because the same in-depth technical expertise is needed for both mandates. As stated in section 6.1.1, the development of guidelines and technical specifications for SSS is of high importance also from a policy, recognition and funding perspective for overall urban sanitation service delivery.
2. The CPCB/SPCB (MoEFCC) and the CPHEEO (MoHUA) have overlapping mandates, in the fields of trainings and guidelines. This highlights the need for coordination.
3. On the one hand, SPCBs have a training and technology evaluation mandate. On the other hand, SPCBs are clearly identified as the agencies with the most pressing need for capacity building in the SSS area (➲ sections 3.3.3, 5.3 and 5.4, as well as Table 12 on p. 100).

In accordance with these observations and the previous recommendations in this report (e.g., in section 6.1.1), it would make sense to create an MoHUA-led inter-ministerial committee to design capacity building strategies, ideally with representatives from all stakeholders who would benefit from capacity development. Such a committee was already recommended for the development of proposed governmental SSS oversight and support units (➲ section 6.3.3) and an online platform (➲ section 6.4.1). Indeed, the oversight and support units, online platform and capacity building programmes should be developed hand in hand: SSS oversight and support units – besides taking on the overall administration of the platform – could be established as the designated nodal agency for trainings and dissemination of best practice at state level. In the medium to long term, once the oversight and support units have experienced expert pools who concentrate the necessary expertise, they could provide targeted trainings for different actors at state and city level, possibly in partnership with a suitable training agency in the state and/or experts from the private sector (e.g., through an industry association).

Figure 21 shows how SSS capacity building could be initiated and coordinated at the national level, starting with the training of experts for SSS oversight and support units. This should be done in collaboration with NIUA's Sanitation Capacity Building Platform for curricula development, and possibly with other centres that have the required expertise

(e.g., CDD Society, CSE[28], academia like IIT Madras or NEERI[29], and private sector companies). Importantly, the state level SSS units should quickly have a few trainers at their command in order to be able to support the city level SSS units within WSSBs and ULBs.

It is recommended to start first with the piloting of an SSS oversight and support unit in a pioneer state (e.g., Karnataka). The pioneers can then train others in different states, or in various cities of their own state.

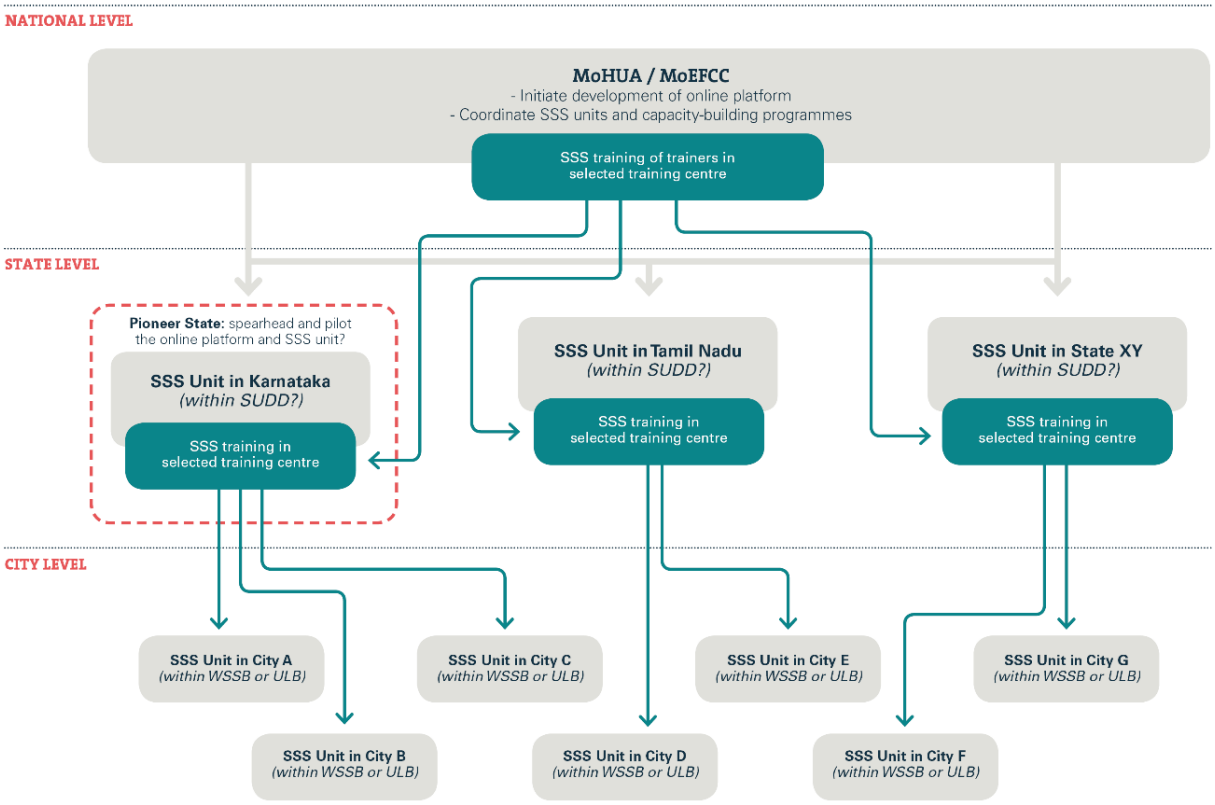


Figure 21: The central government should initiate and coordinate the development of a national SSS capacity building strategy and programme, along with the creation of state and city level SSS oversight and support units (➲ section 6.3.3). These units should be trained first, and capacitated to become the nodal agencies for trainings and dissemination of best practice. Implementation should start with a pilot phase in a pioneer state.

A capacity building platform can ultimately also strengthen the relations not only between different levels, but between different actors on the same level with different sectoral responsibilities.

Trainings conducted as part of such a scheme need to be specific to the target audience, as illuminated in the following four sections.

The big open question is how to finance capacity building initiatives. This should be discussed in priority with all stakeholders concerned – ideally under the leadership of the above-mentioned proposed MoHUA-led committee.

[28] Centre for Science and Environment (https://www.cseindia.org/)
[29] National Environmental Engineering Research Institute (https://www.neeri.res.in/)

6.5.2 Enhancing governance capacity

All the governmental agencies which are currently dealing with SSS are experiencing staff shortages. This is not only the case for SPCBs; especially in ULBs the capacities are low, and in metropolitan cities WSSBs are severely understaffed.

Part C of the CPHEEO Manual on Sewerage and Sewage Treatment Systems (CPHEEO, 2013c) states: *"The state [sanitation] strategy needs to identify agencies that will train its state level ULB personnel and orientation of elected representatives. These agencies could be specialist agencies of the State government, and/or NGOs and private sector organizations. It will also need to focus on capacity building, i.e., not just training but also developing systems and capacities of ULBs in sanitation, in line with the Urban Sector Reforms that the State may be implementing. ULBs will need to provide training on sanitation to their own staff, using State level resource agencies. They will need to utilize GOI and State government schemes for training and capacity building in order to achieve these."*

With regard to SSS governance (extending beyond ULB responsibilities), there is a need for guidance and capacity building in particular on the following key aspects:

- In general, authorities need to build up trust and know-how in SSS (➲ section 5.1).
- Planning departments in state level agencies and ULBs need to be trained on how to integrate SSS systems alongside large-scale systems and FSSM (➲ section 6.1.2).
- Capacity building should focus on empowering the state and city level authorities in charge of management and monitoring (➲ section 6.4). In particular, increased capacities are needed for database management (➲ section 6.4.1) and performance monitoring (➲ section 6.4.3). These capacities are also important to promote institutionalised learning processes and adaptive governance, ensuring that technological and governance-related lessons are dynamically incorporated into the formulation of policy and regulation (Moglia et al., 2011).
- Government officers authorising systems need to be equipped to critically examine design proposals (through trainings, checklists etc., ➲ sections 6.3.1 and 6.3.2).

In 2007, the MoHUA launched the Peer Experience and Reflective Learning (PEARL)[30] programme. This programme provides a network to connect local government officers to facilitate exchange of experience for collective cross-learning. PEARL also published a compendium of good practices on urban solid waste management in Indian Cities. A programme like PEARL can also be useful for SSS governance capacity enhancement.

6.5.3 Enhancing the capacity of implementation stakeholders

The market-driven model of SSS implementation in India has spawned a competent industry that is able to design and build a wide spectrum of small-scale sewage treatment and reuse systems, from relatively simple non-mechanised plants up to very sophisticated membrane systems with tertiary treatment stages that can generate water of potable quality. Private sector stakeholders involved in SSTP design and implementation include architects, MEP consultants, and technology providers. While most of the SSS expertise in India is with these private players, it is observed that the level of professionalism varies widely among the private players in the market, in terms of competence, quality of services and workmanship, as well as reliability. Therefore, problems in the SSTP design and construction quality are still relatively common (see also 4S Project Report Vol. I on

[30] http://pearl.niua.org/

Technology and Vol. III on Finance). Of bigger concern is the issue of technology choice: consultants and engineers are typically very specialised on few technologies or products. Decision-makers are not familiar with the whole range of options and their differences, especially in terms of management requirements or life cycle cost (➲ section 5.4).

It is, therefore, recommended to enhance the SSS technology competence of implementation stakeholders through the following two measures:

- Develop practitioner trainings on SSS technology selection (short to medium-term measure): in order to make informed decisions on the most suitable technologies for specific cases, multiple criteria need to be considered in a systematic way. Decision-makers should have a basic understanding of all existing technology families and the long-term implications of their choices.
- Include SSS in university curricula (long-term measure): wastewater engineering programmes currently focus on conventional large-scale sewage management concepts. These programmes should also impart knowledge on the specifics of the increasingly relevant small-scale sewage treatment and reuse systems and related design considerations (➲ section 3.2.4).

For both of these recommended measures, a technology guide would be a useful resource (➲ Box 13 on p. 81).

6.5.4 Enhancing the capacity of SSTP operators

This study clearly reveals the need for systematic operator trainings (➲ sections 3.3.2 and 5.5). Based on the findings and relevant international experience, the following suggestions are made:

- Create networks and professional bodies to help operators support each other, to prevent them from being isolated and to allow them to participate in exchange or capacity building events. This can also contribute to making the job more attractive and increasing the recognition of O&M personnel. Networks and collaborative arrangements showed promise in countries which established decentralised water or wastewater management schemes in rural communities (Rickert et al., 2016). Such schemes will result in an increase in capacities and efficiency, a higher level of professionalism in the sector and eventually in growing legitimacy for SSS concepts (Harris-Lovett et al., 2015).
- Create mandatory operator training programs, adapted to technology, design and context-specific O&M requirements. Train operators not merely in day-to-day operation, but also in doing preventive maintenance, understanding the treatment process, making performance judgements, and troubleshooting (including what to do in case of underperformance). Operators should be certified upon successful completion of trainings (passing examination). If mot made mandatory, operator trainings should be incentivised (incentives for plant owners and/or operators).
- Consider licensing operators. Trained operators can be “empanelled” with a regulatory authority for sustained engagement. This would allow for greater quality control and efficient dissemination of sectoral developments (Dasgupta et al., 2019). Through the introduction of licenses, operators would become part of the regulatory system and get more responsibilities. In the long term, only accredited operators should be authorised to operate SSS systems, as practiced in Malaysia (➲ section 4.1.3) and Japan (➲ section 4.5). In Austria, most authorities require that owners have a

maintenance contract with an O&M company and/or that the owners/operators pass the training course (➲ section 4.4).

The feasibility of operator licensing needs to be discussed. Trained and licensed operators would demand higher salaries, thereby increasing the operating cost of plants. Already today, the financial burden on SSTP owners is high, and the willingness to pay for SSTP operation is low (➲ sections 5.4 and 5.5). The government should consider providing subsidies to SSTPs operated by certified or licensed operators.

- The fostering of SSS O&M companies, i.e., the concentration of expertise through a more centralised management model, should also be considered, especially in conjunction with a higher degree of SSTP automation (➲ Box 21 on p. 120).
- Trained supervising engineers are equally important.

6.5.5 Enhancing the capacity of SSTP managers

SSTP management entities (such as building owners and facility managers) play a crucial role for ensuring sustainable SSS operations. However, they commonly lack awareness of their responsibilities or they don't have access to good information to make informed management decisions. Training for the personnel of management entities should, therefore, also be made available, promoted and incentivised. Financial management (including life cycle cost planning) of the SSTP is one of the key training needs identified (see 4S Project Report Vol. I on technology). Trainings should also highlight the importance of proper supervision and documentation of O&M activities, as well as the anticipation of maintenance works.

A few years ago, a private company recognised the need for skilled property managers (beyond SSTPs) and launched a training institute for multi dwelling unit (MDU) management (➲ **Box 22**). The courses offered by the institute also include modules on wastewater management. This and other relevant initiatives should be supported and replicated across urban India in order to address the identified training needs and enhance the management skills relevant for small-scale sewage treatment and reuse systems.

Box 22: The ApartmentADDA Institute of MDU Management (AIMM)

In 2014, a Bangalore-based private company involved in apartment management recognised the demand for trained facility managers which need to keep their knowledge and skills up to date. To address this demand, the company launched the AIMM, India's first training institute for multi dwelling unit (MDU) management. In collaboration with industry experts from the different fields, the institute offers specialised courses on engineering, operations, administration, compliance, finance and soft skills for the management of residential and commercial complexes. Trainings also impart skills in wastewater management, as water and sewage treatment plants were identified to be among the key problem areas. To facilitate participation of working professionals, courses are held in part-time programmes. The institute also intends to serve as a forum where property managers can exchange ideas and share learnings (Citizen Matters, 2015b).

More information on the AIMM website: **http://aimm.apartmentadda.com/**

6.5.6 Summary of recommendations: building capacity for the implementation, O&M, management and governance of SSS systems

- **Enhancing the capacities for the governance, implementation, O&M and management of SSS systems should be a top priority** and go on par with the implementation and enforcement of SSS policy.

- Capacity building **needs centralised coordination**. The concentration of related expertise at the state and national levels offers an enormous potential for **economies of scale**, allowing for easy reinforcement and multiplication of capacities.

- Governmental agencies can **initiate and/or support the creation of training centres and curricula about SSS**, ideally using synergies from relevant existing programmes, such as the National Skill Development Mission.

- According to the analysis, it would make sense to **create an MoHUA-led committee to design capacity building strategies**, ideally with representatives from all stakeholders who would benefit from the capacity development.

- Capacity building programmes should be **developed hand in hand with the proposed SSS oversight and support units** (➲ section 6.3.3) **and online platform** (➲ section 6.4.1): state level SSS units – besides taking on the overall administration of the platform – could be established as the **designated nodal agency for trainings and dissemination of best practices** at the state level.

- SSS capacity building should be initiated and coordinated at the national level, **starting with the training of experts for SSS oversight and support units**. This should be done in collaboration with NIUA's Sanitation Capacity Building Platform for curricula development, and possibly with other centres that have the required expertise. Importantly, the **state level SSS units should have a few trainers at their command** who could support the city level SSS units within WSSBs and ULBs.

- It is recommended to **start first with the piloting of an SSS oversight and support unit in a pioneer state** (e.g., Karnataka). The pioneers can then train others in different states, or in various cities of their own state.

- **Enhancing governance capacity:**
  - In general, authorities need to **build up trust and know-how** in SSS.
  - Planning departments in state level agencies and ULBs need to be trained on **how to integrate SSS systems alongside large-scale systems and FSSM**.
  - Capacity building should focus on **empowering the state and city level authorities in charge of management and monitoring**. In particular, increased capacities are needed for database management and performance monitoring.
  - Government officers authorising systems need to know how to **critically examine design proposals** (through trainings, checklists, etc.)
  - In 2007, the MoHUA launched the Peer Experience and Reflective Learning (PEARL) programme. This programme provides a network to connect local government officers and facilitates the exchange of experience for collective cross-learning. A **programme like PEARL can also be useful** for SSS governance capacity enhancement.

- **Enhancing the capacity of implementation stakeholders:**
  - **Develop practitioner trainings on SSS technology selection** (a short to medium-term measure): the making of informed decisions on the most suitable technologies for specific cases requires considering multiple criteria systematically. Decision-makers should have a basic understanding of all existing technology families and the long-term implications of their choices.
  - **Include SSS in university curricula** (a long-term measure): wastewater engineering programmes currently focus on conventional large-scale sewage management concepts. These programmes should also impart knowledge on the specifics of small-scale sewage treatment and reuse systems and related design considerations.
  - For both of these measures, a **technology guide** would be a useful resource.

- **Enhancing the capacity of SSTP operators:**
  - **Create networks and professional bodies** to help operators support each other, to prevent them from being isolated and to allow them to participate in exchange or capacity building events. This can also contribute to making the job more attractive and increasing the recognition of O&M personnel. Such schemes will result in an increase in capacities and efficiency, a higher level of professionalism in the sector and eventually in growing legitimacy for SSS concepts.
  - **Create mandatory operator training programs** adapted to technology, design and context-specific O&M requirements. Operator trainings should go beyond day-to-day operation: they should impart basic knowledge on treatment processes, preventive maintenance, performance judgements and troubleshooting. Operators should be certified upon successful completion of the trainings.
  - **Consider licensing operators**. Trained operators can be "empanelled" with a regulatory authority for sustained engagement. This would allow for greater quality control and efficient dissemination of sectoral developments. Through the introduction of licenses, operators would become part of the regulatory system and get more responsibilities. In the long term, only accredited operators should be authorised to operate SSS systems.

- **Enhancing the capacity of SSTP managers:**
  - SSTP management entities (i.e., building owners and facility managers) play a crucial role in ensuring sustainable SSS operations. **Training for SSTP managers** should, therefore, be made available, promoted and incentivised. **Financial management** (including life cycle cost planning) of the SSTP is one of the key training needs that has been identified. Trainings should also highlight the importance of proper **supervision and documentation of O&M activities**, as well as **how to anticipate maintenance needs**.
  - **Existing relevant initiatives for the training of facility managers should be supported and replicated** across urban India to address the training needs that have been identified and to enhance the management skills relevant for small-scale sewage treatment and reuse systems.

Open questions:

- *How to finance capacity building initiatives and programmes?*
- *Which organisation(s) should deliver the different types of training?*
- *How feasible is the licensing of operators? How to sustainably cover the higher salaries of skilled operators? Through subsidies?*

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Appendices

Appendix 1: List of stakeholders interviewed

Table 16 lists all the stakeholders with whom a formal interview or survey was done for this governance analysis. The three columns represent the three types of interactions with the stakeholders:

1. The semi-structured interviews provided in Appendix 2, aiming at understanding the sector.
2. The written survey given to key stakeholders for the social network analysis (SNA), provided in Appendix 3, aiming at understanding the relationships between stakeholders.
3. The interviews done for the SNA, complementing or replacing the written survey when needed.

Besides government stakeholders, the list includes an important share of private players, as they form a significant, heterogeneous group of key stakeholders. The SSS sector is mostly in the hands of the private sector (privately built, owned and operated systems), and a lot of information about SSS governance, especially informal aspects, can be obtained from private stakeholders.

Table 16: List of stakeholders interviewed and surveyed for the 4S governance analysis

Stakeholder	Place / City	Type	Semi-structured interview	Written survey (SNA)	Interview (SNA)
Central Public Health and Environmental Engineering Organisation (CPHEEO)	Delhi	National	✔	✔	✔
Central Pollution Control Board (CPCB)	Delhi	National		✘*	✔
City Managers' Association, Karnataka (CMAK)	Karnataka	State		✔	✔
Commissionerate of Municipal Administration (TN)	Tamil Nadu	State		✔	✔
Directorate of Municipal Administration (KT)	Karnataka	State		✔	✔
Infrastructure Development Corporation (Karnataka) Ltd. (iDeCK)	Karnataka	State		✔	✔
Karnataka Rural Water Supply & Sanitation Department (KRWSSA)	Karnataka	State		✘	✔
Karnataka State Industrial and Infrastructure Development Corporation (KSIIDC)	Karnataka	State		✘	✔
Karnataka State Level Environmental Impact Assessment Authority	Karnataka	State		✘	✔
Karnataka State Pollution Control Board (KSPCB)	Karnataka	State	✔	✔	✔
Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC)	Karnataka	State		✘	✔
Karnataka Urban Water Supply and Drainage Board (KUWSDB)	Karnataka	State	✔	✔	✔
Lake Development Authority (Karnataka)	Karnataka	State		✘	✔
Tamil Nadu Pollution Control Board (TNPCB)	Tamil Nadu	State	✔	✘	✔
Tamil Nadu Urban Infrastructure Financial Services Ltd. (TNUIFSL)	Tamil Nadu	State		✘	✔
Tamil Nadu Water Supply & Drainage Board (TWAD Board)	Tamil Nadu	State	✔	✔	✔
Bangalore Water Supply and Sewerage Board (BWSSB)	Bengaluru	City (ULB)	✔	✔	✔

Chennai Metropolitan Development Authority (CMDA)	Chennai	City (ULB)		✗	✓
Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB)	Chennai	City (ULB)	✓	✓	✓
Mysuru City Corporation	Mysuru	City (ULB)		✓	✓
Centre for Policy Research (CPR)	Delhi	Think Tank	✓	✗	✓
National Institute of Urban Affairs (NIUA)	Delhi	Think Tank		✓	✓
Indian Green Building Council (IGBC)	Hyderabad	Non-Profit Organization	✓	✓	✓
German Agency for International Cooperation (GIZ) (INDIA)	Delhi	International		✓	✓
Aqua Designs India Pvt. Ltd.	Chennai	Private		✗	✓
Samruddhi Waterworks Pvt. Ltd.	Bengaluru	Private		✓	✓
Akar Impex Pvt. Ltd.	Delhi	Private	✓		
Bisineer Pvt. Ltd.	Bengaluru	Private	✓		
Ellennvee Enviro Engineers	Bengaluru	Private	✓		
Murali Sesh Enviro Engineers Pvt. Ltd.	Bengaluru	Private	✓		
WESP Engineering	Bengaluru	Private	✓		
Paradigm Environmental Strategies Pvt. Ltd.	Bengaluru	Private	✓		
Vision Earthcare	Bengaluru	Private	✓		
Indus Eco-Water Private limited	Hyderabad	Private	✓		
Bangalore Test House	Bengaluru	NABL-accredited Laboratory	✓		

* ✗ means that the survey was shared with a stakeholder for filling, but never returned.

Appendix 2: Semi-structured interview questionnaires

To the State Pollution Control Boards (SPCB)

- Who are the key actors that hold responsibility for devising policies related to SSS, providing consents (CTE and CTO), operation and monitoring the performance of SSS systems? (Network diagram)
- Could you provide the exact documentation of the legislation/order which prescribes SSS in the city?
- Do you have any classified database of SSS systems? (this question suits the context of cities like Hyderabad) Which department/wing holds responsibility for collating the database? If no, what are the main reasons for not having a proper database of existing number of small-scale sanitation systems and available technologies? (E.g., technical reasons/understaffed, etc.) Don't the regulations deem mandatory, an inventory of the private providers?
- How do you keep a record of emerging new technologies and their related efficiencies? Are new technologies encouraged?
- How do you verify the system design on ground after issuing a consent? How does the SPCB ensure that buildings install an SSS system?
- What percentage (approx. value) of waste water is treated through small-scale sanitation units in your respective state/city? What percentage of systems are operational (approx.)? What percentage of systems reach prescribed standards (approx.)?
- What is the overall situation of functional status of small-scale sanitation systems in cities?
- Does SPCB/WSSB do any outreach/awareness program to raise awareness about the benefits of SSS in the city?
- What are the monitoring mechanisms adopted to check the overall performance of installations? How frequently they are done? Is it effective? What are the potential segments to be improved?
- What about the enforcement, after monitoring? What penalties are levied? How effective are they? Status of show cause notices – How many show cause notices did you issue in the last five years? Does it reflect on the improvement in monitoring mechanism?
- How did you arrive at the existing standards? What are the references? Is zero discharge possible considering the quality of treated water and usage?
- On what basis is a consent provided to a small-scale sanitation unit of a respective technology? Is there any reference of matrix of technologies to provide consent?
- How effective is the coordination between Central, State and District[31] Pollution Control Boards? Which type of relationship?
- Coordination with other agencies?
- Are there any overlapping responsibilities with urban local bodies? Should existing relationship with governmental processes be reengineered? If yes, what are your recommendations?
- Link between the desired performance and actual environmental impact? (e.g., when clean, treated wastewater is discharged in a dirty drain) Is it allowed?
- In many cases buildings have excessive treated wastewater. What are the suggested options to reuse to the fullest extent?
- Consent to reconnect to underground sewerage? Under what circumstances it is provided? Which departments need to approve in such cases? (Network diagram) What happens if a sewerage

[31] Depending on the state, PCBs have regional, zonal and/or district offices.

network is once available in the city? Doesn't reconnection to sewer networks dilute the policy of compulsory establishment of SSS systems?

- Who approaches for consent? Is it builder or the SSS provider?
- Is it feasible to implement online monitoring systems to monitor the performance of SSS systems? Is it a recommendable solution? What are the plausible challenges to implement?
- Who influences/implements the decisions like introducing implementation of online monitoring systems to monitor SSS system performance?
- Institutional amendments required in order to implement effective online monitoring system (Network map)?
- Do State Pollution Control Boards have authority to initiate such an extensive online monitoring mechanism?
- What are the additional human, technological and financial resources required in order to set up an effective management system? Who funds it?
- How was the online monitoring mechanism implemented in the case of industries? What were the additional human, technological and financial resources needed in place in order to set up an effective management system? Who funded the same?
- How much money (approx.) will user have to bear to install online monitoring devices (If online monitoring system is proposed)? How can this be coordinated in the case of already installed systems?
- In which ways is the proposed institutional framework more efficient than a conventional one?
- Is interdepartmental coordination required for effective monitoring and penalising? (Network map)
- Are you tracking the reuse of treated wastewater by various buildings? What are the indicators (similar to Environmental Impact Assessment guidelines)?

To the State Water Supply and Drainage Boards (SWSDB)

- What are your major responsibilities? What is your scope of working?
- Which acts define roles and responsibilities of SWSDB?
- Are small-scale sanitation systems are considered as alternative solution to the conventional systems? If yes, in which contexts SSS is considered?
- What is the scale of SSS proposed in the small and medium towns?
- What is the functioning status of the systems that were installed so far in the small and medium towns?
- Can you describe the SSS management handover transfer process? Fund allocation for continuous operation and management? Do you interfere if there are any major issues?
- Who monitors performance of these systems? Do you consider these into account while providing infrastructure? Do you receive any performance report post-handover process?
- There is a shortage of financial resources to provide sewerage services to the small and medium cities. Can small-scale sanitation can be a viable alternative? Yes or no? Why?
- What are the obstacles for up-scaling of small-scale sanitation in small and medium towns?
- Fund allocation mechanism in the case of AMRUT Service Level Improvement Plans? On what basis central government approves the funding? How the process has to be reengineered in order to up-scale small-scale sanitation?

- Under AMRUT scheme, how many cities are receiving funding to improve underground drainage and treatment facilities?
- For towns of size 100'000, decentralised systems could be an affordable option. Do you have authority to allocate funds and opt for centralised or decentralised option? In most of the towns, what are the preferred sanitation systems?
- Are notified slums covered under these formal networks? Do they also have to pay for sewage cess charges? Do they get any subsidies?
- Does SWSDB prepare any sanitation master plans for any cities? Do you consider them while allocating infrastructure?
- Tamil Nadu specific: In 2004, SWSDB has implemented several small-scale sanitation systems across the state (E. g. Tsunami Rehabilitation project). Who monitors these systems? What is the functional status of these systems? Is it possible provide a list of small-scale sanitation systems in the states?

To the Water Supply and Sewerage Boards (WSSB)/Urban Local Bodies (ULB)

- What is the influence of MoHUA and State Urban Development Authorities on the Water Supply and Sewerage Board?
- What are the responsibilities of WSSB? Who directs WSSB?
- How much are residents charged as sanitary charge? How does it vary among various establishments (residential, commercial, etc.)?
- Is sanitary charge applicable to apartment buildings with an SSS?
- WSSB issues a certificate post construction of SSS systems. What is the protocol followed in verifying the design and engineering of the plant? (Design evaluation toolbox?) Who assesses the systems?
- Are apartments allowed to discharge treated wastewater into sewer lines or stormwater drains or nearby water bodies? What are the apartments doing with the discharge of excess of treated wastewater?
- What are the future steps taken to tackle the issue of sewage? Are you taking existing SSS systems into account to design future centralised systems?
- Does SPCB/WSSB do any outreach/awareness program to inform about the benefits of SSS in the city?
- What is the rationale behind forcing apartments that are already connected to sewerage network to construct their own SSS systems?
- Monitoring and enforcement of SSS? Sharing of responsibilities? Who is responsible? List of systems? Technology selection?
- SPCB has a significant shortage of staff to monitor these treatment systems? Does WSSB cater any special budget for monitoring these new SSS systems? Is there any framework already available to monitor these plants?
- Any incentives to building owners? What about the buildings which already installed and efficiently running the treatment plants? Are they eligible for any incentive?
- What is the long-term plan to deal with small-scale systems? Or is it seen as a temporary solution?
- What are the challenges in providing sewerage treatment infrastructure? What is the vision of sanitation?

To the private sector stakeholders

- Your business
  - Since when are you in this business?
  - Who are your clients when it comes to small-scale wastewater treatment systems?
  - What services do you provide (consultancy, design, implementation, production of hardware and components, O&M, turnkey, etc.)?
  - What type of small-scale WW treatment systems / technologies do you install?
  - How many of each type have you installed so far?
  - What is the size range and average size of the systems you implemented so far (in hydraulic load or PE)?
  - What are the technical details of your completed projects (exact technology description, sludge treatment and reuse, etc.)?
  - Can you share a list of implemented systems?
- Small-scale sanitation systems and technology choice
  - What are your incentives to build SSS systems?
  - In your opinion, what are the key (dis-)advantages of a small-scale system compared to a centralized large-scale system?
  - What minimum / maximum size of a system would you recommend and for what reasons?
  - What are the advantages of your technologies?
  - What are the factors governing your choice on which technology to use? How do you choose which technology to apply?
  - For which context do you recommend which technology? Or: in which context can your technology be used?
- Design
  - Which stakeholders are typically included in the decision-making processes concerning the choice of technology, site selection etc.? If other stakeholders are involved, how and when?
  - Which parameters do you use as a design basis?
  - How do you estimate population / connection numbers? How do you include initial unused capacity (low wastewater generation due to low occupancy of buildings) in your designs?
  - What per capita values do you base your designs on?
    - Standard per capita values
    - Estimated per capita values based on field conditions
    - Actual investigations in the field through basic assessment, sampling, questionnaires, etc.
  - What background information do you usually get prior to design processes? Is this generally sufficient to properly make the right dimensioning and design decisions?
  - Do you use prefabricated components? Why?
- Implementation and handover
  - Are you involved in obtaining consents to establish / operate?
  - From which regulatory body do you have to take consents? How difficult is it to obtain consents? How much time does it normally take?
  - At what project stage does your responsibility/ involvement end?
  - How is the quality of your installation assessed at the end of your project involvement? What are mechanisms for commissioning after the installation of a system?
  - What type of documents do you have to hand over to the client at the end of your project involvement? Do you hand over a manual for operators?
  - Do you provide trainings for operators or managers?

- O&M and management
  - In your opinion, concerning correct system operation and maintenance, …
    - what knowledge and awareness are required from the users, and how can it be guaranteed?
    - what are required qualifications of the operators / caretakers? What are adequate ways for training?
    - are there any other requirements?
  - How are your systems managed?
    - Parties involved and responsibilities
    - Money flow between parties
  - What challenges do you see regarding this management and financial flows? Any recommendations for improvement?
  - What do you think about a design-build-operate approach?
- System performance and quality assurance
  - Do you maintain regular contact or information exchange with the managers / operators of your systems? Do you visit those systems?
  - Do you know if the systems you were involved in are currently operational or not? If yes, how do you get to know this?
  - Do you know if they function as designed?
  - Do you ever receive complaints or other feedback by clients?
  - Research and development: do you make evaluations of your designs in the field and corresponding technology or design improvements? How do you proceed?
  - Do you guarantee a certain effluent quality?
  - Have you ever thought about online monitoring of your STPs? If yes, what do you think about it?
- Governance, regulations and accountability
  - What do you think about the government's role and involvement, as well as current policies concerning SSTPs? What kind of additional support would be helpful?
  - Which regulations do you have to comply with when designing / installing / constructing the systems?
  - What is your opinion on the prescribed standards for treated wastewater? Are they adequate or are revisions required?
  - Who is legally responsible for achieving the effluent standards?
  - If the effluent quality doesn't meet the standards, what are the consequences?
  - Do you fear being held accountable for a system that doesn't perform as it should? Does it ever happen that the regulator prosecutes design companies / technology providers?
- Costs and economy
  - What is the minimum size that you recommend from an economic point of view for cost-effectiveness?
  - What are the capital costs of systems? How much (in %) would that be as part of the total construction cost of an apartment building?
  - What are the operating and maintenance requirements and costs of systems?
  - What is the design lifespan of your systems? Are there any components with a lower life span than that? How frequently do they have to be replaced? How much would that cost? What are the life cycle costs?
  - How difficult do you find it to provide accurate estimates of the costs of a system? Do you experience differences between your cost estimates and the actual cost at the end of the implementation?

- Market and innovation
  - Do you anticipate big business opportunities in this sector?
  - How big is the competition? How does the competition differ for specific technologies? How good are other players?
  - Conventional and established vs. innovative and emerging technologies: is it more difficult to implement innovative ones?
  - Do you know any technology innovations in the wastewater treatment sector that were successfully introduced to the market? Or that remained unsuccessful? What are the main reasons?
- Challenges
  - What are the main challenges you face when designing, implementing and/or operating SSS systems? E.g., concerning…
    - design estimations (per cap values, population estimates)
    - construction supervision
    - collaboration with construction companies
    - administrative procedures
    - legal requirements
    - corruption
    - etc.
  - What are the challenges faced if treatment systems have to be installed for existing buildings (e.g., in the case of Bangalore where all buildings with 20+ apartments were suddenly requested to install STPs)?

Appendix 3: Written survey to private and public stakeholders for the social network analysis

Network governance in small-scale sanitation systems in India

This questionnaire is part of a research project known as 4S (Small-Scale Sanitation Scaling-Up), conducted by Eawag (The Swiss Federal Institute of Aquatic Science and Technology), The Indian Institute of Technology (IIT) Madras, and Bremen Overseas Research and Development Association (BORDA, Germany), the first systematic assessment of small-scale sanitation systems in South Asia. Karnataka State Pollution Control Board adopted a policy requiring residential establishment of more than 20,000 m^2 within sewered areas, and 5,000 m^2 or 50 apartment units outside sewered areas, to install a treatment plant with zero discharge of treated wastewater. Commercial establishments larger than 2,000 m^2 (outside sewered areas) must also have an on-site treatment plant. Such on-site wastewater treatment plants are referred as small-scale sanitation systems.

The goal of this project is to develop evidence-based policy recommendations for improved sanitation system design, implementation, and operation and maintenance (O&M). More specifically, this will allow decision-makers to make informed strategic decisions about sanitation systems and to accelerate the provision of collection and treatment services for used water and faecal sludge in South Asia. The aim of this questionnaire is to get an overview of the different stakeholders involved in this sector, their relations and their view of current and future challenges.

Since your organization plays an important role in the implementation of small-scale sanitation policies, your participation in the survey is very important for the success of this research project. We would like to thank you in advance for filling in the questionnaire. This should **not take you more than 30 minutes** without side discussions.

Our questionnaire includes the following three sections:

- Section 1: Organization characteristics
- Section 2: Collaboration and information exchange
- Section 3: Current and future challenges

Please answer the questions from the perspective of your organization and not from your individual perspective. Please follow the pre-structured questions.

Name		**Date**	
Designation			
Organization/ Department			
		City	
Address		**Zip**	
		State	
Email		**Phone**	

SECTION 1: ORGANIZATION CHARACTERISTICS

1. **For each issue in small-scale sanitation systems, how much is your organization involved?**

Parameters	No Involvement at all	Incidental to the work of your organisation	Important topic my organization deals with	Main topic my organization deals with
Infrastructure (establishing and implementing projects of small-scale sanitation and wastewater infrastructure)	☐	☐	☐	☐
Research (conducting research in sanitation relevant topics and developing new approaches & solutions)	☐	☐	☐	☐
Environment (monitoring of pollution, environmental protection, and sustainable use of natural resources)	☐	☐	☐	☐
Health (issuing discharge standards on sanitation, monitoring diseases related to sanitation, promoting effective risk assessment)	☐	☐	☐	☐
Technology (managing technological activities related to small-scale sanitation, providing new technologies for sanitation systems)	☐	☐	☐	☐
Administration (setting regulations, guidelines, frameworks, monitoring, enforcement)	☐	☐	☐	☐

2. Total number of staff (Full + Part time)

Admin ☐ Technical ☐ Don't know ☐

3. Total number of staff, involved in small-scale sanitation issues (Full + Part time)

Admin ☐ Technical ☐ Don't know ☐

4. What is the approximate share of activities in percentage dedicated towards small-scale sanitation issues?

☐ % Don't know ☐

5. The estimated increase in the number of staff in the next 5 years, who will be directly or indirectly, involved in small-scale sanitation issues (Approximately).

Admin ☐ Technical ☐ Don't know ☐

6. Given below is the list of activities related to small-scale sanitation systems. Kindly check all activities in which your organization was involved during last 10 years.
(Please indicate only those activities which are related to small-scale sanitation.)

a. Inquiry/Demand

☐ Submit proposals for small-scale sanitation projects

b. Feasibility assessment

☐ Technical ☐ Economical ☐ Operational ☐ Legal

c. Contracting/Tendering

☐ Selection of builder ☐ Selection of land/location

d. Design

☐ Planning of the treatment system ☐ Field visit ☐ Establish time plan

e. Implementation (construction)

☐ Building STPs ☐ Site supervision ☐ Jointly implementing projects (technical)

f. Monitoring

☐ Convening or participating in meetings ☐ Monitoring STPs
☐ Sharing data, advice, and information with other organizations
☐ Knowledge enhancement from another organization (capacity building)

g. Evaluation

☐ Making policy recommendations ☐ Joint research projects with other org.
☐ Review of draft policies, declarations, strategies, implementation programs & plans

h. Operation and Maintenance (O&M)

☐ Jointly carrying out sensitization of the public ☐ Operating treatment plants

i. Others

☐ _____

SECTION 2: COLLABORATION AND INFORMATION EXCHANGE

1. **If your organization was engaged in any meetings related to small-scale sanitation activities within the last 10 years, please answer these following questions:**
   (Please check all that apply)

   a. **What types of meetings did your organizations engage in the last 10 years? How Many?**

Type of meetings	Yes/No	No. of meetings per Year (approx.)
Scientific Conference	☐	
Project Meeting (Local Level)	☐	
Departmental Meeting (Administrative Level)	☐	
Capacity building initiatives (Workshops, trainings, awareness campaigns, exhibitions)	☐	

   b. **What types of participants did attend these meetings?**

- ☐ Academic
- ☐ Government
- ☐ NGO representatives
- ☐ Private sector representatives
- ☐ International organization representatives
- ☐ Other

2. Influence of actors and information exchange

A number of actors have been involved in the field of small-scale sanitation systems in India within the last 10 years. The following page presents a list as complete as possible of actors involved in the mentioned field.

- In the first column, please check all the actors that have been particularly influential in the domain of small-scale sanitation systems from the point of view of your organization.

- For the remaining columns, kindly check all actors with which your organization regularly exchanged either

  (a) technical information or,
  (b) administrative information or,
  (c) has been collaborating in projects related to the implementation of small-scale sanitation systems within the last 10 years.

By influential actor we mean their ability to impact small-scale sanitation implementation in India, given their political influence, financial resources, land ownership, or others.

By technical information we mean sharing the technical aspects of small-scale sanitation systems (e.g., different technical solutions for construction of on-site sanitation systems, design, quality etc.)

By administrative information we mean sharing new requirements, legal frameworks, and guidelines. (e.g., new requirements for the construction for small-scale sanitation systems etc.)

By project collaboration we mean implementing the existing policies regarding sanitation systems and working together in order to realize small-scale sanitation projects.

If there are actors missing, please add them to the bottom of the list and indicate if you exchange information or regularly collaborate with them.

List of Actors	Influential Actor	Information Exchange and Collaboration		
		Technical Information	Administrative Information	Project Collaboration
National Level Actors				
CPHEEO	☐	☐	☐	☐
Ministry of Environment, Forest and Climate Change	☐	☐	☐	☐
Swachh Bharat Mission National Advisory and Review Committee	☐	☐	☐	☐
Ministry of Water Resources, River Dev. and Ganga Rejuvenation	☐	☐	☐	☐
Bureau of Standards	☐	☐	☐	☐
Ministry of skill development and Entrepreneurship	☐	☐	☐	☐
Others:	☐	☐	☐	☐
State Level Actors				
Urban Development Department	☐	☐	☐	☐
City Managers Association	☐	☐	☐	☐
Pollution Control Board	☐	☐	☐	☐
Urban Water Supply and Sewerage Board	☐	☐	☐	☐
Environmental Impact Assessment Authority	☐	☐	☐	☐
Housing Boards	☐	☐	☐	☐
Department Forest Ecology Env.	☐	☐	☐	☐
SBM High Powered Committee	☐	☐	☐	☐
Lake development authority	☐	☐	☐	☐
Karnataka Urban Infrastructure Development and Finance Corp.	☐	☐	☐	☐
State Industrial Development Corporation	☐	☐	☐	☐
Others:	☐	☐	☐	☐
City Level Actors				
City/District Office of Pollution Control Board	☐	☐	☐	☐
Metropolitan development authority	☐	☐	☐	☐
Municipal planning authority (directorate town)	☐	☐	☐	☐
Water Supply & Sewerage Board	☐	☐	☐	☐
State Level Technical Cell (AMRUT /Smart City Mission)	☐	☐	☐	☐
Others:	☐	☐	☐	☐

List of Actors	Influential Actor	Information Exchange and Collaboration		
		Technical Information	Administrative Information	Project Collaboration
NGO/ Research Institutes/ Education Institutes				
National Institute of Urban Affairs	☐	☐	☐	☐
Environmental Law Research Society	☐	☐	☐	☐
Industrial Training Institute	☐	☐	☐	☐
Centre for Policy Research	☐	☐	☐	☐
Indian Green Building Council	☐	☐	☐	☐
International development agencies/Donor organisations (GIZ; ADB; World Bank)	☐	☐	☐	☐
Others:	☐	☐	☐	☐
Private stakeholders				
Architects	☐	☐	☐	☐
Contractors	☐	☐	☐	☐
STP designers/suppliers	☐	☐	☐	☐
STP O&M providers	☐	☐	☐	☐
Buyers of treated wastewater	☐	☐	☐	☐
Confederation of Real Estate Development Association of India (CREDAI)	☐	☐	☐	☐
MEP (Mechanical, Electrical, Plumbing) Consultants	☐	☐	☐	☐
Association for Decentralised Sanitation Infrastructure and Service Providers (ADSIS)	☐	☐	☐	☐
Facility Service Provider companies (ADDA, Tandem Allied Services)	☐	☐	☐	☐
Consultancy firms (e.g., CH2M)	☐	☐	☐	☐
Individual consultants	☐	☐	☐	☐
AMRUT/Smart City plan drafters	☐	☐	☐	☐
Plumber Association	☐	☐	☐	☐
Others:	☐	☐	☐	☐

SECTION 3: CURRENT AND FUTURE CHALLENGES

Below is the list of current challenges, related to small-scale sanitation systems in India. Please indicate how important each of these challenges is, according to your organization.

Challenges	Very important	Rather important	Rather unimportant	Completely unimportant
Contamination of ground and surface water supplies from wastewater	☐	☐	☐	☐
Regular maintenance of on-site sanitation systems	☐	☐	☐	☐
Monitoring of waste water treatment plants (small-scale sanitation systems)	☐	☐	☐	☐
Building of wastewater treatment plants	☐	☐	☐	☐
Involvement of the private sector in small-scale sanitation management	☐	☐	☐	☐
Unclear responsibilities between different organizations and sectors	☐	☐	☐	☐
Unclear responsibilities between the local and national levels	☐	☐	☐	☐
Inadequate regulation at the local level	☐	☐	☐	☐
Inadequate enforcement at the local level	☐	☐	☐	☐
Blockages from certain relevant institutions/responsible individuals	☐	☐	☐	☐
Low consultation to local communities at the city level	☐	☐	☐	☐
People opposed to the reuse of treated waste water	☐	☐	☐	☐
People opposed to the implementation of small-scale sanitation due to lack of space	☐	☐	☐	☐
Users do not want to pay O&M fees	☐	☐	☐	☐
Sub-optimal implementation of the MoEFCC notification	☐	☐	☐	☐

Lack of awareness of beneficiaries about small-scale sanitation and people active in the sector	☐	☐	☐	☐
Lack of financial resources	☐	☐	☐	☐
Lack of human resources	☐	☐	☐	☐
Others:	☐	☐	☐	☐

What recommendations do you have for tackling the challenges faced in the field of small-scale sanitation?

1) Click here to enter text.

2) Click here to enter text.

3) Click here to enter text.

4) Click here to enter text.

5) Click here to enter text.

6) Click here to enter text.

7) Click here to enter text.

8) Click here to enter text.

Thank you for your time and providing valuable information.

If you have further remarks or ideas about the topic of small-scale sanitation systems in India or about the questionnaire, please share them below.

Click here to enter text.

Appendix 4: Characteristics of different groups in the power-interest matrix

Group	Location	Interest	Power	Characteristics
A	Bottom Left	Low	Low	• Academic organizations, and few central ministries. • Little influence and incidental involvement in small-scale sanitation. • Should be monitored with minimal effort.
B	Bottom Right	High	Low	• Mostly private stakeholders and various NGOs. • Little influence but high interest. • Collaboration with this group can be crucial for efficient sanitation management. Should be empowered and at least consulted during policy-making processes.
C	Top Left	Low	High	• Mostly authorities from central government. • High power but lesser direct interest on the ground. • Have power to influence the system by reforming policies and taking actions whenever necessary.
D	Top Right	High	High	• Local development authorities and Pollution Control Boards. • Powerful stakeholders with high interest. • Directly involved in the sector and responsible for policy making, planning, wastewater management and monitoring on the ground.

Appendix 5: Network graphs for Chennai, Mysuru and Coimbatore

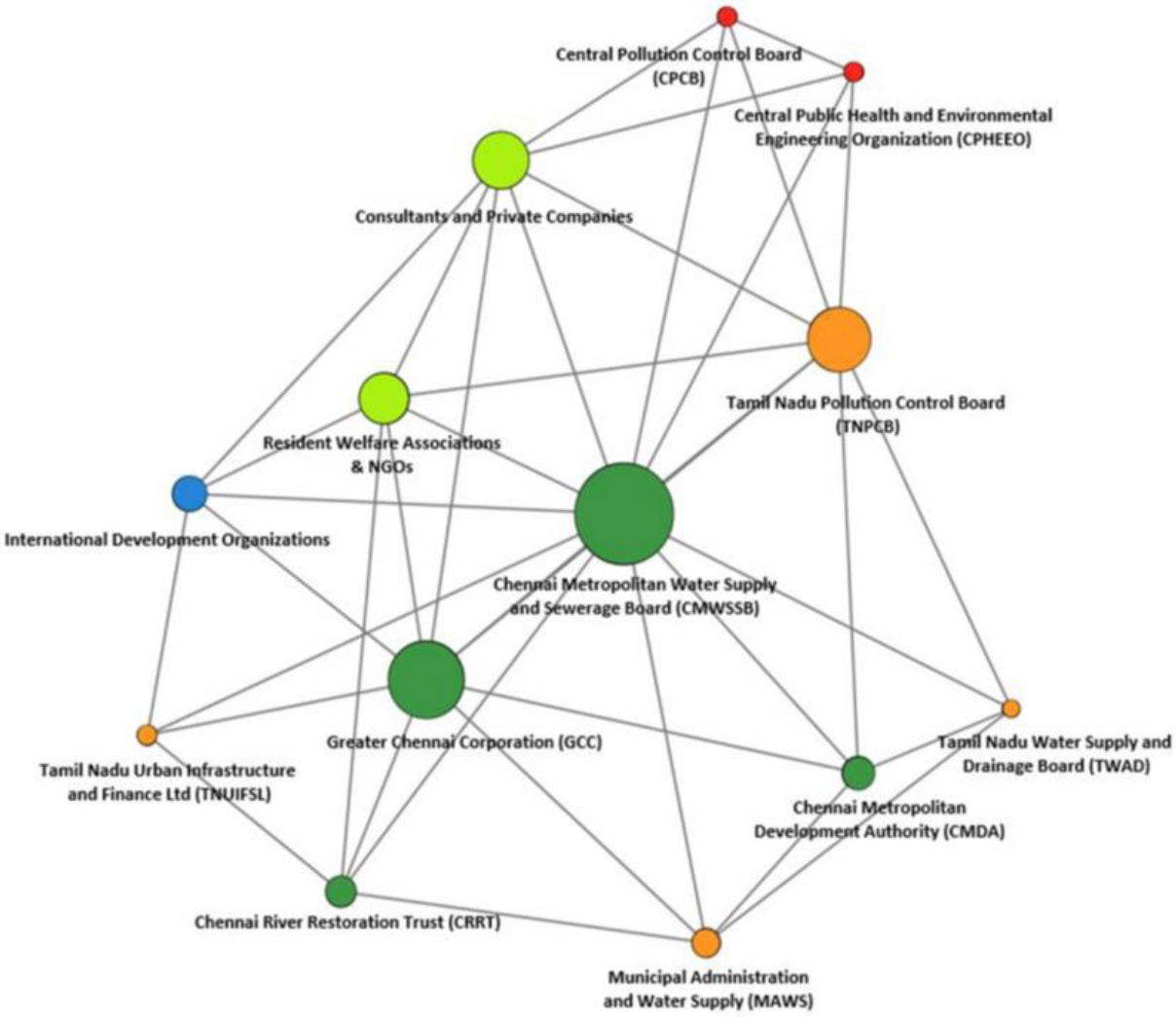

Figure 22: Network graph for Chennai, illustrating how SSS stakeholders at city, state and national levels exchange among themselves. Colours of stakeholders are as in Figure 8 on p. 52; sizes of nodes are relative to outdegree centrality, i.e., the number of connections mentioned by each stakeholder. Figure source: Narayan et al. (2020).

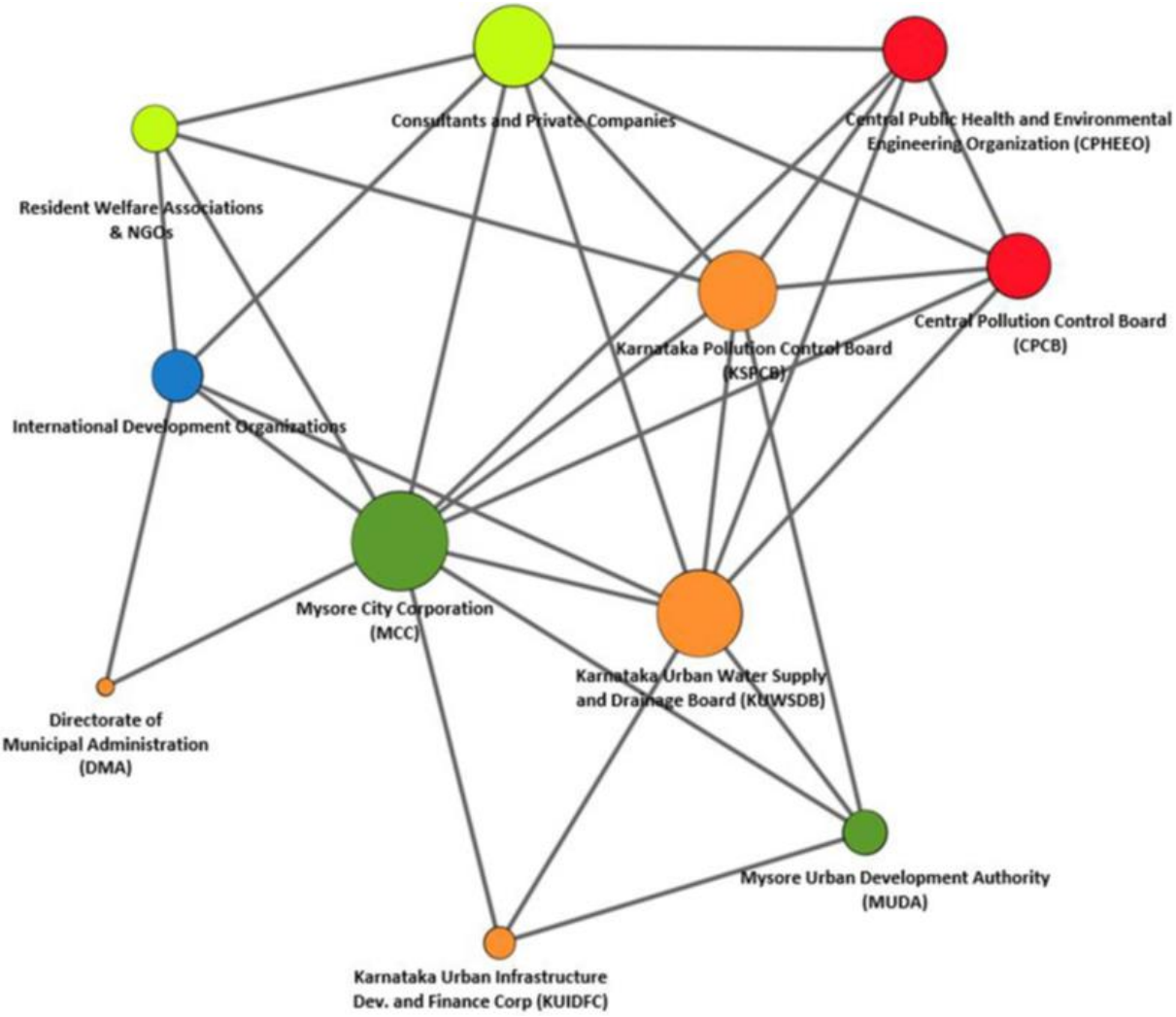

Figure 23: Network graph for Mysuru, illustrating how SSS stakeholders at city, state and national levels exchange among themselves. Colours of stakeholders are as in Figure 8 on p. 52; sizes of nodes are relative to outdegree centrality, i.e., the number of connections mentioned by each stakeholder. Figure source: Narayan et al. (2020).

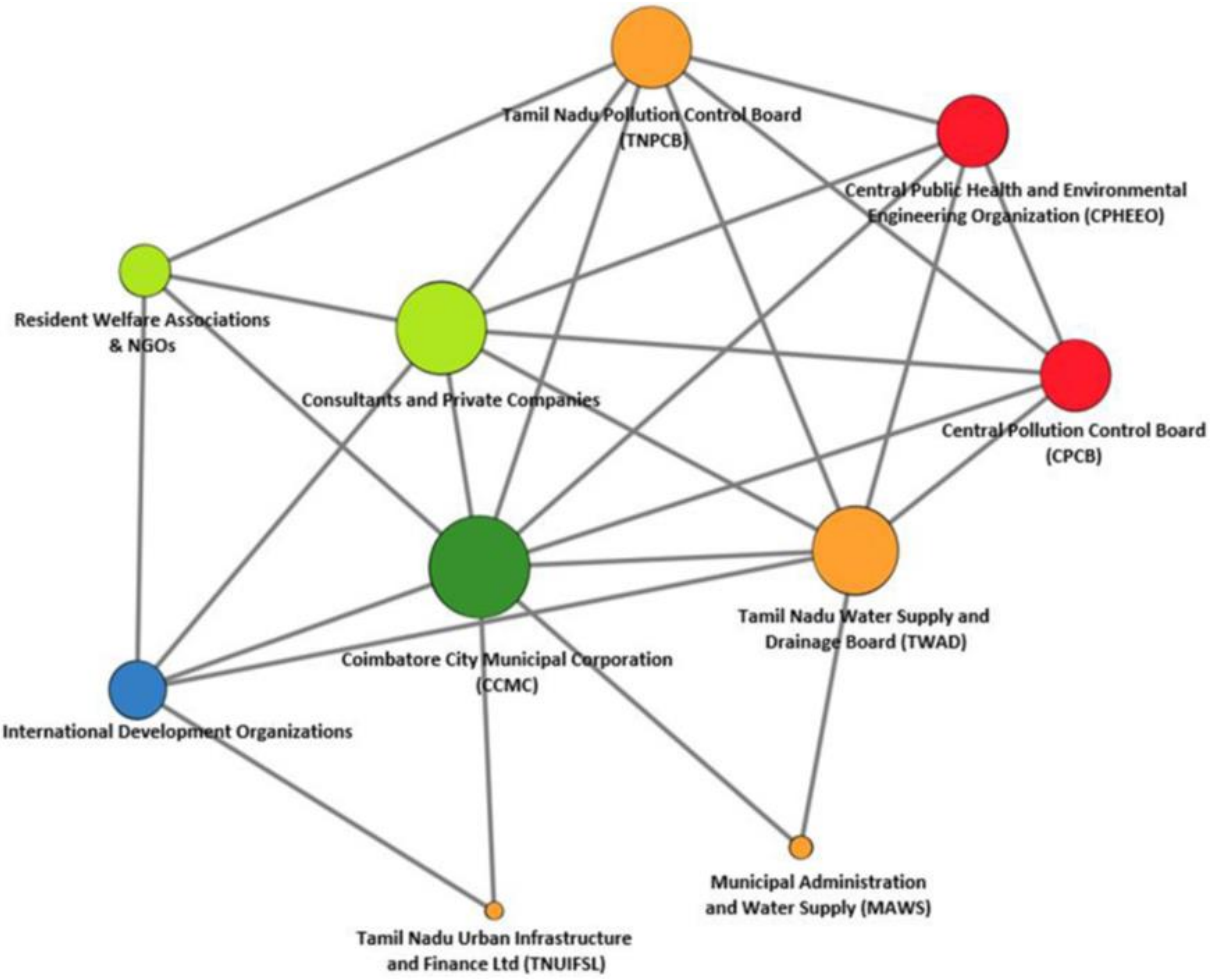

Figure 24: Network graph for Coimbatore, illustrating how SSS stakeholders at city, state and national levels exchange among themselves. Colours of stakeholders are as in Figure 8 on p. 52; sizes of nodes are relative to outdegree centrality, i.e., the number of connections mentioned by each stakeholder. Figure source: Narayan et al. (2020).

Small-scale sanitation (SSS) systems (also known as decentralised or distributed sanitation systems) have great potential in areas where extending trunk sewerage infrastructure is too costly or otherwise challenging, and where there is a necessity to reuse treated water. Small-scale sewage treatment plants (SSTPs) are the core component of an SSS system. By removing pollutants from sewage and greywater, they reclaim valuable water for toilet flushing, irrigation of urban gardens and other purposes. Thereby, such systems simultaneously contribute to healthy and water-secure cities.

In urban India, thousands of these small-scale wastewater treatment and reuse systems already exist. These units are mostly implemented and operated at building level by the private sector, largely as a result of various pollution abatement and water saving policies. However, they often do not achieve the desired performance and create substantial financial burdens for their owners and operators.

The research project Small-Scale Sanitation Scaling-Up (4S) was the first systematic assessment of SSS systems in South Asia. This report deals with the governance of SSS in India. It presents the results from an analysis of the stakeholders, policies and institutional arrangements for SSS and provides recommendations for stakeholders.

Eawag (the Swiss Federal Institute of Aquatic Science and Technology) together with the Indian Institute of Technology Madras, BORDA (Germany), CDD Society and other partners implemented 4S under the auspices of the Indian Ministry of Housing and Urban Affairs. The project was conducted between 2016 and 2018 and jointly funded by the Bill & Melinda Gates Foundation (main donor) and the German Federal Ministry for Economic Cooperation and Development.

Project website: www.sandec.ch/4S