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Business Models for Fecal Sludge Management in India

Krishna C. Rao, Sasanka Velidandla, Cecilia L. Scott and Pay Drechsel

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Business Models for Fecal Sludge Management in India

Krishna C. Rao, Sasanka Velidandla, Cecilia L. Scott and Pay Drechsel

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Acronyms and Abbreviations

ADB	Asian Development Bank
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ASCI	Administrative Staff College of India
ASP	Activated Sludge Process
ATP	Adigaratty Town Panchayat
BMC	Bhubaneswar Municipal Corporation
BMGF	Bill & Melinda Gates Foundation
BOD	Biochemical Oxygen Demand
BORDA	Bremen Overseas Research and Development Association
BOT	Build-Operate-Transfer
BSFL	Black Soldier Fly Larvae
BWC	Blue Water Company
C-WAS	Center for Water and Sanitation
CBS	Container-based sanitation
CCMC	Coimbatore City Municipal Corporation
CDD	Consortium for DEWATS Dissemination
CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
CPCB	Central Pollution Control Board
CSP	City Sanitation Plan
CSR	Corporate Social Responsibility
DBOT	Design-Build-Operate-Transfer
DEWATS	Decentralized Wastewater Treatment System
DFBOT	Design-Finance-Build-Operate-Transfer
DGIS	Ministry of Foreign Affairs of the Netherlands
DJB	Delhi Jal Board
DPHE	Department of Public Health Engineering
DTMC	Devanahalli Town Municipal Council
DTP	Directorate of Town Panchayats
E&T	Emptying and Transport
EPC	Engineering, Procurement and Construction
FCO	Fertilizer Control Order
FINISH	Financial Inclusion Improves Sanitation and Health
FS	Fecal Sludge
FSM	Fecal Sludge Management
FSTP	Fecal Sludge Treatment Plant
FTE	Full-time Equivalent
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GNN	Ghaziabad Nagar Nigam
GoI	Government of India
GoK	Government of Kerala
GoR	Government of Rajasthan
GoTN	Government of Tamil Nadu
GPS	Global Positioning System
GWMC	Greater Warangal Municipal Corporation
ha	hectares
HPEC	High Powered Expert Committee

H&UDD	Housing and Urban Development Department
IIHS	Indian Institute for Human Settlements
INR	Indian Rupee
JMP	Joint Monitoring Programme
KeTP	Ketti Town Panchayat
kg	kilograms
KL	kiloliters (1 KL = 1 m^3)
KLD	kiloliters per day (= m^3 per day)
KMC	Kochi Municipal Corporation
KSUDP	Kerala Sustainable Urban Development Project
KTP	Karunguzhi Town Panchayat
L	liter or liters
LPG	Liquefied Petroleum Gas
LSGD	Local Self Government Department
m^3	cubic meters (1 m^3 = 1 KL)
MBBR	Moving Bed Biofilm Reactor
MCL	Municipal Committee Leh
MLD	million liters per day
MNRE	Ministry of New and Renewable Energy
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MoHUA	Ministry of Housing and Urban Affairs
MT	Metric ton
NFSSM	National Faecal Sludge and Septage Management
NGO	Non-governmental Organization
NMC	Nashik Municipal Corporation
NPV	Net Present Value
NSS	Non-sewered Sanitation
O&M	Operation and Maintenance
ODF	Open Defecation Free
OSS	On-site Sanitation Systems
OTP	One-time Password
OWSSB	Odisha Water Supply and Sewerage Board
p.e.	population equivalent
PDB	Planted Drying Bed
PHED	Public Health Engineering Department
PPE	Personal Protective Equipment
PPP	Public-private Partnership
PSI	Population Services International
PTC	Portable Toilet Cabin
R&D	Research and Development
RDO	Rural Development Organisation
RUIDP	Rajasthan Urban Infrastructure Development Project
SBM	Swachh Bharat Mission
SBM-G	Swachh Bharat Mission - Gramin
SD	Standard Deviation
SDG	Sustainable Development Goal
SeTP	Septage Treatment Plant
SHE	Sanitation and Hygiene Education
SHG	Self-help Group
Sida	Swedish International Development Cooperation Agency

SPS	Sewage Pumping Station
SRT	Sludge Retention Tank
STP	Sewage Treatment Plant
Sulabh	Sulabh International Social Service Organisation
SWFF	Securing Water for Food
SWM	Solid Waste Management
ThMC	Thiruvananthapuram Municipal Corporation
TLBP	Toilet-linked Biogas Plant
TMC	Trichy Municipal Corporation
TNUSSP	Tamil Nadu Urban Sanitation Support Programme
TPD	tons per day
TSU	Technical Support Unit
TTPL	Tide Technocrats Private Limited
TWAD	Tamil Nadu Water Supply and Drainage Board
UASB	Upflow Anaerobic Sludge Blanket
UGD	Underground drainage
ULB	Urban Local Body
UNICEF	United Nations Children’s Fund
USAID	United States Agency for International Development
VPGF	Vertical Planted Gravel Filter
WASH	Water, Sanitation and Hygiene
WASHi	Water, Sanitation and Hygiene Institute
WAVE	Women's Action for Village Empowerment
WHO	World Health Organization
WMC	Wai Municipal Council
WtE	Waste-to-Energy

Foreword

The Resource Recovery and Reuse series of reports published by the International Water Management Institute (IWMI) is very close to my heart. I see this latest report, the 18th in the series, as being of particular value.

The report's focus on Fecal Sludge Management (FSM) in India covers a location where both the scale and the context are very exciting for the progress of sanitation. Under the Swachh Bharat Mission, more than 100 million toilets have been built to eliminate open defecation. FSM is a natural extension of this effort and a critical complement to it.

There is reason also for excitement and optimism given the speed with which uptake of FSM in India is taking place. National- and state-level policies have quickly led to implementation programs on the ground that address the critical gap in treatment capacity. Anchored in a combination of informal but entrepreneurial private desludging operators and state-funded infrastructure development, FSM is seeing rapid scale-up. This reflects global interest, with FSM becoming a prominent solution to provide sanitation where sewer systems are not viable.

This report provides a timely contribution to this rapidly evolving picture, relevant not just in India but also for cities in Asia and Africa. It explores linkages between technology, costs, contracting models, and regulations. It covers questions such as: What do robust service chains look like? Who should be paying for these services? How viable are these businesses for private enterprises? How can we ensure quality while delivering good service? In short, this report answers key questions about how to sustain this momentum created around sanitation and FSM in India.

In answering the questions, the authors have spoken to more than one hundred private desludging operators, officials from 22 municipalities, and operators of 18 existing fecal sludge treatment plants. The cases range from "sanitation is a public good", where government pays for everything, to "polluter pays", with households and end beneficiaries paying for sanitation services; the majority adopt more pragmatic and shared payment models. The value of this report lies in showing real examples of delivering sanitation solutions by organizing stakeholders in many different ways, but always with a target of sustainability.

As an academic with a great interest in how to attain private and public services that function well, I find this report fills a significant gap in the literature. It caters to a wide audience, starting with my fellow academicians and researchers, but more importantly reaching out to city managers, investors and decision makers, guiding them to choose an appropriate model for implementing FSM in a sustainable way.

I am confident this report will be a great aid to a better understanding of the FSM landscape and the options for practical decisions, offering a pathway to developing countries to achieve the United Nations Sustainable Development Goal (SDG) 6.2 on access to adequate and equitable sanitation and hygiene.

Prof. Dr. Kalanithy Vairavamoorthy
CEO, International Water Association

Summary

Globally, 50% of the population relies on On-site Sanitation Systems (OSS) such as septic tanks and pit latrines and, hence, is in need of Fecal Sludge Management (FSM) solutions. FSM is the safe emptying, transport, treatment and reuse/disposal of fecal matter from OSS. In India, under the largest program (Swachh Bharat Mission) of its kind anywhere, the government built more than 100 million toilets from 2014 to 2019, with significant success in changing open defecation behavior. The FSM interventions required when toilet pits/septic tanks fill up are now critical for continued toilet usage. This report presents findings on related business models implemented across India and provides insights for scaling up and sustaining FSM.

The report is divided into two parts:

- **Part A** presents findings on Emptying and Transport (E&T) and treatment components of the sanitation value chain. The analysis is based on case studies (Part B) and interviews conducted with 105 E&T operators in 72 towns and cities across 16 states in India, 22 municipalities that own emptying vehicles, 18 Fecal Sludge Treatment Plant (FSTP) operators and more than 30 officials across 15 states; non-governmental organizations (NGOs) and members of the National Faecal Sludge and Septage Management (NFSSM) Alliance involved in implementing FSM were also interviewed.

- **Part B** documents 18 FSM business models based on the analysis of 36 FSM business case studies implemented in India. The 18 business models are classified into six typologies whose features and value propositions are discussed in Part A.

In its approach to business models and the analysis undertaken, this report is based on a previous study conducted by Rao et al. (2016). The key findings from Part A are summarized below:

- **Analysis of E&T:** Much is already known about E&T operators anecdotally, which this study corroborates. A vast majority (85%) of the operators are sole proprietors running informal businesses, a majority ply only one truck and a third of them have purchased used trucks. Business is essentially demand driven with operators traveling long distances (50% of the respondents travel more than 25 kilometers [km]) to serve their customers. More than 70% of the respondents among E&T operators dump fecal sludge in an unsafe manner due to lack of designated safe disposal sites. While the sole proprietors earn a reasonable income, recovering capital deployed seems to be a challenge. Entrepreneurs who manage between 400 and 1,500 trips annually and charge more than Indian Rupee (INR) 1,000 remain profitable. Businesses which can only manage under 400 trips have a high probability of failure, despite the fees charged, and those businesses that carry out many more trips but charge less than INR 1,000 usually make a loss.

- **Analysis of FSTPs:** India does not have sufficient sewage treatment plants and FSTPs to treat the quantum of fecal sludge (FS) generated and collected. At the end of 2019, India had about 30 FSTPs in operation and about an equal number under construction. The per capita cost of an FSTP to serve 100,000 people is about INR 156 to 197, and the annual operating cost per capita is INR 16.6 to 29.4. The total per capita cost of setting up FSM (including E&T) is about INR 196 to 237 per capita, and the annual operating cost is INR 35.8 to 48.6 per capita. In India, in comparison to the networked sanitation system, the capital and operating costs to provide safely managed sanitation services through FSM is 46 and 12 times cheaper, respectively. Further, the time required for deployment of FSM is very short – less than one year for typical projects. Thus, FSM demonstrates that it can be rapidly scaled up to achieve Target 6.2 of the United Nations Sustainable Development Goals (SDGs) - by 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. A 5-year mission has the potential to provide safely managed sanitation for all in India.

- **Payment models for FSM:** Households and institutions requiring desludging services pay for E&T services. However, the prices charged by E&T operators are insufficient to also pay disposal fees to the FSTPs. Reuse of treated solids and effluent is an additional revenue source for the FSTP, but its contribution to a stand-alone FSTP will only be a fraction of the FSTP Operation and Maintenance (O&M) costs. Therefore, the operational costs of an FSTP have to be largely borne by the public sector. Alternatives (and the associated challenges), such as local governments regulating FSM markets by setting tariffs (user acceptance of tariffs) or by providing services against a sanitation tax (political will, collection efficiency), are briefly discussed.

- **Procurement of FSM services:** Procurement models adopted by governments are an important factor in scaling up FSM. Most FSM-related public procurement has followed the Public-private Partnership (PPP) mode. The evolving nature of FSM in India is reflected in the wide range of standards and specifications prescribed in the tenders. This report presents an analysis of current FSM tenders and provides contracting models corresponding to the prevalent FSM business models.

The primary challenge in FSM remains its acceptance as a viable option in sanitation. While India has taken policy and program measures on this front, globally, significant work has to be done in mainstreaming FSM. Specifically, in reporting data on FSM services (e.g., under the WHO/UNICEF JMP), allocating significant and dedicated funds, mainstreaming education including FSM as a part of the sanitation solution, and citizens demanding such services from their local governments.

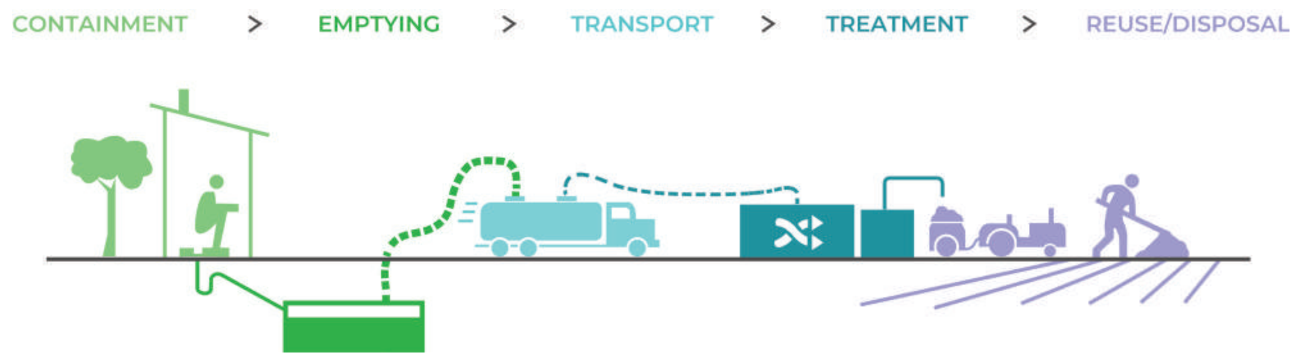
1. Introduction

Fecal Sludge Management (FSM) for On-site Sanitation Systems (OSS) such as septic tanks and pit latrines is one of the key solutions to achieving Target 6.2 of the United Nations Sustainable Development Goals (SDGs) - by 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations (United Nations 2019). FSM comprises in this context the collection, transport, treatment, and disposal/reuse of fecal sludge (FS), as shown in Figure 1.

Globally, out of the 6.1 billion people using improved sanitation facilities, 3.1 billion rely on toilets connected to OSS, i.e., containment units such as septic tanks or leach pits, instead of sewerage networks; 1.5 billion people use septic tanks; and 1.6 billion use pit latrines and other improved facilities (WHO/UNICEF JMP 2019). Figure 2 provides a breakdown of the number of people using OSS in different regions.

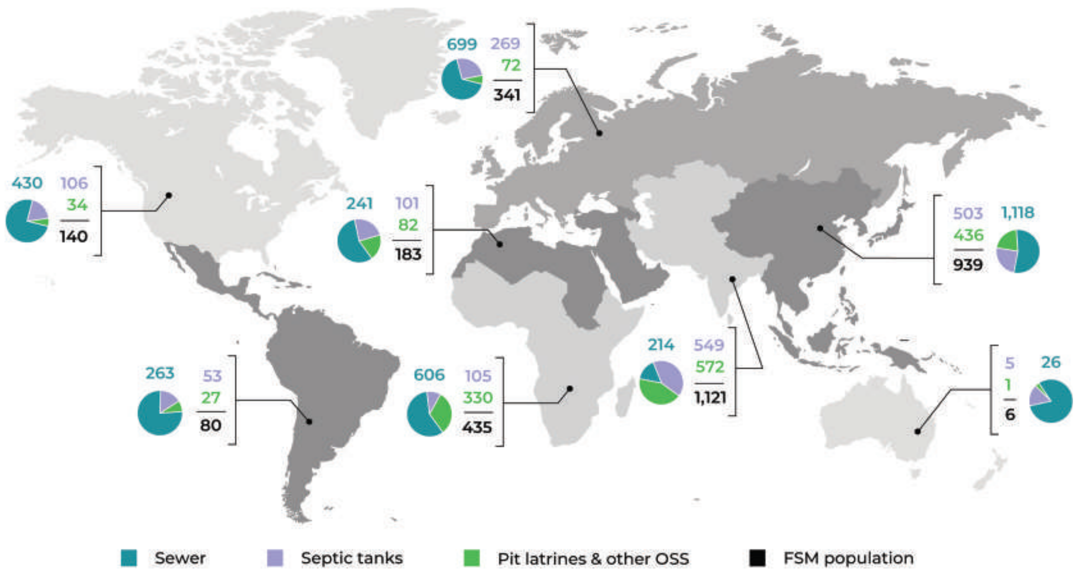
While the population is equally split between those using sewer connections and OSS, the coverage of

FIGURE 1. FSM SANITATION VALUE CHAIN.



Source: Bill & Melinda Gates Foundation 2015.

FIGURE 2. NUMBER OF PEOPLE USING OSS IN DIFFERENT REGIONS IN 2017 (IN MILLIONS).



Source: Data from WHO/UNICEF JMP 2019.

sewerage is more prevalent in developed countries and urban areas. In fact, 8 out of 10 people with sewer connections live in urban areas. However, in Central and South Asia and sub-Saharan Africa, there has been a far greater increase in the use of OSS compared to sewer connections, and as of 2017, urban areas have had a higher percentage of people using OSS (WHO/UNICEF JMP 2019). Even where sewers are provided, the willingness of households and capacity to connect should not be taken for granted, especially where households have to pay for the connection (WSP 2015). With 50% of the global population relying on OSS, the need to provide FSM-based sanitation solutions has only increased.

1.1 FSM in India

According to the 2011 Census of India, 11.9% of the population was covered by sewerage, 32.3% by septic tanks and other systems, and almost 50% defecated in the open (Office of the Registrar General & Census Commissioner, India 2011). The Government of India (GoI) launched the Swachh Bharat Mission (SBM) in 2014 as a nationwide drive to end open defecation. The SBM resulted in decreasing incidence of open defecation by 3% per year between 2000 and 2014, and by up 12% per year between 2014 and 2019 (MoHUA 2019). In urban areas, from 2011 to 2017, the population relying on OSS increased from 45% to 64%, while there was a drop in coverage through sewer connections from 33% to 30% (Office of the Registrar General & Census Commissioner, India 2011; WHO/UNICEF JMP 2019).

Lack of sewerage infrastructure has resulted in an increased dependence on OSS in recent years, as 5.7 million new household toilets were constructed under the SBM between 2014 and 2019 in urban areas (MoHUA 2019). WHO/UNICEF JMP (2019) reported that 11% of households nationwide had sewer connections, with 30% in urban areas and less than 1% in rural areas. In bigger cities with populations above 100,000, a higher percentage of people – around 50% – had sewer connections. The World Health Organization and United Nations Children's Fund (WHO/UNICEF) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) uses a benchmark to compare service levels across countries through a sanitation ladder (Box 1). Figure 3 presents the WHO/UNICEF JMP (2019)

analysis on safely managed sanitation in India. Insufficient sewerage infrastructure, combined with almost no FSM-related treatment infrastructure, has led to a growing gap between access to improved sanitation and safely managed sanitation services.

This gap will increase significantly due to the rural toilet construction efforts under the SBM program. With over 100 million toilets constructed (27% estimated to be twin pits), about two-third of them are expected to require FSM services (Kantar Public and IPE Global 2019). The scale and seriousness of the FSM problem in rural India cannot be underestimated given the political, social and economic investment in the SBM program.

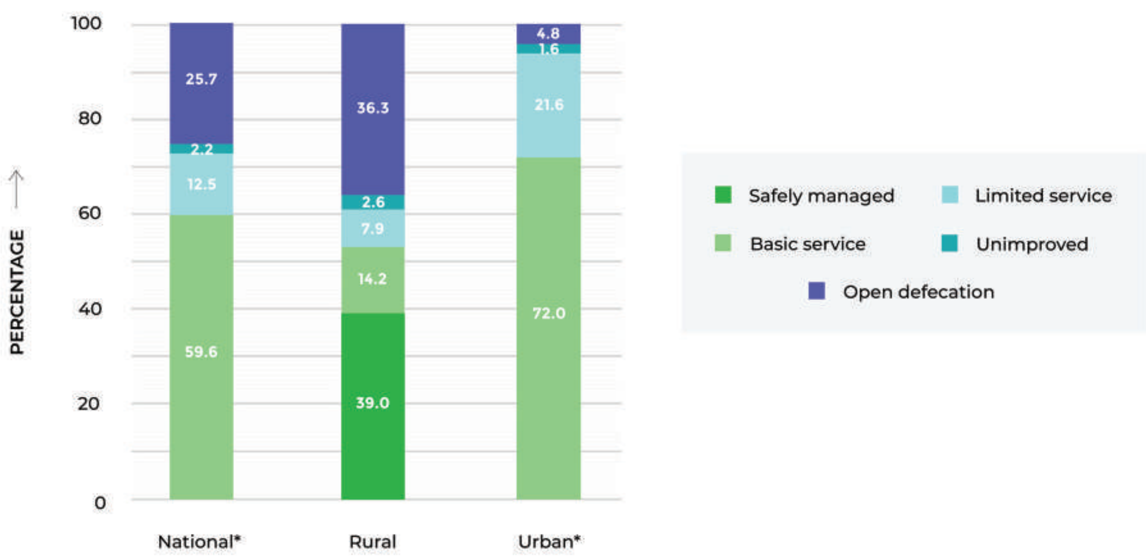
BOX 1. SANITATION LADDER.

The World Health Organization and United Nations Children's Fund (WHO/UNICEF) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) uses a benchmark to compare service levels across countries through a sanitation service ladder. The new ladder builds on the established improved/unimproved facility type classification with additional criteria related to service levels as mentioned below:

- **Safely managed –** use of improved facilities that are not shared with other households and where excreta are safely disposed in situ or transported and treated off-site
- **Basic –** use of improved facilities that are not shared with other households
- **Limited –** use of improved facilities shared between two or more households
- **Unimproved –** use of pit latrines without a slab or platform, hanging latrines or bucket latrines
- **Open defecation –** disposal of human feces in fields, forests, bushes, open bodies of water, beaches, and other open spaces or with solid waste

Source: WHO/UNICEF JMP 2019

FIGURE 3. SANITATION LADDER FOR INDIA.



*No safely managed estimate available
Source: WHO/UNICEF JMP 2019.

Unsafe sanitation in India has high economic, environmental, and health costs. The country suffers heavy economic losses due to poorly managed sanitation – Indian Rupee (INR) 2.4 trillion annually, an equivalent of 6.4% of India's gross domestic product (WSP 2011). The poorest quintile of urban households bears the highest costs, around 1.75 times the national average of per capita losses, due to inadequate sanitation (WSP 2011). At the same time, 70% of water in India is polluted, in part due to fecal contamination, with the country ranked 120 out of 122 countries in terms of water quality (Kant 2018).

In order to address the growing need for managing FS from OSS in urban India, the Ministry of Housing and Urban Affairs (MoHUA) issued the National Policy on Faecal Sludge and Septage Management in 2017 (Ministry of Urban Development, India 2017). The policy provides the required impetus for the uptake of FSM projects by the state governments in India – from a single Fecal Sludge Treatment Plant (FSTP) in 2014 to almost 30 FSTPs as of 2019 (see section 4: *Financials of Treatment of Fecal Sludge*) and another few hundred are in various stages of procurement and construction. For rural India, significant policy thrust is expected through the Open Defecation Free (ODF) Plus program, of which FSM is an integral component. Allocation of significant and dedicated funds remains a work in progress.

The FSM sector in India is nascent but rapidly emerging. Several projects have been implemented across the country and serve to demonstrate technical as well as business model aspects of FSM. Some of the noteworthy projects aim to demonstrate scheduled desludging or Public-private Partnerships (PPPs) and regulatory aspects such as licensing, implementation of sanitation tax, and so forth. The sector needs to rapidly learn from these projects, as well as the technology pilots, in order to develop solutions for scaling up FSM. These solutions have to connect all components of the sanitation value chain, along with institutions (stakeholders and regulations), technical solutions and appropriate financing models to sustain FSM implementation. A strategy for scaling up FSM, as part of a larger sanitation plan, can then emerge.

1.2 About the Report – Business Models for FSM in India

This report documents successful and unsuccessful FSM projects in India with a special focus on questions such as "Who is paying for FSM?" and "Is that the best arrangement?" Although lack of data over a significant time period precludes detailed analysis, emerging trends on how FSM is being organized are discussed. This report complements, with a new focus and in-depth analysis, the study conducted by Rao et al. (2016), by trying to answer the central questions – "What is the best way to ensure that FSM is paid for in the long term?" "What arrangements should the key stakeholders make for a successful FSM project?" and "Are such projects replicable?" These discussions will hopefully benefit FSM implementation in India and other countries. The case studies presented here cover all components of the sanitation value chain, except for business models aimed solely at providing toilets.

The report is divided into two parts:

- **Part A** summarizes the analyses and key findings from 36 business case studies and 18 business models in relation to financial data collected on the emptying, transportation, and treatment components of the value chain, along with procurement practices and key policy recommendations to scale up FSM in India.
- **Part B** presents business models and related business case studies of FSM in India.

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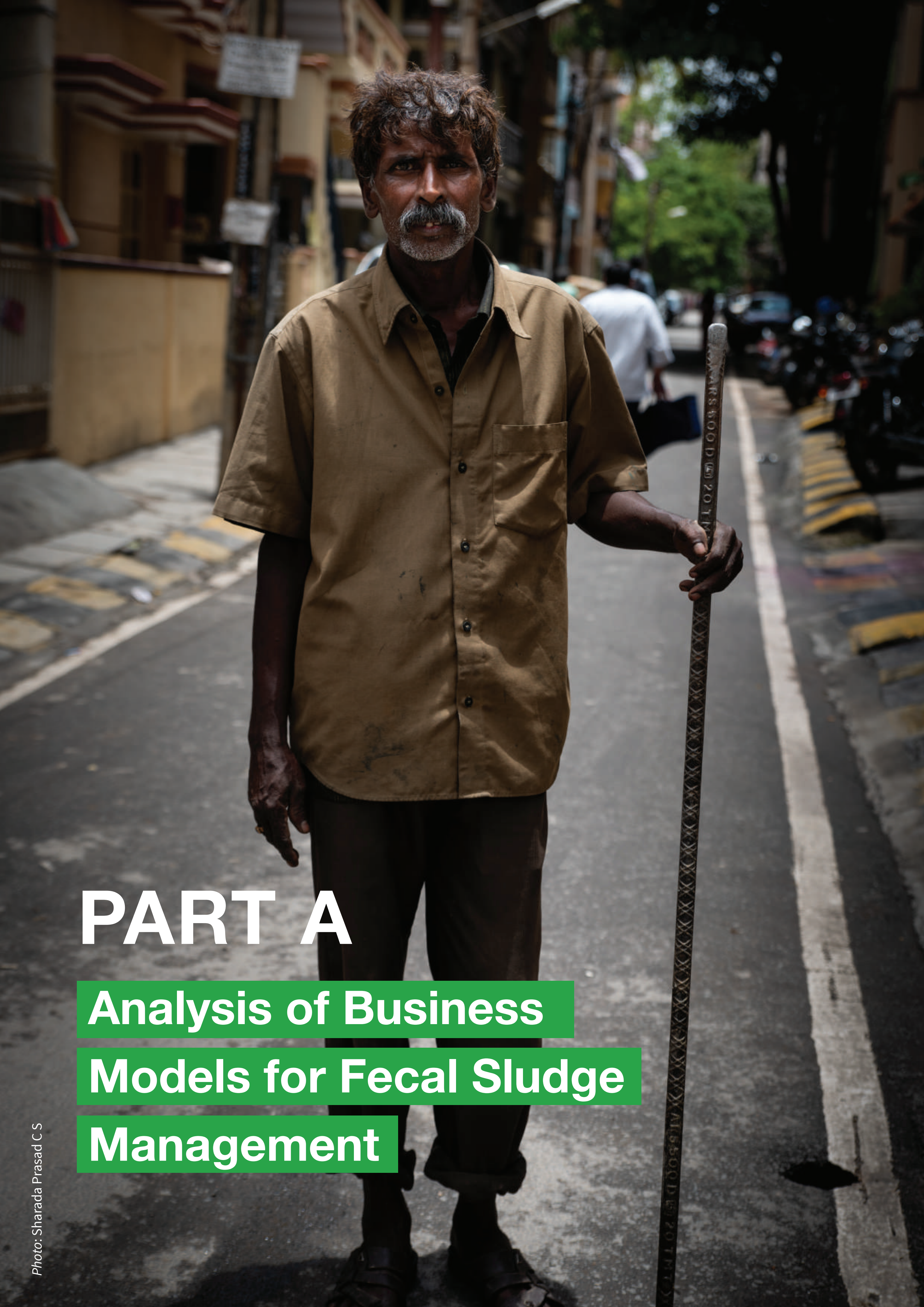


PART A

Analysis of Business Models for Fecal Sludge Management

Photo: Sharada Prasad C S

2.

Business Models for FSM

2.1 What is the Meaning of 'Business Model' in FSM?

The term 'business model' can be a misnomer in the sanitation sector, as a 'business' is typically associated with income generation and profits. In this report, the term business model follows the definition by Osterwalder and Pigneur (2010) as previously applied to waste management and sanitation (Otoo and Drechsel 2018):

> *A business model is defined by who your customers are, which markets you operate in, who your partners are, what costs you have, where your revenues come from, which activities you engage in, and how is value created and delivered to your customers.*

In this report, the term 'business model' is used as a tool to articulate FSM solutions – their costs, potential for revenue generation for cost recovery, and partnerships and engagement between diverse stakeholders (government, donors, entrepreneurs, technology providers, community-based organizations [CBOs], and non-governmental organizations [NGOs]).

The provision of sanitation is like waste management, traditionally a public service to maintain public health and budgeted as such by municipalities. According to Trémolet (2012), sanitation services should, however, not be considered as a purely public good, but in market terms, with different actors demanding and providing services along what is now commonly referred to as the 'sanitation value chain'. In this sense, the sanitation value chain appears so far to be prone to market failures due to external effects, imperfect information, disadvantages of monopolies, and destructive competition among many actors – resulting in sanitation goods and services that are not provided in sufficient quantity and quality, both on the demand and supply sides (Trémolet 2012), despite an increasing share of enterprises providing toilets as well as Emptying and Transport (E&T) services.

The market failures in sanitation are addressed typically through subsidies to influence investment decisions, defining and enforcing regulations and standards to alleviate public health and environment externalities, and supporting market-based solutions by facilitating finance, dissemination, or provision of business support. In India, the government uses each of these mechanisms to address the market failures, making it still the most important stakeholder in any business model for sanitation service provision.

This report analyzes the business models from both the public and private sector perspectives and the

contractual arrangements between them. The business models presented cover all components of the sanitation value chain. The report highlights mechanisms that enable solutions to issues faced by FSM stakeholders, along with opportunities for increased private sector participation in sanitation service delivery. The information was generated through face-to-face interviews with 105 E&T operators in 72 towns and cities across 16 states in India, interviews with 22 municipalities that own emptying vehicles, 18 FSTP operators, more than 30 officials across 15 states, and NGOs and members of the National Fecal Sludge and Septage Management (NFSSM) Alliance.

2.2 Generic FSM Business Model for India

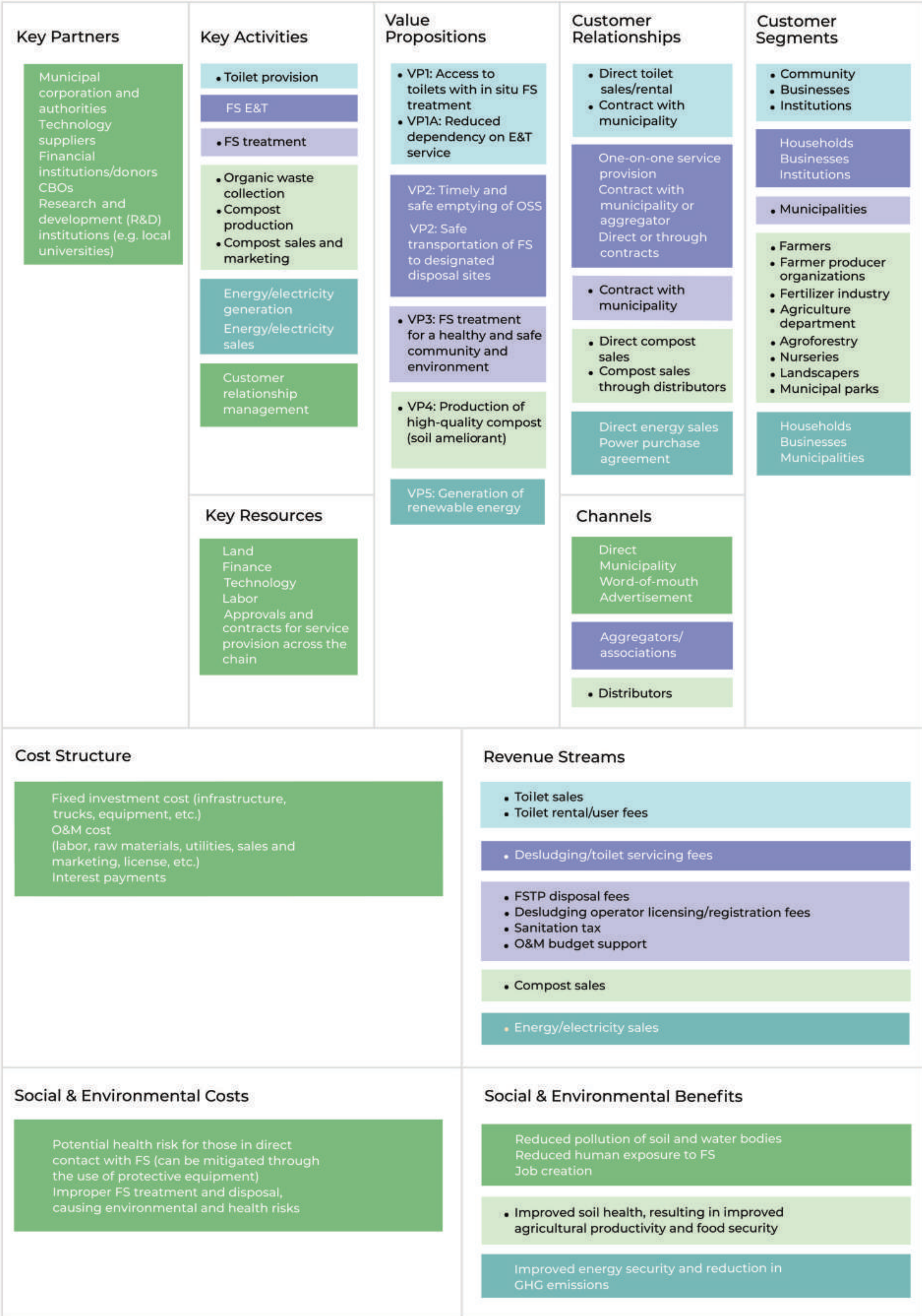
A business model canvas is a framework developed by Osterwalder and Pigneur (2010) to present a business model, as shown in Figure 4. The core of a business model is the 'value' (Value Proposition) a 'customer' (Customer Segment) is deriving from FSM services. Then follows 'how' (Customer Relationships) and through 'whom' (Channel) the service is delivered to the customer. Once the mechanism of service delivery is established, its viability is analyzed through the Revenue Streams and Cost Structures. According to Otoo and Drechsel (2018), the business model canvas has been adapted by integrating the social and environmental costs and benefits.

Broadly, the FSM business models in India provide the following value propositions (see also Rao et al. 2016):

- **Value Proposition 1 (VP1) –** Providing improved sanitation service to underserved communities or households through access to toilets with in situ FS treatment.
    - ***Value Proposition 1A (VP1A)*** – Reduced dependency on E&T services.
- **Value Proposition 2 (VP2)** – Timely and safe emptying of OSS in households, businesses, and institutions.
    - ***Value Proposition 2A (VP2A)*** – Safe transportation of FS to designated disposal sites.
- **Value Proposition 3 (VP3) –** Treatment of FS for a healthy community and environment.
- **Value Proposition 4 (VP4) –** Recovery of nutrients from FS to produce high quality compost as a soil ameliorant.
- **Value Proposition 5 (VP5) –** Recovery of energy from FS to generate renewable energy for heating or electricity generation to reduce energy costs and greenhouse gas (GHG) emissions.

The business model canvas presents the above-mentioned value propositions (color coded) and their corresponding customer segments and other elements categorized with specific color codes. Depending on each value proposition offered by the business, its customer segment will vary – e.g., for a business providing E&T services (VP2), the customer segments are individual households, businesses, and institutions. For FS treatment (VP3), it is the municipality. The customer segments for reuse value propositions depend on the type of resource recovered; for a business providing treatment of FS for recovery of nutrients and the sale of fertilizer (VP4), the primary customer segments are farmers, farmer producer organizations, and fertilizer distributors. For the energy recovery business, they are households, the municipality, and energy-intensive businesses. The other elements of the business canvas are self-explanatory.

FIGURE 4. GENERIC BUSINESS MODEL CANVAS FOR FSM.



Note: Colors indicate relevance to the corresponding value proposition. Dark green is applicable to all VPs.

2.3 Typology of FSM Business Models in India

Figure 5 provides an overview and typology of the 'business model' areas of focus across the sanitation value chain. These business models were developed based on the analysis of 36 FSM business case studies from India, as shown in Figure 6. In total, 18 business models emerge from 36 case studies across all components of the sanitation value chain. See Part B of the report for further details on the FSM business models and business case studies. The business models have been grouped into six main categories:

A. Models for Toilet Access and In Situ Energy and Nutrient Recovery
B. Models for Emptying and Transport of FS
C. Models Linking Emptying, Transport, and Treatment of FS
D. Models for Operating Treatment Plants
E. Models Emphasizing FS Reuse at the End of the Value Chain
F. Models Covering the Entire Sanitation Value Chain

Each of the business models presented is an attempt to solve a problem. In studying these models, it should be kept in mind that enabling policies and empowering regulations are key for making them effective. For example, when a scheduled desludging contract with performance-based payments is in effect, the city should have strong regulation and communications campaigns to raise awareness in households regarding cooperation with the contractor to enable desludging. If such cooperation is not forthcoming, the contract becomes unviable. Each model thus requires different sets of regulations to make it effective. Another key requirement is appropriate risk-sharing between the municipality (contracting authority) and the service provider (contractor). For example, an integrated tender with performance-based payments (*Model C*) may seem ideal for FSM. However, if the service provider is burdened with the collection of user fees for scheduled desludging, the tender may not attract bidders due to high perceived risk. The municipality should shoulder its share of the burden in a nascent sector such as FSM.

In comparison to Rao et al. (2016), a new category of business model has emerged – Models for Operating Treatment Plants. In addition, India has demonstrated new business models such as household toilet with nutrient and energy recovery, desludging association, integrated emptying, transport, and treatment, public-private partnership FSTP and co-treatment models. However, business models such as franchise E&T, non-profit E&T, incentivized disposal, and container-based sanitation are not yet observed in India.

Model A (*Toilet Access and In Situ Energy and Nutrient Recovery*)
The model does not require 'Emptying-Transport-external Treatment', resulting in overall low investment costs, both tangible and environmental. This might be the reason for the GoI to encourage the adoption of twin-pit toilets which support this model. However, the model assumes that households will take responsibility of emptying the pits when required. Whether they will actually do so or will require continuous motivation remains to be seen. It will be interesting to monitor what kind of business models will emerge where households are reluctant to manage their pits by themselves.

Model B (*E&T of FS*)
Large parts of the country are served by private E&T operators, complementing public services where they exist. Governmental support remains crucial where demand for emptying is too low to ensure business viability and where the ability to pay for E&T is a challenge. However, there are cities where the government is providing E&T service despite existing private service providers.

The ***Licensing business model*** under Model B addresses the critical need for private emptying operators to be recognized formally. Due to the informal nature of the business and stigma associated with it, the private operators face harassment from residents, police, and local governments, especially while disposing of fecal sludge. Licensing also ensures standards for safety and service.

FIGURE 5. BUSINESS MODEL TYPOLOGY ALONG THE SANITATION VALUE CHAIN.

A Models for Toilet Access and In Situ Energy and Nutrient Recovery.

1. Community or public toilet complex with energy recovery
2. Household toilet with nutrient recovery
3. Household toilet with energy recovery

B Models for Emptying and Transport of FS.

1. Government-owned E&T
2. Privately-owned and operated E&T
   - E&T licensing
   - Call center
   - Desludging association

C Models Linking Emptying, Transport, and Treatment of FS

1. Scheduled desludging & sanitation tax
2. Integrated emptying, transport, & treatment
3. Transfer station

D Models for Operating Treatment Plants.

1. Government-managed FSTP
2. Cluster FSTP
3. Public-private partnership FSTP
4. Co-treatment

E Models Emphasizing FS Reuse at the End of the Value Chain.

1. Nutrient recovery
2. Energy recovery

F Models Covering the Entire Sanitation Value Chain.

1. Integrated toilet-to-treatment

A ***Call center business model***, on the other hand, is a market-making intervention that works by easing access to information for those looking for E&T services (customer channel segment in the canvas).

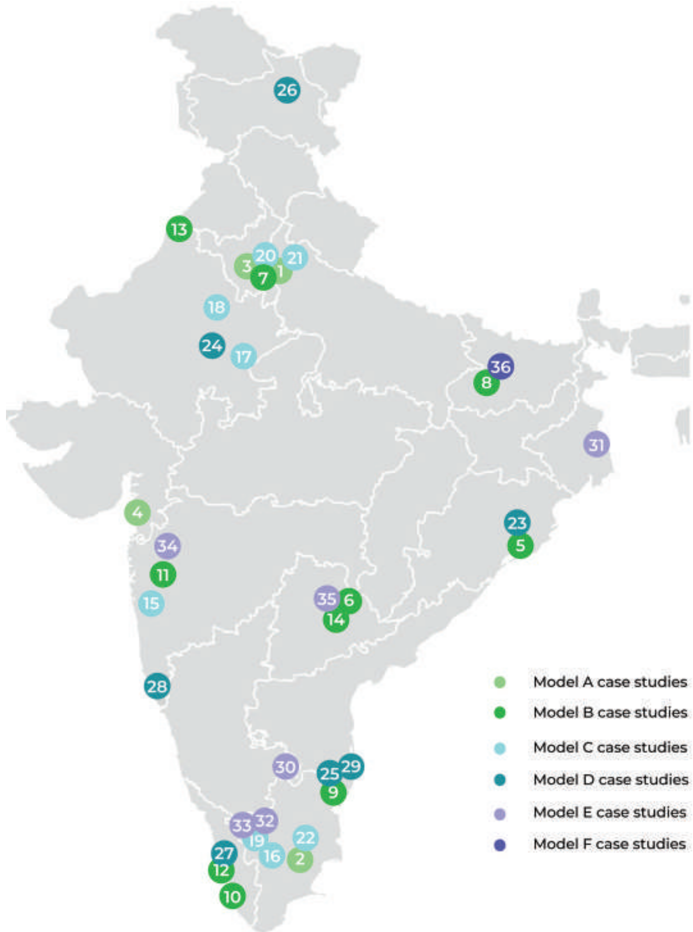
Cost reduction for households can be achieved when E&T services are auctioned by the independent call center. The members of the call center have to adhere to certain standards in order to build and sustain confidence in their services. Therefore, licensing of trucks and the center are necessary conditions for a call center to succeed. Finally, the ***Desludging association business model*** combines the benefits of licensing and a call center but keeps management with the truck operators' association. Self-regulation and adherence to certain quality standards will be inherent to the association's success.

The business models under Model B are all intrusive and can affect the existing free market situation – sometimes deleteriously. Licensing norms when stringent, call centers when adopting auction models, and associations when forming strong cartels all create barriers to entry for new or other existing small entrepreneurs. Unless designed with consideration of possible market opportunities and risks, these models can create unforeseen market distortions. The local government should play a critical role in the training, monitoring and handholding of these entities.

Model C (*Linking Emptying, Transport, and Treatment of FS*)

The ***Scheduled desludging with sanitation tax business model*** takes away the discretion of the household from the emptying decision, thus avoiding the risk of not desludging on time. An added benefit of a sanitation tax is the ability to charge different tax rates based on ability to pay, as well as to charge enough to cover the Operation

FIGURE 6. FSM BUSINESS CASE STUDIES.



1. Sulabh Public Toilet-Linked Biogas Plants
2. Trichy Bio-digester-Linked Community Toilet & Kitchen
3. Swachh Bharat Mission Twin-Pit Toilets
4. Valsad Household Toilet-Linked Biogas Plants

5. Odisha Government-owned E&T
6. Warangal Desludging Licensing
7. Delhi Desludging Licensing
8. Patna Desludging Call Center
9. Karunguzhi Desludging ICT Tool
10. Thiruvananthapuram Call Center
11. Pune Honeysucker Mobile Application
12. Kochi Associations of Desludging Operators
13. Ganganagar Desludging Union
14. Warangal Desludging Association

15. Wai Scheduled Desludging and Sanitation Tax
16. WASH Institute Mobile Septage Treatment Unit
17. Lalsot Integrated E&T and FSTP
18. Khandela Integrated E&T and FSTP
19. Coimbatore FS Transfer Station
20. Delhi Sewage Pumping Stations as FS Transfer Stations
21. Ghaziabad Sewage Pumping Stations as FS Transfer Stations
22. Tiruchirappalli Sewage Pumping Stations as FS Transfer Stations

23. Bhubaneshwar Government-managed SeTP
24. Sambhar-Phulera Cluster FSTP
25. Karunguzhi-Maduranthagam Cluster FSTP
26. Leh PPP in FSM
27. Kochi PPP FSTP
28. Panaji Co-Treatment of FS and Sewage at STP
29. Chennai Co-Treatment of FS and Sewage at STP

30. Devanahalli FSTP & Co-Composting Unit
31. Bansberia Co-Composting Unit
32. Ketti FSTP & Co-Composting Unit
33. Adigaratty FSTP & Co-Composting Unit
34. Nashik Waste-to-Energy Plant
35. Warangal FSTP

36. Patna Portable Toilets and FSTP

and Maintenance (O&M) costs of the FSTP, thus making the entire service chain viable. The ***Integrated business model*** allows performance-based payments (especially when coupled with the sanitation tax), thus creating a stronger link between money spent and outcomes achieved. It makes monitoring easier for the municipality because there is only one entity to be held accountable. And finally, the ***Transfer station business model*** reduces time and distance to the disposal site, which is critical for the viability of a desludging operation. In India currently, sewage pumping stations are functioning as FS transfer stations. In large cities, with distantly located FSTPs, a transfer station can improve compliance by private operators. The cost of transport from the transfer station to the FSTP should be borne by the government.

Both scheduled desludging and integrated services (the same service provider handling E&T and other FSM operations) models create monopolistic scenarios. In this context, these models require interventions such as published tariffs and performance-based payments to mitigate market distortions.

Model D (*Operating Treatment Plants*)
Running and scaling up treatment infrastructure is a major challenge in the FSM value chain, as treatment is so far the least attractive component for private sector investment. The straightforward mode to achieve treatment is through the ***Government-managed FSTP business model*** – the government builds and operates FSTPs as a program, which is happening in some states. The ***Co-treatment business model*** is the fastest way to enable treatment, by allowing FS to be treated at existing sewage treatment plants (STPs) able to accept sludge. Co-treatment also tends to be the lowest cost option. To enable economies of scale, the ***Cluster FSTP business model*** shows clusters of towns and surrounding villages coming together to share FSTP infrastructure.

Finally, various ***PPP business models*** exist, like the Design-Built-Operate-Transfer (DBOT) or the Build-Operate-Transfer (BOT) models. If we emphasize that, in a PPP, both parties accept defined risks, the models in Andhra Pradesh and Telangana are interesting, as they have floated FSM tenders with partial capital investment requirements from the private partners in the Design-Finance-Build-Operate-Transfer (DFBOT) mode, while the Leh city FSTP in the Himalayas is already a 100% DFBOT. Typically, PPP projects require mature standards and well-evolved specifications for DBOTs to succeed. As FSM in India is at a nascent stage, these are evolving, and therefore expert support is critical to managing the process.

Model E (*Emphasizing FS Reuse at the End of the Value Chain*)
Value creation from the products of FS treatment is critical for the FSTP to function effectively. Overcoming the social barriers to using FS-based products will ensure timely evacuation and hence smooth functioning of the FSTP, as sludge disposal has significant financial and environmental dimensions. The case studies discussed under this model demonstrate value from FS products for farmers and other stakeholders, thereby generating revenues for the FSTP or reducing disposal costs. In general, the intangible benefits of resource recovery for the environment usually outweigh the revenues generated.

Model F (*Covering the Entire Sanitation Value Chain*)
These models are common in Africa and Latin America, but are not prevalent in India, except for pilots in slums, e.g., by Sanitation First or for portable toilets provided to labor colonies in the construction industry, with the toilet waste transported to treatment facilities. The ***Container-based sanitation (CBS)*** business model is a well-known global model that serves households in remote or densely populated areas and covers the entire value chain, from toilet provision to sludge disposal or reuse.

Each of these categories of business models can have multiple value propositions (Figure 7) with diverse variations. For example, in a desludging association business model, the association offers advocacy support to improve the business environment for its members; a scheduled desludging and sanitation tax business model enhances the performance of containment systems; and a transfer station business model reduces transportation costs for desludging operators.

FIGURE 7. VALUE PROPOSITIONS OF BUSINESS MODEL CATEGORIES.

A Models for Toilet Access and In Situ Energy and Nutrient Recovery.

- Providing improved sanitation service to underserved communities or households through access to toilets.
- Energy and nutrient recovery from treatment of FS helps reduce energy costs and improve soil health.
- Reduced dependency on E&T services.

B Models for Emptying and Transport of FS.

- Timely and safe emptying of OSS in households, businesses, and institutions.
- Safe transportation of FS to designated disposal sites.

C Models Linking Emptying, Transport, and Treatment of FS.

- Timely and safe emptying of OSS in households, businesses, and institutions.
- Safe transportation of FS to designated disposal sites.
- Treatment of FS for a healthy community and environment.

D Models for Operating Treatment Plants.

- Treatment of FS for a healthy community and environment.

E Models Emphasizing FS Reuse at the End of the Value Chain.

- Treatment of FS for a healthy community and environment.
- Recovering nutrients from FS to produce high-quality compost as a soil ameliorant.
- Recovering energy from FS to generate renewable energy for heating or electricity to reduce energy costs and GHG emissions.

F Models Covering the Entire Sanitation Value Chain.

- Providing improved sanitation service to underserved communities or households through access to toilets.
- Timely and safe emptying of toilet containment units.
- Safe transportation of FS to designated disposal sites.
- Treatment of FS for a healthy community and environment.

2.4 Recommended Combinations of FSM Business Models

Business models, especially in neglected sectors such as sanitation, are ultimately only effective when there is a source of sustained funds for running the system effectively. The basic principle touted in such circumstances is that of *Polluter Pays* (UNEP 2001). In FSM, the household is willing to pay for E&T services when directly affected (toilet blockage, odor, etc.). A preventive approach such as scheduled desludging may not elicit a willingness to pay and requires tax-based financing. The challenge is how to cover the costs of FS treatment, which has much higher operating expenses than the operating margins of a typical E&T service provider (see *section 3.3.3* and *section 4.5*). Therefore, FS treatment continues to require public funds.

Most of the presented FSM business models only cater to sections of the entire value chain. Therefore, local governments need to seek combinations of the models outlined above and perhaps minimize the need for public subsidies. Possible combinations of business models that could be sustainable are:

1. *Model A* provides a complete solution. However, if the household does not take responsibility for maintaining the toilet, business models for O&M of the toilets may need to be encouraged.

2. *Model B* and *Model D* should be implemented in tandem, along with *Model E*, through appropriate contracts, regulations, and community awareness.

3. Alternatively, *Model B* interventions may be enhanced to *Model C* to enable performance-linked payment models aligned with outcomes. Supporting regulations and community awareness programs will be important.

While planning for these combinations, it is critical that the primary objective should be to provide universal FSM service coverage. Care should be taken to assure service is accessible to the poor and vulnerable sections of the society through differential tariffs/taxes, as appropriate. Stakeholder consultation in a gender inclusive and participatory manner is vital in designing the business model. Please refer to *Relevance* section of the business models described in *Part B.*

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3.

Financials of Fecal Sludge Emptying and Transport

The phrase ‘Is it full?’ in small lettering in the southern Indian language Telugu, followed by a 10-digit cell phone number painted in large numerals, is ubiquitous on compound walls along highways in small towns and rural areas in the states of Andhra Pradesh and Telangana. The phrase reflects how difficult it is to talk about an essential but sensitive subject – that of desludging septic tanks and pits. Further, the interval between successive desludging for an OSS is years apart and this adds another challenging aspect to marketing the service. While promoting the business is difficult, there is no settled client base, and actual operations are even more challenging – physical risks during emptying, harassment during informal disposal, unstructured working hours, and small profit margins. Helping people deal with their overflowing toilets is a tough business. E&T is a critical service that defines FSM and is the most underappreciated component of a sector that has only recently received increased public attention (SBM).

The need for spreading the message about emptying is becoming more urgent by the day. With more than 100 million toilets constructed under SBM, the need for mechanical emptying of pits will grow severalfold across urban and rural India. There is evidence to suggest that the affordability and ability to empty an OSS is a key concern for households, and it influences their toilet-use behaviors (Nair et al. 2018). This section presents an overview of the E&T sector in FSM.

A total of 105 operators in 72 towns and cities across 16 states in India were interviewed, and details regarding their business operations were solicited. The responses were often reluctant, given the perception challenges the sector is facing. As such, several gaps exist in the data collected; hence, each part of the analysis uses a subset that is complete for that purpose. In addition, 22 municipalities that own emptying vehicles were also approached to gain an understanding of their experiences. The towns and cities are broadly categorized by population (Figure 8).

Much is already known anecdotally and otherwise about E&T operators (Bhat et al. 2011; Chowdhry and Koné 2012). Most of them (almost 85% of the respondents) are private, unregistered businesses operating as sole proprietorships (Figure 9). Only a handful of partnership firms and companies were found in the towns covered in the study. E&T service providers are small businesses with most entrepreneurs owning only one truck (see Figure 10). Typical capital investment is below INR 2.5 million[1], with a little more than one-third of the trucks bought being pre-used.

[1] USD 1.00 = INR 71.25 as of October 2019.

FIGURE 8. INTERVIEW SAMPLE FOR THE STUDY.

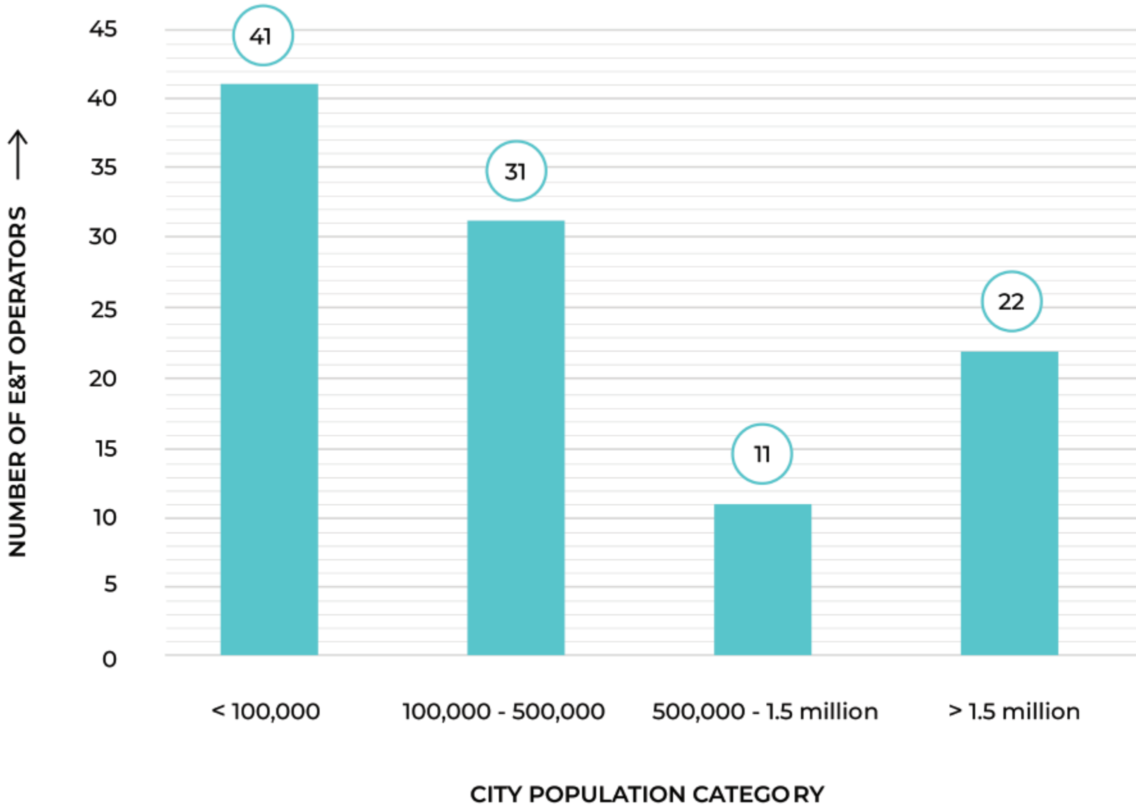
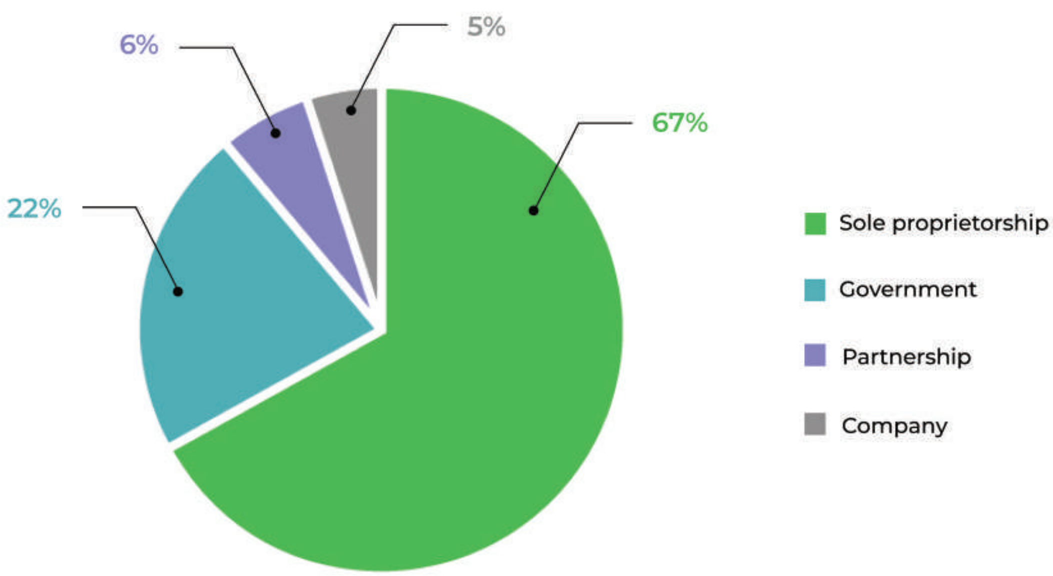


FIGURE 9. LEGAL STRUCTURE OF ENTITIES PROVIDING E&T SERVICES.

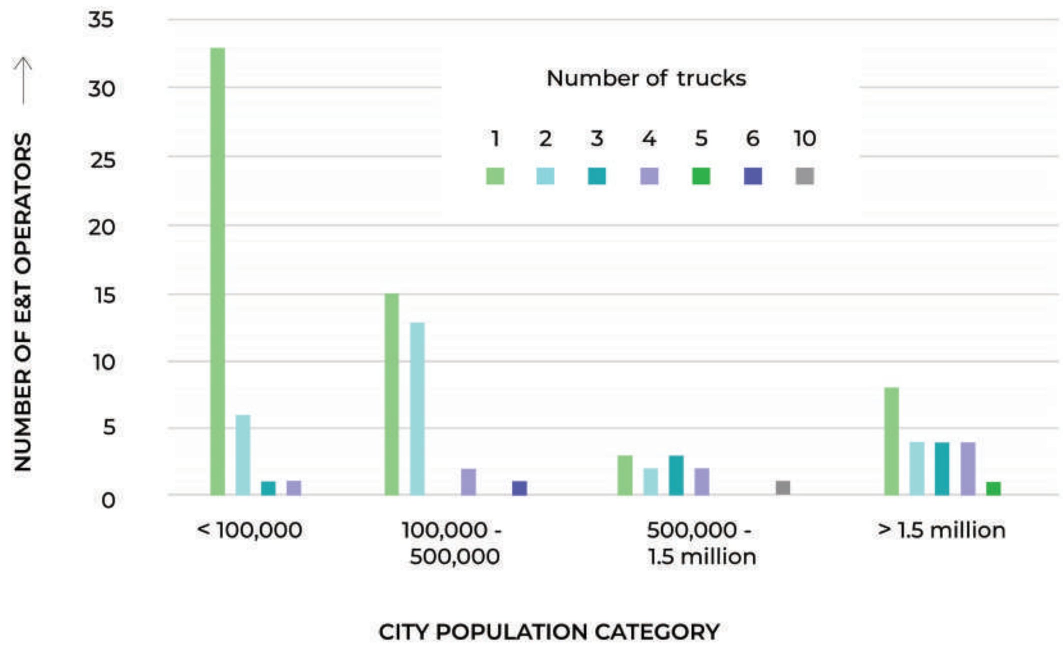


When asked why they became E&T operators, the operators gave two main reasons: 1) They recognized a business opportunity, and 2) The activity was recommended by friends/family. Through their previous work as drivers and mechanics, housekeeping staff, manual scavengers, pit diggers, and municipal employees, many of these entrepreneurs had become familiar with the business. Several entrepreneurs claimed they had "no other option" when they took up this business.

Once they adopted the profession, most entrepreneurs seemed to be untroubled by the health risks to themselves or their workers. Sixty-eight of 77 respondents cited no health concerns, while a few spoke of skin rashes, fever, and headache. Alcohol consumption among the workers seemed to be a bigger worry than ailments. There is some awareness about Personal Protective Equipment (PPE), but usage is inadequate at best. PPE cited ranged from the usual gloves and masks to shoes, uniforms, and goggles. About one-third of the respondents reported did not use PPE.

Only 23 respondents indicated major operational challenges, while 48 denied having any. The major challenges cited were harassment by police, municipal authorities, and residents in general, as well as lack of a designated disposal location. For 51 out of 60 respondents, this profession was their primary source of income.

FIGURE 10. NUMBER OF TRUCKS OWNED BY E&T OPERATORS ACROSS CITY POPULATION CATEGORIES.



3.1 Marketing and Pricing of Desludging Services

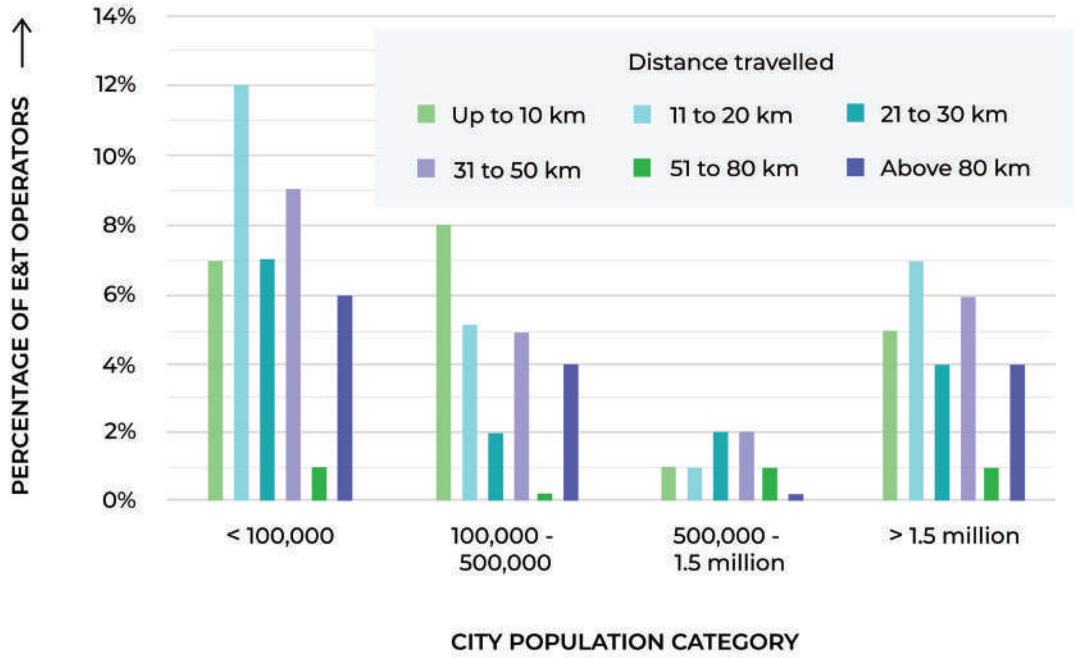
As mentioned earlier, devising an effective marketing strategy for an E&T operator is a challenge. The emptying service tends to take place at long intervals, and, therefore, customer recall and loyalty cannot be relied on. The need for the service arises at disparate times in various places, so targeted marketing is ineffective. These reasons explain the ubiquitous walls, trees, and electric poles with painted phone numbers, a marketing method subscribed to by 87 out of 124 respondents. Entrepreneurs based in larger metropolitan areas, however, find this method ineffective and resort to newspaper advertisements

and online service directories, such as JustDial. Alternatively, operators use influencers, such as the neighborhood plumbers who receive the first distress call.

As a result of these challenges, E&T operator services remain essentially demand driven. Most operators are willing to travel long distances to serve customers (Figure 11), regardless of city size. Roughly 50% of the respondents travel more than 25 km. In most cases, this means that services are extended way beyond the boundaries of the city or town. Most of rural India and hilly regions are served this way – from service providers in the nearest town and from the plains, respectively.

The operators' willingness to travel long distances to desludge OSS raises questions about their ability to set prices for full cost recovery and profit. Figure 12 provides an overview of the pricing bands prevalent across various city sizes. It is notable that most pricing bands are prevalent across all four city categories and likely reflect variations in common travel distances.

FIGURE 11. MAXIMUM DISTANCE TRAVELLED BY E&T OPERATORS TO SERVE THEIR CLIENTS.



3.2 E&T Operations

Time needed to desludge an OSS: The actual process of emptying a pit or septic tank seems to be relatively simple. Most operators reported anywhere between 10 to 30 minutes for the process. With thicker sludge, more time is needed, and the process can take up to 2 hours. To ease the operations for their workers, 30 out of 74 respondents reported using substances such as kerosene and salt.

Types of desludging vehicles: Two types of desludging vehicles are typically used: truck-mounted and tractor-mounted. Out of the 85 respondents, 33 had used trucks, and 52 had new trucks. All the trucks were locally manufactured. The tractor-mounted vehicle provide flexibility for the vehicle (typically a tractor) to be decoupled and used for other applications.

Sizes of either type of vehicle were reported to be in the range of 1.5 to 7 cubic meters (m^3) by respondents, with 3 m^3 being the most preferred size.

Collected FS desludging sites and methods: There are very few safe FS disposal sites for E&T operators. Several municipalities have designated spots for E&T operators to dispose of FS — typically isolated sites or open solid waste dump yards. However, based on feedback from 13 operators in 12 cities and 6 states, these cannot be considered safe sites for disposal. Figure 13 shows that most of FS is dumped in an unsafe manner.

FIGURE 12. NUMBER OF OPERATORS WITHIN EACH PRICING BAND BY CITY POPULATION CATEGORY.

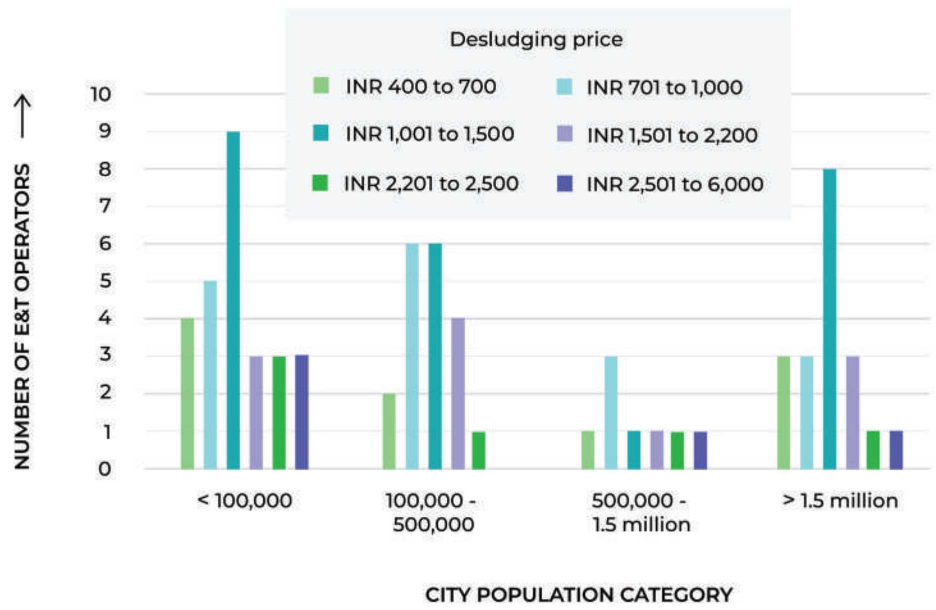
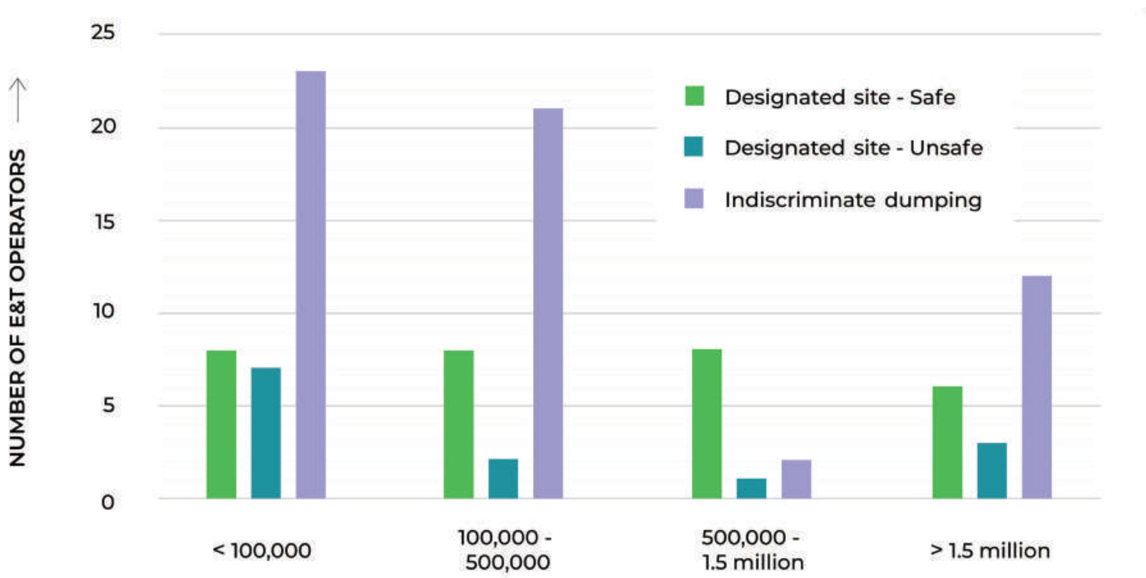


FIGURE 13. DISPOSAL SITES BY CITY POPULATION CATEGORY.



3.3 Key Issues in E&T

The E&T sector is grappling with issues and challenges such as the distance to the household, distance to the designated disposal site, willingness of the operator to pay disposal fees, financial attractiveness of the business, and the challenges/benefits of scheduled desludging. This section is based on the analysis of E&T operators' responses in this context.

3.3.1 How Far Away Should a Designated Disposal Site be?

The central problem of FSM is lack of safe designated disposal sites after an OSS is emptied. Any distance travelled with a full truck load is a non-value-added expense for the operator, and until the truckis empty, the next emptying service request cannot be taken up. Hence, there is an opportunity cost associated with the time taken to dispose of the FS (Ravi et al. n.d.). The E&T operators are sensitive to these factors and prefer a distance of 10 km or less for disposal of FS. In Table 1, the minimum and maximum distances are beyond standard statistical limits and hence can be considered outliers. The standard deviation (SD) is relatively low and shows that the variation in preferred distance is minimal. This preference is quite consistent across city population categories and probably reflects the tolerance limit in the profit margin. This has important implications for FSTP siting and/or tariff setting.

TABLE 1. PREFERRED DISTANCE OF E&T OPERATORS TO DESIGNATED DISPOSAL SITES.

City population	Average distance to disposal site (km)	SD of distance to disposal site (km)	Min distance to disposal site (km)	Max distance to disposal site (km)
Below 100,000	7	5.65	1	25
100,001 to 500,000	8	5.51	2	30
500,001 to 1.5 million	10	6.18	5	25
Above 1.5 million	13	5.11	5	25

3.3.2 Can Disposal Fees be a Viable Form of Revenue for an STP or FSTP?

Of the 41 operators who responded to the question about willingness to pay for access to a designated disposal site, only 15 responded positively. However, none of them were willing to specify how much they would be willing to pay. Another 24 respondents were unwilling to pay. Based on operators' feedback, it seems that the concept of disposal fees will be a hard sell unless FSTP/designated disposal sites are provided and tariffs on households are regulated.

3.3.3 Is the E&T Business as Lucrative as it is Made Out to be?

It is instructive to look at the pricing power of E&T operators before delving into profitability. As shown in Figure 14, there is no clear correlation between trips per truck per annum and the price charged per trip. This reflects a typical market situation where the upper price limit is bound by competitors and the lower by the required profit margin. It can also reflect

customers' unwillingness to pay beyond a certain limit. Figure 14 also shows that entrepreneurs who manage between 400 and 1,500 trips and charge more than INR 1,000 remain profitable. Businesses that can only run below 400 trips have a high probability of failure. Also, businesses that can make many more trips but charge less than INR 1,000 are usually loss making. Hence, both the number of trips and the fee play a critical role in determining the health of the business.

Profitability analysis can be based on gross or net profit margins or include the cost of capital deployed, i.e., the portion of margins to be paid towards interest on debt or return on equity. While debt payments are seen as a strong financial obligation, most small entrepreneurs that self-finance (equity) capital costs tend to ignore the need for returns on those funds and settle for operating profits that meet their lifestyle expenses. Therefore, profitability analysis has been undertaken in two steps, with the second step being more stringent regarding profitability requirements:

1. Ability to make 15% surplus on operating expenses, i.e., revenue target1 (RT1) = total expenses × 115%
2. Ability to meet 15% surplus on operating expenses and a further 20% return on capital costs, i.e., revenue target2 (RT2) = total expenses × 115% + capital costs × 20%

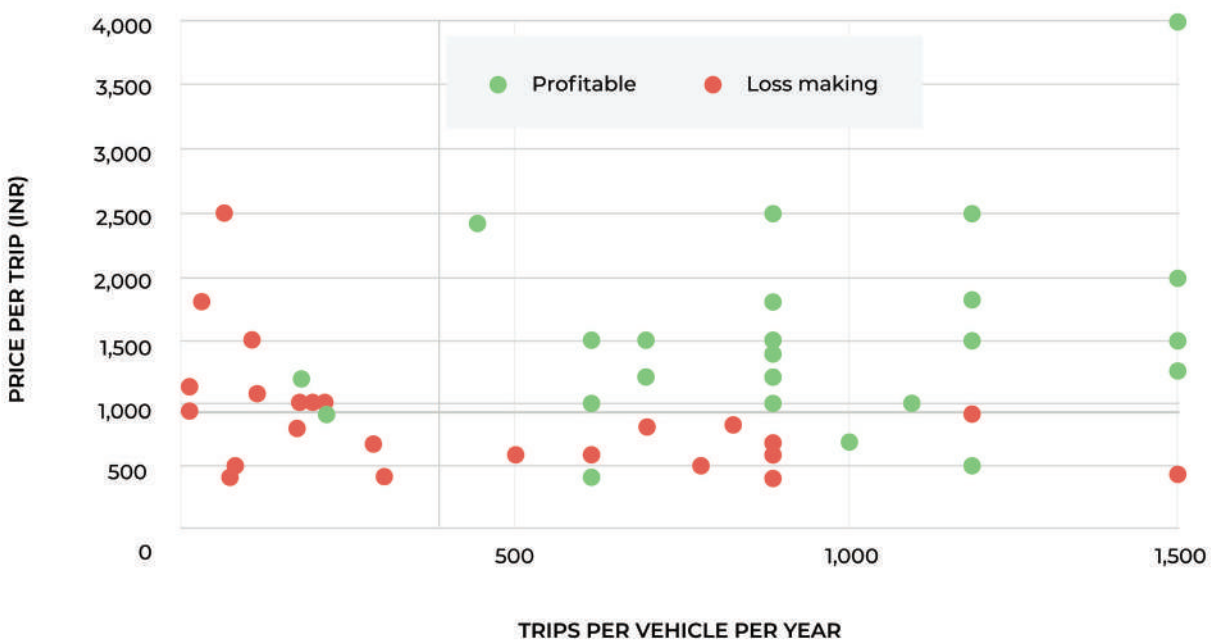
Most E&T operators declined to share actual profit numbers, so a simulation was undertaken to determine the feasibility of making certain predetermined profits. The 115% and 20% benchmarks chosen are arbitrary. The data available from the interviews were: average price, maximum price, average non-peak trips, average peak trips, and a breakdown of expenses. Hence, it was possible to estimate the revenue targets. The following formula was applied to determine the percentage of trips to be charged at peak price to achieve the revenue targets:

$$RT = (P_{max} \times T_{max}) + (P_{avg} \times [100-T_{max}])$$

Where: RT is revenue target; P_{max} is maximum price; T_{max} is % of total annual trips charged at maximum price; and P_{avg} is average price.

This formula determines T_{max}, the '% of trips charged at maximum price' necessary to meet the desired revenue targets mentioned above. Without factoring

FIGURE 14. PROFITABILITY ANALYSIS OF E&T OPERATORS.



in higher priced trips (T_{max} = 0), out of 55 operators, 29 met RT1, and 22 met RT2. As the percentage of trips priced at the maximum price increased from zero towards 100, an additional seven operators reached RT1, and only two additional operators managed to reach RT2. Profitability seems to be a challenge for close to 50% of the operators in this sample. The E&T sector seems to be generating sufficient cashflow for operators to earn a basic living (only a few exceptional operators make significant net profits). However, for most sole proprietors, it seems to be a challenge to recover capital.

The implication is that as we move towards the licensing of operators in each jurisdiction, it is essential to set minimum tariffs and to guarantee a minimum number of emptying opportunities that will positively impact the livelihoods of these critical service providers.

3.3.4 Will Shifting to Scheduled Desludging Help E&T Operators?

Given the same pricing, does scheduled desludging improve the profitability of an E&T operator? The implicit assumption made in asking this question is that a typical truck is currently underutilized, whereas with scheduled desludging, households will be asked to increase the frequency of desludging. As households will have a limited motivation to do so, the service would, for example, be paid via a tax addition.

To assess the validity of this scenario, the difference in peak and off-peak demand was quantified for operators who experienced seasonal variation. Only 70% of the peak seasonal demand was considered as the maximum utilization, as it may be difficult to sustain this level of service provision throughout the year when emptying is scheduled. An average value of this adjusted peak demand was used for those with no seasonal variations. There were a few cases where current utilization was higher than the average adjusted peak demand; these were discarded.

The analysis showed that the improvement in utilization with scheduled desludging has a significant impact on revenue. Assuming adequate trucks and FSTP/designated disposal capacity are available, revenues improve between 10% and 600% and more (limited by the number of toilets in the area), due to the increased number of trips undertaken overall. Factoring in the operational costs, however, the gains are more muted. This is because variable costs such as fuel predominate the overall cost structure, and hence, expenses increase linearly with the number of trips. Nevertheless, from a business perspective, scheduled emptying results in increases in revenue and profit, and also helps provide more regular income.

However, that does not mean scheduled emptying should be adopted across the board. That choice depends on the nature of OSS in the area under consideration and should primarily be a technical decision. In short, scheduled emptying is essential for septic tanks (and, in general, water-tight OSS structures with an outlet), while it is optional for leach/soak pits. Given the proclivity of many households to build structures much larger than necessary, the scheduled emptying interval should be carefully evaluated before implementation. Otherwise, the negative externality of burning fossil fuels (via transport) might outweigh any positive health outcomes of potentially leaking tanks.

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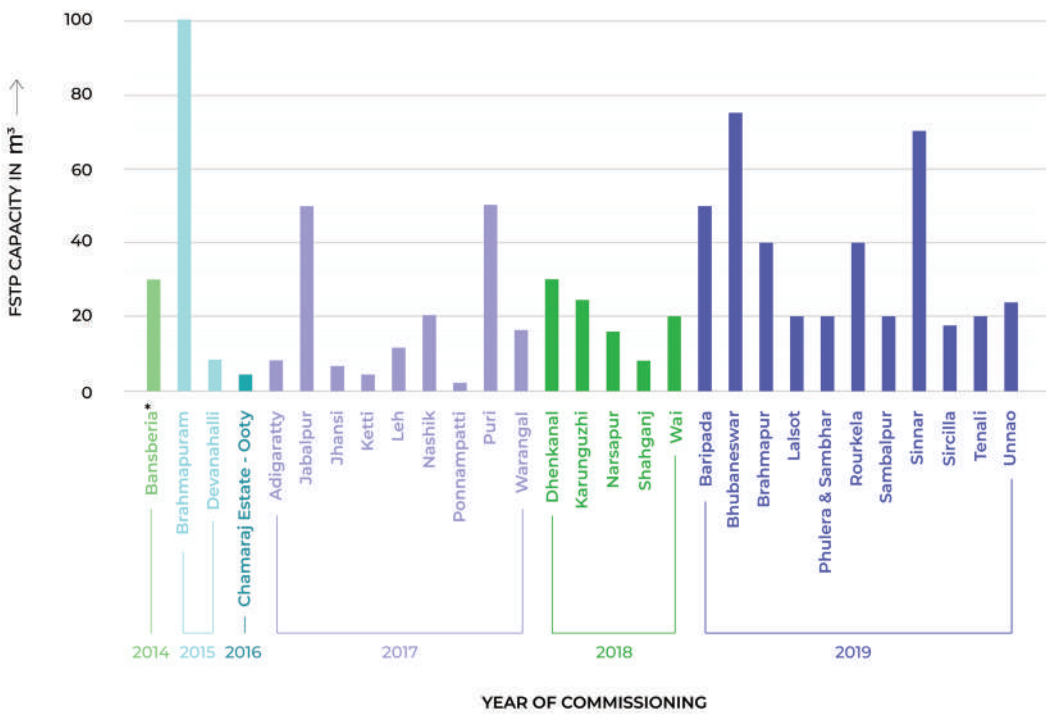
4. Financials of Treatment of Fecal Sludge

At the end of 2019, India had about 30 FSTPs in operation (Figure 15), an equal number under construction, and over 200 FSTPs in various stages of procurement. The momentum for implementation of FSM started in 2015, triggered by the adoption of a national FSM policy, and, later, state-specific FSM policies, guidelines, and regulations. The advocacy efforts and Technical Support Units (TSUs) provided by donors (especially the Bill & Melinda Gates Foundation [BMGF]) and the NFSSM Alliance catalyzed an increase in the number of FSTPs across the country.

FIGURE 15. FSTPs IN INDIA.



* The Bansberia FSTP was built in 2009; however, it was 2014 by the time the operator received the necessary approvals and the FSTP was commissioned.

The analysis presented in this section is based on the 29 FSTPs that are in operation and interviews with FSTP operators and members of the NFSSM Alliance involved in establishing these FSTPs. Given that the sector is nascent, most of the FSTPs commissioned were demonstration projects, and it is too early to standardize costs for the planning of future FSTPs. The evolution of FSTP technology will continue as the sector matures. The analysis presented attempts to respond to the typical questions raised by the decision-maker in a municipality or state. These pertain to: technology information, capital and operating cost of the technology, land area required for an FSTP, benefit comparison with sewerage systems, and potential for reuse to recover FSTP operational costs. Please refer to the Annex for key data points from the 29 FSTPs.

4.1 FSTP Technology

Broadly, the technologies implemented in FSTPs in India can be classified into three types: a) Mechanical, b) Passive, and c) Thermal. Box 2 highlights an alternative solution to setting up FSTPs. Figure 16 shows that most of the FSTPs are passive systems.

- **Mechanical treatment:** The technology used for treatment is predominantly based on mechanical equipment. Solid-liquid separation is done via filtration through fabric filter cloths/centrifuges, filter presses, or volute screw presses. Effluent is treated using, for example, an Upflow Anaerobic Sludge Blanket (UASB) Reactor or a Moving Bed Biofilm Reactor (MBBR).

- **Passive treatment:** The technology used for solid-liquid separation, effluent treatment, and treatment of solids is a natural and biological process. Settling/thickening tanks and/or unplanted or planted drying beds are used for solid-liquid separation. Effluent is treated using aerobic/anaerobic processes such as planted gravel filters, anaerobic baffle reactors, anaerobic filters, and sand filters. Solids are treated using composting, storage or solar drying.

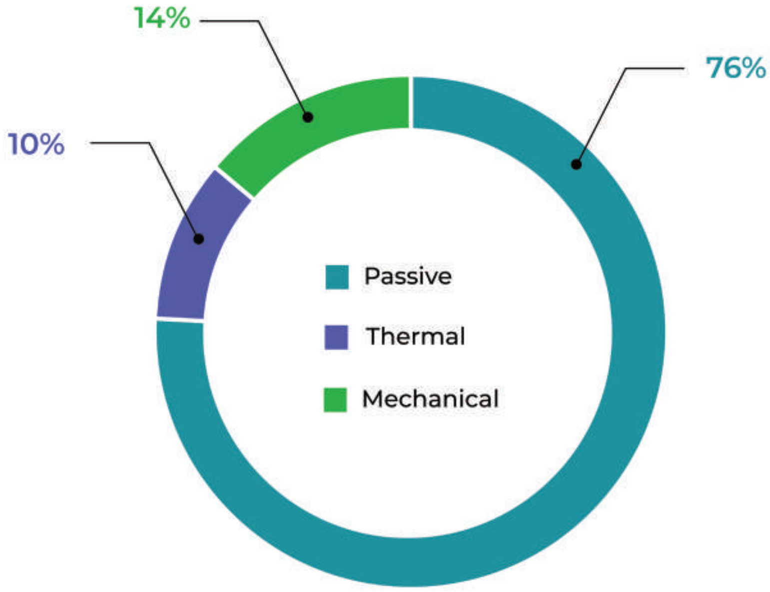
- **Thermal treatment:** The technology used for solid-liquid separation or effluent treatment can be either a mechanical or passive treatment system. However, for treating solids, a pyrolyzer (thermal unit) is used.

In practice, there are different combinations of solid-liquid separation, liquid and solid treatment, and/or resource recovery possible.

BOX 2. CO-TREATMENT OF FS IN STPs IN INDIA.

Co-treatment is the combined treatment of FS and wastewater in a FSTP. According to a Central Pollution Control Board (CPCB) estimate, based on a performance evaluation of 152 STPs across 15 states, the treatment capacity utilization is about 66% (CPCB 2013) and ast of 2016, India had more than 900 STPs (MoEFCC 2016). A study commissioned by the BMGF found that for about 400 cities and towns with STPs, co-treatment could serve up to one-third of households with OSS within the city, and, for 44 cities, co-treatment could treat 100% of septage generated (Gupta et al. 2018). Co-treatment of FS is practiced in some of the STPs in India, and multiple states are planning to make provisions for desludging operators to dispose of FS at STPs. For more information, refer to *Co-Treatment of FS & Sewage at STPs in Panaji, Goa & Chennai, Tamil Nadu*. Co-treatment is a cost-effective option for rapid scale up of FS treatment.

FIGURE 16. FSTPs BY TYPES OF TECHNOLOGIES.



4.2 FSTP Funding Sources in India

Financing of the capital and operating costs of 90% of FSTPs in India is by donors and public entities (Figure 17).

Capital cost: The FSTPs in operation have been implemented to demonstrate the concept and technology. Hence, the capital cost of almost all FSTPs has been financed through grants. Most FSTPs are funded by public entities (e.g., municipalities or state governments), followed by donors. The BMGF has been the primary donor, followed by the United States Agency for International Development (USAID). The Asian Development Bank (ADB) funded FSTPs in Rajasthan under its Sanitation Financing Partnership Trust Fund with the BMGF. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) funded the Nashik FSTP to demonstrate usage of the bio-methanation technology to process both FS and organic waste. Financing by the public sector also comes in the form of grants from the state and central governments through the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) programme, the SBM, funds from the 14th Finance Commission to municipalities, and state urban development department budgets, or dedicated state loans from multilateral donors. The experience of private entities in financing the capital cost is limited to three FSTPs – Leh, which is solely financed by a private entity and, in part, Nashik and Bansberia.

Operating cost: Financing of the operating cost is mostly done by public entities (Figure 18). Donors have provided financing in the form of grants for the first one or two years of FSTP operations. Thereafter, the FSTP operations are transferred to the municipality. Engaging private entities under PPP contracts (see *Chapter 5. FSM Procurement*) to operate FSTPs seems to be the preferred mode. The private entity is given a performance-based contract for at least 5 years for fixed fees. Typically, the private entity has to pre-finance several months of working capital, as the payment from the municipality is rarely transferred on a monthly basis. The funding for the operating cost borne by the municipality typically comes from one of the following options: the municipal budget, sanitation tax levied, or funds from state and central government programs. FSTPs can generate revenue from disposal fees and license fees collected from E&T operators and the sale of reuse products (e.g., compost, biochar, biogas, etc.). However, this revenue is very limited and usually cannot cover the entire operating cost.

FIGURE 17. FSTPs BY CAPITAL COST FUNDING SOURCES.

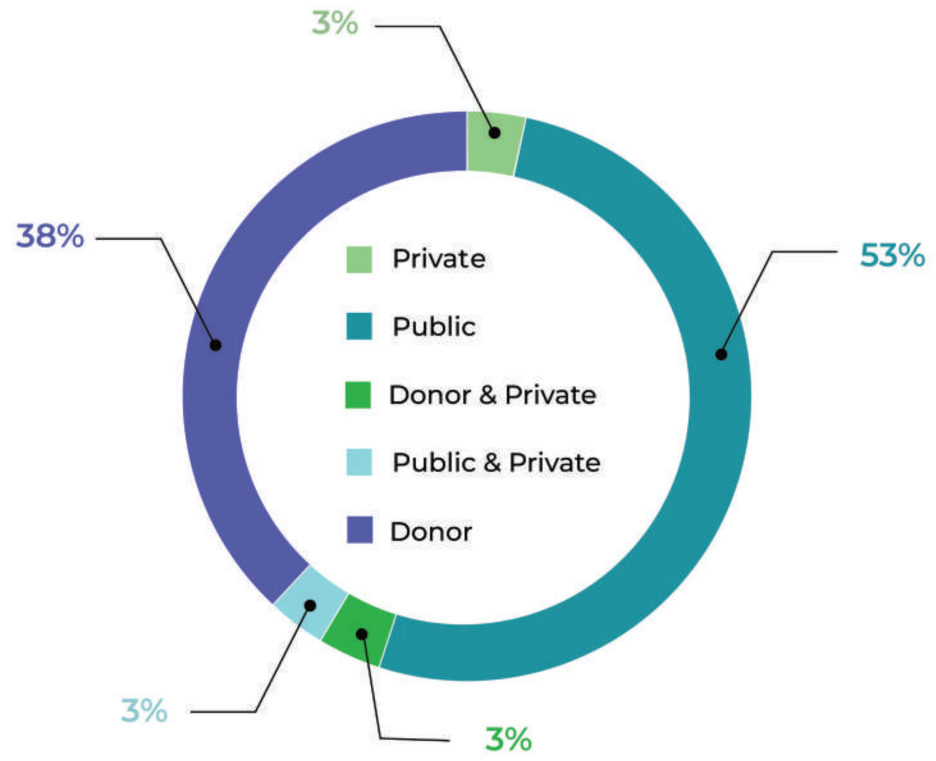
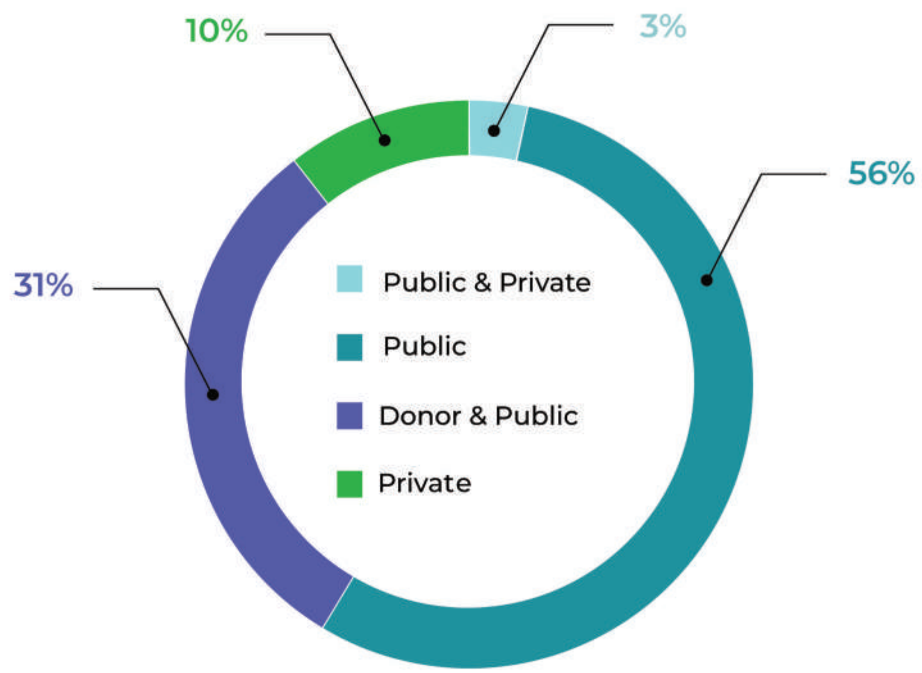


FIGURE 18. FSTPs BY OPERATION FUNDING SOURCES.



4.3 FSTP Capital and Operating Costs

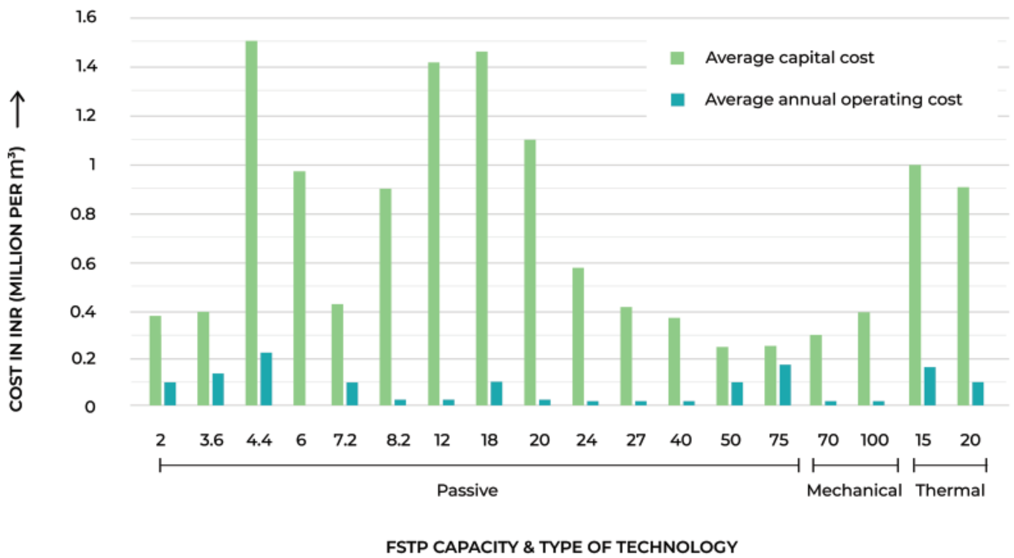
The size of FSTPs installed varies from 1.7 to 100 m^3/day, and most of them are in the range of 10 to 30 m^3/day, serving populations of 20,000 to 50,000. The analysis presented here is constrained by the availability of granular data on the breakdown of costs and the specific resource requirements such as land, labor, skills, raw material inputs such as chemicals, and the actual maintenance cost of the plant. Table 2 provides a comparison of the average land area allocated on m^2/capita, as well as capital and operating costs on a per m^3/day basis across different types of FSTP technologies in India. Figure 19 presents the capital and operating costs per m^3/day for FSTP technologies with different capacities.

TABLE 2. AVERAGE LAND AREA ALLOCATED AND CAPITAL AND OPERATING COSTS OF FSTPs.

Type of FSTP technology	Average land allocated (m^2/capita)*	Average capital cost (million INR/m^3/day)$^{\delta}$	Average annual operating cost (million INR/m^3/day)$^{\delta}$
Passive†	0.96	0.746	0.079
Thermal	0.51	0.938	0.140
Mechanical†	0.27	0.346	0.022

* Land area is based on total land used for the FSTP and not the actual built-up land area required for the FSTP.
† Data from FSTPs with incomplete treatment units and outliers in terms of multiple waste streams treated and abnormally high capital costs were not considered.
$^{\delta}$ USD 1.00 = INR 71.25 as of October 2019.

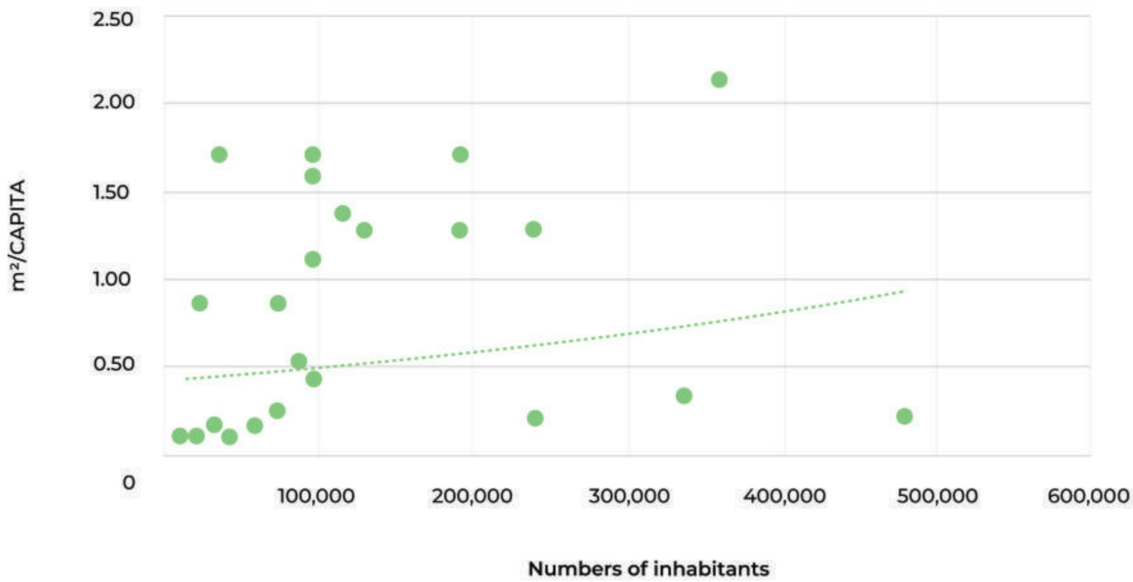
FIGURE 19. CAPITAL AND OPERATING COSTS OF FSTPs.*



* Data from FSTPs with incomplete treatment units and outliers in terms of multiple waste streams treated and abnormally high capital cost were not considered.

Land requirement for FSTPs: Table 2 suggests that the average land requirement for passive systems is higher than that required for thermal or mechanical systems. However, for the FSTPs included in the assessment, the total land area for the site often included total land allocated or available at the site, and not the actual footprint of the treatment units. The breakdown of land required for the treatment infrastructure was not available for the plants, and therefore comparisons regarding the land area required for passive, thermal and mechanical systems were not possible. As seen from Figure 20, within the limits of the data provided, it can be observed that a land area of 0.96 m^2/capita is needed in order to set up an FS treatment facility. According to available literature, the required land would range from 0.05 to 0.12 m^2/capita (Steiner et al. 2002) for passive solids-liquid separation followed by a pond system for effluent treatment.

FIGURE 20. PLOTTED PER CAPITA LAND REQUIREMENT FROM EXISTING FSTPs.



Note: Data plotted reflect the total land area of the treatment facility, not necessarily the built-up area.

Capital and operating costs of FSTPs: The analysis seems to suggest that the capital and operating costs of mechanical FSTPs are the lowest, followed by passive and thermal technologies, respectively. While there are no data or analysis in the literature for India, the assessment done by NIUA (2019) comes the closest. The analysis in the assessment shows the life cycle cost of mechanical systems is the highest expense, but it exponentially decreases with increase in treatment capacity. A key constraint is the availability of data on the cost of boundary walls, office building and equipment, laboratory, engineering design, treatment units, ancillary facilities, and utilities. Not all FSTP units have in-house laboratory and ancillary facilities. Data on the actual utilities' cost, maintenance costs, and labor required for maintaining the treatment plant, landscaping, and the production, packaging, marketing, and sale of reuse products are required.

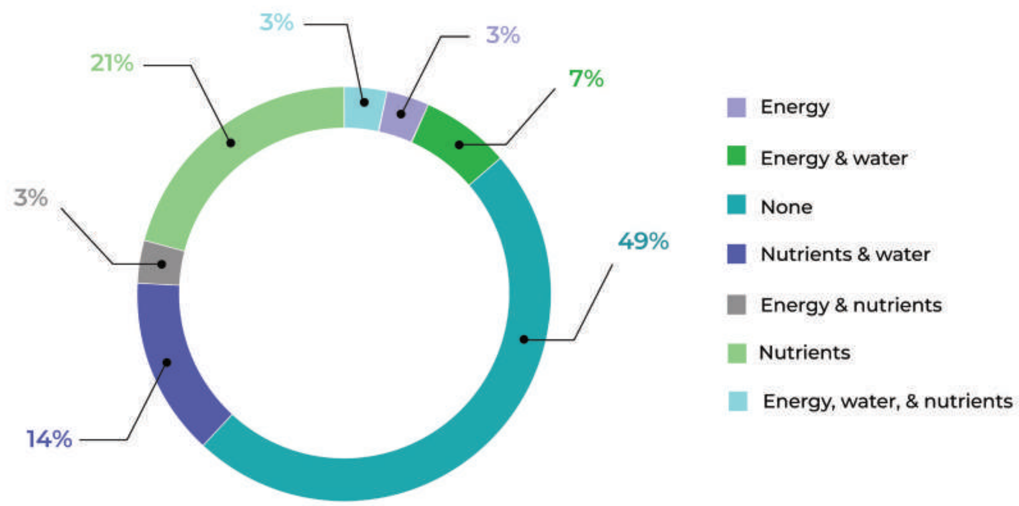
When comparing the observed costs for passive, thermal, and mechanical systems, it is important to note that the cost of landscaping and maintaining site aesthetics can result in higher capital and operating costs in many cases. This is especially relevant because several of these plants have been established as demonstration plants, with scale-up either underway or being planned in several states. Most passive and thermal systems have these integral costs, in comparison to mechanical systems.

4.4 FS Treatment for Reuse – Operational Cost Recovery

FS contains resources such as organic substances, plant nutrients and energy that can be recovered to offer monetary gain for the treatment plant. This can be revenue but also avoidance of disposal costs. Over time, management of solids will become an issue in FSTP operations if solutions to either treat solids for reuse or dispose them appropriately are not incorporated. Similarly, the treated effluent in the FSTP needs to be managed if there is no waterbody nearby or means to discharge it safely. The quantity of treated effluent is typically not very high, and it can be used within the FSTP to water plants and trees.

Figure 21 gives a snapshot of the resources recovered from FSTPs in India. Most of the FSTPs do not have recovery of resources planned. The FSTPs that have incorporated reuse recover one or two of the resources, except for the FSTPs in Kochi and Nashik, which recover energy, water and nutrients. In Kochi, the treated water is disposed of in drains that are connected to nearby farmland and used for irrigation, while in Nashik, it is used in the digestate process. Despite having implemented resource recovery, only six of the FSTPs have monetized the resources, and the rest of them are using the resources internally – for example, treated effluent is used for landscaping. FSTPs based on thermal technology have in-built mechanisms for heat recovery across different stages of treatment; however, data on the quantum of heat recovered and reused were not available.

FIGURE 21. FSTPs BY TYPE OF RESOURCE RECOVERED.



Monetization of reuse products is mostly done in cases of nutrient recovery, except for Nashik FSTP, where electricity generated is fed into the grid and used gratis by Nashik Municipal Corporation. At FSTPs recovering nutrients, co-compost is sometimes produced onsite and sold to farmers – for example, in the cases of Devanahalli, Adigaratty Town Panchayat, Ketti Town Panchayat and Bansberia. In the case of Karunguzhi, solids from the FSTP are transported to a solid waste composting facility, and compost is sold to farmers, while in Brahmapuram, solids are given away gratis. The revenue from compost sales covers part of the operating cost. Table 3 presents the percentage of the FSTP operating cost recovered through the sale of compost, which varies from as low as 6% to the entire cost recovered, plus profits generated.

TABLE 3. OPERATING COST RECOVERY FROM FS COMPOSTING.

FSTP location	% operating cost recovery	Price of compost*
Devanahalli	6	Initially INR 3/kg and later increased to INR 7/kg
Ketti Town Panchayat	56	INR 4.2/kg
Adigaratty Town Panchayat	95	INR 4.2/kg
Chamraj Tea Estate – Ooty	86	Not sold; savings from fertilizer
Bansberia	215	Co-compost – INR 6/kg Vermicompost – INR 8/kg

*USD 1.00 = INR 71.25 as of October 2019.

The FSTP in Bansberia does not provide a complete treatment solution, and it sells vermicompost and regular compost, along with the co-compost. The plant demonstrates that an FSTP built within an existing composting facility has the potential to recover the entire operating cost. In the case of the Chamraj Tea Estate FSTP in Ooty, there are no costs incurred for selling compost, as it is used onsite, which results in savings for the tea estate from the purchase of less fertilizer/manure. The FSTPs in Adigaratty and Ketti are built within existing solid waste resource recovery parks that produce compost from organic waste and recycle non-biodegradable waste. In comparison to Devanahalli FSTP, where organic waste has to be sourced, the sale of reuse products covers a higher percentage of the operating cost in Adigaratty and Ketti.

The price of compost and scale of operations influence operating cost recovery. According to Stantec (2019), increasing the compost price from INR 2/kg to INR 7/kg can result in improving operating cost recovery from about 40% up to 90%; however, the study does not consider investment in marketing and distribution of compost. Resource recovery from FS may not always make business sense; however, when considering externalities – benefits to soil and improved food, energy, and water security, reuse is highly valuable for the environment and economy. Moreover, even if a sludge-based compost or co-compost is sold under production value, the need to dispose of it safely would also have costs that resource recovery can reduce.

4.5 Cost Comparison – FSM and Sewerage Systems

Comparing a sewerage system to FSM can be challenging because the sewerage system transports and treats both toilet waste and greywater generated from households, businesses, and institutions, while FSM only addresses toilet waste. As of 2018, the total sewage generation in urban India was 61,948 million liters per day (MLD), and installed treatment plant capacity was 23,277 MLD, which translates to 38% treatment capacity (MoEFCC 2016). In Class I cities (population of more than 100,000) and Class II towns (50,000-100,000), 38,255 MLD of sewage are generated, of which only 30% is treated (Mallapur 2016). According to the Census 2011, only 33% of India's population (reduced to 30% in 2017) is connected to the sewer network, and connection does not necessarily translate into sewage treatment (Office of the Registrar General & Census Commissioner, India 2011).

Sewer networks are mostly limited to large Indian cities and towns (above 100,000); small towns lack sewerage. Furthermore, with water scarcity

and limited water consumption (less than 75 liters per capita per day) in urban India, the long-term technical viability of centralized sewer networks is low. With 600 million people in India facing high to extreme water stress, and projections that 40% of households will have no access to drinking water by 2030 (Kant 2018), water scarcity presents a major challenge to implementing sewerage in most towns and cities. This is further aggravated by lack of funds available for all required infrastructure in India and also because installing sewerage systems takes significantly more time than establishing FSM systems, which can be implemented in less than one year. Thus, a comparison between FSM and sewerage systems is warranted. Table 4 presents data on FSM and sewerage system costs. The data for sewerage are taken from HPEC (2011) and NFSSM Allliance (2018). It is revealed that FSM is significantly cheaper than sewerage.

The per capita cost of an FSTP to serve 100,000 population equivalent (p.e.) is about INR 156 to 197, and conveyance, about INR 40. The total per capita cost of setting up FSM comes to about INR 196 to 237 per capita, whereas a centralized sewer system costs INR 7,013 to 10,930 per capita to serve a city with the same population. The annual operating cost of FSM is also significantly lower: INR 35.8 to 48.6 per capita vs. INR 596 for

TABLE 4. COST COMPARISON OF NETWORKED AND NON-NETWORKED SANITATION SYSTEMS.

Item	Capital cost/capita in INR	Annual operating cost/ capita in INR
Non-networked sanitation system: FSM & greywater for 100,000 p.e.		
Passive system FSTP**	156	16.6
Thermal system FSTP**	197	29.4
E&T – conveyance of FS**	40	19.2
Total FSM cost	**196-237**	**35.8-48.6**
Decentralized Wastewater Treatment System (DEWATS) – greywater system (without conveyance)‡	2,946	32
Total FSM & greywater system (without conveyance)	**3,142-3,183**	**67.8-80.6**
FSM & greywater system$^{\delta}$	3,071	369
Networked sanitation system: Sewerage		
Total average for all city sizes*	6,908-13,668	298-851
Network for 100,000 p.e.*	4,807-6,674	Not available
Treatment for 100,000 p.e.*	2,206-4,256	Not available
Total cost for 100,000 p.e.*	**7,013-10,930**	**596**
Network + treatment cost $^{\delta}$	**11,050**	**631**

* Data from HPEC 2011. Value of INR translated to its equivalent in 2019.
$^{\delta}$ Data from NFSSM Alliance 2018. Value of INR translated to its equivalent in 2019.
‡ Data extrapolated from cost curves for DEWATS in India, Eawag and BORDA 2018.
**USD 1.00 = INR 71.25 as of October 2019. In 2018, USD 1.00 = INR 68.41.

sewerage. At the higher end, the capital and operating costs to provide safely managed sanitation services through sewerage are 46 and 12 times the cost, respectively, through FSM in India.

One may argue that FSM is not a complete solution in comparison to sewerage. In India, households with OSS discharge effluent from septic tanks and greywater into open drains. If the FSM system is efficiently managed, the biological oxygen demand (BOD) of the mixed wastewater (effluent from septic tanks and greywater) will be about 150 to 400 milligrams per liter (mg/L) (MDWS 2015), which can be effectively treated using small scale STPs. Assuming use of open drains for conveyance of the mixed wastewater, the capital and operating cost of setting up a complete FSM and greywater treatment system is also substantially lower than that of a sewerage system (Table 4).

The capital cost of FSM is majorly driven by the treatment system, as opposed to the construction of a sewer network for a sewerage system. However, when it comes to operating cost, FSM is influenced by the collection system, and the sewerage system, by treatment infrastructure. Stantec (2019) and Tsephel and Das (2017) have also compared the cost of FSM and sewer-based solutions in India, and both researchers have reported higher per capita capital and operating costs for sewer-based systems compared to FSM.

Both FSM and sewerage offer high potential for recovery of resources, as they are rich in organic matter, nutrients, and energy. Especially in the case of FSM, nutrient recovery has little or no risk of chemical contamination, compared to sludge captured in sewerage systems often co-serving industrial areas. Overall, considering India's current situation of 64% of the population dependent on OSS and requiring FSM services (WHO/UNICEF JMP 2019), lack of funds available to completely connect Indian cities to sewer networks, and the low technical viability of sewer networks given economic and physical water stress (Kant 2018); FSM is a highly relevant and vital approach to providing safely managed sanitation services for achieving Target 6.2 of the SDGs and beyond.

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5.

FSM Procurement

Formal procurement processes are aimed at price discovery, cost efficiency and transparency driven by standardization. However, the FSM sector is still discovering the appropriate technology and service expectations, resulting in challenges to conform to the desired quality of procurement. With the government being the major stakeholder and constituting the bulk of the procurement effort, FSM procurement needs urgent strengthening. This section will present key findings based on the analysis of the FSM procurement processes related to FSTPs in 13 states in India.

Globally, PPPs are widely used by governments as a way of increasing the population's access to infrastructure services. A key reason for governments to enter into a PPP contract is to ensure better value for money, either through reduced costs or improved quality in service provision. In the sanitation sector, PPP allows the government to:

- Access financial resources from a private entity
- Benefit from the technical capacity and experience of the private entity, given that most Urban Local Bodies (ULBs) in India have severe capacity constraints; and
- Most importantly, share the project-related risks typically borne entirely by the government, most often by outsourcing sanitation services, and thus implementation risks.

In tendering for FSTPs in the PPP mode, two avenues are available: 1) specific technologies with detailed designs and specifications bid out for construction and O&M – the BOT method, and 2) leaving the choice of technology open with only specifications and standards prescribed – the DBOT method. Both methods have been tried and are in various stages of implementation. The BOT method, especially for relatively simple technologies, does not have significant implementation risk. The risk is in the choice of technology and its suitability to the context.

Being 'technology neutral' requires the DBOT method to have mature technical vetting processes as part of tender evaluation. In the absence of strong technical oversight and with standards and specifications yet to be firmed up, currently the risk in DBOT projects is much higher. This is especially true for niche/proprietary technologies for which implementation skills are unproven. The discussion is not about which is the better method instead it is about identifying and mitigating the risks associated with either.

In FSM, the tenders are typically issued by the ULB or parastatal agency or state government departments. The tender documents are prepared based on customization of model documents developed by the erstwhile Planning Commission (Ministry of Finance) and Namami Gange project and procurement contracts developed by multilateral agencies. In addition, AMRUT

guidelines have also influenced the contracts. Most FSM tenders in India have been a single-stage process. In two states, expression of interest was called to assess market response and to get feedback.

5.1 Nature of Contract and Scope of Work

Procurement for FSM in India has been done either through Engineering, Procurement and Construction (EPC) or PPPs in the form of BOT, DBOT (including the Hybrid Annuity Model), and DFBOT. Most tenders issued are for the treatment and disposal component of the sanitation value chain, with few E&T tenders, either standalone or integrated. Regarding the FSM technologies procured, tenders can be classified into three categories based on choice of technology: a) open technology, b) indicative treatment process, and c) prescriptive technology solution. All the tenders are silent on reuse and the sale of treated water and bio-solids. Depending on the structure of the contract, the tenders typically consist of 1 year of construction, followed by a 1-year defect liability period and anywhere from 3 years to 10 years of O&M.

5.2 Information Provided in the Tender

Most tenders reviewed have not provided information required for bidding to the level of detail necessary for a quality bid. Several key items of information are missing from tenders, thus increasing bidder risk and chances of subsequent project failure. Table 5 summarizes the key items provided and not mentioned in the tenders.

TABLE 5. TECHNICAL INFORMATION IN FSM TENDERS.

Inputs provided in the tender	Inputs not provided in the tender
• City overview and FSM scenario • Volume of FS to be treated per day – basis for estimation not shared • Input FS characteristics based on the Advisory Note on Septage Management in Urban India, MoHUA • Standards for effluent disposal, similar to those set for sewage treatment plants by the CPCB	• Details on the land, its area, and site characteristics (topography, hydrogeology, soil characteristics, drainage, etc.) • Actual FS characteristics – the tender does not provide details on type of containment systems (septic tanks vs. pits, pour flush vs. cistern flush) nor characteristics of FS being collected • Due to lack of standards on bio-solids in India, most tenders are either silent on this or refer to multiple standards, thus confusing the bidder • Process or service standards expected from the FSTP or E&T operation

The key role of the government is to monitor the performance of the private entity and enforce the terms of the contract. The government needs to make land available for inspection. The bidder is responsible for meeting the scope of work outlined in the tender, including obtaining all approvals and clearances. However, the tenders state that the government will assist the bidder in obtaining these approvals.

5.3 Eligibility Conditions for Bidders

The eligibility conditions in the FSM bidding process are outlined in Table 6.

FSM has been largely driven by small private entrepreneurs in the E&T sector. Further, the FSTPs for small towns or even clusters are essentially small treatment plants more amenable for local entrepreneurs to undertake O&M contracts. Doing so will ensure lower costs as well as sustainability of the assets. Therefore, the eligibility criteria in FSM tenders should be open with low barriers to eligibility to encourage greater private sector participation.

TABLE 6. ELIGIBILITY CONDITIONS.

Item	Assessment of tenders
Legal status of the entity	Most tenders allowed a range of entities to apply – companies, trusts, public entities, individuals, and proprietorship firms. Some restricted eligibility for companies, while others mandated that the firm submitting the bid be a registered contractor with the state department.
Years of operation	Many tenders did not stipulate any minimum number of years the entity had to have been in business. Some mandated anywhere from a minimum of two to three years of operations prior to the bidding date.
Consortium bid submission	Most tenders allow a joint venture or consortium to participate because there are few market players that can execute the entire scope of the tenders alone.

5.4 Bidder Qualification and Selection Criteria

Eligible bidders are assessed for qualification through two parameters – technical experience and financial capacity:

A. Technical experience: Tenders allow experience in similar sectors, such as sewage treatment and solid waste management (SWM), to demonstrate 'technical experience' for FSM projects. As the market for FSM evolves, the experience requirement can become more fine-tuned to allow only project-specific sector experience.

B. Financial capacity: The bid documents assess the entity's financial experience based on its turnover and/or other criteria such as net worth or cash flow. When multiple tenders are issued simultaneously, an additional assessment in the form of bidder's residual capacity is assessed.

Bidders clearing the qualification step of procurement are ranked based on total score on technical and financial selection criteria.

A. Technical proposal: Bidders have to submit the following: a) the proposed treatment technology, b) the staffing plan, c) scheduling and material sourcing, and d) conceptual drawings. The evaluation of technical proposals is in the form

of a 'pass or fail' test, and only submissions that pass the minimum technical criteria are considered for evaluation of the financial proposal.

B. **Financial proposal:** Tenders adopt the least cost selection method. In DBOT tenders, the bid parameter is an aggregate of the construction cost and net present value (NPV) of O&M costs for the project tenure, discounted at current prices (Table 7). However, NPV is restricted to the contract period without a residual value calculation. This may negatively impact bidders proposing infrastructure with longer life. Discount rates are not always specified, which is confusing to bidders. Typically, BOT and EPC tenders are structured around the bill of quantities derived from nominal designs. The bidder quotes and is bound to the price of each material. This allows for flexibility to pay for changes to nominal design due to site conditions. The bid parameter is the total cost of construction derived from the bill of quantities.

5.5 Payments and Penalties

In an ideal PPP, the private sector contributes to the project's capital cost; however, in almost all FSM contracts, the capital and operating cost is completely borne by either the government or a donor. The FSTP in Leh is an exception, as it was completely financed by a private entity. Two states have implemented hybrid annuity models where bidders are expected to shoulder 50% to 60% of the capital risk in return for a proportionate annuity. The private sector arranges finance in the form of debt or equity to manage its cashflow for the construction and operation phases. The private sector's costs are mostly recovered through payments from the government, which are based on performance standards set out in the contract. For construction, most tenders have adopted a conventional payment structure based on construction milestones or monthly progress. The payment for O&M, however, is typically linked to performance, based on effluent discharge and/or treated bio-solids' standards. There can be penalties for failing to meet these standards; however, violations and corresponding penalties are not clearly defined, leading to unquantifiable risks for the bidder. None of the tenders put any penalties on the ULB for failing to meet their part of responsibilities.

5.6 Monitoring Mechanisms

Monitoring is done to ensure quality assurance and effective contract management. It is the responsibility of the procuring agency – the government, in this case. For the design and construction, some states have appointed third-party agencies. However, in other states, they rely on municipal engineers. In the construction phase, monitoring is typically done fortnightly/monthly. Monitoring during the O&M stage includes sample collection and testing, and tenders provide detailed sampling requirements, including frequency of testing FS influent and effluent parameters. Reporting requirements are rarely defined in detail in tender documents, although periodic monitoring reports have sometimes been mandated. Lack of robust monitoring mechanisms has the potential to undermine the performance-based penalty regime for O&M. Monitoring mechanisms are not comprehensive and are limited to FSTP outputs rather than to overall FSM as a sanitation service.

TABLE 7. CONTRACT MODELS IN FSM.

Business model category	Description of the contract model	Bid parameter	Basis of payment	Payment from and payment to	Payment mechanism
Model B: E&T of FS	1) Outsourcing the operation of ULB-owned desludging vehicles for providing on-demand desludging services	I. Price per desludging trip	Ia. Providing desludging service Ib. If number of trips is less than guaranteed minimum trips per quarter – compensation for shortfall in trips • Performance based penalties (deduct)	Ia. Household or institutions to operator at the time of service Ib. ULB to operator quarterly	Ib. Designated account having funds equal to the fee for minimum guaranteed number of trips for one quarter • Penalties to ULB for late payments
	2) Outsourcing the operation of ULB-owned desludging vehicles for providing scheduled desludging services	I. Price per desludging trip	I. Number of desludging trips • Performance based penalties (deduct)	I. ULB to operator monthly	I. Designated account having funds equal to three months of monthly trip payments • Penalties to ULB for late payments
	3) ULB outsourcing of scheduled desludging services	I. Price per desludging trip	I. Number of desludging trips • Performance based penalties (deduct)	I. ULB to operator monthly	I. Designated account having funds equal to three months of monthly trip payments • Penalties to ULB for late payments
Model C: Linking Emptying, Transport, and Treatment of FS	1) Integrated FSM tender for: • Outsourcing the operation of ULB-owned desludging vehicles for providing on-demand desludging services • DBOT of an FSTP	NPV of three values: I. Price per desludging trip II. Construction cost III. FSTP O&M cost per year NPV of (II + (I × Expected number of trips × yearly escalation × contract period in years) + III × yearly escalation × contract period in years)	Ia. Upon providing desludging service Ib. If number of trips is less than guaranteed minimum trips per quarter – compensation for shortfall in trips II. Meeting construction milestones for FSTP III. O&M of FSTP • Operator earns additional revenue from sale of reuse product • Performance based penalties (deduct)	Ia. Household or institution to operator at the time of service Ib. ULB to operator quarterly II. ULB to operator upon reaching milestones III. ULB to operator monthly	Ib, II & III. Escrow account having funds equal to - FSTP O&M payments for three months - Or upcoming milestone payment during FSTP construction period • Penalties to ULB for late O&M payments

(Continued)

TABLE 7. CONTRACT MODELS IN FSM (CONTINUED).

Model C: Linking Emptying, Transport, and Treatment of FS	2) Integrated FSM tender for: • Outsourcing the operation of ULB-owned desludging vehicles for providing scheduled desludging services • DBOT of an FSTP	NPV of three values: I. Price per desludging trip II. Construction cost III. FSTP O&M cost per trip NPV of (II + (I + III) × Expected number of trips per year × yearly escalation × contract period in years)	I & III. Monthly number of trips II. Meeting construction milestones for FSTP • Operator earns additional revenue from sale of reuse product • Performance based penalties (deduct)	I & III. ULB to operator monthly II. ULB to operator upon reaching milestones	I, II & III. Escrow account having funds equal to - Total O&M payments for three months - Or upcoming milestone payment during FSTP construction period • Penalties to ULB for late O&M payments
	3) Integrated FSM tender for: • ULB outsourcing scheduled desludging services • DBOT of an FSTP	NPV of three values: I. Price per desludging trip II. Construction cost III. FSTP O&M cost per trip NPV of (II + (I + III) × Expected number of trips per year × yearly escalation × contract period in years)	I & III. Monthly number of trips II. Meeting construction milestones for FSTP • Operator earns additional revenue from sale of reuse product • Performance based penalties (deduct)	I & III. ULB to operator monthly II. ULB to operator upon reaching milestones	I, II & III. Escrow account having funds equal to - Total O&M payments for three months - Or upcoming milestone payment during FSTP construction period • Penalties to ULB for late O&M payments
Model D: Operating Treatment Plants	1) DBOT of an FSTP	NPV of two values: I. Construction cost II. FSTP O&M cost per year NPV of (I + II × yearly escalation × contract period in years)	I. Meeting construction milestones for FSTP II. O&M of FSTP • Operator earns additional revenue from sale of reuse product • Performance based penalties (deduct)	I. ULB to operator upon reaching milestones II. ULB to operator monthly	I & II. Escrow account having funds equal to - FSTP O&M payments for three months - Or upcoming milestone payment during FSTP construction period • Penalties to ULB for late O&M payments
	2) Outsourcing the O&M of an existing FSTP	I. FSTP O&M cost per year	I. O&M of FSTP • Operator earns additional revenue from sale of reuse product • Performance based penalties (deduct)	I. ULB to operator monthly	I. Designated account having funds equal to three months of FSTP O&M payments • Penalties to ULB for late O&M payments

Note: Reuse aspects from Model E are included in Models C1, C2, C3, D1 and D2. Formal procurement is not a critical requirement in Model A and Model F. BOT and EPC tenders can also be similarly developed.

5.7 Contracting Models for FSM

FSM is currently an evolving sector which does not have defined standards on outcome, process and service parameters, along with clarity in responsibility and degree of risk sharing between the ULB and contractor. In addition, FSM is unique in comparison to other infrastructure procurement by the government, as the projects are relatively small in investment but technically complex. Currently, FSM tenders are silent on making FSM services universal. The tender documents need to be geared to ensure affordability of FSM services for the underserved and the poor. Given the situation, following are key recommendations for FSM procurement:

- **Standardization of procurement documents:** The tenders being floated are based on various sources and formats borrowed from other sectors. FSM needs standardized procurement templates incorporating all elements – eligibility, qualification, bid parameter, responsibilities, payment and penalty mechanisms, etc. – to better fit into the procurement processes of governments of India. Based on the evaluation of the business models, Table 7 provides possible contract models in FSM for India along which the tender formats can be standardized.

- **Standards and performance based payments/ penalties for FSM operations:** There is need for uniform standards on outcome, process and service parameters in the tenders. It helps improve accountability by levying penalties for poor performance by the operator. It provides clarity in ULB's role in monitoring. Most importantly, it improves transparency, thus building trust amongst citizens, and can increase their willingness to pay for sanitation services.

- **Technology guidance to ULBs:** The sector is nascent, and technology is evolving. Given the lack of capacity of the ULBs, it is critical to publish a credible list of technologies that meet the performance standards. This will guide ULBs on available technology solutions and also ensure clarity to bidders. However, this should not limit introduction of new technologies, so it is important to have a mechanism to encourage pilot projects and technology trials in a transparent manner that leads ultimately to mainstreaming of the same. While such mechanisms exist (e.g., the Dr. Mashelkar Committee in the Ministry of Jal Shakti and MoHUA), they need to be empowered considerably. The technology list can be modified based on performance data from pilot projects and from operational mainstream plants. It is strongly recommended that 'open technology' tenders be restricted to specified technologies.

- **Risk sharing:** The tender documents should ensure appropriate risk sharing based on the nature of contract and business model. Some examples are: 1) minimum guaranteed trips to government outsourced E&T operator, 2) given that user fees model in sanitation has been difficult to implement, putting the burden on the operator to collect user fees in an integrated contract is unfair, 3) integrated contract needs longer term to allow operators to recover costs and make it attractive for them to bid, and 4) integrated contract with sanitation tax has payment for FSTP O&M and E&T operations based on number of trips; this aligns the operator incentives towards FSM service delivery.

- **Eligbility and qualification:** To increase the pool of bidders, the eligibility and qualification criteria have considered experience in other sectors such as SWM and wastewater. Over time, as the FSM sector matures with increased implementation, these criteria need to be streamlined and made specific to FSM.

- **Payment mechanisms and penalties to ULBs:** It is recommended that escrow or designated accounts be created with sufficient coverage of operations funds. ULBs should be held accountable through financial penalties, similar to the operator's performance linked penalties, for not discharging their duties as per the contract, especially for delayed payments.

6. Key Takeaways for FSM in India

In India, investments in the FSM value chain beyond the toilet have witnessed rapid adoption, as it is a cost-effective way to provide basic sanitation at scale. Since 2014, India has been piloting FSM in various ways. Several states have now adopted FSM as their primary approach to sanitation. At the moment, several hundred FSTPs are in various stages of procurement and implementation. With India poised to scale up FSM, it is imperative to draw lessons from the journey so far. A review of similar reports highlights the following key lessons:

- There is a need for appropriate regulatory measures and policy guidelines at the state and ULB for FS emptying, transport, and treatment, as well as capacity building and buy-in at all levels in the FSM value chain (C-WAS 2019; Rohilla et al. 2017; NIUA 2019).
- There is a need for promotion of business opportunities to attract more private players, bundled contracts to attract larger private players, innovative financing mechanisms, customized contracting structures, and development of reuse markets (C-WAS 2019).
- There is a need for closing the loop by promoting reuse, which helps meet multiple SDGs and also has potential to serve as a source of revenue for the FSM business (Rohilla et al. 2017).
- Scheduled desludging needs to be advocated as a way to enable regular desludging, thus increasing the demand for E&T operators and making desludging a public service (C-WAS 2019; Rohilla et al. 2017; NIUA 2019).

This report, based on the analysis of execution of FSM business models, including the entire project cycle (planning, implementation and operations) for successful scaling up of FSM across India, lists the following recommendations:

Prioritize FSM to provide urgent sanitation needs: Given that 64% of India's population is dependent on OSS, FSM provides a rapidly scalable and lower cost option for providing basic sanitation coverage to all. FSM enables India to achieve Target 6.2 of the SDG for safely managed sanitation. Hence, the central and state governments should prioritize FSM through allocation of financial resources under a specific time bound FSM mission. The FSM mission should be designed to ensure public health and environment outcomes and be inclusive of gender, disabled, and most vulnerable sections of the society.

Sharing urban infrastructure for rural FSM: In rural India, almost 50% of households need FSM services. Due to limited funds in rural communities for setting up FSTPs, it is recommended that ULBs share their infrastructure with nearby rural areas.

In addition, the regulations in FSM, including licensing of private truck operators, should be seamless across administrative boundaries and not restricted to urban or rural settings. Starting with FSTPs and STPs in urban areas and allowing truck operators to dispose of FS collected from rural households will optimize FSM operations.

Willingness to charge for treatment of FS: FSM has successfully demonstrated willingness to pay, by households for installation of OSS and for E&T services. When it comes to treatment of FS, it is unclear if there is willingness to pay as there is no direct perceived benefit. Other sources of revenue for the FSTP, such as sale of reuse products and tipping fees from E&T operators, are too low to cover the O&M costs. Therefore, the most suitable option is to collect user charges indirectly, such as through water bills or property tax (e.g., Wai, Maharashtra), or directly through a specific sanitation user charge. Municipalities in India have suboptimal tariff levels for water and sanitation services to recover O&M costs. There is a need for political will to charge for sanitation services and ring-fence budgets to gradually move away from the subsidization of O&M costs.

Incentives for operators emptying manually to purchase mechanical E&T equipment: The government should provide support to enable operators emptying FS manually (also known as manual scavengers in India) to upgrade their tools and invest in mechanical emptying equipment, thereby improving their livelihoods and ensuring increased safety. This could be done, for example, by strengthening institutions working for the development of manual scavengers, such as the National Safai Karamacharis Finance & Development Corporation.

Need for investment in behavior change: People relying on OSS have to be appraised of the benefits of desludging and treatment of FS collected. This will help municipalities raise tax revenues and in the process fulfil the *Polluter Pays* principle in FSM, especially to cover the O&M cost of FSTPs. The government needs to invest in creating awareness among citizens on FSM and payment for desludging and treatment services.

Promote reuse: Tenders should have emphasis on reuse; otherwise, they miss circular economy opportunities and possible revenue, while disposal of solids may become a serious issue and impact FSTP operations. One approach could be to amend the Fertilizer Control Order (FCO) definition of city compost to include treated/composted FS (so called 'co-compost'), thus making it eligible for prevalent subsidies.

Standards: In FSM, treated effluent and solids' standards are currently 'borrowed' from other sectors (sewage, MSW). For example, the FCO standards for MSW compost specify 'Nil' pathogens – an impractical standard for FSM, which should instead follow the WHO (2006) standards for agricultural sludge reuse or evolve standards specific to FS. However, further to outcome standards, it is important to define process and service standards that help governments to monitor effectively and service providers to benchmark their performance and constantly improve.

Standardization of tender documents: FSM is a nascent sector, lacking standards and specifications, clarity on responsibility, degree of risk sharing, and so forth; thus, tender document standardization is needed. FSM projects are of smaller size but involve relatively complex technical solutions. In integrated E&T and FSTP O&M contracts, the division of responsibility between the government and the service provider should be well defined. The sector needs standardized procurement templates to ensure all elements of the bidding documents are addressed and well structured.

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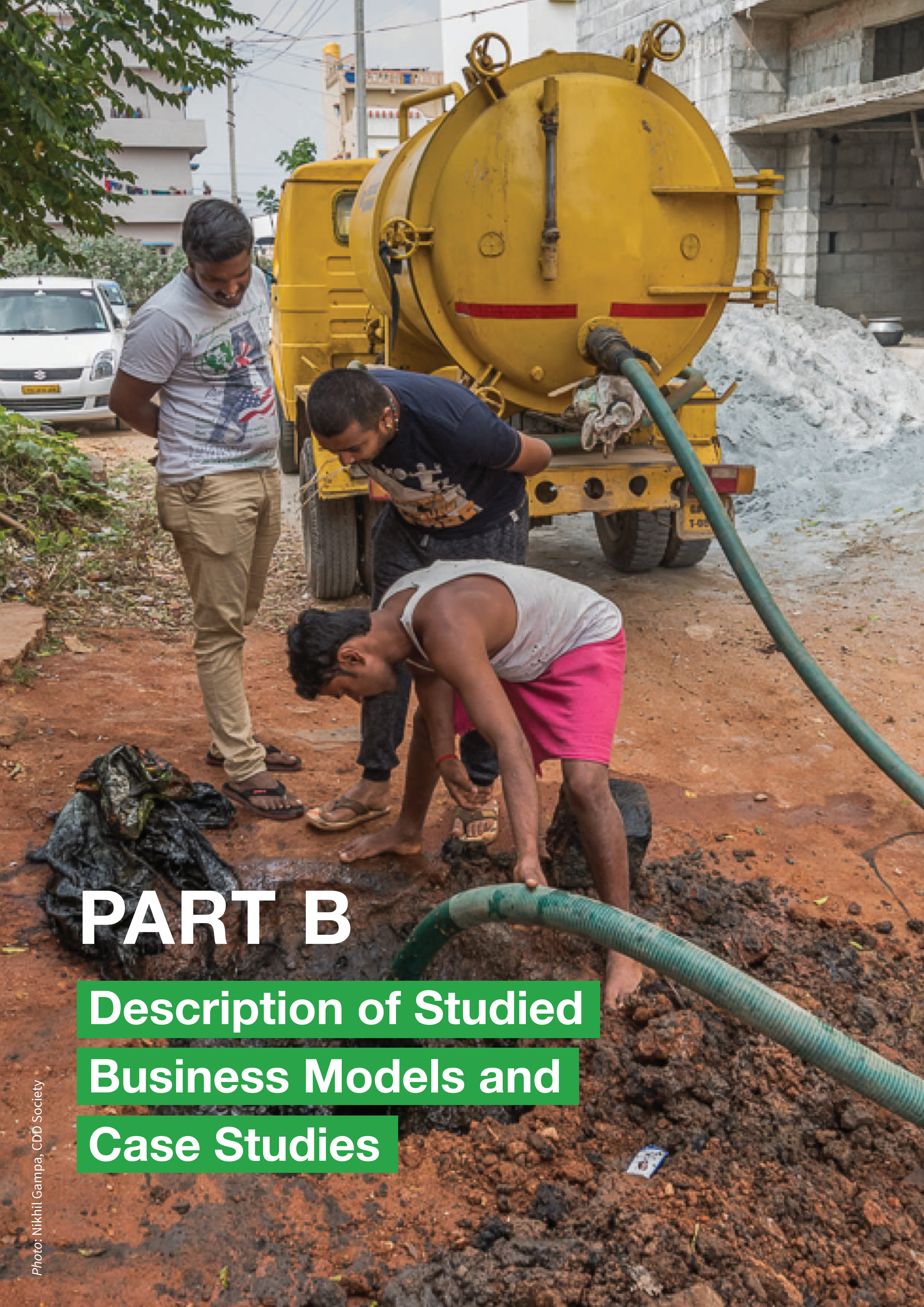


PART B

Description of Studied Business Models and Case Studies

Photo: Nikhil Gampa, CDD Society

7.

Models for Toilet Access and In Situ Energy and Nutrient Recovery

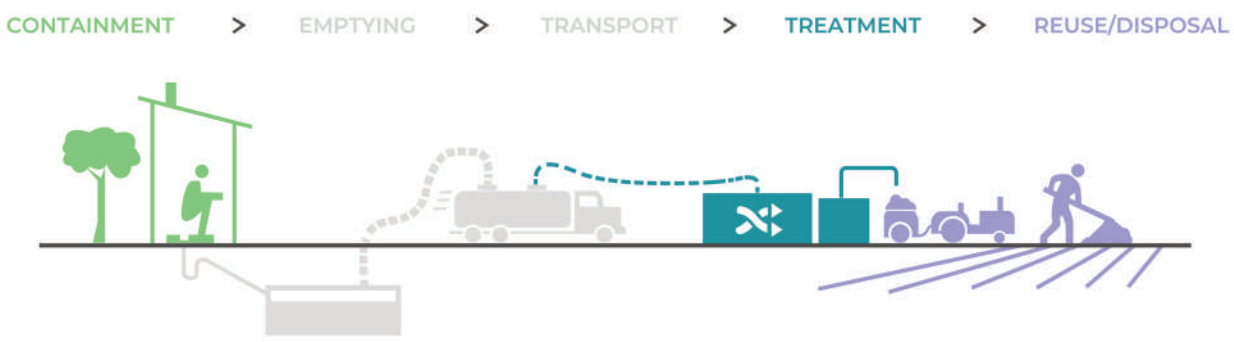
Business models in this section cover the toilet provision and FS treatment and reuse components in the sanitation value chain. The models offer the following value propositions:

1. Providing improved sanitation services to underserved communities or households through access to toilets
2. None or much reduced dependency on E&T services
3. Energy and nutrient recovery from treatment of FS helps to reduce energy costs and improve soil health

These models are cost-effective, promote a circular economy (through recovery of energy and nutrients) and contribute to reduction of GHG emissions, making them the most sustainable business models of all. The models are applicable where people lack access to toilets, and there is adequate space to build toilets with nutrient or energy recovery systems and, ideally, demand for reuse products.

The following business models are explained in this section:

1. Community or public toilet complex with energy recovery
2. Household toilet with nutrient recovery
3. Household toilet with energy recovery



7.1 Business Model: Community or Public Toilet Complex with Energy Recovery

7.1.1 Value proposition

The model focuses on toilet provision and treatment and reuse components in the sanitation value chain by producing biogas from human waste from public toilet complexes. It offers the following value propositions:

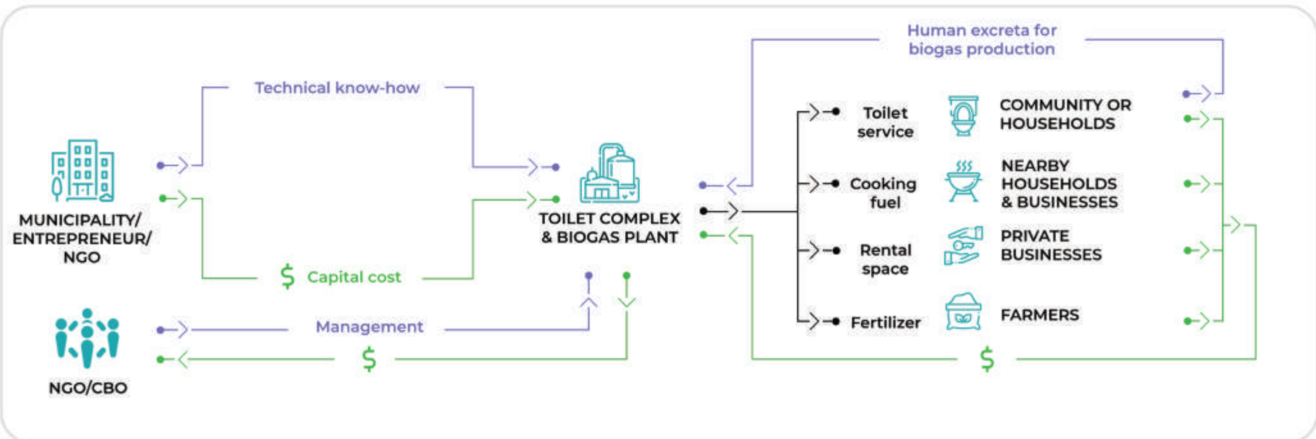
- *Providing improved sanitation services to underserved communities through access to toilets*
- *Reduced need for E&T services*
- *Production of biogas through FS treatment helps to reduce energy costs for the toilet complex or provides high-quality cooking fuel for households*

7.1.2 Description

In the model, community and public toilet complexes connected to bio-digesters are constructed to provide toilet access and treat human waste at the source. The municipality provides land for the infrastructure. Community and public toilet users pay user fees to the operator, and these fees are used to cover the operating cost. Toilet waste from the community/public toilet is fed directly into the bio-digester, where biogas is produced. The municipality can source organic waste for the bio-digester to increase biogas yield. The biogas can be used for internal lighting and heating in the toilet complex or sold to nearby households and businesses for cooking/heating. Slurry from the bio-digester should be further treated and can be used in landscaping or vegetable gardens within the complex. Depending on the land available, the toilet complex can rent out a space within the complex to a private business such as a retail store. It can also use the walls for advertisements and generate additional revenue. The relationships among the various stakeholders in the business model are shown below in Figure 22.

Owner and operator: The business model is implemented under a PPP arrangement. The municipality owns the infrastructure, and a private entity is contracted to operate the toilet complex. The contract could be structured as a DBOT, BOT or O&M service contract.

FIGURE 22. VALUE CHAIN OF COMMUNITY OR PUBLIC TOILET COMPLEX WITH ENERGY RECOVERY MODEL.



7.1.3 Funding and financing

Capital cost: This is mostly covered by grants from donors and funds from state or national government programs focused on provision of toilet access to underserved communities.

Operating cost: The private entity typically finances this cost predominately through collection of toilet user fees, compared to other revenue sources – sale of biogas, rental, and advertising. Revenue from biogas sales or energy savings incurred is not significant. The toilet complexes are typically implemented from 100 up to 1,000 users per day. Alternatively, the municipality can contract the operations of the bio-digester to a private entity for a fixed fee, when biogas is supplied to households for cooking and serves a larger social purpose.

7.1.4 Risks and benefits

Risks

- User acceptance of biogas from FS for cooking
- Non-payment from users or reduction in number of users may lead to toilet becoming dysfunctional

Benefits

- Promotes a circular economy (energy and nutrients) and contributes to the reduction of GHG emissions

7.1.5 Relevance

Most suitable for residential institutions, low-income settlements with no toilets, public toilet facilities at bus stands, markets, etc., and where there is onsite demand for biogas for cooking or heating. It is important that the land for the bio-digester is available near the toilet facility. To make this business model inclusive, the following interventions may be considered:

1. Public and community toilets design should be gender, child, and disabled friendly
2. User fee should be affordable to the poor

The following case studies are explained in this section:

- 'Sulabh' Public Toilet-Linked Biogas Plants, Pan-India
- Trichy Bio-digester-Linked Community Toilet & Kitchen, Tiruchirappalli, Tamil Nadu

Related models from other countries have been reported, e.g., in Nairobi, Kenya and Kampala, Uganda.

CASE STUDY

‘Sulabh’ Public Toilet-Linked Biogas Plants, Pan-India

Location	Pan-India
Value offered	Toilet services, nutrient-rich slurry and production of biogas for energy
Organization type and name	NGO – Sulabh International Social Service Organisation ('Sulabh')
Project status	Operational since 1982
Major partners	Central and municipal governments
Financing entities and revenue source	***Capital cost***: Municipality and GoI subsidy ***Operating cost***: User fees and/or municipality or donor funds/grants; possibility of Corporate Social Responsibility (CSR) funding from corporates and private companies

Context and background

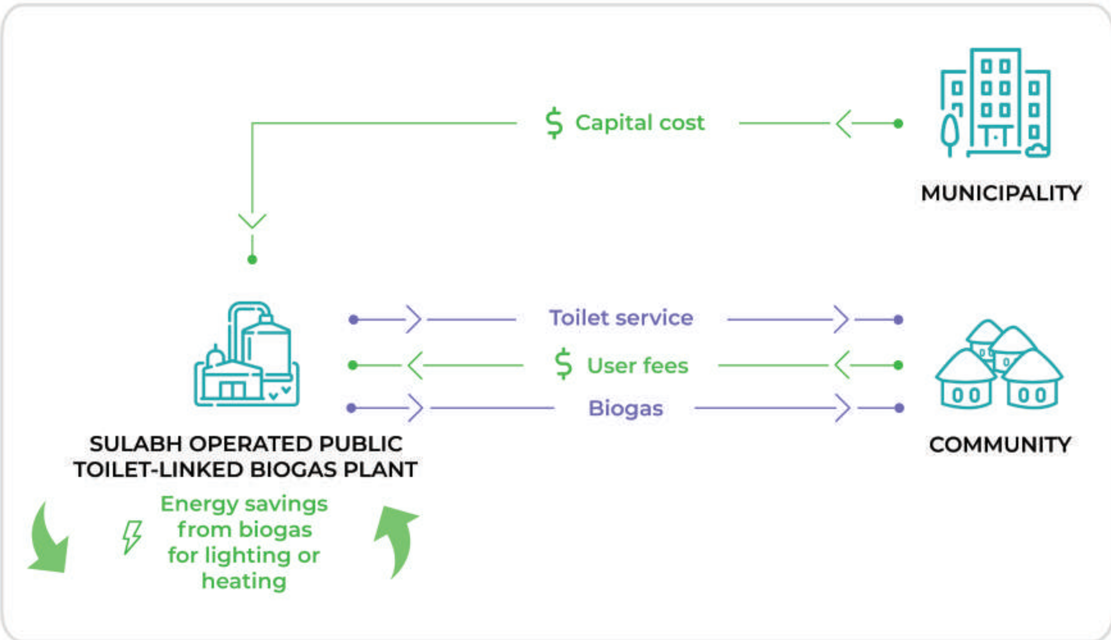
In India, ‘Sulabh’ has pioneered household ‘Sulabh Shauchalaya’, a twin leach pit pour-flush composting toilet, which has been adopted across India and other countries. The organization has also pioneered both pay-per-use public toilets and public toilets connected to bio-digesters (Sulabh 2019a, 2019b). The widespread lack of facilities in public places throughout India led ‘Sulabh’ to develop a pay-per-use public toilet service in public places and low-income communities. The idea for connecting public toilets to bio-digesters was to create a simple, affordable technology with minimal skill required for O&M in order to treat fecal matter in the absence of a sewerage network or in order to reduce the load on the existing sewerage network. The development of the bio-digester technology started in 1982. With continuous R&D, the design was enhanced, and finally, design approval, along with an 80-90% subsidy, was obtained from the then Ministry of New Energy Sources (now Ministry of New and Renewable Energy) in 1992; ‘Sulabh’ installed most of its systems in the 1990s and early 2000s. Around 190 public toilet-linked biogas plants were established (Sulabh 2019b). The rate of installation has decreased in the past decade due to increasing focus on sewerage, lack of space, and removal of the subsidy for small-scale bio-digesters.

Key indicators (for 1,000-user system, as of March 2019)	
Installed capacity	5 m^3/day
Allocated land area	0.049 acres
Labor requirements	3-4 persons (Full-time Equivalent [FTE])
Inputs	Wastewater, including raw FS – 4-5 m^3/day
Outputs	10,020 m^3 of biogas produced annually

Case description

Although this venture started as a social work initiative, there is business potential. The goal is to provide an affordable, human waste treatment solution with energy recovery for non-sewered public toilets. 'Sulabh' was the pioneering organization, driving the entire process, including fundraising, liaising with the government, and technology provision. 'Sulabh' is approached by the municipality or other local government agencies and private sponsors to establish a public toilet-linked biogas plant. The municipality typically provides the land and funds for construction. A survey is carried out to determine the appropriate design attributes and capacity of the toilet complex and bio-digester, followed by construction and commissioning. After commissioning of the plant, O&M is carried out by 'Sulabh' during the concession period (typically 20 to 30 years). The operating cost is recovered through the collection of user fees. The biogas is used for cooking and lighting in the toilet complex or to generate electricity, or is given away as fuel to nearby businesses and households (Otoo and Drechsel 2018). The relationships among the various stakeholders in the value chain are shown in Figure 23.

FIGURE 23. VALUE CHAIN OF THE 'SULABH' PUBLIC TOILET-LINKED BIOGAS PLANT MODEL.



Lately, 'Sulabh' has been facing the following business challenges:

- High dependence on the government and external agencies to fund the capital cost. Recently, the subsidy for bio-digesters has shifted to large-scale biogas systems and no longer applies to smaller systems.

- The GoI's program on provision of household toilets for underserved households has reduced the number of public toilet users, resulting in a lower quantity of toilet waste for biogas production.

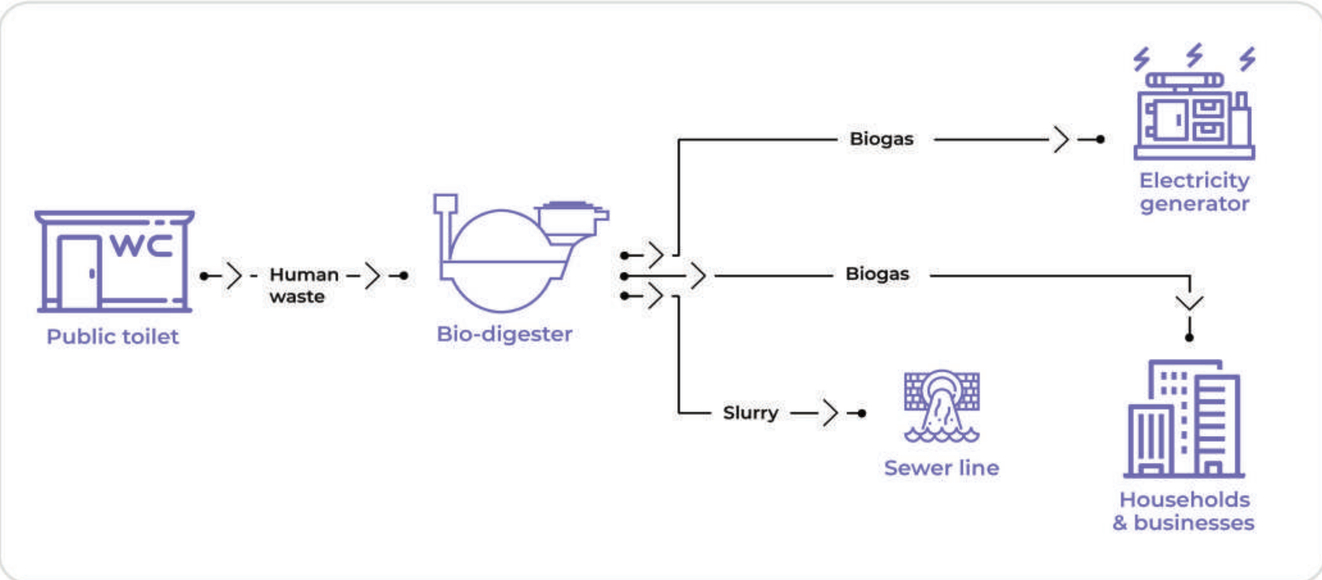
- Local governments are connecting public/ community toilets to sewer lines and demolishing bio-digesters to make land available for other purposes.

As a result, 'Sulabh' is targeting new customer segments for toilet-linked biogas systems, such as private schools in non-sewered areas. These systems are funded by CSR initiatives of private entities and public sector undertakings. The school provides land, operates the system, and covers the O&M cost. As in the case of public toilet complexes, 'Sulabh' designs and constructs these toilet-linked biogas plants in schools.

Technology and processes

The 1,000-user 'Sulabh' public toilet-linked biogas plant processes about 5 m^3/day of wastewater, including FS, to generate around 30 m^3 of biogas per day. Bio-digester linked public toilet complexes are typically designed for 1,000 to 2,000 users, but they can be set up for 500 to 5,000 users using a similar design. The excreta along with flush water from the public toilet complex is fed to an underground bio-digester through gravity, in which biogas is produced due to anaerobic fermentation over a 30-day period (Bahadur 2010). Constructing the bio-digester underground has two benefits: gravity flow without power consumption and thermal insulation. The bio-digester effluent coming out of the outlet is channeled to a secondary treatment facility or to soak pits or put into a nearby sewer line, if available. In a few cases, highly efficient Sulabh Effluent Treatment Plants have been installed to treat the bio-digester effluent to a BOD of 10 mg/l or lower (Jha 2005). The settled digested sludge in the bio-digester is removed every 2 years and put on a drying bed for aerobic stabilization and final pathogen elimination. An overview of the technology process is given in Figure 24.

FIGURE 24. TECHNOLOGY PROCESS OF THE 'SULABH' PUBLIC TOILET-LINKED BIOGAS PLANT.



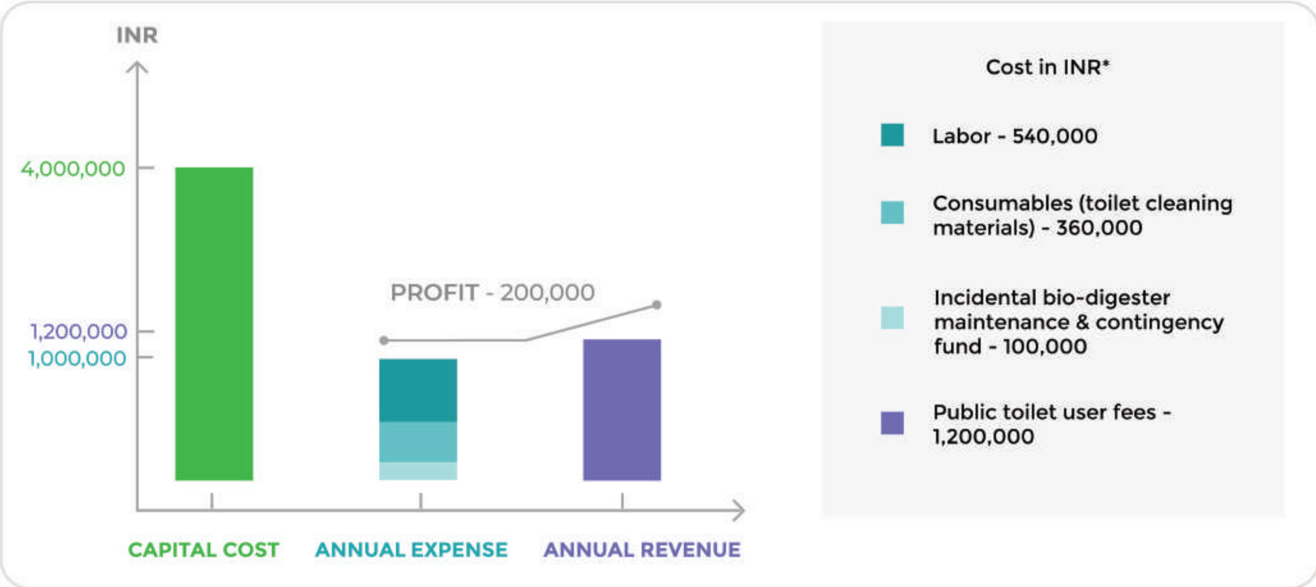
Source: Sulabh International Social Service Organisation.

Funding and financial outlook

The capital cost of a 1,000-user public toilet-linked biogas plant, including the toilet complex, is typically INR 4 million. The cost may vary according to the situation on the ground (soil strength, material and labor cost, etc.). Funds for the capital cost come from multiple sources: the municipality, local government agencies, and private sponsors. 'Sulabh' covers the operational costs of the system. For a 1,000-user system, the annual operational cost is INR 1 million, which is mostly for labor and cleaning material costs. A 1,000-user system requires about six to eight part-time operators (for the male and female sections of the toilet and the bio-digester).

The sole source of revenue is from user fees charged to toilet users. 'Sulabh' is yet to monetize biogas except for internal usage, resulting in energy savings. With consistent user fee collection, 'Sulabh' can have a margin per toilet complex of up to 20%, as detailed in Figure 25. Sulabh uses profits generated from profitable toilet complexes to cross-subsidize O&M of community toilets in slums.

FIGURE 25. FINANCIAL OVERVIEW OF THE 'SULABH' PUBLIC TOILET-LINKED BIOGAS PLANT FOR 1,000 USERS.



Source: Sulabh International Social Service Organisation.
*USD 1.00 = INR 71.25, as of October 2019.

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CASE STUDY

Trichy Bio-digester-Linked Community Toilet and Kitchen, Tamil Nadu

Location	Tiruchirappalli, Tamil Nadu
Value offered	Toilet access and in situ treatment of FS and organic fractions of solid waste to produce biogas
Organization type and name	PPP – Trichy Municipal Corporation & private entity
Project status	Operational since 2016
Major partners	Gramalaya, Women's Action for Village Empowerment (WAVE) Federation
Financing entities and revenue source	***Capital cost***: Trichy Municipal Corporation ***Operating cost***: User fees for the community toilets and the municipality for the bio-digester and community kitchen

Context and background

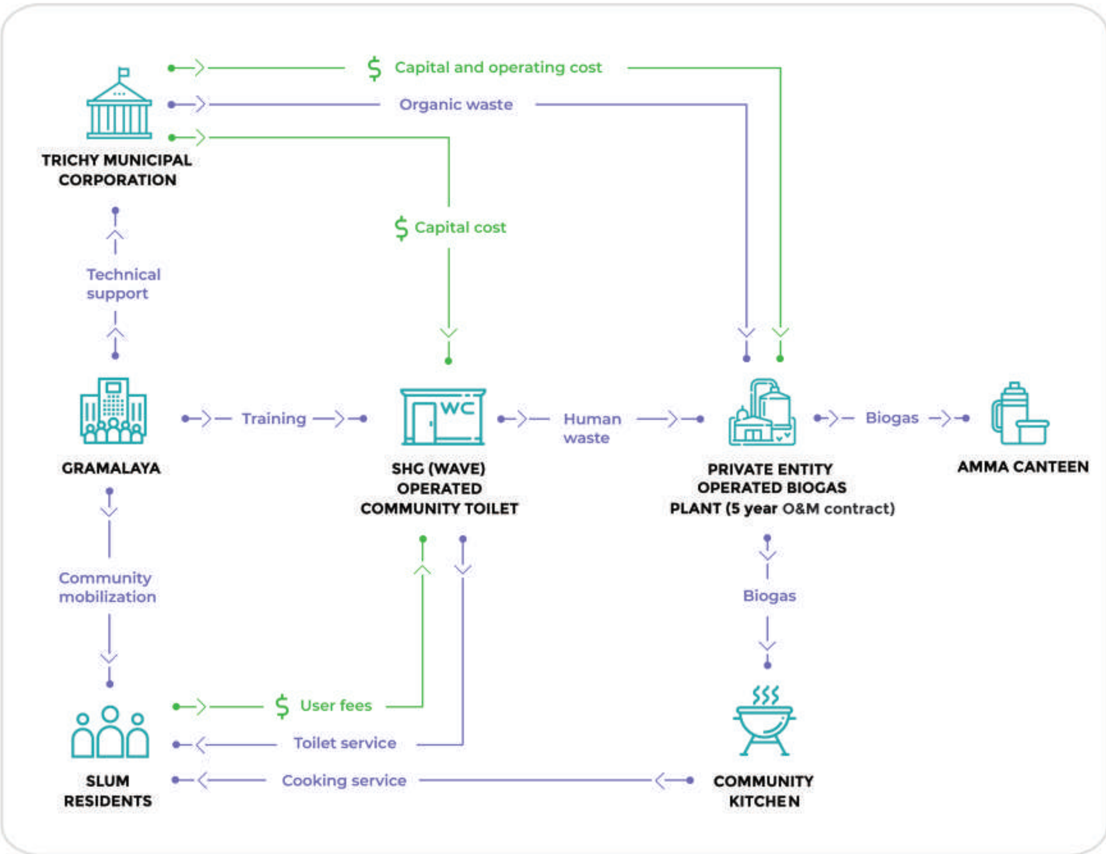
Gramalaya, an NGO, has been working in rural areas and urban slums to provide water, sanitation, and hygiene (WASH) to socio-economically disadvantaged people since 1987. In Tiruchirappalli (Trichy), in Tamil Nadu, Gramalaya undertook WASH awareness in Viragupettai slum, where families did not have access to toilets and practiced open defecation. Gramalaya's advocacy effort with the Trichy Municipal Corporation (TMC) led to the construction of a 20-seater community toilet in 2001 and subsequently other community toilets in slums across the city. In 2016, based on Gramalaya's proposal, TMC constructed a bio-digester linked to the community toilet at Viragupettai slum, replacing a septic tank. The biogas would be used at the newly constructed community kitchen run by slum residents (Gramalaya 2016, 2019).

Key indicators (as of May 2019)	
Installed capacity	4-5 m^3/day
Allocated land area	0.0093 hectares (ha)
Labor requirements	1.5 persons (FTE)
Inputs	Raw FS – 4 m^3/day; organic waste – 0.6-1 Metric ton (MT)/day
Outputs	Biogas: 30 m^3/day

Case description

Gramalaya is the key driver in setting up the community kitchen run on biogas generated from the bio-digester linked to the community toilet. Gramalaya formed women's Self-help Groups (SHGs) across all the slums of Trichy to promote WASH awareness, and members of these SHGs formed Sanitation and Hygiene Education (SHE) teams to manage the O&M of community toilets through collection of user fees. Elected members from the SHE teams formed the WAVE Federation, which monitors the management of the community toilets (Chatterjee 2019). TMC provided land and funds for the capital and operational costs of the bio-digester and community kitchen, along with design and construction of the facilities. TMC contracted operations of the bio-digester and community kitchen to a private entity for 5 years. In addition to the human waste, the bio-digester treats organic waste, which is supplied by the TMC from a nearby market. The biogas produced is supplied to the community kitchen. Residents of the slum use the community kitchen facility gratis to cook meals. Surplus biogas is supplied gratis to the government-operated Amma Canteen, which provides subsidized food. The relationships among the various stakeholders in the value chain are shown in Figure 26.

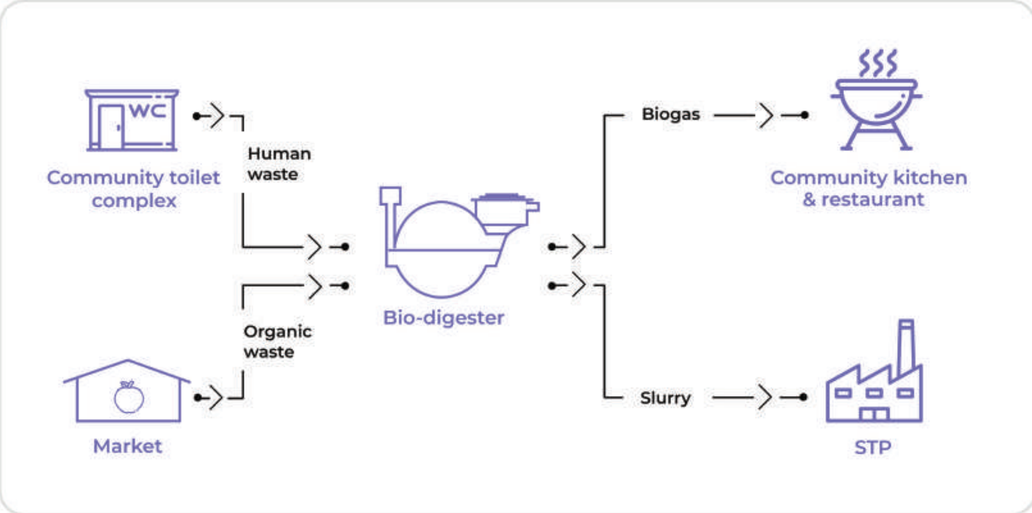
FIGURE 26. VALUE CHAIN OF THE TRICHY BIO-DIGESTER-LINKED COMMUNITY TOILET AND KITCHEN MODEL.



Technology and processes

The bio-digester installed is designed to process 4 m^3/day of human waste from 800 users and 600 kg to 1 MT of organic waste per day. The biogas produced is transported via pipelines to the community kitchen, which is used by 84 families from the slum, and surplus biogas is given to the nearby Amma Canteen. The slurry from the bio-digester is removed once a year and transported to the nearest STP. The technology process is summarized in Figure 27.

FIGURE 27. TECHNOLOGY PROCESS OF THE TRICHY BIO-DIGESTER-LINKED COMMUNITY TOILET.



Source: Gramalaya.

Funding and financial outlook

The capital cost of the bio-digester and community kitchen is INR 4.5 million,[2] which was funded by the TMC from its budget, along with operational costs. Two workers are required for operations – one full-time cleaner and one part-time mechanic. The private entity managing the bio-digester and community kitchen gets its revenue from the fixed O&M fee paid by the TMC. The operational cost of the community toilet is INR 25,000 per month, and the SHE team manages it through collection of user fees. The SHE team charges slum residents INR 1 per toilet use, but people from outside the slum must pay INR 2 per use. The community toilet generates monthly revenue of INR 33,000 to 36,000 and makes a profit[3].

References

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[2] USD 1.00 = INR 67.18 in 2016.
[3] USD 1.00 = INR 71.25 in October 2019.

7.2 Business Model: Household Toilet with Nutrient Recovery

7.2.1 Value proposition

The model is based on toilet provision and treatment and reuse components in the sanitation value chain by recovering nutrients in FS from toilets to produce fertilizer. It offers the following value propositions:

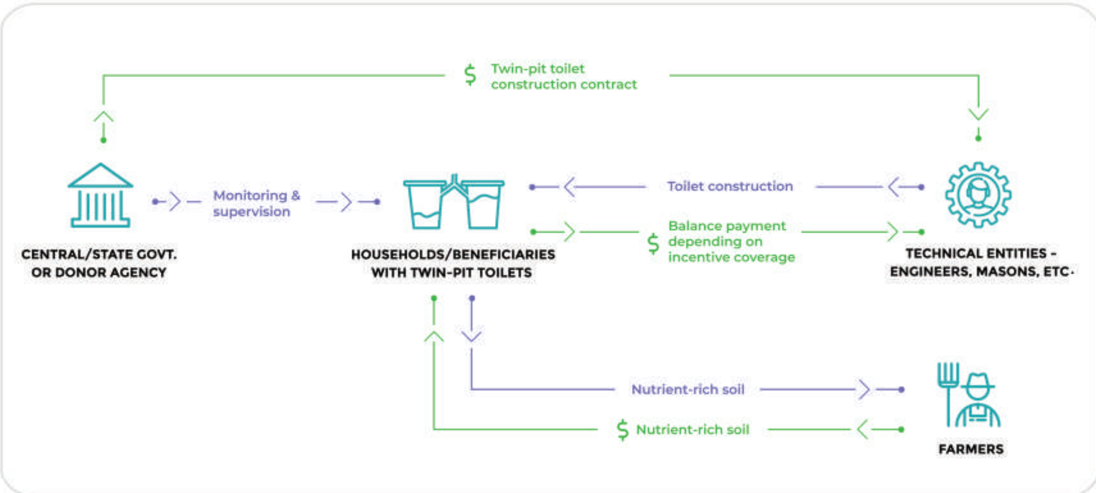
- *Providing improved sanitation services to households through toilet access by giving incentives to construct toilets*
- *Production of a soil ameliorant with a high-nutrient value*

7.2.2 Description

In the model, toilets such as the twin-pit system with in situ treatment and nutrient recovery are implemented at the household level. The government or donor drives the construction of toilets at the household level. The nutrient-rich soil ameliorant from this type of toilet can be used directly by the household in a kitchen garden or on agricultural land. If the household is reluctant or unable to undertake pit emptying, the model offers potential livelihood opportunities, wherein the local government/municipality can contract pit emptying to an individual entrepreneur, SHG or NGO. The collected pit content can be sold by the entrepreneur as a soil ameliorant to farmers. The relationships among the various stakeholders are shown in Figure 28. An alternative to the twin-pit is the tiger toilets (Box 3), which produces vermicompost.

Owner and operator: The business model is implemented by the government, a donor or an NGO. The implementing entity facilitates toilet construction and can provide funds for construction. Households are the owners and operators of the toilets with nutrient recovery. If E&T services are engaged, a contracted individual entrepreneur, SHG or NGO takes charge of the activities.

FIGURE 28. VALUE CHAIN OF THE HOUSEHOLD TOILET WITH NUTRIENT RECOVERY MODEL.



7.2.3 Funding and financing

Capital cost: This is covered by a combination of grants from donors, subsidies from state or central government programs for toilet access, and household contributions.

Operating cost: The household is responsible for toilet maintenance, including pit emptying. When emptying is contracted to another entity by the local government, the cost of operations is financed by the entity selected. The entity can recover the operating cost by charging a fee to the households and from sales of the pit content as a soil ameliorant.

7.2.4 Risks and benefits

Risks

- Willingness of users to maintain (manually empty) the twin-pit system
- Reuse may not happen if the household does not transfer stabilized fecal matter to a farm
- Acceptance of stabilized fecal matter as a soil ameliorant by farmers
- Highly dependent on government incentives for adoption

Benefits

- Removes the need for the municipality to implement FSM – emptying, transport, and
- treatment – centrally, reducing costs and avoiding GHG emissions
- Promotes circular economy through nutrient recovery, which improves soil health

7.2.5 Relevance

The twin-pit technology is applicable to areas with higher soil permeability, low water table, and where space is available within the household. This business model is most suitable when the household is willing to manage the toilet on its own. The following case study is explained in this section:

- Swachh Bharat Mission Twin-Pit Toilets, Pan-India

BOX 3. TIGER TOILETS.

PriMove Infrastructure Development Consultants Pvt. Ltd (Primove), based out of Pune, India, is promoting use of *Eisenia fetida*, or tiger worms, in containment systems to treat excreta at source. This type of toilet technology is called the Tiger Toilet, which consists of a prefabricated toilet room and a bio-digester (also known as Tiger bio-digester). The bio-digester is made of either fiber-reinforced plastic or reinforced cement concrete and uses tiger worms to consume FS and produce vermicompost. Ninety percent of the solids in the FS are digested within 24 hours. The bio-digester has to be emptied once every 10 years and can be emptied by the user, as the vermicompost is a stable, soil-like material. The Tiger Technology was approved in the 9th Meeting of the Dr. R. A. Mashelkar Committee by the Ministry of Drinking Water and Sanitation in January 2018. As of November 2019, over 4,500 Tiger Toilets had been installed in 50 villages across India (TBF 2019).

Reference

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CASE STUDY

Swachh Bharat Mission Twin-Pit Toilets, Pan-India

Location	Pan-India
Value offered	Access to toilet and in situ treatment of FS to produce a soil ameliorant
Organization type and name	GoI
Project status	Operational since 2014
Major partners	State governments and local governments
Financing entities and revenue source	***Capital cost***: SBM and state governments ***Operating cost***: Households

Context and background

According to the 2011 Census of India, less than half of the population had household toilets, and nearly half of the population defecated in the open (Office of the Registrar General & Census Commissioner, India 2011). In 2014, the GoI launched the SBM, a five-year program with the mission of ensuring hygiene, waste management, and sanitation across India. One of the primary objectives of the SBM is to eliminate open defecation through the construction of household-owned toilets and community toilets (Ministry of Urban Development, India 2014). At the time of writing, more than 100 million toilets had been built (MoHUA 2016; MDWS 2019). While the GoI provides flexibility in choosing the toilet technology, the twin-pit toilet is the most recommended option.

Case description

The GoI has been the primary driver in eliminating open defecation in the country through the implementation of the SBM. MoHUA and the Ministry of Drinking Water and Sanitation are the implementing agencies in urban and rural areas, respectively. They monitor and supervise the implementation of the program at the state level and ensure disbursement of funds.

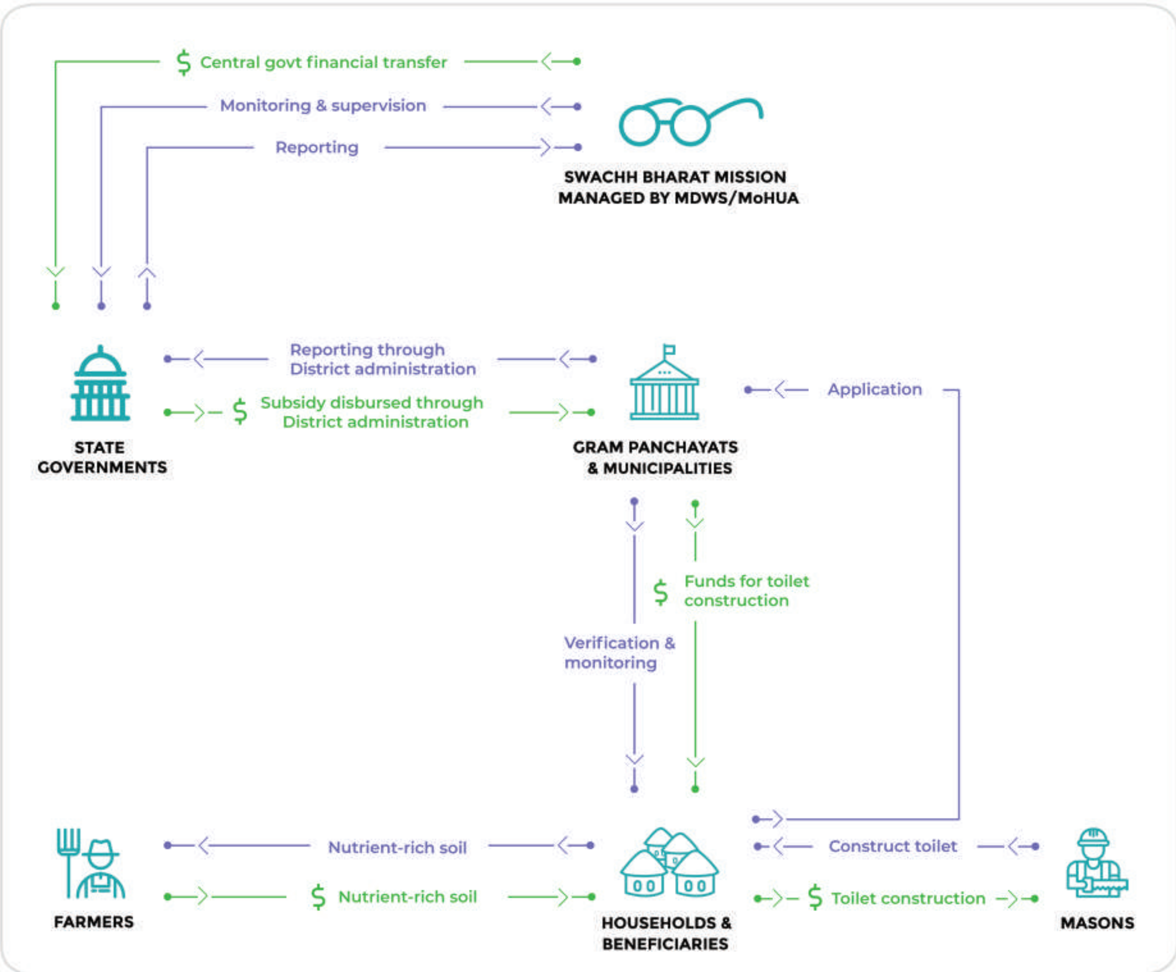
Construction of toilets at the household level is facilitated through the application of toilet construction subsidies. The SBM Guidelines 2014 specify that households that do not have access to a sewerage line must connect their toilet to an approved OSS technology (Ministry of Urban Development, India 2014). The GoI promotes twin-pit toilets, which ensure in situ treatment and conversion of FS into a safe soil ameliorant. According to the National Annual Rural Sanitation Survey 2018-19, about 27% of households in rural areas had installed twin-pit systems (Kantar Public and IPE Global 2019). The twin-pit model has been adopted more by households in states such as Uttar Pradesh, where the state government mandated twin-pit construction in order to get the SBM subsidy (Yadavar 2018).

The local government body (municipality or Gram Panchayat) identifies households in need of toilets through a baseline assessment; eligible households apply for the subsidy, either online or at the local government office. The local government is responsible for verifying space availability and technical viability for the toilet. Based on the

progress in toilet construction, the subsidy is released in two to three installments, typically to the beneficiary household. The household can plan and manage the toilet construction. Alternatively, the local government bundles the households eligible for toilets and hires a contractor, who is paid based on construction progress. The output of the twin-pit toilet is a nutrient-rich soil that can be applied as fertilizer in kitchen gardens or agricultural land or safely disposed of.

In order to successfully implement SBM nationwide, there has been a particular focus on capacity building and behavior change. Over 1 million masons, 120 million students, 625,000 sanitation workers, 250,000 village leaders, 700 district magistrates, over 500 young professionals, and 50 national brand ambassadors were involved in SBM as behavior change agents, to ensure people actually use the toilets and do not defecate in the open (Iyer 2019). The government also partnered with private sector stakeholders, e.g., through CSR initiatives, to leverage additional financing for toilet construction and behavior change. The relationships among the various stakeholders in the value chain are depicted in Figure 29.

FIGURE 29. VALUE CHAIN OF THE SBM TWIN-PIT TOILET MODEL.

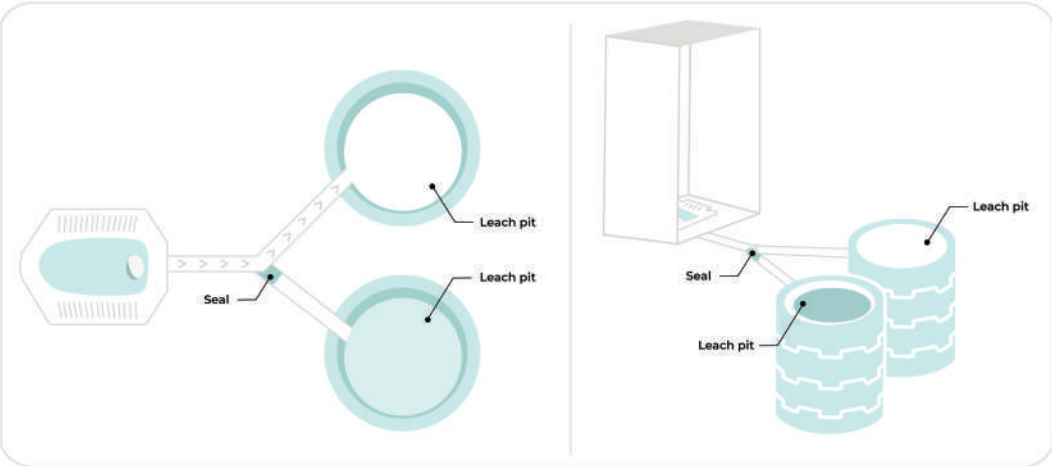


Technology and processes

The twin-pit toilet consists of two leach pits, with concrete-cement or brick lining on the sides, connected to the toilet. One pit is blocked from receiving waste from the toilet. Once the pit in use fills up, it is blocked from receiving human waste, and the second pit is used. The filled pit is left isolated for at least one year, and during this time, the sludge gets treated through

anaerobic digestion and turns into a nutrient-rich soil. When the second pit fills up, the first pit is emptied and put into use again (Spuhler 2019). The treated sludge can be handled directly by the household. The twin-pit design is depicted in Figure 30. A web-based platform and management information system is implemented by the GoI to track SBM subsidy disbursal and toilet construction progress (MoHUA 2019).

FIGURE 30. TECHNOLOGY PROCESS OF THE TWIN-PIT TOILET.



Source: Tilley et al. 2014.

Funding and financial outlook

The national and state governments provide a total subsidy of up to INR 12,000[4] for construction of toilets, which is the total unit cost per household toilet as prescribed by the GoI (MoHUA 2019). The household is responsible for financing any additional amount required for toilet construction. Some households have opted to build a single leach pit instead of the twin-pit because it is cheaper and requires less space. The O&M cost is negligible because pit emptying can be done by the households themselves; nevertheless, due to the stigma associated with the handling of FS, many households use emptying services.

SBM has been able to mobilize INR 250 billion from various stakeholders for marketing and communications, which is 10 times the government's investment in behavior change. The increase in toilets and open defecation-free areas has had positive impacts on health. A BMGF study found that in open defecation-free areas in India, there were 32% fewer diarrhea cases among children (Iyer 2019).

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7.3 Business Model: Household Toilet with Energy Recovery

7.3.1 Value proposition

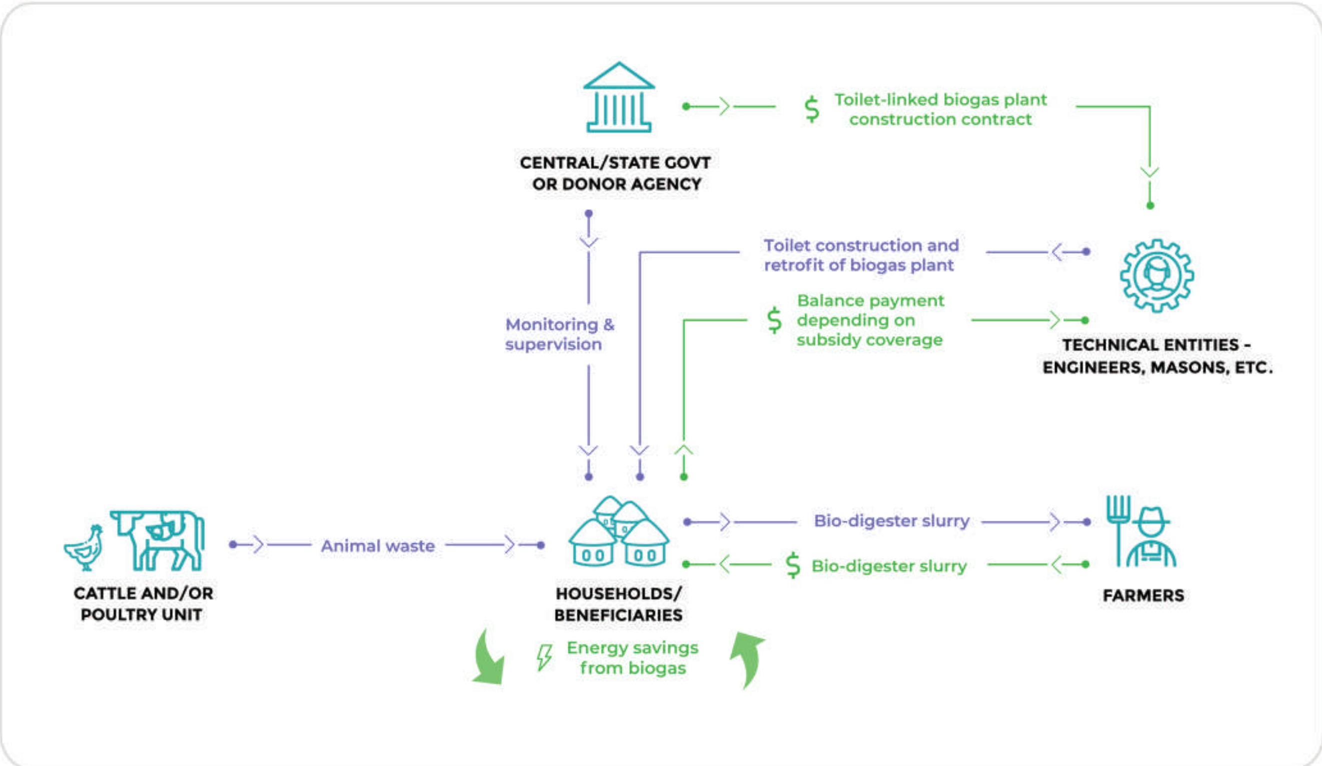
The model focuses on toilet provision, treatment and reuse components in the sanitation value chain, by producing biogas from household toilets linked to bio-digesters. It offers the following value propositions:

- *Providing improved sanitation service to households through toilet access by giving a toilet construction incentive*
- *Savings in energy costs through use of biogas produced from FS and organic waste*

7.3.2 Description

In the model, toilets connected to bio-digesters are implemented at the household level. Human waste from the toilet is fed directly into the bio-digester, and households feed organic waste such as cattle dung into the bio-digester. The biogas produced is used directly by the household for cooking and heating. Nutrient-rich slurry from the bio-digester can be applied in a kitchen garden or on agricultural land as fertilizer. There is a high degree of responsibility placed on households to maintain their toilets and bio-digesters. The model could target households with existing cattle dung biogas plants and, in partnership with a milk cooperative society, identify households and arrange financing through the cooperative society to link toilets to existing biogas plants. The relationships among the various stakeholders are shown in Figure 31.

FIGURE 31. VALUE CHAIN OF THE HOUSEHOLD TOILET WITH ENERGY RECOVERY BUSINESS MODEL.



Owner and operator: The business model is implemented by the government, a donor or an NGO. The implementing entity promotes the toilet-linked bio-digester design, facilitates construction, and often provides funds for construction. Households are the owners and operators of the toilet-linked bio-digesters.

7.3.3 Funding and financing

Capital cost: This is covered by a combination of grants from donors, subsidies from state or national government programs for toilet access and small-scale biogas, and households' own contributions.

Operating cost: The household manages maintenance of the toilet-linked bio-digester on its own and could potentially be compensated through energy savings.

7.3.4 Risks and benefits

Risks

- Household acceptance of using biogas from FS for cooking
- Subsidized liquefied petroleum gas (LPG) from the government is more convenient and hence deters adoption of bio-digester-linked toilets
- Highly dependent on government incentives for adoption

Benefits

- Promotes circular economy (energy and nutrients) and contributes to reduction of GHG emissions

7.3.5 Relevance

While the bio-digester-linked toilet technology is applicable for areas where space is available within the household, the business model is most suitable when the household is willing to manage the toilet on its own. To make this business model inclusive, participation from household members (especially women) should be ensured throughout the project cycle. The following case study is explained in this section:

- Valsad Household Toilet-Linked Biogas Plants, Valsad, Gujarat

Related models from other countries have been reported, e.g., in Lesotho and Nepal.

CASE STUDY

Valsad Household Toilet-linked Biogas Plants, Gujarat

Location	Valsad, Gujarat
Value offered	Treated FS, production of biogas for cooking/heating and slurry as a soil ameliorant
Organization type and name	NGO – FINISH Society
Project status	Completed in 2017; biogas units still operational
Major partners	WASTE, ICCO Cooperation, MDRTTC, Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), SBM, Ministry of New and Renewable Energy (MNRE)
Financing entities and revenue source	***Capital cost:*** GoI programs, MDRTTC, and households ***Operating cost:*** Households

Context and background

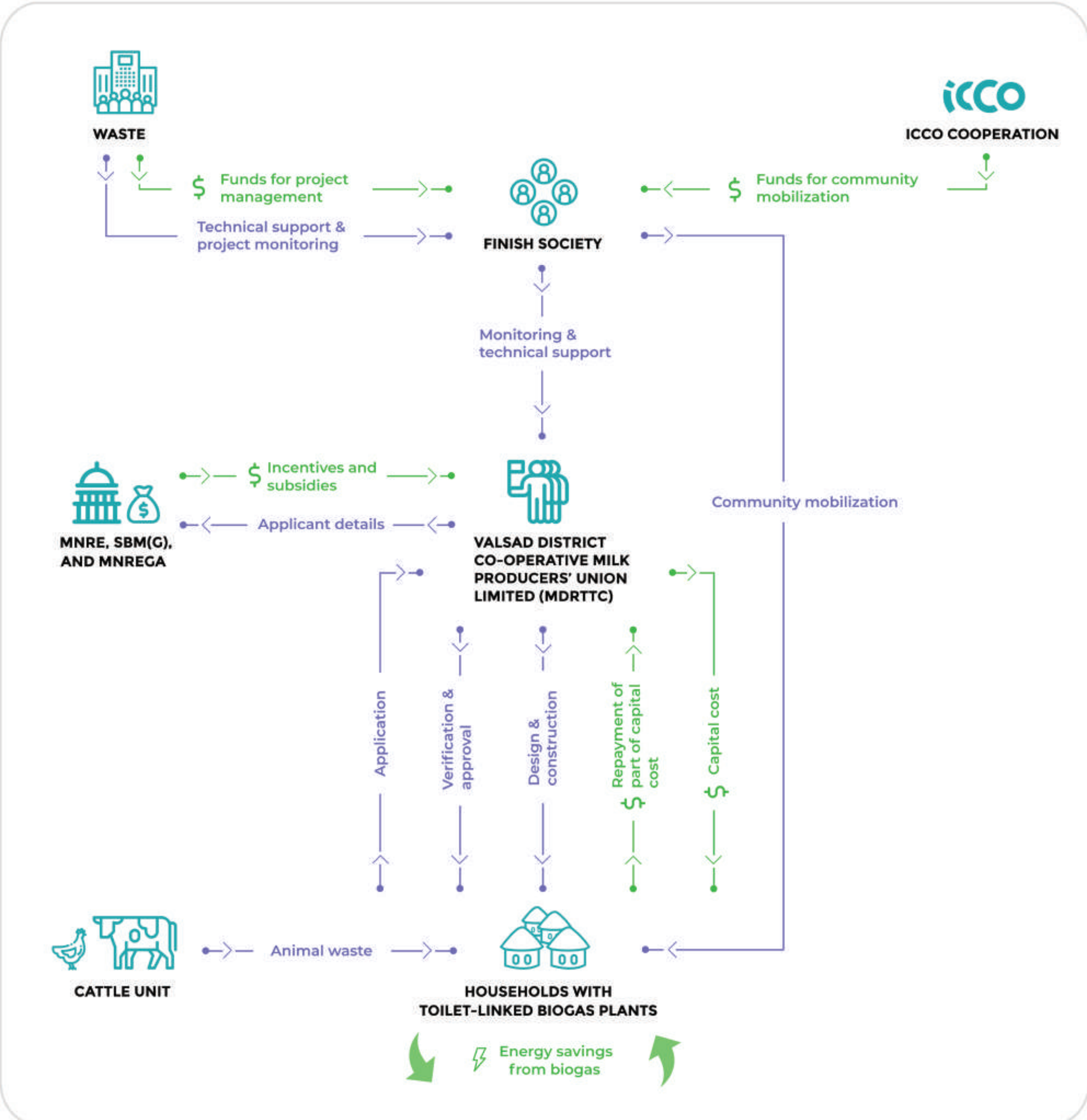
In 2009, the Dutch-funded program Financial Inclusion Improves Sanitation and Health (FINISH) Society was established by an Indian-Dutch consortium led by WASTE, TATA-AIG, SNS-REAAL, and UNU-MERIT with the aim of achieving universal sanitation. FINISH Society, an NGO, was created to enable the program to run independently in India once programmatic support was withdrawn, to continue to improve quality of life through the provision of safe sanitation (Sustainable Sanitation Alliance 2019). FINISH Society worked in Valsad District, Gujarat to improve toilet access. The region had many dairy farmers and therefore good potential for biogas. ICCO Cooperation (ICCO), a Dutch NGO with interest in biogas, provided funds for household biogas plants to WASTE. WASTE, ICCO, and FINISH Society partnered to implement Toilet-linked Biogas Plants (TLBP).

Key indicators (as of 2017)	
Installed capacity	2 m^3
Allocated land area	0.0032 acres
Labor requirements	None (household members maintain the systems)
Inputs	Raw FS – 50 L/day; cow dung – 25 kg/day ; agricultural waste
Outputs	~1.2 m^3 of biogas/day

Case description

FINISH Society was the implementing organization responsible for networking with local partners, supervising TLBP construction, community mobilization, monitoring, and communication with investors and all the partners. WASTE, a Dutch NGO, provided partial funding for the project management costs, as well as technical support for the FINISH Society. The relationships among the various stakeholders in the value chain are depicted in Figure 32. While ICCO provided funding for the project, existing subsidies from the MNRE, Swachh Bharat Mission-Gramin (SBM-G), the MNREGA, and fixed financial support from the Gujarat state government, were accessed for the capital cost of the TLBPs. To access the subsidy from the MNRE, FINISH Society engaged with a state nodal agency – Valsad District Cooperative Milk Producers' Union Limited. The cooperative had a strong network of dairy farmers and thus households with cattle;

FIGURE 32. VALUE CHAIN OF THE VALSAD HOUSEHOLD TOILET-LINKED BIOGAS PLANT MODEL.



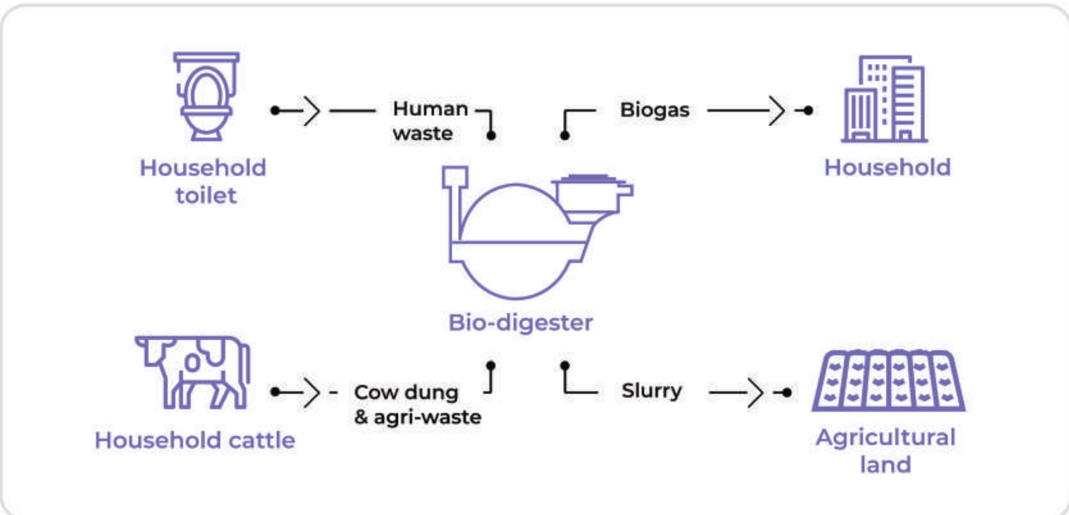
households with TLBP had two to nine cattle. The cooperative's technical and research arm, MDRTTC, worked with FINISH Society on community mobilization, aggregated demand for TLBP at the dairy, and submitted the subsidy applications to the state government. Initially, MDRTTC played a critical financing role by constructing TLBP upfront for interested households and directly received the government subsidy. However, once the government policy changed to transferring the subsidy directly to individual beneficiaries' accounts, households were responsible for financing and constructing TLBPs and subsequently received the subsidies. The major by-products of the TLBP are biogas and slurry. Biogas is used by the households for cooking or heating water, and slurry is used in farms as fertilizer.

There was resistance from the communities to connect their toilets to bio-digesters and use the gas for cooking. The people who considered cooking with biogas from FS as a taboo, as well as the households requiring biogas for cooking, were often from the lower economic groups; thus, the economic advantages of TLBPs were a primary factor in generating social acceptance and needed to be demonstrated. In relation to this, two research studies were undertaken by WASTE and UNESCO-IHE to change the community's perspective: 1) The first study demonstrated that a TLBP produced 25% to 30% more biogas than cow dung fed bio-digesters (Jha 2014); and 2) The second study showed that slurry from a TLBP had no pathogens and resulted in higher crop yields (Jha 2017).

Technology and processes

After construction, bio-digesters, typically 2 m^3, are connected to household toilets. Human waste from the toilet and cow dung/agricultural waste are fed to the plants. The technology process is shown in Figure 33. A prefabricated steel mold was made to construct bio-digesters using reinforced cement concrete; this helped to reduce labor and construction time (Post et al. 2014). The technology is simple, requires minimal maintenance, is easy for the household to operate, and generates biogas for use as cooking gas and a high-nutrient soil ameliorant for application in agriculture.

FIGURE 33. TECHNOLOGY PROCESS OF THE VALSAD HOUSEHOLD TOILET-LINKED BIOGAS PLANT.



Source: FINISH Society.

Funding and financial outlook

The funding for project development and management was covered by ICCO and WASTE. MDRTTC contributed to the technical innovation cost and investment in the prefabricated steel mold for the bio-digester to the amount of INR 1,020,000.

The capital cost of the TLBPs was covered through a combination of government subsidies and direct finance by the households in the form of labor and materials. SBM-G (previously Nirmal Bharat Abhiyan) provided the toilet subsidy, along with labor provided by MNREGA (in cases where the dairy cooperative was able to access MNREGA support for its members), and the MNRE provided the biogas subsidy. The dairy cooperative provided an interest-free loan initially when it could receive subsidies directly and collected the gap amount not covered by the government subsidies through its payments due for the milk sold by the households (Post et al. 2014). The capital cost breakdown for the TLBP system is give in Table 8.

TABLE 8. CAPITAL COST BREAKDOWN OF THE VALSAD HOUSEHOLD TOILET-LINKED BIOGAS PLANT MODEL.

Items	Cost in INR*
Biogas subsidy (average amount from central and state governments)	14,000
Toilet subsidy (SBM + MNREGA)	9,100
Interest-free loan (MDRTTC)	4,000
Household contribution (labor and materials)	4,900
Total Capital Cost	**32,000**

Source: Post et al. 2014.
*USD 1.00 = INR 61.01 in 2014.

Seven hundred and thirty-one TLBPs were installed under the project, at an average cost of INR 32,000 per unit. An additional 1,914 biogas units were installed with provision for connection to the toilets. The remaining households, if and when interested, could directly connect their toilets to biogas plants. The O&M cost was negligible and borne by the households. The biogas resulted in fuel savings of INR 800 to 900 per month per household compared to using LPG. Households already having piped LPG connections opted to get disconnected after installing TLBPs, as LPG was no longer needed. Some of the households were able to reduce usage of urea by up to 50% by applying slurry in their fields (Jha 2017). Demonstration of higher yields and quality of different crops using biogas plant slurry instead of urea and other fertilizers helped farmers to accept the technology at a larger scale.

Despite the benefits to households, the initiative had to be curtailed due to the shift in government policy regarding subsidies and challenges faced by the dairy cooperative in collecting money lent to the households for construction of TLBPs.

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8. Models for Emptying and Transport of Fecal Sludge

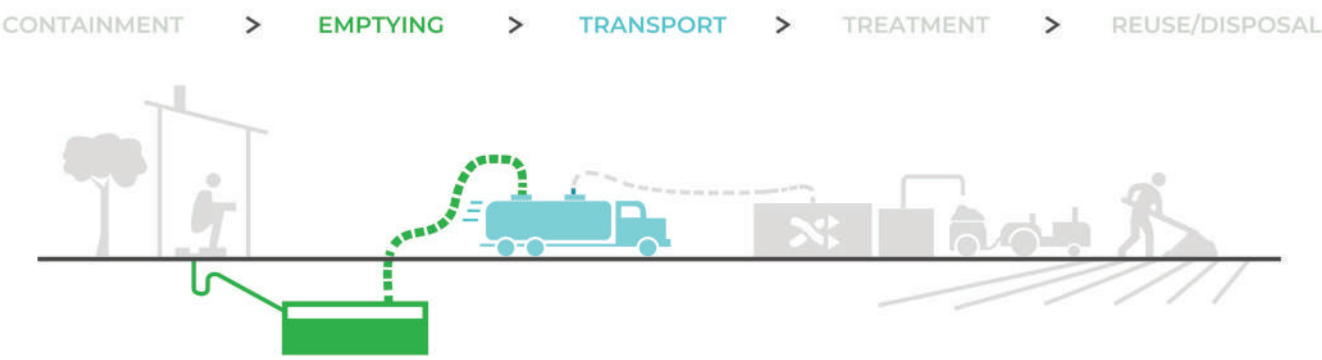
Business models in this section cover the E&T component in the sanitation value chain. The public sector is typically responsible for providing sanitation services. However, a wide variation is observed in practice with municipalities being sole service provider, a thriving private services market, or even a combination of both. The E&T models offer the following value propositions:

1. Timely and safe emptying of OSS in households, businesses, and institutions
2. Safe transportation of FS to designated disposal sites

The models covered focus on provision of timely, affordable desludging services for OSS users while enabling the municipality to regulate E&T services to ensure the safety of public health and the environment. They also improve the business environment for increased private sector participation in sanitation. The models are applicable in municipalities without sewer networks and where there is a demand for E&T services.

The following business models are explained in this section:

1. Government-owned E&T
2. Privately-owned and operated E&T
    a. E&T licensing
    b. Call center
    c. Desludging association



8.1 Business Model: Government-owned E&T

8.1.1 Value proposition

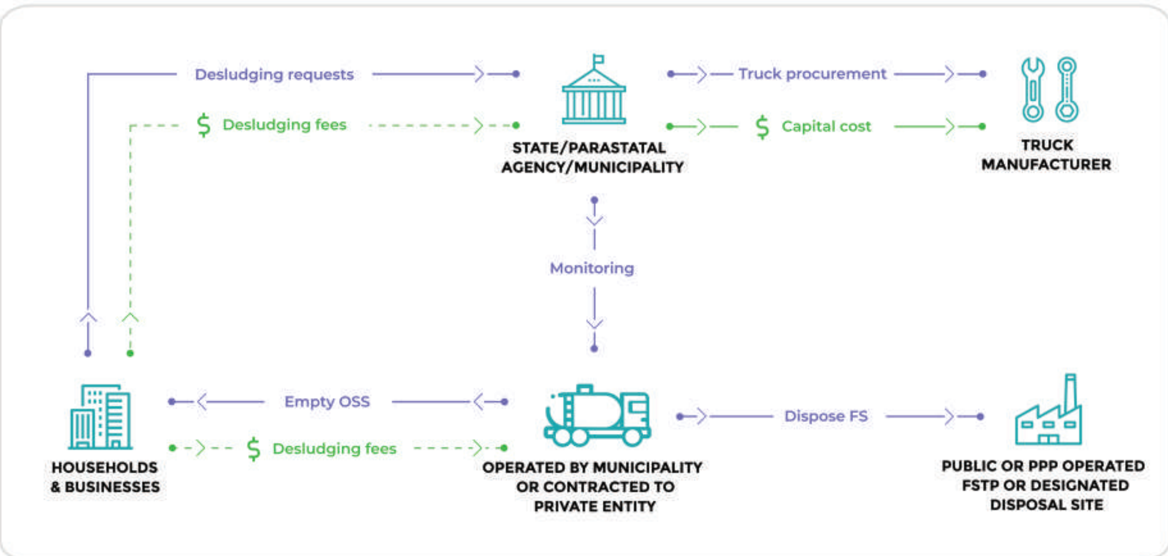
The model focuses on the E&T component in the sanitation value chain and offers the value proposition of safe E&T of FS from OSS to designated disposal sites.

8.1.2 Description

The model is driven by market failure of private entities to provide desludging services in a municipality owing to insufficient demand for E&T services to ensure business viability. In this model, desludging vehicles are procured by the municipality, which can undertake desludging operations or outsource operations to a private entity. OSS users submit desludging requests to the municipality and pay desludging fees in advance if the municipality operates the business. When the private entity operates the business, desludging requests are submitted either to the municipality or the private entity. The municipality is expected to operate a toll-free number or a call center to register desludging requests and customer grievances. FS collected from households and businesses is transported to the FSTP or designated disposal site. In the case of a private entity operating the trucks, the municipality must monitor operations and ensure the safety of public health and the environment by verifying that the private entity is following standard operating protocols and disposing FS at designated sites. It is highly recommended that the private entity is made to collect desludging fees from the households instead of the municipality. The relationships among the various stakeholders in the business model are shown in Figure 34.

Owner and operator: The business model is implemented by the government or through a PPP. The municipality is the owner of the desludging vehicles. In the case of a PPP, the municipality enters into a service contract with the private entity for desludging operations.

FIGURE 34. VALUE CHAIN OF THE GOVERNMENT-OWNED E&T BUSINESS MODEL.



8.1.3 Funding and financing

Capital cost: Desludging vehicles are procured by the municipality from state or national government programs for improving urban infrastructure or municipality funds, if available.

Operating cost: If the municipality is the desludging operator, the municipality finances the operating cost through collection of desludging fees.

If the private entity is the desludging operator, the municipality pays the operator based on the bid price submitted on a per trip basis and number of service requests undertaken on a monthly basis; fines are levied for not following safety and operation protocols. The private entity is paid based on the number of trips made to the designated disposal site and submission of disposal forms signed by the municipality's desludging request center operator, OSS user, and designated disposal site operator. The municipality should ensure a guaranteed minimum number of trips on a monthly basis for the private operator.

The fundamental dilemma in a government operated truck is that of pricing for services. Should the price be aimed at full cost recovery, or should it be aimed at being affordable for all? The former choice may make the service unaffordable for poor families, and the latter will add to the financial burden on the local government. There are not enough data to make rational pricing decisions yet, but differentiated pricing by locality or size of dwelling offers better pricing options.

8.1.4 Risks and benefits

Risks

- Unable to provide desludging services in a timely manner, especially if the end beneficiary has to make the payment first
- In small towns with low demand for desludging, asset utilization can be low

Benefits

- Preventing manual E&T where private sector desludging is absent
- The government can ensure equity in terms of service provision and fees charged, especially to poor households

8.1.5 Relevance

High applicability for small towns where private entities are non-existent in the desludging sector due to low demand for desludging or lack of access to finance for investing in desludging vehicles. To make this business model inclusive, a differentiated tariff structure should be implemented for desludging fees based on location or other suitable parameters to make desludging affordable for the poor. The following case study is explained in this section:

- Odisha Government-owned E&T, Odisha

Related models from other countries have been reported, e.g., in Dhaka, Bangladesh.

CASE STUDY

Odisha Government-owned E&T

Location	Odisha
Value offered	Safe emptying and transport of FS
Organization type and name	Government – municipalities; Private – private desludging operators
Project status	Operational since 2017
Major partners	Housing & Urban Development Department (H&UDD), Government of Odisha Odisha Water Supply & Sewerage Board (OWSSB) Ernst & Young – as the TSU funded by the BMGF
Financing entities and revenue source	***Capital cost:*** Government of Odisha ***Operating cost:*** User fees and/or municipality

Context and background

In Odisha, 53% of urban households rely on OSS. Until 2016, only 2% of FS was safely treated and disposed of (Nayak 2016). In order to address FSM in the state, the Government of Odisha published the Odisha Urban Septage Management Guidelines & Regulations 2016 and Odisha Urban Sanitation Policy 2017 (Panda 2018; Government of Odisha 2016, 2018). The regulations provide specifications for safe E&T of FS. Based on the policy, the Government of Odisha allocated 86 desludging trucks to 56 municipalities. These trucks were procured by the OWSSB and allotted to municipalities based on population and demand for desludging. In 40 out of the 56 towns and cities, the municipality manages desludging operations. In the remaining 16, the municipality has outsourced desludging to private operators. Since 2017, Ernst & Young, an international consulting firm, has set up a TSU on FSM within the Government of Odisha, with funding from the BMGF, to support the state government, OWSSB, and municipalities in FSM implementation.

Case description

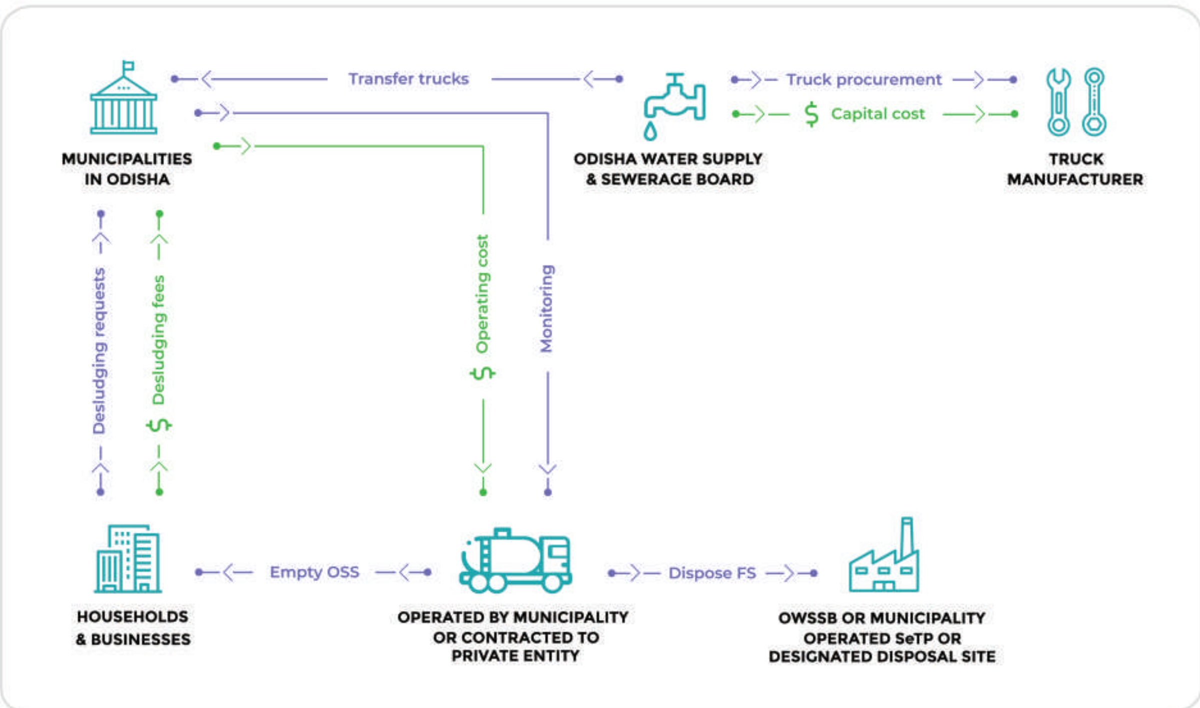
The Government of Odisha is the primary driver for ensuring safe E&T of FS by allocating funds for procuring desludging trucks. The OWSSB is the agency responsible for implementing the sanitation policy in Odisha and procures desludging trucks and allots them to the selected municipalities. TPS Infrastructure Limited, a private enterprise, was selected to provide desludging trucks and truck maintenance for three years. The municipalities have a mandate from the Government of Odisha to contract desludging operations to private entities, but due to lack of participation in the bids, many municipalities are operating the vehicles. While some of the municipalities have managed to contract new trucks to private entities, they still continue to operate old desludging vehicles. An OSS user requiring desludging submits a request at the municipal office and pays for the desludging fee in advance. Based on this request, the municipality provides the desludging service, and the FS is transported to a Septage Treatment Plant (SeTP) or designated disposal point.

In municipalities where desludging operations are contracted to a private entity, the municipality and service provider sign a 7-year service contract. The private entity must provide service for 28 days per month and carry out a minimum number of daily trips (six trips per vehicle) or number of applications received whichever is lower. The private entity is required to maintain the truck. The operator is penalized if it does not meet the performance targets, provide desludging service within three days of service request and respond within 48 hours to attend to redressal of any complaint. The operator is required to deposit fines as calculated by the authority at the end of every month within the first seven days of the following month. The private entity is required to install a Global Positioning System (GPS) device on all the trucks, follow the municipality's reporting structure, adhere to guidelines on desludging and wearing protective gear, and have the vehicle inspected and certified on a quarterly basis (Puri Municipality 2017a, 2017b; Berhampur Municipality 2017a, 2017b; Balasore Municipality 2017; Baripada Municipality 2017).

The municipality fixes desludging rates (INR 700 to 1,000 per trip), coordinates with the private operator regarding desludging scheduling, and monitors the operations. OSS users must go to the municipal office to submit desludging requests. Some municipalities have also started accepting requests via telephone. Desludging services are provided during working hours; hence, it typically takes 2 to 3 days to provide the service once the request is submitted. Municipalities are required to set up a desludging call center or a web-based platform to process customer requests and complaints. Since some of the municipalities have old desludging vehicles, they operate them only after the private entity has undertaken the required minimum number of daily trips according to the contract (Ernst & Young 2017a-2017i).

In most cases, the municipality collects desludging fees, transfers the fees to an escrow account, and makes monthly payments to the private operator based on the number of trips completed. Alternately, the private operator directly collects desludging fees from the customers. Municipalities have also established call centers for desludging services and undertake programs for motivating private desludging operators to transport FS to the SeTPs, where available. The relationships among the various stakeholders are depicted in Figure 35.

FIGURE 35. VALUE CHAIN OF THE ODISHA GOVERNMENT-OWNED E&T MODEL.



Technology and processes

The municipalities have each been allocated one or more 3 m^3 desludging trucks. The older vehicles owned by the municipalities are tractor-mounted vehicles mostly used for narrow lanes and inaccessible pits/tanks. A new fleet of smaller vehicles is being procured. Trials have been conducted in Baripada municipality with double boosting pumps to increase the desludging distance for the 3 m^3 desludging truck.

Funding and financial outlook

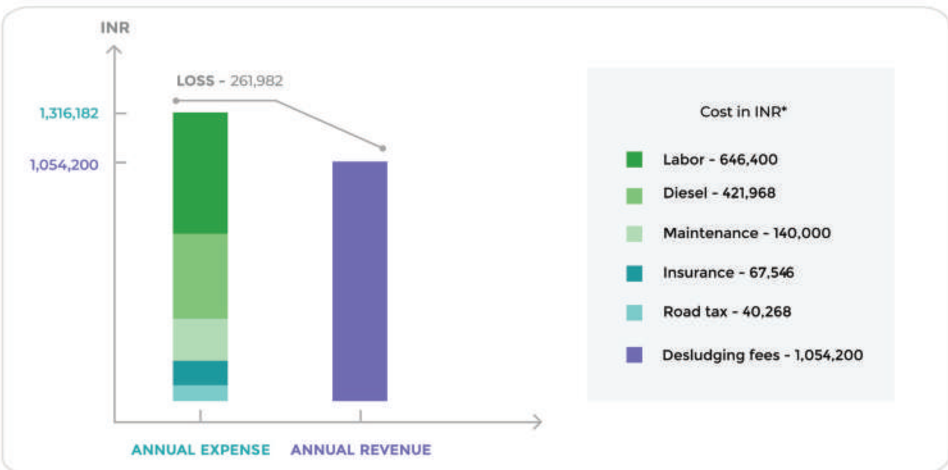
The capital cost of the new trucks is funded by the Government of Odisha. In the case of municipality-operated trucks, the municipality does not always hire dedicated desludging staff and sometimes uses workers involved in other departments, such as solid waste management, to operate desludging trucks when required. When they do hire dedicated staff, the bulk of the O&M expenditure goes towards labor and fuel for the vehicle. Figure 36 provides the annual financial details estimated for each truck in Bhadrak, a town with three municipal desludging trucks and desludging fees of INR 900 per trip for the first desludging, and INR 700 for the second (Eawag and Sandec 2018, 2019).

In the case of municipalities that have contracted desludging trucks to private entities, the desludging fees are fixed by the municipalities – INR 750 to 1,000 per trip. The operators must complete at least three trips per day to achieve break-even of operational costs. In certain cases, operators have also invested in public awareness campaigns on mechanized emptying in order to increase the number of trips.

Private entities are unwilling to bid for the contract in smaller towns (below 100,000 population) where the number of trips per day is limited. Most municipalities with new desludging trucks are yet to contract operations to private entities. A few private entities are submitting bids as a secondary business since they have existing contracts with the municipality in another domain, such as solid waste management. However, the introduction of the Faecal Sludge and Septage Management Regulations, 2018 in Bhubaneswar could provide the regulatory push needed to increase desludging services and perhaps enhance the attractiveness of this business to private operators, as the regulations mandate desludging every 3 or 5 years for all septic tanks (Bhubaneswar Municipal Corporation 2018). The government is also exploring how to engage local SHGs to streamline services because they have lower overheads and therefore can operate at low margins. SHGs also have the advantage of better understanding of local areas and the local community.

The governments of Karnataka and Maharashtra have models similar to that of Odisha to outsource municipal desludging operations to private entities.

FIGURE 36. FINANCIAL OVERVIEW OF THE GOVERNMENT-OWNED AND OPERATED DESLUDGING MODEL IN BHADRAK.



Source: Ernst & Young.
* USD 1.00 = INR 71.30 in September 2019.

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8.2 Business Model: Privately-owned and Operated E&T

8.2.1 Value proposition

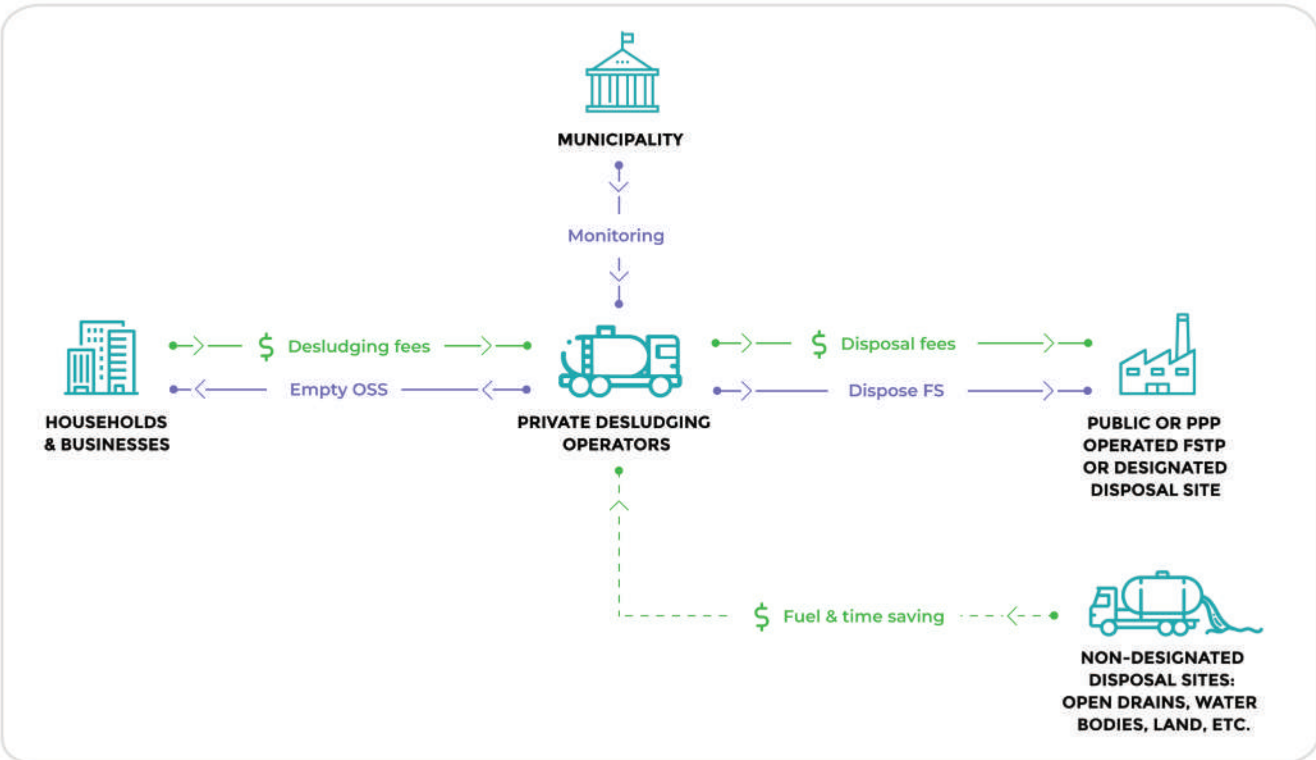
The model focuses on the E&T component in the sanitation value chain led by privately-owned E&T operators. It offers the value proposition of timely E&T of FS for OSS users.

8.2.2 Description

This is a market-driven business model. OSS users engage the services of the private entity, which markets its services through word of mouth, local plumbers funnelling orders for a commission, and bills/stickers on electric poles with telephone numbers. FS collected from OSS is transported to a disposal point – a municipality-designated point, vacant or agricultural land, or the nearest canal or waterbody. The private entity charges desludging fees to the customer, which are based on market pricing and the containment system (type, number of trips required to empty it, length of pipe required to desludge it and distance from the disposal point). The relationships among the various stakeholders in the business model are shown in Figure 37. Typically, the municipality's monitoring function is weak or entirely lacking.

Owner and operator: The owner and operator of the desludging vehicles is the private entity.

FIGURE 37. VALUE CHAIN OF THE PRIVATELY-OWNED AND OPERATED E&T BUSINESS MODEL.



8.2.3 Funding and financing

Capital cost: The private entity finances it through personal financial resources, a personal loan from a friend, family member, or moneylender, and/or a formal loan from a local bank.

Operating cost: The desludging fees charged to the households and the minimum number of households serviced monthly should cover the operating cost.

8.2.4 Risks and benefits

Risks

- In the absence of effective monitoring, the health and safety of workers and proper disposal of FS at designated sites may not be ensured
- Desludging fees can be unaffordable for poor households
- Service maybe refused for OSS with access issues

Benefits

- No capital and operational expenditure by the government
- Timely and improved service provision to households

8.2.5 Relevance

Applicable for towns with sufficient demand for desludging. This is the most common model across the country, which has evolved organically in response to local conditions. As such, the model suffers from several inefficiencies as already discussed above – informal service providers, ineffective marketing, and poor customer experience. A few variations on this business model are now being attempted by the municipality and the operators themselves. However, each of these variations leads to market distortions with possible undesirable consequences. In addition, none of the variations by themselves address the primary concern of universal and inclusive service coverage and hence require specific actions to ensure the same. The report explains following variations of the model along with measures to ensure inclusivity in this section:

1. E&T licensing
2. Call center
3. Desludging association

Internationally, related models have been reported across Asia and Africa.

8.2a Business Model: E&T Licensing

8.2a.1 Value proposition

The model focuses on the E&T component in the sanitation value chain. It offers the following value propositions:

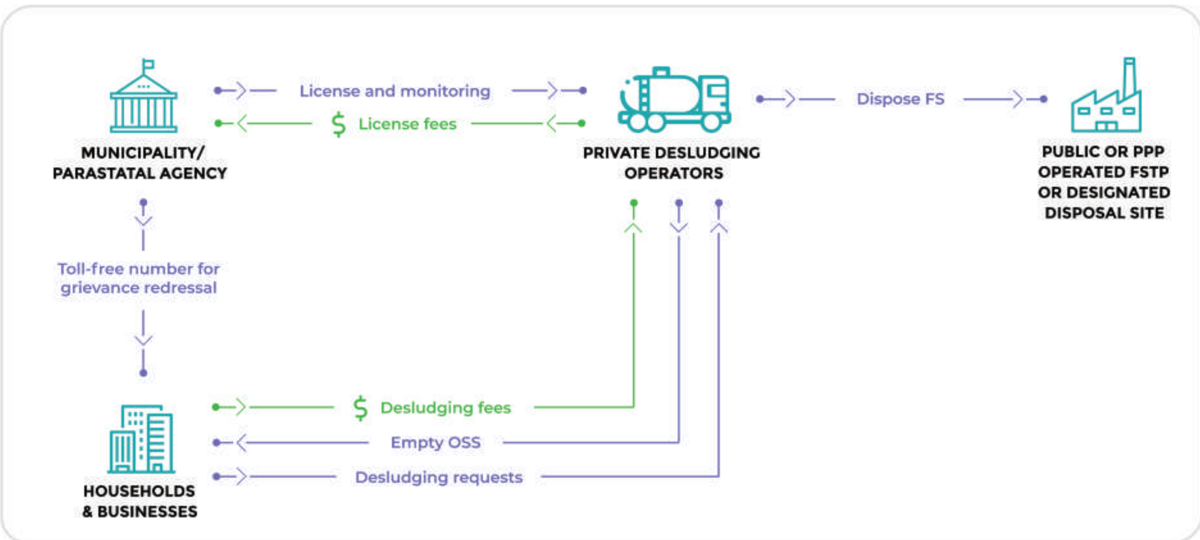
- *Timely and safe emptying of OSS in households, businesses and institutions*
- *Safe transportation of FS to designated disposal sites*

8.2a.2 Description

The private desludging operators, who largely operate without any regulations and on an informal basis, are formalized through provision of licenses by the municipality or parastatal agency to operate their businesses. The municipality/parastatal agency prescribes criteria such as a valid driving license, vehicle fitness certification, GPS installation, use of PPE, and so forth for the private desludging operator to be eligible to receive the license. The private operator is required to pay a stipulated amount as license fees to obtain the permit. Typically, the license requires periodic renewal. The operator may be required to obtain the license to operate the business and/or to drive the desludging vehicle. The operator is required to display the E&T license number on the vehicle.

The municipality/parastatal agency can regulate desludging tariffs, especially for poor families, and advise OSS users to only avail of desludging services from licensed operators. The municipality/parastatal agency must establish grievance redressal centers for customer feedback. It is the responsibility of the municipality/parastatal agency to monitor compliance of desludging standards and protocols by licensed operators. If an operator violates any regulations, fines or penalties may be levied or the license may be revoked. The relationships between the various stakeholders in the business model are shown in Figure 38.

FIGURE 38. VALUE CHAIN OF THE E&T LICENSING BUSINESS MODEL.



A licensing model is an intrusion into a free market scenario and can potentially create barriers to entry for smaller or new operators. Licensing norms should account for current capacities of private operators and gradually move towards desired benchmarks. The licensing fee should only offset basic costs of

administering the license. Licensing should be seen by municipalities as an enabler for improved service provision, thereby leading to further investment in building capacities of the private operators.

Owner and operator: The municipality/parastatal agency is responsible for issuing licenses to private desludging operators. Desludging vehicles are owned and operated by private entities.

8.2a.3 Funding and financing

Capital cost: There is no capital cost associated with the licensing model, except that suitable tools and equipment, along with PPE, as prescribed by the licensing agency, must be procured and financed by the desludging operators.

Operating cost: The private desludging operators recover their operational costs through the collection of desludging fees and by serving a minimum number of households on a monthly basis. The license fees collected by the municipality or parastatal agency should only be used to recover the associated costs.

8.2a.4 Risks and benefits

Risks

- In the absence of effective monitoring, the health and safety of workers and disposal of FS at designated sites may not be ensured
- Licensing norms and fee can become barriers to entry for small or new entrepreneurs if not designed judiciously

Benefits

- Provides a legal umbrella for desludging operators and hence prevents harassment from police and society
- Ensures equipment and service standards
- The municipality can regulate pricing to ensure services reach every household

8.2a.5 Relevance

Applicable for all towns where a private entity provides desludging services. To make this business model inclusive, the licensing process should allow for dialogue between the municipality and service providers. This participatory process can enable more intrusive measures, such as regulated pricing or tariffs. While these measures deviate from the market driven origins of this business model, they enable universal FSM service coverage, which may not be an objective shared by private operators earlier. The report covers following case studies:

- Warangal Desludging Licensing, Warangal, Telangana (explained in this section)
- Karunguzhi-Madurantakam Cluster FSTP, Karunguzhi, Tamil Nadu
- Kochi Associations of Desludging Operators, Kochi, Kerala
- Odisha Government-owned E&T, Odisha
- Sewage Pumping Stations and Open Drain as FS Transfer Stations, Delhi, Tamil Nadu, & Uttar Pradesh
- Wai Scheduled Desludging & Sanitation Tax, Wai, Maharashtra

Related models from other countries have been reported, e.g., in Dakar, Senegal; Kumasi, Ghana; and Nairobi, Mombasa, and Kisumu, Kenya.

CASE STUDY

Warangal Desludging Licensing, Telangana

Location	Warangal, Telangana
Value offered	Safe collection and transport of FS to FSTPs
Organization type and name	Government – Greater Warangal Municipal Corporation (GWMC) Private – desludging operators
Project status	Licensing underway since 2016
Major partners	Administrative Staff College of India (ASCI), BMGF
Financing entities and revenue source	***Capital cost:*** Private desludging operator ***Operating cost:*** User fees

Context and background

In 2015, the GWMC, with support from the ASCI, conducted a diagnostic study on FSM. The study was funded by the BMGF to understand key areas for improvement and to develop an FSM action plan. The study led to the city taking several initiatives to address gaps in FSM. Notably, in March 2016, Warangal became the first city in the country to issue FSM regulations and septage management guidelines. One of the key aspects of the regulations mandated licensing of private desludging operators and tracking of FS disposal, as there were many private E&T businesses operating in the city. This led the ASCI and GWMC to form a partnership to implement the new FSM regulations in Warangal (Chary et al. 2017).

Case description

The goal of licensing private desludging operators and tracking FS disposal is to ensure safe E&T of FS to protect public health and the environment. With no designated disposal sites, only safe emptying of OSS could be ensured initially. However, since the commissioning of the Warangal FSTP in November 2017, licensed desludging operators can safely transport and dispose of FS. The GWMC has established the FSM Non-sewered Sanitation (NSS) cell, a TSU within the municipality headed by the Municipal Commissioner, to monitor FSM in the city.

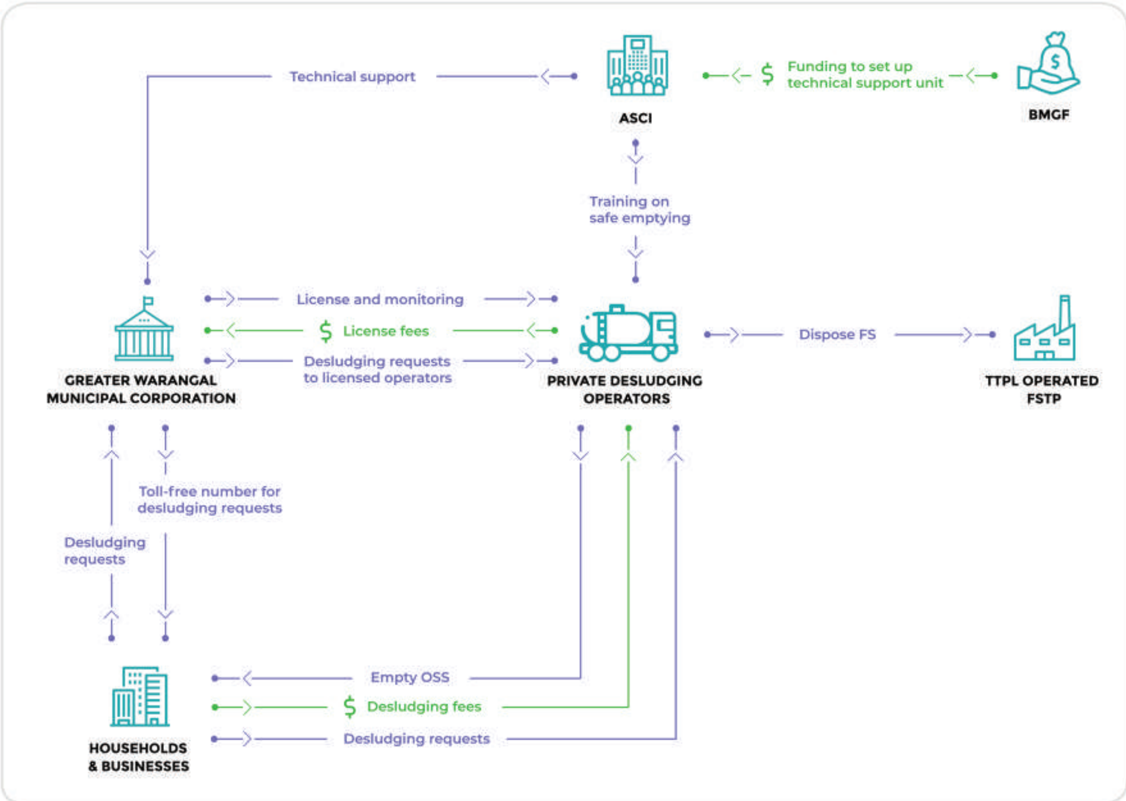
As a key step to operationalize the regulations, the GWMC initiated licensing of private operators, with annual renewal required. To obtain the license, private operators must ensure the following:

- Vehicles meet the approved standards
- Workers are equipped with uniforms and required PPE and tools
- GPS devices are installed on their vehicles

The NSS cell tracks the GPS data in real time to make sure desludged FS is disposed of at the FSTP. GWMC maintains a list of licensed operators on its website

to provide customers ease of access to information and has a toll-free number for sanitation queries from citizens. Any desludging request submitted to the GWMC is passed on to licensed operators. The ASCI also provided training to desludging operators on desludging standards and procedures, including usage of PPE. The private operators are required to inform the GWMC about every desludging undertaken through the FSM tracker mobile application developed by the ASCI. The GWMC has plans to implement scheduled desludging soon, and there is strong interest amongst the operators, as they expect it to improve their businesses (Chary et al. 2017). The relationships between the various stakeholders are depicted in Figure 39. Box 4 presents the licensing model implemented by Delhi Jal Board (DJB).

FIGURE 39. VALUE CHAIN OF THE WARANGAL DESLUDGING LICENSING MODEL.



Technology and processes

There are nine licensed private desludging operators in Warangal, with a total of 14 vehicles of 3 m^3 to 7 m^3 capacity. On average, each of these vehicles makes around three to four desludging trips every day, travelling around 15 km per trip. The operators are required to enter the following information into the FSM tracker mobile application every time they provide a desludging service: type and age of the septic tank, quantity of septage, user charges collected, and any accidents/spillage.

Funding and financial outlook

The cost of implementing FSM regulations in Warangal is borne by the GWMC, with support from the ASCI through a BMGF grant. The GWMC does not charge fees to issue licenses to private operators. The operators must incur the cost of GPS installation, uniforms, and PPE to meet the requirements for obtaining the license – approximately INR 7,812[5] for GPS installation and INR 5,000 per vehicle per year[6] for uniforms and PPE (Chary et al. 2017).

[5] USD 1.00 = INR 65.10 in 2017.

[6] USD 1.00 = INR 71.25 as of October 2019.

BOX 4. LICENSING OF DESLUDGING OPERATORS IN DELHI.

In 2015, the DJB, responsible for water supply and wastewater treatment in Delhi, issued septage management regulations. The regulations mandated licensing of private desludging operators and specified 106 sewage pumping stations (SPS) within its sewerage network to serve as decanting points for licensed desludging vehicles (Delhi Jal Board 2015). In late 2018, the DJB issued a public notice inviting private desludging operators to apply for licenses. In order to obtain a license, each desludging operator must pay a registration fee of INR 1,000, along with a bank guarantee deposit of INR 10,000 per vehicle[7]. As of May 2019, 150 private desludging operators had registered with the DJB (Baruah 2019). The licensed operators transport FS to the designated SPS, where the SPS operator checks the desludging operator's bank guarantee slip or license. The operator must record details on the FS load and the source in a prescribed format, which will be reviewed and signed by the SPS operator.

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[7] USD 1.00 = INR 69.77 in May 2019.

8.2b **Business Model: Call Center**

8.2b.1 Value proposition

The model focuses on the E&T component in the sanitation value chain. It offers the following value propositions:

- *Timely and safe emptying of OSS in households, businesses, and institutions at the lowest cost and highest quality*
- *Safe transportation of FS to designated disposal sites*

8.2b.2 Description

The model involves leveraging networks by creating a network of peers – in this case, private desludging operators. A call center is established to connect OSS users with private desludging operators and acts as a network orchestrator. Private operators register with the call center for a fixed annual fee or a percentage of desludging fees for every desludging request. Payment can be made by households to the call center or to the desludging operator directly. If payment is made to the call center, it keeps part of the revenue and transfers the remainder to the operator. If payment is made to the desludging operator, the operator keeps part of the revenue and gives the remainder to the call center. The entity in charge of operating the call center is responsible for marketing the services and maximizing the number of requests from OSS users.

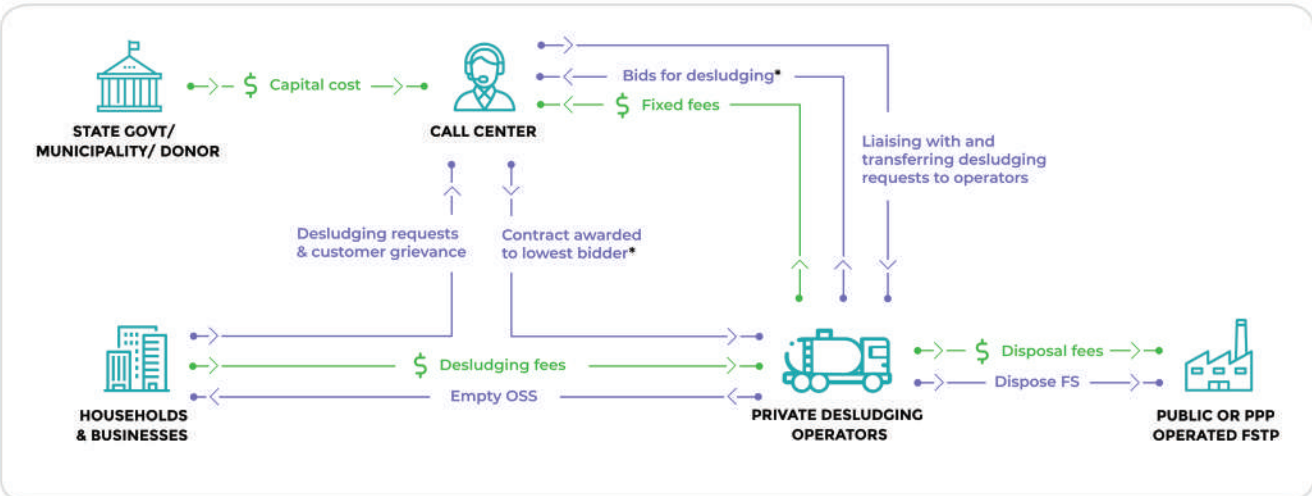
OSS users approach the call center for desludging. It allocates the request to operators using one of the following methods:

1. A price bidding process for E&T services is initiated through a mobile application, and the lowest bidder wins the contract.

2. Alternatively, desludging requests are allocated to operators on a rotational basis or based on the operator closest to the customer. In this case, the desludging pricing is fixed by the call center.

The relationships among the various stakeholders are shown in Figure 40.

FIGURE 40. VALUE CHAIN OF THE CALL CENTER BUSINESS MODEL.



* Payment models based on fixed tariffs by locality can also be implemented

The call center should be equipped with a robust web-based platform or smartphone application to effectively manage the operators and customers. For a price-bidding process, the call center staff should be well-trained to ask precise questions about the OSS, such as location, type, size, road width and desludging accessibility, date of last desludging, etc. This information is critical and should be provided to the operators so as to determine the appropriate bid price. If requests are allocated based on operator proximity to the customer, GPS tagging is needed to identify the closest operators to the customer. GPS tagging can help the municipality track operators and ensure they transport FS to the designated disposal point. The call center should seek customer feedback as a way to monitor E&T service quality. If the desludging protocols are not followed, the call center can direct the municipality to penalize the operator. It is evident that a call center model assumes registration and licensing in some form, and hence is an enhancement of the licensing business model.

A call center eases the customer experience by removing the need to interview multiple operators and negotiate prices. For emptying operators, it broadens the market and hence stabilizes demand while removing their marketing burden. In a business where marketing involves publicizing a phone number, call centers have a distinct advantage. On the other hand, call centers have to manage the competing interests of several private operators. How do operators decide to add a new truck? How does the call center ensure trust among its registered members? Their success lies in being able manage their members' business interests.

Recently, online business listing websites are providing part of the benefits of a call center, i.e., access to service providers. Price negotiation and risk of service quality still remain challenges with online listings, but the operators can make independent business decisions. It will be interesting to see which of these alternatives gains more traction in the long run.

Owner and operator: The business model can be implemented by a public or private entity; however, for the latter, the private entity needs to closely engage with the municipality. The entity operating the call center enters into a service contract with the private desludging operators. The desludging operators are the owners and operators of their respective desludging businesses.

8.2b.3 Funding and financing

Capital cost: The capital cost of the call center can be covered by grants from donors or local government funds. The desludging vehicles are self-financed by the private desludging operators.

Operating cost: The entity operating the call center typically finances the operating cost of the center through collection of annual registration fees from desludging operators and/or a percentage of desludging fees. The call center can collect its fees through the following mechanisms:

- The call center collects desludging fees directly from customers, keeps a fixed commission for each request, and pays the desludging operators a set fee after disposal of FS at a designated point. This method can ensure ease of monitoring of desludging operators and penalize them for violating desludging protocols.

- The private operator collects desludging fees from customers and pays a fixed amount to the call center for each trip to the designated disposal point.

8.2b.4 Risks and benefits

Risks

- Cost recovery of the call center operations is unlikely and hence dependent on funds from the municipality for operations

Benefits

- Convenience to end-users, leading to a reduced chance of them opting for manual E&T services instead
- Can reduce the cost of the desludging service to the end-beneficiary based on competitive bidding or through pricing regulation by the municipality
- Efficiency of monitoring is increased for the municipality due to direct customer feedback and tracking of FS disposal at designated sites/FSTPs

8.2b.5 Relevance

A fully functional call center with price bidding is applicable for towns/regions with at least 500,000 OSS users and multiple private entities providing desludging services. Limited functionality call centers can be adopted in smaller towns. This business model requires specific interventions to ensure inclusive and universal coverage. Call centers have to be able to respond to customers that have limited ability to pay. Differential pricing or discounts for such customers based on location or other distinctly identifiable parameters must be introduced. The report covers following case studies:

- Patna Desludging Call Centre, Patna, Bihar (explained in this section)
- Karunguzhi-Maduranthagam Cluster FSTP, Karunguzhi, Tamil Nadu
- Wai Scheduled Desludging & Sanitation Tax, Wai, Maharashtra
- Warangal Desludging Licensing, Warangal, Telangana
- Odisha Government-owned E&T, Odisha

Related models from other countries have been reported, e.g., in Dakar, Senegal and Kampala, Uganda.

CASE STUDY

Patna Desludging Call Center, Bihar

Location	Patna, Bihar
Value offered	Safe emptying and transport of FS
Organization type and name	NGO – Population Services International (PSI) India
Project status	Operational since 2017
Major partners	Bihar Rajya Tankers Association, BMGF
Financing entities and revenue source	***Capital cost:*** BMGF ***Operating cost:*** BMGF

Context and background

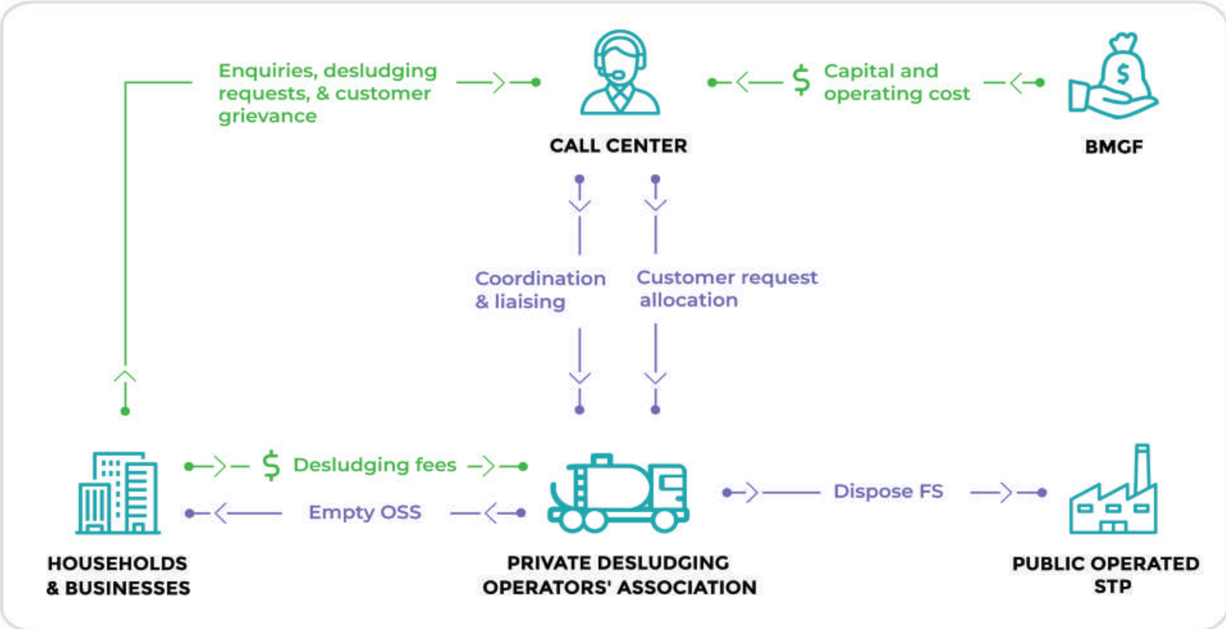
PSI India, an NGO, started working on sanitation in 2012 through a BMGF-funded project in rural Bihar. PSI India undertook a study to understand the sanitation landscape in Bihar, which resulted in Project Prasaadhan, subsequently funded by the BMGF in 2014, which focused on the development of integrated business models for toilet provision, desludging, and treatment of FS (see *Case Study: Patna Portable Toilets & FSTP, Bihar*) (SRI 2014; Sustainable Sanitation Alliance 2019). The integrated model could not sustain itself due to insufficient revenue generation, so PSI India decided to work with Bihar Rajya Jal Parishad (BRJP) in Patna, Bihar on co-treatment of FS at existing STPs. To ensure safe and timely provision of E&T services to OSS users, PSI India mobilized private desludging operators to form an association called Bihar Rajya Tankers Association in 2015, and subsequently, in 2017, a call center was established to generate regular business for desludging operators and manage customer desludging requests.

Case description

PSI India is the driver for implementing the call center under the funding provided by the BMGF. PSI India set up a toll-free number and a dedicated office space to operate it. OSS users requiring desludging services call the toll-free number, and the information on desludging requests is passed on to the association, which in turn allocates the requests to its members on a rotational basis. The association members provide desludging services and transport the FS to designated STPs. After the operator has provided the service, the tele-operator at the call center follows up with the customer for feedback. If any problem with the desludging service is not resolved remotely, PSI India staff visits the site to assess the situation. PSI India undertakes marketing for the call center using multiple mediums, such as distribution of flyers, radio and newspaper advertisements, and marketing stalls. A few of the desludging operators, with support from PSI India, have also painted the toll-free number on their respective vehicles. Due to the quantum of business generated

through the call center, the association is in the process of taking over its operations. The various relationships among the different stakeholders in the value chain are depicted in Figure 41. Box 5 presents case examples on call centers using information and communications technology.

FIGURE 41. VALUE CHAIN OF THE PATNA DESLUDGING CALL CENTER MODEL.



BOX 5. INFORMATION AND COMMUNICATION TECHNOLOGY USED IN DESLUDGING CALL CENTERS.

There are two major challenges in the E&T component of the sanitation value chain that can be addressed with technology. First, due to information asymmetry, OSS users lack information on emptying services and their cost, and desludging operators cannot access the market potential of their business. Second, the municipality is unable to monitor private desludging operators. Web-based tools and smartphone applications have been developed to connect OSS users, desludging operators, and municipalities to improve the efficiency of E&T services.

Karunguzhi Desludging Tool: To implement scheduled desludging and track E&T operations, the Indian Institute for Human Settlements (IIHS) developed a web-based application called the 'Karunguzhi Desludging Tool' for Karunguzhi town in Tamil Nadu. The application captures the household, type of containment, and desludging operator details to provide an automatic desludging schedule, generate household desludging notices, and track household response. Currently, the tool processes demand-based desludging requests for the single private desludging operator in the town and generates bills for the operator. When the vehicle disposes of FS at the FSTP, the volume and date of FS disposal is updated by the FSTP operator against the generated bill in the desludging tool to close the desludging status (Palanisamy et al. 2019).

Thiruvananthapuram Call Center: Thiruvananthapuram Municipal Corporation (ThMC) in Kerala has implemented a Smart Trivandrum application to register desludging services within the city,

along with a vehicle tracking system. Private operators are licensed by the ThMC for an annual fee of INR 3,500 per vehicle and are mandated to install GPS tracking devices and provide PPE for their workers. Through the Smart Trivandrum application, customers can register a desludging service and pay online in advance. Any available operator can accept the service request. The user receives a One-time Password (OTP) on their phone, and a trip pass is issued to the operator. The user must give the OTP to the desludging operator at the time of desludging and can submit feedback through the application. FS disposal is only permitted at Thiruvananthapuram's STP; there is radio-frequency identification control at the STP gate, which records photographs, vehicle information, and driver and operator details. The STP operator checks the QR code for the trip pass on the application. The ThMC has 14 registered private desludging operators and receives around 25 desludging requests per day. The ThMC pays INR 2,500[8] to the operator for each request, and the remaining amount goes to the municipality towards maintenance of the application.

Pune Honeysucker Mobile Application: Saraplast Pvt. Ltd. has created an Android application called Honeysucker to enable customers to register and pay for desludging services. The application provides a list of nearby STPs to the operator and gets them permission to decant FS at designated treatment/disposal points. Saraplast aims to cover the application's operational costs through a commission charged to the operators for each request. Saraplast is in the process of rolling out Honeysucker in Pune, where there is high demand for desludging services.

Funding and financial outlook

The capital cost associated with the call center is negligible. The start-up costs – toll-free number, telephone line, and office space – are its operational costs. The BMGF funds cover the operational costs, as the call center has no source of revenue. The major expense is for labor – the dedicated tele-operator and marketing staff. The expenses are summarized in Table 9.

TABLE 9. FINANCIAL OVERVIEW OF THE PATNA DESLUDGING CALL CENTER MODEL.

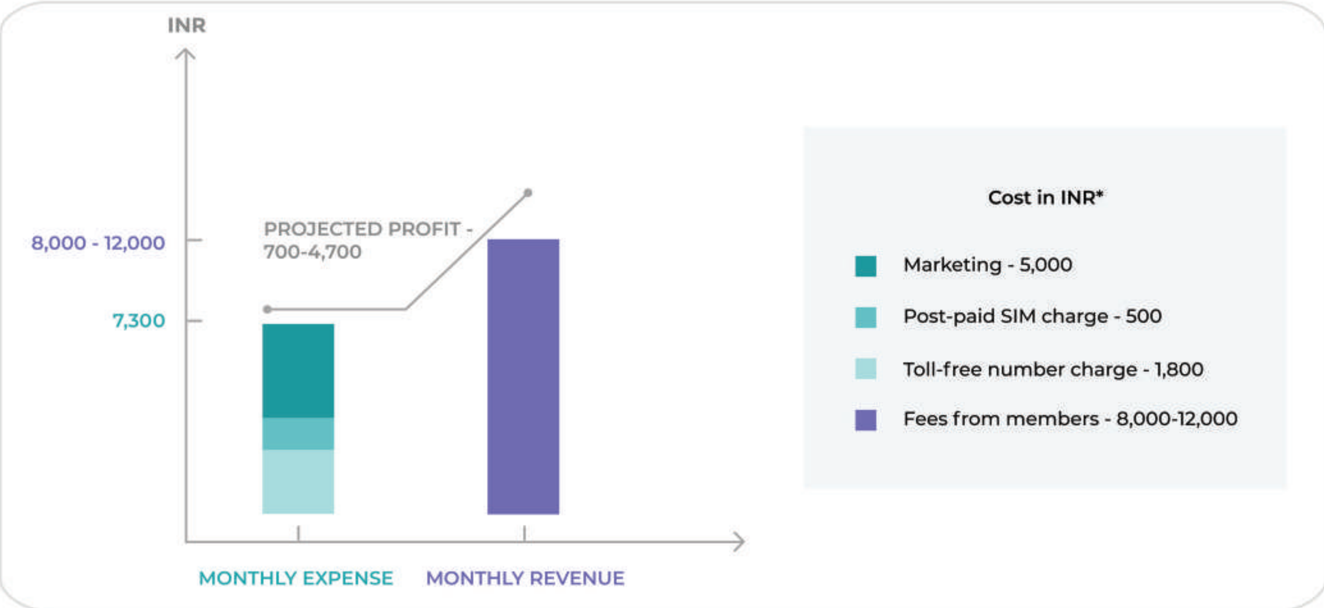
Monthly Expense Items	Cost in INR*
Labor	16,000
Toll-free number charge	1,800
Telephone line charge	350
Office rent and electricity bill	7,000
Marketing	5,000
Total Monthly Expense	**30,150**

Source: PSI India.
*USD 1.00 = INR 71.25 as of October 2019.

[8] USD 1.00 = INR 69.77 in May 2019.

Currently, the call center receives 35 to 40 desludging requests every month, along with 30 to 35 enquiry calls. Desludging operators cover their expenses from fees charged for desludging. Typically, a desludging request requires 1 to 2 trips to empty the OSS, and a fee of INR 1,500 per trip is charged to the OSS user. Due to high demand, the association is in the process of taking over the call center, and it has plans to run it without any office space or dedicated tele-operator, to keep operational costs low. The association will invest in a post-paid SIM linked to the toll-free number. The association will collect INR 1,000 to 1,500 per month from each of its eight members to cover operational costs. This is equivalent to 10% of their business generated from the call center on a monthly basis. The projected expenses and revenue for the association are given in Figure 42.

FIGURE 42. PROJECTED EXPENSES AND REVENUE FOR THE ASSOCIATION-RUN DESLUDGING CALL CENTER MODEL.



Source: PSI India; Bihar Rajya Tankers Association.
* USD 1.00 = INR 71.25 as of October 2019.

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8.2c Business Model: Desludging Association

8.2c.1 Value proposition

The model focuses on the E&T component in the sanitation value chain. It offers the following value propositions:

- Timely E&T of FS from OSS in households, businesses, and institutions
- Advocacy support to E&T operators for a better business environment

In addition, the desludging association can assist the municipality in monitoring E&T operations through peer monitoring and ensure safe E&T operations for public health and the environment.

8.2c.2 Description

A well-known practice of individuals or enterprises engaged in a common profession is to come together to promote and/or safeguard their activities/ business interests. This is typically done through the formation of either unions or associations. Similarly, private desludging operators can come together to form desludging or emptying associations for the following purposes:

- Advocacy with government agencies to improve the business environment
- Demarcation of geographical boundaries for business operations
- Agreement on a set of informal rules for plying vacuum truck operations, including setting tariffs; and
- Peer learning

The association engages with the municipality for advocacy on policy and regulations, and in return, the municipality or parastatal agency – whosoever is responsible for providing sanitation services – engages with the association to ensure:

- Equity in E&T services by regulating tariffs
- Peer monitoring to implement E&T safety protocols, and ensure disposal at the designated site; and
- Provision of a suitable environment for operating the business

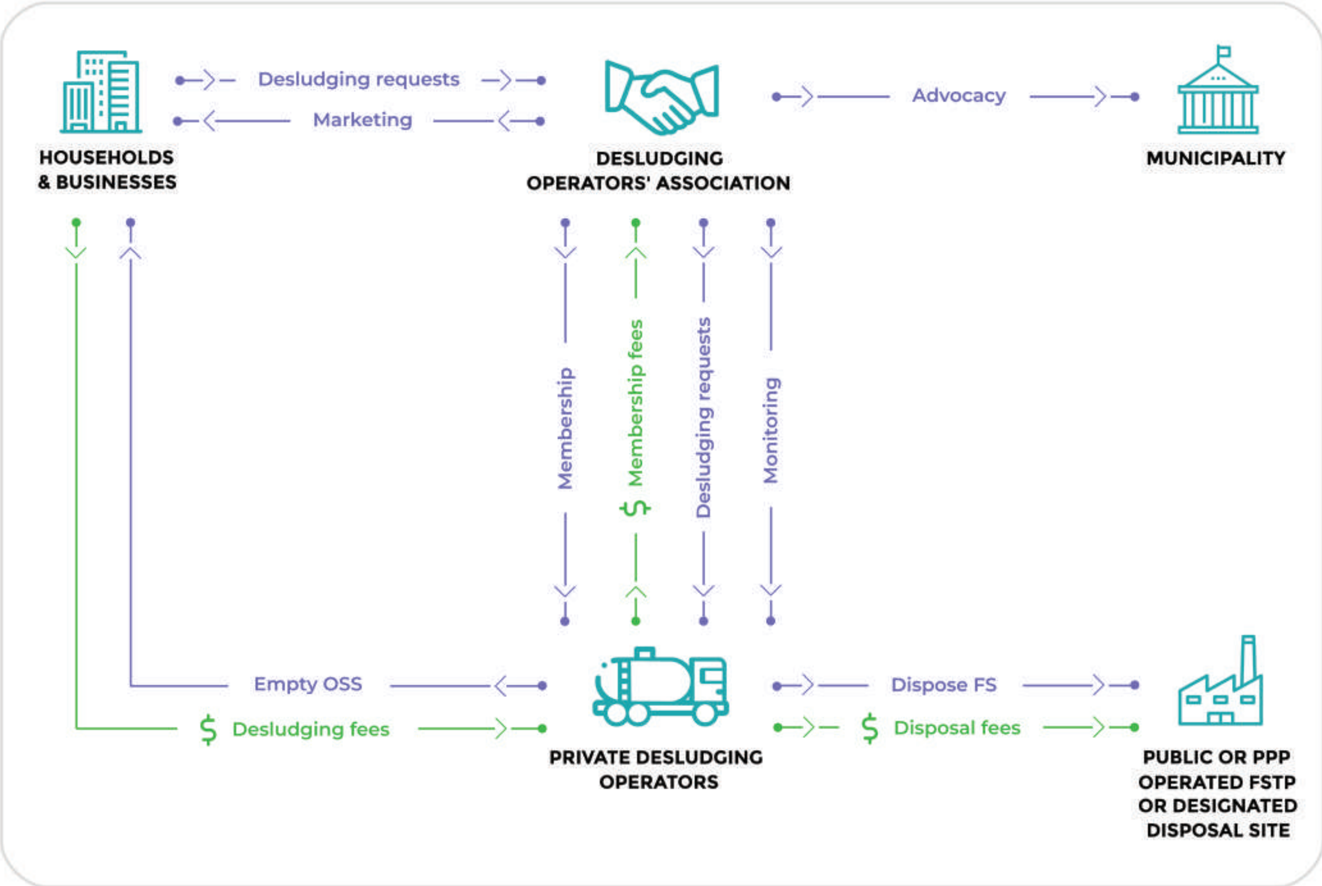
The municipality can engage the association to implement new schemes or awareness programs to improve sanitation in the region.

The association charges membership fees, regulates desludging fees, and processes desludging requests (see *8.2b Business Model: Call Center*). The association undertakes marketing to generate business for its members. The association liaises with the municipality for contracts and the issuing of licenses for its members. FS collected from OSS is decanted at the FSTP or designated disposal point, which is monitored by the municipality. In the future, there is the scope for municipalities to contract FSTP operations to desludging associations, resulting in a self-regulation approach for the FSM sector. The relationships among the various stakeholders are shown in Figure 43.

This model incorporates elements from the licensing and the call center business models. An association works only when the members subordinate their interests to that of the association's. However, the model suffers from the same contradictions as a call center model. If demand increases and the market expands, which member gets to buy a new truck? Why should new service providers be encouraged, if existing members will experience reduced demand as a result? Any model that distorts a free market has to be able to handle the contradictions that arise as a consequence. Perhaps associations of operators can develop a participative way of doing so.

Owner and operator: The business model is implemented by private entities involved in desludging. Private operators own and operate the association.

FIGURE 43. VALUE CHAIN OF THE DESLUDGING ASSOCIATION BUSINESS MODEL.



8.2c.3 Funding and financing

Capital cost: There is no capital cost associated with the establishment of an association except registration fees to form a legal entity. These can be covered by membership fees. The association members cover the capital cost of their respective desludging vehicles.

Operating cost: The association finances the operating cost through collection of one-time or annual membership fees. The association can collect additional fixed fees from members for each desludging, if the association generates business.

8.2c.4 Risks and benefits

Risks

- Can lead to price gouging for end-users if left unregulated
- New entrants can find it challenging to enter a market dominated by a closed association

Benefits

- Enables collective bargaining for an improved business environment, and the municipality can hold one entity accountable

8.2c.5 Relevance

Applicable for large towns or contiguous urban centers with enough desludging operators in close proximity. This business model requires regulated tariffs along with differential pricing for poor households in order to ensure universal service. The report covers following case studies:

- Kochi Associations of Desludging Operators, Kochi, Kerala (explained in this section)
- Patna Desludging Call Center, Patna, Bihar

Related models from other countries have been reported, e.g., in Accra, Ghana; Cotonou, Benin; Dakar, Senegal; and Khorogo, Côte d'Ivoire.

CASE STUDY

Kochi Associations of Desludging Operators, Kerala

Location	Kochi, Kerala
Value offered	Safe collection and transport of FS
Organization type and name	Private associations – All Kerala Cleaning Contractors' Welfare Association, All Kerala Sewage and Septic Cleaning Vehicle Owners' Association, and Sewage and Septic Tank Cleaners' Associations.
Project status	Registered in 2012, 2017, and 2018, respectively
Scale of operations	Serves 13,000 households (65,000 people) annually
Major partners	Kochi Municipal Corporation
Financing entities and revenue source	***Capital cost:*** Members of the associations ***Operating cost:*** User fees and/or members

Context and background

In Kochi, only 5% of households are connected to the underground drainage system (UGD). Kochi has a high water table in many parts of the city, and containment systems fill up faster and require frequent emptying – at least once a year (Roeder 2016). Due to high demand for desludging services, Kochi has 130 desludging operators (Lalu 2019). Despite desludging being prevalent, it is largely perceived as a clandestine activity, and operators often face harassment from the police and residents. In order to address this, some of the private desludging operators united and registered three different associations – the Sewage and Septic Tank Cleaners' Association, All Kerala Cleaning Contractors' Welfare Association, and All Kerala Sewage and Septic Cleaning Vehicle Owners' Association. Box 6 presents case examples of desludging associations in Ganganagar and Warangal.

Case description

The associations were initially formed to shield members from police harassment and facilitate advocacy with the government to recognize their business. Once the FSTP was commissioned at Brahmapuram in Kochi in 2015 (see *Case Study: Kochi Public-Private Partnership FSTP, Kerala*), the associations facilitated the disposal of FS at the treatment plant. The two oldest associations, All Kerala Cleaning Contractors' Welfare Association and All Kerala Sewage and Septic Cleaning Vehicle Owners' Association, are issued six disposal passes each from the Kochi Municipal Corporation (KMC) daily to dispose of FS at the FSTP. A representative from each association collects the passes from the KMC (Lalu 2019). It is the responsibility of the associations to

issue the passes to 12 members with active service requests for the day. The selected private operators pay the disposal pass fees to the municipality at the FSTP. The FSTP is around 20 km from Kochi, so the operator has to travel at least 20 to 40 km every day. Since the FSTP only accepts FS from 12 trucks, the remaining FS collected by the operators is disposed of in the open. The desludging trucks each have a capacity of approximately 5 m^3, and an operator completes about one to three desludging trips per truck per day. The relationships among the various stakeholders are depicted in Figure 44.

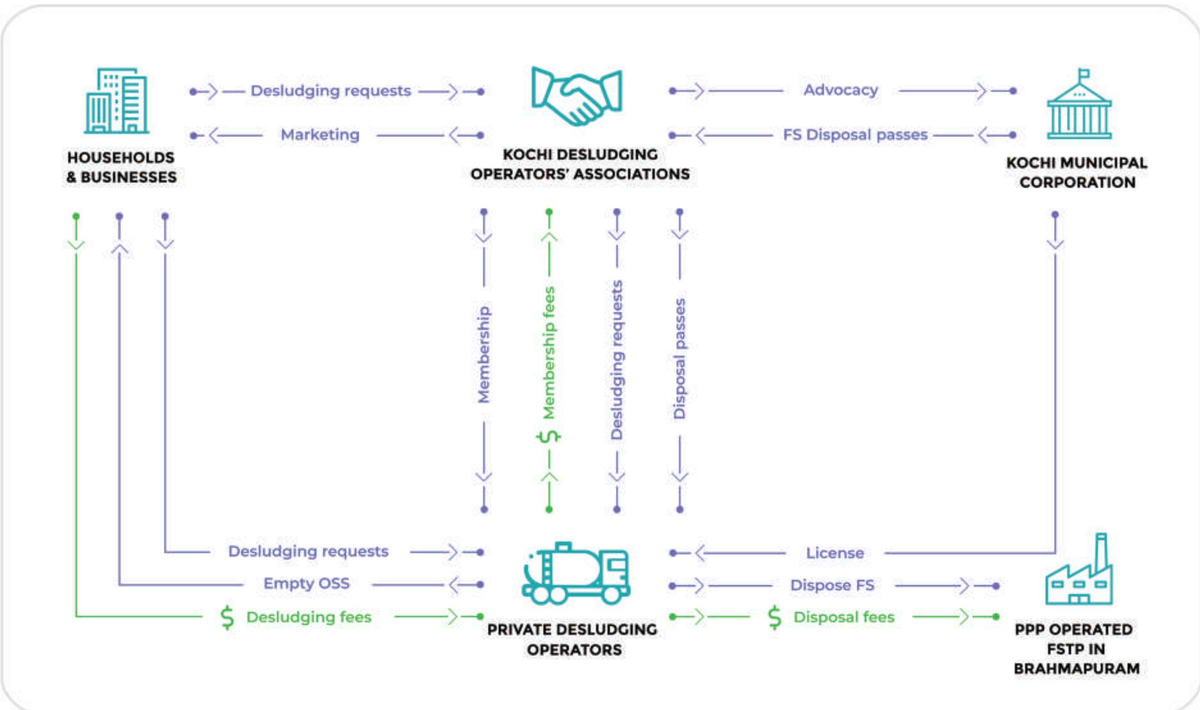
BOX 6. DESLUDGING ASSOCIATIONS IN GANGANAGAR AND WARANGAL.

As the demand for desludging has grown and more private operators have entered the market, a number of desludging operator associations have emerged in different cities.

In **Ganganagar, Rajasthan**, an unregistered union of private desludging operators was formed in 2014 to address the lack of designated FS disposal points and harassment from local residents. The union members must assemble at a designated parking point in the town. The union regulates the desludging rates and salaries of drivers and helpers. The union operates a phone number to process desludging requests, which are distributed to members on a rotational basis. The union does not collect any membership fees or other charges, but if a member undertakes desludging service without informing the union, the association imposes a fine of INR 3,500[9]. The funds are used to help other union members finance additional vehicles or equipment.

In **Warangal, Telangana**, there is a registered association of desludging operations called Kaktiya Owners Septic Tank Association, which charges INR 1,000[10] as a membership fee and advertises on behalf of its members in the local newspaper.

FIGURE 44. VALUE CHAIN OF THE KOCHI ASSOCIATIONS OF DESLUDGING OPERATORS MODEL.



[9] USD 1.00 = INR 66.97 in February 2017.
[10] USD 1.00 = INR 69.41 in April 2019.

Occasionally, the associations advertise desludging services in local newspapers. Business generated by the association or by any individual member is communicated to the members through a WhatsApp group. The associations are in discussion with the KMC to provide government desludging contracts to them for sanitation services at public events.

Funding and financial outlook[11]

The cost of registering an association is INR 1,000. There is no dedicated office space rented by the associations, and their operating cost is mostly for advertisements – INR 10,000 to 20,000 per year. The associations generate revenue from one-time membership fees ranging from INR 5,000 to 6,000 per member. When customers contact the desludging associations, the desludging service is provided at a fixed rate of INR 3,000 per trip, which is higher than the market rate of INR 2,500 per trip. Currently, the association does not charge its members for the business generated; however, it could potentially earn revenue by charging fixed fees to cover its operational costs. The FSTP disposal pass fee is INR 400 and is paid directly by the private operators to the KMC.

The newest association, Sewage and Septic Tank Cleaners' Association, is negotiating with the KMC to get its share of the disposal passes; the KMC has agreed to issue two passes to this association, which means the two older associations would get five passes each, but this is yet to be implemented (Lalu 2019).

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[11] USD 1.00 = INR 69.58 in March 2019.

9.

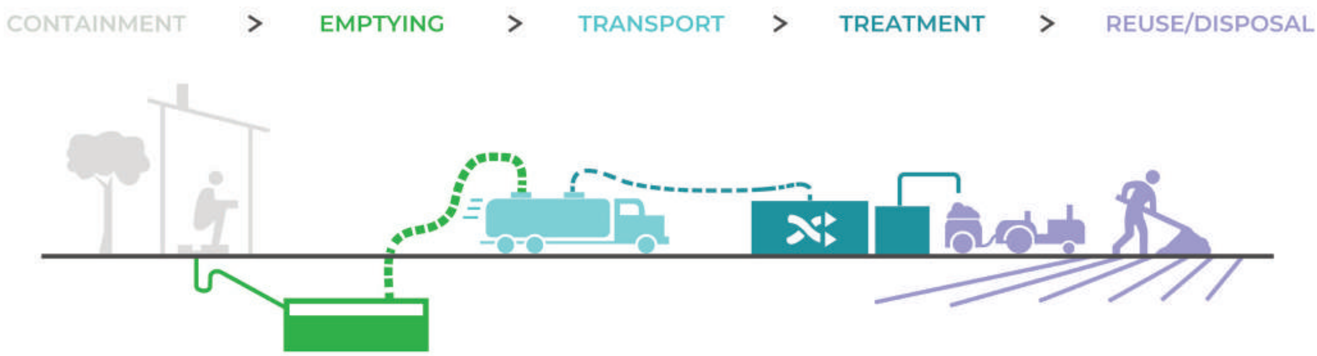
Models Linking Emptying, Transport, and Treatment

Business models in this section cover the E&T and treatment components in the sanitation value chain. The models offer the following value propositions:

1. Timely and safe emptying of OSS in households, businesses, and institutions
2. Safe transportation of FS to designated disposal sites
3. Treatment of FS for a healthy community and environment

The models in this section link the E&T and treatment components and, in the process, build a mechanism for reducing the monitoring burden on the municipality to ensure disposal of FS at treatment sites. The following business models are explained in this section:

1. Scheduled desludging and sanitation tax
2. Integrated emptying, transport, and treatment
3. Transfer station



9.1 Business Model: Scheduled Desludging and Sanitation Tax

9.1.1 Value proposition

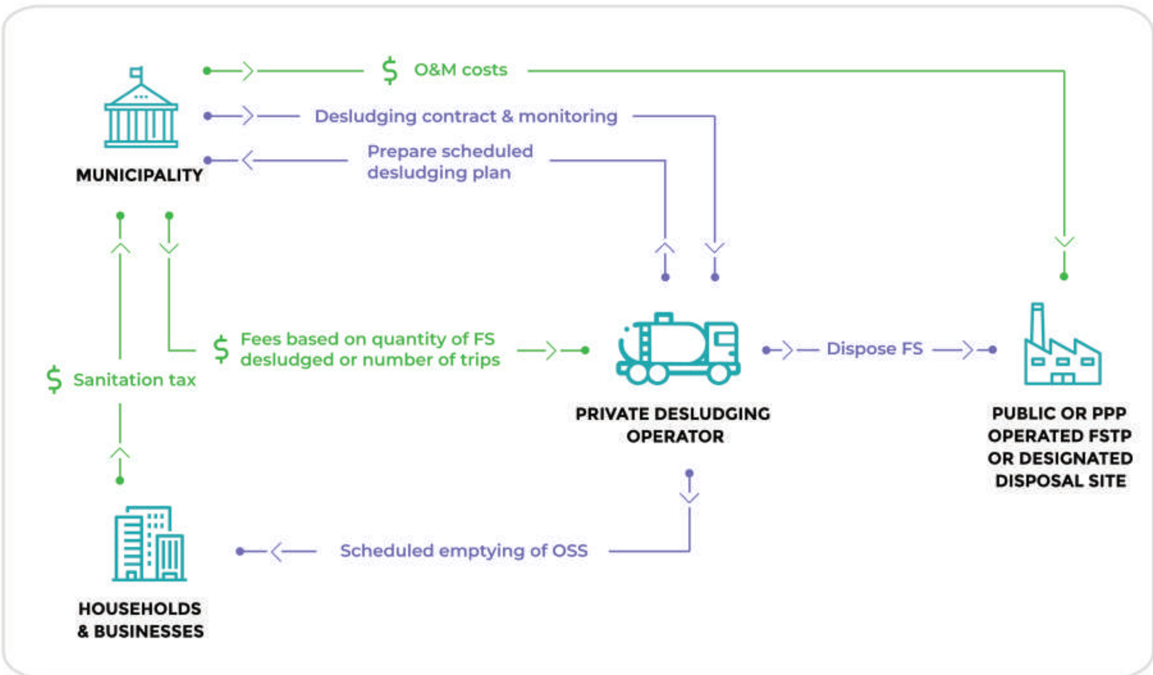
The model focuses on the E&T component in the sanitation value chain. It offers the following value propositions:

- *Safe emptying of OSS in households, businesses, and institutions periodically, thus ensuring improved performance of containment systems and improved public health and environment*
- *Safe transportation and disposal of FS at designated sites*

9.1.2 Description

Scheduled desludging means mandatory desludging of containment systems according to a fixed schedule. This is undertaken to assure better outcomes by avoiding user preference in desludging decisions. Regular desludging of septic tanks alleviates the quality of effluent discharged into the environment. In the case of single pits, regular desludging reduces the need for manual intervention due to hardening of sludge. Since users typically pay for desludging triggered by specific problems (e.g., toilet backing up), they may be unwilling to pay for the greater frequency of desludging proposed. Therefore, scheduled desludging works well with the collection of a sanitation tax, instead of collecting emptying fees from the OSS users at the time of emptying. Thus, the operator providing the desludging service should focus on service delivery, instead of collecting user fees. The relationships among the various stakeholders are shown in Figure 45. In this model, the municipality

FIGURE 45. VALUE CHAIN OF THE SCHEDULED DESLUDGING AND SANITATION TAX BUSINESS MODEL.



contracts private entities to do scheduled desludging and transport FS to designated disposal or treatment sites. Desludging vehicles are sourced either by the municipality or the private entity. The municipality, in discussion with the OSS users, develops a plan for scheduled desludging and informs OSS users of the scheduled date and time of desludging. The private entity responsible for desludging is paid by the municipality only for disposal of FS at the treatment plant or designated disposal site, and hence is better aligned with FSM outcomes. The municipality is responsible for collecting the sanitation tax from the OSS users to cover the cost of operations.

If an OSS user requires an unscheduled desludging service, the user submits the request to the municipality and pays for the service in advance. A critical aspect of the model is to undertake public awareness on scheduled desludging, informing OSS users at least a week in advance of the desludging date and time and required presence of any individual to allow the truck to access the containment system. A management information system should be developed to monitor and track the progress.

Scheduled desludging addresses the specific risk of users not desludging in a timely fashion by taking that decision away from the user, and a sanitation tax enables this approach. It also allows for cross-subsidy through differential taxes thus removing the risk of affordability. Indirect payments provide for recovering the O&M costs of the FSTP, hence ensuring that the entire value chain is sustained.

However, scheduled desludging should not be introduced without careful considerations. Scheduled desludging should be mandatory for septic tanks, as the quality of effluent deteriorates if sludge is not removed at appropriate intervals. For pits, there is no reason to implement scheduled desludging unless sludge tends to solidify and becomes difficult to desludge. In either case, the desludging interval has to be chosen carefully; otherwise the carbon footprint of desludging can outweigh its benefits. Also, hardening of sludge can slow down the desludging process and hence delay the schedule significantly, causing significant loss of revenue to the operator. Scheduling should therefore be adopted with due consideration given to technical and financial factors. The scheduled desludging model creates geography-based oligopolies, where a few operators serve the entire market. Making this transition where private operators already provide services can be disruptive.

Owner and operator: The business model is implemented through a PPP. Either the municipality or the private entity is the owner of the desludging vehicles. The municipality enters into a performance-based service contract with the private entity for desludging operations.

9.1.3 Funding and financing

Capital cost: If the private entity owns the vehicles, it covers the cost through self-financing or bank loans. Municipality-owned trucks are funded through state or national government programs for improving urban infrastructure.

Operating cost: The private entity responsible for desludging is paid based on one of the following mechanisms:

1. The number of OSS desludged and number of trips to the FSTP per disposal site. The private entity must collect signed forms from OSS users and the treatment plant operator to receive payment
2. The quantity of FS disposed of at the FSTP/ disposal site

The municipality finances the payment to the private entity through the sanitation tax, which is collected through a cess charged on sewerage or solid waste management bills, a percentage of surcharge on water bills or by adding a sanitation tax component to the existing property tax.

9.1.4 Risks and benefits

Risks

- Lack of collection of sanitation tax from end-users poses risk to operational viability

Benefits

- Reduces the cost of the desludging service due to improved logistics in comparison to demand-based desludging, resulting in benefits to end-users and private operators
- Ensures proper maintenance of septic tanks and hence reduces public health and environmental risks
- Assured FS disposal at designated sites due to performance-based payment
- Sizing of FSTP and its operational efficiency can be better planned in comparison to demand-based desludging

9.1.5 Relevance

The model is applicable to any town. It is important that the residents and businesses in the town are willing to pay the sanitation tax. Sanitation taxes are very amenable to differential rates based on water consumption or dwelling size which are accepted practices. Therefore, this business model can potentially assure universal coverage of FSM service, including full recovery of treatment plant costs from users. The report covers following case studies:

- Wai Scheduled Desludging and Sanitation Tax, Wai, Maharashtra (explained in this section)

- Leh Public-Private Partnership in FSM, Leh, Jammu & Kashmir

Related models from other countries have been reported, e.g., in Hai Phong, Vietnam; Bekasi City, Indonesia; Baliwag, Dumaguete, and San Fernando, the Philippines; and locations across Malaysia.

CASE STUDY

Wai Scheduled Desludging and Sanitation Tax, Maharashtra

Location	Wai, Maharashtra
Value offered	Regular emptying of OSS and FS disposal at FSTP
Organization type and name	Private – Sumeet Facilities Ltd.
Project status	Operational since May 2018
Major partners	Wai Municipal Council (WMC), CEPT University
Financing entities and revenue source	***Capital cost:*** Sumeet Facilities Ltd. ***Operating cost:*** Sanitation tax from OSS users and Wai Municipal Council

Context and background

In 2008, CEPT University started the Center for Water and Sanitation (C-WAS) with funding from the BMGF to undertake action research on urban water and sanitation (CEPT University 2019). Under this action research, C-WAS worked closely with the state government of Maharashtra to support implementation of SBM and development of ODF+ and ODF++ guidelines (C-WAS 2017; UDD 2016). Wai was selected as one of the towns, in consultation with the state government, to develop a city sanitation plan (CSP) in 2012/2013. Based on the CSP, the city requested C-WAS for implementation of recommendations in the CSP (CEPT University 2014). In 2015, Wai was declared ODF, and as it strived to become ODF+ and ODF++, Wai Municipal Council (WMC) passed a resolution for scheduled desludging through a performance-based contract, along with a sanitation tax (Bharmal and Salunke 2019).

Case description

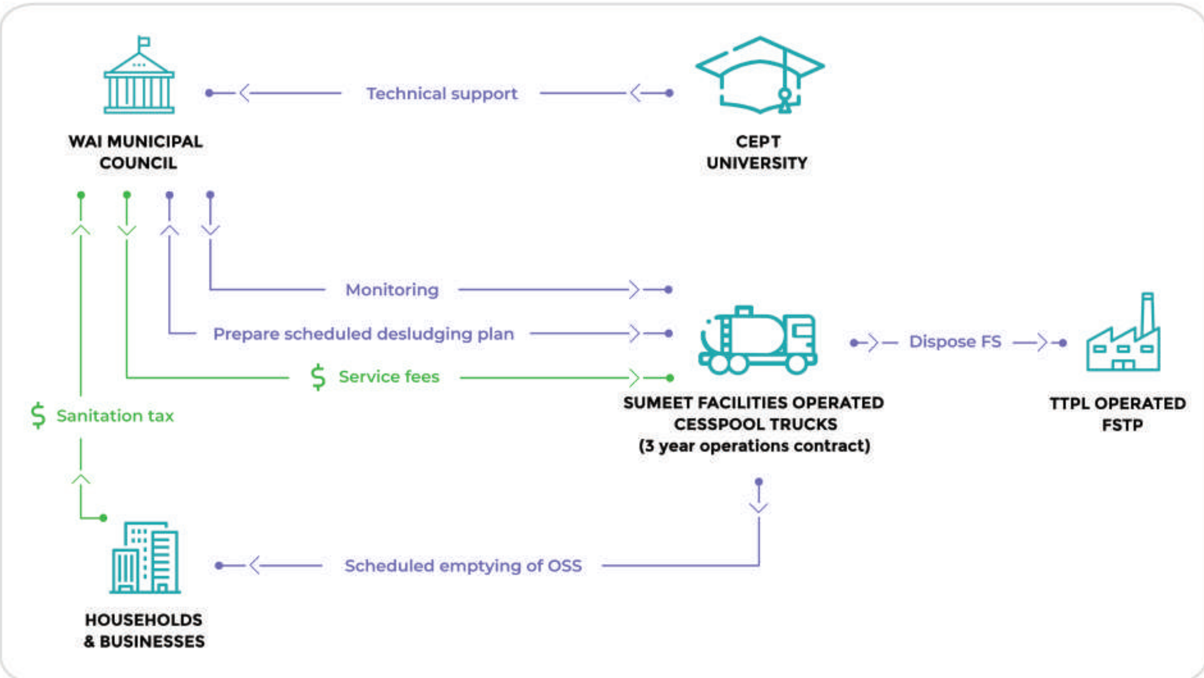
C-WAS partnered with the WMC to implement scheduled desludging of all septic tanks once every 3 years. A city-wide survey was carried out to create an OSS database to facilitate scheduled desludging. A tender was issued by the WMC, and a 36-month performance-based contract was given to Sumeet Facilities Ltd, a private desludging operator. They were required to cover the capital cost of the desludging trucks and desludge a fixed number of septic tanks over the contract period. The WMC is responsible for collection of sanitation tax from OSS users as part of the property tax. The payment to the private operator is made on a monthly basis based on the number of septic tanks desludged. A tripartite agreement was made amongst the WMC, Sumeet Facilities and the Bank of Maharashtra for an escrow account, which would maintain three times the monthly contractual fees and thus provide security and safeguards against delays in payments to the private operator (Bharmal and Salunke 2019; C-WAS 2019; CEPT University 2014; Mehta 2017).

To implement scheduled desludging, the city was divided into three zones, with one zone targeted to be covered every year. The private operator, in consultation with the WMC, has a planned route for desludging, which optimizes truck utilization and human resources, so as to reduce the cost of

desludging. The private operator also provides on-demand desludging services on an emergency basis, which is first approved by the WMC sanitary inspector post-inspection. OSS users must pay separately for this service. The private operator sends an SMS to the OSS user 2 days prior to the date of scheduled desludging and also visits 1 day prior, to inform the OSS user about the desludging. On the scheduled date, the operator checks the availability of the OSS user and carries out the desludging. Desludging is postponed by 15 days if the OSS user is unavailable on the scheduled date. If the OSS user is still unavailable on the later date, the desludging is marked as incomplete, with justification given, and is reported to WMC officials (Bhavsar et al. 2019).

The OSS users must open their septic tank covers for desludging. Since many septic tanks do not have a proper access cover, it is difficult for OSS users to open their septic tanks before the arrival of the desludging vehicle. To resolve this issue, WMC provided a mason to accompany the desludging operator. The mason opens the septic tank and makes a provision for access covers. The OSS user is responsible for paying for the tank opening and rectification. On completion of desludging, a quadruplicate manifest form is generated for the WMC, the private operator, the FSTP operator, and the OSS user. The manifest form has a unique survey number for the specific property, which is used to monitor and track E&T operations (Bhavsar et al. 2019). The private operator transports the FS to the FSTP. WMC staff undertake random checks to verify that desludging services are provided. The relationships among the various stakeholders in the value chain are depicted in Figure 46.

FIGURE 46. VALUE CHAIN OF THE WAI SCHEDULED DESLUDGING AND SANITATION TAX MODEL.



Technology and processes

The private operator has deployed two desludging vehicles with capacities of 0.6 m^3 and 3 m^3 to desludge a target of 6,000 septic tanks in 3 years, i.e., six tanks per day on an average. The 0.6 m^3 vehicle is deployed to navigate the narrow streets, but it limits the desludging operations, as the septic tanks are 3 m^3 in size. The private operator is sourcing another 3 m^3 vehicle to replace this smaller vehicle. Many septic tanks have never been desludged, resulting in hardened sludge, so more time is needed to empty them.

To manage and monitor scheduled desludging, C-WAS has developed an Android-based application called SaniTab. The application creates a database of OSS users, along with household/property data linked to a Geographic Information System, which is used for scheduling and route mapping. The application is also used to record desludging and track trucks via the GPS. The WMC monitors scheduled desludging services through a SaniTab dashboard (Bhavsar et al. 2019). Another application called SANITRACK is being developed to monitor desludging operations.

Funding and financial outlook

The capital cost of the 3 m^3 desludging vehicle was INR 2.2 million,[12] and was financed by Sumeet Facilities. Their monthly cost of operations is INR 176,500[13]. Each vehicle requires a driver and two helpers for desludging. The sole source of revenue for Sumeet Facilities is the operating fee of INR 800 per tank from the WMC. The bid for desludging is on a single tank basis instead of each trip to the FSTP. This has caused some difficulties, as desludging a septic tank may require several trips to the FSTP. This has resulted in higher operational costs than the bid value, resulting in operational loss. The private operator can recover some of these losses by desludging more than one small septic tank in a single trip, but such instances are less common. The private operator has now decided to deploy another desludging vehicle of 3 m^3 to 5 m^3 capacity to recoup some of these operational losses. Despite the financial challenges for the operator, scheduled desludging provides a more affordable, inclusive option for OSS users in Wai.

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[12] USD 1.00 = INR 67.52 in May 2018.
[13] USD 1.00 = INR 71.25 as of October 2019.

9.2 Business Model: Integrated Emptying, Transport, and Treatment

9.2.1 Value proposition

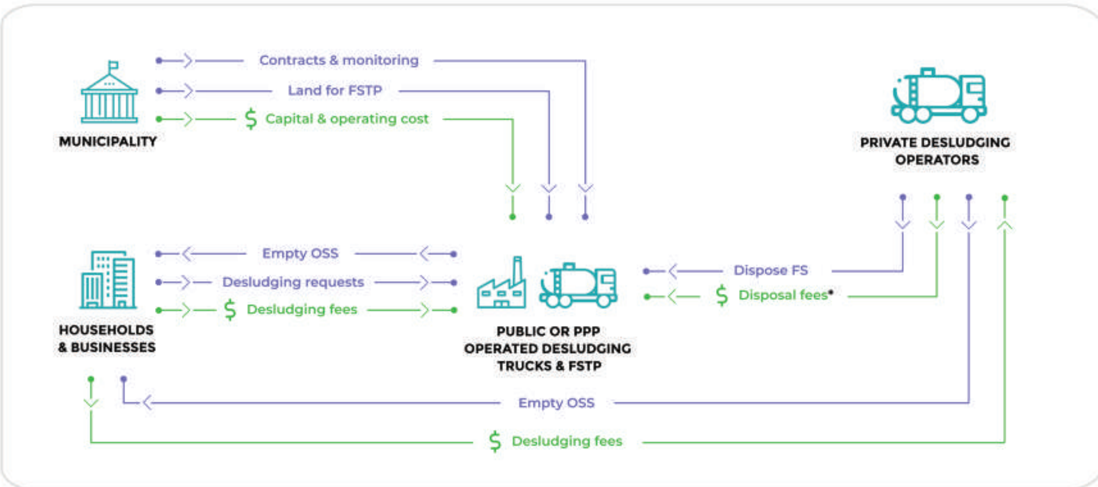
The model focuses on the E&T and treatment components in the sanitation value chain. It offers the following value propositions:

- *Timely and safe emptying of OSS in households, businesses, and institutions*
- *Safe transportation of FS to designated disposal sites*
- *Treatment of FS for a healthy community and environment*

9.2.2 Description

One entity, either the municipality or a private entity, is responsible for managing desludging and FSTP operations. The entity provides the desludging service and collects fees from OSS users and disposes of the FS at the FSTP that it manages. The municipality monitors FSM service provision. The relationships among the various stakeholders are shown in Figure 47. With technology evolution, where both transportation and treatment happen simultaneously, the integrated emptying, transport and treatment model happens by default as demonstrated in Box 7.

FIGURE 47. VALUE CHAIN OF THE INTEGRATED EMPTYING, TRANSPORT, AND TREATMENT BUSINESS MODEL.



* Charging a disposal fee from other E&T operators is not recommended as it is discriminatory.

This model enables implementation of performance linked payments for the entire value chain. This, when coupled with incentives to promote reuse, creates the ideal FSM business model. Integrated business models are a tempting option for local governments, who can solely focus on monitoring while service provision is handled entirely by a private entity. However, care should be taken that the vendor's scope of work is not onerous. There have been instances of burdening the vendor with user fee collection in addition to the operational responsibilities. Such a system poses financial feasibility risks to the private entity given the general unwillingness to pay for scheduled desludging.

Owner and operator: The business model is implemented by the municipality. For PPP, the municipality enters into aperformance-based contract with a private entity. The contract for the FSTP can be DBOT or BOT with designs provided by the municipality.

9.2.3 Funding and financing

Capital cost: This is mostly covered by grants from donors and/or funds from state or national government programs for improving urban infrastructure. Depending on the project viability, a DFBOT contract can be implemented based on the availability of private finance to partially or fully invest, as demonstrated by the *Case Study: Leh Public-Private Partnership in FSM, Jammu & Kashmir.*

Operating cost: The financing of the operating cost is dependent upon the PPP contract. For the integrated model with scheduled desludging, the municipality pays the private entity on a pay per trip model that compensates for E&T and FSTP O&M costs. However, in the case of demand-based desludging, a similar payment mechanism with a minimum guaranteed number of trips is preferred.

The municipality finances the cost through multiple sources – user fees charged for desludging services, local tax collection, and state and central government financial assistance. The municipality can incentivize the private operator to generate additional revenue by selling treated sludge or other FSTP by-products, thus encouraging reuse.

9.2.4 Risks and benefits

Risks

- Dependency on a single entity to manage all FSM services – hence, a need for appropriate contractual provisions
- Moral hazard risk if unregulated or weakly monitored, e.g., reducing E&T and FSTP operating cost through illegal disposal of FS
- Limited number of entities with the capacity to manage the entire FSM chain

Benefits

- The integrated model enables linkage of FSM investment directly to successful service delivery
- Ease of management for the municipality since it deals with only one entity – hence, greater focus on monitoring is feasible

9.2.5 Relevance

The model is applicable to any town where the government predominantly provides emptying services, and limited or no private service providers exist. While this model enables direct linking of performance to pay, it requires specific interventions to assure universal coverage and inclusivity as discussed in previous sections. The report covers following case studies:

- Lalsot Integrated E&T and FSTP, Lalsot, Rajasthan (explained in this section)
- Leh Public-Private Partnership in FSM, Leh, Jammu & Kashmir
- Nashik Waste-to-Energy Plant, Nashik, Maharashtra

Related models from other countries have been reported, e.g., in Bamako City, Mali; Cotonou, Benin; Gulariya, Nepal; and Rayong, Thailand.

BOX 7. WASH INSTITUTE MOBILE SEPTAGE TREATMENT UNIT.

The Water, Sanitation and Hygiene Institute (WASHi), an NGO, has developed a Mobile Septage Treatment Unit (MTU) system comprised of a truck equipped with desludging and treatment equipment. In the MTU, FS is separated into effluent and solids by a centrifuge, with the latter stored in a 0.2 m^3 drum, which fills up after emptying 20 septic tanks. The solids can be disposed of at an FSTP or safely buried where the water table is low. The effluent is passed through multiple filters and is of permissible standard to be discharged in nearby farmland, gardens, or drains. The MTU comes with two design capacities – 2.5 and 5 m^3 of septage treated per hour (WASHi 2018). A key advantage of the MTU over desludging trucks is reduced travel to FS disposal points. The MTU has been tested mostly with FS from septic tanks, and it requires an external electricity source to operate. The WASHi plans to further develop the technology to treat the solids and, thus, make it a mobile FSTP.

The technology has been developed with funding from the BMGF and is being tested and validated by the Research Triangle Institute; post validation, the MTU will be commercially deployed. The WASHi has pilot tested the MTU in both rural and urban areas in Tamil Nadu and Kerala, where it has received positive feedback from the customers. The capital cost of the MTU ranges from approximately INR 1.2 million to 1.5 million[14], which is similar to the cost of a desludging truck (WASHi 2018). If successful, the MTU technology has the potential to disrupt existing business models for FSM implementation, not only in India, but also internationally.

Reference

WASHi (Water, Sanitation and Hygiene Institute). 2018. Brief note on Mobile Septage Treatment Unit (MTU). New Delhi, India: Water, Sanitation and Hygiene Institute.

[14] USD 1.00 = INR 67.52 in May 2018.

CASE STUDY

Lalsot Integrated E&T and FSTP, Rajasthan

Location	Lalsot, Rajasthan
Value offered	Treated FS and (possibly) organic waste, treated water for irrigation/ gardening, and possible production of co-compost as a soil ameliorant
Organization type and name	PPP – Lalsot Municipality & Divija Construction Private Limited
Project status	Under construction and to be commissioned in 2019
Major partners	Rajasthan Urban Infrastructure Development Project (RUIDP), IPE Global Limited, ADB
Financing entities and revenue source	***Capital cost:*** ADB grant ***Operating cost:*** User fees and/or municipality

Context and background

The Government of Rajasthan's (GoR) Sewerage and Wastewater Policy 2016 plans to expand sewerage networks, which would serve 60% of the state's urban population; the remaining 40% would be dependent upon FSM. Furthermore, many towns in Rajasthan have limited funding available, and with insufficient water supply, the technical viability of sewerage networks is unclear. Thus, the GoR decided to address full-scale FSM for urban towns with populations of less than 50,000 and partial and gap-filling FSM for other towns (GoR 2018).

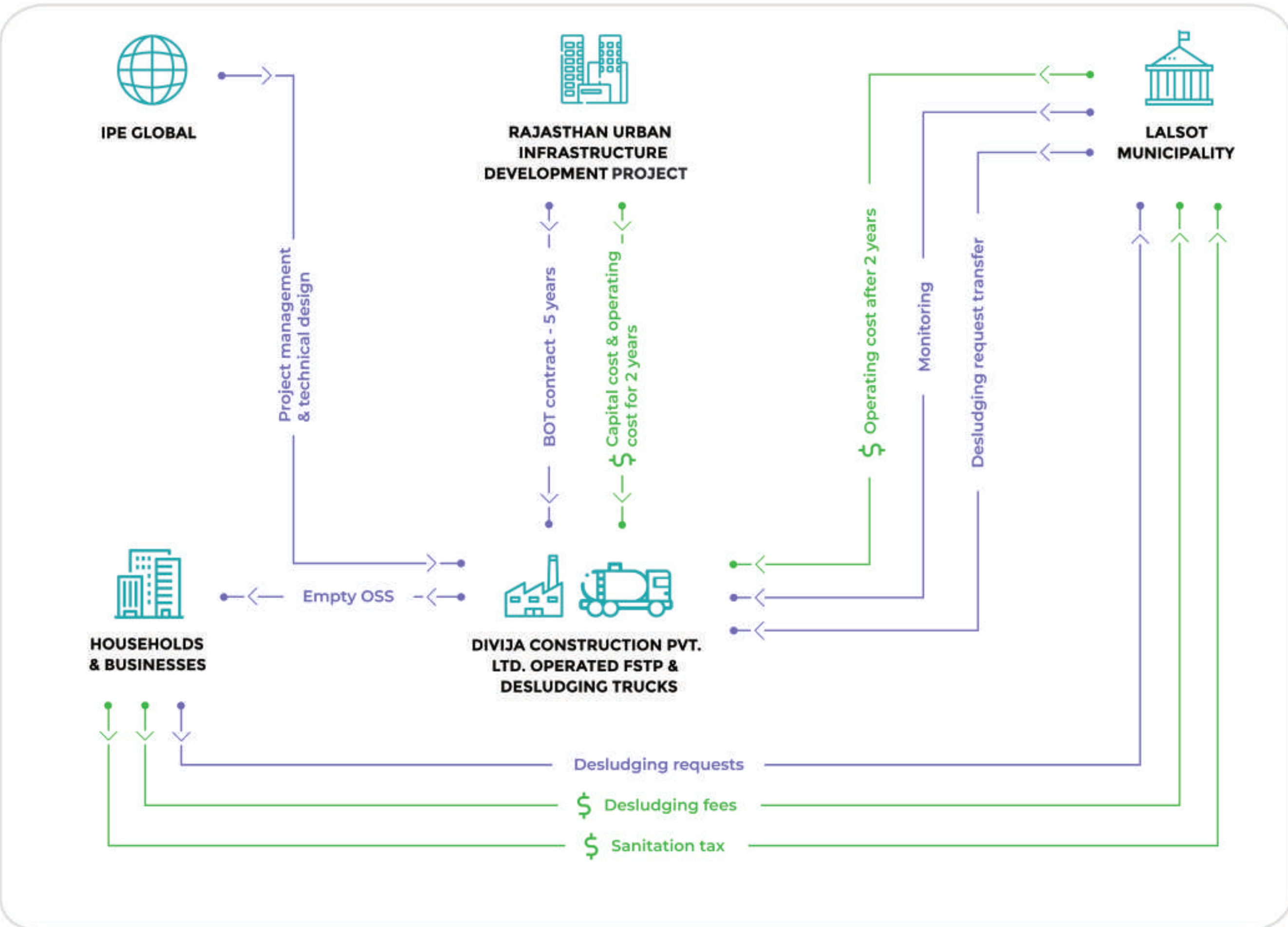
To implement the policy for full-scale FSM in small towns, the GoR initiated three pilot FSTPs through the RUIDP, a special purpose vehicle created in 1998 with support from the GoI and ADB to enhance urban infrastructure facilities. Lalsot, a small town in Dausa District with a population of about 45,000, is one of the selected FSM pilot sites. The town has neither private nor government desludging operators; households rely on operators from nearby towns such as Dausa, Gangapur, and Tonk to provide desludging services, resulting in high desludging costs. To address both desludging and treatment of FS, an integrated FSM model was planned for Lalsot (RUIDP 2018). The FSTP is under construction and is expected to be commissioned in late 2019.

Key indicators (as of March 2019)	
Designed capacity	20 m^3/day
Allocated land area	1.85 acres
Labor requirements	4 persons (FTE) – 1 FSTP operator, 2 other FSTP workers, and 1 desludging vehicle driver

Case description

RUIDP was the primary agency responsible for project management, and it contracted project implementation – including FSTP design, construction supervision, and technical support during O&M, as well as drafting of an FSM policy and operative guidelines – to IPE Global Limited (IPE Global), a consulting agency. RUIDP and Lalsot Municipality issued a five-year BOT contract to Divija Construction Private Limited (Divija) for FSTP O&M and provision of desludging services. RUIDP provided capital funds and O&M funds for the first two years of operations, after which it is the responsibility of the municipality. OSS users will place desludging requests with the Lalsot municipality, which will set up a system to process customer requests, collect desludging fees, and coordinate with Divija to provide the desludging service. According to the contract, Lalsot municipality will ensure a minimum number of desludging trips for Divija, and Divija will be paid based on the number of trips made to the FSTP each month. Lalsot municipality will cover the cost of spare parts for the desludging truck. The municipality will pay fixed fees for FSTP O&M. After the first two years of operations, the municipality will cover the O&M cost of the FSTP through user fees for desludging and collection of sanitation tax, either through a sanitation surcharge on water bills collected by the Public Health Engineering Department (PHED) or sanitation cess on the solid waste management fee collected by Lalsot municipality (IPE Global Limited 2018). The relationships between the various stakeholders in the value chain are depicted in Figure 48. Box 8 presents a similar approach implemented in Khandela, Rajasthan.

FIGURE 48. VALUE CHAIN OF THE LALSOT INTEGRATED E&T AND FSTP MODEL.



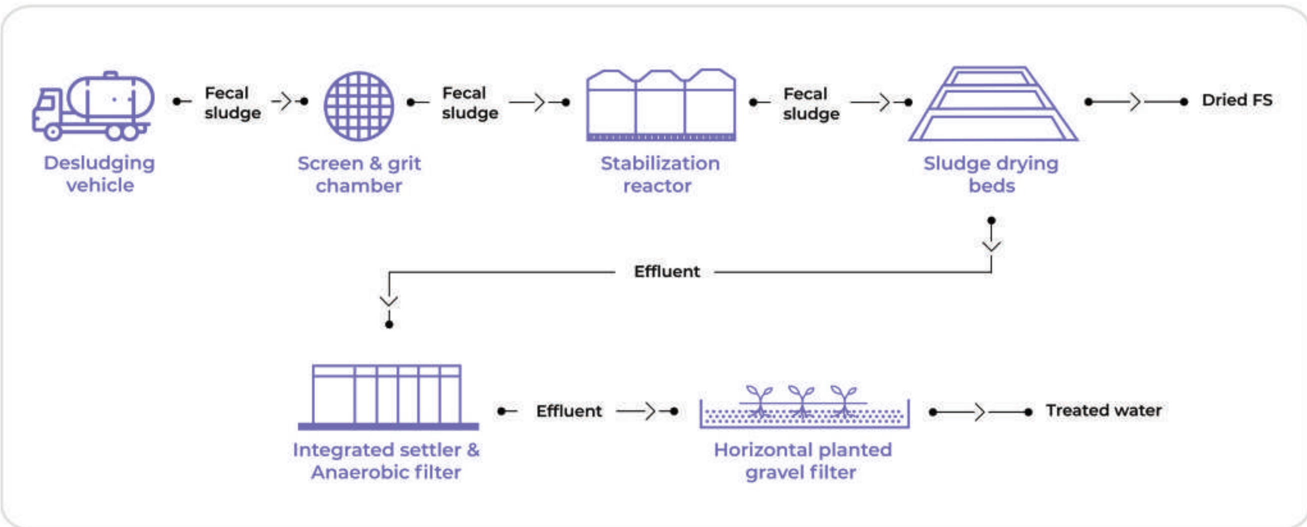
BOX 8. INTEGRATED FSM IN KHANDELA, RAJASTHAN.

Khandela is a small town selected by RUIDP for an integrated FSM solution – provision of E&T services and FSTP operation by one entity. CDD Society has been sub-contracted by IPE Global to design the FSTP, supervise construction, and provide technical support during O&M (Suman and Nagaraj 2018). The FSTP will have a capacity of 10 m^3 per day, and the design features biological processes – planted sludge drying beds combined with a DEWATS. RUIDP and Khandela Municipality have issued a five-year BOT contract to Divija Construction Private Limited. for provision of desludging services and FSTP O&M, similar to the contract in the Lalsot case. The capital cost of the FSTP and one desludging vehicle is INR 22.6 million, and the estimated annual O&M cost is INR 0.7 million[15] (IPE Global Limited 2019). FSTP construction is expected to start in late 2019 (IPE Global Limited 2019).

Technology and processes

The capacity of the FSTP is 20 m^3 per day and is based on biological processes. The technology comprises a stabilization reactor and unplanted sludge drying beds, along with a DEWATS for effluent treatment. The FSTP is designed to use treated water from the FSTP for landscaping and treat dried sludge through co-composting and sell it to the farmers. The technology process is shown in Figure 49. In terms of desludging, the town has been provided with two vehicles with capacities of 1 and 4 m^3. The smaller vehicle will be used to provide desludging services to households in narrow lanes that are difficult to access (IPE Global Limited 2018).

FIGURE 49. TECHNOLOGY PROCESS OF THE LALSOT FSTP.



Source: IPE Global Limited 2018.

Funding and financial outlook

ADB provided a grant of USD 2 million to RUIDP for three pilot FSM projects. This grant comes from a Channel Financing Agreement between ADB and the BMGF for USD 15 million through a Sanitation Financing Partnership Trust Fund under the Water

[15] USD 1.00 = INR 71.25 as of October 2019.

Financing Partnership Facility. The total capital cost for the FSTP and desludging vehicles is INR 39.7 million, and the total estimated O&M cost annually is INR 0.84 million (IPE Global Limited 2019). According to the contract, Divija must complete at least 900 desludging trips each year. Divija plans to hire a driver for the vehicles and will engage one of the FSTP workers for desludging operations as and when required. The total project costs, including five years' O&M, are summarized in Table 10.

Lalsot municipality plans to cover the annual O&M cost of E&T and the FSTP through collection of desludging fees from households and businesses and additional fees for all households of either INR 10 each month on their water bills or INR 15 each month on the solid waste management fees.

TABLE 10. FINANCIAL OVERVIEW OF THE LALSOT INTEGRATED E&T AND FSTP MODEL.

Items	Cost in INR*
FSTP construction	37,500,000
Procurement of desludging vehicles	2,200,000
FSTP and desludging O&M for 5 years	4,200,000
Total Project Cost	**43,900,000**

Source: IPE Global Limited 2019.
* USD 1.00 = INR 71.25 as of October 2019.

References

GoR (Government of Rajasthan). 2018. *Faecal Sludge & Septage Management (FSSM).* Draft Policy. Jaipur, India: Government of Rajasthan. Available at http://urban.rajasthan.gov.in/content/dam/raj/udh/organizations/ruidp/MISC/FSSM%20Policy.pdf (accessed June 26, 2019).

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9.3 Business Model: Transfer Station

9.3.1 Value proposition

The model focuses on the E&T component in the sanitation value chain, through provision of intermediate transfer stations for FS.

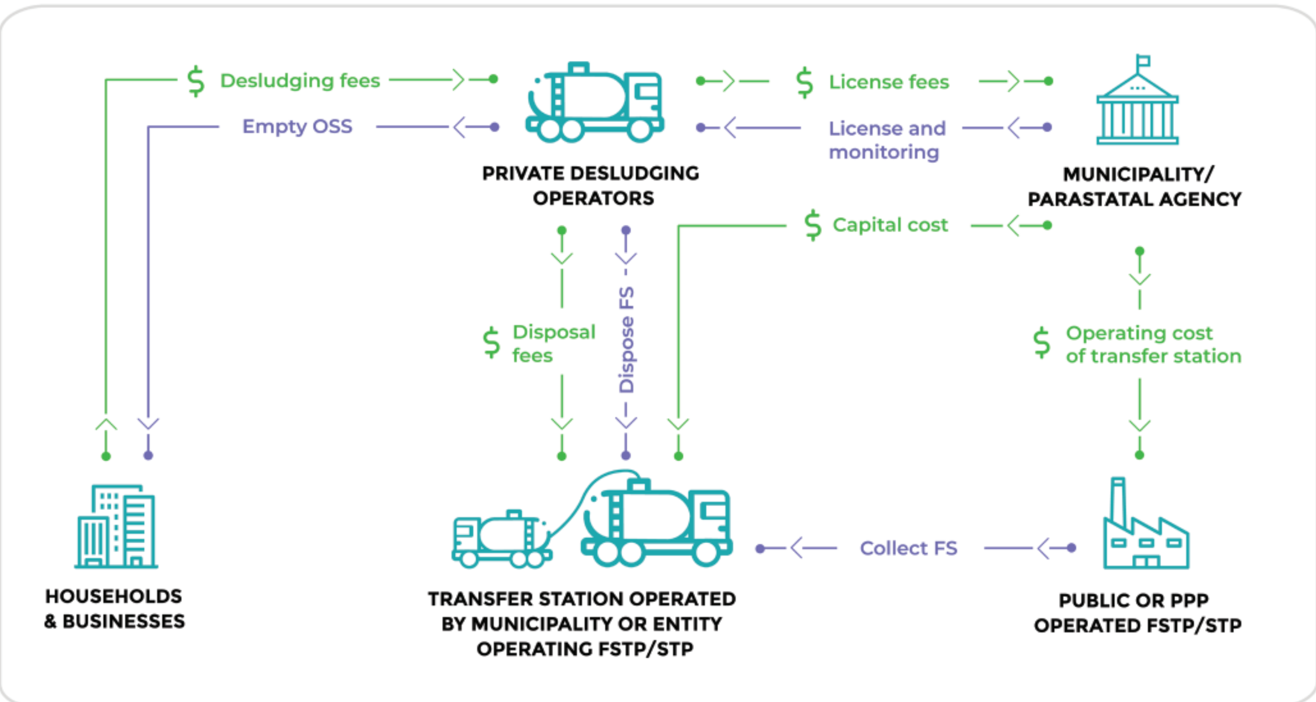
It offers the following value propositions:

- *Safe transportation of FS to treatment plants*
- *Reduction of transportation costs for E&T businesses*

9.3.2 Description

The biggest expenses for an E&T business are the labor (time) and transport (fuel) costs and are key factors for managing revenues and costs, respectively. Labor costs can be effectively utilized by ensuring more trips are undertaken daily. However, the time required to transport FS to a designated disposal site can limit the number of trips per day. Similarly, transport costs increase with distance and traffic density. Hence, for a desludging operator, the critical decision to dispose in the open as against transport of FS to a designated disposal site is heavily influenced by time and distance to the site. Increasing desludging prices is not always feasible, as it is dependent upon OSS users' ability and willingness to pay, along with pricing by other desludging operators. This model optimizes desludging operations by introducing conveniently located transfer stations where private desludging operators dispose of FS collected from households and businesses. The transfer station operator collects FS disposal fees from desludging operators. The entity operating the transfer stations can be the same entity operating the treatment plant, and, hence, it is responsible for transporting FS from the transfer stations to the treatment plant. The relationships among the various stakeholders are shown in Figure 50.

FIGURE 50. VALUE CHAIN OF THE TRANSFER STATION BUSINESS MODEL.



Broadly, there are two types of transfer stations:

1. **A fixed transfer station:** As the name suggests, these are permanent structures, often underground holding tanks with a connection to the sewerage network or an outlet pipe for transferring sludge into larger desludging trucks. In India, sewage pumping stations (SPS) can act as fixed transfer stations.

2. **A mobile transfer station:** Mobile units such as large desludging trucks or detachable tanker trailers are strategically located to collect FS from smaller desludging vehicles and transport it to a treatment plant.

Owner and operator: The business model is implemented by a municipality or a parastatal agency. The municipality/parastatal agency contracts operations of the transfer station to the entity managing the treatment plant.

9.3.3 Funding and financing

Capital cost: This is covered by the municipality/parastatal agency using its own funds or funds from state or national government programs for improving urban infrastructure.

Operating cost: The municipality or parastatal agency typically collects a small FS disposal fee from desludging operators at the transfer stations. However, the municipality/parastatal agency should cover the O&M cost of the transfer station through its own funds.

9.3.4 Risks and benefits

Risks

- The municipality must bear the cost of constructing and operating the transfer station

Benefits

- Enables private emptying operators to travel less distance to dispose of FS, thus reducing the cost to end-users as well as risk to the environment and public health from indiscriminate disposal

9.3.5 Relevance

Mostly applicable to large towns where private emptying operators may have to travel large distances to dispose of FS, which can be a disincentive for them. This model transfers some of the costs of transport to the treatment plant operator. Typically, such costs are borne by the government since it helps reduce direct user charges and leads to improved coverage of services. The report covers following case studies:

- Sewage Pumping Stations and Open Drain as FS Transfer Stations, Delhi, Tamil Nadu, and Uttar Pradesh (explained in this section)
- Co-Treatment of FS and Sewage at STPs in Panaji, Goa & Chennai, Tamil Nadu

Related models from other countries have been reported, e.g., in Accra, Ghana; Addis Adaba, Ethiopia; Blantyre, Malawi; Dhaka, Bangladesh; Lusaka, Zambia; Maseru, Lesotho; and locations across Malaysia.

CASE STUDY

Sewage Pumping Stations and Open Drains as Fecal Sludge Transfer Stations, Delhi, Tamil Nadu, and Uttar Pradesh

Location	New Delhi, Delhi; Coimbatore and Tiruchirappalli, Tamil Nadu; & Ghaziabad, Uttar Pradesh
Value offered	Safe collection and transport of FS
Organization type and name	Public sector – DJB, Coimbatore City Municipal Corporation (CCMC), Trichy Municipal Corporation (TMC), and Ghaziabad Nagar Nigam (GNN)
Project status	Operational since as early as 2011
Major partners	Private desludging operators
Financing entities and revenue source	***Capital cost:*** State and/or central government funds ***Operating cost:*** Disposal fees, license fees, and/or municipality funds

Context and background

Large cities in India often have UGDs, but a significant portion of the population is still served by OSS. The cities have SPS installed to move the sewage to the STPs. Some of the STPs are located at a distance from the city center and in regions where communities are dependent on OSS. While private desludging operators provide desludging services to OSS users, they are not provided with designated disposal points when there is no FSTP. STPs in India are largely operating well below their design capacities. SPS spread across the city can serve as FS disposal points for desludging operators. For this purpose, four cities – New Delhi, Coimbatore and Tiruchirappalli in Tamil Nadu, and Ghaziabad in Uttar Pradesh – have initiated disposal of FS by private desludging operators at SPS and other designated disposal points along the sewerage networks. These disposal sites are effectively working as FS transfer stations (NIUA 2017a, 2017b, 2017c).

Case description

This case of SPS and open drains as transfer stations in four cities is driven by the municipality or parastatal agency as described below:

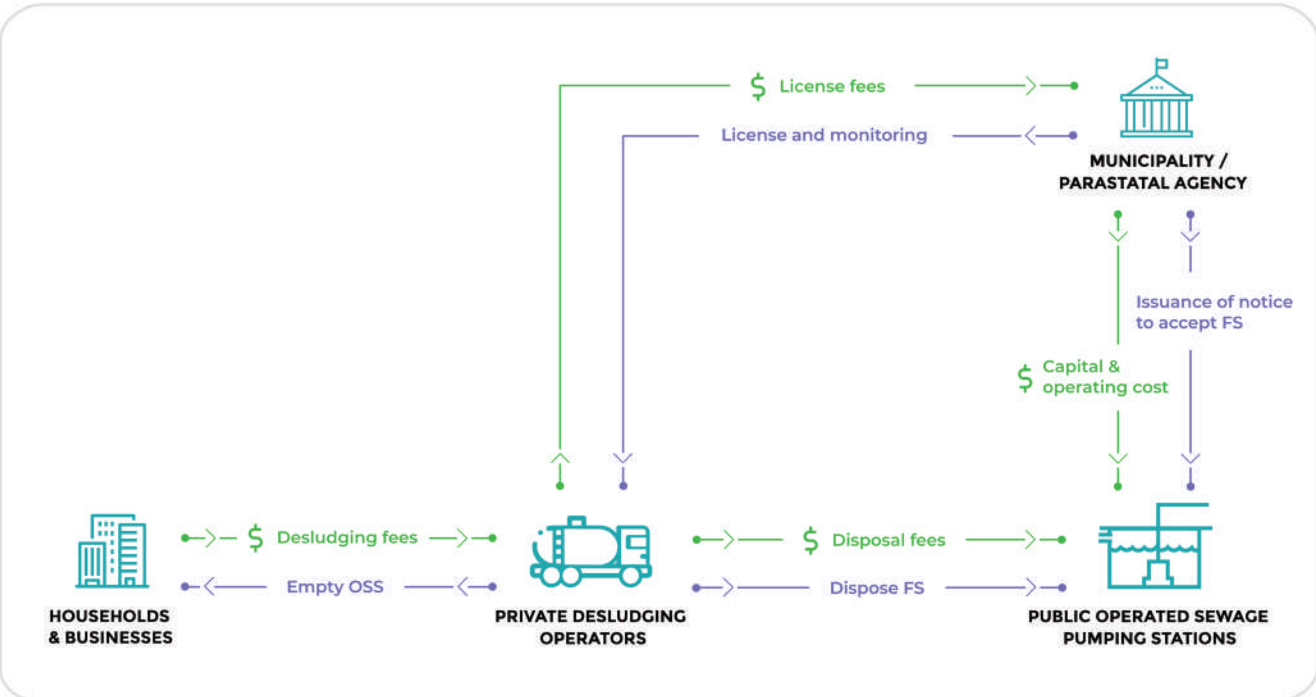
- In New Delhi, the DJB – the parastatal agency responsible for water supply and sewerage in Delhi – designates specific SPS as FS disposal points and issues licenses to private desludging

operators. The DJB collects annual license fees from the operators. It operates the SPS and STPs and monitors FS disposal at the SPS (Baruah 2019).

- In Tamil Nadu, the Government of Tamil Nadu, in its Operative Guidelines for Septage Management 2017 for Local Bodies in Tamil Nadu, designated STPs in Coimbatore and Tiruchirappalli for FS co-treatment and mandated the establishment of FS disposal points in the sewerage networks (Municipal Administration and Water Supply Department 2017).
  - In Coimbatore, the CCMC designated an open drain as an FS disposal point, issued licenses to private desludging operators, and imposed fines on unlicensed desludging operators. The CCMC collects FS disposal fees from the operators and operates the STP; no monitoring is carried out at the FS disposal point (NIUA 2017c).
  - In Tiruchirappalli, the TMC designated specific SPS as FS disposal points and retrofitted the stations to enable disposal of FS. The TMC owns and operates desludging trucks, which are used to desludge community toilets, and it issues licenses to private desludging operators. It collects annual license fees and FS disposal fees from the operators. The TMC operates the SPS and STPs and monitors FS disposal at the SPS (NIUA 2017b).
- In Ghaziabad, the GNN designated one SPS as an FS disposal point, issued licenses to private desludging operators, and regulated desludging fees charged by the private desludging operators to customers. The GNN collects annual license fees from the operators. It operates the SPS and STPs; no monitoring is carried out at the SPS (NIUA 2017a).

In the four cities, only registered private desludging operators and municipal desludging operators can use the designated disposal points. The relationships among the various stakeholders in the value chain are depicted in Figure 51.

FIGURE 51. VALUE CHAIN OF SPS AND OPEN DRAINS AS FS TRANSFER STATION MODEL.

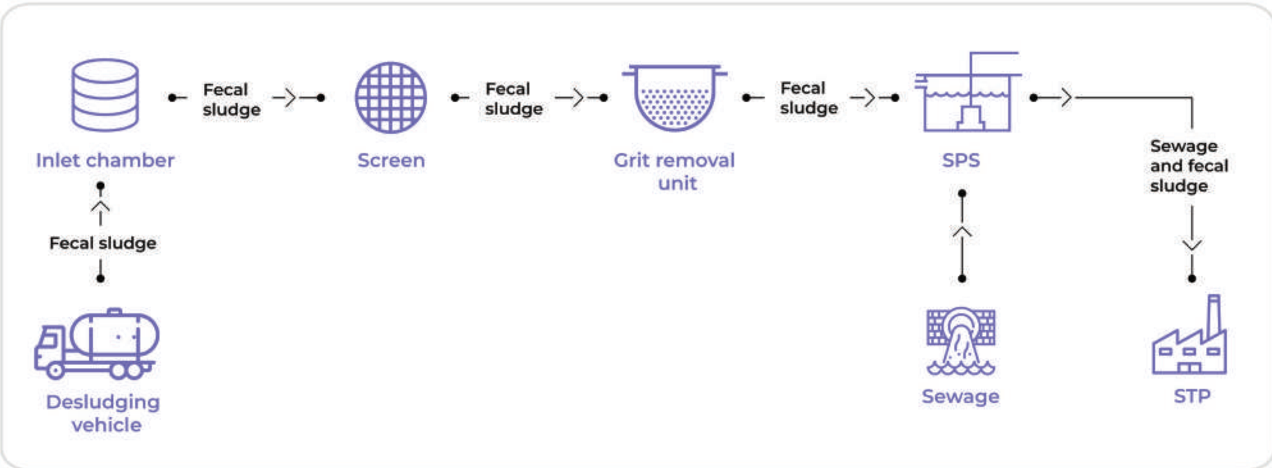


Technology and processes

In New Delhi, Tiruchirappalli, and Ghaziabad, SPS effectively act as FS transfer stations. In Coimbatore, an open drain 500m from the STP is the designated FS disposal point. In New Delhi, Coimbatore, and Ghaziabad, no retrofit measures have been undertaken at the SPS/open drains for the incoming FS. In Tiruchirappalli, an inlet chamber/storage tank and screens and grit removal chambers have been installed in three of the four designated SPS. This enables preliminary treatment of FS before it is mixed with sewage and conveyed to the STP. The other designated SPS in Tiruchirappalli has screens and grit removal chambers, but no inlet chamber. None of the sites undertake testing of FS before it is mixed with sewage (NIUA 2017a, 2017b, 2017c). The technology process for the Tiruchirappalli SPS is shown in Figure 52.

No measurable impact was observed on the treatment process in any of the STPs in the four cities, as the incoming FS load is less than 3% of the total load being treated in the STPs (NIUA 2017a, 2017b, 2017c).

FIGURE 52. TECHNOLOGY PROCESS OF THE TIRUCHIRAPPALLI SPS.



Source: NIUA 2017b.

Funding and financial outlook[16]

In New Delhi, Coimbatore, and Ghaziabad, there was no investment or retrofitting implemented, and hence, there was no associated capital cost. In Tiruchirappalli, the capital cost was minimal (data are not available) and was financed by the TMC. No additional operational cost was incurred at any of the sites.

- In New Delhi, the sole source of revenue is the annual license fees from private desludging operators. The annual license fee is INR 1,000 for each vehicle. As of May 2019, 150 desludging vehicles had been registered, generating revenue of INR 150,000 for the DJB (Baruah 2019)[17].
- In Coimbatore, no license fees are charged, and the sole source of revenue is fixed disposal fees of INR 1,500 for each desludging vehicle monthly. The annual revenue from disposal fees from the 65 registered vehicles is INR 1.17 million (NIUA 2017c).
- In Tiruchirappalli, there are two sources of revenue: annual license fees and disposal fees. The annual license fee is INR 2,000 for each desludging vehicle, and the disposal fee is INR 30 for each trip. With 41 registered vehicles, total annual revenue is estimated at INR 802,000 (NIUA 2017b).

[16] USD 1.00 = INR 65.11 in 2017.
[17] USD 1.00 = INR 69.77 in May 2019.

- In Ghaziabad, the sole source of annual revenue is license fees, at INR 2,000 for each vehicle. The annual revenue from 23 registered vehicles is INR 46,000 (NIUA 2017a).

In Coimbatore, due to a lack of registration fees and high fines levied on unregistered vehicles – INR 25,000 to 50,000 for each vehicle – all vehicles operating in the municipality have been registered (NIUA 2017c). In all the cities, regardless of whether tipping fees are charged, registered vehicles make two to three trips per day to the designated FS disposal points.

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NIUA. 2017c. *Ukkadam STP, Coimbatore: Co-treatment case study.* New Delhi, India: National Institute of Urban Affairs. Available at https://scbp.niua.org/download.php?fn=Coimbatore.pdf (accessed July 8, 2019).

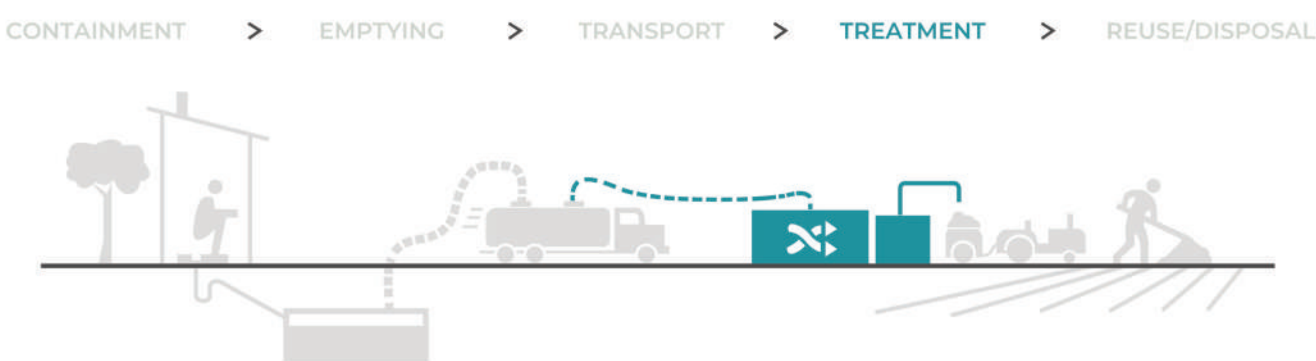
10. Models for Operating Treatment Plants

Business models in this section cover the treatment for disposal or reuse component in the sanitation value chain. The models offer the value proposition of treatment of FS for a healthy community and environment.

The simplest form of FS treatment is where an existing STP with excess capacity can accept the FS for co-treatment with sewage. In the absence of STPs, various business models are emerging for the implementation of standalone FSTPs. The government has traditionally provided sanitation services, and it is but natural that municipalities are managing FSTPs with the support of parastatal agencies. On the other hand, FSM being an emerging sector, PPPs allow for municipalities to share risk by sourcing private funds and technology.

Assuring viability for FSM projects has been a challenge. FSTPs being relatively low cost, and the per capita FS generation being very low, governments have had to cluster neighboring towns to generate sufficient scale for a viable FSTP. The following business models are explained in this section:

1. Government-managed FSTPs
2. Cluster FSTPs
3. Public-private partnership FSTPs
4. Co-treatment



10.1 Business Model: Government-managed FSTP

10.1.1 Value proposition

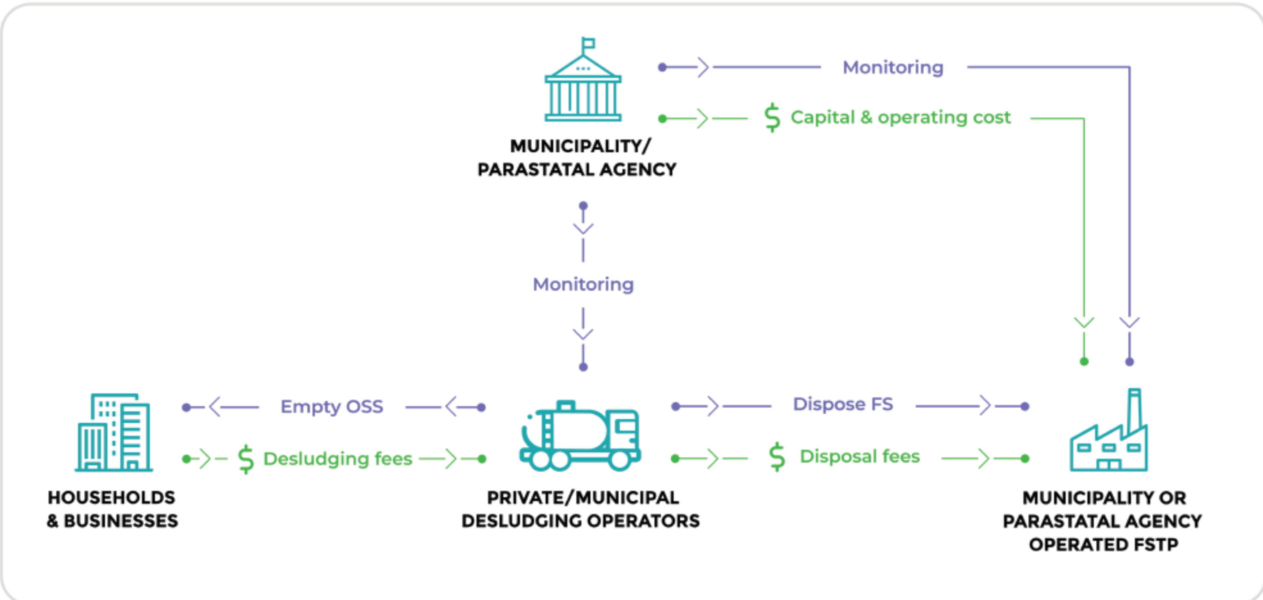
The model focuses on the treatment component in the sanitation value chain. It offers the value proposition of treatment of FS for a healthy community and environment.

10.1.2 Description

The government finances, designs, constructs, and manages the operations of the FSTP. FS is collected by municipal or private desludging operators and transported to the FSTP. The municipality or parastatal agency conducts self-regulation and monitors FSTP operations. The model depends on the financial and technical skills of the local and/or state government to implement the FSTP. The relationships among the various stakeholders are shown in Figure 53.

Owner and operator: The business model is implemented by the state government or the municipality. The municipality or a parastatal agency owns and operates the FSTP.

FIGURE 53. VALUE CHAIN OF THE GOVERNMENT-MANAGED FSTP BUSINESS MODEL.



10.1.3 Funding and financing

Capital cost: This is covered by funds from state or central government programs for improving urban infrastructure. Sometimes a donor may provide a grant to the municipality to build the FSTP.

Operating cost: The state or municipality typically finances this cost through a combination of local taxes and state and central government financial assistance. The FSTP could generate revenue from the disposal fees charged to desludging operators and from sales of FSTP by-products.

10.1.4 Risks and benefits

Risks

- Budget limitations and lack of capacity results in poor management of the FSTP

Benefits

- Model ensures public health and environmental outcomes

10.1.5 Relevance

Highly applicable for small towns where private entities may not find it viable to undertake O&M of FSTPs. The report covers following case studies:

- Bhubaneswar Government-managed SeTP, Bhubaneswar, Odisha (explained in this section)
- Karunguzhi-Maduranthagam Cluster FSTP, Karunguzhi, Tamil Nadu

Related models from other countries have been reported, e.g., in Gulariya, Nepal; Hanoi and Ho Chi Minh City, Vietnam; Korhogo, Côte d'Ivoire; Kossodo, Sourgobila, and Zagtouli, Burkina Faso; and locations across Malaysia.

CASE STUDY

Bhubaneswar Government-managed SeTP, Odisha

Location	Bhubaneswar, Odisha
Value offered	Treated FS and treated water for landscaping
Organization type and name	Public – OWSSB
Project status	Operational since 2018
Major partners	Bhubaneswar Municipal Corporation (BMC), H&UDD, Government of Odisha, OWSSB, and Ernst & Young – as the TSU funded by the BMGF
Financing entities and revenue source	***Capital cost:*** GoI Programs ***Operating cost:*** OWSSB and revenue from surplus power generated by a solar photovoltaic system

Context and background

In Odisha, 53% of urban households rely on OSS. Until 2016, only 2% of FS was safely treated and disposed (Nayak 2016). In order to address FSM, the Government of Odisha published the Odisha Urban Septage Management Guidelines & Regulations in 2016 and Odisha Urban Sanitation Policy in 2017 (Panda 2018; Government of Odisha 2016, 2018). The latter policy mandates prioritizing FSM and allows sewerage plans in cities with populations of 100,000 and above. The OWSSB, a parastatal agency responsible for the provision of sanitation services, was assigned as the implementing agency for the FSM policy. Nine towns were chosen to implement FSM solutions, including SeTPs; treatment plants in Odisha only accept septage from OSS, rather than unstabilized FS. The GoI's AMRUT programme financed the SeTPs in these towns. Currently, more than 39% of the urban population in Odisha is linked to FS treatment facilities, and another 44% will be linked to treatment units that are at various stages of development. Around 80% of the municipalities without FS treatment facilities have constructed Deep Row Trenches as interim disposal measures, to prevent pollution from unsafe disposal of FS. Six SeTPs were inaugurated in October 2018, including one in Odisha's capital city, Bhubaneswar, where 75% of people rely on OSS (Ernst & Young 2017).

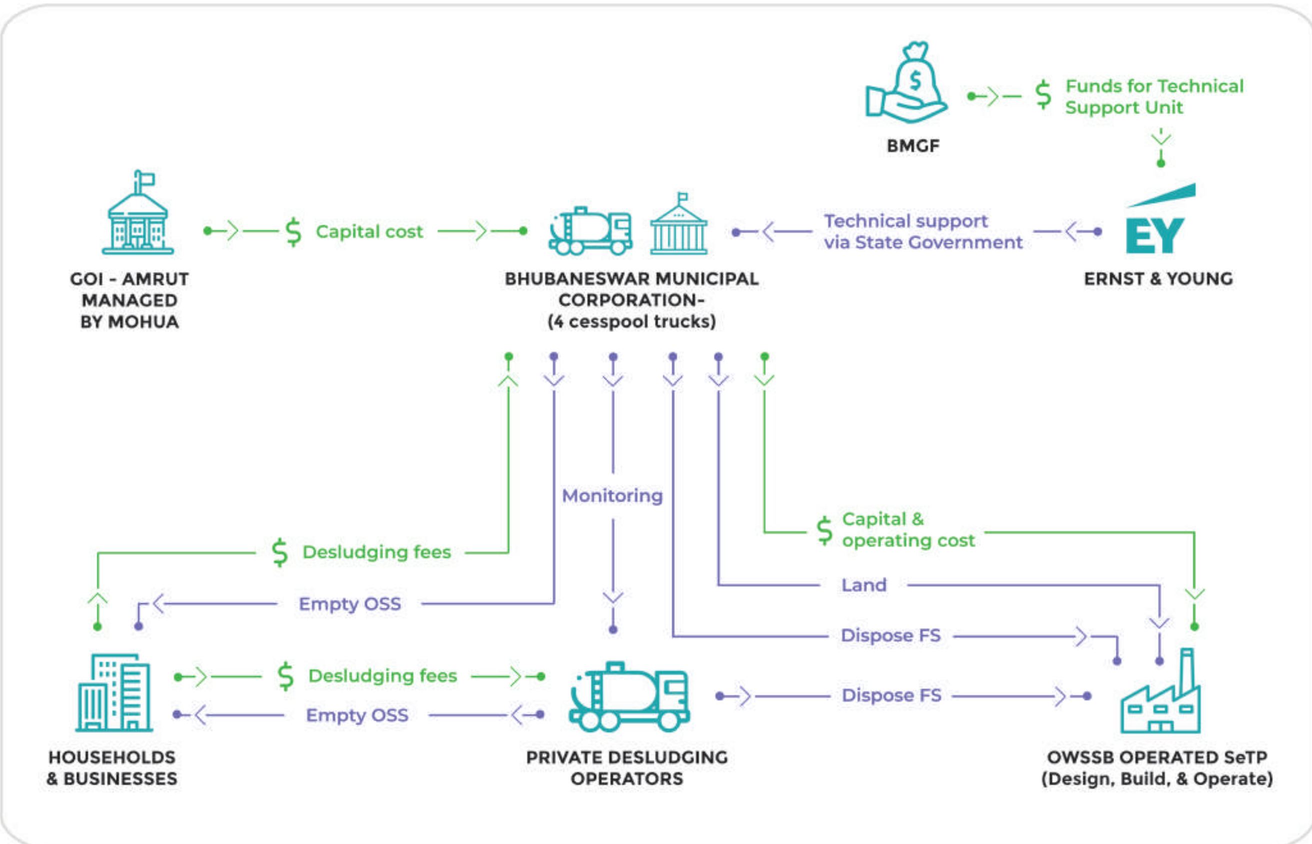
Key indicators (as of April 2019)	
Installed capacity	75 m^3/day
Allocated land area	2.5 acres
Labor requirements	8 persons (FTE)
Inputs	Raw septage – 35-45 m^3/day, up to 75 m^3/day
Outputs	Dried sludge and treated water (not valorized)

Case description

The OWSSB designed the SeTP and supervised the plant's construction. The design was validated by the Indian Institute of Technology Kharagpur. The SeTP was co-located at a proposed STP site in Bhubaneswar. The BMC owns four desludging vehicles and transports FS to the SeTP. The plant also receives FS from private desludging operators. The OWSSB is responsible for managing the SeTP and covering its O&M cost (Eawag and Sandec 2018, 2019).

The OWSSB drafted standard operating procedure for SeTP O&M and updates them periodically. Since 2017, Ernst & Young, an international consulting firm, established a TSU on FSM within the Government of Odisha, with funding from the BMGF, to support the state government, OWSSB, and municipalities in FSM implementation. In Bhubaneswar, Ernst & Young supports the E&T component, aiming to ensure that higher quantities of FS are delivered to the SeTP. This is accomplished by facilitating enforcement of the Faecal Sludge and Septage Management Regulations, 2018, which have made indiscriminate disposal an illegal and punishable offense (BMC 2018). The relationships among the various stakeholders in the value chain are depicted in Figure 54.

FIGURE 54. VALUE CHAIN OF THE BHUBANESWAR GOVERNMENT-MANAGED SeTP MODEL.

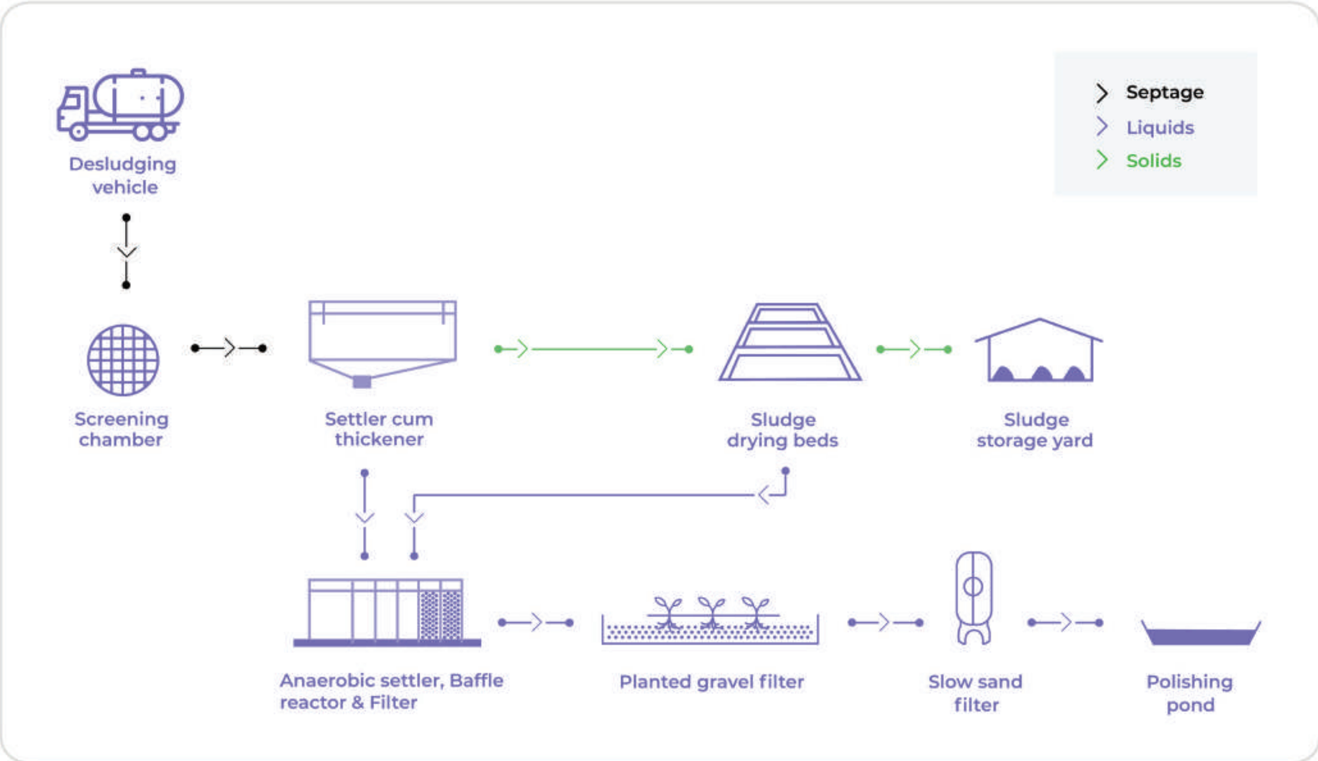


Technology and processes

The installed capacity of the SeTP is 75 m^3 per day, and, on average, the plant receives about 60% of installed capacity. The technology consists of biological processes and requires minimal maintenance and low labor skills. The desludging vehicle decants FS into the intake and screening chamber, and from there, FS moves to settling

thickening tanks (STT), where solid-liquid separation occurs. The thickened sludge is pumped from the STT onto unplanted sludge drying beds. Dried sludge from the drying beds is placed in a dried sludge storage shed. The effluent from the STT and unplanted sludge drying beds flows through DEWATS and a slow sand filter and is collected in a polishing pond (Eawag and Sandec 2018, 2019). The process is shown in Figure 55.

FIGURE 55. TECHNOLOGY PROCESS OF THE BHUBANESWAR GOVERNMENT-MANAGED SeTP.



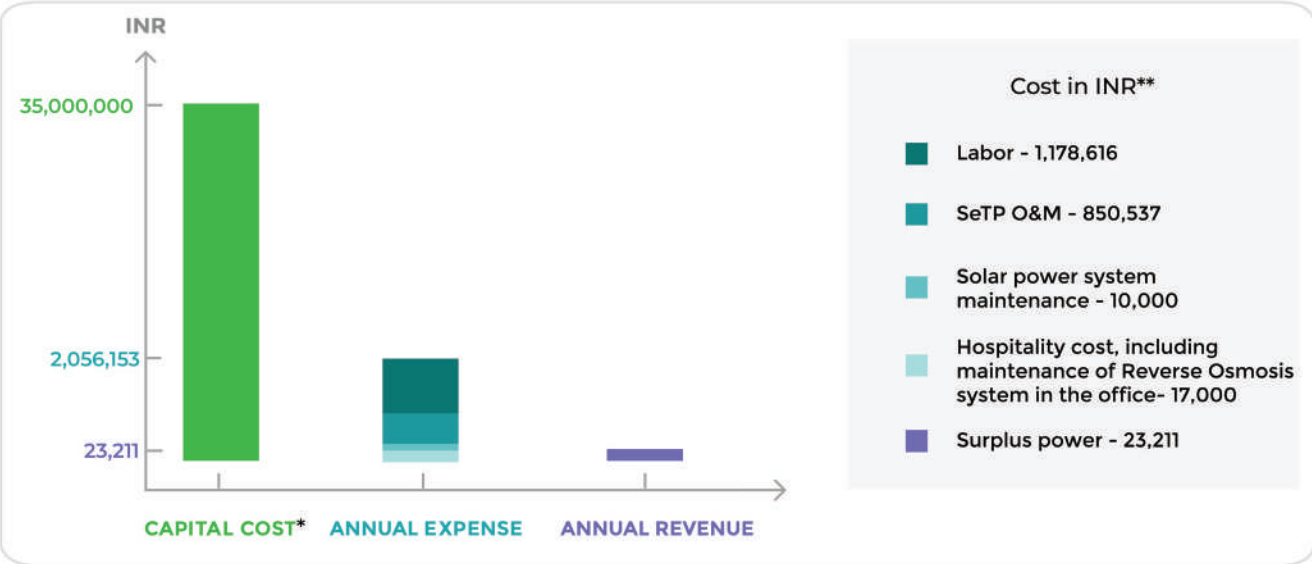
Source: Ernst & Young 2019.

All SeTP operations are powered by a solar photovoltaic system, and surplus power is sold to the grid. An onsite laboratory tests the influent and effluent of each treatment module of the SeTP on a weekly basis. Treated water from the plant is used for landscaping at the SeTP. The SeTP was initially underutilized due to fewer private desludging operators coming to the plant; however, the capacity utilization has improved, reaching 100% on some days, due to the implementation of the FSSM Regulations, 2018 (BMC 2018). A coordinated effort from local enforcement authorities (the BMC, the police, and the Regional Transport Office) helped bring about this change. Now, the BMC and private desludging vehicles transport FS to the SeTP.

Funding and financial outlook

The capital cost for the SeTP was INR 35 million and was funded under AMRUT. The annual operational cost is approximately INR 2.06 million. Labor accounts for over half of the O&M cost and includes one chemist-cum-plant manager, one pump operator, two sweepers, and four guards. The OWSSB allocates funds from its budget to cover the O&M cost. The SeTP generates revenue from surplus power produced by the onsite solar photovoltaic system. Figure 56 provides a financial breakdown of the Bhubaneswar SeTP.

FIGURE 56. FINANCIAL OVERVIEW OF THE BHUBANESWAR GOVERNMENT-MANAGED SeTP MODEL.



Source: Ernst & Young.
* USD 1.00 = INR 73.59 in October 2018.
** USD 1.00 = INR 71.25 as of October 2019.

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10.2 Business Model: Cluster FSTP

10.2.1 Value proposition

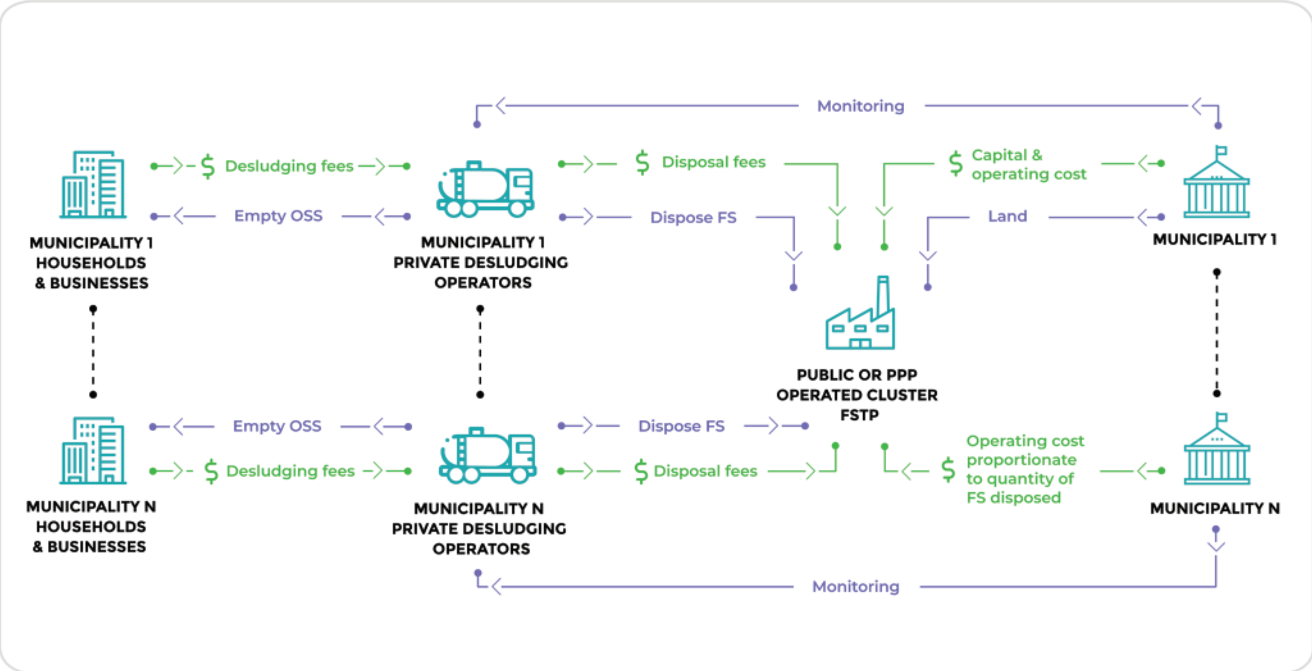
The model focuses on the treatment component in the sanitation value chain. It offers the value proposition of FS treatment from multiple municipalities for a healthy community and environment.

10.2.2 Description

The model entails treatment of FS from two or more municipalities in a single FSTP. The cluster FSTP should be strategically located within a 10 to 15 km radius of each municipality so that E&T operators dispose of FS at the FSTP. In a cluster FSTP model, one of the municipalities provides land for the FSTP and finances FSTP operations. The lead municipality signs a memorandum of understanding (MoU) with one or more nearby municipalities. All involved municipalities ensure that municipal and private desludging operators in their respective jurisdictions transport FS to the FSTP. The relationships among the various stakeholders are shown in Figure 57.

Owner and operator: The business model is implemented by a public entity (typically a parastatal agency or state agency). The municipality that provides land for the FSTP is the owner of the plant. This municipality can either manage the operations or contract operations to a private entity.

FIGURE 57. VALUE CHAIN OF THE CLUSTER FSTP BUSINESS MODEL.



10.2.3 Funding and financing

Capital cost: This is mostly covered by grants from donors or funds from state or central government programs for improving urban infrastructure.

Operating cost: The municipality in charge of FSTP management typically finances this cost through a combination of local taxes and state and central government financial assistance. As part of the MoU, participating municipalities can agree to pay a fixed operating cost or part of the cost based on the quantity of FS disposed of at the cluster FSTP.

10.2.4 Risks and benefits

Risks

- The institutional mechanism for ownership of shared assets amongst multiple municipalities is unclear; therefore, responsibility of sustaining FSTP operations largely falls on one municipality

Benefits

- Clustering enables achievement of economies of scale, hence, lowering costs

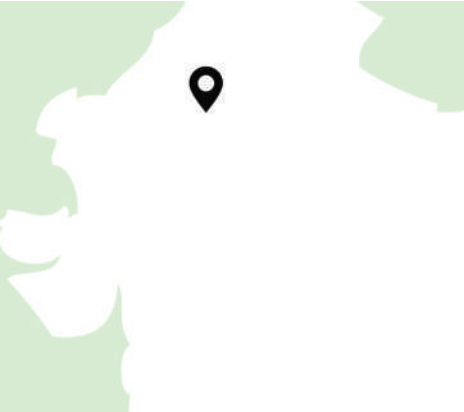
10.2.5 Relevance

Applicable for small towns that are within a viable transportation distance of the site identified for the FSTP. The following case studies are explained in this section:

- Sambhar-Phulera Cluster FSTP, Phulera, Rajasthan
- Karunguzhi-Maduranthagam Cluster FSTP, Karunguzhi, Tamil Nadu

CASE STUDY

Sambhar-Phulera Cluster FSTP, Rajasthan



Location	Phulera, Rajasthan
Value offered	Treated FS for two municipalities and treated water for irrigation/gardening
Organization type and name	PPP – Phulera Municipality and Divija Construction Private Limited
Project status	Under construction and to be commissioned in late 2019
Major partners	RUIDP, IPE Global Limited, CDD, and ADB
Financing entities and revenue source	***Capital cost:*** ADB grant ***Operating cost:*** User fees and/or municipality

Context and background

The GoR Sewerage and Wastewater Policy 2016 plans to expand sewerage networks, which would serve 60% of the state's urban population; the remaining 40% would be dependent upon FSM. Furthermore, many towns in Rajasthan have limited funding available, and with insufficient water supply, the technical viability of sewerage networks is unclear. In view of this, the GoR took a policy decision to address full scale FSM for urban towns with populations of less than 50,000 and partial and gap-filling FSM for other towns. To address the constraints of availability of funds, the policy recommends the clustering of adjacent municipalities to treat FS. A total of 24 clusters were identified for either co-treatment or sharing of FSTPs (GoR 2018). To demonstrate the cluster-based FSM approach for small towns, the GoR initiated a pilot through RUIDP. Sambhar and Phulera are the two small towns selected for the pilot and are in close proximity to one another – around 10 km apart. A site between the two towns was selected for the FSTP (RUIDP 2018). Currently, the FSTP is under construction is expected to be commissioned in late 2019.

Key indicators (as of March 2019)	
Designed capacity	20 m^3/day
Allocated land area	1.31 acres
Labor requirements	4 persons (FTE) – 1 operator and 3 additional workers

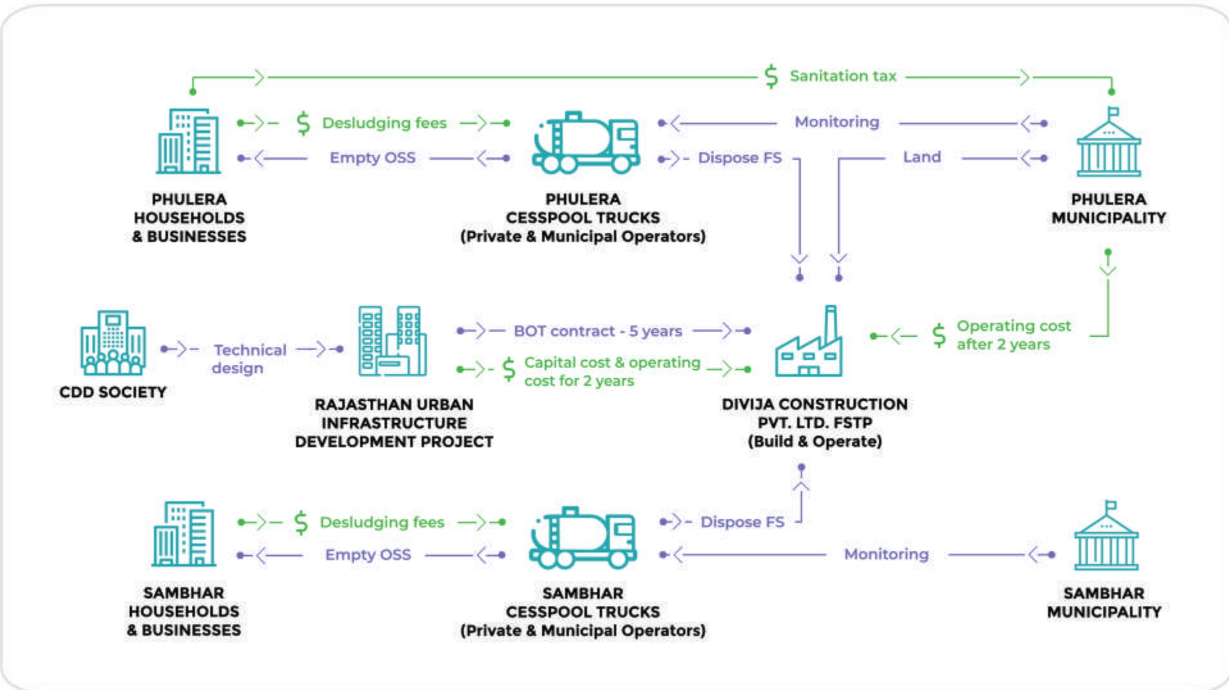
Case description

RUIDP was the primary agency responsible for project management, and it contracted IPE Global Limited (IPE Global), a consulting agency, for project implementation – FSTP design, construction supervision, and technical support during O&M and drafting of FSM policy and operative guidelines. IPE Global, in turn, contracted FSTP design, construction supervision, and technical support during O&M to the CDD Society. Phulera municipality provided land for the FSTP. Based on the designs developed by the CDD Society,

RUIDP and Phulera municipality tendered FSTP construction and five years' O&M to Divija Construction Private Limited. RUIDP provided funds for the capital cost and O&M for the first 2 years of operations, after which it is the responsibility of Phulera municipality. To cover this cost, Phulera municipality plans to collect sanitation tax, either through a sanitation surcharge on water bills collected by the PHED or sanitation cess on SWM fees collected by Phulera municipality.

Sambhar municipality is not required to collect additional taxes and does not have to pay towards FSTP O&M. Both municipalities have municipal desludging vehicles and must ensure that FS is transported to the FSTP. Phulera has private desludging operators who will register with the municipality and will be required to dispose of FS at the FSTP. Both towns have plans to implement scheduled desludging to ensure a regular supply of FS to the FSTP. Treated effluent from the FSTP will be used for gardening and irrigation, and there are plans to mix dried sludge with organic waste to make co-compost, which would then be given to farmers (CDD Society 2017). The relationships among the various stakeholders in the value chain are depicted in Figure 58.

FIGURE 58. VALUE CHAIN OF THE SAMBHAR-PHULERA CLUSTER FSTP MODEL.



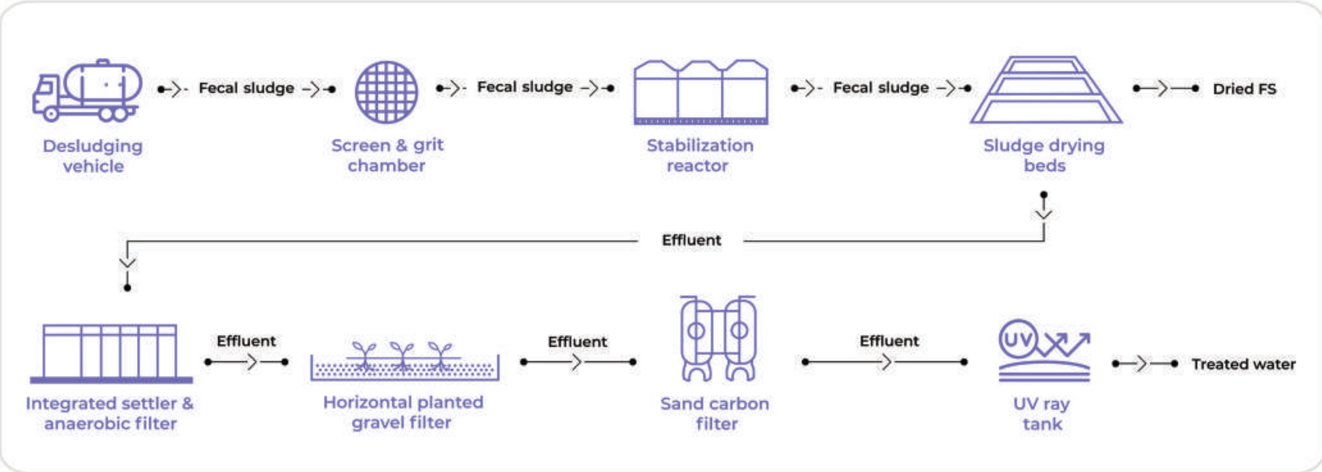
Technology and processes

The capacity of the FSTP is 20 m^3 per day to cater to the population of both towns and, probably, surrounding villages too. The technology comprises of a stabilization reactor and unplanted sludge drying beds, along with a DEWATS system, sand carbon filter, and UV ray tank for effluent treatment (CDD Society 2017). This design has both biological and mechanized processes and pumps are required at different stages. The mechanized processes will require electricity and skilled labor. The technology process is shown in Figure 59.

Funding and financial outlook

The capital cost for the FSTP is INR 28.9 million, which is financed through a grant from ADB. The grant covers the O&M cost for two years (IPE Global Limited 2019). Plant operations require one operator and three additional workers (CDD Society 2017). The estimated capital cost and expenses are summarized in Table 11.

FIGURE 59. TECHNOLOGY PROCESS OF THE SAMBHAR-PHULERA CLUSTER FSTP.



Source: CDD Society 2017.

TABLE 11. FINANCIAL OVERVIEW OF THE SAMBHAR-PHULERA CLUSTER FSTP.

Items	Cost in INR*
Capital Cost	28,900,000
Annual O&M Expense	880,000
Total Project Cost (including 5 years' O&M)	**33,300,000**

Source: IPE Global Limited 2019.
* USD 1.00 = INR 71.25 as of October 2019.

Phulera municipality plans to cover the annual O&M cost of E&T and FSTP through collection of sanitation tax from every property, through additional fees of either INR 15 each month on the SWM fees or INR 10 each month on their water bills. The municipality has 90% water connection coverage, and the PHED would collect the amount and transfer it to the Department of Local Self Government, which in turn would transfer the funds to Phulera municipality.

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CASE STUDY

Karunguzhi-Maduranthagam Cluster FSTP, Tamil Nadu

Location	Karunguzhi, Tamil Nadu
Value offered	Treated FS and organic waste, production of co-compost as soil ameliorant and treated water for irrigation/gardening
Organization type and name	Government – Karunguzhi Town Panchayat (KTP)
Project status	Operational since August 2017
Major partners	Indian Institute for Human Settlements (IIHS), Government of Tamil Nadu (GoTN), Tamil Nadu Water Supply and Drainage Board (TWAD)
Financing entities and revenue source	***Capital cost:*** GoTN through TWAD ***Operating cost:*** GoTN (until 2021) & KTP

Context and background

In September 2014, the GoTN issued Septage Management Operative Guidelines. In 2015, the BMGF supported the establishment of a TSU led by the IIHS called the Tamil Nadu Urban Sanitation Support Programme (TNUSSP) within the TWAD to aid the GoTN in its urban sanitation mission (TNUSSP 2019b). The KTP was selected as a pilot site, due to the town's lack of sewerage and the potential for a cluster FSTP solution with a nearby municipality. In 2018, a cluster FSTP was commissioned in Karunguzhi to serve the populations of both KTP and Maduranthagam municipality (TNUSSP 2019a).

Key indicators (as of April 2019)	
Installed capacity	23 m³/day
Allocated land area	2 acres
Labor requirements	4 persons (FTE) – 2 plant operators, 1 supervisor, & 1 gardener
Inputs	Raw FS: 11-13 m³/day; organic waste: 100 kg/day co-composted with dried sludge
Outputs	300 kg co-compost (first batch, monthly production)

Case description

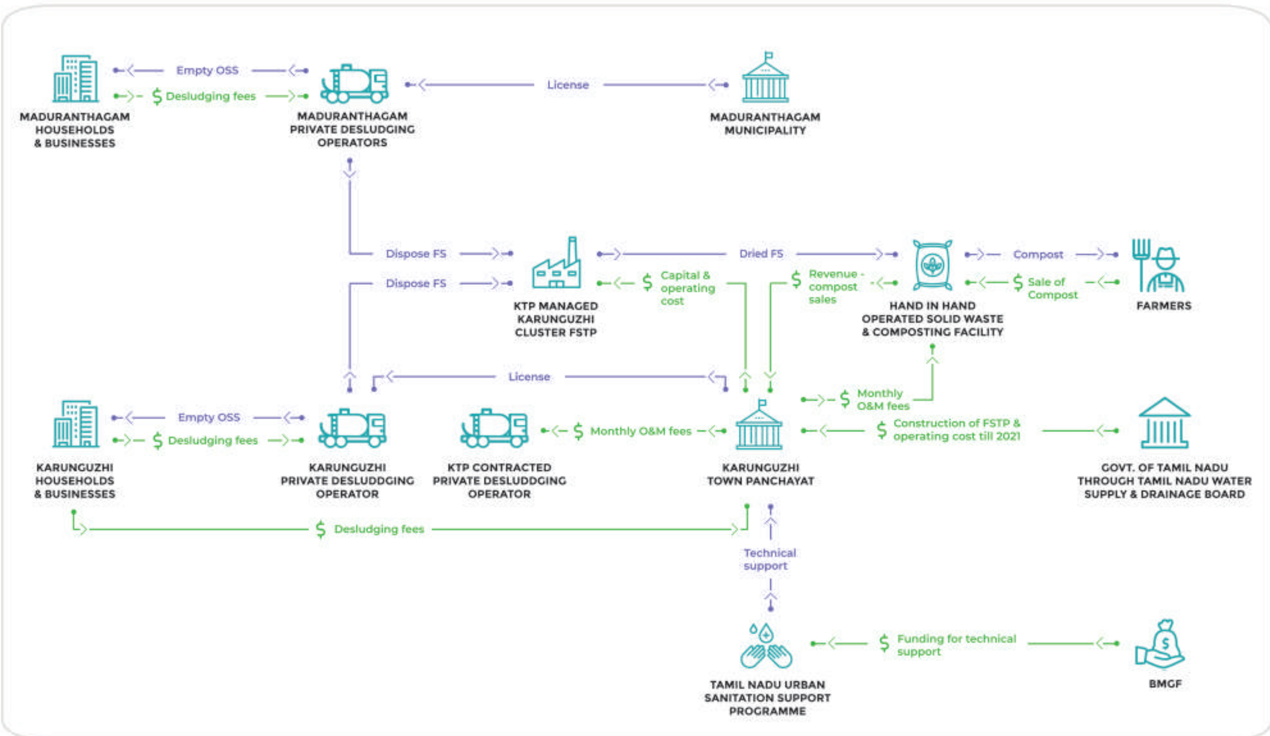
The TWAD was the lead agency and conceptualized the cluster FSTP for Karunguzhi and Maduranthagam, identified Karunguzhi as the site for the FSTP, and got approval from the Tamil Nadu Directorate of Town Panchayats (DTP) for the land and construction of the treatment plant. TWAD undertook the construction of the FSTP and managed its

operations for the first year. GoTN is financing the capital and O&M cost until 2021. IIHS provided technical support to develop a web-based platform to track household desludging, created an FSTP operations manual, and facilitated testing through external agencies and private laboratories of FSTP effluent and co-compost. In November 2018, the cluster FSTP operations was handed over to the KTP, which issued a labor contract to the NGO Hand in Hand to run the FSTP operations. The KTP continues to manage and oversee the operations of the unit.

The KTP handles FSTP operations and ensures that the private desludging operator in Karunguzhi disposes of FS in the FSTP. The KTP provides a license to a private desludging operator. The KTP has contracted desludging operations to a private operator in Karunguzhi and regulates desludging fees charged to the households. The KTP receives customer requests for desludging and passes on the requests to the operator. The customer can also directly contact the desludging operator. The KTP collects fees from the households and pays the desludging operator on a monthly basis based on the number of trips made to the FSTP to dispose of FS, which the FSTP operator tracks. The KTP charges disposal fees to the operator, which are deducted by the KTP from collected desludging fees based on the number of trips. The KTP plans to implement scheduled desludging and is currently issuing notices and assigning unique identification numbers to all the listed properties. Under the cluster operations, Maduranthagam municipality is responsible for issuing licenses and ensuring private desludging operators dispose of FS at the Karunguzhi FSTP; this is still under discussion.

The FSTP has two by-products: treated water and dried sludge. Treated water is used for onsite landscaping. Hand in Hand has a contract from KTP to operate a SWM facility to produce compost. Since March 2019, dried sludge from the FSTP has been transported to the SWM facility for co-composting. The SWM facility produces three compost streams – vermicompost, bio-compost made with cow dung, and co-compost. The compost is sold directly to farmers, and the revenue from the sale of compost is given to the KTP. The relationships among the various stakeholders in the value chain are depicted in Figure 60.

FIGURE 60. VALUE CHAIN OF THE KARUNGUZHI-MADURANTHAGAM CLUSTER FSTP MODEL.

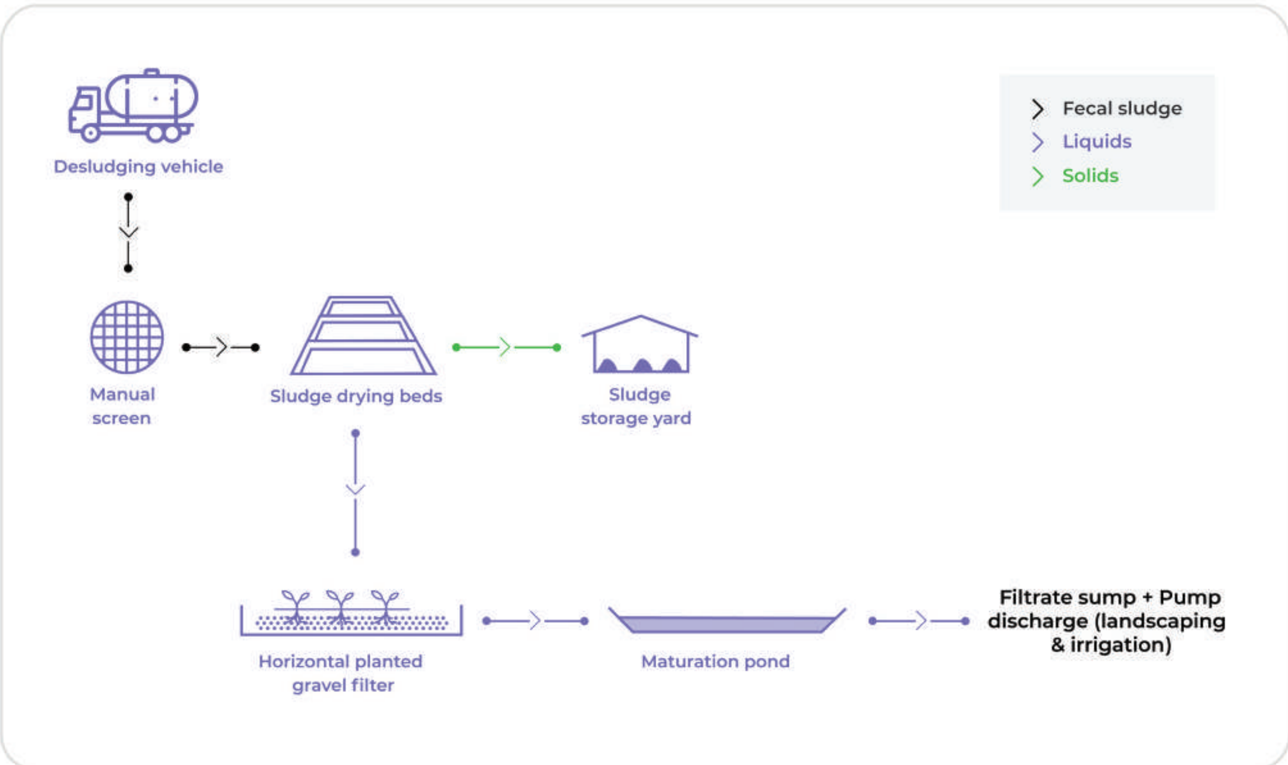


In June 2018, due to the success of the Karunguzhi pilot, the GoTN sanctioned INR 2 billion to build 49 FSTPs across the state under the Commissionerate of Municipal Administration. Eleven cluster FSTPs are being constructed in other town panchayats under the DTP based on the Karunguzhi model (MoHUA 2019).

Technology and processes

The plant capacity is 23 m^3 per day, and it currently receives about two truckloads of FS each day and processes 11 to 13 m^3 per day of FS. The technology comprises unplanted sludge drying beds for solid and liquid separation, with the effluent from the drying beds being treated in a horizontal planted gravel filter and a maturation pond. The process is given in Figure 61. The dried sludge is co-composted with organic waste at the SWM facility at a ratio of 1:3, and the treated effluent is collected in a filtrate sump for landscaping and irrigation purposes. The FSTP has received ISO 14001:2015 certification (TNUSSP 2019a).

FIGURE 61. TECHNOLOGY PROCESS OF THE KARUNGUZHI-MADURANTHAGAM CLUSTER FSTP.

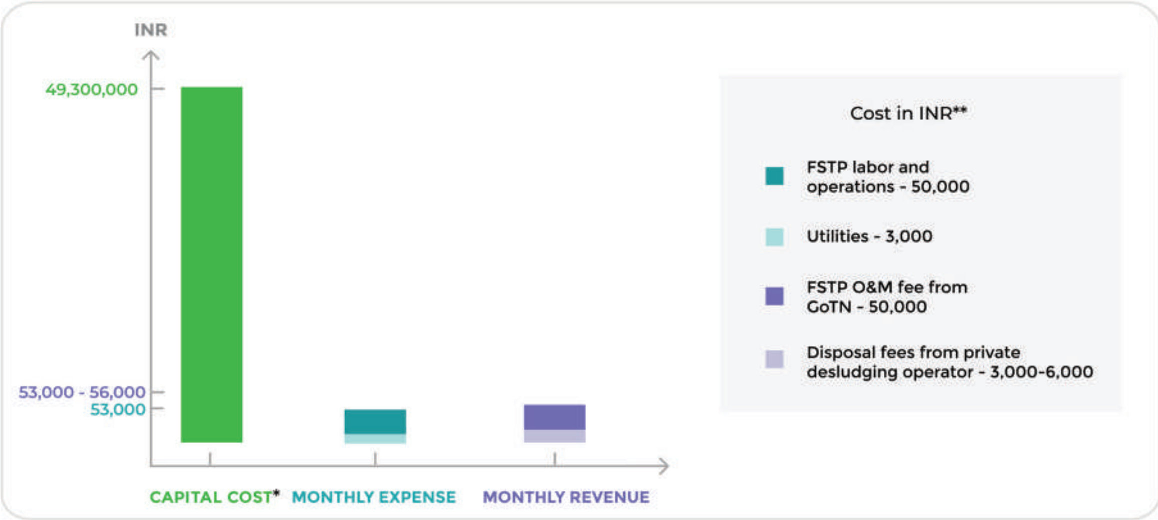


Source: KTP 2019; TNUSSP 2019a.

Funding and financial outlook

The capital cost of the FSTP is INR 49.3 million (CSE 2019) and was provided by the GoTN, along with one year of O&M, which was later extended to 2021. Most of the capital cost went towards site development, due to the challenging site conditions. The KTP uses existing contracted labor for FSTP operations. Other costs incurred by the FSTP, such as utilities, are paid for directly by the KTP. There is no additional labor required for co-composting, since it is done at the existing SWM facility run by Hand in Hand. KTP generates revenue from the FS disposal fees. The desludging fee is currently fixed at INR 1,600 per 6 m^3 tank, which includes INR 100 for the disposal fee and INR 1,500 for the private operator. The operator makes one to two trips per day to the FSTP. The costs and revenue for the KTP are summarized in Figure 62.

FIGURE 62. FINANCIAL OVERVIEW OF THE KARUNGUZHI-MADURANTHAGAM CLUSTER FSTP MODEL.



Source: Karunguzhi Town Panchayat.
* USD 1.00 = INR 63.92 in August 2017.
** USD 1.00 = INR 71.25 as of October 2019.

The KTP plans to increase its revenue from disposal fees by charging INR 100 to private desludging operators from Maduranthagam and other nearby towns at the FSTP. The KTP plans to expand FSTP coverage to three additional town panchayats near Karunguzhi.

Revenue from compost sales is currently minimal, around INR 1,500 each month for 300 kg of vermicompost and bio-compost (co-compost has not been sold yet), compared to 3 to 4 MT produced each month. Hand in Hand has not found a reliable market for compost, as it does not have a separate marketing and sales team. Currently, it sells compost to individual farmers.

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10.3 Business Model: Public-Private Partnership FSTP

10.3.1 Value proposition

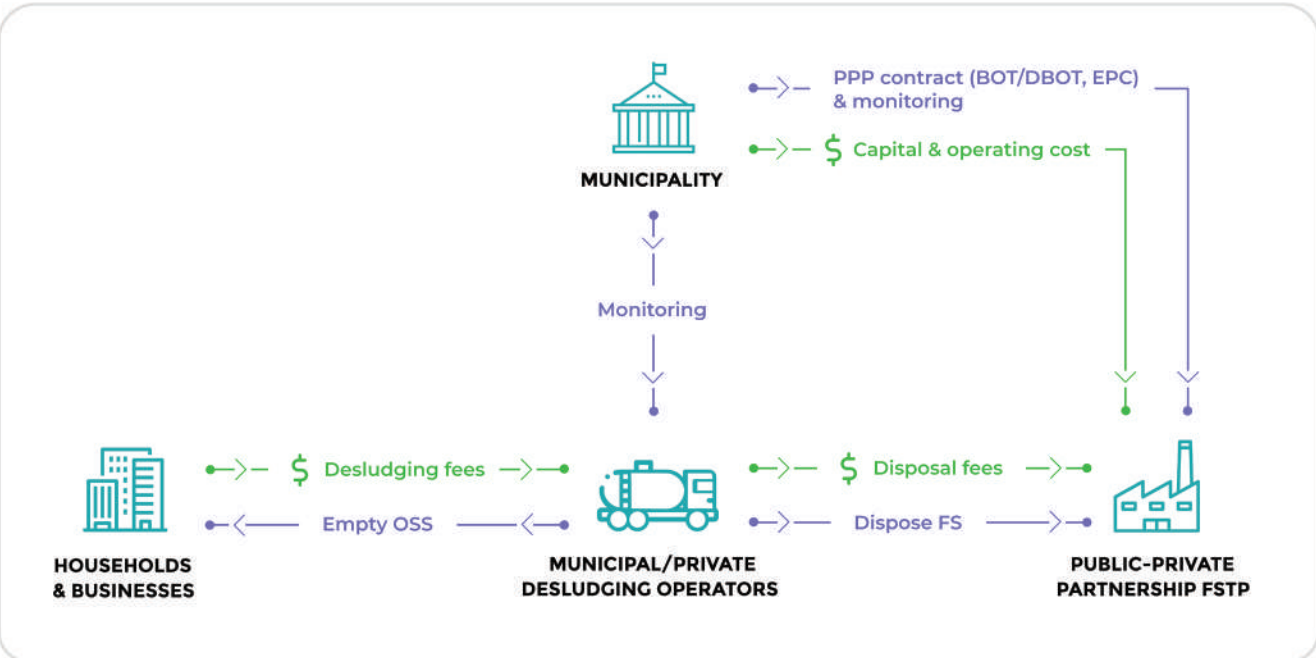
The model focuses on the treatment component in the sanitation value chain. It offers the value proposition of treatment of FS for a healthy community and environment.

10.3.2 Description

This model engages the private sector in the provision of sanitation services. Limited technical capacity and sometimes financial capacity of the municipality are key reasons to engage the private sector. In this model, the municipality contracts some or all components of the project cycle (planning and design, implementation, construction, and operations) for establishing an FSTP with a private entity. The contract, which can be BOT, DBOT, DFBOT, or EPC, dictates the engagement level of the private entity. It is the responsibility of the municipality to ensure delivery of FS to the FSTP when engaging the private sector only for the treatment component of the value chain. The relationships among the various stakeholders are shown in Figure 63.

Owner and operator: The business model is implemented by the municipality through a PPP contract. The municipality is the owner, and if the PPP contract has an operations component, the private entity is the operator. If the funding comes from a donor through a grant, typically it is given to the municipality either directly or through an institution. In such a case, the owner and operator structure is contingent on the project structure.

FIGURE 63. VALUE CHAIN OF THE PPP FSTP MODEL.



10.3.3 Funding and financing

Capital cost: This is mostly covered by either funds from state or national government programs for improving urban infrastructure or grants from donors. Depending on project viability, the private entity can finance part of the capital cost, which is recovered from the revenue generated.

Operating cost: The municipality, private entity, and/or donor finances the FSTP operating cost. Donor finance is limited to the first few years after commissioning of the FSTP. The municipality typically funds it through a combination of local taxes and state and national government financial assistance. The municipality can generate revenue from licensing fees and FS disposal fees charged to desludging operators. The private entity funds the cost through a fixed O&M fee from the municipality. The private entity could raise revenue from the sale of reuse products.

10.3.4 Risks and benefits

Risks

- PPP projects for FSTP construction and O&M are typically small in size in comparison with other infrastructure projects and hence may not attract suitable private entities

Benefits

- The municipality can leverage technical expertise and finance for the investment and operations

10.3.5 Relevance

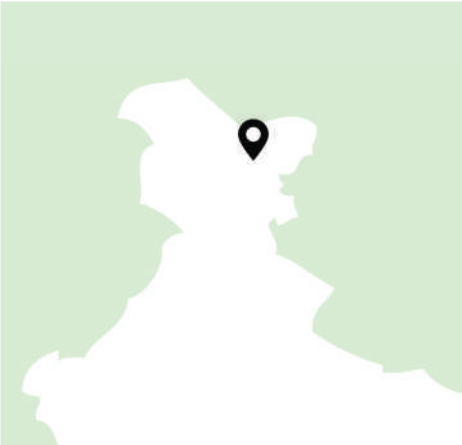
Applicable when the municipality seeks to leverage private sector technical expertise and finance. The report covers following case studies:

- Leh Public-Private Partnership in FSM, Leh, Jammu & Kashmir (explained in this section)
- Kochi Public-Private Partnership FSTP, Kochi, Kerala (explained in this section)
- Lalsot Integrated E&T and FSTP, Lalsot, Rajasthan
- Sambhar-Phulera Cluster FSTP, Phulera, Rajasthan
- Karunguzhi-Maduranthagam Cluster FSTP, Karunguzhi, Tamil Nadu
- Bansberia Co-Composting Unit, Bansberia, West Bengal
- Nashik Waste-to-Energy Plant, Nashik, Maharashtra
- Warangal FSTP, Warangal, Telangana

Related models from other countries have been reported, e.g., in Accra, Ghana; Dakar, Senegal; and locations across Vietnam.

CASE STUDY

Leh Public-Private Partnership in FSM, Jammu and Kashmir



Location	Leh, Jammu & Kashmir
Value offered	Treated FS and periodic desludging of OSS
Organization type and name	PPP – Blue Water Company Private Limited (BWC) & Municipal Committee Leh (MCL)
Project status	Operational since 2017
Major partners	Bremen Overseas Research and Development Association (BORDA), CDD Society, Leh Development Authority (LDA)
Financing entities and revenue source	***Capital cost:*** BWC ***Operating cost:*** User fees & MCL

Context and background

BORDA and the CDD Society's implementation of India's first-of-its-kind FSTP in Devanahalli, Karnataka was the trigger for prioritization of FSM across India. BORDA and the CDD Society saw the need for a private company to manage FSM O&M. The BWC was established with funding from BORDA in 2017 to provide FSM services throughout India. BORDA identified Leh municipality in Jammu & Kashmir as a city in need of an FSM solution. Leh is a high-altitude, cold desert municipality with a high dependence on groundwater. Most of the local population uses eco-san toilets (no desludging required) whereas water flush toilets are provided for tourists. Hence, the hotels and homestays are the key customer segment. The BWC partnered with the MCL to pilot integrated desludging and FS treatment (BORDA 2018).

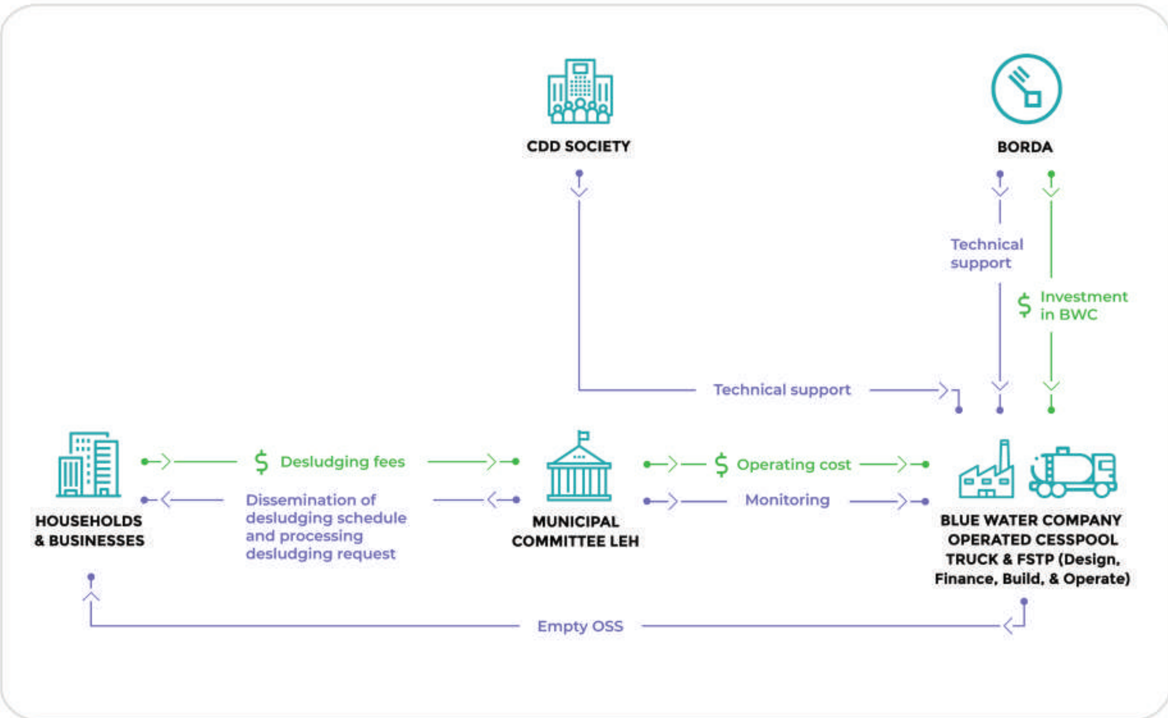
Key indicators (as of March 2019)	
Installed capacity	12 m^3/day
Allocated land area	0.18 acres
Labor requirements	8 persons (FTE)
Inputs	Raw FS – 12 m^3/day
Outputs	Treated water + dried sludge (neither product is monetized)

Case description

Driven by BORDA and CDD Society, a PPP between BWC and MCL for a five-year DFBOT contract was signed. The LDA allocated land for the FSTP, which was financed by the BWC. BORDA and CDD Society provided technical support for FSTP design, construction, and initial operations. It took less than four months to implement the FSTP, thanks to strong support and cooperation from the local government and other project partners.

According to the contract, the BWC is responsible for managing FSTP operations, along with provision of scheduled and demand-based desludging services. The MCL provided one existing desludging vehicle. The BWC prepares the schedule for desludging, which is shared with the MCL, who notifies customers of the desludging dates. Scheduled desludging is undertaken twice a week. The remaining days in the week are reserved for on-demand desludging. The MCL collects desludging fees from the hotels and home stays at the time of renewal of the yearly license to operate. Once the desludging service has been provided, the BWC is paid 90% of the revenue (INR 3,500 for each trip) upon submission of documentary evidence of service provision. The municipality monitors desludging and FSTP operations. The relationships among the various stakeholders in the value chain are shown in Figure 64.

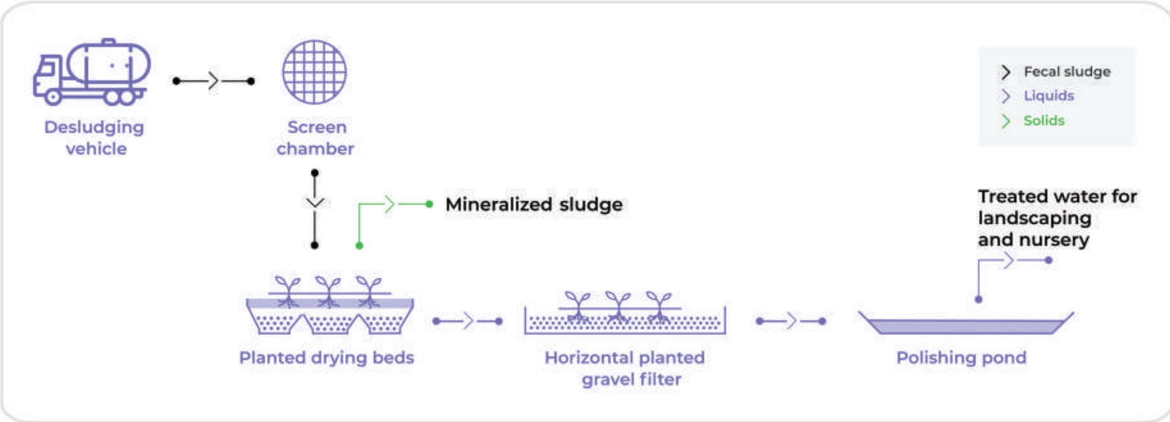
FIGURE 64. VALUE CHAIN OF THE LEH PPP FOR FSM MODEL.



Technology and processes

Leh's harsh winters, with minimum temperatures as low as minus 30° Celsius, cause FS to freeze; hence, desludging is not feasible from November to March. As a result, the FSTP is operational for eight months in a year; BORDA and the CDD Society chose planted drying bed (PDB) technology since it is the most robust biological process. Sludge accumulated on the beds is removed every 18 to 24 months. Effluent from the PDB is treated in a horizontal planted gravel filter and polishing pond. The technology process is shown in Figure 65. Desludging is technically challenging in Leh; households are often not accessible due to narrow lanes, and double booster pumps have to be used because of the high altitude, thus requiring an extra worker for each vehicle (BORDA 2018).

FIGURE 65. TECHNOLOGY PROCESS OF THE LEH FSTP.

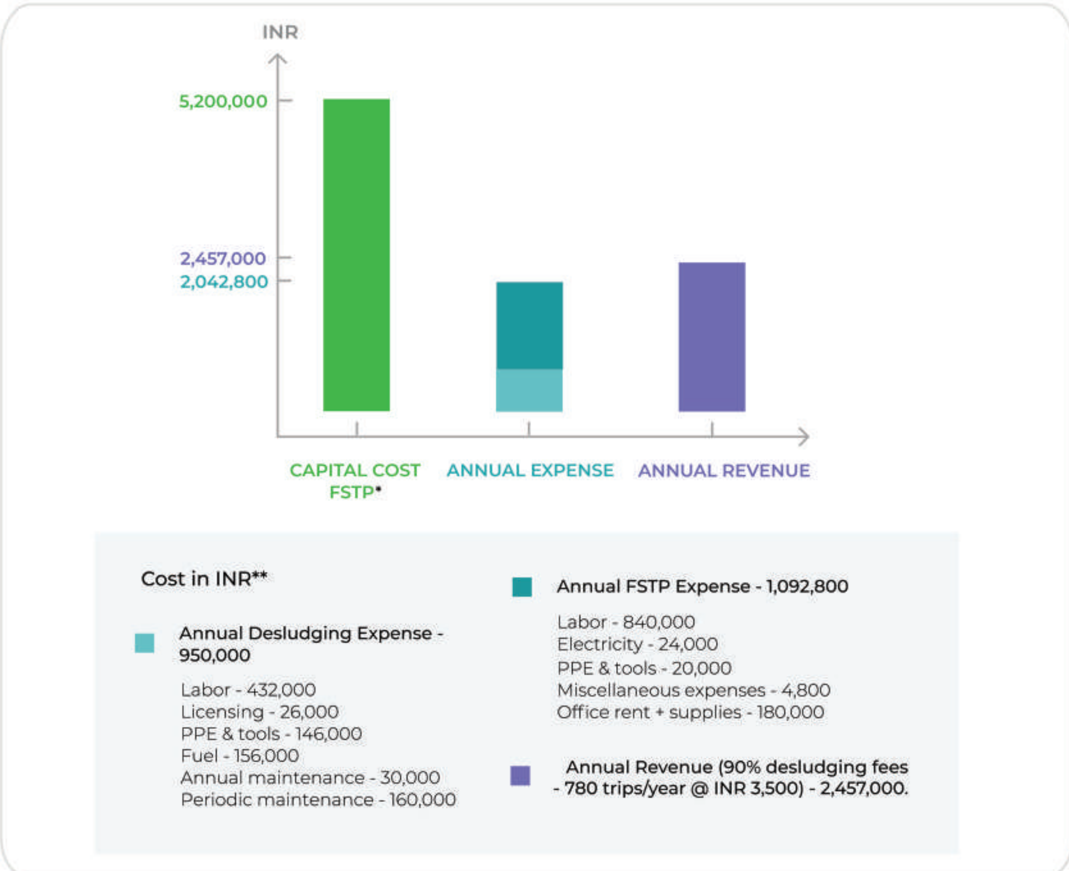


Source: BORDA 2018.

Funding and financial outlook

The capital cost of the FSTP was INR 5.2 million, financed by the BWC through a grant from BORDA. The MCL has existing desludging vehicles (BORDA 2018). The annual cost of desludging and FSTP operations is around INR 2 million (Figure 66), with

FIGURE 66. FINANCIAL OVERVIEW OF FSM IN LEH.



Source: Blue Water Company.
* USD 1.00 = INR 63.92 in August 2017.
** USD 1.00 = INR 71.25 as of October 2019.

over half of this cost going towards labor. Even though operations are only carried out for eight months in a year, there are eight full-time BWC operational staff who are paid for the entire year, including one driver and two operators for each desludging vehicle and two FSTP workers. The BWC finances the operating cost with 90% of the desludging fees collected by the MCL. The MCL is promoting scheduled desludging to prevent groundwater pollution from OSS. Through scheduled desludging carried out by the BWC, desludging with the government-owned, private-operated truck has increased from four to six monthly trips to nearly 100.

Figure 66 shows that the core objective of demonstrating a capital recovery model is unlikely within the five-year project period. Two key reasons emerge: 1) E&T operations are at 75% utilization while the treatment plant is close to 100% utilization, leading to significant revenue losses. As payment is linked to service provision, E&T revenues are not being realized fully; 2) Lack of strong enforcement means that only about 43% of the expected collections is being realized. Further, of this amount, the BWC is only able to claim 30%, as scheduled service is being refused by hotels and homestays during peak tourist periods. While this leaves Leh Municipality with a healthy surplus (about INR 1.1 million expected in 2019), the BWC is forced to expand services elsewhere, at lower margins for each trip, to meet expenses. At the time of writing this case study, the BWC was exploring technological options to expand the FSTP's capacity and looking at ways to reuse the treated water and possibly sell it to the local government.

Reference

BORDA (Bremen Overseas Research and Development Association). 2018. *FSM for Leh*. Bremen, Germany: Bremen Overseas Research and Development Association. Available at https://www.borda.org/wp-content/uploads/2018/08/BORDA_FSM_for_Leh_HF.pdf (accessed July 24, 2019).

CASE STUDY

Kochi Public-Private Partnership FSTP, Kerala

Location	Brahmapuram, Kerala
Value offered	Dried sludge and treated wastewater
Organization type and name	PPP – KMC & ABG Engineering Private Limited
Project status	Operational since 2015
Major partners	Kerala Sustainable Urban Development Project (KSUDP), Clean Kerala Company, Suchitwa Mission
Financing entities and revenue source	***Capital cost:*** KSUDP ***Operating cost:*** KSUDP & KMC

Context and background

Open dumping of FS is a major issue in Kerala, and local newspapers frequently report incidents of FS disposal in water bodies and paddy fields. Based on a Public Interest Litigation, in 2013, the Supreme Court directed the Government of Kerala (GoK) to develop appropriate FS treatment and disposal facilities (Samuel 2013). The GoK, through the KSUDP, a special purpose vehicle of the GoK to implement multi-discipline projects envisaged under the Local Self Government Department (LSGD), selected Kochi as one of the sites for FSTPs in the state. The existing sewer network and the STP in Kochi can cater to 6% of households, and the rest rely on FSM (KMC 2018). The KSUDP commissioned the FSTP, at Brahmapuram in Kochi municipality, in 2015.

Key indicators (as of 2018)	
Installed capacity	100 m^3/day
Allocated land area	0.25 acres
Labor requirements	4 persons (FTE) (3 people full-time, 2 people part-time)
Inputs	Raw FS – 60-70 m^3/day
Outputs	Treated water, biogas (reused within the plant for heat generation), dried sludge (none of the products are monetized)

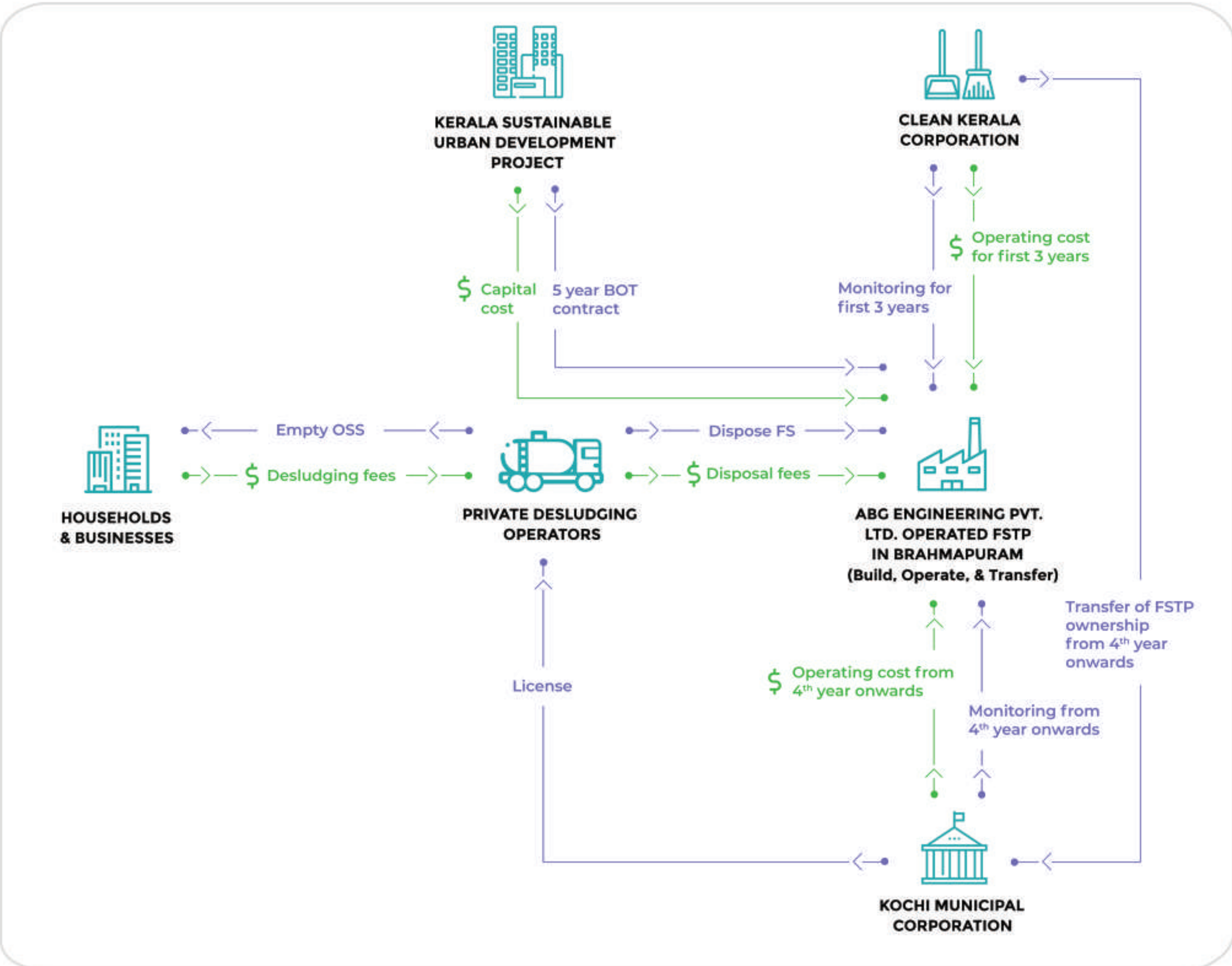
Case description

The KSUDP was the lead agency for implementing the FSTP at Brahmapuram, Kochi, which was financed by grants from the GoK, under a loan from the ADB. The KMC provided the land for the FSTP. Suchitwa Mission, a technical directorate for the GoK, provided technical guidance for the project. The GoK funded the capital cost and part of the operational cost

through the KSUDP, which developed the design of the FSTP and issued a five-year BOT contract to ABG Engineering Private Limited (ABG Engineering). After the commissioning of the FSTP, the GoK delegated FSTP monitoring, issuance of FS disposal passes to desludging operators, and payment of electricity charges to Clean Kerala Company Limited, which was formed under the LSGD to ensure hygiene management across the state. In April 2017, the state government transferred these responsibilities to the KMC.

The KMC transfers a fixed monthly fee to ABG Engineering for FSTP O&M and pays the electricity charges. Payment to ABG Engineering is subject to certification of the FSTP operations by the health inspector from the KMC. The health inspector visits the plant once a week to inspect reports on inlet and outlet quality of effluent tested by the FSTP operator. The Kerala State Pollution Control Board is responsible for monitoring the FSTP effluent's compliance with discharge standards. Treated water from the FSTP is discharged into a drain that irrigates nearby farmland. The region has very little agriculture, and the demand for compost is low; hence, ABG Engineering gives away the dried sludge to farmers gratis. The biogas generated is used internally. Kochi has around 200 truckloads of FS collected each day by the private operators. Twelve private operators dispose of FS at the FSTP and pay a disposal fee to the KMC, which has collaborated with the Port Authority in Kochi to commission another FSTP of similar size. The relationships among the different stakeholders in the value chain are depicted in Figure 67.

FIGURE 67. VALUE CHAIN OF THE KOCHI PPP FSTP MODEL.

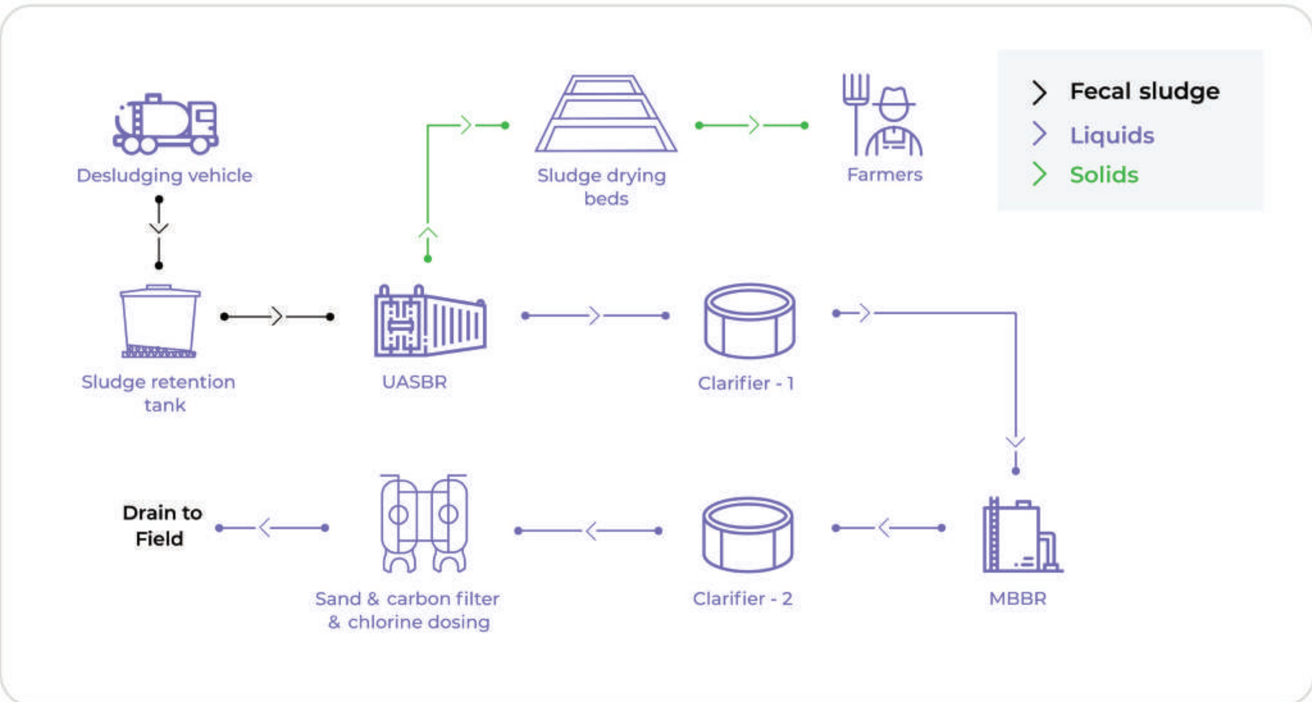


Technology & processes

The capacity of the FSTP is 100 m^3 per day; it uses a combination of biological and mechanized processes. The truck decants FS into a Sludge Retention Tank (SRT) of 30 m^3 capacity, from where sludge is pumped into the UASB reactor with a hydraulic retention time of four to five hours. Biogas generated in the UASB reactor is used in heat exchangers to maintain the UASB reactor's temperature at 37° Celsius. The sludge from the UASB reactor is transferred onto unplanted sludge drying beds once every two to three months, and the effluent is pumped through clarifiers, an MBBR, and a sand and carbon filter, before it is discharged into the drain. The technology process is shown in Figure 68. Lime is added to the SRT to maintain its pH, and polyaluminum chloride and chlorine are added in the effluent treatment process. The technology requires electricity, and a diesel generator is used for backup during power outages (CSE 2019).

Due to opposition from Brahmapuram residents to the movement of desludging trucks in the area during the day, the FSTP receives FS between 18.00 and 06.00. The FSTP receives around 10 to 12 truckloads of FS daily, which is equivalent to 60 to 70 m^3 per day. Since the entire load is received over 12 hours, the capacity of the SRT constrains the quantity of FS treated daily. The KMC plans to expand the capacity of the SRT to 70 m^3 to address this issue.

FIGURE 68. TECHNOLOGY PROCESS OF THE KOCHI PPP FSTP.



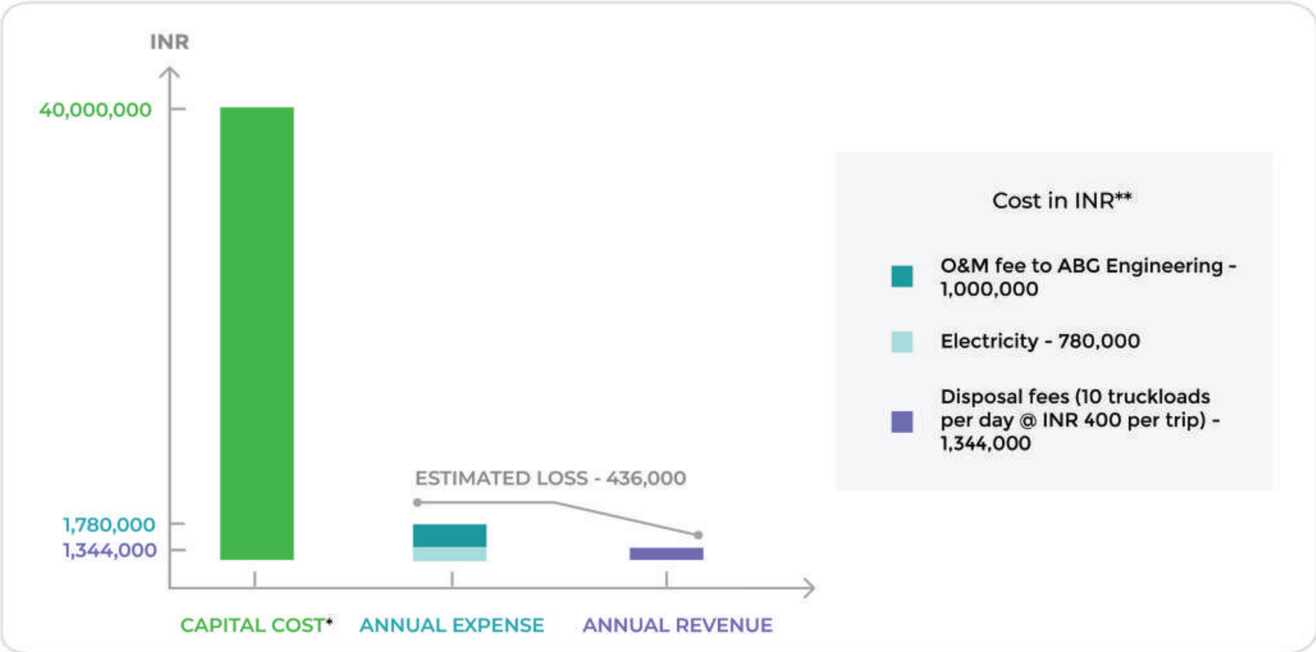
Funding and financial outlook

The project cost is INR 45 million, which includes the capital cost and 5 years' O&M cost, excluding the electricity cost. An estimated total of INR 43 million was funded by the state government through the KSUDP under an ADB loan, which covers the capital cost and three years of O&M. The KMC is covering the O&M cost from the fourth year onwards, including the electricity cost. Figure 69 shows the capital cost and expenses and revenue for the KMC.

There are five workers at the FSTP: two operators, working alternatively in 12-hour shifts, one laboratory technician to test FS and effluent, one supervisor, and one manager. The KMC

earns revenue from the disposal fees paid by private desludging operators to obtain FSTP disposal passes, but this is not sufficient to cover the O&M cost. Clean Kerala Company Limited did not collect disposal fees from private operators, an amount of approximately INR 1.5 million, initially. Since the FSTP was transferred to the KMC, they are trying to collect the arrears. The municipality could increase its revenue by operating the FSTP at its full capacity and, thus, improve its recovery of the O&M cost. Revenue from reuse has not been feasible thus far, since the market for co-compost in the region is limited. Currently, the KMC's focus is on FS treatment, rather than revenue generation.

FIGURE 69. FINANCIAL OVERVIEW OF THE KOCHI PPP FSTP MODEL.



Source: Kochi Municipal Corporation.
* USD 1.00 = INR 64.12 in 2015.
** USD 1.00 = INR 69.58 in March 2019.

References

CSE (Centre for Science and Environment). 2019. *FSTP at Brahmapuram, Kerala.* New Delhi, India: Centre for Science and Environment. Available at https://www.cseindia.org/fstp-at-brahamapuram-kerala-9159 (accessed June 23, 2019).

KMC (Kochi Municipal Corporation). 2018. *Septage management byelaw (draft).* Kochi, India: Kochi Municipal Corporation.

Samuel, S. 2013. *Septage: Kerala's looming sanitation challenge.* World Bank Blogs. Washington, DC, USA: World Bank. Available at https://blogs.worldbank.org/water/septage-kerala-s-looming-sanitation-challenge (accessed June 23, 2019).

10.4 Business Model: Co-Treatment

10.4.1 Value proposition

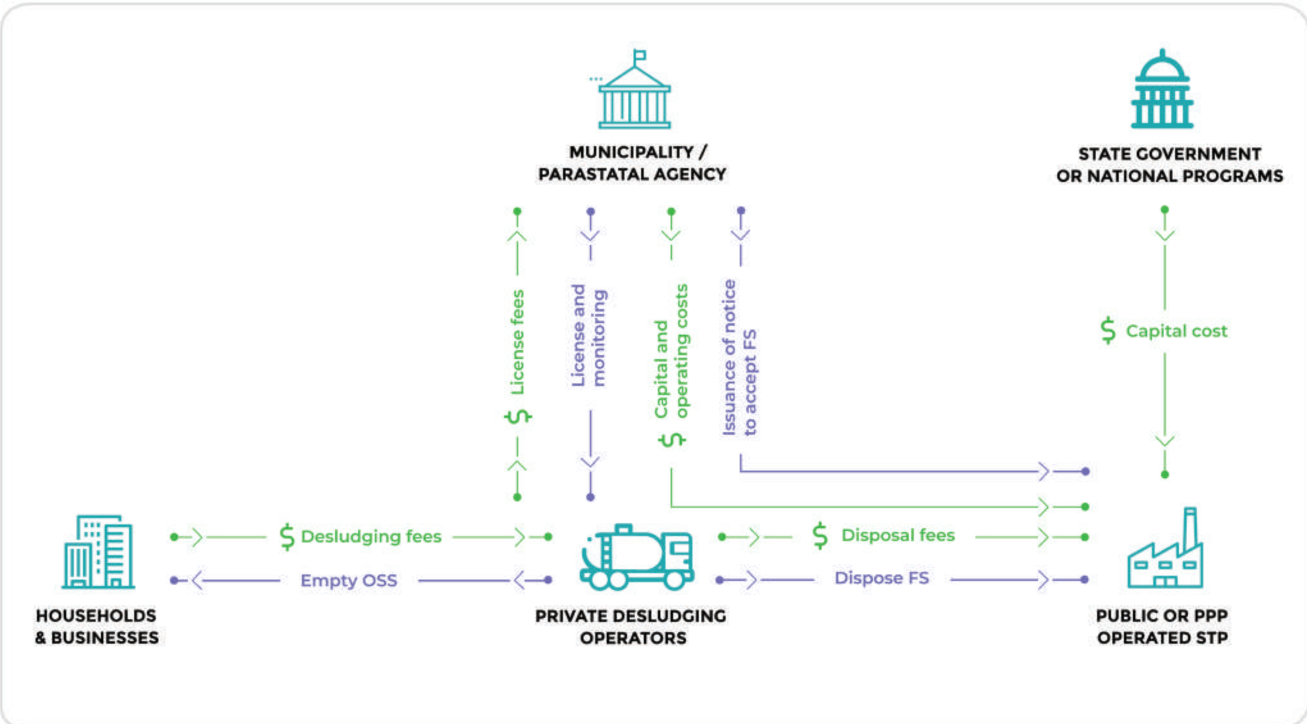
The model focuses on the treatment component in the sanitation value chain. It offers the value proposition of treatment of FS for a healthy community and environment.

10.4.2 Description

The model is built on the usage of existing underutilized infrastructure. STPs are designed with capacities for a longer term (at least 10 to 15 years), assuming population growth and network coverage, and they are always built first, before installing a sewerage network. As such, most STPs are rarely operating at their designed capacity and can absorb suitable FS loads. In the model, FS is mixed with sewage and treated in STPs. FS is collected from OSS users by municipal or private desludging operators and transported to the STP or designated decanting points connected to the sewerage network. Desludging operators pay disposal fees to the STP operator. The STP operator only allows licensed desludging operators to decant FS and is responsible for monitoring them to ensure industrial waste is not decanted. The relationships among the various stakeholders in the business model are shown in Figure 70.

Owner and operator: The business model is initiated by a municipality or parastatal agency responsible for sanitation, which is the owner of the sewerage infrastructure. The municipality or parastatal agency can operate the STP or contract operations to a private entity.

FIGURE 70. VALUE CHAIN OF THE CO-TREATMENT BUSINESS MODEL.



10.4.3 Funding and financing

Capital cost: This is covered by local government funds or funds from state or national government programs for improving urban infrastructure.

Operating cost: The municipality or responsible parastatal agency finances this cost through registration fees and/or disposal fees charged to desludging operators, along with its existing budget for sewerage infrastructure operations.

10.4.4 Risks and benefits

Risks

- The location of the STP, if remote, may create viability issues for private emptying operators

Benefits

- No incremental cost for providing treatment service and, hence, extending sanitation to non-sewered areas
- Disposal fees charged to emptying operators offers an additional source of revenue for the STP

10.4.5 Relevance

Applicable to towns with existing STPs that are underutilized and can absorb FS loads. The following case study is explained in this section:

- Co-Treatment of Fecal Sludge and Sewage at STPs in Panaji, Goa and Chennai, Tamil Nadu

Related models from other countries have been reported, e.g., in Kuala Sawah, Malaysia.

CASE STUDY

Co-Treatment of Fecal Sludge and Sewage at Sewage Treatment Plants in Panaji, Goa and Chennai, Tamil Nadu

Location	Panaji, Goa and Chennai, Tamil Nadu
Value offered	Safe treatment of FS
Organization type and name	Public sector: Chennai – Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) Panaji – Department for Public Health and Engineering (DPHE)
Project status	Operational since 2005
Major partners	Private desludging operators
Financing entities and revenue source	***Capital cost:*** CMWSSB & DPHE ***Operating cost:*** License fees and disposal fees

Context and background

Large cities in India often have UGD, but a significant portion of the population is still served by OSS. While private desludging operators provide desludging services to OSS users, there is no established FS treatment system. STPs serving UGD systems in the cities are largely operating well below their design capacities. In most cases, they can accept additional loads of FS and co-treat it with sewage. Co-treatment enables private desludging operators to safely dispose of FS when there is no dedicated FSTP. In addition, implementing co-treatment provides the option to have multiple designated disposal points within the sewerage network across the cities (see *Case Study: Sewage Pumping Stations and Open Drains as Fecal Sludge Transfer Stations, Delhi, Tamil Nadu, and Uttar Pradesh*). This case study covers co-treatment at Nesapakkam STP in Chennai, Tamil Nadu and Tonca STP in Panaji, Goa.

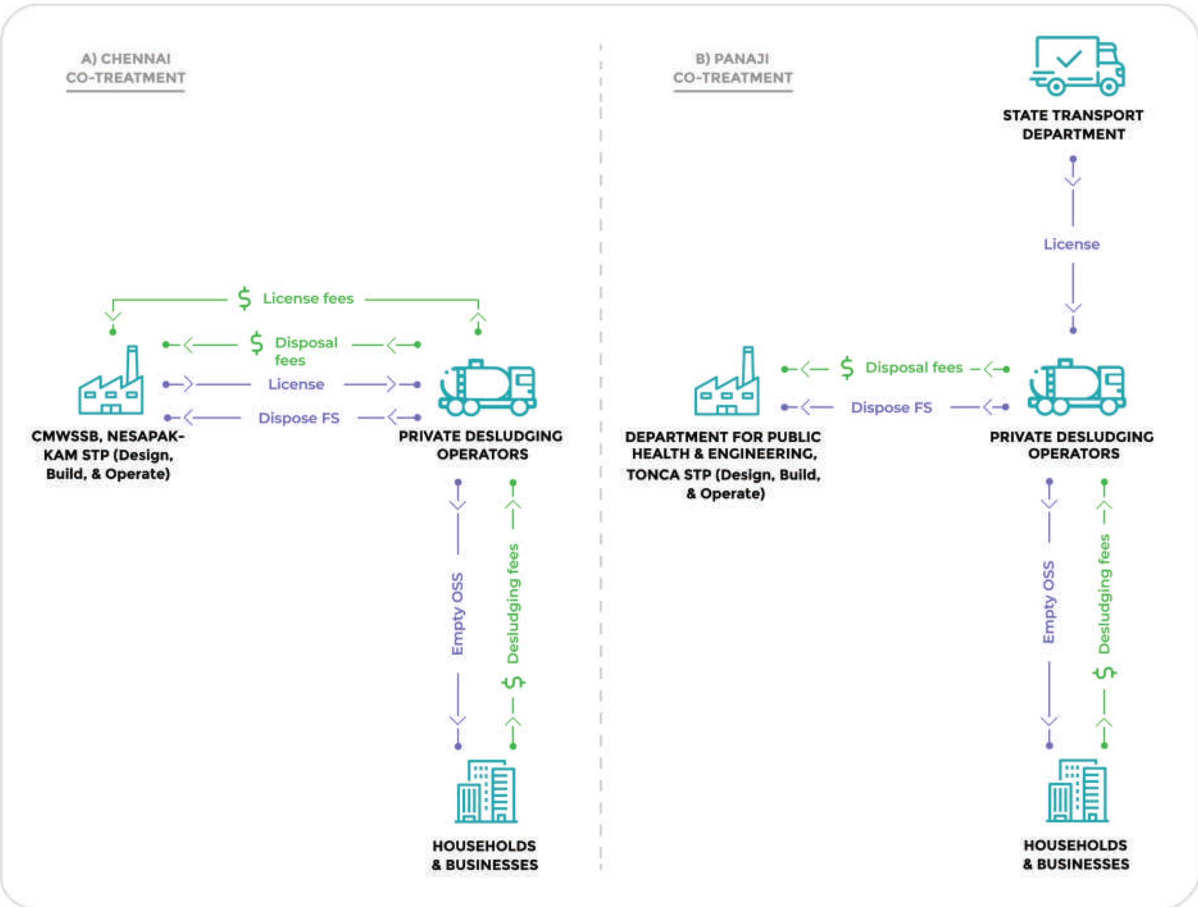
Case description

In Chennai, the CMWSSB is responsible for design, construction, and operation of STPs in the Greater Chennai Municipal Corporation area. The CMWSSB issues licenses to private desludging operators and has designated Nesapakkam STP for FS disposal. Private desludging operators pay disposal fees to the CMWSSB. The decanting facility has space for four desludging trucks to decant simultaneously. Trucks are permitted between 05.00 and 17.00, except on Sundays and government holidays. The supervisor at the STP maintains a record of the vehicle number, disposal fees paid, and number of trips completed against the disposal fees paid for each vehicle. The supervisor monitors the type of waste disposed of based on color and smell, so as to ensure it is not industrial waste – suspicious waste samples are tested at the on-site laboratory. The operator's license is revoked if caught decanting industrial effluent (NIUA 2017a).

In Panaji, the state DPHE is responsible for the design, construction, and operation of STPs in Goa. The State Transport Department issues licenses to private

desludging operators, and the DPHE has designated Tonca STP for FS disposal. Private operators pay disposal fees to the DPHE. Municipal desludging operators desludge public toilet septic tanks and dispose of FS at the Tonca STP; however, they do not pay disposal fees. The DPHE staff are required to maintain records of desludging vehicles that decant at the STP. The decanting facility has space for two desludging trucks to decant simultaneously. Trucks are permitted between 09.00 and 17.00, except on Sundays and government holidays. The supervisor at the decanting facility maintains a record of the vehicle number, the desludging location, and disposal fee payment linked to each vehicle. There is no procedure to test whether the disposed waste is FS or industrial waste (NIUA 2017b). The relationships among the various stakeholders in the value chain are shown in Figure 71.

FIGURE 71. VALUE CHAIN OF THE CO-TREATMENT MODEL AT STPs IN CHENNAI AND PANAJI.

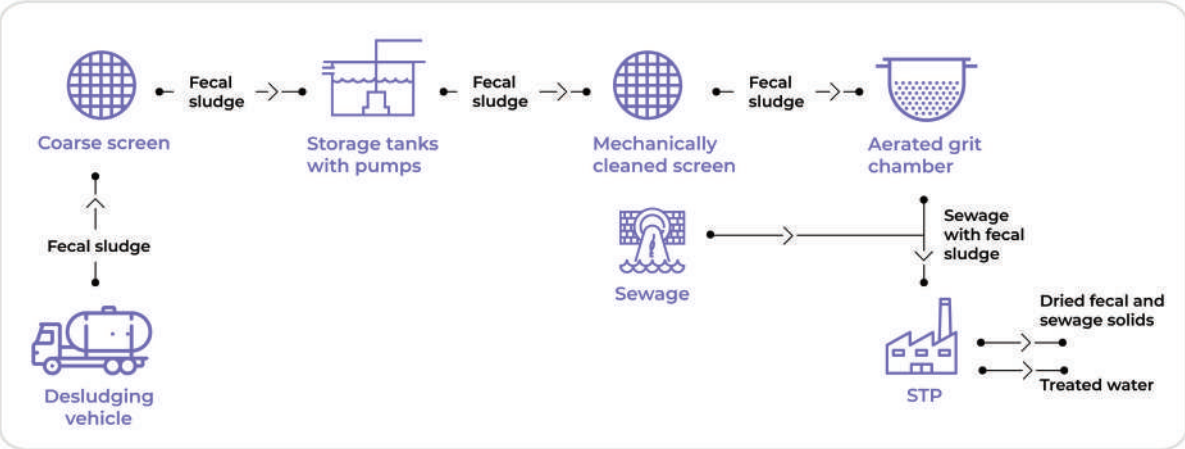


Technology and processes

The capacity of Nesapakkam STP in Chennai is 117 MLD, and it receives 100 MLD of sewage and 1.8 MLD of FS (i.e. less than 2% of the sewage load). At the STP, there is a decanting station to handle the FS load. The decanting station has a receiving tank, grit removal chamber, and screens. The receiving tank is connected to an odor control scrubbing unit. FS from the decanting station flows through the trunk sewer line to the terminal pumping station feeding into the STP, where the FS is mixed with sewage before being treated. During the monsoon, demand for desludging is high, and the CMWSSB allows operators to decant FS at a designated SPS. The STP is based on Activated Sludge Process (ASP) technology. No retrofits to the STP infrastructure are required, besides the addition of the decanting facility to handle incoming FS. The STP meets the required effluent standards (NIUA 2017a). The technology process is depicted in Figure 72.

The capacity of Tonca STP in Panaji is 12.5 MLD, and it receives 9 to 10 MLD of sewage and 0.48 to 0.96 MLD of FS (i.e. 5 to 10% of the sewage load). There is a decanting station at the STP to handle FS loads. The decanting station consists of a manhole where trucks dispose of FS. The manhole is connected to the main inlet of the STP. Private desludging operators are only allowed to dispose of FS at the STP and not at any SPS. The STP is based on ASP technology, and no retrofits have been required for the infrastructure, besides the addition of the decanting facility. There have been no changes in operational protocols, and the STP is able to meet the required effluent standards (NIUA 2017b).

FIGURE 72. TECHNOLOGY PROCESS OF THE NESAPAKKAM STP DECANTING STATION.



Funding and financial outlook [18]

The capital costs of the decanting facilities at Nesapakkam and Tonca STPs are INR 20 million and INR 140,000, respectively. In Nesapakkam, it was financed by the CMWSSB, and, in Tonca, by the DPHE. The Nesapakkam STP incurs higher energy costs from increased hours of aeration due to the addition of FS. Tonca STP has not observed any changes in O&M costs (NIUA 2017a, 2017b).

The CMWSSB has two sources of revenue from co-treatment: license and disposal fees from private desludging operators. Currently, 52 private desludging operators are licensed and pay a one-time fee of INR 2,000 for each vehicle. The disposal fee is set at INR 100 per trip per vehicle and must be deposited at the CMWSSB office in advance. Most operators pay a lump sum for multiple trips. Based on 200 trips made by private desludging operators to the STP every day, the CMWSSB generates an estimated annual revenue of INR 6 million from disposal fees (NIUA 2017a).

In Panaji, the DPHE has one source of revenue from co-treatment – disposal fees from private desludging operators. The disposal fee is set at INR 500 per trip per vehicle. Operators usually pay a lump sum for 10 to 40 trips. Based on 120 trips made by operators to the STP every day, the DPHE generates an estimated annual revenue of INR 18 million from disposal fees (NIUA 2017b).

References

NIUA (National Institute of Urban Affairs). 2017a. *Nesapakkam STP, Chennai: Co-treatment case study (draft).* New Delhi, India: National Institute of Urban Affairs.

NIUA. 2017b. *Tonca STP, Panaji: Co-treatment case study* (draft). New Delhi, India: National Institute of Urban Affairs.

[18] USD 1.00 = INR 65.11 in 2017.

11.

Models Emphasizing Reuse at the End of the Value Chain

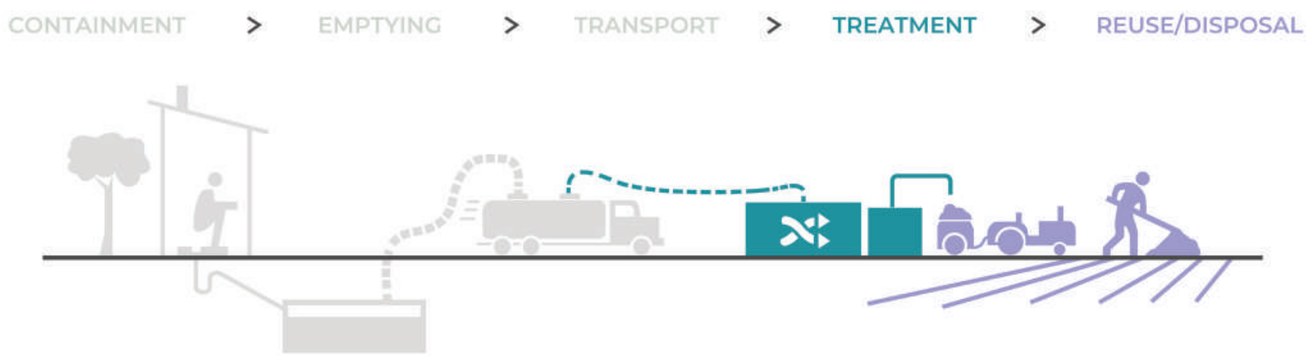
Business models in this section cover the treatment and reuse components in the sanitation value chain. Models for cost recovery through FS reuse are emerging as the FSM sector develops. The reuse models offer the following value propositions:

1. Treatment of FS for a healthy community and environment
2. Recovering nutrients from FS to produce high-quality compost as a soil ameliorant
3. Recovering energy from FS to generate renewable energy for heating or electricity

The reuse business models offer scope for reduced dependency on subsidies through increased operational cost recovery. These business models require a shift in approach, from the operator being a sanitation service provider to the operator becoming a seller of a product. The models require greater focus on market development through identification of appropriate customer segments, so that the cost of delivery of reuse products is minimized. Reuse models enhance energy or food security, promote the circular economy, and contribute to the reduction of GHG emissions.

The following business models are explained in this section:

1. Nutrient recovery
2. Energy recovery



11.1 Business Model: Nutrient Recovery

11.1.1 Value proposition

The model focuses on the treatment and reuse components in the sanitation value chain by recovering nutrients in FS and organic waste to produce co-compost[19]. The by-product of this model improves soil health and offers the following value propositions:

- *Treatment of FS for a healthy community and environment*
- *Production of a high-nutrient value soil ameliorant (co-compost) from FS and organic waste*

11.1.2 Description

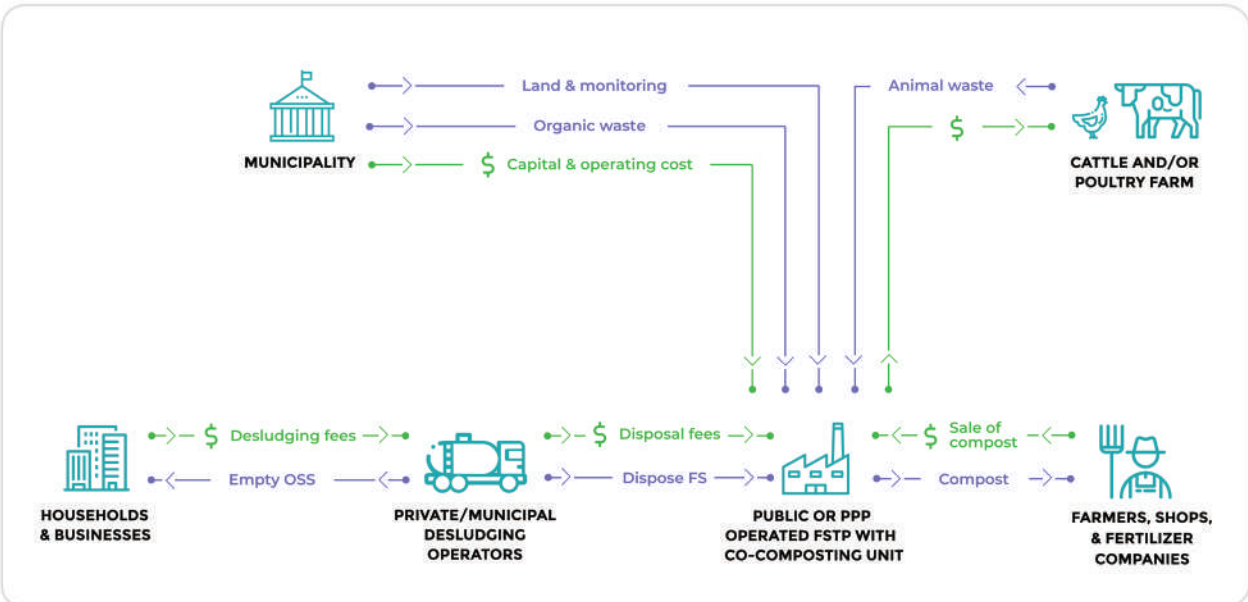
FS is collected from OSS by municipal or private desludging operators and transported to the FSTP. Organic solid waste is sourced from the municipality or collected by the private entity from households and markets. The dried and dewatered FS is co-composted with the organic waste. There are two possible ways to implement the co-composting unit:

1. The FSTP and co-composting unit are at the same site

2. The FSTP and co-composting unit are at different sites. In this case, the dewatered FS is transported to the nearest composting site

The co-compost produced can be sold to multiple customer segments – farmers, farmer producer organizations, landscapers, nurseries, fertilizer companies and their distributors, and to the agro-forestry. The co-compost can be enriched with natural (e.g., rock phosphate) or industrial fertilizer and/or sold in a pelletized form for ease of transport. The relationships among the various stakeholders are shown in Figure 73. There is ongoing research on nutrient recovery from FS using black soldier fly larvae, as highlighted in Box 9.

FIGURE 73. VALUE CHAIN OF THE NUTRIENT RECOVERY BUSINESS MODEL.



[19] Co-composting refers to the simultaneous composting of at least two organic sources – in this case, nitrogen rich FS from OSS and the carbon rich organic fraction of solid waste

Market development is one of the key aspects of any compost-based model, especially in regions where a supply chain for fertilizer and/or compost does not exist. The compost should be marketed to the customer segment with the lowest cost of distribution. Alternately, targeting networks of farmers through farmer producer organizations can be a cost-effective delivery mechanism. Bulk purchasers such as agroforestry, landscapers, and plantations have year-round demand in comparison to individual farmers, whose demand is seasonal.

BOX 9. RESEARCH ON USAGE OF BLACK SOLDIER FLY LARVAE IN FS TREATMENT IN INDIA.

The black soldier fly is a non-pest detritivore (*Hermetia illucens*), the larvae of which feed on decomposing organic matter. Black soldier fly larvae (BSFL) can be used for the bioconversion of organic waste, including FS, into protein and oil (CAWST and Eawag 2016). Usage of BSFL to digest and stabilize FS is under investigation at the Indian Institute of Technology Roorkee and Freshrooms Lifesciences Private Limited (Banks et al. 2014; Sarkar 2018). BSFL treat FS by eating and digesting it, producing treated sludge. The larvae are fed to livestock or fish as a source of protein, and the treated sludge can be used as fertilizer or to make briquettes (CAWST and Eawag 2016). Both FS and organic waste can also be fed to BSFL, thus co-treating two waste streams. Initial experiments at the institute showed that the number of larvae required and weight gain are more favorable if a mixture of FS and organic waste is used (Sarkar 2018).

FS treatment using BSFL presents an interesting opportunity for valorizing FS, as not only can the treated FS and organic waste be reused, but the treatment agent itself becomes a valuable product in the process. BSFL have a high content of protein and fats and can be used as high-protein animal feed. Since the BSFL treatment process currently does not eliminate all pathogens from FS (particularly helminth eggs), further studies are required to assess whether pathogens are transferred through the food chain (Sarkar 2018).

An important customer segment is the Agriculture Department, especially if it has extension agents under it, or the Department of Forestry. The fertilizer industry can be a major customer segment. The Solid Waste Management Rules 2016 mandates that the Department of Fertilizers and Ministry of Chemicals and Fertilizers provide market development assistance, and fertilizer companies should sell three to four bags of compost for every six to seven bags of fertilizer sold. A compost producer with roots in the sanitation sector rarely understands agricultural market segments; thus, it can be strategic to partner with organizations familiar with compost users.

Owner and operator: The business model is implemented by any of the following entities: public, private, or a PPP. For PPP, the municipality will enter into a contract with a private entity that can include design, construction, and operation of the treatment plant or only operation.

11.1.3 Funding and financing

Capital cost: This has been largely covered by grants from donors and funds from state or national government programs for improving urban infrastructure. The business model has potential for a private entity to partially or fully invest in, as demonstrated by the case in Bansberia, West Bengal.

Operating cost: The state or municipality typically finances this cost through a combination of local

taxes and state and central government financial assistance. The FSTP could generate revenue from the disposal fees charged to desludging operators and from sales of co-compost. In a PPP setup, to encourage reuse, the municipality could, in the initial years, cover the operating cost until the market for compost is established; thereafter, operational costs funded by the municipality could be recovered through a percentage of the co-compost sold.

11.1.4 Risks and benefits

Risks

- Market acceptance of product made from FS
- Shift from traditional business operations – from being a service provider (running FSTP operations) to becoming a product developer (producing compost)
- Requires regular supply of FS and organic waste for reuse business sustainability

Benefits

- The reuse business model offers scope for reduced dependency on subsidies through increased operational cost recovery
- Co-compost improves soil health by increasing its carbon content and ensures food security
- Promotes a circular economy and contributes to reduction of GHG emissions

11.1.5 Relevance

The model is highly recommended for regions where farmers have high willingness and ability to pay for compost. It is also recommended for regions with poor soil health – i.e. low carbon content in the soil. It is most suitable for a municipality that wants to address management of both solid waste and FS in one facility. The model can manage the challenge of land allocation and availability by establishing a combined facility in one location, instead of setting up different treatment units. Municipalities that have implemented segregation of waste at the household level can implement the model within the FSTP by diverting organic waste to it. The report covers following case studies:

- Devanahalli FSTP & Co-Composting Unit, Devanahalli, Karnataka (explained in this section)
- Bansberia Co-Composting Unit, Bansberia, West Bengal (explained in this section)
- The Nilgiris District FSTPs & Co-Composting Units, Ketti and Adigaratty, Tamil Nadu (explained in this section)
- Karunguzhi-Maduranthagam Cluster FSTP, Karunguzhi, Tamil Nadu

Related models from other countries have been reported, e.g., in Accra, Ghana; Balangoda, Sri Lanka; Firozpur and Khustia, Bangladesh; and Hanoi and Ho Chi Minh City, Vietnam.

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CASE STUDY

Devanahalli FSTP and Co-Composting Unit, Karnataka

Location	Devanahalli, Karnataka
Value offered	Treated FS and organic waste to produce co-compost as a soil ameliorant and treated water for landscaping of FSTP
Organization type and name	NGO – CDD Society
Project status	Operational since 2015
Major partners	Devanahalli Town Municipal Council (DTMC), BORDA, BMGF, Kam-Avida Enviro Engineers Private Limited, and Cube Bio Energy Private Limited
Financing entities and revenue source	***Capital cost:*** BMGF ***Operating cost:*** BMGF, DTMC, and sale of co-compost

Context and background

The CDD Society, an NGO with expertise in decentralized and biological wastewater treatment systems, recognized the need to address FSM in India. Devanahalli was selected as the project site due to its highly motivated municipal staff and demand for FSM; the entire town was dependent on OSS. The municipality operated a desludging truck, and due to lack of a designated disposal site, FS was dumped in the open. In collaboration with BORDA, the CDD Society developed an FS treatment solution for Devanahalli. The first-of-its-kind, town scale FSTP in India was inaugurated on November 19, 2015. The FSTP was set up to ensure treatment of FS for public health and environmental safety. However, a year after the start of FSTP operations, in order to deactivate the helminth eggs that are retained in the solid component of FS at the end of the treatment process, a co-composting unit was set up. This also helped in tackling the disposal of huge quantities of organic waste generated in the town (from hotels, municipal markets, event halls, etc.).

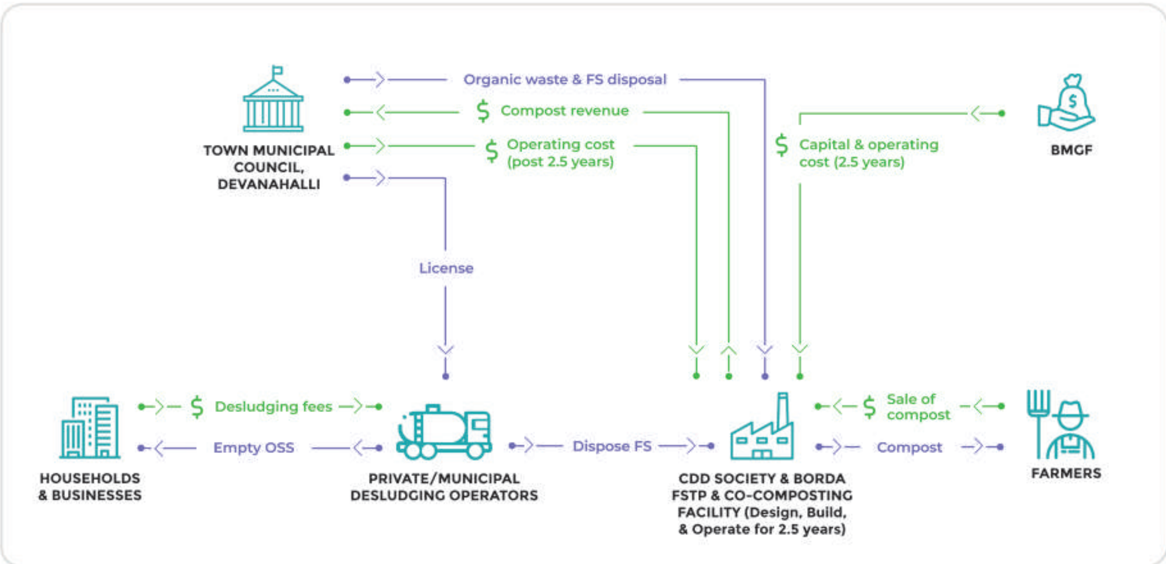
Key indicators (as of January 2019)	
Installed capacity	6 m^3/day
Allocated land area	0.16 acres
Labor requirements	2 persons (FTE) and 4 persons (intermittent-co-composting and landscaping)
Inputs	Raw FS – 3 m^3/day and organic waste – 150-200 kg/day
Outputs	Co-compost – 10 MT/year

Case description

The CDD Society was the primary driver in implementing the project. They liaised with the municipality to provide land and approvals for construction and raised funds for the FSTP. In partnership with BORDA, the CDD designed the plant and supervised its construction. The DTMC was responsible for operating its desludging vehicle on a fee for service basis, issuing licenses to private desludging operators, and ensuring FS was disposed of at the FSTP. Once the co-composting facility was set up, the DTMC was also required to deliver organic waste to the plant. The BMGF partially supported the capital and O&M costs for 2.5 years. Since April 2018, the DTMC has been providing funds for desludging and FSTP operations, including the co-composting unit. After commissioning of the FSTP, the CDD Society was responsible for FSTP operations for about two years, and in April 2018, the DTMC awarded an O&M contract to the consortium of Kam-Avida Enviro Engineers Private Limited, the CDD Society, and Cube Bio Energy Private Limited. In June 2019, the FSTP operations were handed over to the DTMC on expiry of the contract.

The co-compost produced is sold to farmers, who procure it from the FSTP's co-compost facility. The CDD Society collects payment for the co-compost and transfers it to the DTMC at the end of the month (after covering incidental costs for maintenance, if any, with the DTMC's approval). The municipality facilitates identification of clients for the co-compost. The treated water is used for landscaping within the FSTP. The relationships among the various stakeholders in the value chain are shown in Figure 74.

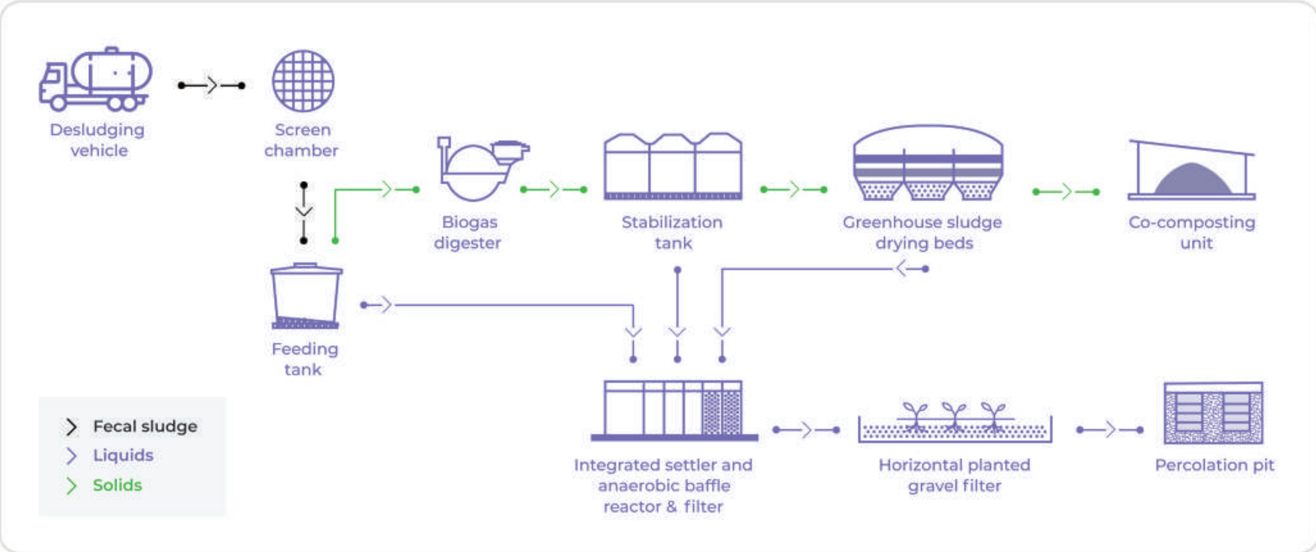
FIGURE 74. VALUE CHAIN OF THE DEVANAHALLI FSTP AND CO-COMPOSTING UNIT MODEL.



Technology and processes

The capacity of the FSTP is 6 m^3 per day, and it receives 3 m^3 per day of FS. The technology process is shown in Figure 75. Box 10 presents an upcoming technology process called vermicomposting to treat FS and recover nutrients from FS. The CDD Society and BORDA designed the system based on biological processes, low O&M costs (Table 12), and ease of operation by unskilled labor. The incoming FS undergoes solid-liquid separation in the feeding tank, and solids go to the biogas digester and stabilization tank in one stream and stabilization reactor in another stream. These two streams converge at the DEWATS unit for the liquid treatment and sludge drying beds for further drying and treatment of the solids.

FIGURE 75. TECHNOLOGY PROCESS OF THE DEVANAHALLI FSTP AND CO-COMPOSTING UNIT.



Source: CDD Society 2019.

BOX 10. VERMICOMPOSTING FSTPs IN KERALA.

Kerala is a densely populated state with a significant proportion of households depending on OSS. In August 2018, extensive flooding in Kerala caused OSS to overflow, resulting in the discharge of FS into the local environment. As part of the flood rehabilitation measures, the UNICEF decided to address the lack of adequate FSM. UNICEF provided a grant for the capital cost and one-year operational cost for two 10 m^3 per day FSTPs in Wayanad and Thrissur districts. The design, construction, and initial operations of the FSTPs were contracted out to PriMove Infrastructure Development Consultants Private Limited. Both the FSTPs are based on vermicomposting technology. The FSTP in Kalpetta town in Wayanad district was commissioned in May 2019 (PriMove 2019a). As of October 2019, the FSTP in Thrissur city in Thrissur district had received a completion certificate and was ready for commissioning (PriMove 2019d, 2019e).

The FSTPs employ biological and mechanical processes. The plant design centers on the use of *Eisenia fetida*, or tiger worms, for vermifiltration to rapidly treat FS. In this technology, tiger worms digest FS as an energy source for metabolism and reproduction and produce vermicompost. The worms only require air, water, and organic matter to generate a sustainable population in the vermifilter. In the Kalpetta FSTP, FS is decanted into the plant and passes through a screening chamber, solid-liquid separation tank, and bio-digester before entering the tiger biofilter beds, whereas in the Thrissur FSTP, the screened FS enters sludge storage tank and anaerobic stabilization reactor before entering the tiger biofilter beds. FS is consumed by the worms and converted into vermicompost in the tiger biofilter in 15-25 days (PriMove 2019a). The effluent from the tiger biofilter is further treated in a horizontal planted gravel filter, pressure sand and activated carbon filters, and through chlorination. The treated water can be used in landscaping at the FSTP site or for irrigation. FSTP operations require one operator and two helpers, as well as regular supply of electricity (PriMove 2019b). As of October 2019, the Kalpetta FSTP is receiving 0.3-1.3 m^3 per day of FS (PriMove 2019c).

The dried solids from the drying beds are mixed with organic waste at a ratio of 1:2, and composting is done using the windrow process. The co-composting unit processes 150 to 200 kg of organic waste per day (CDD Society 2019).

The Devanahalli FSTP and co-composting unit has provided valuable operational and design learning for future FSTPs in India. Since its commissioning, the plant has been operating under capacity due to low demand for desludging and FS delivery by the municipal truck. This necessitated adjustments to the technical design to ensure optimization of the treatment process. In addition, the roof over the sludge drying beds was replaced with a solar roof with a blower to increase drying efficiency, and one of the original biogas digesters, which had developed a crack, was replaced, along with the stabilization tank, with a stabilization reactor.

TABLE 12. FINANCIAL OVERVIEW OF THE DEVANAHALLI FSTP AND CO-COMPOSTING UNIT.

Items	Cost in INR*
Capital Cost (FSTP & co-composting unit)**	8,704,000
Annual FSTP & Co-Composting Expense (estimated)***	
Labor for FSTP	328,865
Labor for co-composting	322,660
Provident fund & employee state insurance for FSTP & co-composting labor	119,620
Labor for overall operations management	500,000
Utilities for the FSTP	18,000
Utilities for co-composting	15,000
Raw materials (filter material) for the FSTP	18,000
Raw materials & consumables for co-composting	45,000
Tool repair/replacement	49,533
Service charges/incidentals	138,455
Total Expense	**1,555,133**
Annual FSTP & Co-Composting Revenue (estimated)	
O&M contract fee	1,555,133
Sale of co-compost****	87,281
Total Revenue	**1,642,414**

Source: CDD Society 2017; CDD Society.
*The expense and revenue are based on estimates provided in the service contract and the amount allocated in the contract for FSTP & co-composting O&M. The revenue from co-compost sales are actuals.
** USD 1.00 = INR 67.73 in November 2016.
*** USD 1.00 = INR 65.11 in 2017.
**** USD 1.00 = INR 69.58 in March 2019.

Funding and financial outlook

The capital cost of the FSTP, including the co-composting unit, is approximately INR 8.7 million, which was funded by the BMGF. Since 2018, the DTMC has allocated an annual budget of INR 2.42 million for O&M of the FSTP, co-composting unit, and municipal desludging vehicle (CDD Society 2019). The FSTP and co-composting project costs and revenue are summarized in Table 12.

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CASE STUDY

Bansberia Co-Composting Unit, West Bengal

Location	Bansberia, West Bengal
Value offered	Treated FS, cow dung, organic fraction of solid waste, and poultry remains and waste, production of co-compost and vermicompost as soil ameliorants
Organization type and name	Private – Greenery Bio Compost & Animal Farming Private Limited
Project status	Operational since 2014
Major partners	Bansberia Municipality
Financing entities and revenue source	***Capital cost:*** Bansberia Municipality and Greenery Bio Compost & Animal Farming Private Limited ***Operating cost:*** Greenery Bio Compost & Animal Farming Private Limited through sale of compost

Context and background

In Bansberia, West Bengal, a private entity initiated co-composting of FS and organic waste well before FSM became a mainstream topic in the sanitation sector in India. The facility was constructed in 2009 as a SWM facility. The private entity, Greenery Bio Compost and Animal Farming Private Limited (Greenery Bio Compost), initially wanted to set up a poultry farm and learned about the existing composting infrastructure available with the municipality. Greenery Bio Compost developed the existing composting facility on government land to receive other organic waste such as FS, poultry waste and agricultural waste; the plant was commissioned to manage FS in 2014. Since then, the business has grown and is one of the best examples of a profitable FS and solid waste reuse business in India.

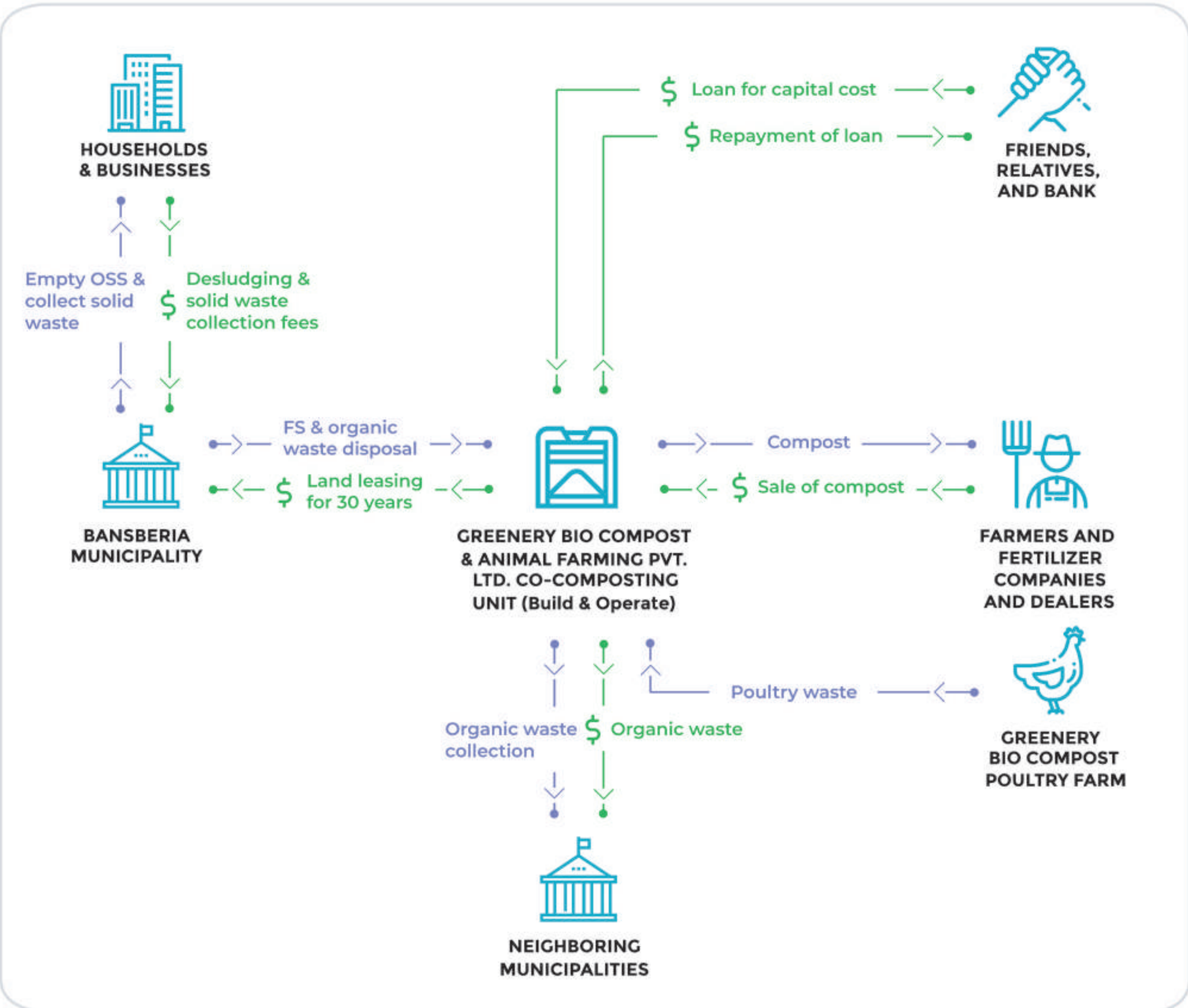
Key indicators (as of April 2019)	
Installed capacity	30 m^3/day
Allocated land area	5 acres
Labor requirements	10 (FTE) (5 for treatment and co-composting operations and 5 for compost packaging, sales & marketing, transport, & management)
Inputs	Raw FS – 2 m^3/day & Organic waste – 3 MT/ day
Outputs	Co-compost: 700 MT/year; Vermicompost: 150 MT/year

Case description

Greenery Bio Compost's business motive is to produce and sell compost made from any available organic waste stream, including FS. Greenery Bio Compost engaged with Bansberia Municipality to lease land for 30 years for the co-composting unit. The municipality is responsible for collection of organic waste and FS and delivers the waste to the co-composting unit. The municipality owns and operates a desludging vehicle, and there are no private operators in the town.

Greenery Bio Compost has an onsite poultry farm and uses the poultry waste as an additional input in the production of co-compost. When the quantity of organic waste is insufficient, Greenery Bio Compost procures additional waste from nearby municipalities; similarly, when there is not enough poultry waste, the company procures animal waste from local farmers. The co-compost produced is packaged and delivered to clients at their doorstep. Greenery Bio Compost clients are fertilizer companies, dealers, and distributors and farmers. The relationships among the various stakeholders in the value chain are depicted in Figure 76.

FIGURE 76. VALUE CHAIN OF THE BANSBERIA CO-COMPOSTING UNIT MODEL.

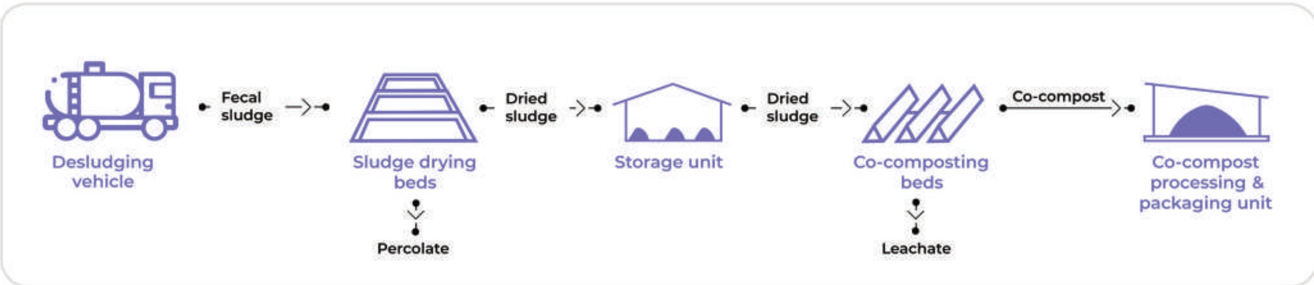


Technology and processes

The installed capacity of the FSTP is 30 m^3 per day, but on average, the plant gets about 2 m^3 per day of FS. The desludging trucks deposit the sludge on composting-cum-unplanted drying beds. The plant does not treat the effluent from the drying beds; it is released in the open. Poultry excreta is added to increase the nitrogen content of FS, along with lime to kill pathogens. The dried sludge is spread out on the co-composting beds and left there for several months.

A three-layer compost is formed and mixed together – 1) dried sludge; 2) ash from burning the poultry slaughterhouse leftovers such as animal skin; and 3) Kheri, which consists of animal blood mixed with coconut peel and husks. In parallel, vermicompost is produced from cow dung and organic waste. The vermicompost and three-layer compost are then mixed together to form a nutrient-rich co-compost (CSE 2017, 2019). The co-compost is packaged and delivered to clients. The technology used for co-composting of FS and organic waste is inexpensive, requiring minimal maintenance, but is labor and time intensive. The process is summarized in Figure 77.

FIGURE 77. TECHNOLOGY PROCESS OF THE BANSBERIA CO-COMPOSTING UNIT.



Source: Greenery Bio Compost.

Funding and financial outlook

Most of the treatment and co-composting infrastructure, such as the composting chambers (now used as sludge drying beds), sieving shed, parking shed, and office building, was already present when the unit was handed over to Greenery Bio Compost. The capital cost for the original setup was INR 38.8 million. Greenery Bio Compost had to invest an additional INR 2.4 million in buildings, machinery, licensing, and procurement of initial raw materials. In order to finance the capital investment, the entrepreneur used his own savings and took a loan of INR 180,000 at an interest rate of 1% a month by pawning gold, as well as around INR 1 million as a loan from friends and family. As of April 2019, the entire gold loan and 80% of the other loans had been repaid from the profits generated by the business.

Co-composting operations require one production manager and four workers for operating and maintaining the composting-cum-sludge drying beds, and five staff are required for packaging, transport, and sales and marketing of the co-compost. The annual operational cost of running the co-composting unit is about INR 2.5 million, with more than half of the expense going towards purchase of input raw materials, and nearly a third spent on labor. Greenery Bio Compost's annual revenue is INR 5.4 million, which comes from sales of 850 MT of compost. Co-compost is sold at a rate of INR 6 per kg, and vermicompost is sold at INR 8 per kg. Table 13 provides a financial breakdown of Greenery Bio Compost operations.

Based on the growth in business and increased profits, the owner of Greenery Bio Compost plans to invest around INR 3 million to construct new co-composting facilities in neighboring towns along the Hooghly River. The company also plans to improve the technical process of co-composting to produce higher-nutrient value compost, along with diversifying the customer base.

TABLE 13. FINANCIAL BREAKDOWN OF GREENERY BIO COMPOST OPERATIONS.

Items	Cost in INR
Capital Cost*	41,200,000
Annual Revenue**	
Sale of co-compost	4,200,000
Sale of vermicompost	1,200,000
Total Revenue	**5,400,000**
Annual Expense**	
Labor	750,000
Electricity (for lighting & ventilation)	40,000
Fuel for transport	180,000
Raw materials (organic waste)	1,100,000
Delivery van repairs & maintenance	50,000
Site maintenance	33,333
Rent	100,000
Licensing & registration	50,000
Packaging	250,000
Advertising	100,000
Total Expense	**2,653,333**
Profit	**2,746,667**

Source: Greenery Bio Compost.
* Includes initial capital cost of INR 38.8 million & additional investment by Greenery Bio Compost of INR 2.4 million. USD 1.00 = INR 61.01 in 2014.
** USD 1.00 = INR 69.58 in March 2019.

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CASE STUDY

The Nilgiris District FSTPs and Co-Composting Units, Tamil Nadu

Location	Ketti and Adigaratty, Tamil Nadu
Value offered	Treated FS and organic fraction of solid waste, production of co-compost as soil ameliorant
Organization type and name	NGO – Rural Development Organisation (RDO) Trust
Project status	Operational since August 2017
Major partners	WASTE, Ketti and Adigaratty Town Panchayats, FINISH Society
Financing entities and revenue source	***Capital cost:*** United States Agency for International Development (USAID), Swedish International Development Cooperation Agency (Sida), Ministry of Foreign Affairs of the Netherlands (DGIS), and Government of South Africa ***Operating cost:*** USAID, Sida, DGIS, Government of South Africa, Ketti and Adigaratty town panchayats, and sale of compost

Context and background

The Nilgiris District in Tamil Nadu is a hilly region situated in the Western Ghats, one of the 10 biodiversity hotspots in the world. The economy predominantly relies on agriculture, primarily tea, vegetables, and spices. With declining soil fertility, farmers in the region are facing low agricultural productivity. Additionally, the management of FS, organic waste, and other non-biodegradable waste has become a challenge, especially due to increased environmental pressure as a result of tourism. The RDO Trust, an NGO, has worked on women and farmer empowerment through livelihood provision in the Nilgiris District for the past 35 years. In 2012, the RDO Trust expanded its mission to facilitate access to safe sanitation under the FINISH program and in 2016 collaborated with the FINISH Society and WASTE (technical partners) to set up an FSTP in Chamraj Tea Estates in the Nilgiris District, to treat FS

Key indicators (as of April 2019)	
Installed capacity	Ketti FSTP – 4.4 m^3/day Adigaratty FSTP – 7.2 m^3/day
Allocated land area	Ketti – 1 acre and Adigaratty – 2 acres
Labor requirements	9 persons (FTE) for each plant
Inputs	Ketti: Raw FS – 0.3-0.4 m^3/day & organic waste – 800-1,000 kg/day Adigaratty: Raw FS – 0.6-0.7 m^3/day & organic waste – 1.6-2 MT/day
Outputs	Co-compost: Ketti – 102 MT/year & Adigaratty – 174 MT/year

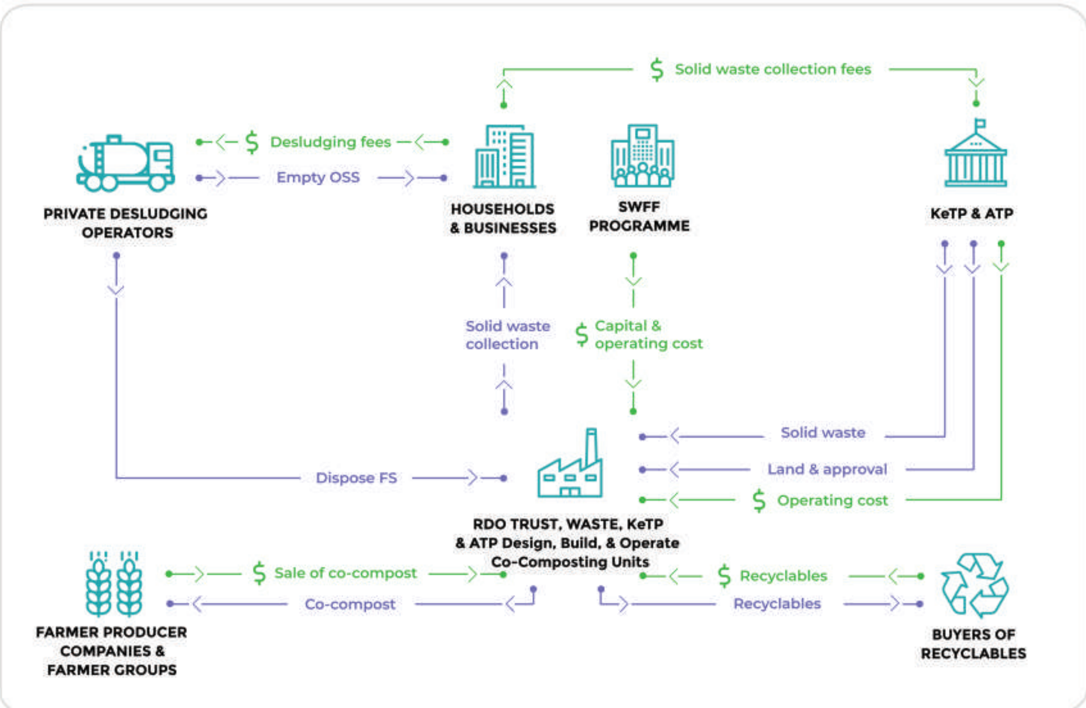
generated from the housing colony for the workers at the tea estate.

In 2017, the RDO Trust collaborated further with WASTE to promote the circular economy in sanitation and SWM in the Nilgiris District through the establishment of two FSTPs with co-compost production in Ketti Town Panchayat (KeTP) and Adigaratty Town Panchayat (ATP). These units were implemented under the Securing Water for Food (SWFF) programme financed by USAID, Sida, DGIS, and the Government of South Africa, which aims to promote science and technology solutions that enable production of more food with less water and/or make more water available for food production, processing, and distribution (Sustainable Sanitation Alliance 2019).

Case description

The RDO Trust, in partnership with WASTE, led the development of the FSTP and co-composting units in KeTP and ATP. WASTE provided technical assistance in the development of FSTP designs, O&M procedures, the business model, and monitoring framework. KeTP and ATP managed their respective composting sites (Resource Recovery Parks) and provided land within the sites for the FSTPs. The funding from the SWFF programme was used for the capital cost and operational costs for three years. KeTP and ATP provided funding for the existing solid waste processing operations at the resource recovery parks. The RDO Trust signed MoUs with KeTP and ATP to manage the FSTPs and co-composting units for three years, after which they will be transferred to the town panchayats. KeTP and ATP collect and deliver organic waste to the composting sites. Private desludging operators collect FS from households and transport it to the FSTPs. Dried sludge from the FSTPs is combined with organic waste to produce co-compost for vegetable farmers. The RDO Trust is responsible for the marketing and selling of the co-compost to its existing network of farmers. The targeted farmers are mainly vegetable farmers who are organized into farmer producer organizations. The relationships among the various stakeholders in the value chain are depicted in Figure 78.

FIGURE 78. VALUE CHAIN OF THE NILGIRIS DISTRICT FSTPs AND CO-COMPOSTING UNITS.

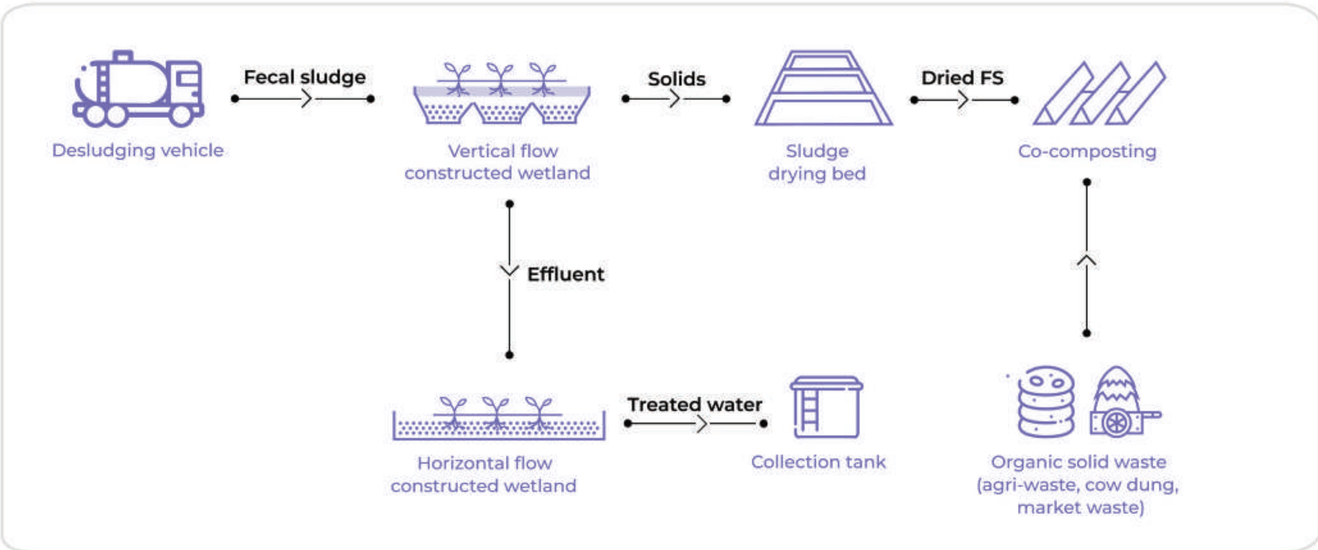


Source: RDO Trust and WASTE 2019.

Technology and processes

The installed capacity of the FSTPs is 4.4 m^3 per day in Ketti and 7.2 m^3 per day in Adigaratty, but on average, they receive one to two truckloads of FS every 10 days. The Ketti plant caters to one town panchayat, whereas the Adigaratty FSTP caters to three. The FSTP design involves biological processes. In each FSTP, FS is fed into the vertical planted gravel filter (VPGF). The effluent from the VPGF is treated in a horizontal planted gravel filter. The sludge from the VGPF is deposited onto planted sludge drying beds. Dried sludge is mixed with organic waste, at a ratio of 1:4, to produce co-compost, which is sent for analysis to ensure the standard parameters are adhered to. The co-compost is then packaged and is picked by the vegetable farmers. The process is labor-intensive, but the technology is low-cost and low-maintenance. The process is summarized in Figure 79.

FIGURE 79. TECHNOLOGY PROCESS OF NILGIRIS DISTRICT FSTPs AND CO-COMPOSTING UNITS.



Source: RDO Trust and WASTE 2019.

Funding and financial outlook

Under the SWFF programme, funds have been allocated for the capital cost and operating costs of the FSTPs and co-composting units for three years. The capital cost has been calculated at INR 1,641,220 and 1,859,100 for the KeTP and ATP FSTPs and co-composting units, respectively. The O&M cost is similar for both, around INR 769,000 annually. Almost half of this amount is spent on labor, and another third of it on laboratory testing of FS, effluent, dried sludge, and co-compost. Nine staff are required to run the FSTP and co-composting operations. The RDO Trust pays for the FSTP operator and four workers for co-composting at each site, and the town panchayats pay for the remaining workers. KeTP and ATP pay for utilities separately.

The RDO Trust facilitates the sale of 276 MT of co-compost annually for both the town panchayats, at a rate of INR 4.2 per kg, thereby generating annual revenue of approximately INR 1.16 million for the town panchayats. Co-compost marketing is minimal because the RDO Trust has an existing network of 2,360 farmers in the region. Table 14 provides a financial breakdown of the operations. As a next step, the RDO Trust plans to lobby with the local governments to hand over FSTP and co-composting O&M to women SHG members working in the Resource Recovery Parks, after empowering them to manage this activity as a social enterprise. The RDO Trust also plans to establish more FSTPs across the Nilgiris District in Tamil Nadu.

TABLE 14. FINANCIAL OVERVIEW OF NILGIRIS DISTRICT FSTPs AND CO-COMPOSTING UNITS.

Items	KeTP (Cost in INR)	ATP (Cost in INR)
Capital Cost*		
FSTP & co-composting unit	734,220	900,000
Shed	577,000	673,000
Machinery & tools	330,000	286,100
Total Capital Cost	**1,641,220**	**1,859,100**
Annual Expense**		
Labor	360,000	360,000
Raw materials (microbial solution)	25,200	25,200
Repair & maintenance	6,000	5,400
Laboratory testing	264,000	240,000
Packaging	60,000	84,000
Marketing	24,000	24,000
Travel & miscellaneous	30,000	30,000
Total Expense	**769,200**	**768,600**
Annual Revenue**		
Sale of co-compost	428,400	730,800
O&M subsidy from town panchayat & SWFF Programme	769,200	768,600
Total Revenue	**1,197,600**	**1,499,400**
Profit	**428,400**	**730,800**

Source: RDO Trust.
* USD 1.00 = INR 63.92 in August 2017.
** USD 1.00 = INR 71.25 as of October 2019.

References

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11.2 Business Model: Energy Recovery

11.2.1 Value proposition

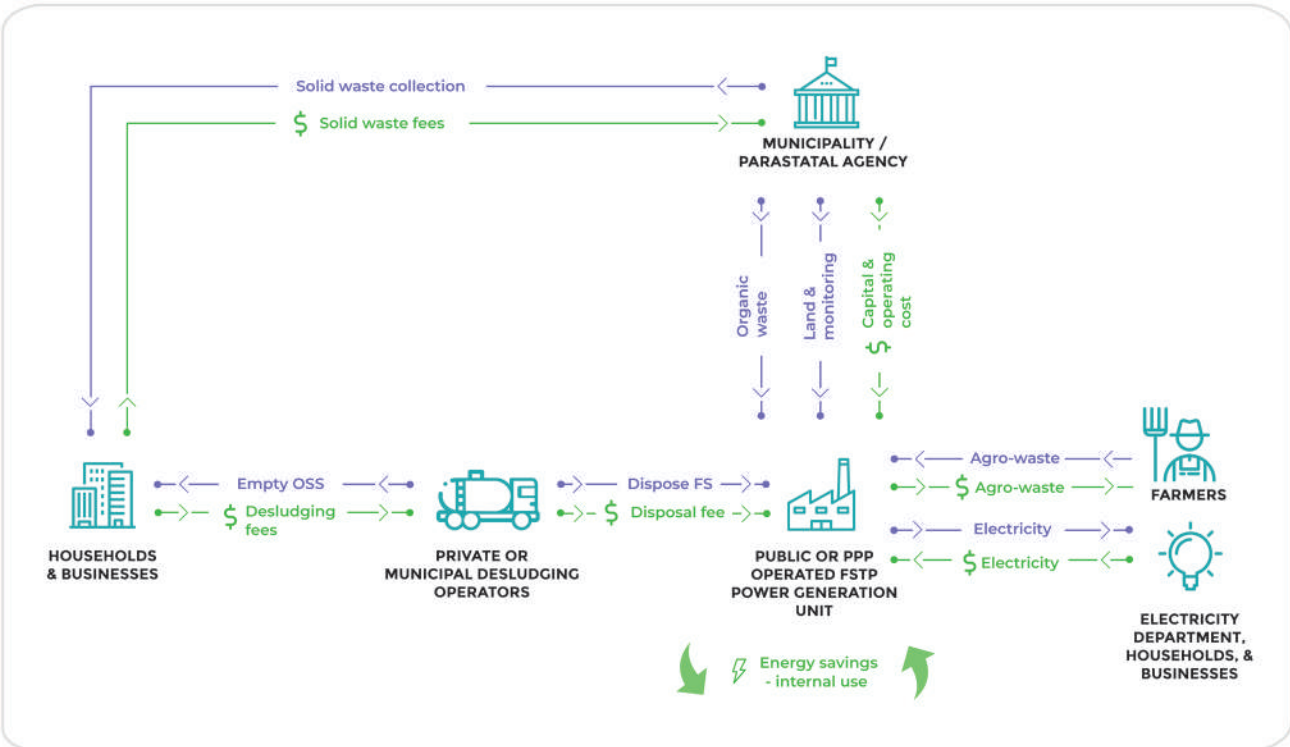
The model focuses on the treatment and reuse components in the sanitation value chain by producing energy from FS. It offers the following value propositions:

- *Treatment of FS for a healthy community and environment*
- *Recovery of energy from FS to generate renewable energy for heating or electricity to reduce energy costs and GHG emissions*

11.2.2 Description

In this model, FS is collected from OSS by municipal or private desludging operators and transported to the FSTP. Organic solid waste may be sourced from the municipality or collected by the private entity from hotels and markets. The energy produced in the FSTP can be used for internal energy requirements such as lighting and heating. Alternatively, it can be sold to nearby households and businesses. In cases where biogas is generated at the FSTP, it can be upgraded by removing carbon dioxide, hydrogen sulfide, and other possible pollutants to increase methane concentration. The upgraded biogas can be directly injected into the natural gas pipeline, used as a vehicular fuel, or bottled to facilitate ease of transportation and storage. If electricity is generated from the FSTP, excess electricity, after meeting the FSTP's energy demand, can be sold to nearby households and businesses or fed into the grid. The relationships among the various stakeholders are shown in Figure 80.

FIGURE 80. VALUE CHAIN OF THE ENERGY RECOVERY BUSINESS MODEL.



Owner and operator: The business model is implemented by any of the following entities: public, private, or a PPP. In the case of PPP, the municipality will enter into a contract with a private entity that can include construction and operation of the treatment plant or only operation.

11.2.3 Funding and financing

Capital cost: This is largely covered by grants from donors and funds from state or central government programs for improving urban infrastructure. The business model has potential for a private entity to partially or fully invest in it, depending on the financial viability from sale of energy products.

Operating cost: The state or municipality typically finances this cost through a combination of local taxes and state and central government financial assistance. The FSTP could generate revenue from disposal fees charged to desludging operators and sales of biogas or electricity. In a PPP set-up, to encourage reuse, the municipality could structure the contract to require the private entity to recover a percentage of its operating cost through the sale of energy, with the municipality paying a minimum fixed O&M fee.

11.2.4 Risks and benefits

Risks

- Requires regular supply of FS (and organic waste) for reuse business sustainability
- Market acceptance of products made from FS

Benefits

- The reuse business model offers scope for reduced dependency on subsidies through increased operational cost recovery
- Energy generation from FS (and organic waste) ensures energy security
- Promotes a circular economy and contributes to reduction of GHG emissions

11.2.5 Relevance

The model manages the challenge of land allocation and availability by establishing a combined facility in one location instead of setting up separate treatment units for two different waste streams. Municipalities that have implemented segregation of waste at the household level can implement the model within the FSTP by diverting organic waste to it. The business model is most suitable for a municipality that wants to address management of both solid waste and FS in one facility. The report covers following case studies:

- Nashik Waste-to-Energy Plant, Nashik, Maharashtra (explained in this section)
- Warangal FSTP, Warangal, Telangana (explained in this section)
- Kochi PPP FSTP, Kochi, Kerala

Related models from other countries have been reported, e.g., in Accra, Ghana and Nairobi, Kenya.

CASE STUDY

Nashik Waste-to-Energy Plant, Maharashtra

Location	Nashik, Maharashtra
Value offered	Treated FS and organic waste to generate electricity and organic fertilizer (processing unit under construction)
Organization type and name	PPP – Nashik Municipal Corporation (NMC) & Vilholi Waste Management System Private Limited
Project status	Operational since December 2017
Major partners	Ministry of Environment and Forests & Climate Change, NMC, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Hamburg Wasser & its private subsidiary ConsulAqua
Financing entities and revenue source	***Capital cost:*** GIZ & Vilholi Waste Management Systems Private Limited ***Operating cost:*** NMC & Vilholi Waste Management Systems Private Limited

Context and background

Nashik municipality, like many towns and cities in India, has struggled to address management of solid waste and FS. In partnership with the German development agency GIZ, it has developed a technical solution to manage the two waste streams while being environmentally responsible and mitigating GHG emissions. The integrated waste management solution was conceived as part of the International Climate Initiative in the German Federal Ministry of Environment, with the aim to implement a Waste to-Energy (WtE) plant in Nashik (Walther 2017).

Key indicators (as of January 2019)	
Installed capacity	30 tons per day (TPD) (10-20 m^3/day FS & 10-15 TPD organic waste)
Allocated land area	1.48 acres
Labor requirements	20 persons (FTE)
Inputs	Raw FS – 1-3 TPD & organic waste – 3-7 TPD
Outputs	~500 kWh electricity produced per day

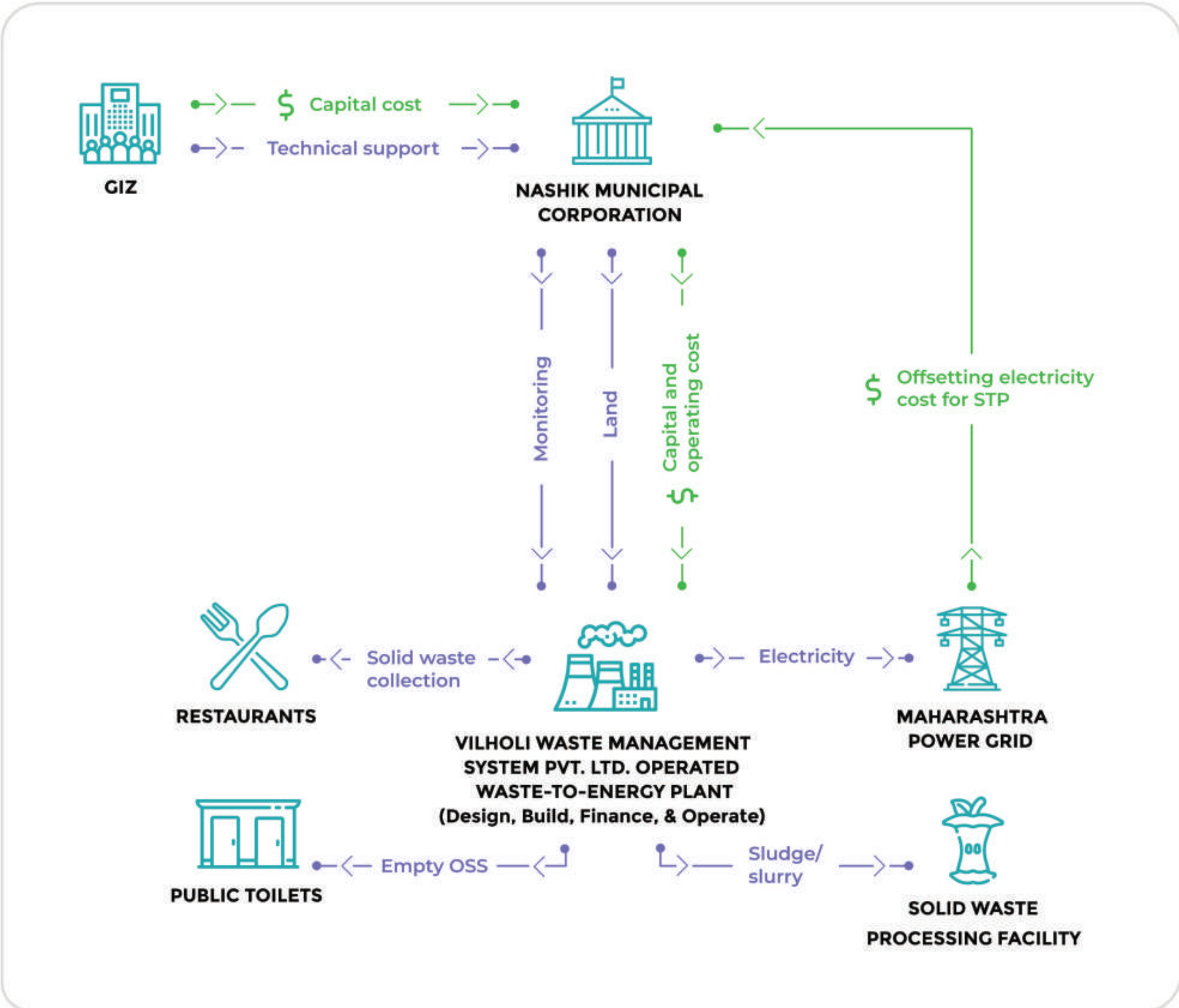
Case description

The goal of the business is to demonstrate an integrated approach to managing FS and organic waste to generate electricity and reduce GHG emissions. GIZ has been the driver in conceptualizing the project, providing technical support and capacity development to the stakeholders, liaising with the municipality to

allocate land and getting necessary approvals, and raising funds for the capital cost. Hamburg Wasser, the public water utility in Hamburg, Germany, provided its WtE technology; its private subsidiary, ConsulAqua, was responsible for monitoring construction.

NMC and Vilholi Waste Management System Private Limited (Vilholi) entered into a 10-year PPP contract on a DFBOT basis. The competitive tender selected Vilholi based on the lowest service fee and highest guaranteed electricity generation (subject to a minimum 1,150 kWh per day). The contract requires Vilholi to cover part of the capital cost and design, construction, and operation of the plant. Vilholi is responsible for sourcing the two waste streams for the plant – solid waste from restaurants and FS from public toilets. In the negotiated contract, Vilholi commits to supplying a minimum of 3,300 kWh of electricity generated from the WtE plant to the Maharashtra Power Grid. Under the Open Access Agreement for Wheeling of Electricity, NMC has access to the supplied quantum of power gratis. NMC provided land for the WtE plant and is responsible for monitoring and paying a fixed monthly O&M fee to Vilholi. The two by-products from the WtE plant are biogas and slurry. The biogas is used to generate electricity, and the slurry from the bio-digester is transported to the nearby municipal solid waste processing site. The relationships among the various stakeholders in the value chain are depicted in Figure 81.

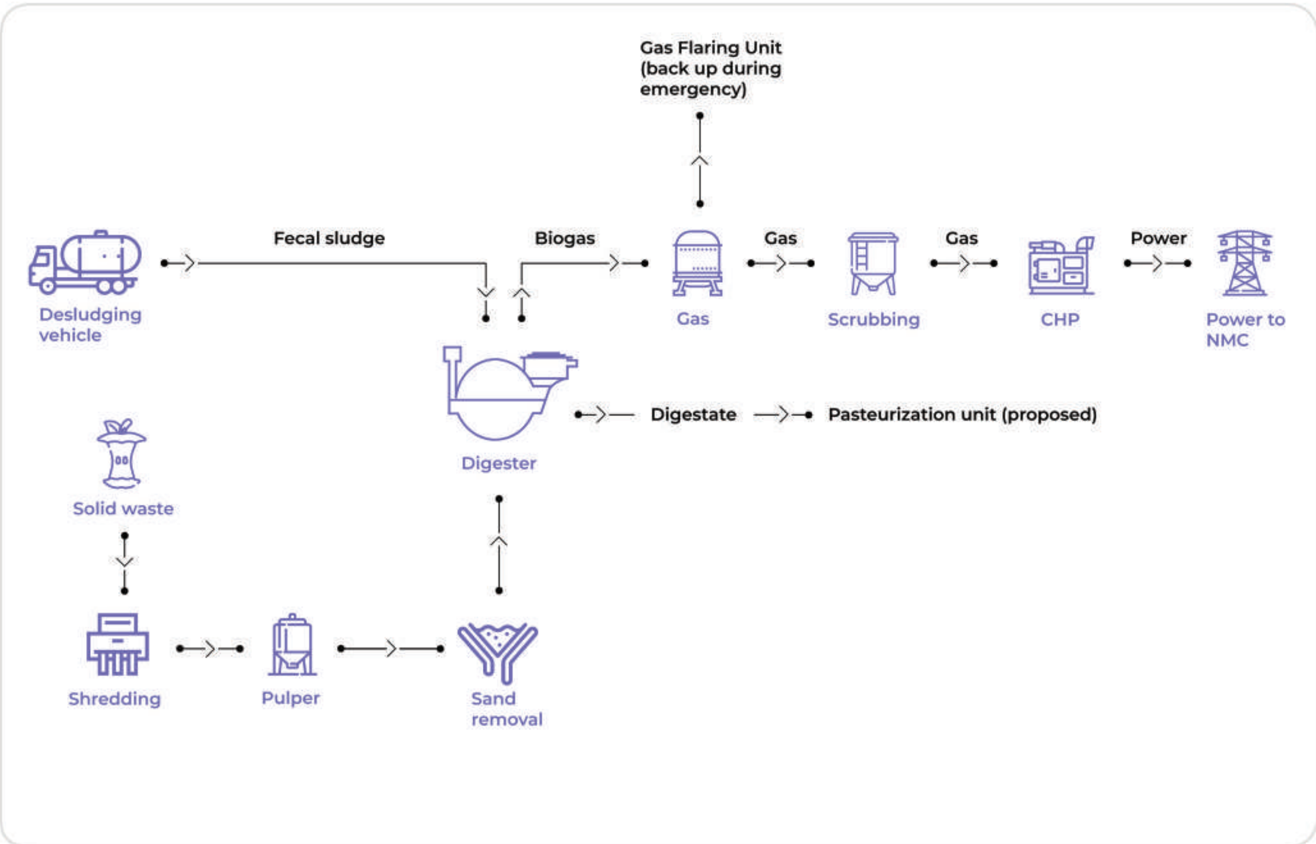
FIGURE 81. VALUE CHAIN OF THE NASHIK WtE PLANT MODEL.



Technology and processes

The WtE plant is designed to process 30 TPD of waste, including 10 to 15 TPD of food and vegetable waste from 1,300 restaurants in the town and 10 to 20 m^3 per day of FS from 400 community toilets (CSE 2018; Walther 2017). At the time of writing, the plant was processing 3 to 7 TPD of organic waste from 50 nearby restaurants and 1 to 3 TPD of FS from 100 public toilets, an equivalent of 40% of its operational design. The solid waste sourced is mixed waste and must be segregated at the plant. The plant design is based on bio-methanation technology. FS and organic waste are fed into the plant at a ratio of 1:2. Segregated organic waste is fed into the crusher and combined with the FS and transferred to a bio-digester. Biogas produced in the digester is purified in the scrubbing unit and used in the combined heat and power unit to generate electricity. The plant is designed to produce 2,200 to 3,300 kWh of electricity per day; at the time of writing, given the lower waste input streams, it was producing 500 kWh every day. A pasteurization unit to treat the bio-digester slurry to produce fertilizer is under construction (Walther 2017). The technology process is depicted in Figure 82. Vilholi has two 4 MT solid waste collection vehicles and one 5 m^3 desludging vehicle.

FIGURE 82. TECHNOLOGY PROCESS OF THE NASHIK WtE PLANT.



Source: Walther 2017.

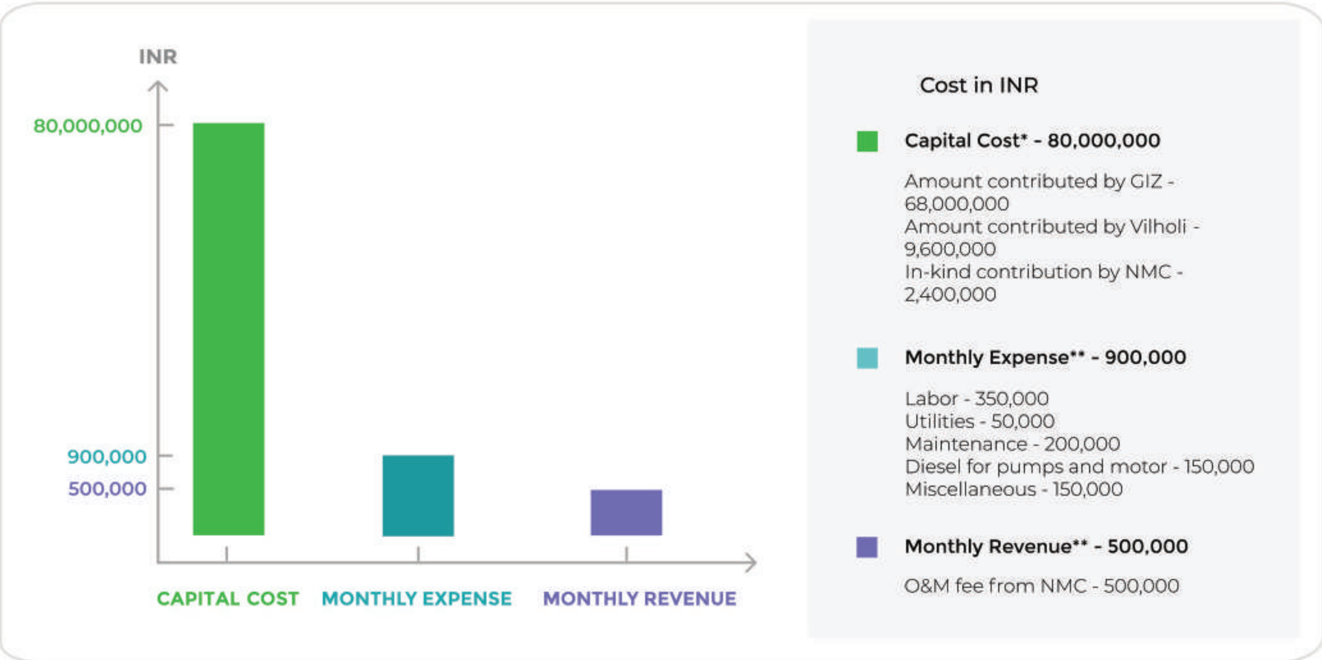
Funding and financial outlook

The capital cost of the project was INR 80 million, of which 85% was funded by GIZ, and 12% financed by Vilholi, and the remainder was contributed in-kind (land provision, road connection, etc.) by NMC. The cost of operations is INR 0.9 million per month, with over a third of the cost going towards labor. Twenty staff are required to run operations — eleven plant operators, one supervisor, one project manager, one chemist, one technical engineer, two drivers, and three security guards. More staff are needed than typically required for plant operations

because the solid waste delivered to the site is unsegregated and has to be segregated at the plant. The labor cost and overall operating cost could therefore be reduced if waste was segregated at the source. The originally estimated operational cost based on the plant design was much lower than the actual operating cost; the plant will undergo performance operation in the future, which should result in lower operational costs.

NMC provides a fixed fee of INR 0.5 million per month to Vilholi towards operational costs. Vilholi finances the remaining cost through its own operations. The O&M fee from NMC is the sole source of revenue. Vilholi could add another source of revenue by selling bio-fertilizer produced from bio-digester slurry. In addition, if Vilholi can increase its waste collection and generate enough electricity to exceed the required amount, it can sell the excess electricity. The capital cost, O&M cost and revenue for Vilholi are summarized in Figure 83.

FIGURE 83. FINANCIAL OVERVIEW OF THE VILHOLI WASTE MANAGEMENT SYSTEM.



Source: Vilholi Waste Management System Private Limited.
* USD 1.00 = INR 64.21 in December 2017.
** USD 1.00 = INR 71.25 as of October 2019.

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CASE STUDY

Warangal FSTP, Telangana

Location	Warangal, Telangana
Value offered	Treated FS for production of biochar as a soil ameliorant or charcoal substitute
Organization type and name	Private - Tide Technocrats Private Limited
Project status	Operational since November 2017
Major partners	ASCI, BMGF
Financing entities and revenue source	***Capital cost:*** BMGF ***Operating cost:*** BMGF

Context and background

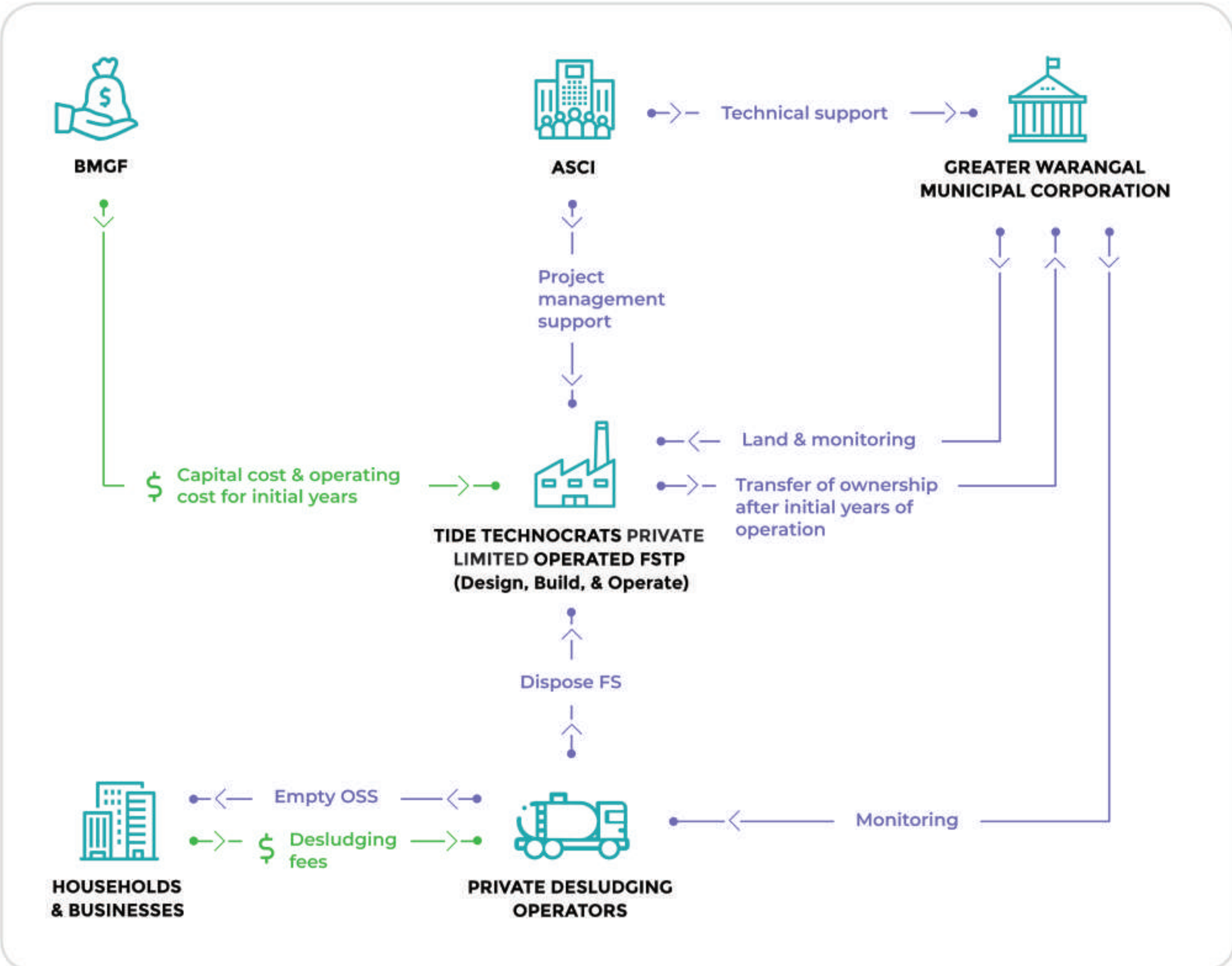
In 2015, the GWMC, with support from the ASCI, conducted a diagnostic study on FSM. The study was funded by the BMGF to understand key areas for improvement and develop an FSM action plan. The study led to the city taking several initiatives to address gaps in FSM. Notably, in March 2016, Warangal became the first city in the country to issue FSM regulations and septage management guidelines (Chary et al. 2017). One of the major achievements in operationalizing the GWMC's FSM Guidelines was the commissioning of the country's first FSTP based on pyrolysis in November 2017. To implement the treatment system, the ASCI and GWMC partnered with Tide Technocrats Private Limited (TTPL), who wanted to pilot its FSTP technology, developed under the BMGF's transformative technology initiative. TTPL piloted the technology in Warangal and Narsapur, Andhra Pradesh, and Wai, Maharashtra. The pilot FSTP in Warangal led to the implementation of FSTPs in PPP models in 76 towns in Andhra Pradesh and 72 in Telangana (Swachh Andhra Corporation 2018; CDMA 2018).

Key indicators (as of March 2019)	
Installed capacity	15 m^3/day
Allocated land area	Allocated: 1 acre; FSTP land area: 0.6 acres
Labor requirements	4-10 persons (FTE) – two 12-hour shifts of 1-3 security guards/gardeners, 1-3 operators, 1-3 assistant operators, and 1 supervisor
Inputs	Raw FS – 9-15 m^3/day
Outputs	1.8 to 2.5 kg biochar per 0.1 m^3 septage treated (currently not being sold)

Case description

The ASCI provided technical support and expertise in Warangal by setting up a TSU on NSS within the GWMC. The TSU spearheaded the implementation of the city's FSM guidelines, from project planning to implementation and monitoring. The TSU worked closely with the private desludging operators and the GWMC to formalize their operations (see *Case Study: Warangal Desludging Licensing, Telangana*). The ASCI and TTPL partnered to address the treatment of FS collected by the desludging operators. TTPL designed and constructed the FSTP and is responsible for O&M for the first two years, which is funded by the BMGF; thereafter, it will transfer the operations to the GWMC. The GWMC provided land, water, and electricity connections for the FSTP and monitors FSTP and desludging operations. Private operators licensed by the GWMC provide desludging services to households and businesses and transport the FS to the FSTP. The ASCI provided support by mobilizing local communities for their buy-in, along with clearances from the pollution control board. The FSTP designed by TTPL generates treated water (used for irrigation in nearby farmland), biochar (added to compost), dried sludge and thermal energy (used to generate the heat required in the FSTP's internal processes). The relationships among the various stakeholders in the value chain are depicted in Figure 84.

FIGURE 84. VALUE CHAIN OF THE WARANGAL FSTP MODEL.

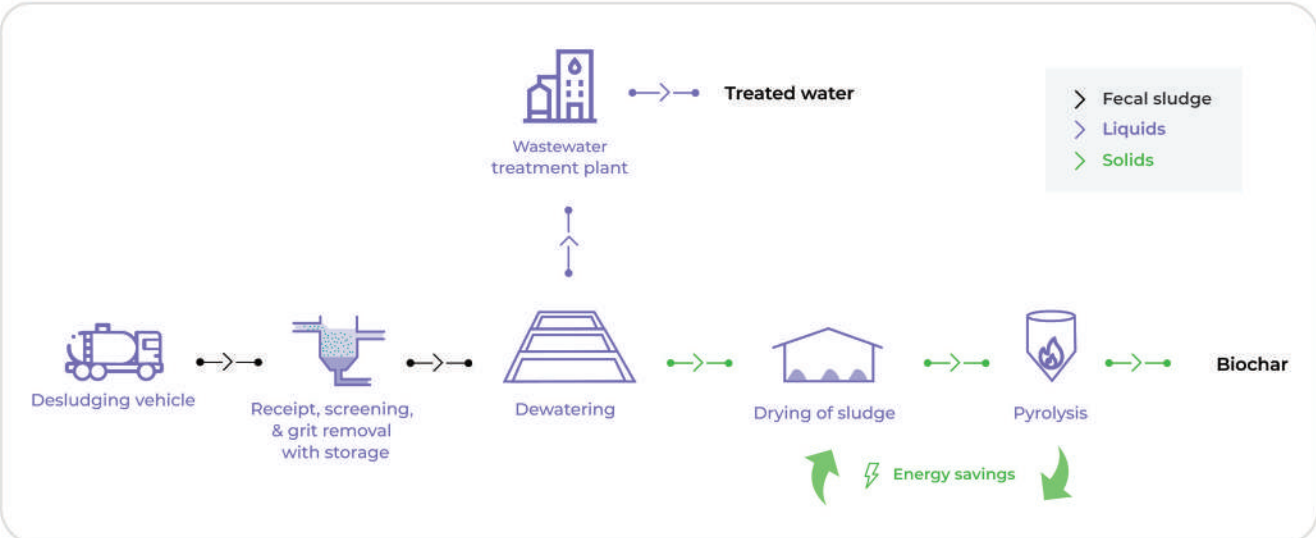


Technology and processes

The capacity of the FSTP is 15 m^3 per day, and it receives around 9 to 15 m^3 per day of FS. The technology is based on a combination of thermal, mechanical, and biological components that have been assembled into a shipping container. The primary process is pyrolysis, the thermochemical decomposition of organic material at elevated temperatures in the presence of controlled oxygen. The FSTP comprises a septage receiving station with screenings and grit chambers, a holding tank, a dewatering unit for solid-liquid separation, a dryer, a pyrolyzer with heat exchanger, and an effluent treatment system based on MBBR wastewater treatment technology. Hot water/air generated in the heat exchanger is used in the dryer. Dewatered, dried sludge is used to generate the heat required in the pyrolyzer. Biochar produced in the pyrolyzer is presently used as an additive in compost. The air used in the drying process is treated through a carbon filter before being discharged (TTPL 2019). Treated effluent is used for irrigation for cotton on a 0.5 acre plot of land near the FSTP.

The technology requires skilled labor and electricity to operate the mechanical equipment. The system does not require an external heat source for the thermal processes, because sufficient heat is recovered through the system to sustain operations. The technology process is shown in Figure 85.

FIGURE 85. TECHNOLOGY PROCESS OF THE WARANGAL FSTP.



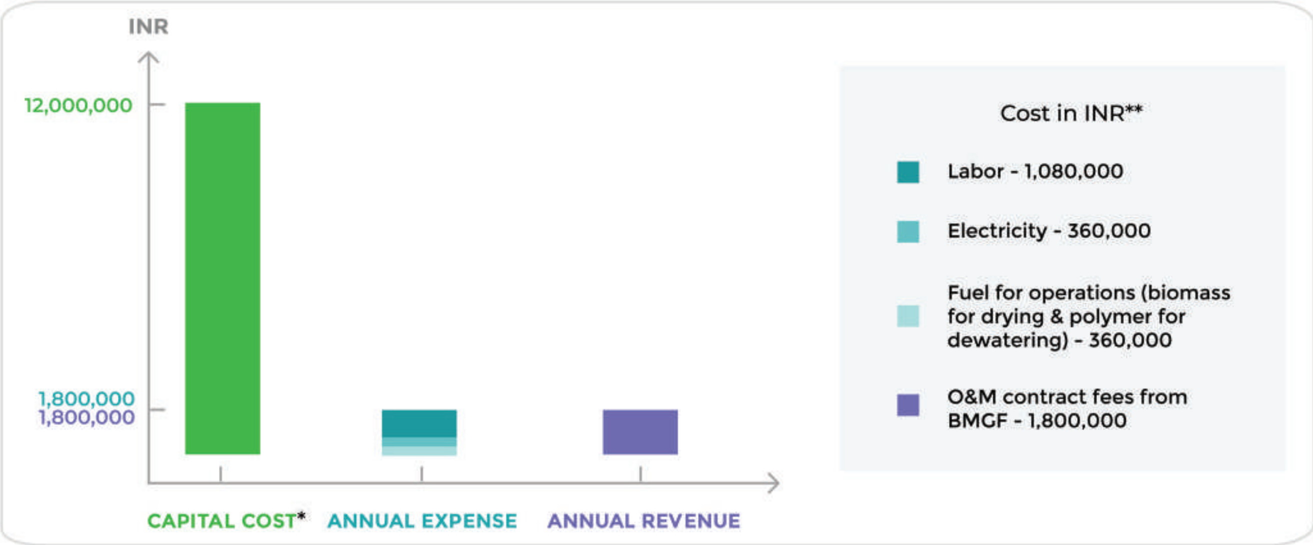
Source: Tide Technocrats Private Limited.

Funding and financial outlook

The capital cost for the FSTP is INR 12 million, and it is funded by the BMGF, along with two years of the O&M cost. Currently, the FSTP does not sell biochar, which could be a future revenue stream. The capital and operational costs and revenue are summarized in Figure 86.

After the FSTP was commissioned, another 10 m^3 per day FSTP, demonstrating geobag technology, was constructed on the same site by Banka Bioloo. Now that the pyrolysis technology has been successfully tested at a pilot scale, the GWMC is planning to set up a 150 m^3 per day FSTP with the same design, in order to treat all FS generated in the Greater Warangal area (The Hans India 2018).

FIGURE 86. FINANCIAL OVERVIEW OF THE WARANGAL FSTP.



Source: Tide Technocrats Private Limited.
* USD 1.00 = INR 64.86 in November 2017.
** USD 1.00 = INR 71.25 as of October 2019.

References

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12.

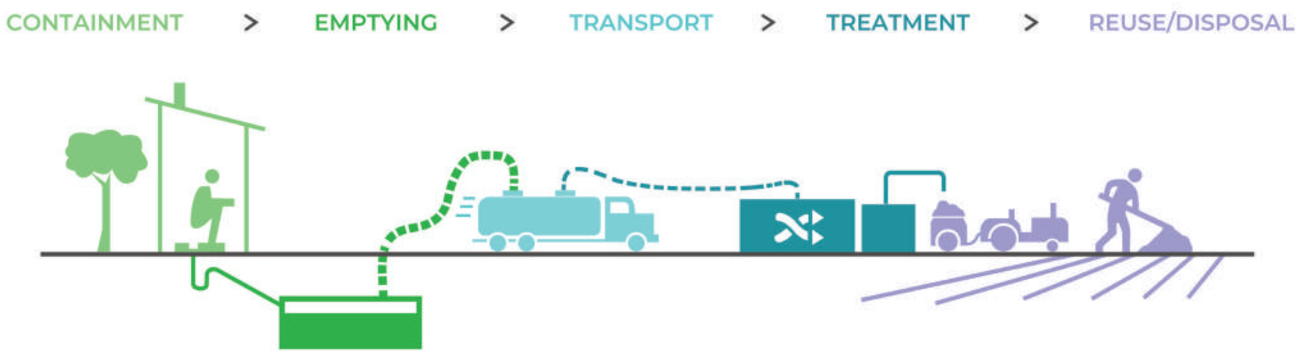
Models Covering the Entire Sanitation Value Chain

Business models in this section cover all components in the sanitation value chain, from toilet provision to FS treatment for disposal or reuse. The models offer the following value propositions:

1. Providing improved sanitation service to underserved communities or households through access to toilets
2. Timely and safe emptying of toilet containment units
3. Safe transportation of FS to designated disposal sites
4. Treatment of FS for a healthy community and environment

By linking all components of the value chain, these models provide end-to-end FSM solutions. The models are applicable where there is a demand for toilets and the presence of skilled organizations with the required technical expertise to implement all activities in FSM. The following business model is explained in this section:

- Integrated toilet-to-treatment sanitation



12.1 Business Model: Integrated Toilet-to-Treatment

12.1.1 Value proposition

The model covers all the components in the sanitation value chain, from toilet access to E&T and treatment of FS. It offers the following value propositions:

- *Providing improved sanitation service to underserved communities through access to toilets*
- *Timely and safe emptying of OSS in households, businesses, and institutions*
- *Safe transportation of FS to designated disposal sites*
- *Treatment of FS for a healthy community and environment*

12.1.2 Description

A private entity is responsible for end-to-end implementation of FSM. The private entity invests in and sets up the FSM infrastructure and equipment – toilets, desludging vehicles, and the FSTP. The private entity can engage with the municipality to provide land for the FSTP or lease it from a private land owner. The model works best when portable toilets or container-based sanitation (CBS) system (see Box 11) are provided. Toilet users pay the private entity a usage/rental fee that covers toilet maintenance, including desludging. The toilets are desludged regularly, and the FS is transported to the FSTP operated by the private entity. The FSTP can allow other private desludging operators to dispose of FS for a fixed disposal fee. The relationships among the various stakeholders are shown in Figure 87.

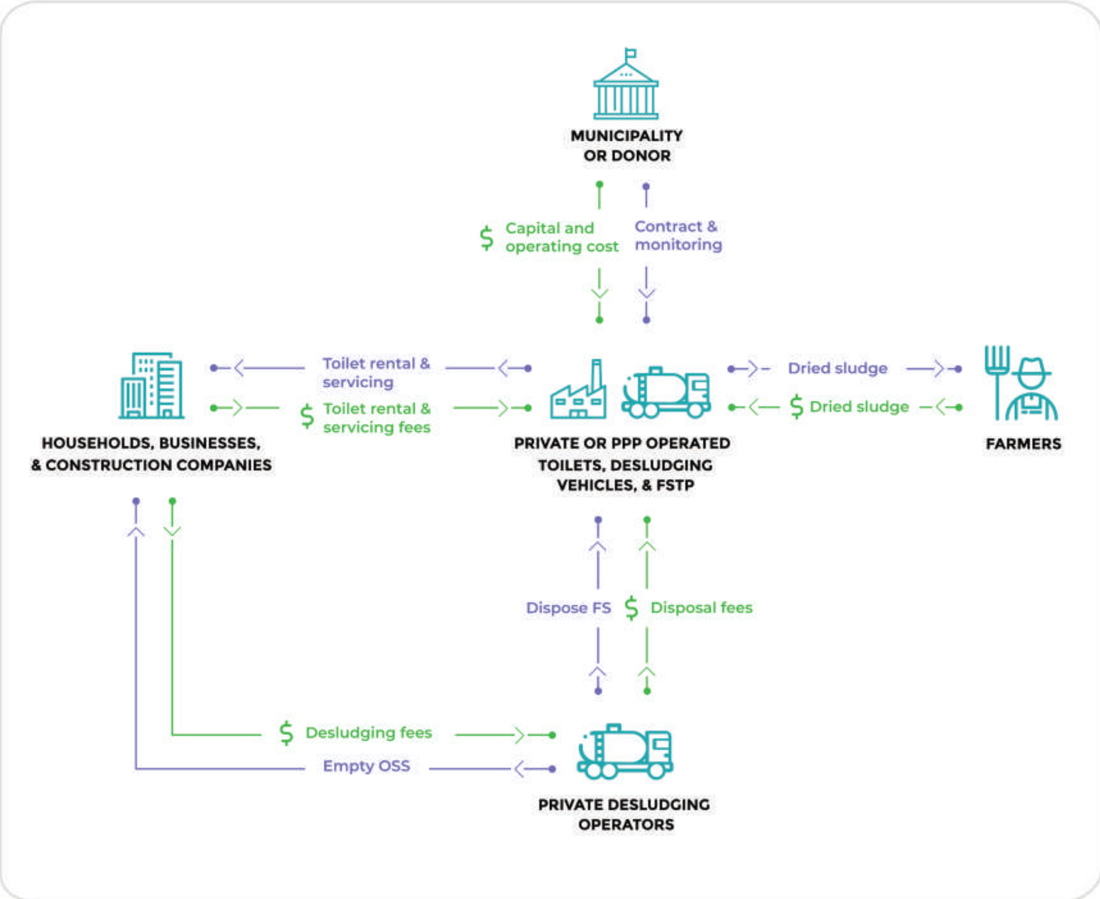
Owner and operator: The business model is implemented by a private entity such as an enterprise or NGO, which is the owner and operator of the FSM infrastructure.

BOX 11. CONTAINER-BASED SANITATION.

The business model covering the entire sanitation value chain is typically addressed through CBS. CBS has emerged as an alternative approach to sewers and OSS for sanitation provision. In CBS, excreta is collected in sealable and removable containers. The containers are regularly collected and replaced. Typically, collection is scheduled once or twice a week, and the container is transported to a treatment plant, where the excreta is treated. The entity providing the CBS service can plan to either recover nutrients or energy at its treatment facility. In the CBS model, the household does not have to invest in a plumbing facility and only has to sign up for the service. The business can be run either by a public or private entity or an NGO. The key revenue for the business is from toilet rental/emptying service fees, complemented by the sale of reuse products (Rao et al. 2016; World Bank 2019).

The CBS model has not been implemented in India. Internationally, the CBS is targeted at the urban poor living in densely packed settlements such as slums, in rented accommodation with no toilets or houses with no formal land title. CBS has been implemented both for individual household toilets and shared toilets. One of its key advantages is its resilience to floods and drought, in comparison to OSS. One of the biggest challenges related to implementing CBS in India would be the social acceptance of the technology, since culturally, Indians prefer using water for anal ablution, and the CBS technology is not suited for water usage. Water usage would create challenges in the transportation of containers, and containers would fill up more frequently and hence require frequent collection services.

FIGURE 87. VALUE CHAIN OF THE INTEGRATED TOILET-TO-TREATMENT BUSINESS MODEL.



12.1.3 Funding and financing

Capital cost: This is covered by investment from the private entity and/or grants from donors.

Operating cost: The private entity typically finances the cost through collection of user fees for toilet usage. This can be supplemented by the sale of reuse products and disposal fees collected from other private desludging operators. An external donor may partially or fully finance the operating cost until the system is taken over by the municipality.

12.1.4 Risks and benefits

Risks

- Dependency on a single entity to manage all FSM services and, hence, the need for appropriate contractual provisions
- Ability of the end-user to pay for the services

Benefits

- The integrated model enables linkage of FSM investment for enhancing public health and environment outcomes
- The private entity is efficiently filling the sanitation gap, thus easing the burden on the municipality

12.1.5 Relevance

Highly applicable to the construction industry for provision of toilets for workers, temporary settlements during disasters, and large festivals/events. The following case study is explained in this section:

- Patna Portable Toilets and FSTP, Patna, Bihar

This model is similar to the CBS model (Box 11), which is reported in other countries, e.g., in Accra, Ghana; Port-au-Prince, Haiti; Lima, Peru; Nairobi, Kenya; and Antananarivo, Madagascar

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CASE STUDY

Patna Portable Toilets and FSTP, Bihar

Location	Patna, Bihar
Value offered	Providing toilets and their maintenance and treating excreta from these toilets
Organization type and name	Private – Saraplast Private Limited
Project status	Started in April 2015; FSTP closed down in January 2018 due to lack of financial viability
Major partners	PSI India, BMGF
Financing entities and revenue source	***Capital cost:*** BMGF ***Operating cost:*** User fees and BMGF

Context and background

PSI India, an NGO, started working on sanitation in 2012 through a BMGF-funded project in rural Bihar. PSI India undertook a study to understand the sanitation landscape in Bihar, which resulted in Project Prasaadhan, subsequently funded by the BMGF in 2014, which focused on the development of integrated business models for toilet provision, desludging, and treatment of FS (SRI 2014; Sustainable Sanitation Alliance 2019). A key gap identified was lack of toilet access, indicating the need for an affordable, portable toilet solution for migratory and underserved populations. PSI India partnered with Saraplast Private Limited (Saraplast), which had experience in the provision of portable toilets. Saraplast had implemented a portable toilet cabin (PTC) rental model in Pune and other cities in South India. The challenge in Bihar was to simultaneously establish a market for PTCs in both urban and rural areas and build and operate an FSTP in Patna to process human waste from these PTCs.

Key indicators (as of December 2017)	
Installed capacity	15 m^3/day
Allocated land area	0.046 ha
Labor requirements	6 persons (FTE)
Inputs	FS – 15 m^3/day

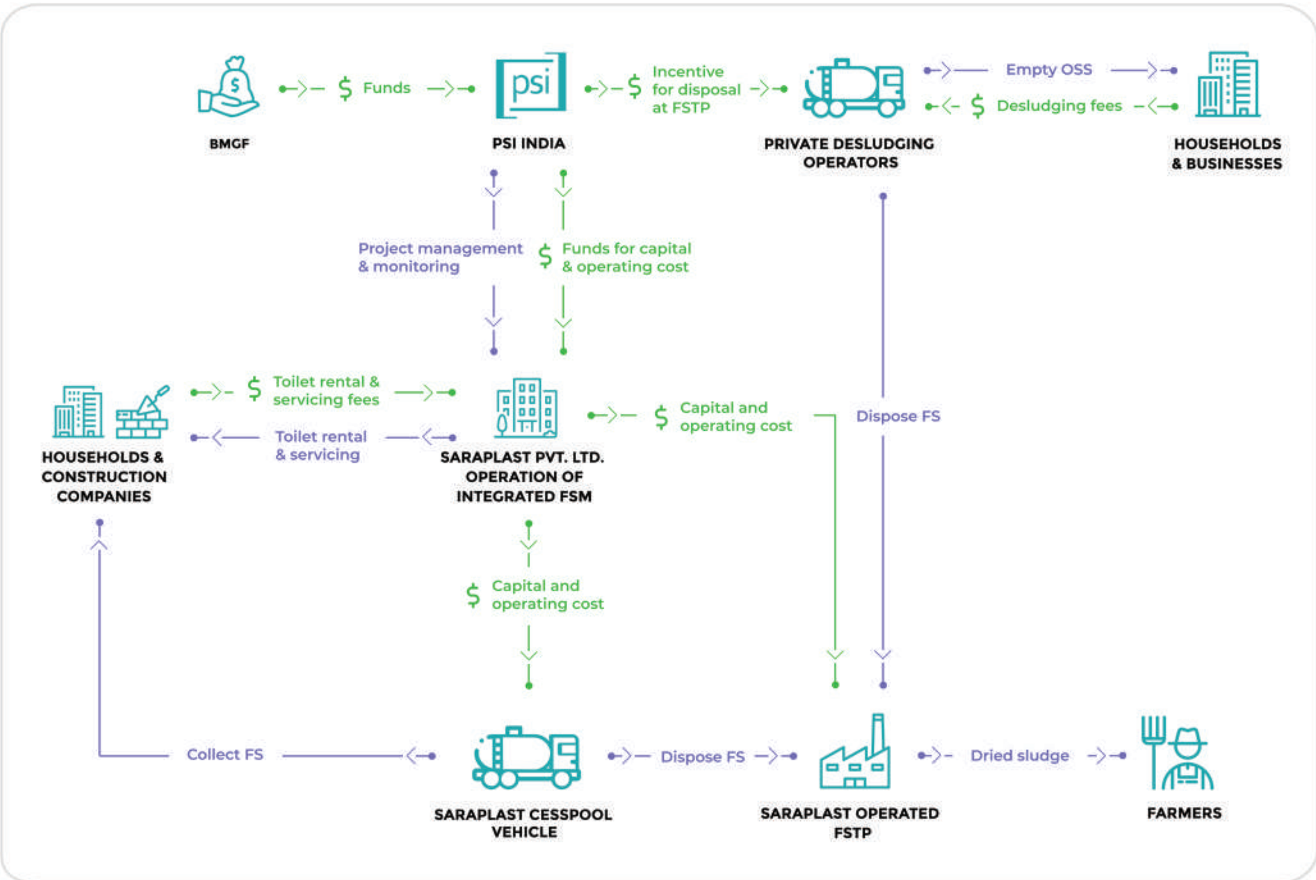
Case description

The partnership of PSI India and Saraplast aimed to provide an FSM solution for the entire sanitation value chain, from toilet provision to safe E&T, treatment, and disposal of FS. PSI India spearheaded the project and was responsible

for overall management, including community mobilization and liaising with local institutions. Saraplast was responsible for providing PTCs, undertaking E&T, and treating human waste from the PTCs. Saraplast leased land from a private individual to establish the treatment plant. PSI India generated demand for the PTCs and mobilized private desludging operators in Patna and gave incentives to them to transport FS to the FSTP.

Construction companies in Patna and large families in villages close to the city were Saraplast's primary customer segments for the PTCs. The urban PTCs were rented for a fixed fee, which included providing a desludging service either daily or on alternate days. Rural families rented out fixed fiber-reinforced plastic toilets with weekly servicing. Saraplast collected fees from PTC customers on a monthly basis. Saraplast also provided toilet desludging services to households and collected maintenance fees. The excreta collected from the PTCs and households was disposed of at the FSTP. According to the partnership, PSI India was expected to partially fund the operational cost of desludging and FS treatment and paid a monthly fixed fee to Saraplast on a per PTC basis. Treated water from the FSTP was used for landscaping and cleaning, while the partially treated sludge was given away to farmers. The various relationships among the different stakeholders in the value chain are depicted in Figure 88.

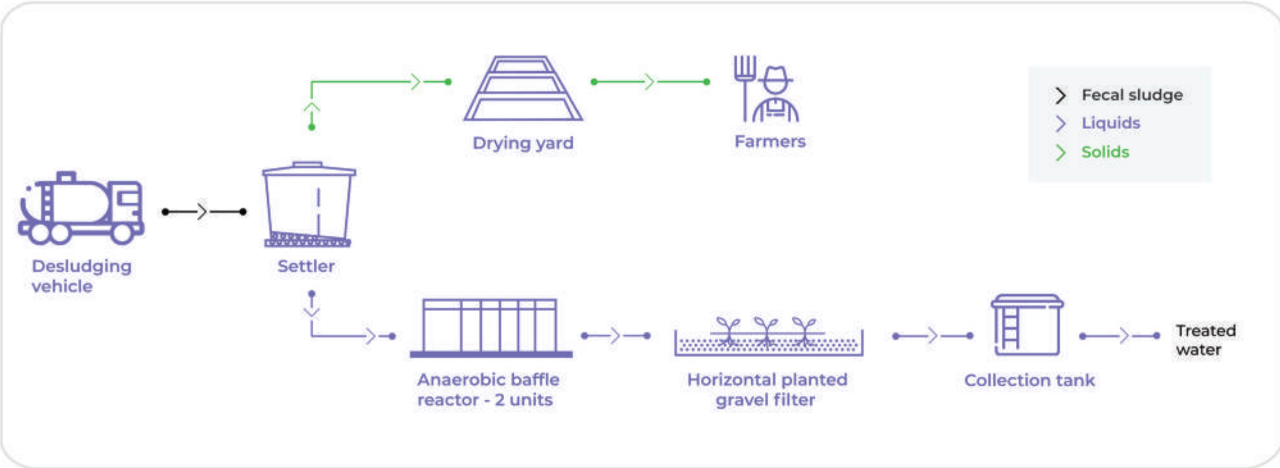
FIGURE 88. VALUE CHAIN OF THE PATNA PORTABLE TOILETS AND FSTP MODEL.



Technology and processes

The capacity of the FSTP was 15 m^3 per day, and the plant mostly operated at full capacity. The plant was designed by the CDD Society and used a biological process to treat FS, with a settler used for solid-liquid separation. Sludge collected from the settler was dried in a yard, and effluent was treated using a DEWATS system. The process is depicted in Figure 89.

FIGURE 89. TECHNOLOGY PROCESS OF THE PATNA FSTP.



Source: 3S.

Funding and financial outlook

The total capital cost of the entire FSM infrastructure amounted to INR 5.7 million, of which Saraplast contributed INR 3.8 million in assets (60 PTCs and 1 desludging vehicle) and INR 0.7 million for the FSTP (Figure 90).

FIGURE 90. FINANCIAL OVERVIEW OF THE PATNA PORTABLE TOILETS AND FSTP.

Source: 3S.
* USD 1.00 = INR 62.61 in April 2015.
** USD 1.00 = INR 65.11 in 2017.

The BMGF funds were used to cover the remaining cost of the FSTP – INR 1.2 million. The O&M was comprised of two major components – PTC servicing and FSTP operations – and cost INR 225,000 per month. BMGF funds were used to cover the entire O&M cost for the first two years. In 2017, the BMGF reduced its O&M grant to one-third of the total amount for managing urban PTCs only. In addition to paying Saraplast, PSI India paid INR 10,000-15,000 per month to incentivize private desludging operators to dispose of FS at the FSTP. Saraplast had three revenue streams – O&M fees from PSI India, PTC rental and desludging service fees, and fees for desludging other OSS in Patna.

Saraplast's revenue covered up to 68% of its monthly expenses. A significant portion of the O&M cost was rental for the private land. Typically, Saraplast is able to generate higher revenue by charging INR 4,500-5,000 per PTC per month; however, in Patna, they could only charge INR 1,000 to 3,600 per PTC per month. Saraplast could not sustain the operations as it was unable to cover its expenses, and the operations had to be shut down, with the FSTP decommissioned in January 2018.

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ANNEX

Photo: Sharada Prasad C S

Annex. FSTP Data.

TABLE A1. FSTP DATA.

SL No.	City	State	Year of commissioning	Designed capacity (m^3/day)	Type of technology	Land allocated (acres)	Capital cost in INR (million)	Operating cost in INR (million/month)	Reuse - resource utilized
1	Sircilla	Andhra Pradesh	2019	18	Passive	0.62	16	0.058	None
2	Tenali	Andhra Pradesh	2019	20	Mechanical*	0.25	2	0.046	None
3	Leh	Jammu & Kashmir	2017	12	Passive	0.18	5.2	0.091	Nutrients and Water
4	Devanahalli	Karnataka	2015	6	Passive	0.16	8.7	0.130	Nutrients and Water
5	Brahmapuram	Kerala	2015	100	Mechanical	0.25	40	0.148	Energy, Nutrients, and Water
6	Jabalpur	Madhya Pradesh	2017	50	Mechanical*	0.01	5	0.077	None
7	Shahganj	Madhya Pradesh	2018	8.2	Passive	0.11	8	0.003	None
8	Nashik †	Maharashtra	2017	20	Passive	1.48	80	0.075	Energy and Nutrients
9	Sinnar	Maharashtra	2019	70	Mechanical	0.38	20.5	0.153	None
10	Wai	Maharashtra	2018	20	Thermal	0.50	17.5	0.2	Energy
11	Baripada	Odisha	2019	50	Passive	1.50	24.1	0.77	None
12	Bhubaneswar	Odisha	2019	75	Passive	2.50	35	0.171	Nutrients and Water
13	Brahmapur	Odisha	2019	40	Passive	1.50	24.8	0.078	Nutrients and Water
14	Dhenkanal	Odisha	2018	27	Passive	1.50	29.6	0.080	None
15	Puri	Odisha	2017	50	Passive	0.25	17.4	0.109	None

(Continued)

TABLE A1. FSTP DATA (CONTINUED).

SL No.	City	State	Year of commissioning	Designed capacity m3/day)	Type of technology	Land allocated (acres)	Capital cost in INR (million)	Operating cost in INR (million/month)	Reuse - resource utilized
16	Rourkela	Odisha	2019	40	Passive	2.00	21.5	0.076	None
17	Sambalpur	Odisha	2019	20	Passive	2.00	19.2	0.074	None
18	Lalsot	Rajasthan	2019	20	Passive	1.85	37.5	0.070	None
19	Phulera & Sambhar	Rajasthan	2019	20	Passive	1.30	28.2	0.072	None
20	Adigaratty	Tamil Nadu	2017	7.2	Passive	2.00	1.86	0.064	Nutrients
21	Karunguzhi ‡	Tamil Nadu	2018	23.4	Passive	2.00	4.93	0.053	Nutrients and Water
22	Ketti	Tamil Nadu	2017	4.4	Passive	1.00	1.2	0.064	Nutrients
23	Ooty	Tamil Nadu	2016	3.6	Passive	0.11	1.4	0.042	Nutrients
24	Ponnampatti	Tamil Nadu	2017	2	Passive	0.11	0.8	0.017	None
25	Narsapur †	Telangana	2018	15	Thermal	0.29	15	0.25	Energy and Water
26	Warangal	Telangana	2017	15	Thermal	1.00	15	0.15	Energy and Water
27	Jhansi ‡	Uttar Pradesh	2017	6	Passive	1.00	20	0.26	Nutrients
28	Unnao	Uttar Pradesh	2019	24	Passive	1.60	35	0.179	None
29	Bansberia	West Bengal	2014	30	Passive**	5.00	41.2	0.209	Nutrients

* Solids are not dewatered and treated
** Effluent is not treated
† Treats both FS and organic waste simultaneously
‡ Capital cost is significantly higher in comparison to that of similar treatment technology

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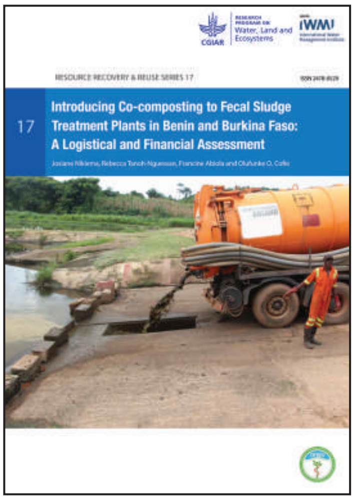

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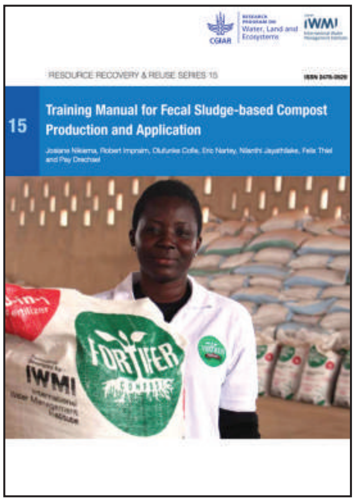

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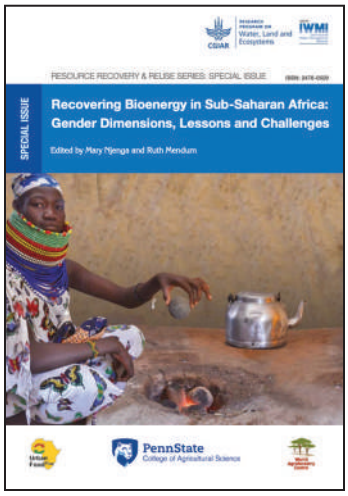

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