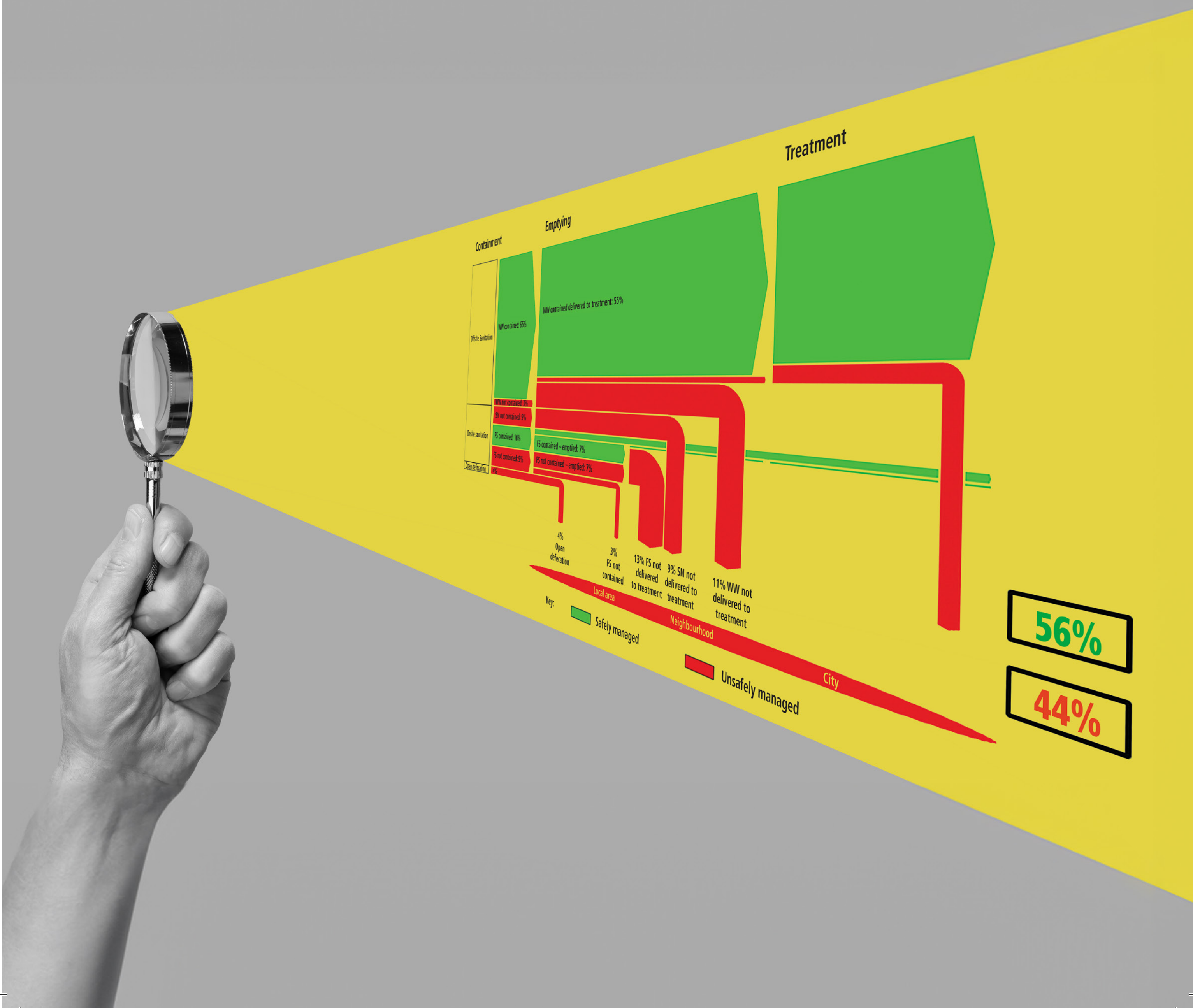
SHIT FLOW DIAGRAM (SFD)

A RESOURCE BOOK FOR PRACTITIONERS



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A RESOURCE BOOK FOR PRACTITIONERS

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Foreword

Urban sanitation systems thinking has undergone a significant change—from infrastructure creation as a measure of progress, to service-level improvement, and now to equity and justice in sustainable service delivery.

The Shit Flow Diagram tool unbundled the sanitation service value chain into distinct components with the aim of addressing service-level improvements at the different stages of the sanitation service chain. Identifying where the sanitation sub-systems were faltering and the specific priorities for rectification. It helped as an advocacy tool as well as a capacity development tool for fixing the challenges of both sewered as well as non-sewered sanitation systems.

The SFD Practitioners Resource Book can serve as a useful learning guide for trainers and practitioners, on how to plan and conduct SFD capacity development trainings. The combination of a graphic representation along with a narrative statement of the problem and its potential solution is a unique feature of the SFD tool. The SFD tool and this resource book is also useful for experts and practitioners from sectors other than WASH, where we deal with a range of processes and sub-systems.

The resource book contains both lessons from SFD implementation in India, as well as a set of training content and collaterals, including critical exercises and case studies that were developed and refined in during the practical trainings conducted by CSE in Africa, Asia and India.

We hope this resource book will help serve as useful learning content, and act as a record of SFD capacity development work done in the last decade.

The SFD tool can be developed further in the coming years, integrating more aspects—from the reuse of treated wastewater and bio-solids, to how inclusion is mapped along the different components of the service value chain.

We would like to thank the Gates Foundation and all our partners in Africa and Asia that partnered with us in this initiative.

Depinder S Kapur
Director
Water Programme
Centre for Science and Environment

Executive summary

Growing inequity in access to affordable and inclusive sanitation infrastructure and services is a major challenge for cities in the Global South. Poor sanitation systems in Global South cities not only result in environmental pollution, it is also a public health issue and, above all, a justice and equity issue.

Maintaining the integrity of the water and nutrient cycle—treating used water and harvesting bio-solids for reuse—remains the focus of CSE's work. The Global South water-sensitive cities framework of CSE[1] addresses the issue of equity, justice and the circular economy of urban water and wastewater.

The Shit Flow Diagram (SFD) has been identified by CSE as an important advocacy tool in promoting a deconstructed sanitation service value chain—shown in a diagrammatic form to city planners and administrators—in areas where sanitation systems are breaking down. The SFD also illustrates the importance of non-sewered sanitation (NSS) systems as an urgent and a paradigm-changing approach to addressing urban sanitation challenges in Global South cities.

In 2014, CSE partnered with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), EAWAG, University of Leeds and Loughborough University to constitute the SFD Promotion Initiative (SFD-PI). This partnership aimed at developing and field-testing the SFD tool, and its applicability for advocacy and urban sanitation planning. The SFD-PI is funded by the Bill and Melinda Gates Foundation (BMGF), and has run in three phases, from 2014 to 2022. Under the SFD project, 252 SFD reports for 234 cities worldwide have been developed, peer-reviewed and published in the Sustainable Sanitation Alliance (SuSanA) portal. CSE has contributed to the preparation of 130+ SFDs across India, Bangladesh, Nepal, Tanzania, South Africa, Ghana and the Caribbean.

What this resource book contains

- Key learnings from the SFD project: sections 1–3
- Lessons from SFD capacity development: section 4
- Learning collaterals from undertaking SFD capacity development/trainings: section 5

Further development of the SFD tool will also benefit from a nuanced framing of water-sensitive cities for which some initial steps have already been taken in terms of creating disaggregated SFDs for poor settlements within a city.

KEY LEARNINGS FROM CSE'S SFD PROGRAMME

ENGAGEMENT AND ACHIEVEMENTS

PART-A

1 Introduction

1.1 Background

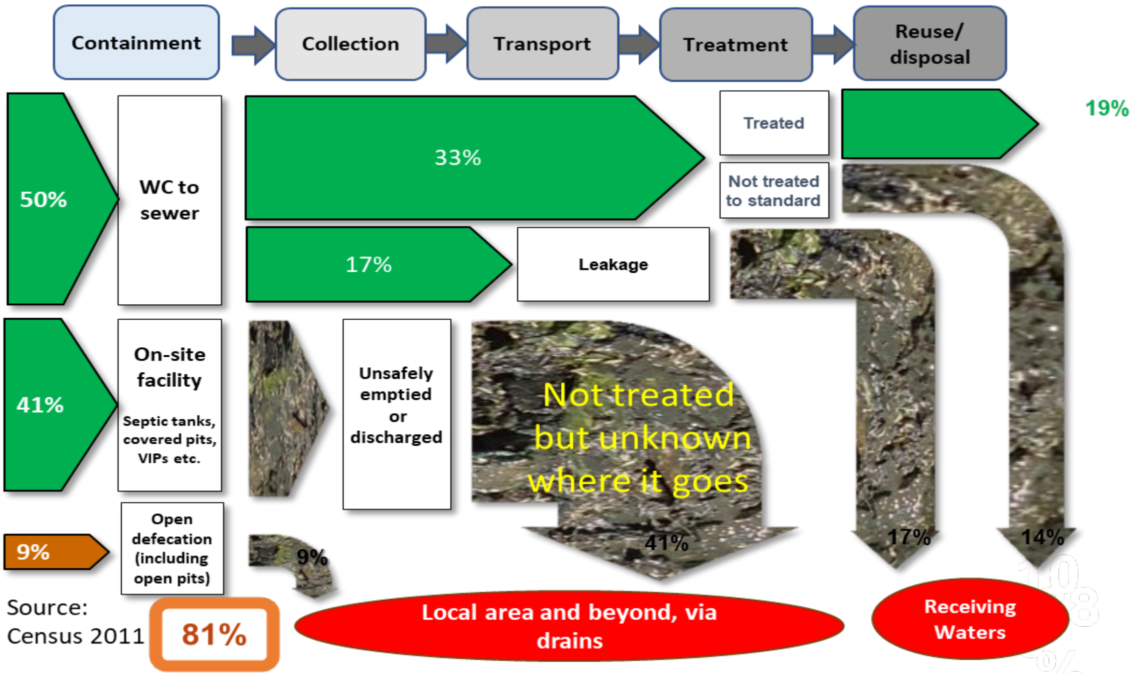
On World Water Day 2018, the UN Secretary General stated that "safe water and adequate sanitation are indispensable for healthy ecosystems, reducing poverty, and achieving inclusive growth, social well-being and sustainable livelihoods".[2] According to the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 46 per cent of people living in urban areas—around 1.9 billion people worldwide—do not have access to safely managed sanitation services. While this marks an improvement from 2014, when 53 per cent lacked such access, the rate of progress still falls short of what is required to meet the targets for adequate and equitable sanitation that were set in the Sustainable Development Goal 6.2.[3]

In 2011, the Centre for Science and Environment (CSE), published 'Excreta Matters,' a seminal study that examined the status of water and wastewater management across 71 cities in India. At the time, millions of people in India were still practicing open defaecation, their faeces left exposed in fields or behind bushes, in ditches, or in open water bodies. But this was not the only route by which faecal matter pollutes the natural environment. Leaky sewer pipes, overloaded sewage treatment plants, septic tanks that emptied into open drains, and illegal dumping of faecal sludge, all played a role. Indian cities were simply growing too fast for their patchwork sanitation systems to keep up.[4]

As per the Census of India 2011, more than 87 per cent of people in Indian cities had access to a toilet and only 20 per cent of urban Indians had no toilet or used a public latrine. However, most of those toilets connected to septic tanks or flowed into open drains. Only the top end, i.e. one third of urban households, had toilets that were connected to underground sewage networks. Even then, not all toilets were connected to treatment plants. Incomplete and leaking sewage systems contaminate rivers and lakes, causing diseases such as cholera.[5]

A biased approach when it comes to improving urban sanitation has disproportionately benefitted the better-off. For half a century, conventional wisdom in the sanitation sector has seen flush toilets linked to sewers as the 'gold standard' of sanitation, regardless of a city's level of economic development. However, these 'off-site' sanitation systems are only accessible to a very a small proportion of urban residents. Only 16 per cent of the urban dwellers in Sub-

Figure 1: Excreta management in urban India in 2011, as observed through an SFD



Source: CSE

Saharan Africa use sewered sanitation; in Central and Southern Asia, the figure is slightly higher, at 38 per cent.[6]

In most low-and lower-middle income countries, the sewers operated by utility companies have been built incrementally upon existing systems, laying new pipes to reach more households with sewer connections. Rarely, however, have these connections extended into poorer neighbourhoods, let alone unplanned, overcrowded settlements on urban peripheries that often lack basic amenities such as piped water and other municipal services. The fixation on sewers has hindered the development of inclusive, city-wide sanitation systems that serve the needs of all residents.[7]

The scenario in urban India was not much different. As per information extracted from the Census of India 2011, 41 per cent of the urban population in India had been using 'on-site' sanitation systems, nine per cent were defecating in the open, and the rest were connected to off-site sanitation systems. However, only 19 per cent of urban India's excreta was being safely managed across the sanitation value chain (see *Figure 1: Excreta management in urban India in 2011, as observed through an SFD*).

The challenge for India is to deal with excreta in ways that are affordable, sustainable and go beyond the modern engineering mind-set. New technologies and ways of thinking are essential for achieving sanitation that 'does not cost the Earth.'

In October 2014, India launched the Swachh Bharat Mission that aimed to make India open-defaecation free (ODF) by 2019 through the construction of 100 million new toilets in urban and rural areas. While access to dignified latrines is important, toilets are synonymous with sanitation. They are the first link in the 'sanitation chain' which begins with the containment of human excreta and extends to emptying, transport, treatment, and disposal or reuse.

1.2 Shit flow diagram (SFD)

The first step towards providing adequate sanitation services in urban areas is to monitor the sanitation service chain and identify its strengths and weaknesses. SFDs can help achieve this by offering a new and innovative way of engaging sanitation experts, political leaders and civil society members in coordinated discussions about excreta management in their cities.[8]

An excreta flow diagram (also described as a Shit Flow Diagram) is a tool to understand and communicate how excreta physically flows through a city or town. The graphic visualizes excreta flows—from the point where it is generated, through its flow, to its final disposal or reuse—and the proportions of it that are safely (and unsafely) managed at each step of the way.[9]

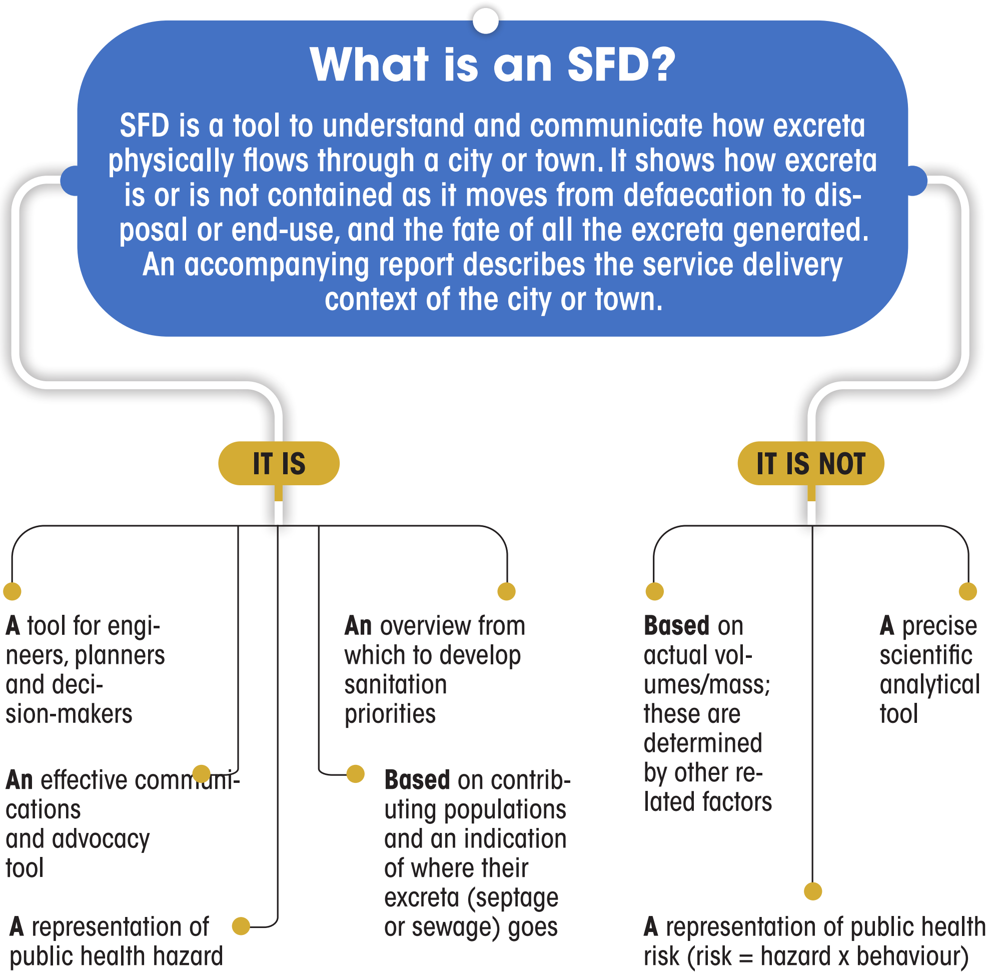
SFDs were originally developed by water and sanitation experts at the World Bank in 2013 as a tool to analyze sanitation systems in rapidly urbanizing areas where the majority of the people did not have access to toilets that connected to a sewer system. The graphics quickly found support in the global sustainable sanitation community that constituted a diverse group of institutions committed to promoting sanitation solutions for the 1.9 billion urban inhabitants worldwide who rely on on-site sanitation solutions, such as septic tanks and latrines.[10]

SFDs provide an alternative to using a traditional mix of statistics, diagrams and photographs, and allow for the presentation of a complicated picture of urban sanitation in a single image (see *Figure 2: What is an SFD?*).

Practitioners and decision-makers should prepare SFDs for the following reasons:

- An SFD presents a clear picture of how wastewater and faecal sludge management (FSM) services are delivered in a city, and the resulting challenges.

Figure 2: What is an SFD?



- The SFD is a diagnostic tool that helps in identifying the aspects of service delivery where improvements are needed.
- An SFD primarily provides technical and non-technical stakeholders with an advocacy tool to support decision-making on urban sanitation planning and programming.
- Importantly, an SFD does not provide a "shortcut" around integrated sanitation planning, promotion, investment, design, construction, operation and maintenance. These remain very necessary components for implementing successful urban sanitation.[11]

The process of creating an SFD includes collecting information about the service delivery context of a defined area and using the collected information to assess the situation. The information available or collected about the assessed area determines the level of SFD that will be produced. The different levels of SFD are:

Level 1—initial SFD

At this level, an SFD is developed with a limited amount of data or information (e.g. only desktop). Limited data may be available as a result of limited interviews or field visits conducted, or due to limited resources. Assumptions could be made during the process of developing an SFD with limited data. However, they should be clearly defined and justified. An initial SFD can be upgraded to a higher level when additional data is obtained.

Level 2—intermediate SFD

At this level, an SFD is developed where extensive data is obtained through interviews with stakeholders, from field visits and reports. Secondary data allows for validation of assumptions based on information received via interviews and/or field visits. An intermediate SFD provides a broader understanding of the sanitation service delivery situation and can be upgraded to a comprehensive level with the systematic collection of desktop data.

Level 3—comprehensive SFD

A comprehensive SFD is developed where at least the same amount of secondary data that has been used in the intermediate SFD is used, along with additional stakeholder engagement and systematic primary data collection. A comprehensive SFD is appropriate for informing the planning of service improvement options or budgeting decisions.

The data/information collected is used to develop—(i) an SFD graphic and (ii) compile an SFD report for the area assessed. Both of these components are required to understand the sanitation journey of the city.

2 SFD project at CSE

2.1 SFD promotion initiative

During 2012–13, the Water and Sanitation Program (WSP) of the World Bank carried out an analysis of excreta management in 12 cities and developed new tools for assessing the context and outcomes related to the flow of excreta through the city. This study aimed at providing a more comprehensive understanding of excreta management along the sanitation service chain (see *Box 2: SFDs as CSE sees it*).

Building on this work, a group of institutions active in the field of excreta management convened in June 2014 to further develop SFDs, and in November 2014, a one-year project titled the SFD Promotion Initiative (PI) was initiated, funded by the Bill & Melinda Gates Foundation. The organizations mentioned below constitute the steering committee of the SFD-PI:

- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Germany
- Centre for Science and Environment, India
- University of Leeds, The United Kingdom
- Department of Sanitation (SanDec), Swiss Federal Institute of Aquatic Science and Technology (EAWAG), Switzerland
- Water Engineering and Development Centre, Loughborough University, The United Kingdom

This SFD-PI is managed by GIZ under the umbrella of the Sustainable Sanitation Alliance. The roles and responsibilities of the steering committee include:

- Providing overall strategic orientation for the initiative
- Formally adopting materials produced by the initiative
- Reviewing SFDs
- Deciding on critical issues concerning implementation
- Conceptualizing a scale-up plan for the global roll-out of SFDs
- Arbitration, in case of conflict

SFD, AS CSE SEES IT

SFDs represent the existing sanitation situation of the city and clearly depict how only a few privileged people get better services compared to the majority of the population who are from low- and middle-income groups. It also suggests which stage of sanitation needs the most attention, or, in other words, it helps decide the priority areas where interventions should be planned.[12]

Under the SFD-PI, CSE has refined the methodology for data collection and analysis, which feeds into the graphic generator. It has also field-tested the graphic, contributing to the preparation of SFDs for more than 130 cities across India, Bangladesh, Nepal, South Africa and Ghana, among other countries. During the Covid-19 lockdown, CSE provided technical support for the preparation of SFDs for more than 30 cities across India, Bangladesh, Nepal, South Africa and the Caribbean. CSE has advocated the use of SFDs as an advocacy tool, a baseline assessment tool, a tool for city-wide sanitation planning, and for field-testing spatial inequities with respect to sanitation in cities.

In addition to field-testing and populating the SFD database, CSE has worked to develop a community of practice for SFDs. It has conducted more than 19 capacity-building workshops/ programmes and training of trainers for the preparation of SFDs in India, Bangladesh, South Africa, and through online courses, capacitating more than 350 practitioners on the preparation and use of SFDs, across South Asia, Africa and the Caribbean.

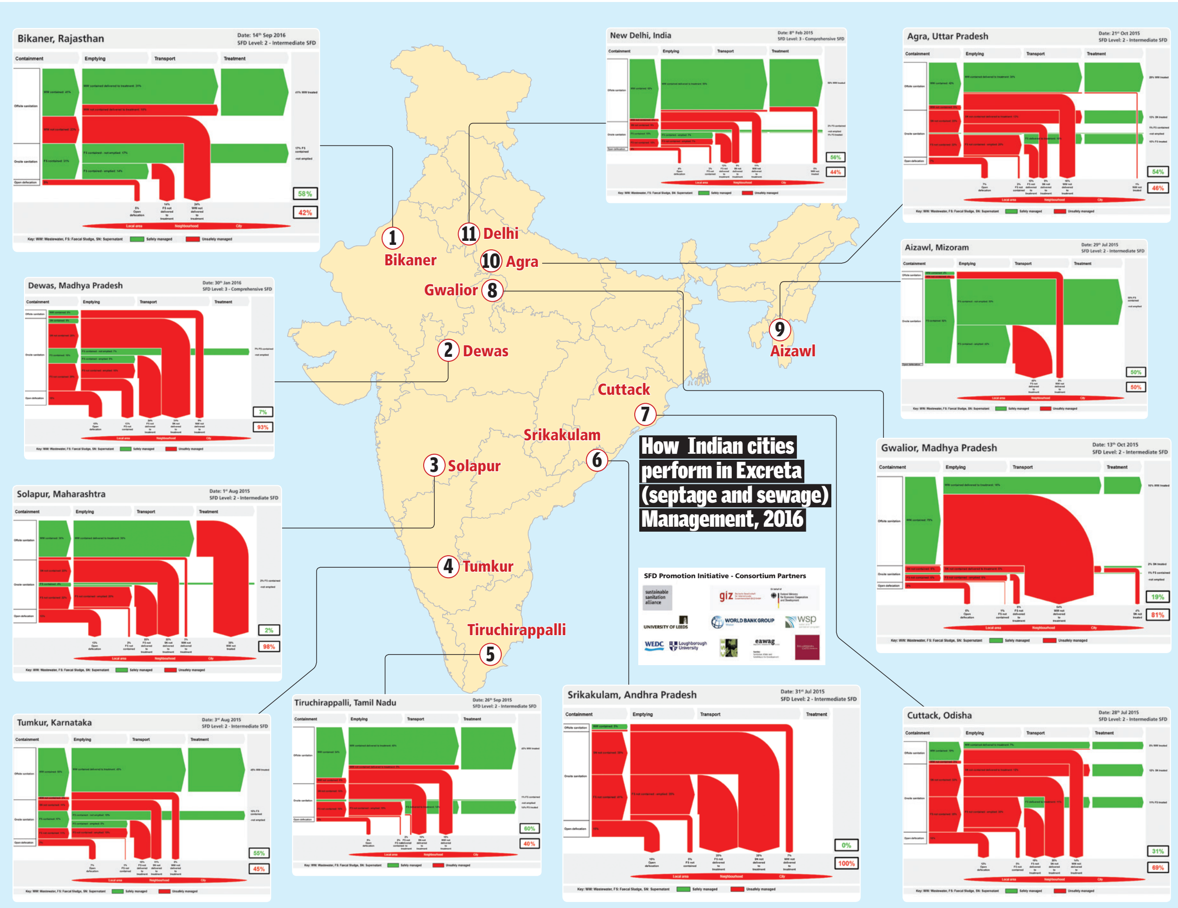
2.1.1 SFD-PI Phase-1

The SFD-PI Phase-1 was a one-year, kick-start project, started in 2014, under which the SFD-PI Steering Committee was formulated. The aim of the SFD-PI Phase-1 project was to field-test the SFD tool, and its applicability for advocacy, urban sanitation planning, and further fine-tuning of the graphic generator. At the same time, the peer review process was put in place to review reports and further develop the urban sanitation database globally.

The objective of Phase-1 of the initiative was the development and rollout of SFDs along with service delivery context analysis by testing the approach/tools in 50 cities worldwide. CSE developed SFDs for 11 cities in India in 2016 (*see Figure 3: SFDs for 11 cities developed under Phase-1*), from different parts of the country representing different agro-climatic regions. These cities were also covered under the publication, 'Excreta Matters'. Under Phase-1, the consortium developed a suite of tools and instruments that can be used at the local level to facilitate an analysis of urban sanitation challenges.

> "The aim of the SFD Promotion Initiative was to set off a series of 'controlled explosions' in the sanitation sector. The idea was to shake up the dominant thinking at the time, which saw most of the investments going into big pipes, treatment plants and other types of infrastructure."
> – Dr Arne Panesar, GIZ[13]

Figure 3: SFDs for 11 cities developed under Phase-1



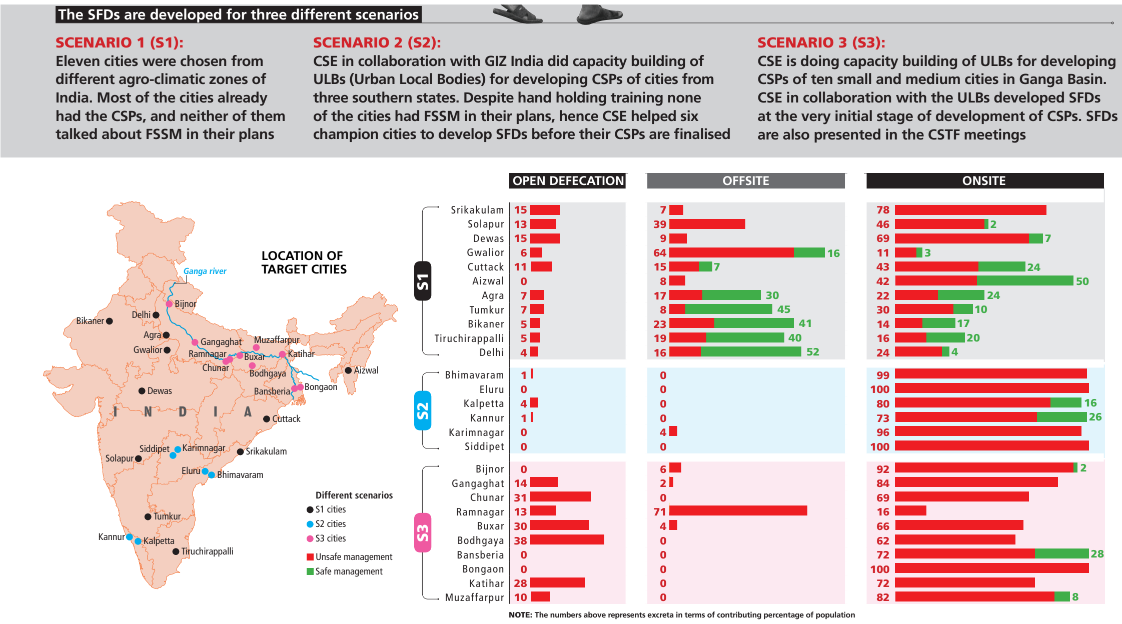
Source: CSE (retrieved from: https://www.cseindia.org/using-excreta-flow-diagrams-sfds-as-an-integral-part-of-city-wide-sanitation-planning-for-indian-cities-8677)

2.1.2 SFD-PI Phase-2

The SFD-PI Phase-2 project was designed as a two-year project, building on the one-year kick-start phase. The aim of this project was to roll out the use of SFDs as a decision support and advocacy tool with the active participation of city stakeholders. This phase ran from 2015–2019. Under this phase, the template for the SFD reports and the graphic generator were also developed and fine-tuned.

Phase-2 of the initiative was based on a demand-driven approach (unlike Phase-1 in which the consortium had chosen the cities). CSE, along with partner institutions, provided support to participating cities and towns that were keen on developing SFDs for their cities and use it as a planning tool to improve the sanitation of the city. Under Phase-2, the existing tool was refined based on empirical validation. Key elements of Phase-2 include:

Figure 4: SFDs for 27 cities developed under Phase-2



Source: CSE (retrieved from: https://www.cseindia.org/using-excreta-flow-diagrams-sfds-as-an-integral-part-of-city-wide-sanitation-planning-for-indian-cities-8677)

- Roll-out support activities
  - Open access to SFD preparation content
  - Discussion forum in the SFD web portal
  - Feedback documentation
- Operational support
  - On-field support to ULBs
  - Training and capacity building of trainers and practitioners
  - Help desk support to promote 'do-it-yourself' SFDs
- Refinement of tools and methods
  - Ready-to-use tools for city authorities and their partners
  - Online tutorial on how to use tools and methods
  - QA & QC of SFDs produced

Under this phase, CSE developed more than 70 SFDs for various towns and cities in India. CSE also developed the methodology for data collection and analysis, introducing the data triangulation method, and the context-adapted SFD. The 2014 research of 11 cities was further expanded to 27 cities, where SFDs were introduced at different stages in the preparation of their city sanitation plan (*see Figure 4: SFDs for 27 cities developed under Phase-2*).

In the cities under the study, most of the city sanitation plans (CSP) neglected faecal sludge management (FSM) and went for conventional sewerage systems.

Since no SFDs are available for Scenario 1 before CSPs were produced, the onsite systems were not acknowledged. It is evident from the SFDs of these cities that there is a serious problem when it comes to handling septage/faecal sludge—from containment to disposal. There is also a major issue with the effluent from onsite systems. Generally, this effluent ends up into the stormwater drain/open drain, which then ends up into a water body or in the local environment.

It was concluded that SFDs have proven to be a good evaluation and advocacy tool. Decision-makers and citizens get a better idea of the critical points of failure in the urban sanitation services of a city or town. In addition to aiding city-wide sanitation planning, SFDs were also used to advocate for faecal sludge management (FSM) in the Ganga basin. SFDs were developed for 10 cities that were along the Ganges, and whose excreta was being largely mismanaged, finding its way to the river Ganga (*see Figure 5: Ganga in peril, 2017*).

The National Urban Sanitation Policy (NUSP)[14] introduced two key planning tools—State Sanitation Strategy (SSS) and City Sanitation Plan (CSP). With the launch of

Figure 5: Ganga in peril, 2017

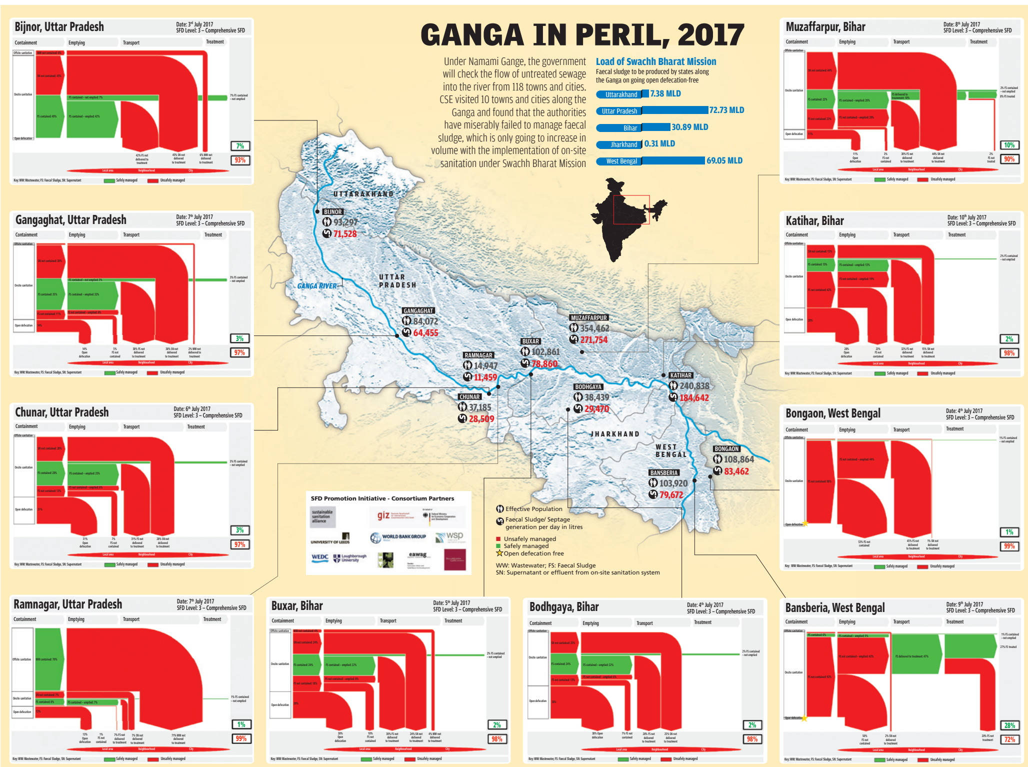


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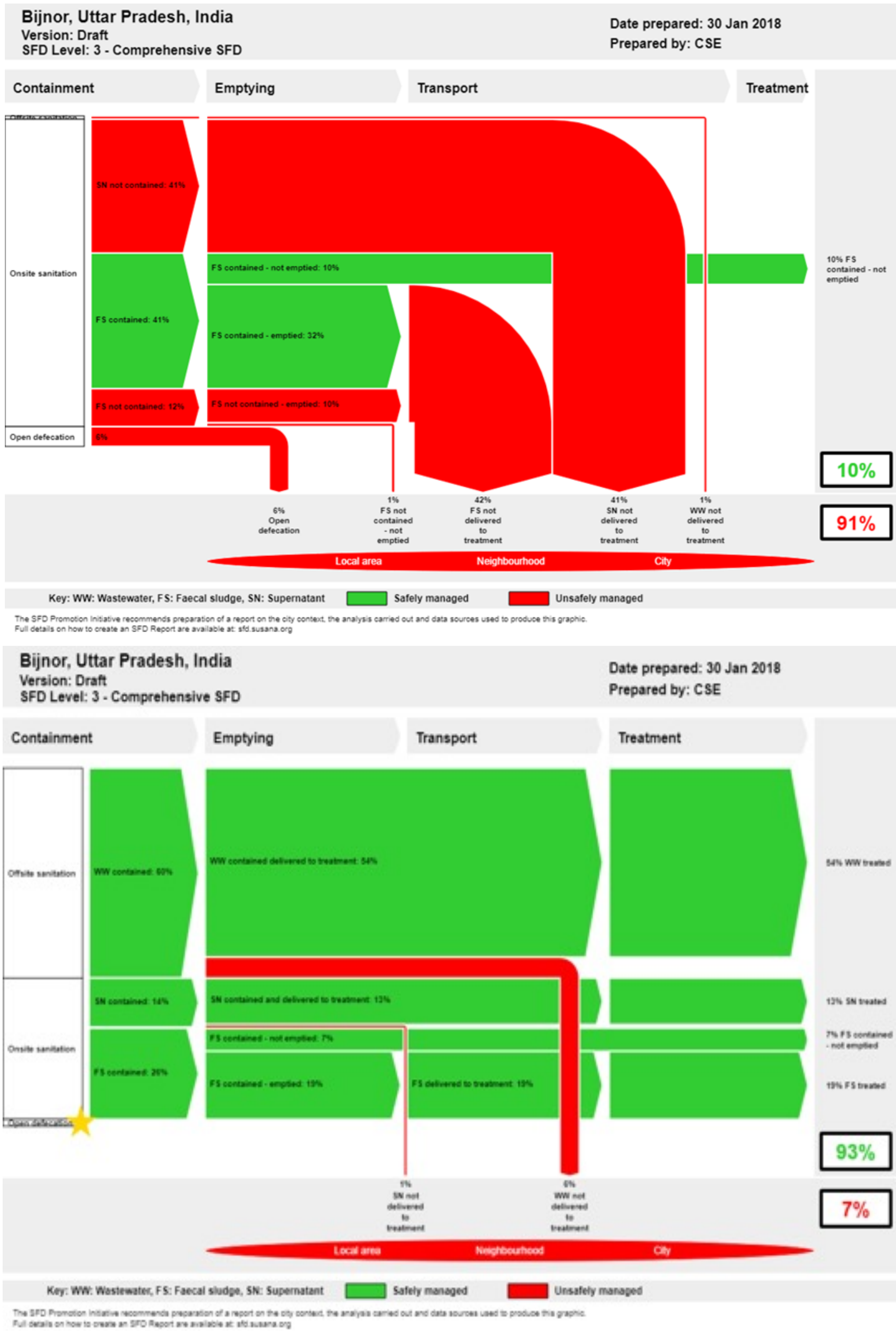
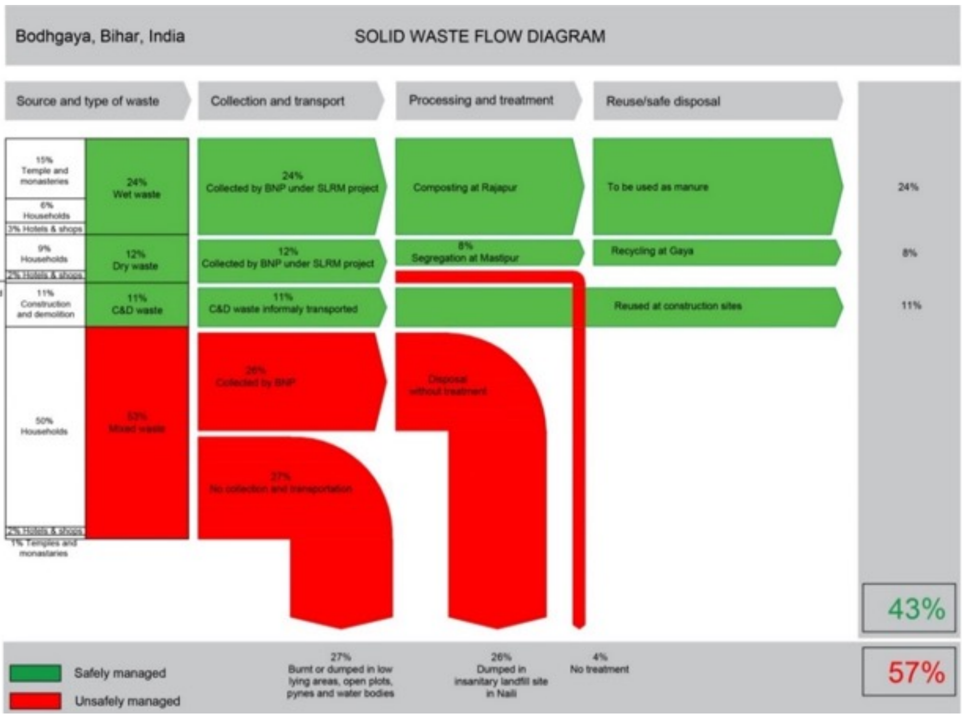
Figure 6: Existing (2017) and projected (2033) SFD for Bijnor area



Source: City sanitation plan for Bijnor, 2033 (prepared by CSE) the Swachh Bharat Mission (SBM) and the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) in 2015–16, India embarked on the journey to end open defecation and improve the sanitation scenario in India. CSE, in partnership with GIZ, prepared the toolkit for, 'Preparation for City Sanitation Plan,' and conducted a series of hand-holding exercises with state and municipal officials for preparing the city sanitation plans (CSP). A key component of the CSP is preparing a baseline of the sanitation value chain which is developed using the SFD tool. CSE prepared two model CSPs in 2017–18—for Bijnor (Uttar Pradesh) and Bodhgaya (Bihar). As part of the CSP, a comprehensive SFD was developed for both towns. Furthermore, a projected SFD was also developed, which showcased what the situation would be if all interventions were implemented over a period of 15 years (see *Figure 6: Existing (2017) and projected (2033) SFD for Bijnor area)*.

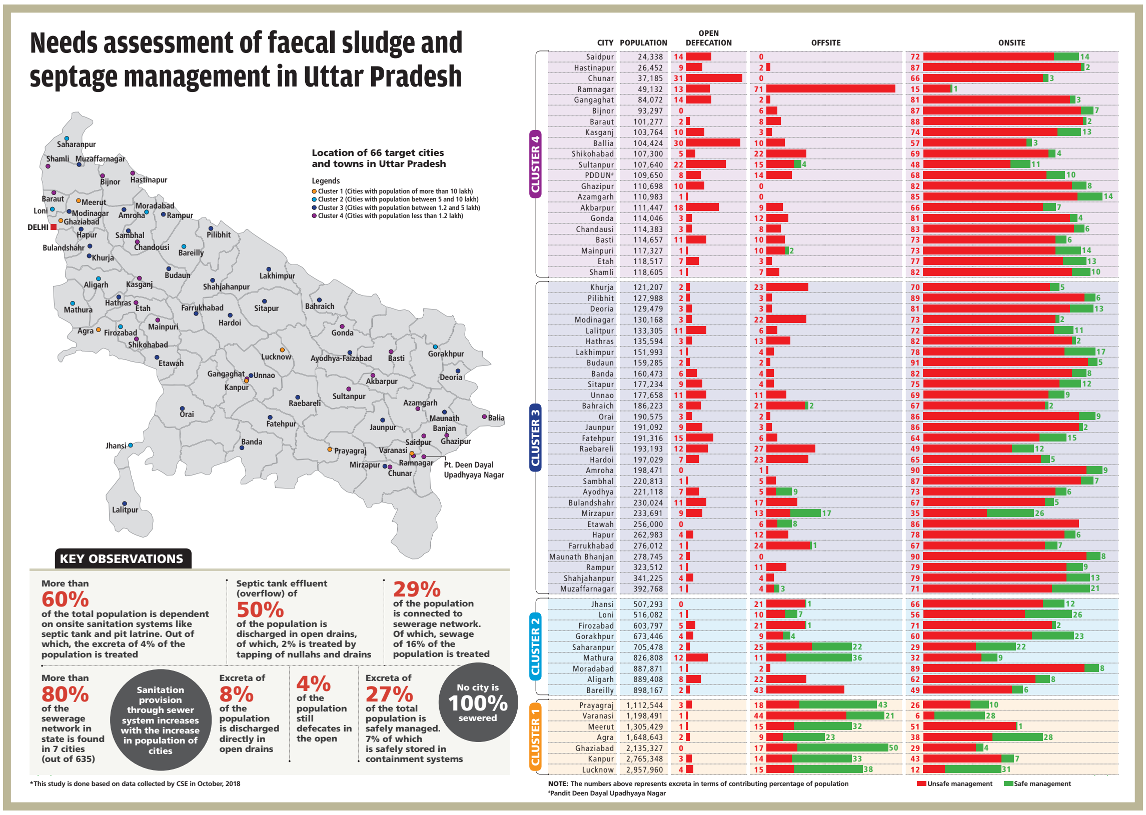
The CSP also covers water supply, stormwater management, access to sanitary toilets and solid waste management. Its larger objective is to integrate urban services. In order to assess the municipal solid waste flow, CSE used the SFD tool to prepare a Solid Waste Flow Diagram (SWFD). In the SWFD, the type of containment is replaced by the source of waste, while the collection and transport, processing and treatment, and reuse and safe disposal are the replaced components of the sanitation value chain (see *Figure 7: Solid waste flow diagram for Bodhgaya)*.

Figure 7: Solid waste flow diagram for Bodhgaya



Source: City Sanitation Plan for Bodhgaya – 2033 (prepared by CSE)

Figure 8: Needs assessment for FSSM in Uttar Pradesh



Source: Rohilla, S.K., Luthra, B et al 2019. Managing Septage in Cities of Uttar Pradesh: An analysis

CSE signed a Memorandum of Understanding (MoU) with the Government of Uttar Pradesh and National Mission Clean Ganga to provide technical support in the implementation of faecal sludge management (FSM). In order to understand the existing situation of excreta management of cities, CSE developed SFDs for 66 major cities in Uttar Pradesh. An urban sanitation strategy was developed for improved river health. These 66 cities were divided into four clusters, based on the population size as mentioned below. These 66 cities represent 60 per cent of the urban population of Uttar Pradesh (*see Figure 8: Needs assessment for FSSM in Uttar Pradesh*).

1. Cluster 1—cities with a population of more than one million
2. Cluster 2—cities with a population between half to one million
3. Cluster 3—cities with a population between 0.12 and 0.5 million
4. Cluster 4—cities with a population of less than 0.12 million

The SFDs for the four clusters provide a case for developing context-specific strategies for city-wide sanitation planning for towns and cities of different sizes

Figure 9: Cluster SFDs for Uttar Pradesh, 2018

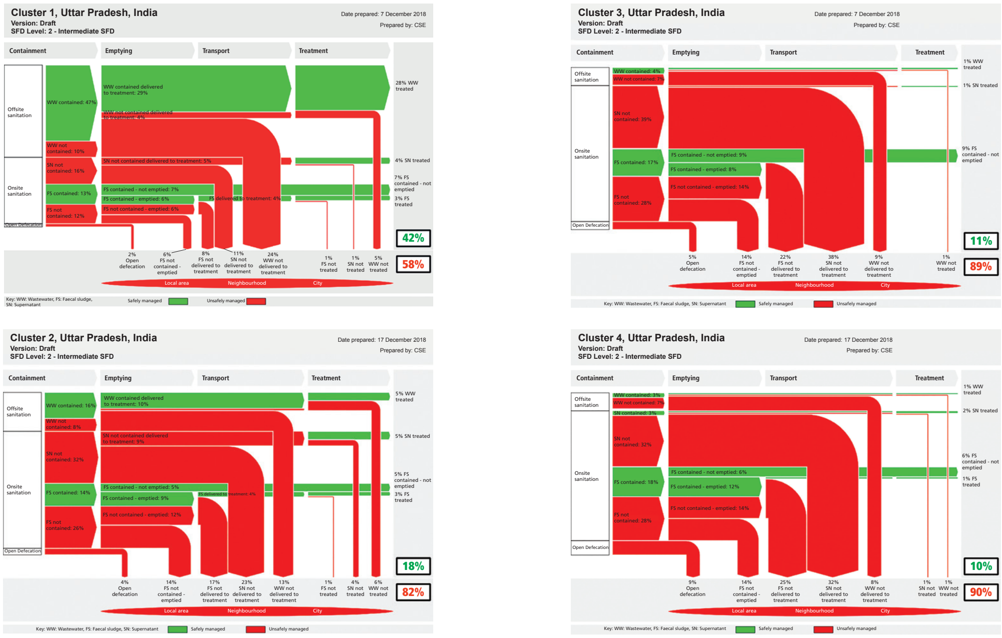
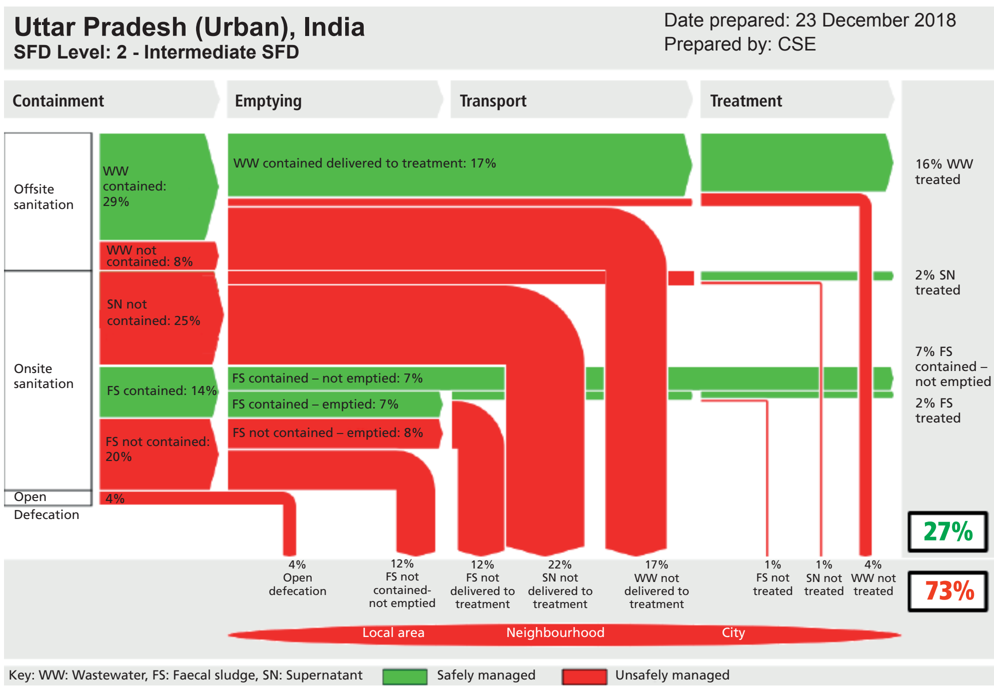


Figure 10: SFD for urban Uttar Pradesh, 2018



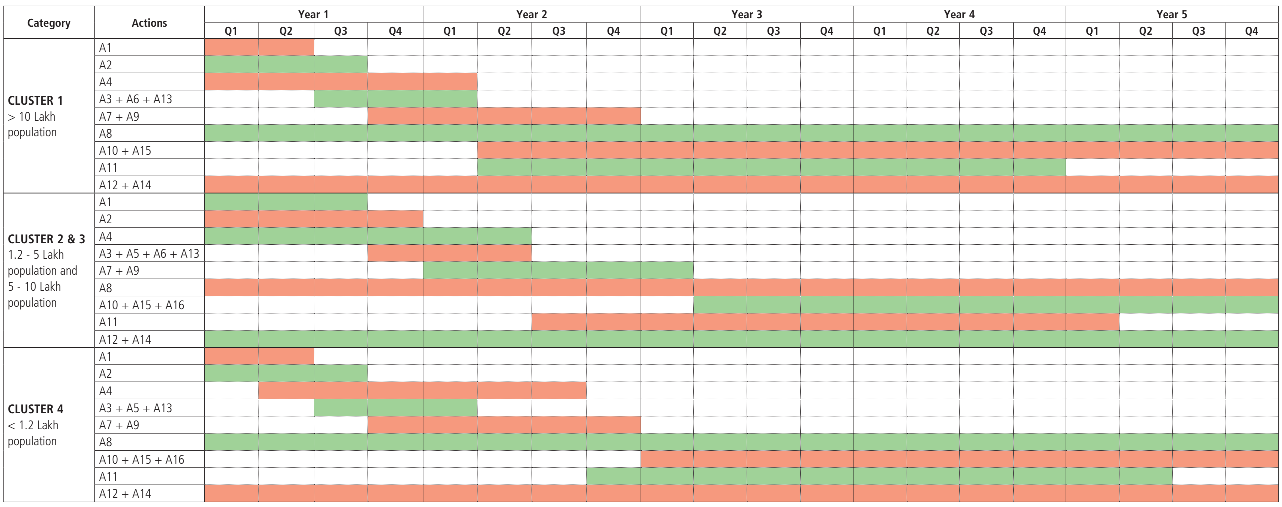
Note: This SFD is done based on study of 66 towns and cities, representing 60% of urban population in UP
To know more about SFDs, visit https://sfd.susana.org

Source: Rohilla, S.K., Luthra, B et al 2019. Managing Septage in Cities of Uttar Pradesh: An analysis (see *Figure 9: Cluster SFDs for Uttar Pradesh, 2018*). A composite SFD for urban UP was prepared, which showcased that the excreta of 73 per cent of the population in the urban areas of UP is not safely managed (see *Figure 10: SFD for urban Uttar Pradesh, 2018*). Based on this analysis, a five-year action plan for faecal sludge and septage management (FSSM), and city-wide sanitation was prepared for each of the four clusters (see *Figure 11: Proposed action plan and FSSM approach for urban areas in Uttar Pradesh, 2018*).

CSE organized the SFD Week from 2–5 April, 2019, where professionals discussed how to implement the best management practices across the sanitation chain for both wastewater and faecal sludge management. The idea behind the conclave was to bring great minds together to deliberate on existing urban sanitation challenges and possible solutions.

The major objectives of the conclave were to reinvent the management of wastewater, faecal sludge and septage for pollution abatement. This includes

Figure 11: Proposed action plan and FSSM approach for urban areas in Uttar Pradesh, 2018



A1: Baseline data collection and formation of City Sanitation Task Force

A2: Preparation of city - level strategy on Faecal Sludge and Septage Management including decentralised liquid waste management

A3: Regulating & licensing of private desludgers and installation of GPS devices in each vacuum tanker (ULB-owned and private)

A4: Preparation of Citywide Sanitation Plan

A5: Identification, construction and designation of trenching sites for safe disposal of faecal sludge, till the time scientifically - designed treatment plant is in place

A6: Operationalising co-treatment at existing STP and/or co-composting with municipal solid waste wherever feasible for safe treatment of collected FSS

A7: Construction and commissioning of faecal sludge treatment plants with effective reuse of by-products (wherever feasible) for safe management of all the collected FSS

A8: Capacity building programme for ULB, service providers, masons, operators etc.

A9: Ensure adequate manpower and efficient equipment for collection and transport of FSS

A10: Implement scheduled desludging, initially on a pilot-scale and eventually extending across the city

A11: Operationalise decentralised wastewater treatment systems for the effluent generated from onsite sanitation systems and greywater

A12: All households with individual toilet in non - sewered areas to have safe onsite sanitation system

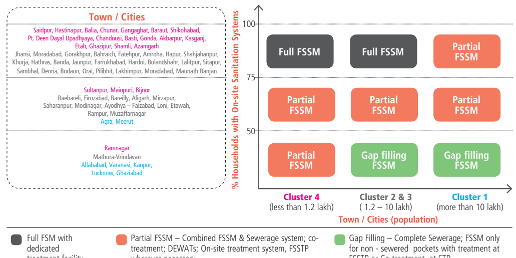
A13: Incorporate FSS co-treatment modules in the STPs which are in planning/designing/construction phase

A14: Conduct GIS survey for geo-tagging of all properties in the city

A15: Ensure enforcement of 'The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013' and provisions for penalising the defaulters

A16: Gap analysis and construction & commissioning of FSTP(s) for safe management of all the generated FSS , in conjunction with the

PROPOSED FSSM APPROACH FOR URBAN AREAS IN UTTAR PRADESH



Source: S.K., Luthra, B et al 2019. Managing Septage in Cities of Uttar Pradesh: An analysis identifying the best-suited technologies and other related aspects such as sharing knowledge on the enforcement of policies related to faecal sludge and septage management (FSSM), guidelines, regulation, behaviour change and more, that are all aimed towards pushing for the convergence of national programmes like Swachh Bharat Mission, AMRUT and Namami Gange.

Experts from different parts of the world were invited to be part of the conclave—14 international and 30 national speakers shared details of their work, and followed it with an engaging question-and-answer session. Around 140 participants (including government officials, NGOs, academicians, researchers and practitioners) attended the SFD Week.

At the end of phase-2, CSE prepared more than 100 SFDs (65+ for states on the Ganga basin and the rest for other cities in India). CSE has made considerable contribution to supporting the production and review of good-quality SFDs as well as helping train practitioners. A demonstrated impact is the uptake of the approach by local, regional and national organizations and governmental agencies, particularly in India, South Africa (Water Research Commission (WRC) launched a national campaign with CSE's technical support), and in state/cities in Africa and South Asia, where SFDs are widely used for advocacy, and as a tool to map the progress across the sanitation value chain.

2.1.3 SFD-PI Phase-3

The SFD Phase-3 project was initiated in 2019 as a two-year project aimed at scaling up the Shit Flow Diagram approach to bridge existing gaps in the availability of data for monitoring safely-managed sanitation (SDG 6.2), improved city-wide sanitation planning and effective sanitation investments in urban areas. The following outcomes were envisaged under Phase-3

Catalyze long-term sustainability of the SFD initiative by establishing a 'Forum of Cities' that manages faecal sludge and septage. A pre-requisite for being part of the forum would be that a city should have a credible SFD. Similarly, advocacy will push for the integration of SFDs in national/state-level policies and programmes.

Rapidly expand the SFD database by handholding approximately 150 cities in developing SFDs (at least 25 cities in Africa and South Asia), with a sizeable number (40–50 per cent) added to the global database, by setting up off-site/ remote 'helpdesk services' that provide services such as support to partners to set up a similar helpdesk in at least one country in Africa and South Asia. Furthermore, capacitate 750 practitioners to develop SFDs for their cities.

Field test and pilot/implement the upgraded SFD tools developed by the University of Leeds in at least 10 cities.

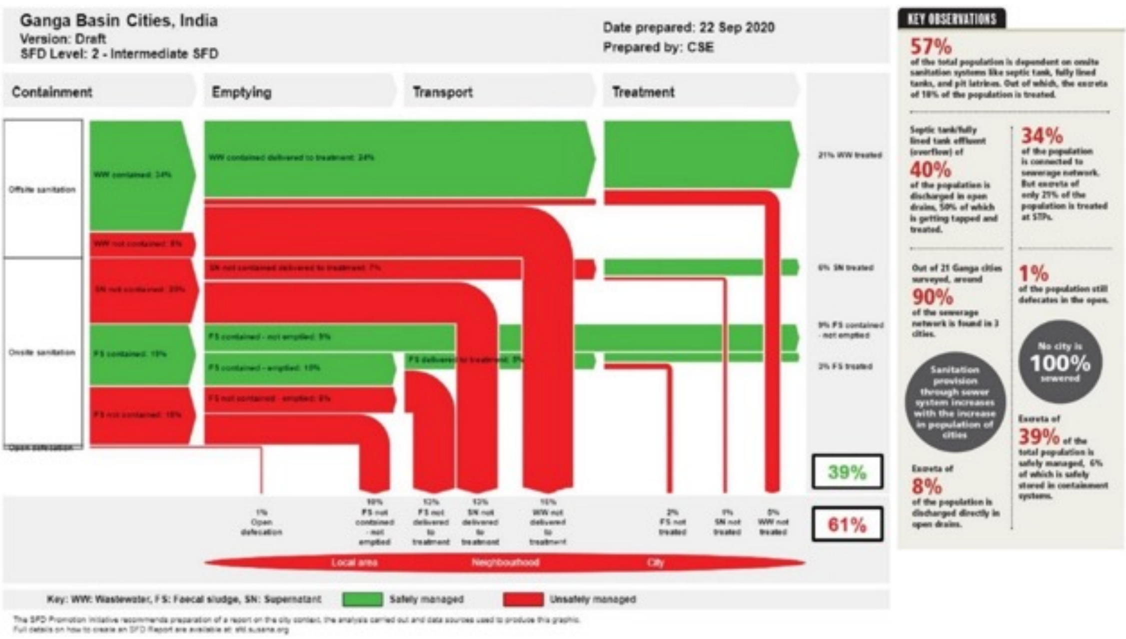
Various activities under SFD Phase-3 were affected due to the Covid-19 pandemic, during which in-person workshops and travel were prohibited. Online workshops were conducted to capacitate practitioners, with the participants preparing the SFD for their hometowns, with technical and financial support provided by CSE. Additionally, CSE prepared SFDs for select towns in the Ganga basin and other parts of India. In totality, CSE prepared and supported the preparation of more than 40 SFDs in India, Bangladesh, Nepal, South Africa, and the Caribbean.

CSE prepared an advocacy report, 'Managing Septage in Ganga Cities,' in 2020, which analyzed excreta management in 21 priority towns through SFDs. The cities were selected along the main stem of the river Ganga, and were classified into clusters based on population size, as mentioned below:

1. Cluster 1—cities with population of more than 0.5 million
2. Cluster 2—cities with population between 0.12–0.5 million
3. Cluster 3—cities with a population that is less than 0.12 million

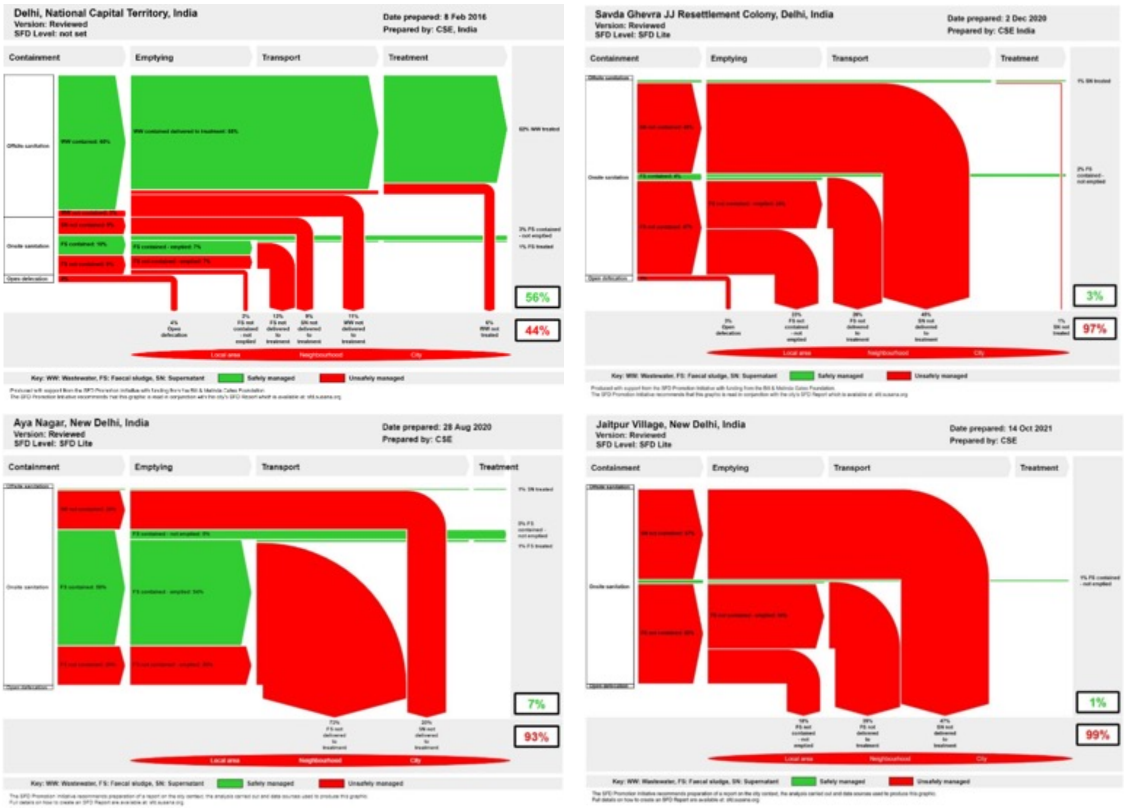
As per the analysis, the excreta of 61 per cent of the urban population in these cities is unsafely managed and finds its way, untreated, into the river Ganga (see *Figure 12: SFD for Ganga basin, 2020*).

Figure 12: SFD for Ganga basin, 2020



Source:

Figure 13: Comparison of SFD for Delhi with SFDs of Aya Nagar, Savda Ghevra and Jaitpur village

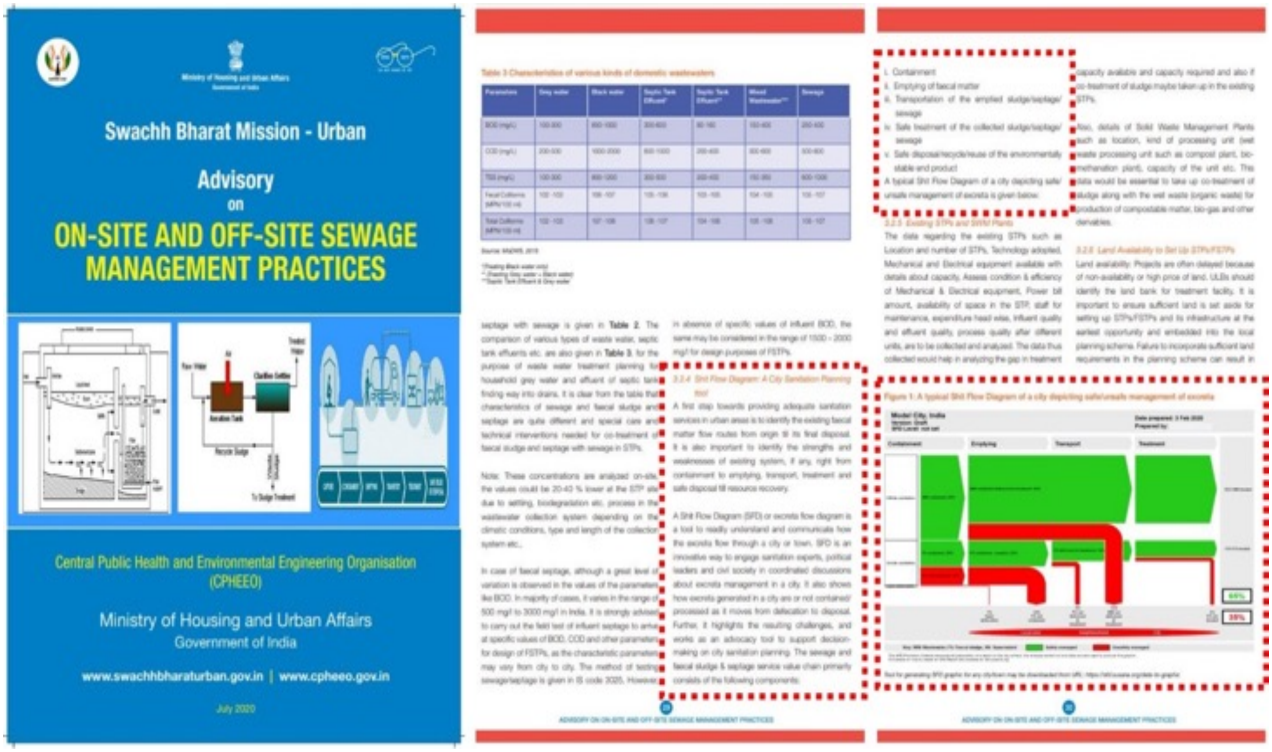


Source: SFD reports for Delhi, Aya Nagar, Savda Ghevra and Jaitpur village (prepared by CSE)

Under Phase-3, CSE also prepared an SFD for low-income settlements, informal settlements, slums and urban villages in the cities. These were done for Delhi, Bijnor, Chunar and Kanpur. The objective of these SFDs was to map inequity and exclusions in sanitation services in urban areas, and undertake a comparative analysis of shit flow diagrams of these low-income areas with the shit flow diagram of the city (see *Figure 13: Comparison of SFD for Delhi with SFDs of Aya Nagar, Savda Ghevra and Jaitpur village*). Additionally, these SFDs provide insight on localized deficiencies—structural and non-structural—and can aid in formulating decentralized strategies for sanitation services that reach the poor.

In July 2020, the Ministry of Housing and Urban Affairs (MoHUA) launched the 'Advisory on On-site and Off-site Sewage Management Practices' drafted by the Central Public Health and Environmental Engineering Organisation (CPHEEO). It advises all cities to develop a city sanitation plan based on an analysis of the existing sanitation status. To analyze the current scenario of sanitation, the advisory advocates the use of SFDs for all urban local bodies. This helps in mapping the

Figure 14: SFD—a city sanitation planning tool in the advisory on sewage management



Source: Advisory on On-site and Off-site Sewage Management Practices – CPHEEO (2020)

flow of excreta across the city, irrespective of the type of sanitation system, on-or off-site. The SFD graphic not only helps in better sanitation planning but also in monitoring the progress of the city with respect to sanitation.

The use of an SFD tool for mapping the baseline of the sanitation value chain, and its use in the city-wide sanitation planning has been nationalized in India, with the launch of this advisory (*see Figure 14: SFD—a city sanitation planning tool in the advisory on sewage management*).

3 Key learnings from the SFD project

3.1 SFD as an advocacy tool for policy impact

The SFD tool has been used for advocating on-site sanitation systems and effective faecal sludge management (FMS) in policy, plans and programmes. It provides a clear picture of the sanitation value chain, and is being increasingly used for baseline profiling. More than 400 SFDs have been developed in India alone. The Sustainable Sanitation Alliance (SuSanA) portal hosts more than 309 peer-reviewed SFD reports for more than 300 cities across the world.

The SFD is a revolutionary practice in conceptualising efficient waste management and comes in bringing management of different strands of FSM and wastewater management together. It visualizes what happens to excreta across an entire city in a single drawing, through off-site sanitation systems as well as on-site ones. In doing so, it reveals parts of the urban sanitation system that have long remained invisible. The SFD graphic is easily comprehensible for non-sanitation experts and stakeholders. This has been crucial in creating a shared understanding and common language to talk about the city's sanitation challenges, the main problems of the sanitation system, and the solutions for an inclusive, integrated, city-wide sanitation system.[15]

Shit flow diagrams (SFD) have emerged as a powerful advocacy tool for pushing investments into on-site sanitation systems. The visualizations are compelling and arrest people's attention. Even Prime Minister Narendra Modi discussed SFDs with Bill Gates during a meeting where they reviewed India's progress in urban sanitation.

In 2017, the Government of India adopted a National Faecal Sludge Management Policy. The policy was a validation of the understanding that it would be impossible for India to reach its commitments under the Sustainable Development Goals without paying due attention to on-site sanitation systems. In 2018, the Swachh Bharat Mission officially broadened its mandate beyond the elimination of open defecation to also include the 'safe containment, processing and disposal of faecal sludge and septage', certifying cities as ODF++/Water+. Indicators related to faecal sludge management were incorporated into Swachh Survekshan, the official system for monitoring and ranking cities according to their progress in sanitation.

This provided even more incentives for cities and states to plan for and introduce interventions aimed at improving on-site sanitation. [16]

3.2 SFD as a planning and monitoring tool

The SFD tool has been used as a baseline assessment tool for urban sanitation in city sanitation plans (CSPs). Under the CSE-GIZ partnership, officials from 35 small and medium towns from Kerala, Telangana and Andhra Pradesh were capacitated to prepare CSP, and develop SFDs as part of this process. Out of these, six champion cities (two from each state) were selected to prepare a comprehensive SFD, as part of their CSP.

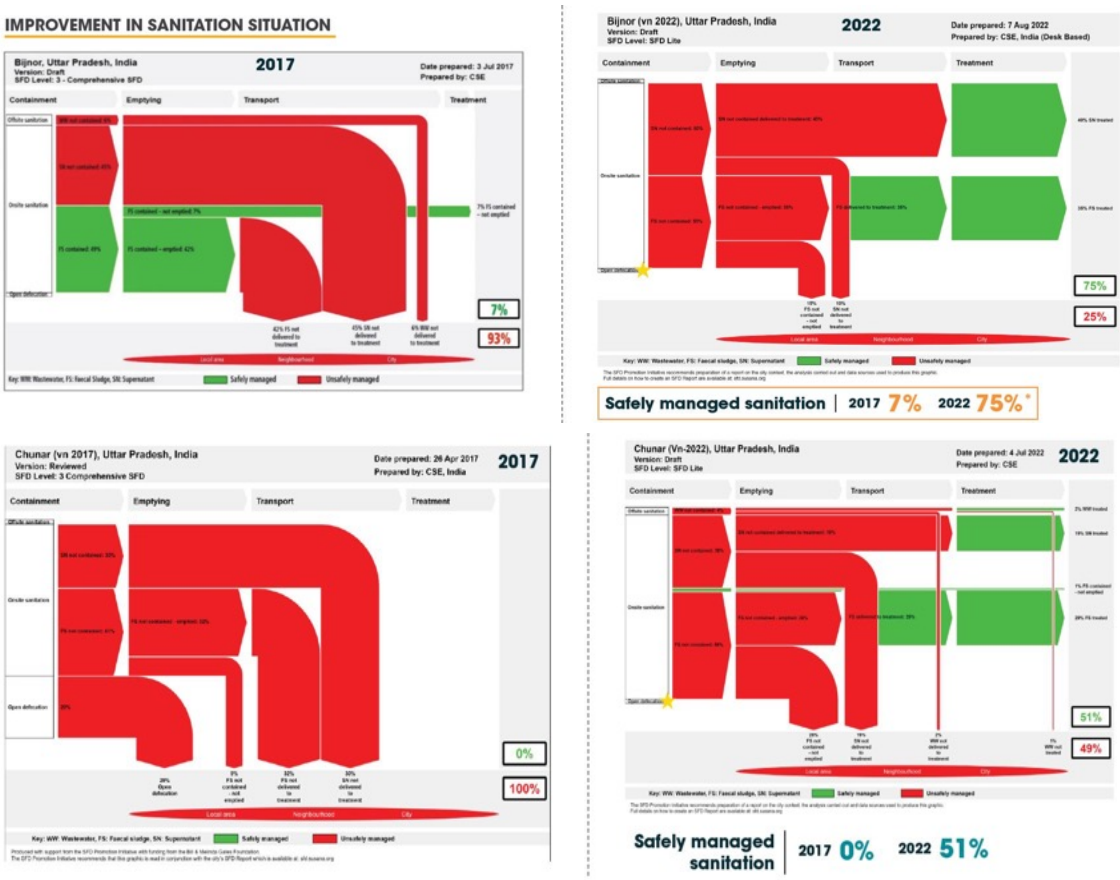
The SFDs provided them with a sound base upon which to plan investments. Today, all six of these cities are among the leaders in effective faecal sludge management in India. The city of Siddipet, for example, has installed a faecal sludge treatment plant, while Karim Nagar has begun the co-treatment of faecal sludge and sewage at the city's sewage treatment plant.[17] These interventions have also been undertaken in Coimbatore, Rishikesh, Bijnor and Chunar, among others.

Often, urban sanitation data in Indian cities is raw, with negligible analysis and no centralization. The SFD brings all the urban sanitation data from various stakeholders, key informants and focussed group discussions in a structured report and graphic. This provides a basis for discussion and ultimately for evidence-based decision-making.

SFDs are increasingly being used to map the progress of various urban sanitation projects and faecal sludge and septage management (FSSM) strategies implemented in towns and cities. CSE provides technical support to Bijnor and Chunar for implementing FSSM strategies. A co-treatment plant of 20 kilo litres per day (KLD) has been operating in Bijnor, as proposed in the city sanitation plan (CSP) for Bijnor that was prepared by CSE. A faecal sludge treatment plant (FSTP) of 10 KLD has been functioning in Chunar. Additionally, other non-structural measures have been taken in both cities—Bijnor has notified the FSSM bye-laws, both Bijnor and Chunar have licenced tank operators and fixed desludging charges, and the plants are receiving adequate septage needed to run operations.

The pre-and post-SFD study of both towns showcase progress made due to these interventions over the past five years, and provide effective communication for further planning and implementation (*see Figure 15: Pre-and post-SFDs for Bijnor and Chunar*). In Bijnor, the percentage of the population whose excreta is safely managed has increased from seven per cent to 75 per cent, while the increase in

Figure 15: Pre-and post-SFDs for Bijnor and Chunar



Source: CSE, 2022

Chunar has been from zero to 51 per cent. Pre- and post-SFD studies also act as a feedback mechanism for implemented strategies that can then help in course correction.

However, it is important to note that while conducting the pre- and post-SFD study, one keeps the geographical boundaries of the ULB inconsideration. If boundaries have expanded, it is not advisable to compare the pre- and post-SFD situations for monitoring progress as that would need further updates and contextualization.

3.3 SFD for city-wide inclusive sanitation (CWIS)

CWIS, as envisioned by the Bill & Melinda Gates Foundation (BMGF), is explained as: 'Everyone benefits from adequate sanitation service delivery outcomes; human waste is safely managed along the whole sanitation service chain; effective resource recovery and re-use are considered; a diversity of technical solutions is embraced for adaptive, mixed and incremental approaches; and onsite and sewerage solutions are combined, in either centralized or decentralized systems, to better respond to the realities found in developing country cities'.[18] It aims to ensure that everyone has access to safely managed sanitation.

Under the city-wide inclusive sanitation (CWIS) framework, a 2x3 matrix is developed (*see Table 1: CWIS framework in the 2*3 matrix*), where the focus is on achieving system outcomes through strengthening system functions of responsibility, accountability and resource planning and management. These can be improved through various non-structural measures—through policy, plans and programmes. Service outcomes of safety, equity and sustainability are impacted by a combination of structural and non-structural measures.

Table 1: CWIS framework in the 2*3 matrix

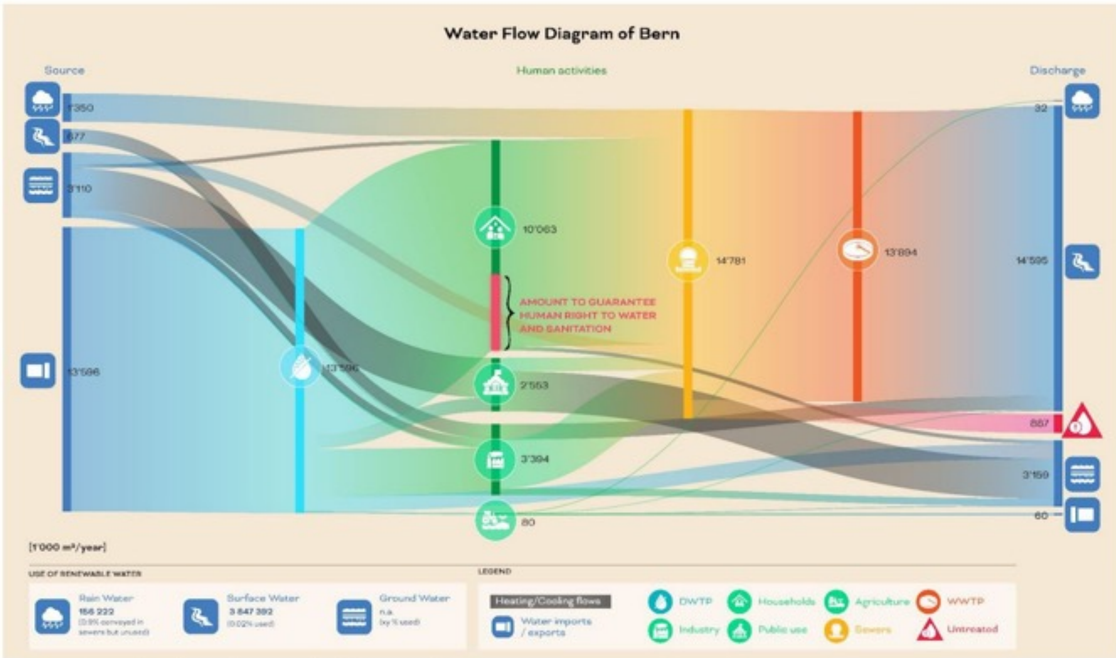
Service outcomes	**Equity:** 'Fairness' in distribution and prioritization of services, service quality service prices, and use of public finance/subsidies	**Safety:** All human waste in managed to protect public goods* for custoers, workers and all communities	**Sustaibavlity:** Management of revenus and resources–financial, labour, energy, water–sustain performance
System functions	**Respossibility:** Authority or authorities execute a clear mandate to ensure inclusive, safe sanitation services	**Accountability:** Performance is monitored and managed with transparency, data, incentives and penalties	**Resource planning and management:** Resources are managed to support implementation of mandate and achieve goals across time/space

The SFD tool provides information about aspects related to equity and safety, and partially about sustainability in service outcomes. All the service delivery changes that were fully implemented, and that affected one per cent or more of the population, are captured in the SFD tool. To assess system functions, the SFD tool needs to be used in combination with the City Service Delivery Assessment (CSDA) tool. The CSDA tool captures all interventions related to an enabling environment.[19]

The SFD tool essentially provides information about the percentage of population with access to safely-managed sanitation across the sanitation value chain. It also provides information about the deficiencies and spatial inequities in the delivery of sanitation services, thereby mapping exclusions.

From the low-income SFDs of Delhi, Bijnor, Chunar and Kanpur, it has been observed that the SFD tool provides insight into service delivery at the local level, and can be used to prepare context-based decentralized solutions for safely-managed sanitation. Since the tool covers both off-site and on-site sanitation, and provides information about wastewater, faecal sludge and supernatant, it can be tested to be used for mapping outcomes of service delivery. However, the SFD tool needs to be augmented with other tools like CSDA to develop effective strategies for CWIS.

Figure 16: Water Flow Diagram for Bern, 2021



Source: EAWAG (2021). Water Stories – Visual Narratives of Urban Flows. EAWAG

3.4 SFD tool for solid waste and water supply

The SFD tool shows the percentage of population whose excreta is safely and unsafely managed across the sanitation value chain. The same logic can be applied to other urban services with process flows—municipal solid waste and water. CSE prepared the 'Solid Waste Flow Diagram' (SWFD) (see *Figure 7: Solid waste flow diagram for Bodhgaya* under Section 2.1.2) for the CSP for Bodhgaya. The SWFD showcases the flow of waste, in terms of quantity of waste, rather than the percentage of population.

In 2021, Sandec (EAWAG) developed the 'Urban Water Flow Diagram (WFD)' in partnership with the Stockholm Environment Institute (SEI), Swiss Water Partnership (SWP), UNICEF and others. Inspired by the SFD tool, the WFD tool aims to visualize urban water flows to facilitate integrated urban water management (*see Figure 16: Water flow diagram for Bern, 2021*). The tool provides an overview of the local urban water situation by visualizing the major water flows from source to discharge, together with a judgement for every flow, and assessing if the management practices are appropriate or problematic. The WFD has three main purposes:

- Advocacy and raising awareness: Provide a quick overview of a city's water situation. It will be intuitive, also for people outside the sector to highlight areas that are in need of political action in urban water management.

- Launch the dialogue: serve as a basis for a constructive, multi-stakeholder dialogue.
- Support better decision-making: visualizing the quantity and quality of water allocated for different activities within a city will facilitate the identification of problematic areas and therewith could influence political priorities and decisions.[20]

3.5 Water flow diagram (WFD)

Like the SWFD, the WFD highlights the flow of water from sources, across human activities that use the water, and its end with discharge or reuse. Unlike the SFD, the WFD showcases the quantity of water as the measurement unit.

4 SFD capacity development lessons

4.1 SFD training material

- The content for training on the process of making Shit Flow Diagrams must include local understandings of water and sanitation. Some example are: the general practice for managing excreta in the locality and awareness of the different types of sewerage networks.
- The content should clearly define and link SFDs with their outcomes. For example, the content should address how SFDs are used in city sanitation plans, advocacy, planning, and baseline study, and to showcase changes in the excreta and wastewater management of the city.
- It has been observed that the hype around SFDs creates a buzz amongst the audience, giving the impression that they are the ultimate solution to all sanitation problems. The trainer should take care to restrict the expectations of the audience. Further, the trainer should state the limitations of SFDs. For example, during some training sessions in Uttar Pradesh, officers and engineers inquired if making an SFD of their city would lead to the securing of funds for sewerage and solid waste infrastructure.
- The content should clearly highlight that SFDs are just a medium to represent the challenges around the management of excreta and wastewater in a pictorial manner. It gives you the result based on the data you feed into it i.e. you get what you put in. SFDs can also help in understanding which sanitation services need to be prioritised and why.
- A broader aim for the SFD should be discussed at each stage during capacity development:
  - o These aims should be clearly discussed with the organizing committee. For example, the purpose of the SFDs and the issues they want to resolve through them must be clearly addressed.
  - o The interventions that are expected once the trainees have understood the methodology of SFD preparation must be discussed.
  - o Government plans once the SFDs have been rolled out.
  - o The trainers should also clarify if SFDs are required at all. For example, if a city has already made substantial progress in FSM infrastructure and sanitation services, then an SFD would be an unnecessary as the implementers are already well-versed with local issues and challenges.

- Determining the risk of groundwater pollution plays an important role in bringing a realistic picture on the ground through the graphic. It has been observed that participants confuse groundwater risk with lower groundwater levels in the city, instead of using the "**Risk of Groundwater Pollution"** tab**.**
- The session on "how to read SFDs" is best understood if followed by group exercises based on reading the case studies. At least two groups should be formed and each must have a mix of participants from different backgrounds.
- The material used for "how to read SFDs" should have at least two case studies. The case studies should be chosen based on the local context. It is helpful if the audience is aware of the city or town whose case study is being shared to them. It helps them understanding better as they are able to relate themselves. The audiences can get understanding on, how different sanitation services on ground are reflected by the SFD graphic.
- In the SFD training conducted in South Africa,[21] we learnt that it is best to use the executive summaries of two or three comprehensive SFDs as case studies. It is also helpful to make two to three groups to read the case studies first so that participants can become familiar with sanitation issues and challenges and are able to identify them for each town. In the second part of the exercise, participants look at the SFD graphic and understand how the data is presented in the graphic. Then each group makes a presentation. In this way the entire exercise takes about two hours.
- The most crucial part of the SFD training is the volumetric calculation of septage and wastewater. This estimate is difficult to arrive at if the exercise is not clear. The exercise needs to provide all the assumptions needed—town population, percentage of towns connected to non-sewered systems, septic tank volume, desludging frequency, town population and household/family numbers, etc. In the training conducted in South Africa, participants ended up confused when it came to household/family numbers and the town population. Therefore, it is best to assume the town population to be 150,000 and the household size as 5 for convenience. However, it should be made clear to the participants that the on-ground data related to containments, emptying, transport and treatment should be taken from multiple sources so that the diversity of challenges in the service delivery is properly understood.
- 'Do-it-yourself' exercises (DIY) should be made keeping in focus the local context. In South Africa, the local context is dry toilets. In addition to this, local groundwater conditions, containments types and sanitation service delivery systems need to be included in a simple and easily comprehensible way. For example: participants from a city that has very minimalistic on-site systems and is majorly dependent on off-site systems may find the DIY exercise useless if the data given is only from the former. The aim of the session is not to make

participants do complex exercises on various variables of town population and treatment systems, but for them to acquire an understanding of the core concepts regarding imputing septage and wastewater estimates onto the SFD graphic. Once they know this, they will be able to incorporate more complex scenarios.

4.2 Online trainings

- The online training on the preparation of SFDs should be conducted in a hybrid manner. It was observed to be effective during the Covid-19 pandemic when the trainings were conducted by CSE in two parts—A and B.[22]
  - Part—A: setting the context on the need for SFDs, what it is (graphic and report), its evolution and various applications. This module was conducted through an e-learning platform where participants were provided with approximately eight to ten hours of reading/audio-visual training material which they were expected to study by themselves. The platform allowed participants and trainers to hold discussion threads where necessary.
  - Part—B: this part involved action learning where participants revised, clarified and concretized what was understood through the self-learning method. Here, three-day virtual sessions were conducted on the Zoom platform to help participants understand how to prepare the SFDs.

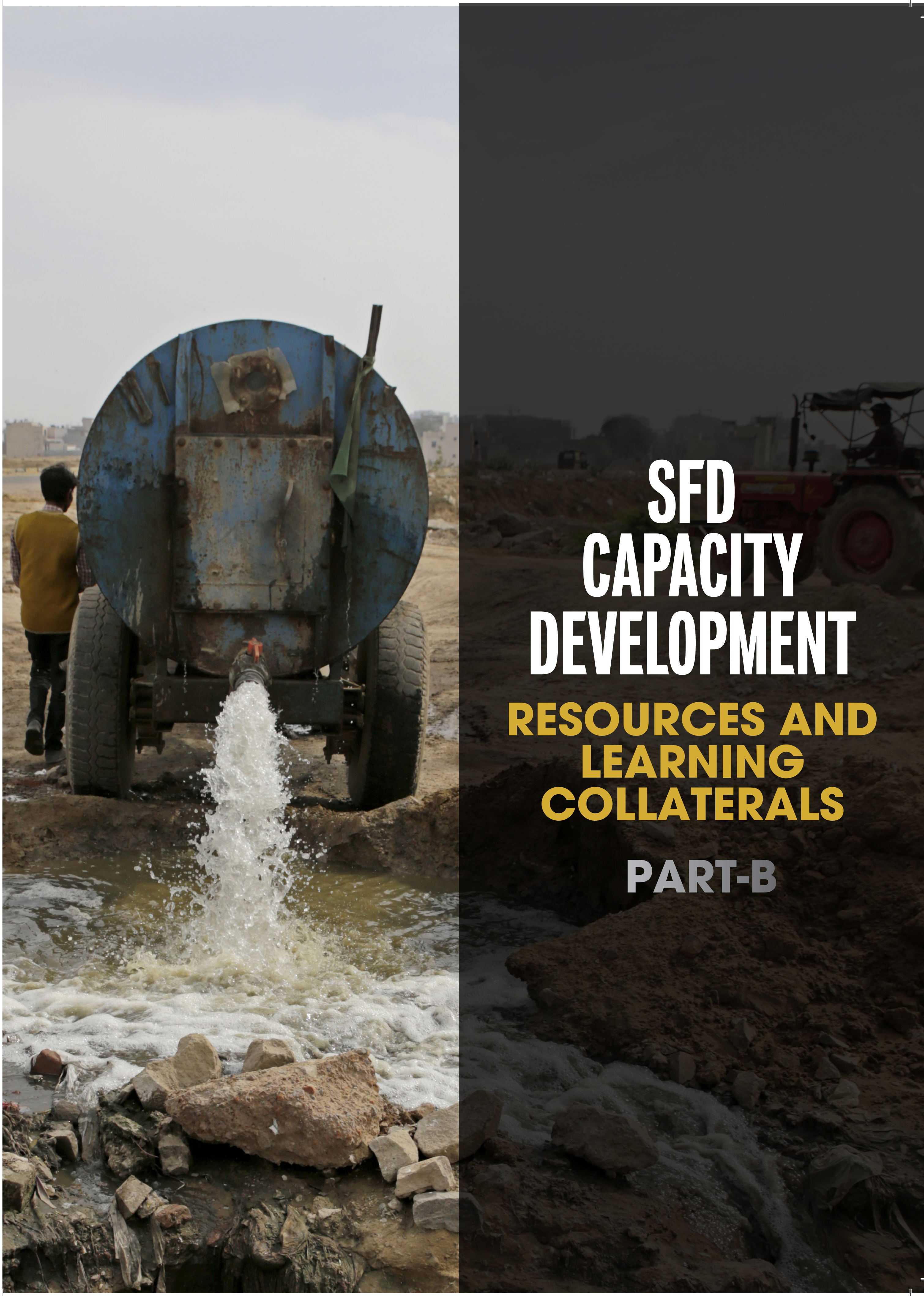
- The online methods of capacity building were a challenge when participants had technical issues or were not well-versed with grasping concepts through online modules on the MOODLE platform. In most trainings, it was observed that around 40–45 per cent of the participants were not being able to use MOODLE or read the content by themselves. They were only able to grasp the concepts in the second part of the trainings. Therefore, the online training should be done as much as possible – as a teaching training mode with competent trainers taking at least four to five critical sessions of 90 minutes each. These sessions should provide instructions on how to read SFDs, calculate sludge and wastewater, input data on SFD online tool, data collection, and do a final preparation of the SFD session.

4.3 Delivery of the content

- At CSE we have conducted online trainings for participants from India, Nepal, Bangladesh, the Caribbean and South Africa during the Covid-19 outbreak. The residential and on-site trainings were conducted for participants of India and South Africa.
- Online workshops were conducted to capacitate practitioners, with participants preparing the SFD for their hometowns, with technical and financial

support provided by CSE. Additionally, CSE prepared SFDs for select towns in the Ganga basin and other parts of India. In totality, CSE prepared and supported the preparation of more than 50 SFDs in India, Bangladesh, Nepal, South Africa, and the Caribbean.

- For on-site trainings, it has been observed that a batch size with 15–20 participants is ideal to achieve better learning. The speed with which participants are able to grasp concepts also depends on their professional backgrounds. It has been observed that discussions were deep, holistic and solution-driven when participants were from diverse backgrounds such as civil servants, engineers, planners, administrators and sanitation supervisors etc.
- A common question that has been raised during the training period is the amount of time and cost that are incurred during the preparation of an SFD for a city. A discrete answer to this question is not possible due to multiple variables and factors. For example, an experienced person may develop an SFD Lite report (smallest and simplest version of an SFD) in a week if the data is available. The same person may take a month if the data is not available easily and external arrangements are required for procuring the necessary data. Similarly, when it comes to costs, a person from the engineering department making an SFD graphic of their city would incur less costs. This is because it is likely that he/she would be aware of the concerned information that is required to be fed into the SFD, or would be able to access possible channels to avail the information.
- For effective training, participants should be given a prior handout of SFDs and their evolution. However it depends on the participants to determine if they are keen on the reading material or prefer classroom sessions first. In South Africa, it was observed that participants were keen to read and then come to classroom sessions. However, in India, it has been observed that officials want to learn everything in classrooms.
- The training should ideally span three days where it could be coupled with an orientation on faecal sludge and septage management (FSSM) and Integrated Water and Wastewater Management sessions on the final day. It would help participants in understanding the applications of SFDs.
- The DIY exercise where participants are exposed to hypothetical data of a town or city to prepare their own SFDs in groups should be conducted on the second day of the training. Ideally, all discussions and calculations under this exercise should be completed within the same day. On the third day of the training, each group can explain and present the SFDs they have prepared. This process gives participants enough time understand the process of making an SFD and hands-on practice with the SFD graphic generator.



SFD CAPACITY DEVELOPMENT

RESOURCES AND LEARNING COLLATERALS

PART-B

5 SFD capacity development—resources and learning collaterals

The learning collaterals for capacity development for preparing SFDs has been compiled and brought together as a separate section in this report. This is meant to serve as a useful reference for anyone involved in SFD capacity development. We have not included the presentation slides, only the case studies and important exercises that were used in imparting SFD trainings in India and Africa.

We hope this report will serve as a useful documentation of the SFD-related work done in India, and also be of use as a resource book for trainers and researchers undertaking SFD capacity development work in Africa and Asia.

We are grateful to our donor Bill & Melinda Gate Foundation for supporting this work and to our partners in the SFD initiative—GIZ, SuSaNa, WEDC EAWAG, Water Research Commission South Africa, WaterAid Bangladesh, Leeds University, the NFSSM Alliance in India, and several individuals and researchers who have made this possible.

SFD capacity development—resources and learning collaterals

This section is a trainer's guide on conducting SFD trainings. It includes all aspects of planning and conducting an SFD training. It also includes case studies and their answer logs. This part of the report is based on CSE's experience of conducting SFD trainings in India, and internationally in Africa and Asia.

5.1 Preparing the agenda for training

The sessions can be spread over two to three days. The emphasis is on enabling trainees to learn and use the SFD tool. Hence a minimum of two full days are required.

The first day should end with an exercise in calculating the faecal sludge estimation of a city. Focus should be on how to read an SFD and how to calculate and assess containment, transport and the treatment of faecal sludge and sewage.

Table 2: How to sequence different sessions in an SFD training

Sessions	Topic	Learning objectives
Session 1 Day 1	• What is SFD, and why are SFDs important • Global implementation of SFDs • India's SFD journey • How to read an SFD • Exercise based on case studies	• Basic understanding of SFD • To understand the purpose and application of SFDs through examples from all around the world • To understand how SFD graphics are interpreted and understood • To understand the implementation of SFDs globally and in India
Session 2 Day 2	• SFD manual, SFD terms, glossary and variables • Methodology for data collection • Wastewater and septage estimation exercise • SFD report and template	• To get acquainted with SFD terminologies (terms and variables) • To identify the type of data required to feed into a graphic generator • To understand the methodology for data collection (CSE style) • To understand background calculations required to fill data for different variables that are used in an SFD • To understand the SFD reporting template and different SFD levels
Session 3	• Understanding graphic generator • DIY exercise—make your own SFD • Group presentations on 'Make your own SFD' • Context adapted SFD graphic	• To understand the process of using SFD graphic generator and the process by which SFD graphics are generated • Group exercise: Participants will learn to develop an SFD graphic from hypothetical data • How an SFD can be customized to local context by changing it manually using other tools
Session 4	• Field work assignment	• Participants are sent to nearby government offices and residential areas to develop an SFD of their own

Case studies should be carefully selected; the same case studies can be used to:

- understand the sanitation challenges of a city
- read an SFD

For the do-it-yourself exercise towards the end of the training, different typologies of town case studies should be used—one with a sewerage system and one without. This will provide perspective on SFD preparation.

Session 4 can be removed if participants are unwilling to go to the field immediately or if local arrangements are not available to facilitate practical exercises.

5.2 Session-1

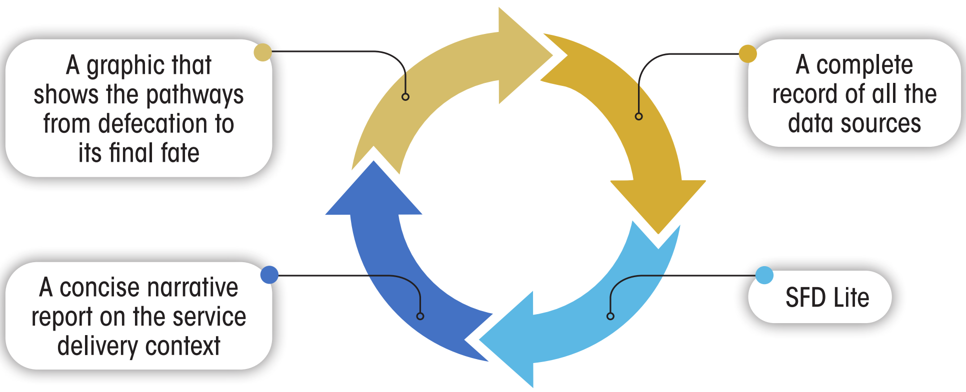
5.2.1 What is SFD and why are SFDs important?

Purpose: The presentation aims to define Shit Flow Diagrams (SFDs) and their purpose. Participants are exposed to the elements of an SFD and its composition. The presentation further provides the need of SFD to understand through simple terms about the ways excreta is maneuvering in the area. Later it connects this understanding to awareness, advocacy and planning which can be facilitated based on the information drawn from the SFD.

Method: Through PowerPoint presentation

Figure 17: Shit flow diagram

An excreta flow diagram (also often described as a Shit Flow Diagram, SFD) is a tool that helps in understanding and visually communicating how excreta physically flows through a city or town. It shows the fate of all excreta at different stages—



containment, transport, treatment, end-use or disposal. An accompanying report describes the service delivery context or the enabling environment with regards to FSM in a city or town.

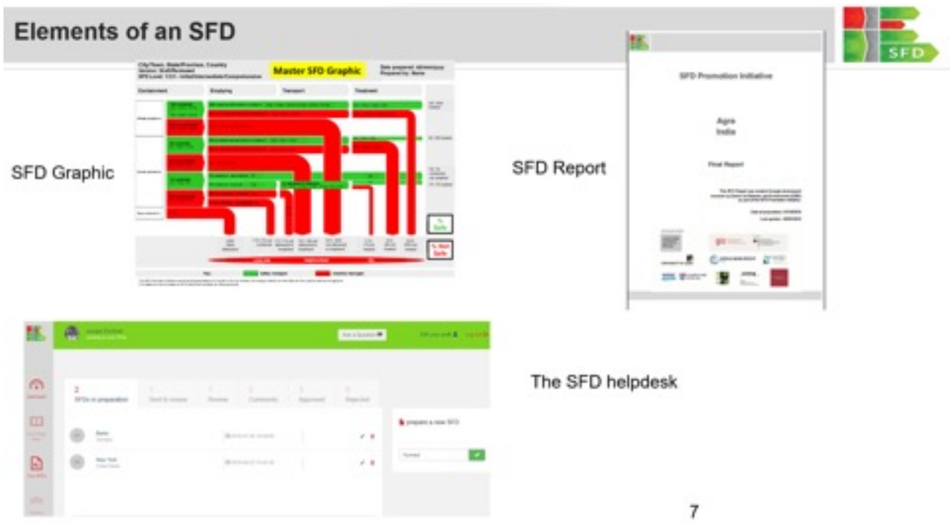
An SFD can be the following

- An effective communication and advocacy tool to engage city stakeholders, such as political leaders, sanitation experts and civil society organizations in a coordinated dialogue about excreta management
- A tool for engineers, planners and decision-makers to help inform urban sanitation programming
- An indicator of where their excreta goes, based on contributing populations
- A representation of a public health hazard
- An overview from which to develop sanitation priorities

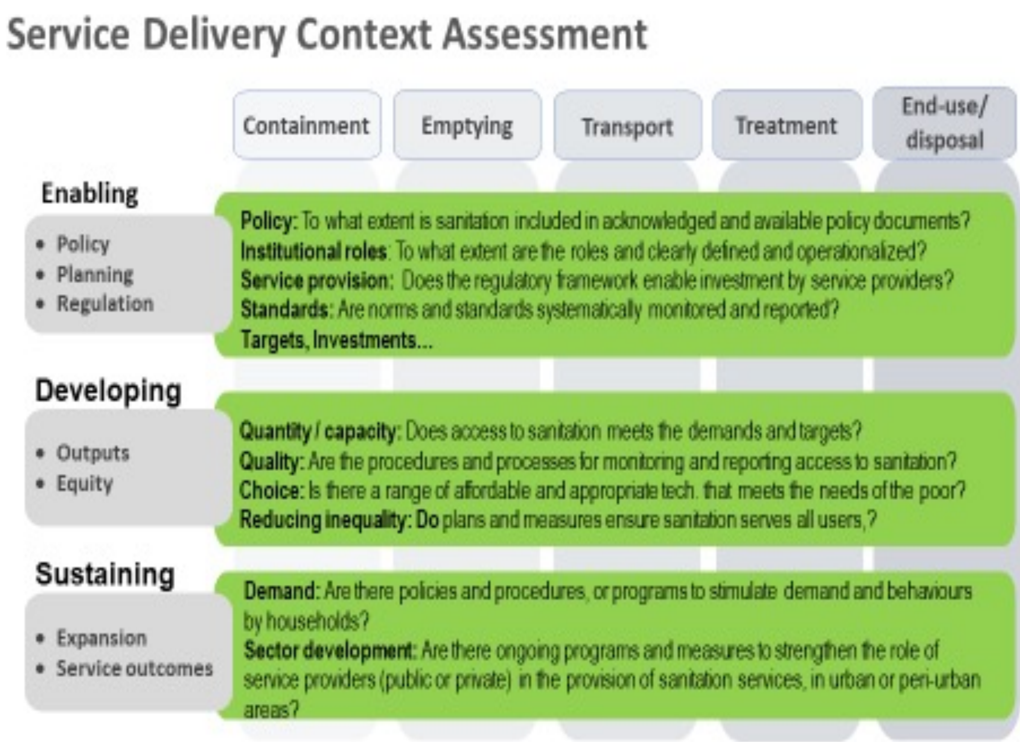
But, SFD is not

- o Based on volumes/mass—these are determined by other related factors
- o A representation of public health risk (risk = hazard x behaviour)
- o A precise scientific analytical tool

Figure 18: Elements of an SFD



What does an SFD report appraise?



5.2.2 Global implementation of SFDs

Purpose: Once SFDs have been defined and their necessity and purpose explained, we focus on informing participants about SFD's journey across the world.

The purpose of this section is to highlight how SFDs came to light and their reach across the world. Further, we link SFDs to the change that was facilitated through them in different parts of the world.

Method: A PowerPoint presentation is used to present different examples from all around the world—selected examples from Asia, South Asia, south-east Asia, Latin America, Africa and Europe are incorporated in the presentation and participants are introduced to the applications of SFDs through the examples of case studies.

If the SFD training is being conducted in a particular area or region of the country, or outside India, we prefer to showcase the case example of the nearest SFD from that area so that participants can relate to the situation themselves and understand how the SFD makes sense.

5.2.3 Choose a country/city SFD's journey to present

Purpose: CSE has used India's SFD experience as it helps participants understand the myriad uses of SFDs in India. SFDs have been used for advocacy at the upper levels in the government hierarchy to trigger change on the ground or to conduct ground-level surveys and provide a baseline picture of a set of cities from a state to advocate for funds with regards to excreta and wastewater management.

Method: Through a PowerPoint presentation.

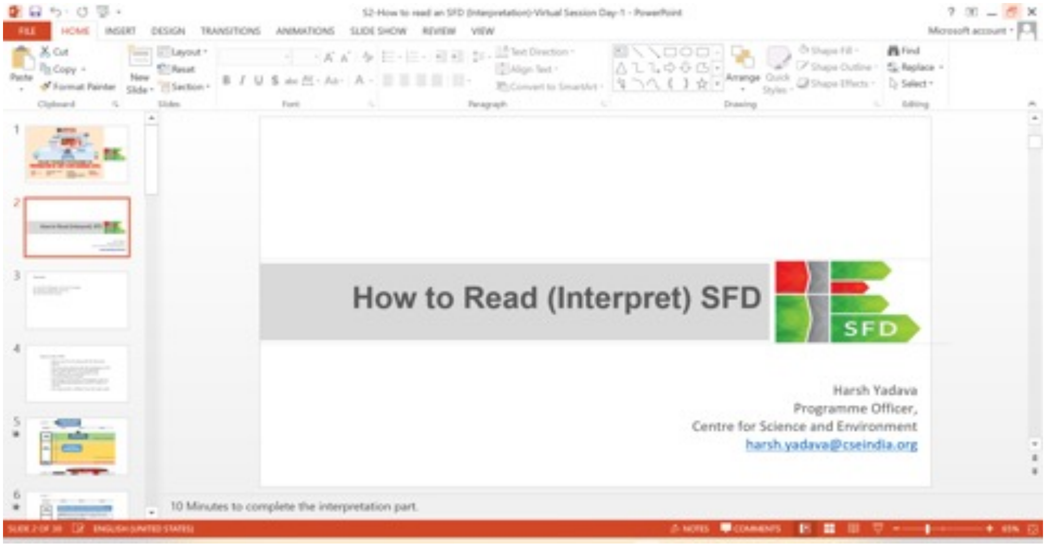
5.2.4 How to read (interpret) an SFD graphic

Once participants have understood the purpose of creating an SFD and its several applications, we dive deeper into understanding the SFD graphic.

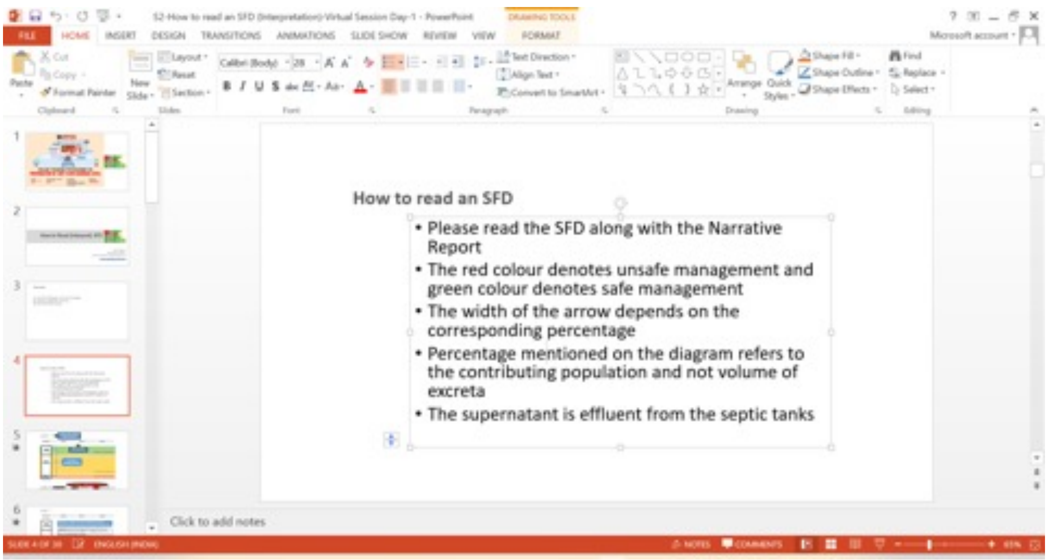
Purpose: The purpose of this part is to understand

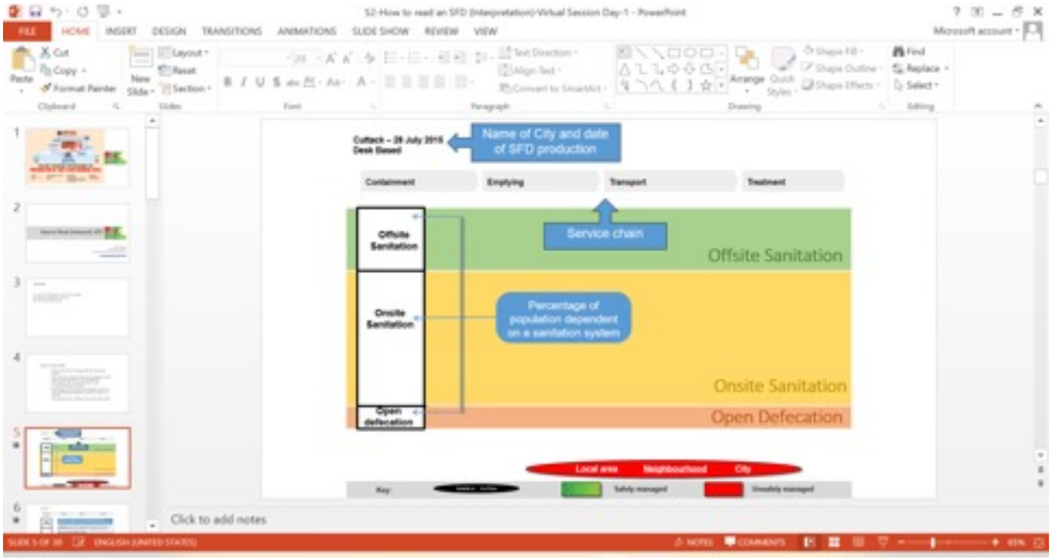
- What an SFD graphic depicts
- Procedure to read the SFD graphic
- How a reader can understand excreta management in the city by seeing the graphic

Method: A presentation is designed by breaking an already published SFD graphic into various sets. The SFD is slowly dismantled in front of participants and each variable, color and abbreviation is explained to the participants along with their purpose. The dismantling is designed in a way that participants can concentrate on different kinds of systems—offsite, onsite and open defecation—individually.


How to Read (Interpret) SFD
SFD
Harsh Yadava
Programme Officer,
Centre for Science and Environment
harsh.yadava@cseindia.org
10 Minutes to complete the interpretation part.


Overview
Narrative of SFD Report
Understand a SFD graphic
Dismantle an SFD
Different SFDs in Africa
Read an SFD-Action Learning


How to read an SFD
• Please read the SFD along with the Narrative Report
• The red colour denotes unsafe management and green colour denotes safe management
• The width of the arrow depends on the corresponding percentage
• Percentage mentioned on the diagram refers to the contributing population and not volume of excreta
• The supernatant is effluent from the septic tanks
Click to add notes



Terminologies like black water, grey water, onsite system, offsite system etc. are also explained through the course of the presentation. To make the session more interactive, terminologies are explained through situations on the ground.

For example, participants are asked questions like, 'If a system has a toilet whose outlet opens directly into a drain, what will it be called?' in order to trigger thinking and allow them to ponder over such situations and link it to ground realities. The right answers by participants are rewarded later.

Similarly, as the presentation proceeds, each section of the graphic is explained to participants. In the end, participants are familiarized with a few more published SFDs from different places, populations and types of sanitation systems, and participants are quizzed on each graphic.

The presentation is followed by a group exercise.

Group exercises: case study-based

Instruction: Conduct an exercise where groups are given at least two case studies of towns with their sanitation statuses. Ask participants to discuss the major challenges faced in sanitation and what needs to be done. This discussion will then feed into the understanding of how to read an SFD that will be prepared for the same case studies in the next session.

Purpose: The purpose of the group exercise is to introduce participants to a published SFD graphic for their analysis. The participants are expected to learn:

- How to read an SFD graphic and its depiction
- How different sanitation systems in the cities change the colour of the graphic
- How reading the graphic along with the reported data can help facilitate immediate action plans

Method: The participants are divided into two or four groups. Each group is provided with a case study with a different context, geographical location and service delivery. The CSE study sheets have an SFD graphic in one section, and an explanation of the service delivery and a "why the situation is like this" part in another section. Participants are allowed 15–20 minutes to read and analyze the situation from the case study of the corresponding city.

Each group is supposed to provide an oral presentation consisting of a few points regarding their understandings from the case study—what are the issues and challenges on the ground and what are the possible immediate actions that can be taken to help improve the SFD graphic?

Both the SFD case studies are selected to portray different situations on the ground. Usually, we prefer showcasing studies that help in understanding how treatment infrastructure along with universal and regular service delivery can change the SFD graphic drastically in comparison to a city where the treatment and service delivery is not regular and universally present or not present at all.

Note: After the completion of the group exercise and presentations participants are provided learning sheets that contains SFD manual. Participants are asked to take an overview following

- SFD terms and variables
- SFD glossary

Case study 1: Durban, Kwazulu Natal, South Africa

Diagram

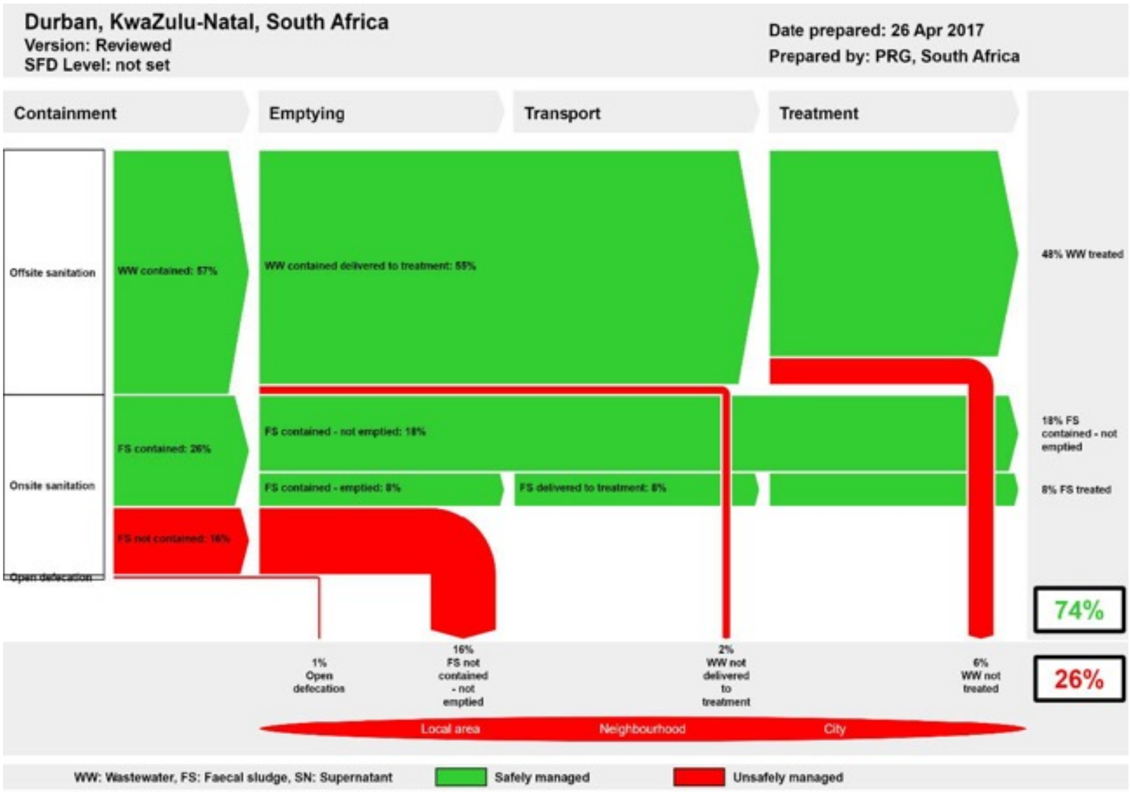


Diagram information

Desk or field-based: This Shit Flow Diagram (SFD) was based on field-based research by the Pollution Research Group (PRG) from the University of KwaZulu-Natal (UKZN) as an internship project for the final requirements of the Integrated Water Resource Management, Masters programme at McGill University.

General city information

The city of Durban is managed by the eThekwini Municipality, which covers a wide area that includes 55 per cent of urban and 45 per cent of rural sectors. This area was chosen for SFD analysis as it has a central public municipality that is responsible for managing and supplying basic sanitation services to the entire region. In 2015, projections from the last Census count in 2011 estimated that the projected population was approximately 3.55 million (eThekwini Municipality, 2015). Most of the influx is concentrated in peri-urban and rural areas due to more affordable land in the traditionally-owned rural areas and due to the historically distorted urban planning arrangements from the apartheid era (eThekwini Municipality, 2015b). Informal settlements are scattered all over the city and are situated mainly on steep land or flood plains that are high-risk areas and present a challenge to service delivery and infrastructure development (eThekwini Municipality, 2015a).

Service delivery context

National policies and legislation specifically focused on sanitation exists to guide the delivery of these services in an equitable and fair manner, including the policy on free basic services for all (Department of Water Affairs and Forestry, 1994). There are clear policies and guidelines that have been adapted at the local municipal-level that has primed the city for a good sanitation service delivery, although 17 per cent of the population remains unserved with basic toilet and hand-washing services (Gounden, 2016). Because of this the eThekwini Water and Sanitation (EWS) municipality largely provides service delivery in sanitation throughout the sanitation chain, although private enterprises (alongside EWS paid services) are responsible for the collection and transport of faecal sludge (FS) from septic tanks and the operation of private decentralized treated plants and landfills.

The lowest acceptable form of sanitation system set by EWS is the dry urine diversion (UD) toilet, but the goal is to allow everyone achieve waterborne toilet systems (eThekwini Municipality, 2015). There are goals and plans in place to improve access to sewers, increase indigent access to basic sanitation (even if that means the use of communal ablution blocks as a temporary solution), and to upgrade treatment facilities as well as sludge disposal/reuse facilities. There are a few clear goals on maintaining or upgrading the expanding sewer network. There are procedures in place to implement sustainable faecal sludge management for the growing number of on-site containment systems. The emptying services that are provided free of charge by the municipality have been failing at keeping up with the growing number of people. Private sector services are becoming more controlled and standardized as the relationship between private organizations and EWS improves.

There are also plans to use Black Soldier Fly (BSF) sludge treatment and Decentralized Wastewater Treatment System (DEWATS) passive treatment, and to increase the capacity of the Latrine Dehydration and Pasteurization (LaDePa) treatment of ventilated pit latrines (VIP) FS. There are also plans to pelletize the sludge from the centralized treatment. There is extensive spatial GIS data for each household that is on the billing system for water services. There is also a GIS database that identifies areas of sanitation infrastructure/facilities at the household level. This is currently being updated with the locations of UD toilets. An aerial photograph of the eThekwini area is taken each year and used to count the existing households that have access to improved toilet facilities in order to estimate backlog figures. Permits and licenses allow for the monitoring of private septic tank-emptying services as well as decentralized treatment works, known as a package plant. Regular monitoring is carried out in all the rivers, estuaries and around the coastal region to assess the environmental impact of the effluent from wastewater treatment works (WWTW).

While many innovative designs are in the final stages of being developed in order to help reduce the proportion of unserved people in eThekwini, delays in the environmental impact assessment (EIA) process have been preventing implementation. Historically, the politics of the country has forced the municipality to assume a reactive position rather than a proactive one when it comes to providing basic services. However, they are using all the resources available to them in an attempt to make an impact in the right direction.

Service outcomes

In Durban, 74 per cent of the excreta is managed safely, with 48 per cent coming from waterborne toilets that are connected to the central sewer network. The bulk of the excreta that is not safely managed is from the 17 per cent of households that do not have improved toilet facilities or access to an emptying service (16 per cent of which are unimproved, community-built pits that are not emptied or buried, and one per cent constitutes open defecation) as well as the estimated overflow from blocked sewer lines. The containment systems for the 42 per cent on-site sanitation are in the form of septic tanks, conservancy tanks (sealed tanks), UD toilets and VIPs. In the SFDs, UD toilets are considered as sealed tanks or 'pits that are safely closed,' where the faeces are collected for the BSF treatment or when the contents are buried safely on-site (the latter making up 18 per cent of safely managed excreta). Emptying and transport of FS from septic tanks, conservancy tanks and VIP toilets is well managed and considered to be a strong private and public industry, with VIP toilet sludge being treated and then sold as fertilizer pellets from the LaDePa treatment facility. The other FS is taken to the centralized treatment facilities where it is mixed with the liquid wastewater from the sewer network and is either sent out to sea through the sea outfall (considered safely disposed of by the legal regulations) or treated at the wastewater treatment works (WWTW). This, along with the small portion of UD toilets that are sent to the BSF treatment, make up eight per cent of the safely disposed excreta. While 56 per cent of off-site sanitation is sent to the central sewer system, it has been estimated that two per cent of the excreta is not transported to the treatment works because of blockages that occur in the gravity driven sewer lines. This estimation is made from assuming that there are 140 blockages per day on an average, with trunk sewers equivalent to 60Ml/d fully blocked for an average of 14 hours (Gounden, 2016). There is little data on the flow through the trunk sewers; therefore this value could be improved with more knowledge on the system. From the Green Drop reports and the annual average inflow to each central WWTW, it was estimated that 88 per cent of the wastewater is treated effectively at these works, making seven per cent of the total excreta not safely treated on disposal (Department of Water and Sanitation, 2014). While there are sludge treatment methods for wastewater sludge at all of the treatment works (aside from the central and southern works that utilize the sea outfall pipes to dispose of the sludge), currently, there is little reuse and the sludge either accumulates in ponds or is dried and stockpiled. There is a project in place to implement a pelletizing contract to allow the reuse of sludge at many of the treatment works (Dyer, 2016).

Overview of stakeholders

The municipal council delegates the responsibility of city services. Septic tanks, conservancy tanks and decentralized treatment outside the urban development area are the responsibility of private households or developers (Dlamini, 2016; Wilson, 2016; Fennemore, 2016). The document on municipal policy and practices lays out the responsibility of EWS with regards to water and sanitation access, and their roles in providing those in need with free basic services. Sewer network maintenance and operation, wastewater and sludge treatment, and providing toilets in low-income areas with collection and sludge treatment fall under the responsibility of EWS. Innovative designs and trial projects are carried out by external agencies such as the Pollution Research Group within the University of KwaZulu-Natal and other academic institutions. These external stakeholders work with EWS to develop better means of treatment, containment and management of sanitation systems. There are good policy and frameworks in place to identify the roles of various players in sanitation services. The biggest challenge is providing good service to the rapidly increasing population, and in urbanized areas. This challenge also implies tackling corruption, addressing bottlenecks in the bureaucratic processes and working within budget constraints (Buckley, 2016; Dyer, 2016; Fennemore, 2016).

Credibility of data

Table 3: Key stakeholders

Key Stakeholders	Institutions / Organizations
Municipal Authority	eThekwini Water and Sanitation
Private Sector	Septic tank emptying companies and Package Plant companies

Data around policy, plans and capacity was sourced from the numerous policy, legislation and framework documents available online. Estimations for the SFD were based on data and key figures provided by key informants when interviewed. There were 13 key informant interviews conducted in order to gather the data required and gain an in-depth understanding of all the sanitation systems. These interviews were almost all with the public water services authority EWS as they are responsible for the majority of the systems along the sanitation chain.

Most of the values used for the SFD were derived from data records from the backlog figures that are counted off the aerial photograph from 2011. Some data was taken from the 2011 Census and from GIS data from EWS.

Assumptions had to be made regarding the private septic tank and conservancy tank services, and the package plant's treatment abilities due to the lack of contact personnel or a central data source. Assumptions also had to be made around the proportion of treated wastewater and the proportion of wastewater delivered to the treatment works, as these are gaps in the available knowledge.

In terms of estimation figures, the field study was essential for the development of this SFD study as the desk study revealed an abundance of knowledge on policy and procedures, but very little on actual proportions of sanitation systems used.

Example of a biocar

Vacuum tanker in place for septic tank emptying

Opening the first compartment of a septic tank

In Iact invert level in the second chamber and watering down to loosen the sludge

DEWAT trial plant

Case study 2: Tiruchirappalli, Tamil Nadu, India

Diagram

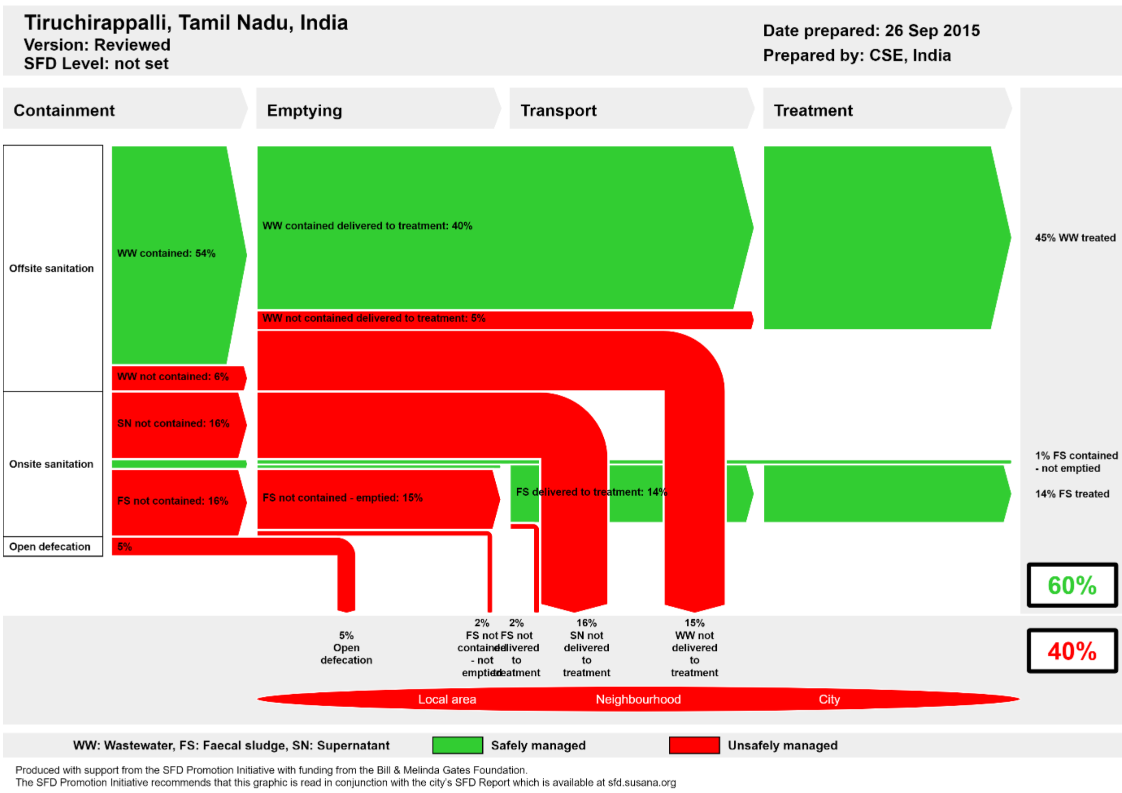


Diagram information

Desk or field based: It is a field-based study
Produced by: Centre for Science and Environment (CSE), New Delhi
Collaborating partners:
Status: This is the final SFD
Date of production: 3 March, 2017

General city information: Tiruchirappalli, also known as Trichy, is one of the largest cities in Tamil Nadu and is known as an important trade, education and pilgrimage centre. The population of the city, as per the 2011 Census, is 916,857. The density of the city is 5,483 people per sq.km which is very high when compared to the state average of 515 persons per sq.km. The total slum population is 2, 28,518 which is 26 per cent of the total population (Census of India, 2011). Municipal boundary has been chosen for the current study. It comprises of an area of 159 sq.km (TCC, 2015).

Service delivery context

In 2008, the Ministry of Urban Development (MoUD) issued the National Urban Sanitation Policy (NUSP). The policy aims to raise awareness, promote behavioural change, achieve open defecation-free cities, develop citywide sanitation plans, and provide 100 per cent safe confinement, transport, treatment and disposal of human excreta and liquid wastes. The NUSP mandates states to develop state urban sanitation strategies and work with cities to develop City Sanitation Plans (CSPs). Furthermore, it explicitly states that cities and states must issue policies and technical solutions that address onsite sanitation, including the safe confinement of faecal sludge (USAID, 2010).

The objectives of NUSP are to be realized through CSPs and state sanitation strategies. As of now there are very few cities that have finalized their CSPs, and those plans are also not implemented. This remains a major drawback in the implementation of NUSP. The advisory note on septage management in urban India, issued by MoUD in 2013, recommends supplementing CSPs with Septage Management Sub-Plan (SMP). Still septage management in India is not prominent due to lack of knowledge, consideration of septage management as an interim solution, lack of sufficient funding and many other socio-political issues. There are no specific legal provisions related to septage management, but there are a number of provisions related to sanitation services and environmental regulations, which majorly stems from The Environment (Protection) Act, 1986 and the Water (Prevention and Control of Pollution) Acts. Municipal acts and regulations usually refer to the management of solid and liquid wastes but may not provide detailed rules for septage management (MoUD, 2013). Tamil Nadu is the first state to develop operative guidelines on septage management. In September 2014, it has passed a government order on "operative guidelines for septage management for local bodies in Tamil Nadu". This order is applicable for 12 Corporations, 124 Municipalities, 528 Town Panchayats and 12,808 Panchayats in the state.

Service outcomes

Overview of technologies and methods used for different sanitation systems through the sanitation service chain is as follows:

Containment: There is a sewerage network which covers 53 per cent of the population. 34 per cent of the city is majorly dependent on septic tanks which generally do not adhere to the design prescribed by the Bureau of Indian Standards (BIS). The effluent from the septic tank flows into open drains. Some households are also connected to pits.

Emptying: There are around 30 private emptiers of varying capacities plying in the city. The emptying fee ranges from Rs 1,000–1,500 or approximately, US $15–22 per trip. Apart from a private service, Tiruchirappalli City Municipal Corporation (TCC) operates its own emptier with a capacity of 4,000 litres. According to the city corporation, approximately 0.756 million litres of septage is collected per month through 190 trips (TCC, 2015b). There are no instances of manual emptying reported.

Transport: Private emptiers transport septage by truck-mounted vacuum tankers. Septage mixes with sewage and is conveyed to the Sewage Treatment Plant (STP) through pumps.

Private emptier discharging FS in sewage pumping stated (Source: Bhitush/CSE, 2015)

Septic tank connected to community toilet in Ariamangalam slum (Source: Bhitush/CSE, 2015)

Treatment: There is one STP of 58 MLD capacity based on Wastewater Stabilization Pond (WSP) technology (TWADB, 2015). Septage is co-treated with sewage.

End-use/disposal: There is an STP with a capacity of 58 MLD capacity based on Wastewater Stabilization Pond (WSP) technology (TWADB, 2015). Private emptiers dispose septage into four sewage pumping stations. Septage is co-treated with sewage (TCC, 2015b). A minimal charge of INR 30 (0.45 USD) is collected as emptying fees from private emptiers. Private emptiers has to renewal their license by paying Rs 2,000 (30 USD) every year. The treated wastewater is discharged in to Koriyaar River. According to Census, 59 per cent of the city is dependent on offsite systems and population connected to sewer line is 53 per cent. It is assumed that 13 per cent of waste water is lost in transportation, and 40 per cent is treated and hence shown safe in SFD. User interface directly discharging in open drain or open ground is around six per cent and 17 per cent of Faecal Sludge (FS) i.e. effluent from septic tanks also joins in open drain. Out of 23 per cent of wastewater in open drain around five per cent is tapped and treated at STP. Rest of the 36 per cent of the city is dependent on onsite sanitation systems (OSS), out of which 34 per cent is dependent on septic tanks and two per cent on pits. The public latrines are either connected to septic tanks and sewers hence are incorporated partially in onsite systems and rest in offsite systems.

Septic tanks are not contained as they are connected to open drains but pits are contained as ground water table is more than 10 mbgl. There is no clear differentiation between percentage of effluent and septage generated from septic tanks, hence it’s assumed to be 50 per cent each. Therefore, 17 per cent of FS which

Example of biocar

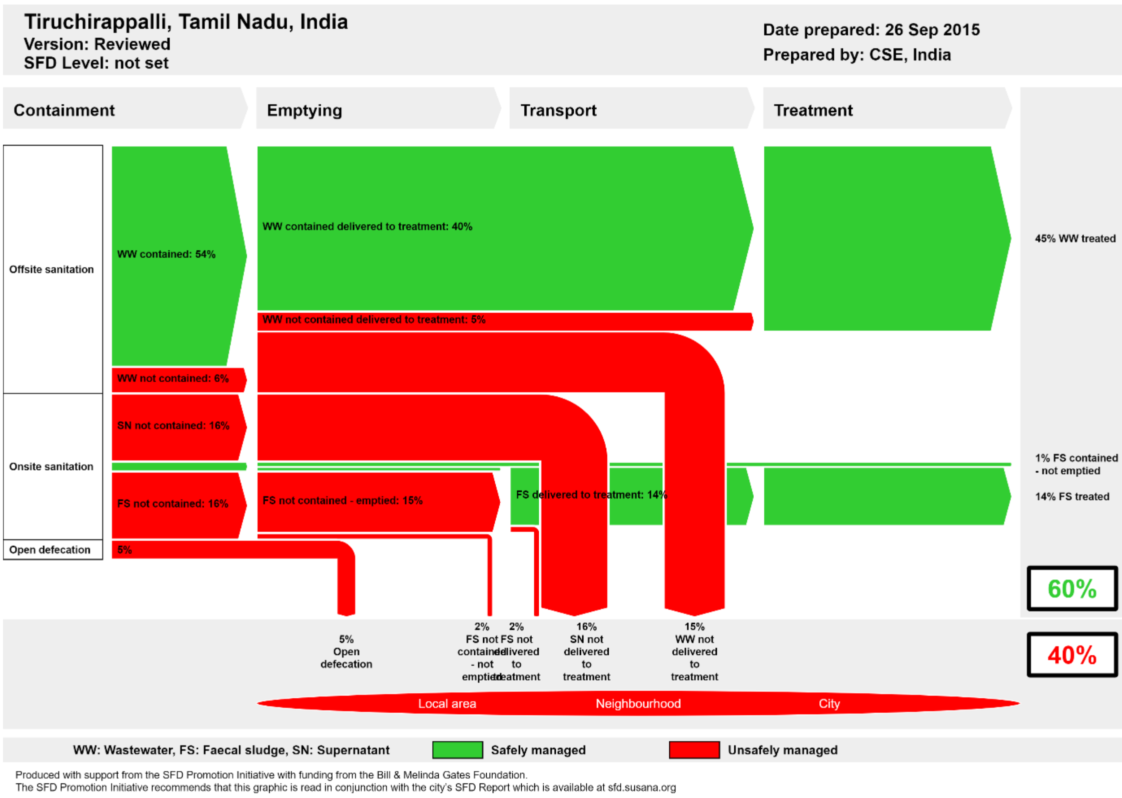
Vacuum tanker in place for septic tank emptying

Opening the first compartment of septic tank

In Iact invert level in the second chamber and watering down to loosen the sludge

DEWAT Trial Plant

is effluent goes into open drain. Some FS is always left in the tanks and is assumed to be two per cent. Whereas one per cent of FS from pits is contained in pits, which includes infiltration of water as well, and rest one per cent of pits are emptied in pumping station. Overall out of 16 per cent of FS emptied 14 per cent is conveyed



Private emptier discharging FS in sewage pumping stated (Source: Bhitush/CSE, 2015)

Septic tank connected to community toilet in Ariamangalam slum (Source: Bhitush/CSE, 2015)

through pumping stations and is co-treated with sewage at STPs. Five per cent of population practices open defecation and hence shown unsafe on SFD.

Overview of stakeholders

The 74th Constitutional Amendment Act of 1992 reformed the sector by transferring responsibility for domestic, industrial and commercial water supply and sewerage (WSS) from state agencies, such as Departments of Public Health Engineering and State Water Boards, to Urban Local Bodies (ULBs). This transfer has resulted in a variety of implementation models, as well as lack of clarity in allocation of roles and responsibilities between state and local agencies, which sometimes leave large gaps in implementation (USAID, 2010). The following stakeholders are responsible for sanitation service delivery in Tiruchirappalli.

TWAD Board is responsible for planning, designing and construction of sewerage system. TCC is responsible for operation and maintenance of sewerage network. The city corporation licenses private emptiers and allows them to dispose septage in sewage pumping stations. Private emptiers and TCC both are responsible for septage management. TNPCB is responsible for monitoring and evaluation of STPs.

Credibility of data

Two key sources of data are used; Census of India, 2011 and data from TCC. Most of the data is then updated by Key Informant Interviews (KIIs). Six KIIs have been conducted with different stakeholders. Data on containment is available in Census. Data on emptying and transport is collected by KIIs. However most of the data is qualitative. Some of the issues and challenges are listed below:

- Data insufficiency and non-availability
    i. No data available on how many septic tanks are connected to open drains and how many are connected to soak pits (for effluent infiltration)

ii. No data available about commercial establishments, institutions etc.

- Accuracy: Discrepancy observed between Census data and actual ground situation
- Data available at different time lines
- Limited data available on reuse (formal / informal)
- Assumptions followed for preparing SFDs:
    i. Data provided by Census of India, 2011 is correct
    ii. Septic tanks and sewer connections on ground are as per septic tanks & sewer connections defined in Census
    iii. Volume of waste water generated is 80% of water supplied
    iv. 90% of the people get their tanks emptied when full

5.3 Session-2

Session 2 is conducted on the second day of the training. A quick round of recap is done with the participants to start from where things were left on the first day. The day's purose is to delve deeper into the making of SFDs and get familiar with technicalities around SFDs. The participants are familiarised with SFD Manual—SFD variables, SFD report templates and SFD report levels, and later to calculations used in SFD generation.

5.3.1 SFD manual, terms, variables and SFD glossary

Purpose: The purpose is to become familiar with different variables, notations, terms and abbreviations used in SFDs. The main idea helps participants understand the way different variables are composed and used in several places in the SFD graphic and report.

Method: Based on the SFD manual shared with participants at the end of Day 1, an overview is conducted in the training hall to understand the manual itself. Participants are asked to open their respective manuals and visit the section that lists SFD terminologies, and later the SFD Glossary in volume-2 of the SFD manual.

Participants are asked to focus on SFD variables and understand how their composition changes with the changing sanitation system in the ground. In this practice, two–three rounds are made where the presenter presents the situation using a power point presentation. In the presentation,

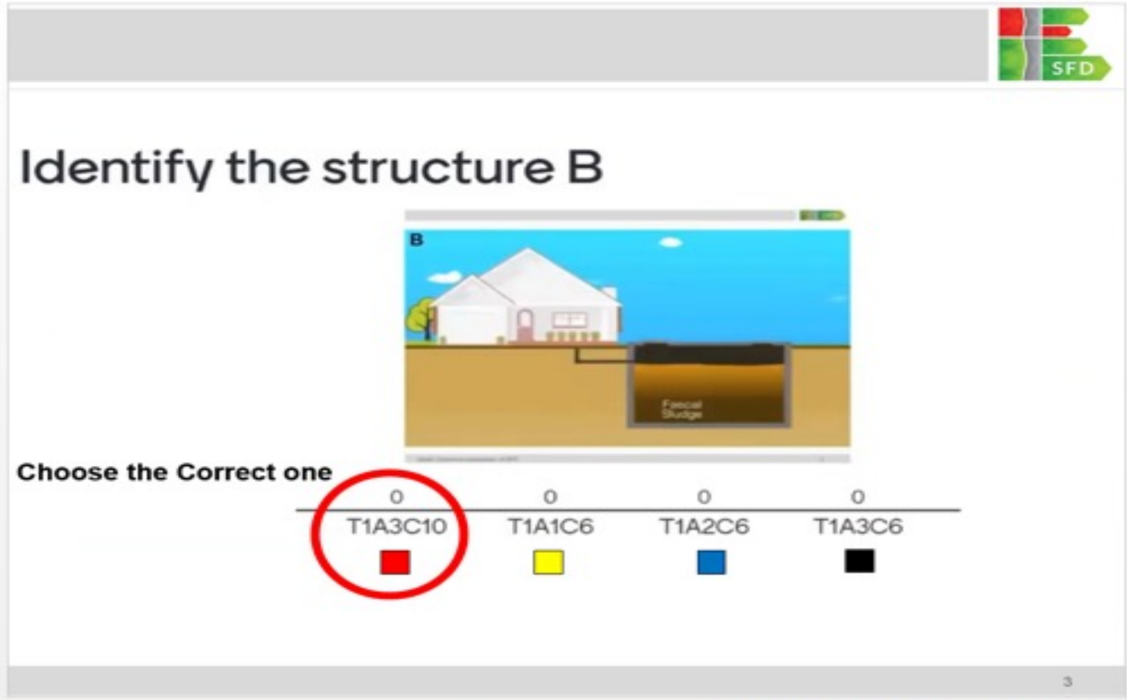
Q-Situation 1. The picture in the presentation slide shows a toilet connected to a tank with baffled walls and one outlet in the drain. Participants are allowed to observe the picture carefully and then four options are opened in front of the participants.

Note: Online software like Socrative and mentimeter are used sometimes to showcase the pitures and relevant options. The answers given by participants are then showed online on a screen in the training hall.

Command: The situation is commanded and the participants are asked to match the situation with the variable and corresponding compositions in the SFD glossary section.

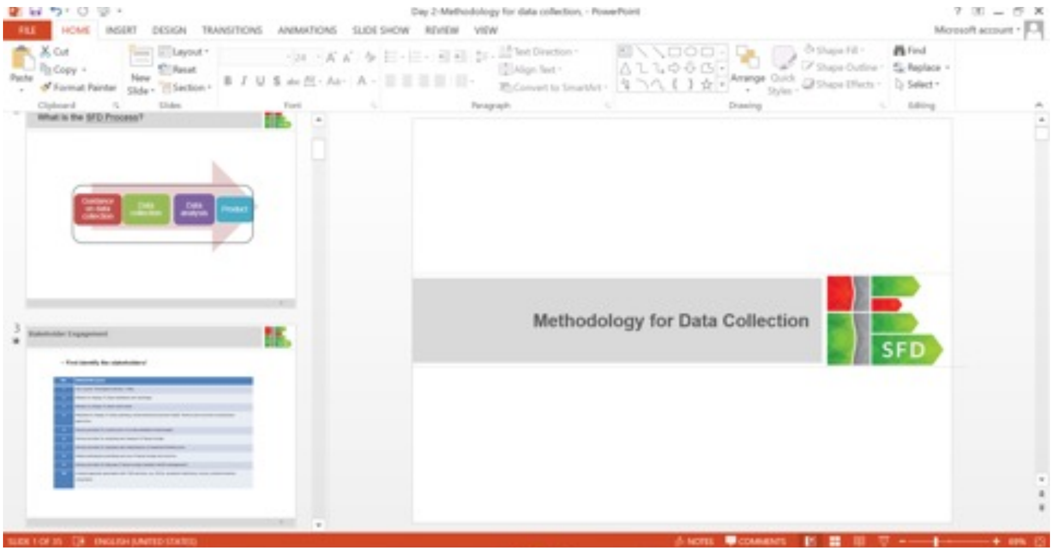
Participant's role: Participants role is to follow the SFD manual in the SFD glossary section to and compose the right reference by using right variables in the manual.

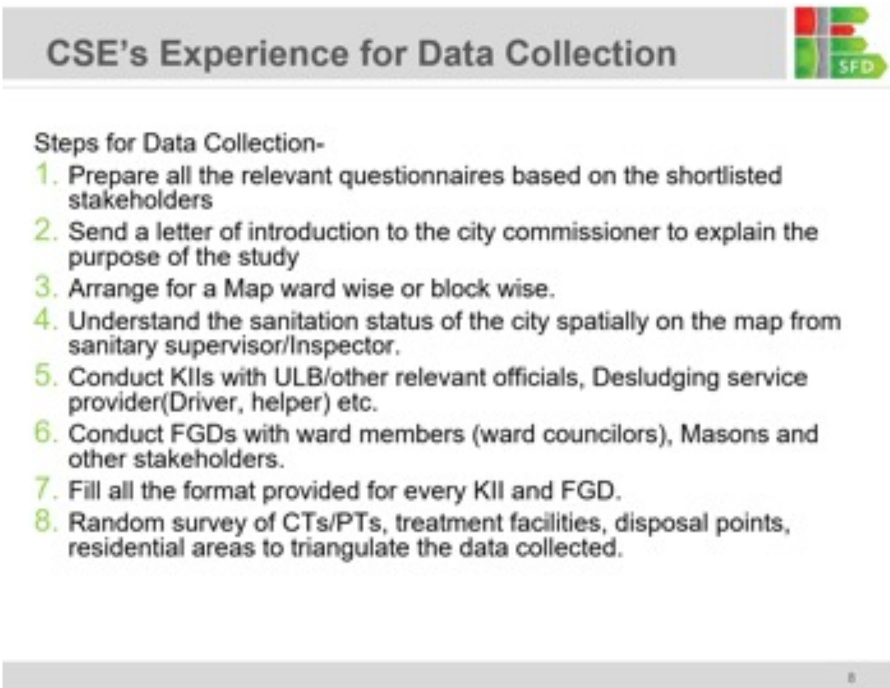
The method used here does not push for cramming variables used in the SFD graphic as it is not required. However it urges participants to understand the logic behind the composition of variables as they are seen frequently during generating the SFD graphic.



5.3.2 SFD methodology for data collection and SFD calculations

Purpose: In this section, participants are exposed to the process through which they can collect data that can be fed directly into the SFD graphic generator or can help in making appropriate assumptions to feed data corresponding to different variables. They use Key Informant Interviews (KII) and Focussed Group Discussions (FGDs) to bring sense of sanitation situation in the city.





Method: Power Point presentation. The presentation covers

- how to proceed with data collection,
- make use of secondary data,
- What are key informant interviews and focussed group discussions?
- Who are the relevant stakeholders?
- How to capture data on complete sanitation value chain.

5.3.3 Wastewater and septage estimation exercise

Purpose: The purpose of this exercise is to make sense of the data collected from the ground when we are dealing with septage and faecal sludge. The exercise illustrates how data based on desk research in the training can be calculated and brought into a form that can be fed into an SFD graphic generator.

For example, for variables like W4a (proportion of wastewater in sewer system, which is delivered to centralized treatment plants) one should know how much wastewater is being generated in the city and how much of that wastewater is actually reaching the centralized treatment plant. For variables like S4e (proportion of supernatant in open drain or storm sewer system, which is delivered to treatment plants) there could be a complicated situation in the city, like the city could be partly sewered or partly dependent on open drains. In that case the researcher will have to procure data on each set of diversion—the quantity of wastewater being diverted to open drains and the quantity channelled to centralized sewers. Later, if open drains are intercepted to sewers then the data on the proportion of the wastewater reaching treatment should also be considered.

Hence the calculations are necessary to understand the complete wastewater faecal sludge pathway inside the city. Sometimes, these calculations are also necessary when relevant data is not received from the ground, or to triangulate the data received.

Method: Participants are provided with a calculation sheet with random hypothetical data. The narrator guides them at every step to understand the assumptions and data required for calculations.

SFD calculation exercise

Calculation of wastewater and septage

This exercise serves as a benchmarking reference to on-ground trothing/estimation of sewage and septage generation, its emptying, conveyance, treatment and reuse in a town when preparing its SFD.

This formula-based calculation cannot replace the on-ground assessment. It should only be used as a cross reference.

Given data of a town

- Current population = 1,00,000
- Total number of households = 20,000
- Water supply in litres per capita per day = 120 LPCD
- Proportion of waste water generated = 80% or above
- Percentage of HH with Sewer connection = 20%

STP-relevant data

- STP capacity = 10 MLD (Million litres per day)
- Proportion of wastewater/sewage reaching the STP = 85%
- Working efficiency of STP = 80%

FSTP-relevant data

- FSTP = one plant of 25 KLD (Kilo Litres per day)
- Proportion of septage reaching the FSTP = 80%
- Working efficiency of FSTP =90%
- Percentage of HH with OSS = 80%
- Annual contained volume in a household septic tank = 1500 litres per year
- Number of Desludging Tanker = 5
- Number of trips by each vehicle per day = 2
- Desludging interval = 3 years
- Capacity of each tanker = 4 KL (Kilo litres)
- Septage generation rate (Indian context)= 120 litres/capita/year

Steps in calculating the emptying, conveyance and treatment of sewage and septage for SFD:

Wastewater

Step 1 - Wastewater generation
= (population based on sewerage x per capita water supply x proportion of waste water generated) = 10000 x 120 x 0.8 = 9.6 MLD

Step 2 - Wastewater reaching the STP (helps in estimating or triangulating W4a or W4c)
= 85% of 9.6 = 8.16 MLD

Step 3 - Wastewater treated (helps in estimating OR triangulating W5a or W5c)
= 80% of 8.16 = 6.52 MLD
Or 0.85x0.80= 68%

SEPTAGE

Step 1 – Applying different approaches. There are **three different methods** of calculating septage generation in a city/town. They are usually considered when constructing an FS treatment plant. The steps have been shown here as a cross reference.

Table 4: Calculation for septage generation in the city

Calculation method	Formula	Result
1) Septage production method	Septage generation litres/ year = Population x sludge/ septage generated per capita per year	80000 x 120 = 9600000 litres/year = 9.6 ML/year
2) Containment method	Septage generation Litres/ year = Annual contained volume of septage x sludge of a household / No. of households	1500 x (80000/5) = 24000000 Litres/year = 24 ML/year
3) Collection method	Septage generation Litres/ year = (average volume of truck x no. of trucks x no. of trips a day by each vehicle x No. of working days)/desludging interval in years	(4000 x 5 x 2 x 300)/3 = 4000000 Litres/year = 4 ML/year

Note: Data triangulation for calculating septage generation:

- Either consider the value that is higher than the two nearby values, or
- If the difference of the two nearby estimates exceeds 50 per cent, then take the average of the two nearby estimates.

Step 2 – Arriving at the estimated sludge generation. As per the above table, septage generation by the containment method seems to be much higher than the other two. The difference between the other two methods is more than 50 per cent, hence the total septage generation will be calculated as the average of the two methods with nearby estimated values – = (9.6 + 4)/2 = 6.8 ML/year
Or 6.8/365days = 18.6 KLD

Step 3 – Faecal Sludge Emptying Percentage (helps in estimating OR triangulating F3)
= (volume of septage collected / septage generated) x 100
= 4/6.8 = 58.8% (let say 59%)
Use ground truthing to identify the real percentage of emptying septic tanks. If it is 4ML a year as per ground assessment, then use it, the emptying percentage will then be 100%.

Step 4 - Proportion of septage reaching the FSTP (helps in estimating or triangulating F4)
= 80% of % emptying = 0.8 x 59% = 47.2% (let say **47%**)
Not all septage collected may reach the FSTP.
Some may be thrown around roads and river bodies or on farm fields

Step 5 - Proportion of septage treated (helps in estimating OR triangulating f5)
= 90% of septage reaching the treatment plant = 0.9 x 47% = 42.3% (let say 42%)
Now apply this to generate an SFD in Do-it-Yourself exercise

5.3.4 SFD reports and template

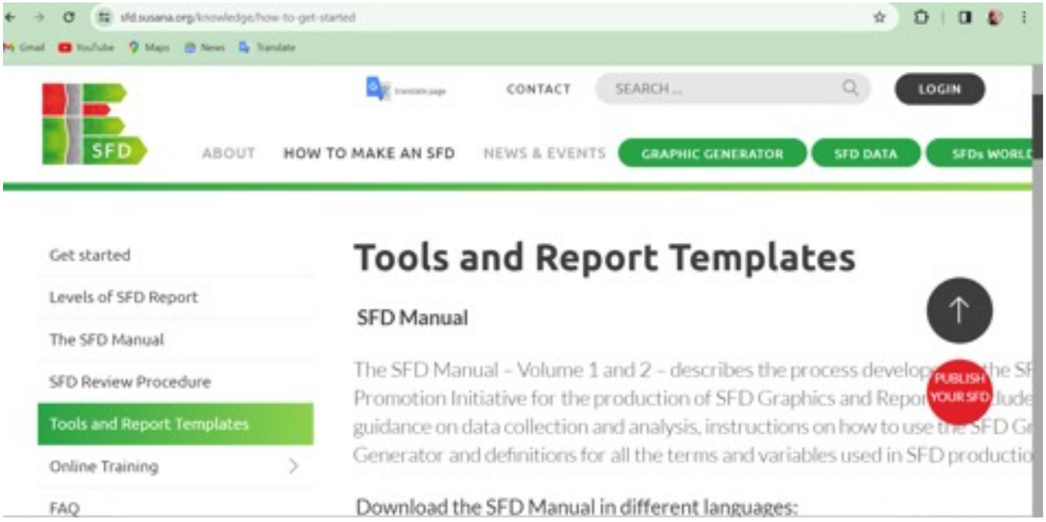
Purpose: The purpose is to understand the following:

- different levels of SFD reports
- how reports differ structurally
- the types of engagement and data required to make the respective types of report
- the ethical considerations necessary for making an SFD and SFD report

Method: Through power point presentation and assessing few reports live on https://sfd.susana.org/ .

Difference in the levels of SFD reports

Enabling environment to service delivery	Data collected at all stages of the service chain	Data collection ✓ = required × = not required If collected = recommended Level of SFD: Lite	Initial (1)	Intermediate (2)	Comprehensive (3)
Policy, legislation and regulation	Policy	×	✓	✓	✓
	Institutional roles	×	✓	✓	✓
	Service provision	×	✓	✓	✓
	Standards	×	✓	✓	✓
Planning	Targets	×	×	Include if data is collected	✓
	Investment	×	×	Include if data is collected	✓
Equity	Choice	×	×	Include if data is collected	✓
	Reducing inequity	×	×	Include if data is collected	✓
Outputs	Quantity / capacity	×	×	Include if data is collected	✓
	Quality	×	✓	✓	✓
Expansion	Demand	×	×	Include if data is collected	✓
	Sector development	×	×	Include if data is collected	✓
Service outcomes	Quantity	✓	✓	✓	✓



5.4 Session-3

Once participants have developed an understanding of the usage, application and processing of data collection for SFDs, we proceed to understand the generation of the SFD graphic with the data collected. Session 3 is all about understanding the SFD graphic generator and its web page.

5.4.1 Graphic generator

Purpose: To help participants understand

- how to run the SFD graphic generator tool
- how to feed data into the generator
- how to save SFD graphic and associate files
- how to edit the already generated SFDs

Method: First, a small power point presentation on, ‘how to use an SFD graphic generator,’ is shown to participants. Later, the narrator takes the participants to the website: https://sfd.susana.org/graphic-generator The presenter helps participants understand the website and graphic generator tool by running the tool through hypothetical data used in the calculations from Session 2. Further, the presenter guides participants on the process of saving the SFD reports and their associated files.

At this point participants have spent some hands-on time with the SFD graphic generator and can manage the data necessary for SFD graphic generation.

5.4.2 Make your own SFD (group exercise)

In this section participants explore the SFD graphic generator independently. They are divided into groups and given two to four sets of readings. If we have more than 30 participants in the training we prefer to provide four sets of readings (in this report we have shared only two sets).

Purpose: The purpose is to practice SFD graphic generation, develop the skill to use various data sets related to faecal sludge, wastewater and city service delivery in SFD graphic generation.

Method: The two sets of readings are based on the hypothetical data of a hypothetical country, state and city. The participants are divided into groups and each group is given a different reading. The groups have to follow the instructions in the reading to make their own SFD. Later, each group has to prepare a presentation that will depict the following:

i. SFD Graphic,
ii. SFD matrix
iii. Assumptions made for generating the graphic.
iv. Recommendations for improving the situation in the city.

Later, groups whose SFD is the closest to the correct SFD with the right assumptions is rewarded.

Exercise: make your own SFD

In this exercise, you are expected to prepare an SFD graphic and a presentation. You are given a case example for which you have to prepare an SFD by analyzing the data provided in the example.

Note: The maps that are used in these exercises shows four types of cities, buthere we have showcased the case studies of only two cities. We normally use four cities if participants are to be divided into groups of four.

Instructions

1. Read the information provided for the case study of Shitpur
2. Using the data from the reading complete Table 1 and Table 2
3. You are free to make assumptions, but duly explain why you have made that assumption
4. Once you have completed the table, proceed to select the type of sanitation systems on the online SFD graphic generator page
5. Now create your SFD matrix by clicking on the "create SFD matrix" button using Table 1
6. Create your SFD graphic by clicking on the "draw SFD graphic" button. You can still go back and make changes in the selection of your system or the matrix.
7. Now make a PowerPoint presentation on your SFD graphic and assumptions made to explain the SFD.

General guidelines

1. 80 per cent of the water supply is wastewater per capita (can be assumed if not given in data).
2. Treatment efficiency of STP could be taken as 80 per cent
3. The groundwater of the city can be assumed from the map provided in the workbook
4. Containments other than septic tanks do not adhere to the standard codes for designing containments
5. MLD= Million litres per day and KLD = Kilo litres per day
6. 1 cubic meter = 1000 litres; 1 MLD = 1,000,000 L per Day ; 1KLD = 1000 litre per day
7. FGD = Focused Group Discussions; KII = Key Informant Interviews
8. CPCB is Central Pollution Control Board
9. For calculating emptying percentages, the participant can use the method of septage generation and the size of containment method shared in the PDF before
10. Assume the desludging interval in all type of OSS to be three years
11. Assume the average of the annual contained volume of all types of septic tanks and FLTs as 1,500 litres/year; all types of pits as 1,000 litres/year ; all types tanks with open bottom as 1,200 litres/year
12. Assume the proportion of the faecal sludge content of each type of onsite container as 50 per cent for septic and fully-lined tanks, and 100 per cent for lined tanks with impermeable walls and open bottoms.

Case study 1: Shitpur city

Reading

Shitpur is a city in the Sanitationbaad province of Excretaland. In October 2010, the city was recognized as a `*Municipality*´ in '*Category A*', which means that it has an annual income of *6 million E$*. The Shitpur Municipal Council (SMC) is responsible for services such as sanitation, roads and water supply in the city. The Water and Sewerage Board (WSB) of Sanitationbaad province provides infrastructure and resources for the water supply and sewerage network. The city is divided into 25 wards spread across 15 sq. km of the total area. The total population of the Shitpur Municipality is 42,000 with a population density of 2,800 persons per sq.km. There are two major slums in the city which consists of 1,400 Households (HH) out of a total of 8,400 total HH in the city. WSB provides provide drinking water supply to SMC through the *Shanti River* which is 40 km from the city.

In the year 2015, the WSB partially connected the city to a piped water supply. In the national wastewater management scheme of 2015, WSB also laid a sewerage network in the city. The sewerage network is currently connected to a five MLD sewage treatment plant through Interception and Diversion as there was no household sewer connection. The STP is in the eastern corner of the city. Sanitationbaad Municipal Corp (SMC) operates the water supply in the city in two ways—piped water supply (east zone) and tanker water supply (west zone). This city faces the challenge of a poor and insufficient waste management system which is frequently reported in the local newspapers. There are no FSSM bye-laws for the city that could bind private emptiers.

In a survey conducted by an NGO with city municipality and Focused Group Discussions (FGD) with various sanitation stakeholders, along with a sample household survey, the following information was noted:

From FGD with SMC and WSB officials

1. For sewerage and water supply, the city is divided into east and west zones by the WSB. Both zones have an equal number of households.
2. Wastewater from open drains in the east zone reaches the 5 MLD STP through interception.
3. In the focus group discussions with operators at STP, it was revealed that STP is treating around 2 MLD of wastewater every day. The treatment is done on the standards set by the Central Pollution Control Board (CPCB) of Excretaland.

4. The WSB ground staff claims that due to power cuts and blockages in the open drains some wastewater is lost before the interception.
5. In focus group discussions with engineers from the SMC Water department, it was revealed that they provide 135 LPCD supply through piped water supply (east zone).
6. Around 840 households use community or public toilets that are connected to septic tanks with soak pits usually seen in the East zone of the city.

From sample HH Survey

1. Instances of faecal sludge discharged on the roadside and water bodies have been seen frequently by citizens.
2. 30 per cent of households in the city are connected to septic tanks whose outlets are in turn connected to open drains. These households are located in the part of the city that has piped water supply.
3. 30 per cent of households in the city have tanks that are lined from all sides, sealed at the bottom and open into an open drain outside the house. These households are located in the area of the city that receives water supply from tankers.
4. There are around 250–300 households in the periphery of the city towards the west zone who still practicing open defecation.
5. 10 per cent of households in the city had connected their toilets directly to open drains outside the house. These households were seen in the east zone of the city which is highly congested and have narrow roads in many wards.
6. Arrangements for hand pumps and underground borings were seen frequently in the west zone of the city.

Survey in slums

1. The two major slums are present in the west zone of the city. All slum households were provided with toilets under the Central Sanitation Scheme in 2019.
2. The toilets were connected to tanks with honeycomb walls and open bottoms.
3. The slums also receive a 70 LPCD water supply through SMC water tankers.
4. In the rainy season the containments overflow and whole area gets filthy. Sometimes they have to manually empty the tanks.

FGD with private desludgers and sanitation staff of SMC

1. Community and public toilets have septic tanks that are connected to soak pits.
2. There are around four private desludgers offering emptying and transportation services in the city**. Each have a tractor-mounted desludging machines each with a capacity of 4,000 litres.**

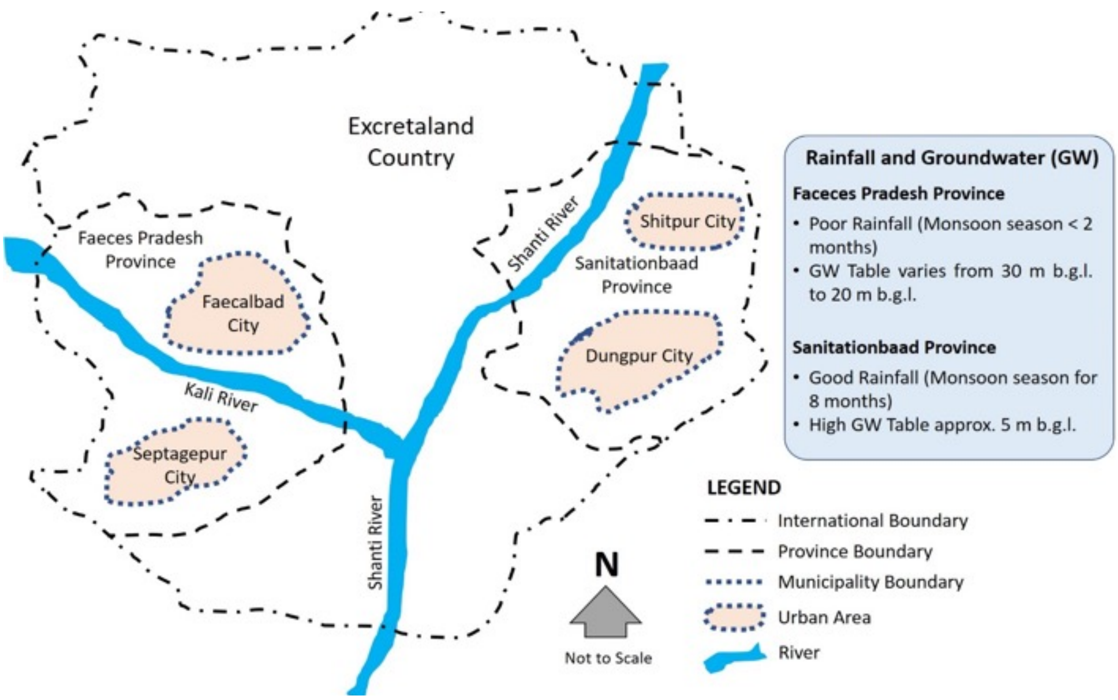
3. The Shitpur Municipality has one tractor-mounted desludging vehicle that is used to provide desludging services on demand in the city, and it is operated by a driver and a helper. It makes an average of two trips per day.
4. Each private desludgers makes 60 trips per month.
5. Sanitation workers (FGD) of SMC revealed that the east zone of the city is highly congested and several instances of faeces in open drains were noticed by them in that area.
6. Focus group discussions also revealed that 70 per cent households with lined tanks are emptying them.

Table 5: Type of sanitation systems and corresponding populations

Practice	Bifurcation	Name of systems	Corresponding SFD typology	Percentage of population using it	Assumption or remark (If any)
Offsite	List out type of offsite systems				
On site	List out type containments				
Open Defecation	List possible location of open defecation				

Table 6: Data on FSS and wastewater

Type of data	Water Supply				Assumption or remark (if any)
Percentage of population	Total	Piped	Tanker	Other	
	Wastewater				
Total amount of wastewater generation in the city (MLD)					
Quantity of wastewater in the sewers (MLD)					
Quantity of wastewater in sewers reaching to treatment (MLD)					
	Faecal Sludge Septage				
Total FSS generation in the city	Per day	Per month	Per Year		
Total FSS generation in the city	Per day	Per month	Per Year		



Answers

Shitpur

Calculation sheet

Type of containments

1. Percentage of population whose septic tanks have outlets that are connected to an open drain= 30%
2. Percentage of population whose toilets are connected to nothing but direct open drains= 10 %
3. Percentage of population connected to semi-lined pits with open bottom systems= 17%
4. Percentage of population with fully lined tanks connected to open drains = 30%
5. Percentage of population practicing open defecation= to be calculated
6. Percentage of population whose septic tanks are connected to a soak pit (hint: community toilet or public toilets)= 10%

Exercise: Calculation of septage and wastewater

Note: Participants are provided with data sets that are required for calculating septage generation and percentage emptying during the PPT

Given data:

- Current population = 42,000
- Total households in the city = 8,400
- Slum households = 1,400
- Slum population= 1400 x 5 = 7000
- Water supply tanker systems = 70 LPCD
- Population connected piped water supply = 21,000 persons
- Population connected with tanker water supply = 21,000
- Capacity of the treatment = 5 MLD
- Water supply in different zones (if different zones have different water supply) = 135 LPCD (in east zone)
- Population or households using community and public toilets= 840 HH
- 80 per cent of total water consumption goes as wastewater
- Wastewater getting treated in the treatment plant everyday= 2MLD
- Treatment efficiency of STP =80%
- Percentage of households with a sewer connection = 20%
- Percentage of HH with OSS = 80%
- Annul contained volume = 1,500 litres/year

- Number of desludging tankers (private)= 4
- Number of desludging tankers (government)=1
- Capacity of the government desludging tank = 5,000 litres
- Capacity of each private desludging tank= 4,000 litres
- No. of trips made by each vehicle per month = 60 trips

Note: 1 MLD = ^{6} litres/day
1 KLD = litres/day

For wastewater calculation:

Step 1 - Wastewater generation = (Population based on sewerage x per capita water consumption x 0.8) = 21000 x 135 x 0.8 = 2.26 MLD (piped water supply)
Wastewater generated through other type of water supply
Tanker water supply =70LPCD
Hence wastewater generation from households using tanker supply is = 21,000 x 70 x 0.8 =1.76 MLD

Wastewater reaching to the treatment plant = i.e. 2.5MLD (obtained from ww treated) = hence percentage of WW in open sewers reaching the plant (W4C) = 2.5/4.02= 62% (approx.)
Wastewater treated (W5c) = 80% (i.e. 2MLD 80% of y) therefore y = 2/0.8 =2.5 MLD

For septage calculation:
Step 1 - There are three different methods of calculating the septage generation of a city/town. Details are given below:

Table 7: Data on FSS and wastewater

Calculation method	Formula	Result
1)Septage production method	Septage generation litres/year = Number of people x Septage Generation Rate (Does not include 10% population discharging toilets directly in open drains via CT PT and 4% population practicing open defecation)	35925x120= 4311000 L/yr =4.31 ML/yr
2) Collection method	Septage generation Litres/ year = (Average volume of truck x No. of trucks x No. of trips/day by each vehicle x No. of working days)/Desludging interval	4000x2x300x5=12000000/3= 4 ML/yr
3) Containment method	Septage generation Litres/ year = Annual contained volume x No. of households	STOD= 1500x2520=3.78 ML/yr FLTOD= 1500x2520 3.78 ML/yr LSO= 1000x 1400= 1.4 ML/yr STSP= 1500 x 840=1.26 total = 10.26 ML/yr

Note: Data triangulation for calculating septage generation: Either consider the value that is higher than the two nearby values, or if the difference of two nearby values exceeds 50 per cent, then take the average of the two nearby values.

Step 2 (if required)

As per the above table, septage generation by the containment method seems to be much higher than the other two. Also, the difference between the other two methods is more than 50 per cent, hence the total septage generation will be calculated as the average of the two methods.

= 4.15

Step 3 - % emptying (F3) = (volume of septage collected/septage generated) x 100

= 4/4.31= 91%

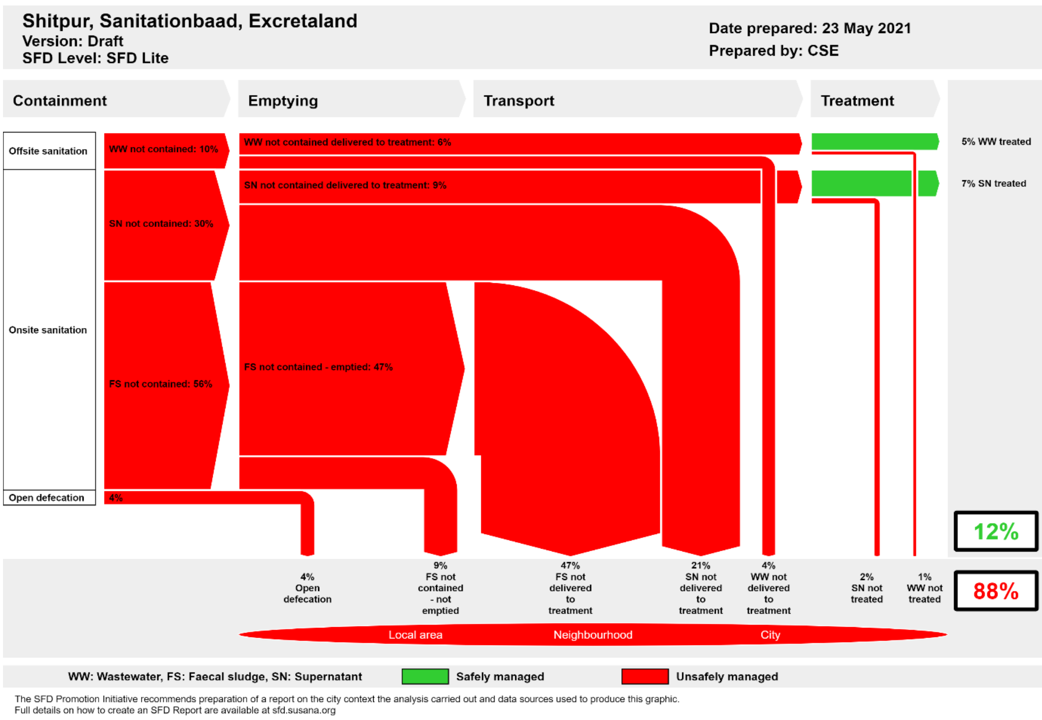
Step 4 - Proportion of septage reaching the treatment plant (F4) =

Since septage treatment and co-treatment are not practiced, the septage doesn't go for treatment.

Step 5 - Proportion of septage treated (F5) =

0%

Final SFD Shitpur city



SFD matrix for Shitpur city

Shitpur, Sanitationbaad, Excretaland, 23 May 2021. SFD Level: SFD Lite Population: 42000 Proportion of tanks: septic tanks: 50%, fully lined tanks: 50%, lined, open bottom tanks: 100%								
Containment								
System type	Population	WW transport	WW treatment	FS emptying	FS transport	FS treatment	SN transport	SN treatment
	Pop	**W4c**	**W5c**	**F3**	**F4**	**F5**	**S4e**	**S5e**
System label and description	Proportion of population using this type of system (p)	Proportion of wastewater in open sewer or storm drain system, which is delivered to treatment plants	Proportion of wastewater delivered to treatment plants, which is treated	Proportion of this type of system from which faecal sludge is emptied	Proportion of faecal sludge emptied, which is delivered to treatment plants	Proportion of faecal sludge delivered to treatment plants, which is treated	Proportion of supernatant in open drain or storm sewer system, which is delivered to treatment plants	Proportion of supernatant in open drain or storm sewer system that is delivered to treatment plants, which is treated
T1A1C6 Toilet discharges directly to open drain or storm sewer	10.0	62.0	80.0					
T1A2C6 Septic tank connected to open drain or storm sewer	30.0			92.0	0.0	0.0	62.0	80.0
T1A3C6 Fully lined tank (sealed) connected to an open drain or storm sewer	30.0			92.0	0.0	0.0	0.0	0.0
T1B11 C7 TO C9 Open defecation	4.0							
T2A2C5 Septic tank connected to soak pit, where there is a 'significant risk' of groundwater pollution	10.0			92.0	0.0	0.0		
T2A5C10 Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	16.0			92.0	0.0	0.0		

Case study 2: Faecalaad

Exercise: make your own SFD

In this exercise, you are expected to prepare an SFD graphic and a presentation on your own. You are given a case study for which you have to prepare an SFD analyzing the data provided in the example.

Instructions

1. Read the information provided for the case study Faecalabaad
2. Using the data from the reading, complete Table 1 and 2
3. You are free to make assumptions, but you must duly explain why you have made that assumption
4. Once you have completed the table, proceed to select the type of sanitation systems in the online SFD graphic generator page.

5. Now create your SFD matrix by clicking on the “Create SFD matrix” button using Table 1.
6. Create your SFD graphic by clicking on the “Draw SFD graphic” button. You can still go back and make changes in the selection of your system or in the matrix.
7. Now make a PowerPoint presentation on your SFD graphic and the assumptions you have made to explain the SFD.

General guidelines

1. 80 per cent of the water supply is wastewater.
2. The treatment efficiency of a sewage treatment plant (STP) could be taken as 90 per cent
3. Groundwater of the city can be assumed from the map provided in the workbook
4. Containments other than septic tanks do not adhere to the standard codes for design containments
5. MLD= Million litres per day and KLD = Kilo litres per ay
6. 1000 litre = 1 cubic meter; 1 MLD = 1,000,000 litres per day ; 1KLD = 1000 litre per day
7. FGD = Focused Group Discussions; KII = Key Informant Interviews
8. CPCB= Central Pollution Control Board
9. To calculate the emptying percentages, you can use the method of septage generation and size of containment method shared in the PDF previously.
10. Assume the desludging interval in all types of OSS as three years
11. Assume the average annual contained volume of all types of septic tanks and FLTs as 1,500 litres/year; all types of pits as 1,000 litres/year; and all types of tanks with open bottoms as 1,200 litres/year
12. Assume the proportion of the contents of each type of onsite container—faecal sludge as 50 per cent for septic tanks and fully lined tanks, and 100 per cent for lined tanks with impermeable walls and open bottoms.

Reading

Faecalbaad is a city in the Faeces Pradesh province of Excretaland. It is situated 25 km to the north-east of Septagepur city and 80 km from the river *Kali*. In October 2000, the city was recognized as a Municipal Corporation in Category B, which means that it has an annual income of 12 million *E$*. The Faecalbaad Municipal Corporation (FMC) is responsible for services such as sanitation, roads and water supply in the city whereas Faeces Pradesh Water and Sewage Board (FPWSB) provides infrastructure and resources for the water supply and sewerage network. The city is divided into 30 wards spread across a total area of

40 sq.km. The total population in the FMC is 1,50,000 with a population density of 1,000 persons per sq. km. There are 25,000 Households (HH) under the FMC administration. FPWSB provides drinking water supply to FMC through the *Kali* river. In 2018 the city was fully connected to piped water supply by FPWSB. In 2018, FPWSB constructed a 24 MLD Activated Sludge Process-based sewage treatment plant under the National Wastewater Management Scheme of 2015. FPWSB has outsourced the O&M of the sewage treatment plant (STP) to Zulu Water Management systems in a contract for five years. Faecalbaad is completely sewered and household connections to the sewer lines is in the process of being set up. FPWSB has recently constructed an 80 KLD FSTP in the West zone of the city which is operated and maintained by FMC. There are no FSSM bye-laws present or notified by FMC. **FMC has one truck-mounted and one tractor-mounted desludging vehicles that help in providing emptying and transportation services in the city. FMC has notified the 80 KLD** FSTP as a designated disposal site for the safe disposal of faecal sludge in a newspaper notification recently.

In a survey conducted by an NGO with the city municipality and through focused group discussions (FGD) with various sanitation stake holders, as well as a sample household survey, the following information was noted:

From FGD with FMC, FPWSB and Zulu water management systems officials.

1. The city is divided into East and West Zones by FPWSB for sewerage and water supply system. Both zones have an equal number of households.
2. FPWSB has connected households located in the East zone to sewer lines.
3. Wastewater flowing through the open drains in the West Zone is intercepted and brought to the 24 MLD sewage treatment plant.
4. The sewage treatment plant (STP) treats 18 MLD of wastewater on an average. In focus group discussions with Zulu Water Management Systems officials, it was revealed that there are instances when they let go 2 MLD wastewater untreated for some extra income.
5. FMC is providing a supply of 135 LPCD of water to the whole city through a piped water supply system. However, households also have arrangements of submersible pumps and hand pumps. There is no clear detailed data available about the percentage of households who have their own borings or hand pumps.
6. FMC has two government desludging tankers. One is tractor-mounted (2,500 litres of capacity) and the other is truck-mounted (5,000 litres capacity). All government desludging vehicles make two trips each per day.

The faecal sludge that reaches treatment is 90 per cent of the total sludge that is transported to the FSTP. All the FS reaching to treatment plant is getting treated.
From Sample HH Survey

1. 50 per cent of the households in the West zone have septic tanks connected to open drains.
2. 50 per cent of the households in the West zone have tanks that are lined from all sides and sealed from the bottom and have an outlet in the open drain outside the house
3. 50 per cent of the households in the remaining city are directly connected to sewer lines.

Focus group discussions (FGD) with private desludgers and sanitation staff of DMC

1. There are eight private desludging operators in the city. Each operator makes two trips per day.
2. Private operators have tractor-mounted desludging vehicles with a capacity of 4,000 litres each.
3. Private emptiers avoid disposing emptied faecal sludge at FSTPs if it is not in the range of 10 kms. Half of the time they do not dispose the FSTP.

Table 8: Type of sanitation systems and corresponding populations

Practice	Bifurcation	Name of systems	Corresponding SFD typology	Percentage of population using it	Assumption or remark (if any)
Offsite	List out type of offsite systems				
On Site	List out type containments				
Open Defecation	List Possible Location of open defecation				

Table 9: Data on FSS and wastewater

Type of data	Water supply				Assumption or remark
Percentage of population	Total	Piped	Tanker	Other	
	Wastewater				
Total amount of wastewater generation in the city (MLD)					
Quantity of wastewater in the sewers (MLD)					
Quantity of Wastewater in sewers reaching to treatment (MLD)					
	Faecal Sludge Septage				
Total FSS generation in the city	Per day	Per month	Per Year		

Answers

Faecalabad

Calculation sheet

Type of containments

1. Percentage of population connected septic tanks with outlets in open drain = 25%
2. Percentage of population whose toilets are connected to nothing but direct open drains = 0 %
3. Percentage of population connected semi-lined pits with open bottom systems = 0%
4. Percentage of population with fully lined tanks connected to open drains = 25%
5. Percentage of population practicing open defecation =
6. Percentage of population whose toilets are connected directly to sewer lines = 50%

Exercise: Calculation of septage and wastewater

Note: Participants are provided with the data sets below that are required for calculating septage generation and percentage emptying during the PowerPoint presentation.

Given data –

- Current Population =150,000
- Total HH in the city=25,000
- Slum Households=None
- Slum Population= =Not Applicable (NA)
- Percentage Population connected piped water supply= 100%
- Population connected with tanker water supply= NA
- Capacity of the treatment = 24 MLD
- Water supply in all zones = 135 LPCD
- Population or households using community and public toilets= None
- 80% of total water consumption goes as wastewater
- FSTP = 80 KLD (Kilo Liters Per Day)capacity
- Wastewater getting treated in the treatment plant everyday= 18 MLD
- Treatment Efficiency of STP =90%
- Percentage of HH with Sewer connection = 50%
- Percentage of HH with OSS = 50%
- Annual contained volume for Septic Tanks and FLT = 1500 ltr/year
- Number of Desludging Tanker (private)= 8
- Number of Desludging Tanker (GOVT)=2
- Capacity of government truck mounted desludger tank= 5000
- Capacity of each private desludging tank= 4000 litres each
- Capacity of government desludger tank= 2500 litrs
- Capacity of each private desludging tank= 40000 litres

Note: 1 MLD = 10^6litres/day

1 KLD = 10^3litres/day

For wastewater calculation:

Step 1: Wastewater generation = (Population based on sewerage x Per capita water consumption x 0.8) = 150000x135x0.8= 16.2 MLD (through piped water supply)

Wastewater generated through other type of water supply?
Tanker water supply = NA

Wastewater generation from HH using tanker supply is = NA

Total WW generation= WW generated from (pipe supply system + tank supply system) = 16.2 MLD + *wastewater generation from groundwater sources which is not known in this case*

Wastewater reaching to the treatment plant = (obtained from ww treated) which is said to be 90% =

Hence as we know WW treated currently is 18 MLD; therefore 90% of y (let's assume ww reaching to treatment is y) =18 MLD. Therefor y= 20MLD (here important thing to note is that ww reaching may be higher because of ground water sources of water supply as mentioned in the text, however, there is no mention blockages in the sewer in the city, therefore the assumed wastewater reaching is taken as 100%). Hence the percentage of wastewater in open sewers reaching the plant (W4C) = 100%

Wastewater treated (W5c) = 90% (given)

Step 1: There are three different methods for calculating the septage generation in a city/town. Details have been provided below:

Table 10: Calculation of septage generation in the Faecalabad

Calculation method	Formula	Result
1) Septage production method	Septage generation litres/year = Number of people x Septage generation rate	= 75000x*120 = 9000000= 9ML/yr
2) Collection method	Septage generation litres/year = (average volume of the truck x no. of trucks x no. of trips/day by each vehicle x no. of working days)/desludging interval	=[(4000*8*2*300) + (2500*2*300*1) + (5000*1*2*300)]/ 3 = 7900000 = 7.9 ML/yr
3) Containment method	Septage generation litres/year = annual contained volume x no. of households	(1500*6250) + (1500*6250) = 187500000 = 18.75 ML/yr

Note: To triangulate data for calculating septage generation, either consider the value that is higher of the two nearby values or if the difference of the two nearby values exceed 50% then take average of two nearby values.

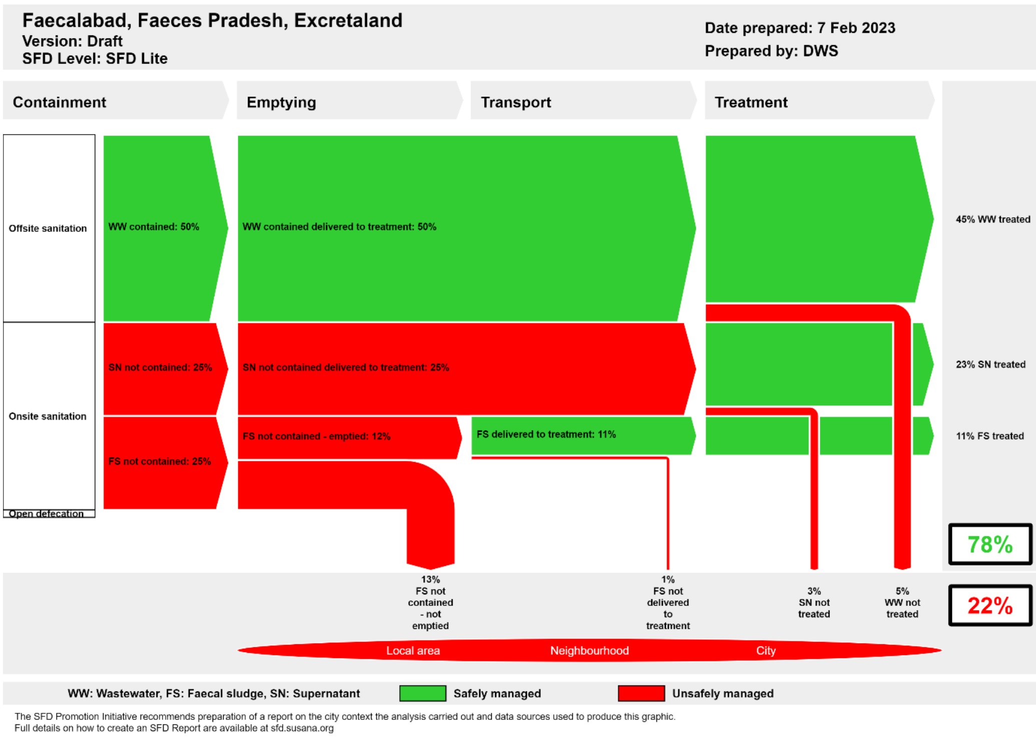
Step 2 (if required): As per the above table, septage generation by containment method seems to be much higher than other two. The difference between two nearby vavlues is less than 50% (septage production method and collection method)

So we take the higher value of the two= 9ML/yr

Step 3: % emptying (F3) = (Volume of septage collected / septage generated) x 100 = 9/19= 47%
Therefore Volume of septage emptied= 18.75 x 0.47= 8.8 ML/year
Volume of septage emptied per day = 8,800 KL/365= 24.10 KLD

Step 4: Proportion of septage reaching to the treatment plant (F4) = 90% of the above= 0.9 x 24.10 = 21.69 KLD

Step 5: Proportion of septage treated (F5) = 100% (given)



Final SFD Faeclabad city
SFD Matrix for Faecalabad city

Faecalabad, Faeces Pradesh, Excretaland, 7 Feb 2023. SFD Level: SFD Lite
Population: 150000
Proportion of tanks: septic tanks: 50%, fully lined tanks: 50%, lined, open bottom tanks: 100%

Containment								
System type	Population	WW transport	WW treatment	FS emptying	FS transport	FS treatment	SN transport	SN treatment
	Pop	W4a	W5a	F3	F4	F5	S4e	S5e
System label and description	Proportion of population using this type of system (p)	Proportion of wastewater in sewer system, which is delivered to centralised treatment plants	Proportion of wastewater delivered to centralised treatment plants, which is treated	Proportion of this type of system from which faecal sludge is emptied	Proportion of faecal sludge emptied, which is delivered to treatment plants	Proportion of faecal sludge delivered to treatment plants, which is treated	Proportion of supernatant in open drain or storm sewer system, which is delivered to treatment plants	Proportion of supernatant in open drain or storm sewer system that is delivered to treatment plants, which is treated
T1A1C1 Toilet discharges directly to a centralised combined sewer	50.0	100.0	90.0					
T1A2C6 Septic tank connected to open drain or storm sewer	25.0			47.0	90.0	100.0	100.0	90.0
T1A3C6 Fully lined tank (sealed) connected to an open drain or storm sewer	25.0			47.0	90.0	100.0	100.0	90.0

Do-it-yourself exercise for online training session

Assignment—make your own SFD

Case Study 1- Hypercity

1. Instructions

- Read the data provided in the following sections clearly and thoroughly.
- The Hypercity is a hypothetical city in a hypothetical state and country.
- Understand the different data sets and apply to fill in the data for the SFD graphic.
- You can use the table at the end of this document to sort the data according to the SFD graphic generator.
- The aim of the assignment is to create an SFD graphic from the data provided below. Use the data to write a short action plan for the improvement of the city sanitation delivery and service outcomes
- 80 per cent of the water supply is wastewater per capita (could be assumed if not given in data).
- Containments other than septic tanks do not adhere to the standard codes for designing containments
- MLD= million litre per day and KLD = kilo litre per day

- 1,000 litre = 1 cubic meter; 1 MLD = 1,000,000 litre per day ; 1KLD = 1,000 litre per day
- You are free to make assumptions but you must explain them in your assignment write-up. (Why did you make this assumption? What data did you consider for making this assumption?)

Hypercity is situated in Hyperstate in Hyperland country

Data sets (hard)
- Name of the city: Hypercity
- Population of the city: 1,00,000
- Households in the city: 20,000
- FSTP present: 32 KLD
- STP present: No
- Number of private and government vacuum tanks: 4
- Number of trips made by each vacuum (private+ government) tank in a day: 4
- Capacity of vacuum tanks: 4,000 litres or 4 cubic metre
- Containment types in the city:
  - Septic tanks connected to open drains: 10,000 HH in the city
  - Full lined tanks connected to soak pit: 5,000 HH in the city
  - Unlined pits: 5,000 HH in the city

- Average containment size
  - For septic tanks: 3 cubic meter
  - For Fully lined tank: 3 cubic meter
  - For Unlined pits: 2 cubic meter
  - For lined tanks average emptying has been observed as 10 years for 50 per cent of HHs and the rest have been emptying their tanks in six years
  - For pits, average emptying has been observed as four years in 50 per cent of HHs and the rest 50 per cent have not been emptying.

- Water supply and wastewater
  - The city extracting water from Damola river
  - Supplying piped water supply @ 120 LPCD to 50 per cent households
  - Supplying tanker water supply @70 LPCD to remaining 50 per cent households
  - 80 per cent of the supply is wastewater
  - All the wastewater in the city goes to the Damola river in the outskirts
  - Groundwater level is 20 MBGL in all the areas of the city

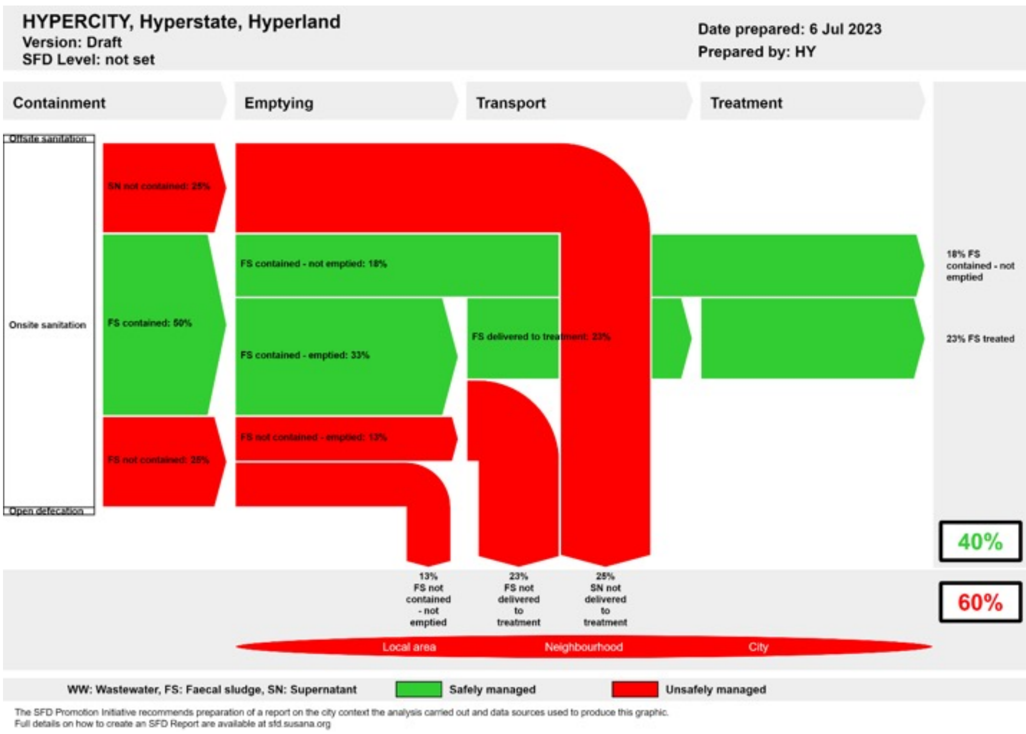
Data sets (soft)

- Households usually empty when the containment is full (visible excreta)
- 50 per cent of what is emptied in the city is transported to the FSTP for treat-

Table 11: Type of sanitation systems and corresponding population

Sanitation type	% Population	Further breakdown (Type of containment system and where it is connected to)	% Population	How it is defined in SFD	% w/w OR SN delivered to treatment plant	% w/w OR SN treated	% FS emptied	% FS Going to treatment	% FS Treated	Notes and assumptions made
No facilities										
Private Toilets										
Public toilets										

Answer
Graphic



ment. The rest is dumped in open land or waterbodies.
- Whatever reaches the FSTP is treated completely
- The Damola river is polluted

Matrix

HYPERCITY, Hyperstate, Hyperland, 6 Jul 2023. SFD Level: not set
Population: 100000
Proportion of tanks: septic tanks: 50%, fully lined tanks: 100%, lined, open bottom tanks: 100%

Containment						
System type	Population	FS emptying	FS transport	FS treatment	SN transport	SN treatment
	Pop	F3	F4	F5	S4e	S5e
System label and description	Proportion of population using this type of system (p)	Proportion of this type of system from which faecal sludge is emptied	Proportion of faecal sludge emptied, which is delivered to treatment plants	Proportion of faecal sludge delivered to treatment plants, which is treated	Proportion of supernatant in open drain or storm sewer system, which is delivered to treatment plants	Proportion of supernatant in open drain or storm sewer system that is delivered to treatment plants, which is treated
T1A2C6 Septic tank connected to open drain or storm sewer	50.0	50.0	50.0	100.0	0.0	0.0
T1A3C5 Fully lined tank (sealed) connected to a soak pit	25.0	50.0	50.0	100.0		
T1A6C10 Unlined pit, no outlet or overflow	25.0	80.0	50.0	100.0		

5.5 Session-4

This session depends on the willingness of the participants. Here, a live SFD is made in a day. Participants are sent to the known government offices and areas to collect data. They are expected to develop an SFD based on the data collected.

Purpose: The purpose of this session is to help participants understand that they may or may not receive the desired data every time they go to a government office. But they have to learn how to amend the available data into a useful form.

6 Way forward

SFDs have been successfully used to advocate for effective sanitation strategies which cover both off-site and on-site sanitation systems. It showcases the status of urban sanitation across the sanitation value chain. They are an effective tool for city-wide sanitation planning and monitoring of key sanitation interventions. SFDs have also been used to map exclusions across the value chain. They hold relevance in understanding the urban sanitation scenario and should be used for the following reasons:

- SFDs has a robust methodology in place to develop a credible graphic and report
- They provides an overview of the sanitation situation without taking recourse to detailed field studies
- The SFD graphic provides immediate visual cues about system failures which can be linked back to institutional aspects of service delivery

In order to sustain the use of SFDs as an advocacy and planning tool, they need to merge with the larger agenda for CSP, FSSM and CWIS. SFDs can be further linked to the Energy Performance and Carbon Emissions Assessment and Monitoring (ECAM) tool to understand the subsequent energy performance and GHG emissions from the utilities. ECAM is the first of its kind to allow for a holistic approach of the urban water cycle to drive GHG emission reduction in water utilities, even those with limited data availability. It promotes transparency, comparability, and consistency. It is designed to assess the carbon emissions that utilities can control within the urban water cycle and prepares utilities for future reporting needs on climate mitigation. It is important to note that SFDs for towns and cities or localities in the cities provides a good database that can be used as a base data for ECAM tool.

The following table provides a way forward for the SFDs in line with other tools and subjects

S No	Name of the tool or subject	How Shit Flow Diagrams can contribute	Possible future studies
1	City-wide Inclusive Sanitation (CWIS)	i. to understand and monitor equity and safety in the service delivery of cities. ii. to gauge sustainability of the treatment infrastructure	i. SFDs of lower-income settlements of a few major cities, and comparing the SFD of the city itself to understand equity in service delivery. ii. SFDs of cities before and after, and understanding the gap in implementation of sanitation and wastewater reforms

2	City Service Delivery Assessment (CSDA) Tool	i. Creating a base for CSDA by bringing understanding on service delivery from the ground.	i. an overall study for a city or a group of cities to understand service delivery in water, wastewater and sanitation along with an enabling environment in the city for the same.
3	Energy Performance and Carbon Emissions Assessment and Monitoring (ECAM) Tool	i. Collecting baseline data for wastewater utilities.	A cumulative study to assess the fate of excreta and effect of mismanagement of utilities on climate due to emissions
4	SFD for monitoring of National missions	Monitoring, advocacy and planning	i. Assessment of implementation of sanitation and wastewater reforms at city-level, state-level and country-level. 2. Comparing different cities with the country in different states based on population, topography, demography, climate on the lines of excreta and wastewater management.

From SFDs to water-sensitive cities—the Global South framing

SFDs played a critical advocacy role in advancing a deconstructed understanding of urban sanitation systems and highlighting the intervention hotspots. It paved the way for the uptake of non-sewered sanitation systems (NSS) in countries of the Global South.

SFD as a sanitation systems tool will remain useful for the next phase of inclusive sanitation systems approach. Inclusive sanitation will become part of the urban water and sanitation systems thinking that links together environment (pollution abetment) as well as a circular economy (reuse of treated biosolids and treated waste water—the last link of the sanitation service value chain).

CSE has developed a global south water sensitive cities framework that pieces together these aspects with the overall objective of achieving equity and justice in water and wastewater management and reuse.

Global South water-sensitive cities framework[23]

The goal

Cities commit to "just and equitable access, use, reuse" of water supply for sewerage/septage and stormwater management.

The Global South water-sensitive cities framework recognizes inequity in urban settlements as the basis for planning and designing interventions for water-sensitive cities. There is no leapfrogging possible without addressing infrastructural deficiencies, especially for underprivileged residents. Climate change impacts everyone, yet the underprivileged are the most affected by its adverse effects. We need to strengthen urban planning instead of looking at design interventions, placemaking and beautification as the only outcomes of water-sensitive cities.

Global South water-sensitive cities index

- **Functional infrastructure and services:** Fix all existing non-functional water, sanitation and stormwater infrastructure and services to improve efficacy and treatment outcomes.
- **Functional and inclusive infrastructure for unserved areas:** Additional grey infrastructure and services may be needed for unserved informal urban settlements that now dominate the urban landscape of cities in the Global South.
- **Substantial reuse of treated wastewater and biosolids:** Reduce wastewater footprint and increase the reuse of treated biosolids and wastewater in a manner that is just and equitable. This may include all measures for reuse and recharge of groundwater and the prevention of pollution of groundwater, waterbodies or peri-urban areas.
- **Mitigating in-situ urban flooding:** Conserving rainwater wherever possible and ensuring that it is as contamination-free as possible. Enhancing stormwater drainage dimensions/norms to address in-situ urban flooding in cities (where built-up area has reduced the potential of groundwater recharge) that is witnessed during normal rainfall periods as well as during high-intensity, climate change-induced episodes.

A nuanced framing of water-sensitive cities will also inform the further development of SFD as a tool. Some initial steps have already been taken in this direction through the development of disaggregated SFDs for poor settlements within a city.

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The SFD resource book is a compilation of CSE's SFD engagement and achievements. It highlights the work done by CSE in capacity building for SFDs and the learning modules developed while doing so. Part A of the report describes the key learnings from CSE's advocacy for excreta and wastewater management—the process by which SFDs were applied as a tool for planning, monitoring and in conjunction with other tools to capture broader sanitation scenarios. Part B is the compilation of resource materials used for conducting onsite trainings. It narrates the methodology for conducting training programs online and offline.

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