

Advancing Mechanization for Safe and Dignified Sanitation Work in Urban India:

A Proactive approach towards estimating mechanization needs through the Swachh Mech Tool

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The Sanitation Value Chain – Occupational Vulnerability

Containment/Emptying

Transportation

Treatment

Job Role



Sewer Line Cleaners



Septic Tank Emptiers



Drain Cleaners



Septic Tank Desludging Vehicles



O&M of Sewage Treatment Plant/FSTP

Level of Vulnerability



* Statistics based on study conducted by Dalberg (2017) and UMC

Potential Occupational Health Hazards

Physical Hazards:

- **Physical injuries/infections** caused by sharp objects such as razors, syringes, blades, broken glass, needles, etc.
- Certain organisms can enter the body through cuts, scratches, or penetrating wounds
- skin infection or eye infection due to direct contact with contaminated water
- injuries due to slips/trips or fall as a result of uneven footing, poor balance, dropping of tools or ladder, etc., leading to strained muscles, torn skin, swelling, and fracture.

Biological Hazards:

- **Burden of diseases** due to exposure to a high concentration of fungi and bacteria, which leads to diseases like asthma, cholera, typhoid, hepatitis, polio, eye and skin burns, and gastroenteritis.
- **Reduced life longevity** - The average life expectancy of sanitation workers is 40-45 years, significantly lower than the national average of 70 years and they experience high rates of prolonged illness and mortality because of the work they do

(Source: <https://idronline.org/article/water-sanitation/no-progress-for-sanitation-workers-what-must-change/>)

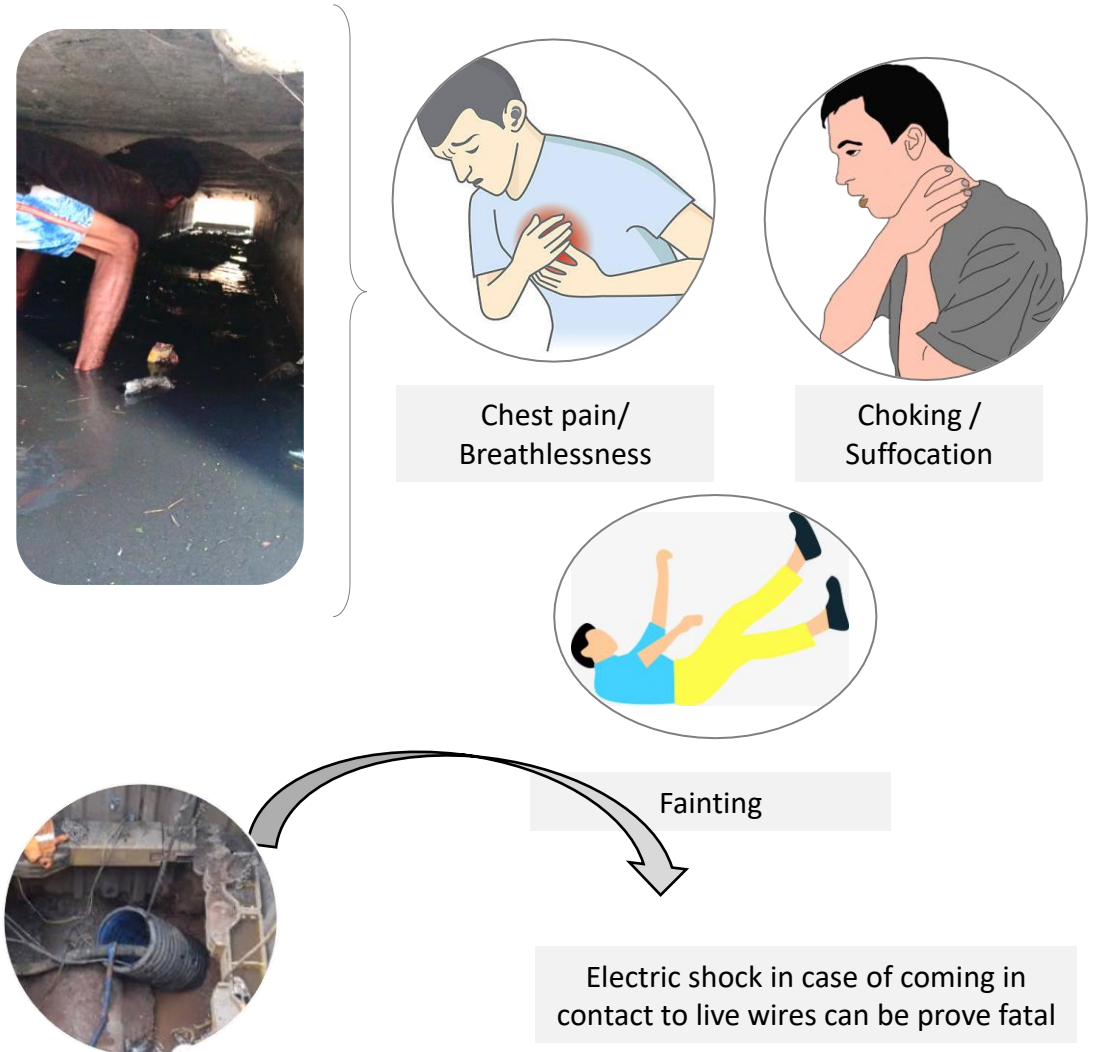


Injuries due to falls or slips

Potential Occupational Health Hazards

Gaseous and Electrical Hazards:

- While working in closed sewers, sanitation workers are commonly **exposed to gases** like hydrogen disulfide (primary gas present in sewers), methane, ammonia. These gases develop sub-acute symptoms, including sore throat, cough, chest tightness, breathlessness, thirst, sweating, irritability, and long-term diseases like Asthma.
- Ammonia can cause eye, nose, and throat irritation, and its long term exposure can lead to organ damage or death
- Methane in higher concentration is extremely flammable
- Carbon dioxide in higher concentrations can lead to respiratory issues and impaired consciousness.



Icon source: 123rf.com, clipartmax.com

Potential Occupational Health Hazards

Fire Hazards:

- Faecal sludge is anaerobically digested and can generate methane which is an inflammable gas. Similarly, fires can light from electric equipment and chemicals.

Ergonomic Hazards:

- Ergonomic hazards are caused by the improper handling of large machinery and equipment, which can lead to injuries affecting bones, muscles, ligaments, nerves.



Injuries affecting bones, muscles, ligaments, nerves



Severe burns can be fatal as well



What improvements are needed

Governance

Regulations and
Enforcement

**Mechanisation of
Sanitation works**

Training

Mechanisation replaces such dangerous manual tasks with safe, machine-led operations. This eliminates human entry, reducing exposure to waste and gases, and ensuring sanitation work is safe, dignified, and efficient.

Case of Enhanced Worker Safety through regular desludging in Malaysia

Key Characteristics	Data-driven approach and technical innovation adopted to improve service delivery and worker safety in desludging and sewer work , Erstwhile fragmented system (managed by 144 local authorities until 1993) centralized under a private company, Indah Water Konsortium (IWK); company nationalized in 2000
Context and Scale	<ul style="list-style-type: none"> •Rapid urbanization (urban agglomerations grew 4 times between 1960 –2000) put pressure on urban sanitation •1.2 Mn septic tanks and ~14,000 km of sewers in Malaysia

Governance

- ★ **Independent regulator**
 - SPAN, setup as an independent regulator in 2006, sits within the Ministry of Energy while IWK, the operator, is under Ministry of Finance
- **Data-based monitoring of desludging since 2008**
 - Data on septic tanks in households
 - Can monitor desludging frequency due to centralized system for desludging requests and GPS-fitted vehicles
- **Data-based monitoring of sewers**
 - ...using SCADA, enables preventive maintenance
- **Centralized system for desludging requests and sewer blockage complaints**
- ★ **Safety equipment mandated**
 - Boots, gloves, vests, glasses etc.

Infra and Tech

- **Tech-based interventions**
 - CCTVs used for sewer inspections since 2010
- ★ **R&D in sewer design**
 - R&D for sewer network design, materials, etc.



Robotic device with camera; inserted in manhole and placed in sewer to locate blockages

Social and Behavioral

- **Technical training**
 - Health and safety training for all workers and officials at dedicated in-house training facilities (beginning 2008)
- ★ **Financial disincentives for desludging non-compliance**
 - Transitioned from scheduled to demand-based desludging in 2008, putting onus on households for desludging as per norms
 - Heavy penalties: fines of up to RM 50K (~USD 16K) for non-compliance

★ Intervention highlights

Mechanization has reduced manual intervention, and a strong monitoring framework has improved worker safety

What challenges do ULBs face in ensuring mechanization?

- Technical Constraints
- Procurement Constraints
- O&M Constraints



Mechanisation: challenges

Technology–Context Mismatch

- *Standardised equipment is designed for ideal conditions, not complex urban realities.*
- *Narrow lanes, dense settlements, variable sewers, and inaccessible septic tanks limit machine reach.*
- *Lack of modular or adaptable designs results in partial mechanisation and continued manual work*

Data, Mapping and Planning Deficits

- *Incomplete mapping of sewers and septic tanks constrains informed deployment.*
 - *Limited use of geospatial data leads to reactive, ad-hoc operations.*
 - *Weak data integration reduces efficiency and equipment utilisation.*

Mechanisation is constrained not just by cost, but by fragmented governance, poor data, and equipment–context mismatch.

Operational Capacity & Incentive Gaps

- *Gaps in technical training in advanced equipment restricts safe and effective equipment use.*
- *Informal employment structures offer few incentives to mechanise.*

Fragmented Governance & Accountability

- *Multiple agencies share sanitation functions with unclear ownership.*
- *Mechanisation mandates are unevenly interpreted and enforced.*
 - *Worker safety receives limited institutional priority.*

Mechanisation

The adoption of mechanization is failing because systemic barriers—including inaccessible urban layouts, a mismatch between standard machinery and local infrastructure needs, and the lower cost or immediate availability of manual labor—force a reliance on manual entry despite government mandates and significant occupational risks.

Furthermore, a critical lack of data-driven planning prevents cities from accurately identifying the specific quantity and type of specialized vehicles required for their unique urban topographies



Financial challenges

Cost

National mechanisation

budget requirement by 2031 to serve an estimated population of 169 crores

Comprehensive mechanised sewer cleaning equipment for city-wide implementation.

Why is this a problem?

High upfront capital costs

Beyond routine ULB budgets

Smaller ULBs most affected

Limited fiscal capacity

Persistent underinvestment

Continued reliance on manual practices

Worker collectives excluded

Limited access to formal credit

Financial Gaps

What exists

- Swachhta Udyami Yojana (SUY)
 - Formal credit mechanisms

What is needed

- Scale & coverage
- Awareness & uptake
- Tailored financing products

Without dedicated, accessible financing, mechanisation remains financially out of reach—particularly for small cities and sanitation worker collectives.

Pathways for operationalizing 100% mechanisation

1

Evidence-Based Planning & Asset Right-Sizing

City-level needs assessments to determine the appropriate type, quantity, and mix of ULB-owned and privately contracted mechanised equipment, aligned with operational demand.

2

PPP-Led Service Delivery & Workforce Transition

Private deployment and maintenance with workers trained as machine operators—safer jobs, faster response.

3

Safety Systems for High-Risk Operations (ERSUs)

Controlled manual entry with full PPE, real-time oversight, and verified safe disposal.

4

Predictive & Preventive Operations through Technology

IoT monitoring and preventive maintenance to reduce emergencies and optimise mechanisation.

5

Institutionalised SOPs & Circular Resource Recovery

Scheduled desludging, standard SOPs, and safe reuse of sludge and septage.

City-level needs assessment

Cities possess sanitation machines, but these are often inadequate or mismatched to the actual needs.

Cities lack clarity on:

1. Type of machine and equipment required
2. Number of machines required
3. How to maintain and operate them
4. Challenges in appropriating machines with road width
5. Model of operation
6. Safety equipment's and their use for SEP
7. Type of Sanitation System – UGS or OSS

Without first assessing this need, cities cannot make informed decisions on procurement or outsourcing, leading to gaps in safety, efficiency, and service delivery.



Framework for City-level needs assessment

Step 1:

Mapping Existing Inventory for machines and equipments for sanitation

Mapping existing mechanized assets at the ULB level.

Step 2:

Calculating Requirements for machines and equipments to address the city's sanitation demand

Estimating normative equipment requirements based on population size, sewer network length, and service frequency assumptions.

Step 3:

Assessing gap between required machines/equipment vs the city's existing inventory

Identifying the gap between existing assets and required capacity

Step 4:

Calculating CapEx and OpEx requirements to address gap

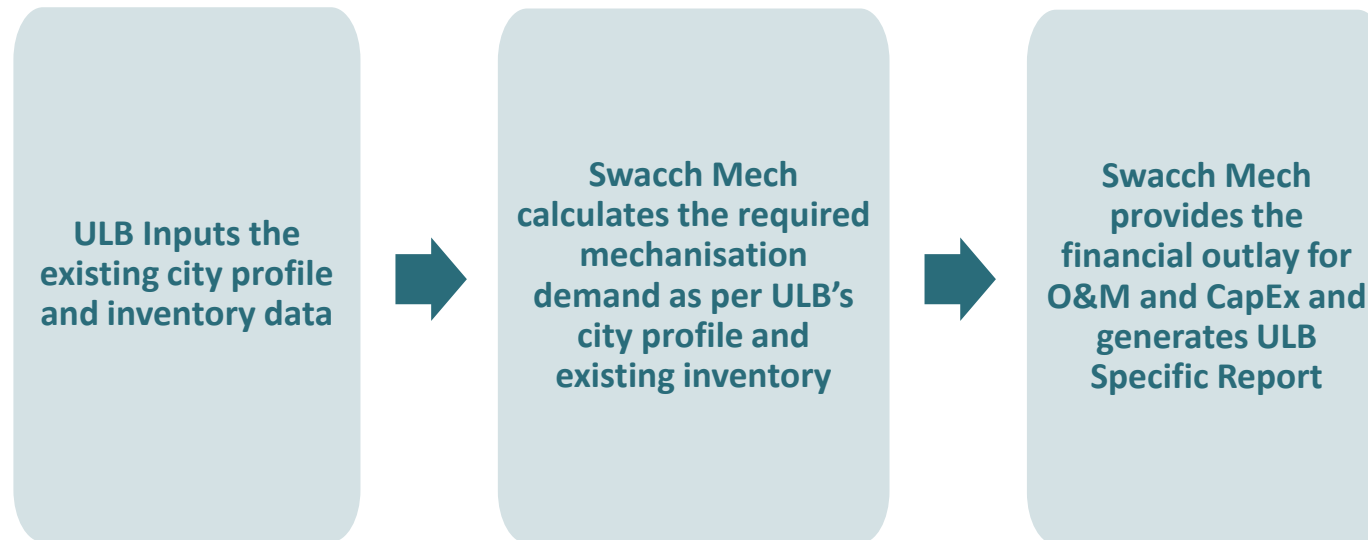
Estimating capital and lifecycle operational costs required to bridge that gap

Conducting city-level needs assessment through Swacch Mech

About Swacch Mech:

SWACHH-MECH (*Sanitation Workforce Advancement through Citywide Cleaning & Handling – Mechanisation for Efficiency, Comfort, and Health*) is a proposed simple to use excel-based city-wide action planning tool for assisting cities to create their action plans for transitioning to complete mechanization of sanitation works (sewer line operations and maintenance & septic tank desludging).

How does it work?



Structure of the tool		
Sheet 1	Sheet 2	Sheet 3
Input Sheet	Cost Assumptions	Vehicle and Equipment Gap
Sheet 4	Sheet 5	Sheet 6
CapEx for Mechanisation	Action Plan	Desludging Schedule

Initial Framework of the Swacch Mech Tool

Step 1:

Gathering ULB specific data to create a ULB Profile

- *ULB name and jurisdiction area*
- *Household, population and demographics*
- *Road network and sewer network length*

Step 2:

Input key parameters to assess the ULB's existing sanitation ecosystem

- % coverage of sewerage and septage systems
- Current fleet inventory (jetting, rodding, combo machines, etc.)
- Available safety equipment (as per ERSU norms)

Step 3:

Vehicle and Equipment Gap Analysis Calculator

- Calculate required fleet by vehicle type
- Compare with current availability
- Identify shortages or excess vehicles
- Recommend procurement or reallocation

Step 4:

Budget and Cost Estimation

- Calculate procurement costs
- Use GeM rates and vendor consultations for realistic budgeting

Step 5:

Procurement Action Plan

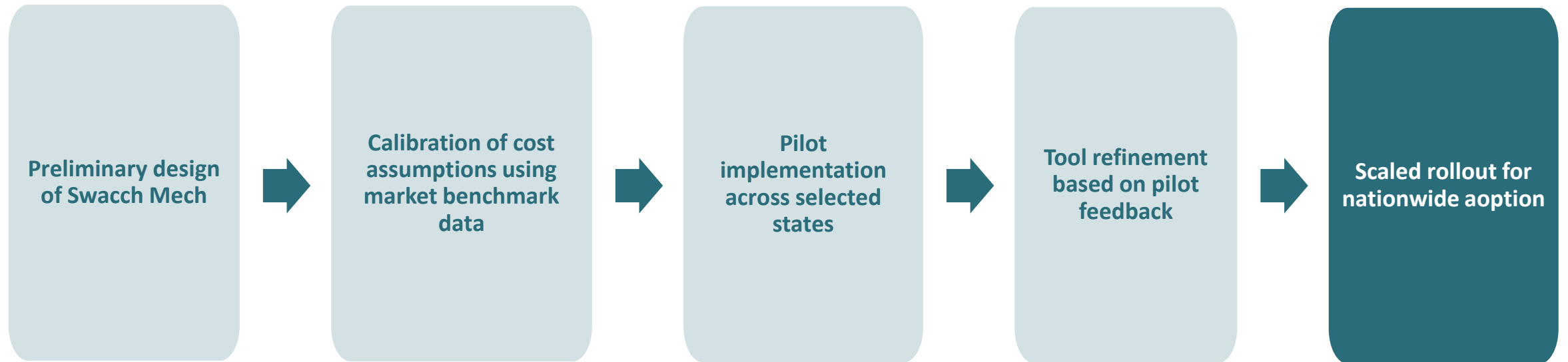
- Define procurement strategy for additional vehicles and equipment
- Identify funding sources/schemes to be utilised for the procurement
- Create a phased implementation roadmap

Assumption

Planning and Service Assumptions

- Recommended cleaning frequency (monthly, quarterly, as required) and number of working days

Assessment Methodology



Calibration of cost assumptions using market benchmark data

To address inconsistencies in mechanization cost estimation caused by fragmented procurement data, a centralized, market-aligned pricing repository was developed to enable standardized and comparable capital planning across ULBs.

A stakeholder consultation was conducted by the Ministry of Social Justice & Empowerment (MoSJE) in partnership with UMC under the NAMASTE Scheme – with 50+ stakeholders including representatives from state governments, Urban Local Bodies, sanitation enterprises, equipment manufacturers, and sector experts.

Direct outcome from the workshop to define the tool:
Structured vendor data → benchmark equipment cost repository

Impact on the tool

- Standardized capex assumptions
- Reduced reliance on ad hoc pricing
- Enabled cross-city cost comparability



Pilot implementation and Tool Refinement

Pilot Implementation

- Piloted in select ULBs in Assam & Odisha to test feasibility across varied contexts
- Assessed analytical robustness and operational usability for national scale-up
- Supported by UMC Technical Support Units in coordination with states/ULBs

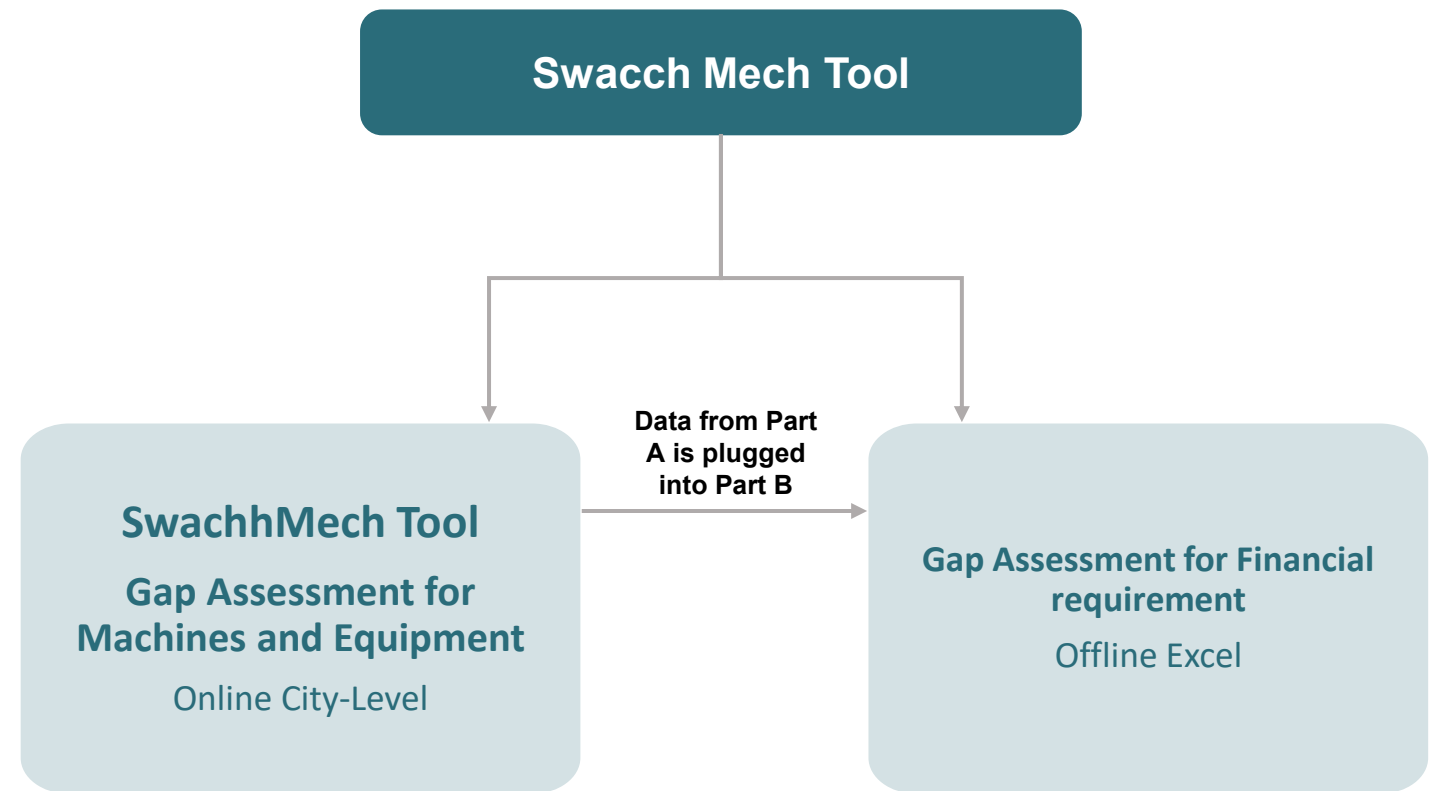
Key Feedback & Constraints

- High data input requirements reduced usability
- Limited familiarity with lifecycle costing
- Time constraints within routine workflows
- Incomplete/inconsistent equipment records
- Need for training and technical facilitation

Key Insight:

While analytically robust, the tool imposed a high reporting burden—highlighting the need to simplify for scalable adoption.

Key Modification: Restructure Swacch Mech into an online and an offline component



Components of the Swacch Mech Tool

Step 1:

Gathering ULB specific data to create a ULB Profile

- *ULB name and jurisdiction area*
- *Household, population and demographics*
- *Road network and sewer network length*

Part A: Online City-Level Gap Assessment

The screenshot displays the 'Mechanization Needs Gap Assessment Tool' interface. At the top, it shows a welcome message for 'Archana' on '07-Apr-2026 03:24:50 PM'. The left sidebar contains navigation options: Dashboard, New Survey, Draft submission, Survey Submissions, Swacchh Mech Tool, Reports, Manage, Settings, and Masters. The main content area is titled 'Section 1: General Information' and contains 13 numbered input fields:

1. State * (Andaman & Nicobar Islands)
2. District * (Nicobars)
3. ULB Name *
4. Name of the Nodal Person * (Archana)
5. Phone Number of the Nodal Person * (8528528525)
6. Designation of the Nodal Person * (-- Select Designation --)
7. Current Population as per ULB assessment (2025): * (Current Population as per ULB assessment (2025))
8. Total no. of Households (HHs) - 2025: * (Total no. of Households (HHs))
9. No. of HHs connected to the Sewer Network - 2025: * (No. of HHs connected to the Sewer Network)
10. No. of HHs connected to Septic Tanks - 2025: * (No. of HHs connected to Septic Tanks)
11. No. of HHs connected to the Open Drain - 2025: * (No. of HHs connected to the Open Drains)
12. No. of HHs connected to the Single Pits - 2025: * (No. of HHs connected to the Single Pit)
13. No. of HHs connected to the Other Sanitation Systems - 2025: * (No. of HHs connected to the Single Pit)


Components of the Swacch Mech Tool

Step 2:


Input key parameters to assess the ULB's existing sanitation ecosystem

- % coverage of sewerage and septage systems
- Current fleet inventory (jetting, rodding, combo machines, etc.)
- Available safety equipment (as per ERSU norms)

Part A: Online City-Level Gap Assessment



Ministry of Social Justice and Empowerment



- Dashboard
- New Survey
- Draft submission
- Survey Submissions
- Swacch Mech Tool
- Reports ▼
- Manage ▼
- Settings ▼
- Masters ▼

Section 2: Data on Machines and Equipment for Liquid Waste Management

Sewer & Septic tank Cleaning Machines and Equipment (Functional)

Name of the vehicle/Equipment *	Capacity *	No. owned by the ULB *	No. owned by the PSSO/Private Contractor *	Additional no. required *	Add / Remove *
Jetting and Suction with Rodding Machine	2000 L	1	1	1	+
HydroVAC - Suction cum jetting vehicle	1000 L	1			+ -
Desilting Grab Bucket and Rodding Machine	500 L	1			+ -
Bandicoot	Select Capac				+ -

B - Status of ERSU

1. Is ERSU set up in your ULB? *

Yes - ERSU is set up in my ULB

2. Is ERSU Functional? *

Yes

3. Is 14420 Helpline functional? *

Yes

4. Have you received safety devices for ERSU under NAMASTE? *

Yes

5. Total number of trained and certified Sewer Entry Professionals (SEP) in the ULB *

5. Total number of trained and certified Sewer Entry Professio

Safety Devices for ERSU:

Name of the safety device *	No. required as per standards *	No. owned by the ULB *	Additional no. required *	Add / Remove *
Safety Tripod Set				+

Components of the Swacch Mech Tool

Step 3:

Part B: Offline Excel based calculator

Vehicle and Equipment Gap Analysis Calculator

- Calculate required fleet by vehicle type
- Compare with current availability
- Identify shortages or excess vehicles
- Recommend procurement or reallocation

Sewer Line Cleaning		Maximum Requirement	Existing		Gap	
Sl No	Name of Vehicle	Maximum Number of Vehicles Required <i>(i.e., the number of vehicles needed for the ULB to meet its specific sanitation demand using only this machine/vehicle)</i>	Total number of vehicles owned by the ULB	Total number of vehicles not owned by the government <i>(available through outsourced PSSOs)</i>	Maximum number of vehicles/equipment that can be procured	Number of vehicles/equipment the ULB wants to procure
1	Large Suction cum Jetting Vehicle	5	4	0	1	0
2	Small Suction cum Jetting vehicle	5	1	0	4	0
3	Suction cum rodding machine	0	3	0	0	0
4	Jetting and suction with rodding machine	0	1	1	0	0
5	Suction and dumping machine	0	2	0	0	0
6	Jetting Machine	5	4	0	1	0
7	Desilting Grab Bucket and rodding machine	0	1	1	0	0
8	Suction cum blow back machine	0	2	0	0	0
9	Gully pit/cesspool emptier	0	2	0	0	0
10	Bandicoot	0	1	0	0	0
11					0	0
12					0	0
13					0	0
14					0	0
15					0	0
16					0	0

Components of the Swacch Mech Tool

Step 4:

Part B: Offline Excel based calculator

Budget and Cost Estimation

- Calculate procurement costs
- Use GeM rates and vendor consultations for realistic budgeting

SI No	Name of Vehicle	Total number vehicles to be procured	Cost per vehicle	Total cost of procurement (in Crores)
1	Large Suction cum Jetting Vehicle	1	9900000	0.99
2	Small Suction cum Jetting vehicle	4	9900000	3.96
3	Suction cum rodding machine	0		0.00
4	Jetting and suction with rodding machine	0		0.00
5	Suction and dumping machine	0		0.00
6	Jetting Machine	1	9900000	0.99
7	Desilting Grab Bucket and rodding machine	0		0.00
8	Suction cum blow back machine	0		0.00
9	Gully pit/cesspool emptier	0		0.00
10	Bandicoot	0		0.00
11		0		0.00
12		0		0.00
13		0		0.00
14		0		0.00
15		0		0.00

Components of the Swacch Mech Tool

Step 5:

Procurement Action Plan

- Define procurement strategy for additional vehicles and equipment
- Identify funding sources/schemes to be utilised for the procurement
- Create a phased implementation roadmap

Part B: Offline Excel based calculator

SI No	Item	Cost (in Crores)							
1	Estimated cost of procuring Sewer Line Cleaning	5.94							
2	Estimated cost of procuring Septic Tank Cleaning	4.15							
3	Estimated cost of procuring Sewer Line Cleaning Machinery and Equipment (in Crores)	0.94							
4	Estimated cost of procuring Septic Tank Cleaning Machinery and Equipment (in Crores)	0.00							
5	Estimated cost of procuring Safety Devices for ERSU (in Crores)	0.01							
6	Total Cost of Procurement	11.04							

VII B - Action Plan									
SI No	Item	Do you have the funds to procure the machine/vehicle/equipment?					How much funding can you allocate for procuring the vehicle? (In crores)	Additional funding required - 8 Crores	Will you outsource the procurement to PSSOs and opt for a maintenance contract?
		Own Source	SUY	SBM Funds	AMRUT	Other State Funds			
1	Sewer Line Cleaning Vehicles	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.0	2.94	<input checked="" type="checkbox"/>
2	Septic Tank Cleaning Vehicles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	0.0	4.15	<input type="checkbox"/>
3	Sewer Line Cleaning Machinery and Equipment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	0.0	0.94	<input type="checkbox"/>
4	Septic Tank Cleaning Machinery and Equipment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0.0	0.00	<input checked="" type="checkbox"/>
5	Safety Devices for ERSU	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	1.0	-0.99	<input checked="" type="checkbox"/>

Way Forward

- **Build City and State Capacity on Mechanisation Decision-Making** Support cities and states in understanding what machines to procure, what problems each machine solves, and which procurement modalities are best suited to their context, scale, and local sanitation challenges.
- **Establish Clear Modes of Engagement and Regulation** Define and institutionalise frameworks for engagement — whether through Urban Local Bodies, Private Sanitation Service Operators (PSSOs), or manufacturers
- **Create a Dedicated Mechanisation Financing Architecture** Develop a coherent financing framework that addresses both capital expenditure (procurement) and operational expenditure (O&M)
- **Strengthen Human Resource Capacity for Machine Operation and Maintenance** Invest in dedicated HR capacity - trained operators, maintenance personnel, and supervisors
- **Develop a National Mechanisation Knowledge and Support Hub** Establish a centralised knowledge platform offering cities and states access to machine catalogues, procurement guidelines, best practices, case studies, and technical support

Thank You

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