Shit Flow Diagrams & System Dynamics (SFD+SD): Moving Past The Snapshot

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Context

- 2.3B people still lack access to basic sanitation. In 89 countries progress is too slow to achieve universal coverage by 2030 and basic sanitation is decreasing in at least 20 countries[1]
- Many countries with low sanitation also have rapidly urbanizing populations, stressing existing infrastructure[2]
- Urban sanitation infrastructure failure rates continue to rise[3] and there is a growing recognition that investments in sanitation hardware cannot be considered in isolation of other non-technical factors (e.g. social, cultural, policy)[4].
- Local decision makers need to determine where, when and how to invest in urban sanitation. These decisions are made within complex local infrastructure systems, usually with limited funds and knowledge.

Urban sanitation infrastructure investments are not sustained and do not achieve their intended impact.

Why?!

And how can we better understand the impact of investments on the whole sanitation system?

Shit Flow Diagrams (SFD)

- Developed by WSP and disseminated by Sustainable Sanitation Alliance and partners[5] in response to a poor understanding of the fate of human waste and urban environments.
- Widely used in assessing urban sanitation projects[6].
- Intended to be accessible to technical & non-technical stakeholders.
- Part of a suite of sanitation service delivery assessment tools

System Dynamic (SD) Models

- An approach to mathematically modeling a multi-component complex system to explicitly consider changes in variables over time, as represented by stocks and flows.
- Incorporates important information about relationships between variables; tipping points, delays, time-variation and non-linearity correlations
- Ease of modeling multi-unit variables
- SD models can be converted to web-based interfaces for open access and ease of user-analysis by decision makers

Applications

The SFD+SD modeling process can be applied to any urban sanitation context for which existing, representative data has or can be reasonably collected. This includes **information collected for past and future SFD studies without modification to the data collection procedures**.

References 1) Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines. WHO UNICEF (2017), 2) World cities report. Urbanization and development. Emerging futures. UN Habitat (2016), 3)Statistics on Sanitation Failures. Improve International. (2014), 4) 5 Reasons Why Just Building Toilets Won't Improve Urban Sanitation Hawkins, P. (2013), 5) sfd.susana.org, 6) Comparison of Tools & Approaches for Urban Sanitation, WaterAid (2016), 7)Visakhapatnam, India Sanitation Assessment USAID, Tetra Tech (2015), 8) www.iseesystems.com/store/products/stella-architect

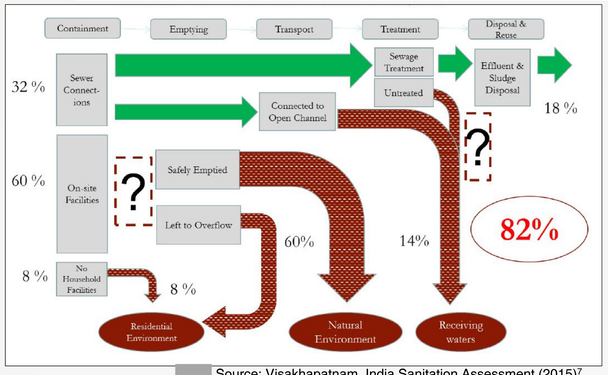
GOAL

Provide a simple and salient tool for understanding urban sanitation systems that allows for the simulation and visualization of decisions without discarding the inherent complexity of these systems.

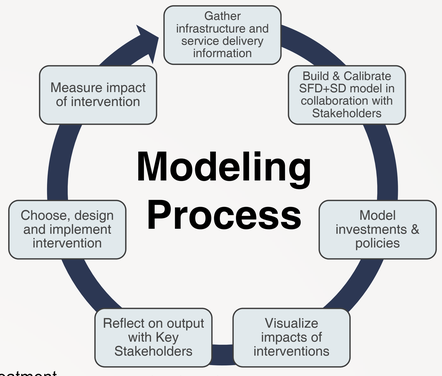
CASE STUDY[7]

Visakhapatnam, Andhra Pradesh State (AP). India
Population: 2,091,000
Improved Sanitation Coverage: 32%##
Safely Managed Fecal Sludge: 18%
Based on: 2015 Sanitation Assessment
Data Collection: 2 weeks

Model Element	Representation	Data Sources
Stocks	Amount of fecal sludge, treated or untreated sewage, bio-solids or clean water accumulated in the different locations	○ Municipalities ○ Utilities ○ Emptying companies ○ Stakeholder focus groups ○ Household Surveys ○ Census Data ○ City Service Delivery Assessments (CSDA)
Flows	Changes in mass flows between different stocks	
Converters	Policy, technology and/or practice that influences fecal flows (~ = time dependent conversion)	

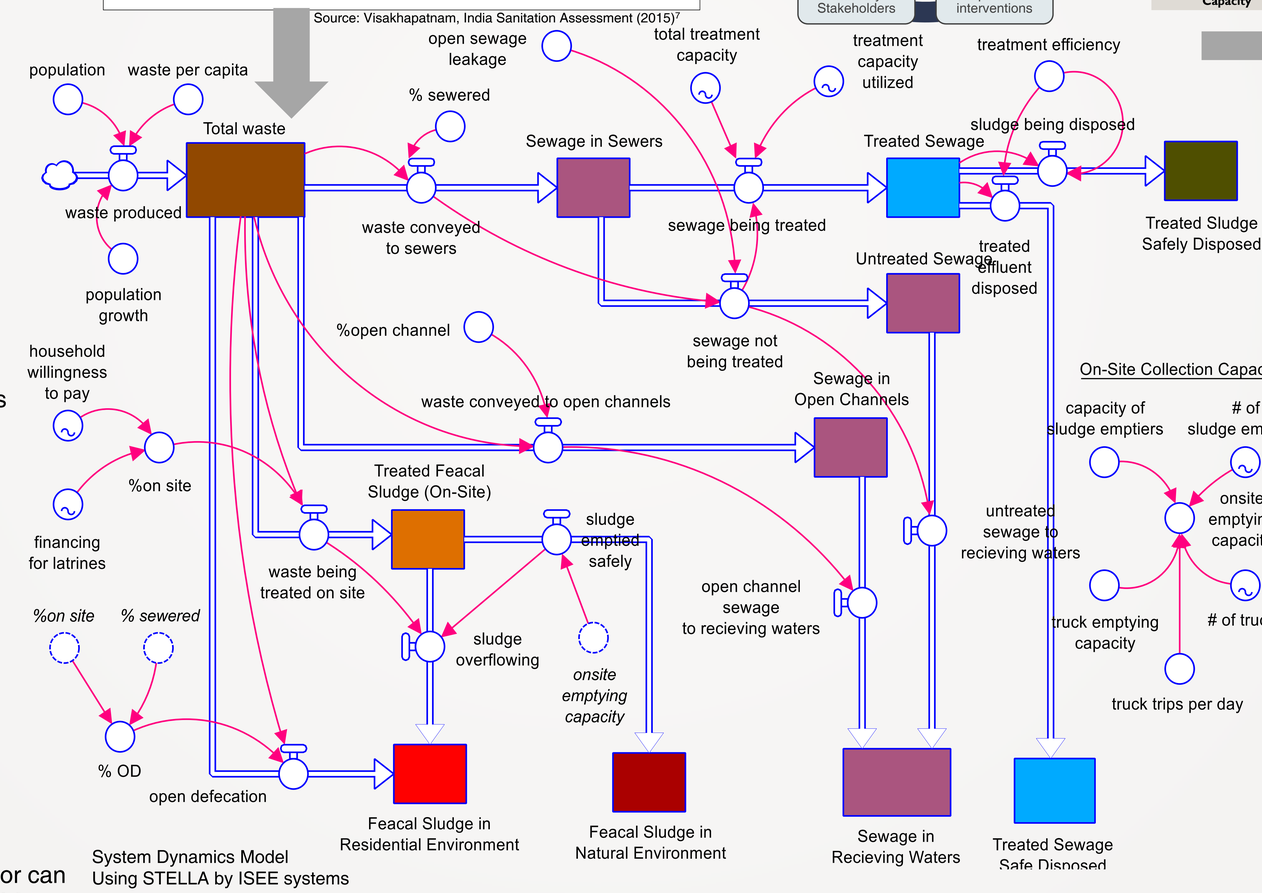


Source: Visakhapatnam, India Sanitation Assessment (2015)[7]



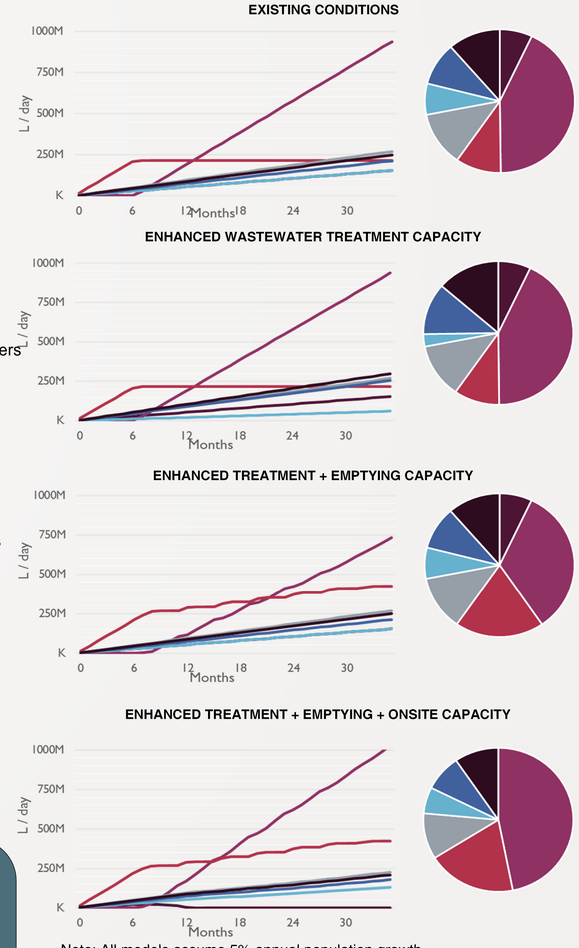
Model Parameters

SCENARIO	Wastewater Treatment: Total Treatment Capacity	Wastewater Treatment: Treatment Capacity Utilized	On-Site Collection: # of \Trucks	On-Site Collection: # of Sludge Emptiers	On-Site Coverage: Household Willingness to Pay	On-Site Coverage: Financing Availability for Latrines	On-Site Coverage: On-Site Coverage
Existing	76 ML/D	46%	18	50	-	-	60%
Expanded Treatment Capacity	76 ML/d → 184 ML/d (+36 ML/d per yr)	40 → 100% (+20%/yr)	18	50	-	-	60%
Expanded Treatment + Collection Capacity	76 ML/d → 184 ML/d (+36 ML/d per yr)	40 → 100% (+20%/yr)	18 → 36 (+~5/yr)	50 → 500 (+150/yr)	-	-	60%
Expanded Treatment, Collection + Onsite Capacity	76 ML/d → 184 ML/d (+36 ML/d per yr)	40 → 100% (+20%/yr)	18 → 36 (+~5/yr)	50 → 500 (+150/yr)	10 → 100% (+30%/yr)	10 → 100% (+30%/yr)	60 → 90% (+10%/yr)



System Dynamics Model
Using STELLA by ISEE systems

Scenario Planning



Note: All models assume 5% annual population growth

Contributions

The SFD+SD modeling process address a current gap in understanding of the dynamics of urban infrastructure systems. Provides an opportunity for decision makers to 'test-drive' investments & policies and manipulate the model to gain a 'systems thinking' understanding of their local systems. Incorporating illustrative modeling into the sanitation planning processes can help ensure that investments made in urban contexts are sustained to deliver intended public health impacts

Evaluating Time-Dependent Interactions Allows Us to Better Understand the Whole 'System'

Increasing treatment capacity and utilization does not change the overall fate of fecal waste in the system' unless there is also an increased investment in on-site sanitation coverage remain limited by collection capacity, as treatment capacity is limited by sewer connectivity