Annexures

Annexure 1 Annual performance of States and Union Territories for municipal solid waste management

States	Waste generated (TPD)	Waste collected (TPD)	Waste Collected (in %)	Waste processed/treated (TPD)*	Waste processed/treated (in %)	Waste landfilled (TPD)**	Waste landfilled (in %)	Gap (TPD)	Gap (in %)
Andhra Pradesh	6,890	6,890	100	1,558	22.61	Not provided	-	5,332	77.38
Andaman and Nicobar	79	78	98.73	74	93.67	2	2.53	3	3.79
Arunachal Pradesh	228	199	87.28	9	3.94	Not provided	-	219	96.05
Assam	1,589	1,333	83.88	575	36.18	744	46.82	270	16.99
Bihar	4,975	Not provided	-	Not provided	-	Not provided	-	4,975	100
Chandigarh	540	540	100	83	15.37	486	90	-29***	-
Chhattisgarh	1,820	1,820	100	1,790	98.35	30	1.64	0	0
DNH&DD	267	267	100	246	92.13	21	7.86	0	0
Delhi	11,108	11,108	100	5,280	47.53	5,828	52.46	0	0
Goa	211	207	98.1	197	93.36	10	4.73	4	1.89
Gujarat	10,095	10,095	100	8,682	86	1,003	9.93	410	4.06
Haryana	8,766	6,691	76.32	4297	49.01	2,218	25.3	2,251	25.67
Himachal Pradesh	383	349	91.12	269	70.23	80	20.88	34	8.87

Jammu & Kashmir	1,550	1,540	99.35	606	39.09	390	25.16	554	35.74
Jharkhand	2,404	1,969	81.9	843	35.06	930	38.68	631	26.24
Karnataka	13,034	11,655	89.41	5,440	41.73	4,198	32.2	3,396	26.05
Kerala	3,472	1,283 and 1,048 decentralized processing	-	2,691	77.5	-	-	781	22.49
Ladakh	52	42	80.76	20	38.46	15	28.84	17	32.69
Lakshadweep	18	18	100	18	100	0	0	0	0
Madhya Pradesh	7,115	6,132	86.18	6,059	85.18	76	1.06	980	13.77
Maharashtra	23,531	23,044	97.93	19,980	84.9	2,067	8.78	1,484	6.3
Manipur	282	199	70.56	133	47.16	66	23.4	83	29.43
Meghalaya	165	137	83.03	27	16.36	119	72.12	19	11.51
Mizoram	374	313	83.68	234	62.56	8	2.13	132	35.29
Nagaland	664	306	46.08	116	17.46	299	45.03	249	37.5
Odisha	2,103	2,020	96.05	1,356	64.47	738	35.09	9	0.42
Puducherry	383	383	100	58	15.14	325	84.85	0	0
Punjab	4,222	4,207	99.64	1,471	34.84	2,736	64.8	15	0.35
Rajasthan	7,973	7,859	98.57	1,926	24.15	5,525	69.29	522	6.54
Sikkim	66	66	100	18	27.27	48	72.72	0	0

Tamil Nadu	14,586	14,471	99.21	7,206	49.4	6,776	46.45	604	4.14
Telangana	11,057	11,057	100	8,611	77.87	1,011	9.14	1,435	12.97
Tripura	333	322	96.69	220	66.06	15	4.5	98	29.42
Uttar Pradesh	14,710	14,710	100	7,321	49.76	4,389	29.83	3,000	20.39
Uttarakhand	1,585	1,452	91.6	1,050	66.24	115	7.25	420	26.49
West Bengal	13,709	13,687	99.83	3,047	22.22	1,187	8.65	9,475	69.11

** Includes information only on processing and treatment of waste. Disposal through sanitary landfill is not included in the column.*
***Includes information on disposal of waste through sanitary landfill only; does not include disposal of waste in dumpsites.*
****The preceding year unprocessed waste (+29 TPD) is being included in the present year treatment and landfilling of waste.*

Annexure 2 Challenges identified at each level of solid waste management through literature review

Supply chain	Challenges	Source
Generation	Lack of Source Segregation	(Joshi and Ahmed 2016); (Kaushal, Varghese, and Chabukdhara 2012); (Manuja et al. 2020); (Zhu et al. 2007); (Rajendiran, Arumugam, and Subramaniam 2022); (Kumar et al. 2009); (Soni, Das, and Kumar 2022); (Ramaswami, Baidwan, and Nagpure 2016); (Priyadarshi and Jain 2018)
	High waste generation	(Joshi and Ahmed 2016); (Kumar et al. 2017); (Zaidi 2014); (Bashir and Goswami 2016); (Mishra and Yadav 2019)
	Open dumping and burning	(Ramadan et al. 2022); (Kumar et al. 2017); (Rajendiran, Arumugam, and Subramaniam 2022); (Zaidi 2014); (Priyadarshi and Jain 2018); (Ramaswami, Baidwan, and Nagpure 2016)
	Lack of baseline data	(Joshi and Ahmed 2016); (Kumar et al. 2017); (Rajendiran, Arumugam, and Subramaniam 2022); (Prajapati et al. 2021)
Collection	Inefficient collection coverage	(Soni, Das, and Kumar 2022); (Kumar et al. 2017); (Zaidi 2014); (Priyadarshi and Jain 2018);

		(Ramaswami, Baidwan, and Nagpure 2016); (Mishra and Yadav 2019); (Prajapati et al. 2021); (Kumar and Agrawal 2020)
	Segregation during collection	(Manuja et al. 2020); (Priyadarshi and Jain 2018); (Prajapati et al. 2021)
	User fees collection	(Manuja et al. 2020); (Kumar et al. 2017)
	Lack of collection data	(Dixit, Singh, and Shukla 2022); (Kumar et al. 2017)
	Collection from open dumps	(Ramadan et al. 2022); (Kumar et al. 2017); (Ramaswami, Baidwan, and Nagpure 2016)
Transportation	Operation & Maintenance (O&M) of vehicles	(Kumar et al. 2009); (Rajendiran, Arumugam, and Subramaniam 2022); (Mishra and Yadav 2019); (Hazra and Goel 2009); (Prajapati et al. 2021)
	Lack of infrastructure at transfer station	(Soni, Das, and Kumar 2022); (Zaidi 2014)
	Inefficient transport coverage	(Soni, Das, and Kumar 2022); (Kumar et al. 2009); (Rajendiran, Arumugam, and Subramaniam 2022); (Mishra and Yadav 2019); (Hazra and Goel 2009)
	Ensuring Segregation During Transportation	(Hazra and Goel 2009)
Processing	Land availability	(Negi et al. 2019)
	Quality and quantity of waste	(Soni, Das, and Kumar 2022); (Ahluwalia and Patel 2018); (Prajapati et al. 2021)
	O&M of facility	(Soni, Das, and Kumar 2022); (Shah et al. 2021); (Mani and Singh 2016)
	Fires	(Negi et al. 2019); (Kumar and Samadder 2017)
	Odor	(Negi et al. 2019); (Kumar and Samadder 2017)
	Lack of demand for end product	(Kumar and Samadder 2017); (Ahluwalia and Patel 2018); (Hazra and Goel 2009)
Disposal	Land availability	(Balasubramanian 2018); (Soni, Das, and Kumar 2022); (Mani and Singh 2016); (Kumar and Agrawal 2020)
	O&M of disposal facility	(Meegoda, Hettiarachchi, and Hettiaratchi 2016)

	Remediation of legacy waste	(Ghosh 2022)
	Fires	(Kumar et al. 2009), (Balasubramanian 2018)
	Odor	(Kumar et al. 2009); (Kumar et al. 2017); (Rajendiran, Arumugam, and Subramaniam 2022); (Hazra and Goel 2009); (Balasubramanian 2018); (Prajapati et al. 2021)
	Accidents	(Kumar et al. 2009); (Priyadarshi and Jain 2018); (Ahluwalia and Patel 2018), (Balasubramanian 2018)
	Lack of environmental monitoring	(Prajapati et al. 2021); (Kumar et al. 2009); (Kumar and Agrawal 2020)

Source: Authors' compilation

Annexure 3 Solid waste generation in the million-plus cities in India

Name of the City	Waste Generation in 2004 (TPD)	Waste Generation in 2021 (TPD)	Increase in waste generation (%)	Waste contribution to PM2.5 (%)
Indore	557	948.6	70.31	7.9
Surat	1000	1523.03	52.30	9.8
Navi Mumbai		706.91		
Visakhapatnam	584	567.82	-2.77	8.1
Vijayawada	374	489.9	30.99	9.3
Bhopal	574	813.8	41.78	8.8
Rajkot	207	657.39	217.58	6.3
Ahmedabad	1302	2479	90.40	8.4
Pune	1175	1975.49	68.13	6.5
Greater Hyderabad	2187	6908.1	215.87	12.9

Raipur	184	503.23	173.49	6.3
Ghaziabad		1375.13		
Thane		967.58		
Vadodara	357	1133.23	217.43	
Meerut	490	735.84	50.17	
Prayagraj (Allahabad)	509	526	3.34	4
Lucknow	475	1253.55	163.91	7.5
Gwalior		558.86		4.8
Pimpri Chinchwad		1129.51		
Nashik	200	684.1	242.05	8.7
Varanasi	425	596.77	40.42	16.2
Jabalpur	216	469.23	117.24	
Agra	654	888.64	35.88	12.4
Kalyan Dombivli		679		
Vasai-Virar		675.92		
Jaipur Heritage		683		
Nagpur		1302.46		11.6
Kanpur	1100	1374.26	24.93	8.9
Aurangabad		435.48		12
Greater Mumbai	5320	6329.35	18.97	3.8
Amritsar	438	417	-4.79	6.2
Jaipur	904	823.87	-8.86	8.5

Dhanbad	77	446.77	480.22	2.6
Faridabad	448	774.19	72.81	7
Patna	511	918.74	79.79	13
Ranchi	208	536	157.69	12.2
Ludhiana	735	967.1	31.58	9.2
Srinagar	428	520	21.50	6.4
Coimbatore	530	970.19	83.05	14.1
Bruhat Bengaluru Mahanagara Palike	1669	5506	229.90	14.4
Chennai	3036	5845.74	92.55	15.6
Madurai	275	668.9	143.24	15
DELHI CANTT.		63.55		
NEW DELHI (NDMC)		249.28		
MUNICIPAL CORPORATION OF DELHI	5922	11000	85.75	7

Annexure 4: Methodology for selection of cities for the study

Rank based on SLP Scores						
Row Labels	Number of city	SLP 2017 (900)	SLP 2022 (3000)	SLP22 -SLP17 (3000 - 900)	SLP22 - SLP17 (% change)	Normalized Change {[(SLP 2022/3000)-(SLP 2017/900)]×100}

Q1 –> Q1						
Surat	1	848.58	2703.65	1855.07	61.84%	-4.17%
Indore	1	875.00	2701.71	1826.71	60.89%	-7.17%
Navi Mumbai	1	856.13	2640.95	1784.82	59.49%	-7.09%
Rajkot	1	812.58	2564.20	1751.62	58.39%	-4.81%
Visakhapatnam	1	869.00	2536.35	1667.35	55.58%	-12.01%
Ahmedabad	1	806.48	2528.38	1721.90	57.40%	-5.33%
Bhopal	1	829.58	2526.46	1696.88	56.56%	-7.96%
Pune	1	870.39	2492.31	1621.92	54.06%	-13.63%
Q1 –> Q2						
Jabalpur	1	847.26	2085.61	1238.35	41.28%	-24.62%
Vadodara	1	837.25	2271.15	1433.90	47.80%	-17.32%
Q1–> Q3						
Greater Mumbai	1	823.08	2008.17	1185.09	39.50%	-24.51%
Q1 –> Q4						
Coimbatore	1	866.58	990.37	123.79	4.13%	-63.27%
Q2 –> Q1						
Vijayawada	1	799.00	2543.46	1744.46	58.15%	-4.00%
Raipur	1	567.70	2334.90	1767.20	58.91%	14.75%
Q2 –> Q2						
Gwalior	1	776.71	2289.16	1512.45	50.42%	-10.00%
Thane	1	602.84	2269.90	1667.06	55.57%	8.68%
Varanasi	1	717.93	2171.18	1453.25	48.44%	-7.40%
Greater Hyderabad	1	733.89	2166.52	1432.63	47.75%	-9.33%
Pimpri Chinchwad	1	673.92	2091.93	1418.01	47.27%	-5.15%
Q2 –> Q3						
Kanpur	1	585.83	1827.80	1241.97	41.40%	-4.17%
Faridabad	1	637.33	1727.88	1090.55	36.35%	-13.22%
Q2 –> Q4						

East Delhi Municipal Corporation	1	567.33	1493.93	926.60	30.89%	-13.24%
Madurai	1	684.77	969.51	284.74	9.49%	-43.77%
Q3 –> Q2						
Nashik	1	537.46	2258.62	1721.16	57.37%	15.57%
Vasai-Virar	1	489.53	2200.31	1710.78	57.03%	18.95%
Lucknow	1	424.88	2188.02	1763.14	58.77%	25.73%
Q3 –> Q3						
Kalyan Dombivli	1	436.68	2081.96	1645.28	54.84%	20.88%
Nagpur	1	531.83	1826.76	1294.93	43.16%	1.80%
South Delhi Municipal Corporation	1	557.14	1751.51	1194.37	39.81%	-3.52%
Q3 –> Q4						
Amritsar	1	481.76	1695.34	1213.58	40.45%	2.98%
Chennai	1	410.71	1519.33	1108.62	36.95%	5.01%
Dhanbad	1	494.13	1460.91	966.78	32.23%	-6.21%
Ranchi	1	410.10	1455.26	1045.16	34.84%	2.94%
Ludhiana	1	548.63	1373.22	824.59	27.49%	-15.18%
Q4 –> Q1						
Prayagraj (Allahabad)	1	376.03	2362.20	1986.17	66.21%	36.96%
Ghaziabad	1	349.36	2305.68	1956.32	65.21%	38.04%
Q4 –> Q2						
Meerut	1	195.89	2236.57	2040.68	68.02%	52.79%
Q4 –> Q3						
Agra	1	370.64	2014.07	1643.43	54.78%	25.95%
Aurangabad	1	346.47	1990.11	1643.64	54.79%	27.84%
Srinagar	1	375.68	1840.68	1465.00	48.83%	19.61%
Jaipur	1	406.21	1743.06	1336.85	44.56%	12.97%
Q4 –> Q4						

Bruhat Bengaluru Mahanagara Palike	1	360.03	1309.61	949.58	31.65%	3.65%
Patna	1	400.79	1200.98	800.19	26.67%	-4.50%
North Delhi Municipal Corporation	1	383.16	1412.41	1029.25	34.31%	4.51%
–> Q4						
Jaipur Heritage	1					
Grand Total	**45**					

Annexure 5 List of Stakeholders Interviewed for understanding the waste management supply chain

Type of stakeholder	Number of each type of stakeholder interviewed in each of the selected City							
	Pune	Navi Mumbai	Indore	Bhopal	Rajkot	Ahmedabad	Surat	Viasakhapatnam
Administration	2	2	3	2	5	3	3	6
City Support Unit	-	-	2	1	1	1	2	-
Academia/ Subject expert	4	1	-	1	-	1	1	2
NGO	3	3	5	3	-	2	-	-
Waste Workers	7	1	3	3	6	4	2	4
Service/Solution Providers	7	2	8	3	7	2	6	4

Note: Some of the stakeholders in each of the cities fall under more than one stakeholder category, therefore counted in each of those categories.

Annexure 6 The questionnaire used in the initial phase of the study:

QUESTIONNAIRE FOR ADMINISTRATION

Background/Objective of the survey

The purpose of the present research study organised at CEEW is to understand the root causes for the challenges faced in the supply chain of municipal solid waste management in urban areas. Further, the study contemplates studying the best practices/solutions employed by urban local bodies to address these root causes.

This questionnaire is devised for the administration personnel regarding the supply chain of municipal solid waste management in urban areas.

SWM official in Municipal Corporation

Generation

1. How do you estimate baseline information of the waste generation, and how do you keep it updated?
2. What strategy/interventions were adopted by the municipality to achieve source segregation? What are the challenges faced by ULBs in this, and how are they addressing it?
3. Are you charging the user fee? What are the criteria set out for charging the user fee, and what is the mode of collection?
4. How does the municipality estimate the waste generation for special events, and does the municipality have a strategy/plan/SOP for such events?
5. How is ULBs enforcing a ban on the usage and manufacturing of certain items like SUPs? What are the different challenges faced during enforcement?
6. What are IEC/awareness interventions introduced by the ULB to reduce waste generation and at source? How did you measure the impact/effectiveness of those interventions?

Collection

1. How is the waste collected in the city? Is it done by the ULB alone or through collaboration with an external agency?
2. How does the ULB deploy the different resources (modes/types of collection infrastructure) for waste collection?
3. Do you have any technological interventions introduced to improve the collection process as well as its monitoring, and how effectively these interventions are used currently? e.g. Management Information System(MIS) for real-time monitoring of collection?
4. What is the timing and frequency of waste collection? How does the ULB collect the waste when the worker is absent due to sickness or other reasons?
5. Does the municipality face issues in collecting waste from specific parts of the city, like slums, or remote areas? Are there any interventions or plans to address it?

Transportation

1. How did the ULB assess its transport infrastructure requirement? What are the number and types of vehicles used for primary and secondary transportation of waste?
2. Does the municipality have a route plan for the waste collection across the city? How does the ULB track and monitor these vehicles?
3. How does ULB address the overhaul/maintenance of the vehicles?
4. Is there a space/infrastructure for further segregation and storage of the collected solid waste in the city? (Transfer station)
5. How does the ULB ensure that segregation happens while transporting the waste? (Do the vehicles have separate compartments based on the type of waste?)
6. What is the timing and frequency of waste transportation, and is it impacted by the road network (narrow lanes, traffic)?

Dry waste / Wet waste Treatment

1. What are the different types of treatment facilities(centralised and decentralised) that the city adopted, and what are the modes of their operations (PPP or ULB owned)?
2. How many treatment facilities are operational, and if some are defunct, what are the reasons? (For instance, fires at the facility)
3. How many of the treatment facilities (dry waste and wet waste) are self-sustainable? What are the main challenges that the units face in becoming self-sustainable, and how did they address these challenges?
4. How the wealth extracted from the waste is consumed, absorbed, or repurposed? For example, what happens to the compost, and how is it used?
5. Does ULB face challenges like odour/ noise release from the treatment facility? If yes, have you done any interventions to address it?
6. What does the municipality do to the waste that cannot be treated (Inert waste)?

Disposal

1. Are there any dumpsites with recurrent dumping of waste? How has ULB identified these sites?
2. What are the steps/intervention the municipality is planning or taking to reduce open dumping?
3. Does the ULB have taken any intervention to keep a data record of how much waste is coming and going for disposal?
4. Has there been any initiative to remediate or reclaim the legacy waste in the landfill?
5. Does the ULB face landfill fires or odours? If yes, have you done any interventions to address it?
6. Does the disposal site have facilities like (a leachate collection system, air and water quality monitoring, gas collection system etc.) as per the norms in Schedule 2 of MSW rules 2016?

Miscellaneous/General Questions

1. What type of waste is more challenging for your municipality to manage?
    a. Food waste
    b. Sanitary waste
    c. Glass
    d. Plastics
    e. Metal
    f. Rubber and leather
    g. Other
2. According to the concerns/ challenges faced at each level, rank the levels of the supply chain.
    - Generation (Source-Segregation)
    - Collection
    - Transportation
    - Treatment
    - Disposal
3. How does the ULB ensure that segregation happens across the supply chain of waste?
4. Is there any other challenge the ULB faced that you would like to mention, and how are you addressing it?
    a. Generation
    b. Collection
    c. Transportation
    d. Treatment
    e. Disposal
5. How many workers are involved in waste management in the city (across the value chain, if possible)?
    a. Formal
    b. Informal
6. Has there been any efforts/scheme for the formalisation of the informal sector in the SWM supply chain?
7. What is the ULB doing to strengthen financial sustainability?
    a. User charges
    b. penalties for violators
    c. Revenue from the sale of waste and by-products
    d. SWM Cess
    e. Landfill tax
    f. Processing fee
8. Were there instances where the strategies failed to meet the desired results, and what were the modifications adopted to improve the strategy? (Across the supply chain)
9. Based on the best practices of your city, what would you like to recommend to other cities to improve solid waste management in their city?

QUESTIONNAIRE FOR NGO

Background/Objective of the survey

The purpose of the present research study organised at CEEW is to understand the root causes and challenges faced in the supply chain of municipal solid waste management in urban areas. Further, the study contemplates studying the best practices/solutions employed by urban local bodies to address these root causes.

This questionnaire is devised for NGO personnel regarding the supply chain of municipal solid waste management in urban areas.

General

1. When was your NGO established?
2. What is the presence of your NGO?
3. What are the aims & objectives of the NGO?
4. Are you working independently or in collaboration with another firm/body? Please specify.
5. Would you like to mention some specific projects related to solid waste management taken up by your NGO?
6. In which geographical locations the campaigns/projects are being run?
7. How many people are engaged in your NGO?
8. Which level of the SWM supply chain is the focus area of your NGO?

Generation

1. Do you have the baseline information of the total waste generated in the city and how is it helpful for your NGO?
2. Which type of solid waste generators are you working with?
3. What are the key issues faced by your NGO at the generation level of SWM?
4. What are the solutions employed by your NGO to address the key issues faced at generation level of SWM?
5. How do you think your involvement has made an impact in the improvement of solid waste management at the generation level?

Collection

1. What is the role of your NGO in the collection of solid waste in the city/area?
2. Have you appointed any specific person who supervises the collection of Solid waste in the area of operation?
3. How much area of the city is covered by your NGO?
4. Which type of solid waste generators are you collecting waste from?
    a. Residential Areas
    b. Society/RWA
    c. Slums
    d. Bulk Waste Generators

e. Others

5. Which type of solid waste is collected by your NGO?
    a. Plastic Waste
    b. Paper Waste
    c. Kitchen Waste
    d. Horticultural Waste
    e. Fabric Waste
    f. Metal Waste
    g. Glass Waste
    h. Wood Waste
    i. Any Other
6. How much of that waste is collected by your NGO (% or MT)?
7. What's the composition of waste collected? Do you measure the collected waste? (If yes, how frequently is it measured?)
8. Does the NGO have any allocated waste collection unit in the city?
9. Who is commissioning the collection of the waste for your NGO?
    a. Informal Waste Picker
    b. NGO volunteers
    c. Generators themselves drop it off at the NGO collection unit
    d. Any other
10. What are the modes they use to collect the waste?
11. What is the timing and frequency of waste collection?
12. Collection of solid waste from which of these waste generators is the most challenging for the NGO?
    a. Slums and informal settlements
    b. Commercial premises
    c. Institutional premises
    d. Multi-storage buildings
    e. Large commercial complexes & malls
    f. Residential Societies
    g. Any other
13. What is the key issue for the NGO in terms of waste collection?
14. Which of the key issues are being faced in the collection process of solid waste in the city, and what are their reasons?
    a. Source-Segregation
    b. Inadequate infrastructure
    c. Lack of human resources
    d. Narrow lanes
    e. Lack of funds
    f. Open Dumpsites
    g. any other
15. Do you have any implementation strategy/plan for the collection of the waste?

16. Please mention and give a brief description of some of the ongoing/ successful/ unsuccessful campaigns/ projects on SWM by your NGO?
17. What are IEC/BCC(Behaviour change communication) interventions introduced to improve the waste collection and what is the level of impact/effectiveness of those interventions?
18. How is waste collection impacted during unfavourable environmental/social conditions? What do they do in those conditions?
19. How do you aim to improve this level of solid waste management supply chain?
20. What are the proposed solutions for the issues faced in the collection of waste?
21. How do you think your involvement has made an impact in the improvement of solid waste management at the collection level?

Transportation

1. What is the role of your NGO in the transportation of solid waste in the city/area?
2. Which type of transportation is done by the NGO?
    a. Primary Transportation
    b. Secondary Transportation
3. What are the number and types of vehicles used by your NGO for transportation?
4. Do the collection vehicles have separate compartments for waste segregation?
5. What is the timing and frequency of waste transportation?
6. Does the NGO have a storage unit/infrastructure for further segregation and storage of the collected solid waste in the city?
7. What is the key issue that the NGO faces in terms of waste transportation?
8. Which of the key issues are being faced in the transportation process of solid waste in the city?
    a. Mixed waste
    b. Inadequate infrastructure
    c. O&M of vehicles
    d. Manpower
    e. Lack of funds
    f. Any other
9. What are the proposed solutions for the issues faced in the transportation of waste?
10. How do you think your involvement has made an impact in the improvement of solid waste management at the transportation level?
11.

Dry waste / Wet waste Treatment

1. What is the role of your NGO in the treatment of solid waste in the city/area?
2. How much of the total waste collected is being treated by your NGO?
3. What is the number of people involved in operating the waste treatment/processing unit handled by your NGO?
4. What are the key issues that the NGO faces in terms of (wet/dry) waste treatment?
5. Which of the key issues are being faced in the treatment process of solid waste in the city?
    a. Characteristics of the waste
    b. Space constraint

c. Regulations
d. Technology
e. Lack of funds
f. Any other

6. What are the proposed solutions for the issues faced in the treatment of (waste/dry) waste?
7. How do you think your involvement has made an impact on the improvement of solid waste management at the treatment level?

Miscellaneous

1. Does the NGO conduct capacity building programs for the improvement of SWM in the area/city?
2. Has your cause/project on SWM been supported/funded by the ULB? If yes, what type of assistance is being provided by the administration?
3. How are you promoting your campaigns/projects related to SWM?
    a. Youtube, Google advertisement
    b. Social Media pages (Specify)
    c. Partnership with various firms
    d. Any other
4. Which type of waste is the most challenging to handle in the Solid waste management supply chain?
    a. Plastic Waste
    b. Paper Waste
    c. Kitchen Waste
    d. Horticultural Waste
    e. Fabric Waste
    f. Metal Waste
    g. Glass Waste
    h. Wood Waste
    i. Any Other
5. According to the concerns/ challenges faced at each level, rank the levels of the supply chain.
    - Generation (Source-Segregation)
    - Collection
    - Transportation
    - Treatment
    - Disposal
6. How important data is for your NGO in implementation of waste management projects in your city?
7. Based on the impact of your projects, what would you like to recommend to other cities to improve solid waste management in their city?

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QUESTIONNAIRE FOR SERVICE PROVIDER

Background/Objective of the survey

The purpose of the present research study organised at CEEW is to understand the root causes and challenges faced in the supply chain of municipal solid waste management in urban areas. Further, the study contemplates studying the best practices/solutions employed by urban local bodies to address these root causes.

This questionnaire is devised for the Service Provider personnel regarding the supply chain of municipal solid waste management in urban areas.

General

1. Where is your company based?
2. How long has your organisation been in this service?
3. Is your organisation working solely or in collaboration with the government body or other organisation?
4. Which services are provided by your firm to the municipality?
    a. Generation (Source-Segregation)
    b. Collection
    c. Transportation
    d. Treatment
    e. Disposal
    f. Data Management
    g. Other
5. On what terms and conditions are you working with the ULB?
6. Please indicate the type of personnel and their number, who are involved in the SWM supply chain services provided by your firm.

Level of Supply Chain	Type of Personnel	Number
Collection		
Primary Transportation		
Transfer Station		
Secondary Transportation		
Treatment		
Disposal		

Generation

1. Does the municipality share the data related to municipal solid waste generators with you?
2. What is the criteria set out for charging the user fee?
3. What are different issues your firm faces at generation level of waste?

4. Does the service firm have a responsibility to undertake waste collection and management for special events or mass gathering?

Collection

1. In how many wards is the service being provided by your firm?
2. How much of total waste is collected by your firm (% or MT)?
3. What's the composition of waste collected and how do they measure it?
4. How many types of human resources are used by your organisation to collect solid waste?
    a. Employed Wastepicker
    b. Informal Sector
    c. Others
5. What are the modes used by your firm to collect the waste?
6. What is the timing and frequency of waste collection?
7. Collection of solid waste from which of these waste generators is most challenging for the municipality?
    a. Slums and informal settlements
    b. Commercial premises
    c. Institutional premises
    d. Multi-storage buildings
    e. Large commercial complexes & malls
    f. Residential Societies
    g. Markets
8. What is the key issue for the service provider in terms of waste collection?
9. Which of the key issues are being faced in the collection process of solid waste in the city?
    a. Source-Segregation
    b. lack of funds
    c. Inadequate infrastructure
    d. Informal supply chain
    e. any other
10. Do you have any technological interventions introduced which have been incorporated to improve the collection process, and how effectively these interventions are used currently?
11. What services/solutions are offered by your firm to the ULB to improve the collection of solid waste in the city?
12. On what basis, the wages of the waste collector are decided?
    a. Number of working days
    b. Number of working days
    c. Any Other (Please Specify)

Transportation

1. What type of vehicles have been procured in the process of waste collection?

Vehicle	Number	Capacity	Separate Compartmentfor	Number of trips per day (From	People involved in handling a	Fuel Used by the vehicle

			different types of waste present or not	**Collection till Transfer Station)**	**single vehicle at the time of collection and transportation**	

2. Do they have GPS, which is tracked by your firm/other organization?
3. Do the primary collection vehicles have assigned ward numbers?
4. What is the timing and frequency of waste transportation?
5. What are your views about the existing infrastructure for solid waste management in the city?
6. What is the percentage composition of the solid waste done by your firm in the allocated wards?

Type of waste	Tonnes/day	In %
Wet Waste		
Plastic Waste		
Paper Waste		
Metal Waste		
Any Other		

7. What is the key issue that the Service providers face in terms of waste transportation?
8. Which of the key issues are being faced in the transportation process of solid waste in the city?
    a. Mixed waste
    b. Inadequate infrastructure
    c. O&M of vehicles
    d. Cost constraint
    e. Space constraint
    f. Weather conditions
    g. any other
9. What services/solutions are offered by your firm to the ULB to improve the transportation of solid waste in the city?

Dry waste / Wet waste Treatment

1. What type of waste treatment service is being provided by your firm?
    a. Dry Waste

   b. Wet Waste
2. How much of that waste is collected for treatment?
3. What type of treatment/processing services is being provided by your firm, and why is it required for the city?
4. Is the treatment/processing facility centralised or decentralised?
5. What are the modes of operation of the treatment facility(PPP or ULB owned)?
6. Please explain the technology used for the treatment of that waste.
7. What are the end products/by-products of the treated/processed waste? How advantageous or disadvantageous is it in terms of financial aspects?
8. What are the key issues you, as the Service provider, face in terms of waste treatment?
9. Which of the key issues are being faced in the treatment process of solid waste in the city?
   a. Characteristic of the waste
   b. Space constraint
   c. Regulations
   d. Technology
   e. Financial sustainability
   f. any other
10. What other services/solutions are offered by your firm to the ULB to improve the treatment of solid waste in the city?
11. How do you think employment of improved technology can help in better processing and treatment of solid waste?

Disposal

1. What services do you provide at the disposal site?
   a. Landfill reclamation
   b. Landfill Designing
   c. Fumes management
   d. Landfill leachate removal

2. What is the total quantity and quality of MSW handled by your firm at the disposal site?
3. What kind of equipment and machinery is installed at the disposal site, and what are their use? What is their source of origin?
4. How often do you inspect and maintain the equipment and machinery used at the disposal sites?
5. Do you follow the regulatory measures to operate at the dumpsite?
6. How is your company providing a service/solution towards the improvement of the disposal level of solid waste management?
7. Which of the key issues are being faced in the disposal of solid waste in the city?
   a. Space constraint
   b. Technology constraint
   c. Quantity and quality of disposed off
   d. Leachate management
   e. Neighbourhood

f. Landfill fire
g. any other

Miscellaneous/General Questions

1. Do you have any monitoring mechanism for the services provided by you?
2. Is there any training or capacity-building programme on SWM that your firm has organised for the employees in the past?
3. If YES, then please answer the following:
    a. Number of training sessions
    b. Objectives of training session
    c. Timeline
4. If NO, mark Yes/No for the following options:
    a. We plan to conduct such training sessions in the future
    b. Municipality/Other organisation is doing it on behalf of the firm
5. Is there any weighing machinery/weighbridges present at the transfer stations or the processing facility?
6. How easy or challenging is it to work with the municipal body?
7. According to the concerns/ challenges faced at each level, rank the levels of the supply chain.
    - Generation (Source-Segregation)
    - Collection
    - Transportation
    - Treatment
    - Disposal
8. How important is data for waste management in the city?
9. What are the safety measures provided to the waste workers involved in waste management?
10. What are the major reasons that the SWM model implemented in this city is/will be successful or partially successful or unsuccessful? Give reasons for the same.

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QUESTIONNAIRE FOR SANITATION WORKER

Background/Objective of the survey

The purpose of the present research study organised at CEEW is to understand the root causes and challenges faced in the supply chain of municipal solid waste management in urban areas. Further, the study contemplates studying the best practices/solutions employed by urban local bodies to address these root causes.

This questionnaire is devised for the Waste Worker regarding the supply chain of municipal solid waste management in urban areas.

General

1. How long have you been working?
2. Which city do you belong to, and where are you residing in the city?
3. In which category do you fall?
    a. Formal
    b. Informal
4. How many days do you work per week?
5. How long have you been working in this sector?
6. Which of these protective equipment is used by you while collecting the waste?
    a. Safety Goggles
    b. Masks
    c. Shoes
    d. Fluorescent Jacket
    e. Gloves
    f. any other
7. Are you part of any waste worker organisation? (If Yes, which organisation and what is its organisational size and structure?)

Generation

1. Is the waste segregated by the generators?

Collection

1. How much area is covered by you?
2. What is the amount of total waste collected by you in a day (% or MT)?
3. What's the composition of waste collected?
4. Is the waste already segregated, or is it done by you?
5. In how many types is the waste further sorted after the collection of the waste?
6. How do you use the modes/resources to collect the waste?
7. What is the timing of waste collection?
8. What is the frequency of waste collection?
    a. Daily
    b. Five days a week
    c. Alternative Days
    d. any other
9. Collection of solid waste from which of these waste generators is most challenging for you?
    a. Slums and informal settlements
    b. Multi-storage buildings
    c. Residential Societies
    d. Markets
    e. Other
10. What is the key issue for the waste picker in terms of waste collection?
11. Which of the key issues are being faced in the collection process of solid waste in the city?
    a. Source-Segregation
    b. lack of resources for collection

c. less manpower
d. no replacement for absenteeism
e. any other

12. On what basis, the wages of the waste collector are decided??
    a. Fixed salary
    b. Daily wage
    c. Paid on the basis of quality/quantity of collected waste
13. What is done with the collected waste?
    a. transferred to secondary collection unit
    b. disposed at the community bin
    c. burned near an open-dumpsite
    d. quality(relevant) waste is extracted, and the rest is thrown away at unauthorised places
    e. any other

Transportation/Transfer Station

1. What is your role at the transfer station/secondary storage unit?
2. How long have you been working here?
3. What is the key issue that the waste worker faces in terms of waste transportation/transfer station?
4. Which of the key issues are being faced in the transportation process of solid waste in the city?
    a. Mixed waste
    b. Inadequate infrastructure
    c. Poor working conditions
    d. Payscale
    e. occupational health problems
    f. any other

Disposal

1. At which dumpsite/landfill do you work?
2. What type of work is being done by you at the dumpsite?
3. Where do you take the sorted waste collected from the landfill/dumpsite?
4. Are you employed at any treatment/processing facility or work on your own?
5. What are the key issues being faced at the landfill/disposal sites in the city?

Miscellaneous/General Questions

1. Has there been any efforts/scheme for the formalisation of the informal sector in the SWM supply chain?
2. Are you facing any occupational health problems?
3. Does the municipality provide any incentives for the waste workers in the city?

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As the study progressed, a Challenge-Root cause matrix was developed to understand the underlying root causes and the solutions employed by the selected cities.

Level of Municipal Solid Waste Supply Chain	Challenge	Root Cause	Root Cause Addressed by the city (Yes/No)	Solution employed for addressed Root Cause
Generation	**Lack of source segregation**	Lack of awareness on benefits of segregation		
		Lack of bins for storage		
		Lack of motivation or incentive		
		No penalisation/legal action		
	Lack of Baseline data	Lack of knowledge on the importance of maintaining baseline		
		Lack of interest by ULB		
		Lack of Infrastructure (manpower/instrument)		
		Lack of technical assistance		
	High waste generation/ Special events/ festival	No formal/legal initiative for waste reduction		
		Lifestyle change		
		Floating population		
		Lack of plan for managing special events/festivals		
		No formal infrastructure system to inform ULB		
	Open dumping and burning	Lack of awareness		
		Lack of information on dumping spots		
		Negligence/ Lack of		

Level of Municipal Solid Waste Supply Chain	Challenge	Root Cause	Root Cause Addressed by the city (Yes/No)	Solution employed for addressed Root Cause
		enforcement		
Collection	**Inefficient City coverage**	No fixed time schedule/Improper timing		
		Lack of appropriate vehicle for primary collection		
		No route planning		
		Absenteeism		
		Lack of manpower		
		Lack of collection services from Secluded/slum area		
		Lack of data of waste generator		
		Generators prefer giving waste to informal workers		
	User fees Collection	Presence of Informal waste collection		
		Lack of data of waste generator		
		Lack of information for user fees collection		
		Reluctance from the users		
	Segregation of waste	Lack of appropriate vehicle for primary collection		
		Lack of system to handle domestic hazardous waste		
		Lack of capacity/awareness among the waste collectors		

Level of Municipal Solid Waste Supply Chain	Challenge	Root Cause	Root Cause Addressed by the city (Yes/No)	Solution employed for addressed Root Cause
		Lack of tracking the waste collected by informal sector		
		Lack of measurement of waste		
	Lack of collection data	Lack of system to monitor the data for waste collection		
		Dumping of non-valuable fraction of waste collected by informal waste collectors		
	Open Dumping of waste	Dumping of waste in the non-designated spots by the ULB's own agency to save the cost of transportation		
		Lack of regular maintenance		
		Obsolete vehicles (Reached EOL)		
	Breakdown of vehicle	Improper usage by the vehicle driver		
		Lack of maintenance of compaction facility		
	Lack of appropriate infrastructure at TS	Electricity/Power insufficiency		
		Lack of data for planning infrastructure/vehicles		
		No Route Planning		
		Lack of monitoring of vehicles		
		Spillover of waste during transportation		
Transportation	**City Coverage/ tranportation Efficiency**	Lack of trained manpower		

Level of Municipal Solid Waste Supply Chain	Challenge	Root Cause	Root Cause Addressed by the city (Yes/No)	Solution employed for addressed Root Cause
Treatment	**Ensuring Segregation During Transportation**	Design of facility/vehicle		
		Lack of capacity/awareness of the operator		
	Land Availability for treatment facility	NIMBY attitude of people		
		Getting approval/ clearance		
		Not enough land to setup under municipality jurisdiction		
	Optimum quanity and quality of waste	Lack of Segregation of waste		
		Lack of capacity/awareness for waste worker		
		Lack of appropriate infrastructure(Transport, pre-processing)		
		Lack of data		
	Operational and Maintenance of treatment facility	Obsolete technology		
		Interuppted power supply		
		Lack of dedicated worker to do O&M		
		Poor maintanance of equipments		
		Negligent attitude of worker in the facility		
	Fires	Poor designing of the facility		
		Lack of monitoring		
		Non-complaince with safety guidelines		

Level of Municipal Solid Waste Supply Chain	Challenge	Root Cause	Root Cause Addressed by the city (Yes/No)	Solution employed for addressed Root Cause
		Negligent attitude of worker in the facility		
	Odor	Poor designing of the facility		
		Poor leachate management		
	Demand for the end product	Quality of the product		
		High logistic cost		
		Lack of regular demand		
Disposal	**Setting up disposal facility**	NIMBY		
		Geographical constraint		
		Getting approval/ clearance		
		Not finding the right concessionaire		
		Insufficient funds for disposal site		
	Fire at the disposal site	Poor design of disposal facility		
		Dumping of mixed waste		
		No Landfill gas collection system		
		Non-complaince with safety guidelines		
		Lack of stabilization of waste		
		Negligent attitude of worker		
	Odor at disposal site	Mixed waste		
		Poor designing of the facility		

Level of Municipal Solid Waste Supply Chain	Challenge	Root Cause	Root Cause Addressed by the city (Yes/No)	Solution employed for addressed Root Cause
		Poor leachate management		
	O&M of disposal facility	No proper road to the facility		
		Poor data management of waste		
		Electricity/Power insufficiency		
		Non-availability of Annual Maintenance Contract (AMC)		
	Remediation of Legacy waste	Not finding the right concessionnaire		
		Electricity/Power insufficiency		
		Obsolete technology		
		Destination for end product		
		Lack of data/study about composition of legacy waste		
	Accidents at disposal facility	Absence/Non-complaince of safety standards or norms		
		Negligent behaviour of workers		
		Slope Instability and Erosion		
	Lack of Environmental Monitoring	Lack of Interest from the side of ULB or the Concessionaire		
		Lack of technology		
		Lack of experts		

Annexure 7 Nine themes were identified for the thematic component of the root cause analysis of the SWM supply chain

S. No.	Theme	Description
1	Infrastructure	Set of physical facilities that are necessary/dedicated to performing the functions of removal, disposal, and recovery of solid waste (Verhoef et al. 2006).
2	Training and capacity building	A systematic approach to develop and continuously improve and enhance organisational and individual skills, knowledge, competencies, and capabilities (ICAR 2018).
3	Data and information	Collection, analysis, and dissemination of facts and figures for evidence-based and informed decision-making (McCloud et al. 2023; European Commission 2020).
4	Attitude and awareness	Attitude refers to a psychological tendency expressed in evaluating a particular entity, encompassing a range of evaluations, including feelings, beliefs, and behavioural intentions towards the entity in question (Leone 1995). Awareness refers to being conscious of something or having knowledge about a particular situation or subject (Gafoor 2012).
5	Policy and governance	The implementation of the system of laws, regulatory measures, courses of action, and other priorities promulgated by a governmental entity or its representatives (IGNOU 2017).
6	Technological	Tools, systems, and machines that are the result of scientific knowledge necessary for innovation, digital transformation, and integration of modern technology (Isman 2012; Coccia 2021).

7	Health and safety	Practices and policies for the promotion and maintenance of the highest degree of physical, mental, and social well-being of workers, and a safe workplace (Alli 2008).
8	Financial resources	Financial resources that are required for establishing infrastructure, workforce, operation and maintenance, and other related work at different levels of the SWM supply chain (Gurevich 2023).
9	Workforce	Occupational group of people who are employed at various levels of the SWM supply chain.

Source: Authors' compilation

References

Balasubramanian, M. 2018. "Municipal Solid Waste Management in India: Status, Problems and Challenges." International Journal of Environment and Waste Management 21 (4): 253–68. https://doi.org/10.1504/IJEWM.2018.093435.

Bashir, Subzar, and Subhrangsu Goswami. 2016. "Tourism Induced Challenges in Municipal Solid Waste Management in Hill Towns: Case of Pahalgam." Procedia Environmental Sciences 35: 77–89. https://doi.org/10.1016/j.proenv.2016.07.048.

Dixit, Abhishek, Deepesh Singh, and Sanjay Kumar Shukla. 2022. "Changing Scenario of Municipal Solid Waste Management in Kanpur City, India." Journal of Material Cycles and Waste Management 24 (5): 1648–62. https://doi.org/10.1007/s10163-022-01427-4.

European Commission. 2020. "Data Governance and Data Policies at the European Commission." https://commission.europa.eu/system/files/2020-07/summary-data-governance-data-policies_en.pdf.

Gafoor, Kunnathodi Abdul. 2012. "Considerations in Measurement of Awareness." https://doi.org/10.13140/2.1.2109.2643.

Ghosh, Nabanita. 2022. "Sustainability Assessment and Reuse Feasibility of Stabilized Legacy Waste in West Bengal, India: A Circular Economy Transition Perspective." PREPARE@u FOSET Conferences. https://doi.org/10.36375/prepare_u.foset.a322.

Hazra, Tumpa, and Sudha Goel. 2009. “Solid Waste Management in Kolkata, India: Practices and Challenges.” Waste Management 29 (1): 470–78. https://doi.org/10.1016/j.wasman.2008.01.023.

Joshi, Rajkumar, Sirajuddin Ahmed, and Carla Aparecida Ng. 2016. “Status and Challenges of Municipal Solid Waste Management in India: A Review.” In Cogent Environmental Science 2 (1): 1139434. https://doi.org/10.1080/23311843.2016.1139434.

Kaushal, Rajendra, George Varghese, and Mayuri Chabukdhara. 2012. “Municipal Solid Waste Management in India–Current State and Future Challenges: A Review.” International Journal of Engineering Science and Technology 4 (4): 1173–89. https://www.researchgate.net/publication/233894305_Municipal_Solid_Waste_Management_in_India-Current_State_and_Future_Challenges_A_Review.

Kumar, Akhilesh, and Avlokita Agrawal. 2020. “Recent Trends in Solid Waste Management Status, Challenges, and Potential for the Future Indian Cities – A Review.” Current Research in Environmental Sustainability 2 (December): 100011. https://doi.org/10.1016/j.crsust.2020.100011.

Kumar, Atul, and S.R. Samadder. 2017. “A Review on Technological Options of Waste to Energy for Effective Management of Municipal Solid Waste.” Waste Management 69 (November): 407–22. https://doi.org/10.1016/j.wasman.2017.08.046.

Kumar, Sunil, J.K. Bhattacharyya, A.N. Vaidya, Tapan Chakrabarti, Sukumar Devotta, and A.B. Akolkar. 2009. “Assessment of the Status of Municipal Solid Waste Management in Metro Cities, State Capitals, Class I Cities, and Class II Towns in India: An Insight.” Waste Management 29 (2): 883–95. https://doi.org/10.1016/j.wasman.2008.04.011.

Manuja, Sourabh, Nirbhay Kumar Singh, Jai Kumar Gaurav, Vaibhav Rathi, Suneel Pandey, Dilshad Ahmad, and Kuldeep Choudhary. 2020. “An Audit of Municipal Solid Waste Management System in Selected Wards of Varanasi – A Case Study.” International Journal of Engineering Research And Technology 9 (5): 631–36. https://doi.org/10.17577/IJERTV9IS050541.

Mani, Shyamala, and Satpal Singh. 2016. “Sustainable Municipal Solid Waste Management in India: A Policy Agenda.” Procedia Environmental Sciences 35: 150–57. https://doi.org/10.1016/j.proenv.2016.07.064.

Meegoda, Jay, Hiroshan Hettiarachchi, and Joseph Hettiaratchi. 2016. “Landfill Design and Operation.” In Sustainable Solid Waste Management, 577–604,. https://doi.org/10.1061/9780784414101.ch18.

Mishra, Geetika, and Mitali Yadav. 2019. “Study on Municipal Solid Waste Management and Challenges Faced in Indian Metropolitan Cities.” International Journal of Home Science 5 (2): 200–205. https://www.homesciencejournal.com/archives/2019/vol5issue2/PartD/5-2-32-512.pdf.

Negi, Harshita, Ruchi Agrawal, Amit Verma, and Reeta Goel. 2019. "Municipal Solid Waste to Bioenergy: Current Status, Opportunities, and Challenges in Indian Context." In New and Future Developments in Microbial Biotechnology and Bioengineering, edited by Jay Shankar Singh and D.P. Singh, 191–203. Elsevier. https://doi.org/10.1016/B978-0-444-64191-5.00014-6.

Prajapati, Kishan Kumar, Monika Yadav, Rao Martand Singh, Priti Parikh, Nidhi Pareek, and Vivekanand Vivekanand. 2021. "An Overview of Municipal Solid Waste Management in Jaipur City, India – Current Status, Challenges and Recommendations." Renewable and Sustainable Energy Reviews 152 (December): 111703. https://doi.org/10.1016/j.rser.2021.111703.

Priyadarshi, Harit, and Ashish Jain. 2018. "Municipal Solid Waste Management Study and Strategy in Aligarh City, Uttar Pradesh India." International Journal of Engineering Science Invention 7 (5): 29–40. https://www.ijesi.org/papers/Vol(7)i5/Version-3/F0705032940.pdf

Rajendiran, Balamurugan, Arun Arumugam, and Sudagar Subramaniam. 2022. "Challenges in Municipal Solid Waste Management: A Key." International Journal of Ambient Energy 43 (1): 2889–99. https://doi.org/10.1080/01430750.2020.1784275.

Ramaswami, Anu, Navneet Kaur Baidwan, and Ajay Singh Nagpure. 2016. "Exploring Social and Infrastructural Factors Affecting Open Burning of Municipal Solid Waste (MSW) in Indian Cities: A Comparative Case Study of Three Neighborhoods of Delhi." Waste Management & Research: The Journal for a Sustainable Circular Economy 34 (11): 1164–72. https://doi.org/10.1177/0734242X16659924.

Soni, Ashish, Pankaj Kumar Das, and Prabhat Kumar. 2022. "A Review on the Municipal Solid Waste Management Status, Challenges and Potential for the Future Indian Cities." Environment, Development and Sustainability 25 (October): 13755–803. https://doi.org/10.1007/s10668-022-02688-7.

Zhu, Da, P. U. Asnani, Chris Zurbrugg, Sebastian Anapolsky, and Shyamala K. Mani. 2007. Improving Municipal Solid Waste Management in India: A Sourcebook for Policymakers and Practitioners. The World Bank. https://doi.org/10.1596/978-0-8213-7361-3.

Verhoef, Evelien, J.A. van Houwelingen, Gerard P.J. Dijkema, and Markus A. Reuter. 2006 "Industrial Ecology and Waste Infrastructure Development: A Roadmap for the Dutch Waste Management System." Technological Forecasting and Social Change 73 (3): 302–15. https://doi.org/10.1016/j.techfore.2004.03.009.

ICAR. 2018. "ICAR HRM Policy: Training and Capacity Building." Indian Council of Agricultural Research. https://hrm.icar.gov.in/data/ICAR-HRM-policy-2018.pdf.

McCloud, Rachel F., Mesfin A. Bekalu, Tom Vaughan, Lydia Maranta, Eliz Peck, and K. Viswanath. 2023. "Evidence for Decision-Making: The Importance of Systematic Data

Collection as an Essential Component of Responsive Feedback." Global Health: Science and Practice 11 (2): e2200246. https://doi.org/10.9745/GHSP-D-22-00246.

IGNOU. 2017. "Unit 1: Understanding Public Policy." Indira Gandhi National Open University. https://egyankosh.ac.in/bitstream/123456789/25798/1/Unit-1.pdf.

Isman, Aytekin. 2012. "Technology and Technique: An Educational Perspective." Turkish Online Journal of Educational Technology 11 (2): 207–13. http://tojet.net/articles/v11i2/11222.pdf.

Coccia, Mario. 2021. "Technological Innovation." In The Blackwell Encyclopedia of Sociology, edited by George Ritzer, 1–6. https://doi.org/10.1002/9781405165518.wbeost011.pub2.

Alli, Benjamin O. 2008. Fundamental Principles of Occupational Health and Safety 2nd Ed. International Labour Organization. https://www.ilo.org/media/326971/download.

Gurevich, Mark. 2023. "Examining the Impact of Financial Resources on Solid Waste Management Practices: A Cross-Country Analysis." National High School Journal of Science. https://nhsjs.com/wp-content/uploads/2023/10/Examining-the-Impact-of-Financial-Resources-on-Solid-Waste.pdf.

Annexure 8

Table 1: Challenges, root causes, and solutions in waste generation

Challenges	Root causes	Theme	Solutions	Additional description
Source segregation	Lack of awareness on benefits of segregation	Attitude and awareness	Specialised campaign for segregation	• *Red Dot Campaign* to segregate sanitary waste
			Organising competitions	• Competitions at various levels (institutional, society, city level) • *Swachh manthan*
			Mass communication	• Wall painting/graffiti, advertisements, jingles on radios, social media, and billboards • Songs on awareness and SWM • *Nukkad natak*/street plays
			Partnering with NGOs and self-help groups for information, education, and communication (IEC) activities	• Door-to-door (D2D) awareness

			Involving Influencers	• Awareness generation through the involvement of social media influencers, celebrities, and religious and local leaders
	Lack of bins for storage	Infrastructure; financial resources	Making infrastructure available	• Distribution of two bins by ULBs for source segregation
	Lack of motivation or incentive	Attitude and awareness	Financial incentives	• Rebate on property tax/user fees
			Organising competitions	• Ward or society-wise competitions to become zero-waste • Competitions among bulk waste generators (BWGs) for managing wet waste at source
			Recognition of active citizens and waste workers	• Public recognition of active citizens and waste workers by authorities for their work on SWM • 'Employee of the Month' or murals to recognise the workers
	Penalisation /legal action for not segregating	Policy and governance	Fines	• Penalisation of household and commercial establishments for not segregating

			Notification of bylaws	• SWM bylaws for BWGs
			Vigilance check	• Surprise visits by government officials
Baseline data	Lack of knowledge of the importance of maintaining baseline data	Training and capacity building	Involvement of experts	• Partnerships with experts and consultants
			Capacity building of the ULB officials	• Dedicated training modules and workshops on the role of data in SWM
	Lack of interest on the part of ULBs in maintaining baseline data	Attitude and awareness	Guidelines and mandates from central/state governments to maintain baseline data	• *Swachh Survekshan* at the national level • State-level initiatives such as *Clean Andhra Pradesh* in Andhra Pradesh to maintain baseline data
	Lack of workforce and infrastructure to maintain the data	Workforce; infrastructure	Dedicated staff for managing data	• Staff at the Integrated Command and Control Centre (ICCC) who manage and monitor baseline data for SWM
			Collaboration with colleges/universities	• Collaborative efforts with universities and their faculty to generate baseline data
	Lack of technical	Policy and governance;	Involvement of experts	• Partnerships with experts and consultants

	assistance to maintain the data	training and capacity building	Collaboration with solution providers	• Collaborations with start-ups and social enterprises working on SWM
			Building the capacities of ULB officials	• Dedicated training modules and workshops on the role of data in SWM • Training of the employees at the ICCC
High waste generation	No formal/legal initiative for waste reduction	Policy and governance	Charging based on waste generation	• Collection from BWGs based on the amount of waste generated
			Financial incentives	• Rebate on property tax/user fees
	Lifestyle change	Attitude and awareness	Mass communication	• Zero-waste weddings and other events • Sensitisation of citizens through waste to wonders
			Promoting eco-friendly products	• Distribution of textile bags as an alternative to plastic bags • Alternative plastic kiosk
	Floating population	Data and information; infrastructure	Quantifying and building infrastructure	• Developing infrastructure to quantify and manage the floating population

	Lack of plan for managing special events/festivals	Policy and governance	Pre-registration of the event with the ULB	• Through a mobile app, citizens can register the occurrence of weddings and other events
			Developing a SOP for special events	• Special operating procedure (SOP) for organising big events and festivals can help in pre-planning
	No formal information system to inform ULB	Infrastructure; data and information	Toll-free number/mobile app to inform ULB	• 311: App to register events • 1902: number for grievance
Open dumping and burning	Lack of awareness of waste disposal	Attitude and awareness	Organising competitions	• *Swachh Manthan*
			Mass communication	• Wall painting/graffiti, advertisements, jingles on radios, social media and billboards • Songs on awareness and SWM • *Nukkad natak*/street plays
			Partnering with NGO and self-help groups for IEC activities	• D2D awareness

	Lack of information on dumping spots	Data and information	Identifying and monitoring GVPs	• Use of Internet of Things (IoT) such as PTZ (Pan, Tilt, and Zoom) integrated with ICCC to monitor GVPs and instances of open dumping
			Utilising data from grievance portals/surveys	• Data from the 311 App or other city/state-level grievance app • Conducting a dedicated survey to identify open dumping locations
	Negligence/ lack of enforcement	Policy and governance	Fines	• Penalising of open dumping
			Vigilance check	• Regular visits and surprise checks by the officials
Source: Authors' analysis				

Table 2: Challenges, root causes, and solutions in waste collection

Challenge	Root causes	Theme	Compiled solutions	Additional description

Collection efficiency	No fixed schedule or improper timing	Policy and governance	Fixing the timing based on the type of waste generator	• Early morning collection from residential generators; morning and evening collection from commercial establishments • Placement of waste bins at the designated spot by the generator and informing the waste collector
			Monitoring points of interest	• GPS-based monitoring of waste collection through ICCC • Field staff track collection using a mobile app
			Provision of alerts for waste collection	• Informing/alerting citizens about the arrival of waste collectors using whistles, loudspeakers, bells, etc.
	Lack of appropriate vehicle for primary waste collection	Infrastructure	Allocation of vehicles based on urban setting and waste generator	• Customised waste collection vehicles such as tippers, e-rickshaws, and handcarts

	No route planning	Data and information; training and capacity building	Developing route plans	• Development of route plans based on a baseline assessment • Assignment of the route plan to each vehicle
			Monitoring route plans	• Monitoring the vehicle through the ICCC or mobile app; alerts are sent to the driver in case of deviation • Deviations are reported as well as the delay from points of interest
	Absenteeism	Attitude and awareness	Attendance	• Biometric attendance • Attendance register
			Substitute personnel	• Assigning a nearby worker or substitute to collect the waste
	Lack of adequate workforce for waste collection	Workforce	Assessment of staff required	• Identifying the number of staff required based on a baseline assessment of the SWM in the city

			Collaboration with waste worker alliances and NGOs	• NGOs help integrate informal workers by providing jobs in D2D collection, material recovery facilities (MRFs), etc. • Examples include the *SWaCH* model in Pune and the *Zero-Waste Slum* model in Navi Mumbai
	Lack of waste collection services in secluded and slum areas	Policy and governance	Involving NGOs	• Examples include the *SWaCH* model in Pune and the *Zero-Waste Slum* model in Navi Mumbai (*Stree Mukti Sanghatana*)
			Customising vehicles	• Collection of waste from narrow lanes using handcarts
	Lack of data on waste generators	Data and information	Baseline survey	• Mapping of waste generators through various methods such as surveys, property tax data, RFID tags on households • Identification of bulk waste generators
			Data from secondary sources	• Generators are identified through property taxes

	Waste generators prefer giving waste to informal waste collectors	Policy and governance; attitude and awareness	Identifying informal waste collectors	• Integration of informal waste collectors into the formal system by providing ID cards
			Providing benefits of government schemes	• Healthcare, child education schemes
			Collaborating with waste worker alliances and NGOs	• NGOs can help in integrating informal workers by providing jobs in D2D collection, MRFs, etc
User fees collection	Presence of informal waste collection	Policy and governance	Identifying informal waste collectors	• Integrating informal waste workers into the formal system by providing ID cards
			Providing benefits of government schemes to the informal worker	• Healthcare, child education schemes
			Collaborating with waste worker alliances and NGOs	• NGOs help in integrating informal workers by providing jobs in D2D collection, MRFs, etc

	Lack of data on waste generators	Data and information	Baseline survey	• Mapping of waste generators through various methods such as city-level surveys • Identifying bulk waste generators
			Data from secondary sources	• Generators are identified through property taxes
	Lack of legal notifications for user fees collection	Policy and governance	Issue of notifications by the state or ULBs	• State or ULB level SWM bylaws or notifications on prescribed user fees for SWM
	Lack of information on user fees collection	Data and information; financial resources	Presence of different modes of payment	• Online applications, website portals, QR-code scanners • D2D collection of user fees
			Collection of fees integrated with tax payments	• Annual collection of user fees integrated with property tax payment
	Users are reluctant to pay	Attitude and awareness	Targeted awareness campaigns for user fees collection	• D2D awareness raising of the importance of user fees collection

			Customised user fees based on the type of generator	• Notification of user fees based on income level and whether it is a slum area or commercial establishment
Segregation of collected waste	Lack of appropriate vehicle for primary waste collection	Infrastructure	Customising the compartments	• Creating compartments for the collection of segregated waste into wet, dry, sanitary waste, domestic hazardous, and e-waste • Colour coding of each compartment based on the type of waste – green for wet waste, blue for dry waste, and black for domestic hazardous waste • Capacity/size of the compartments to fixed based on the ratio of waste collected
	Lack of infrastructure to handle domestic hazardous waste	Infrastructure; health and safety	Customising the compartments	• Separate collection compartment for domestic waste
	Lack of capacity and awareness	Attitude and awareness;	Training/workshops for waste workers	• Regular training of waste workers on the benefits of segregation

	among waste collectors	training and capacity building	Recognition of waste workers	• Motivating and recognising workers through awards such as Employee of the Month, Best Worker, and Best Resident Welfare Association (RWA); posting videos on the website of the best RWAs
			Involvement of NGOs	• Waste collectors accompanied by an NGO volunteer; waste collectors have been strictly told by the authority not to collect if waste if it is not segregated
Data on waste collection	Inability to track waste collected by informal waste collectors	Data and information; policy and governance	Identifying informal workers	• Integration of informal waste workers into the formal system by providing ID cards
			Collaboration with alliances and NGOs	• NGOs can help in integrating Informal workers by providing jobs in D2D collection, MRFs, etc
	Poor waste data management	Infrastructure	Infrastructure for waste measurement and data tracking	• RFID on the vehicle and weigh bridge at the transfer station to measure the collected waste

	Lack of a system to monitor waste collection data	Infrastructure; technological	Integration of information, communication and technology	• ICCC for monitoring of waste vehicles and waste data
Open dumping of waste	Dumping of non-valuable fraction of waste collected by informal waste collectors	Attitude and awareness	Providing storage and recovery facilities	• MRFs are built at the transfer station to segregate valuable and invaluable waste
	Dumping of waste in non-designated spots by ULB's agencies	Attitude and awareness	Monitoring of the vehicle	• Monitoring at the ICCC through geo-fencing and live-route tracking of the vehicles
Source: Authors' compilation				

Table 3: Challenges, root causes, and solutions in waste transportation

Challenges	Root causes	Theme	Compiled solutions	Additional description
Breakdown of vehicle	Lack of regular maintenance of vehicles	Attitude and awareness	Establishment of repair and service garages	• Service and repair of vehicles at the transfer station/service station • A garage in each zone or a combination of wards for immediate servicing in cases of vehicle breakdown

			Regular cleaning and servicing	• Weekly/need-based cleaning of vehicles at the transfer station/service station • Fuel refilling at the transfer station
	Obsolete and old vehicles	Infrastructure	Periodic replacement of old vehicles with new ones	• Periodical procurement/ replacement of old vehicles with new ones
			Spare vehicles for emergency	• A spare fleet is present in the garage for emergencies
	Improper usage by the driver	Attitude and awareness	Monitoring the vehicle	• GPS-based tracking of the vehicle's speed and issuing an automatic alert • The driver is accompanied by a volunteer from the NGO that supervises waste collection and transportation • Live-feed camera for real-time monitoring, which is transferred to the online dashboard
			Capacity building of workers	• Training and development sessions for the workers to ensure proper usage of the vehicles
Infrastructure at the transfer station	Lack of maintenance of the	Training and capacity building	Trained personnel	• Skilled personnel assigned to repair and maintain the compaction facility

	compaction facility			• Supervising compaction of wet and dry waste separately
			Regular cleaning and servicing	• Weekly/need-based cleaning of the compaction facility at the transfer station
	Electricity/ power cuts	Infrastructure	Mechanism for reporting power cuts	• Communication channels such as WhatsApp groups and radio sets to inform officials
			Backup plan /alternative strategy	• Establishing on other power-generating sources such as battery-isolar PV • Diverting primary collection vehicles to other transfer stations
	Lack of data for planning infrastructure / vehicles	Data and information	Estimation based on waste data	• Assessment of required infrastructure and vehicles based on waste-collected data
Transportation efficiency	No route planning	Data and information; training and capacity building	Developing route plans	• Route plans developed based on the baseline assessment of SWM • Affixing to each vehicle the route plan to be followed
			Monitoring route plans	• Monitoring the vehicle route through ICCC

	Lack of monitoring of vehicles	Data and information	Monitoring through GPS	• Monitoring the vehicle through ICCC. In case of deviation, alerts are sent
			Validation at the treatment/ disposal facility	• Validation of data on the waste transported at the end destination to identify any deviation
	Spillover of waste during transportation	Infrastructure	Use of appropriate vehicles	• Use of closed containers/capsules for transporting waste
			Use of covers to prevent spillover during transportation	• Use of a cloth sheet or tarpaulin to cover the waste carried in open vehicles
	Lack of trained workforce	Training and capacity building	Capacity building of workers	• Training and development sessions for workers to ensure proper usage of the vehicles
Segregation during transportation	Poor design of the facility	Infrastructure	Colour coding based on waste type	• Colour coding of the compartment or vehicle based on the type of waste – green for wet waste, blue for dry waste, and black for domestic hazardous waste
			Designated areas based on the type of waste	• Separate areas to unload different types of waste

	Lack of capacity/ awareness of the operator	Training and capacity building	Supervision	• Transferring station managers to supervise incoming waste vehicles to ensure segregation
			Capacity building of workers	• Training and development sessions for workers
Source: Authors' compilation				

Table 4: Challenges, root causes, and solutions in waste processing and treatment

Challenges	Root causes	Theme	Compiled solutions	Additional description
Land availability for establishing the treatment facility	People's NIMBY attitude	Attitude and awareness; Policy and governance	Awareness and consultation	• Stakeholder meetings with the RWA, ward leaders, experts, and officials
			Facility supervised for odour control (nuisance factor)	• Cleanliness at the treatment site is supervised to avoid nuisance created due to odour
			Incorporating treatment facilities in town planning	• Allocation of land within the ULB jurisdiction for setting up treatment facilities when drafting the master plan of the city

	Getting approval/ clearance for land	Policy and governance	Reutilising reclaimed land	• Treatment facilities can be established on remediated dump sites
			Transparent tenders/proposal	• Tenders that clearly define responsibilities, key performance indicators, and timelines in the contract
			Decentralised processing	• Setting up decentralised plants (<5 TPD) for easy approval
	Not enough land to set up within the municipality's jurisdiction	Policy and governance	Reutilising reclaimed land	• Treatment facilities can be established on remediated dump site
			Incorporating treatment facilities in town planning	• Allocation of land within the ULB jurisdiction for setting up treatment facilities when drafting the master plan of the city
Optimum quantity and quality of waste	Lack of segregation of waste for processing	Policy and governance	Financial incentive for the ULB	• Royalty amount to ensure the waste is segregated and of appropriate quality
			Coordination between the ULB and concessionaire	• Coordination with the agencies if the waste received at the facility is not segregated

			Decentralised processing	• Setting up of decentralised facilities next to transfer stations or food markets
			Pre-processing facility	• Pre-processing equipment such as trommel to separate the waste and remove the dirt
			Supervision	• Managers and supervisors at the facility to monitor the segregation of incoming waste into wet and dry
	Lack of capacity/awarenes s among waste workers	Training and capacity building	Incorporation of informal workers	• Employing informal workers who have prior experience in this sector
			Regular training	• Capacity building workshops for the workers in the facility
			Supervision	• Managers and supervisors to monitor and guide the workers in sorting and segregating waste
	Lack of appropriate infrastructure	Infrastructure	Using an appropriate vehicle for transportation	• Separate colour-coded (wet/dry) transport vehicles for transportation

	(transport, pre-processing)		Pre-processing facility	• Pre-processing facility such as trommel to separate the waste and remove the dirt
	Poor data management of waste	Data and information	Infrastructure to measure incoming and outgoing waste	• Weighbridge for measuring the incoming waste at the treatment facility • Maintaining logbooks for data
			Data analysis for effective operation	• Data to track the quantity of waste actually processed at the facility as opposed to the installed capacity • Customising and developing additional infrastructure at the facility based on the data
O&M of the treatment facility	Obsolete technology for processing	Technological	Customisation of existing machinery	• Customisation of machinery based on the quality of incoming waste and desirable end product
			Adoption of new technology	• Adoption of state-of-the-art technologies based on data assessment
	Electricity/ power cuts	Infrastructure	Mechanism for reporting power cut	• Communication channels such as WhatsApp groups and

				radio-set to inform officials
			Backup plan /alternative strategy	• Establishing other power-generating sources, such as solar PV
	Lack of dedicated workers to undertake O&M	Workforce	Regular training	• Regular training of existing technical and non-technical staff • Induction training for new employees
			Capacity building for the workers	• Training and up-skilling of the workers
	Poor maintenance of equipment	Health and safety	Breakdown maintenance and preventive maintenance	• Regular inspection of the equipment and machinery parts • Regular cleaning or oiling of parts if required • AMCs
			Timely inspection of the machinery parts	• Maintaining an inventory of available spare parts • Regular inspection of the equipment and machinery parts • Regular cleaning or oiling of parts if required

	Negligent attitude of workers	Attitude and awareness; Health and safety	Norms on OHS /EHS to be followed	• Safety equipment to be used at the site • Emergency contact details to be displayed
			Supervision	• Managers and supervisors at the facility to supervise the workers to ensure OHS norms are adhered • CCTVs installed to aid supervision
Fire at the treatment facility	Poor design of the facility	Infrastructure	Proper layout plan of the facility	• Layout plan to include fire safety guidelines and emergency exit • Exhaust fans for proper ventilation • Easy access to fire safety equipment such as water sprinklers and fire extinguishers for fire emergency • Installing smoke-detection sensors • Establishing a fire alert system
			Organisation and planning for storage	• Ensuring storage for relocating waste
	Lack of monitoring and supervision	Health and safety; technological	Monitoring through IoT devices	• CCTVs installed to facilitate supervision

				• Smoke-detection sensors
	Non-compliance with safety guidelines	Health and safety	Norms on OHS /EHS to be followed	• Use of safety equipment at the site • Emergency contact details present at the facility
	Negligent attitude of workers in the facility	Attitude and awareness; health and safety	Regular training	• Developing a plan for fire-safety training • Organising fire drills • No-smoking zone in the facility
			Supervision	• Managers and supervisors to supervise the workers for fire safety protocols
Foul odour at the treatment facility	Poor design of the facility	Infrastructure	Proper storage design for untreated waste	• Separate area for storage of different types of waste
			Odour controlling measures	• Use of enzymes such as bioculture • Development of green areas on the facility's periphery
	Poor leachate management	Infrastructure	Rain sheds	• Installing rain sheds so that waste does not get mixed with rainwater

			Leachate treatment plant	• Developing and maintaining a leachate treatment plant at the facility
Demand for the end product	Quality of the product	Technological	Certification	• Legal mark or labelling to validate the quality of the product
			Regular testing	• Continuous tracking of the quality of the product and maintaining records
	High logistic cost of the end product	Policy and governance; financial resources	Collaborating with local partners	• The end product from waste to be sold in the local markets or sold to the municipal corporation in agreement with them
			Storage and data inventory	• Adequate storage and data records of the product from the treatment facility
	Lack of regular demand for the end product	Data and information	Marketing the product	• Creating brochures and videos of the product • Marketing the end product through social media or influencers
			Storage and data inventory	• Using data inventories and records to analyse trends and forecast demand

				• Having enough storage and data records of the product
Source: Authors' compilation				

Table 5: Challenges, root causes, and solutions in waste disposal

Challenge	Root causes	Theme	Compiled solutions	Additional description
Setting up a disposal facility	The NIMBY attitude of people	Attitude and awareness	Supervision	• No habitation within a 500 m radius of the landfill site • Fencing around the landfill site to prevent people and stray animals from trespassing
	Geographical constraints for land	Policy and governance	Incorporating sanitary landfills in town planning	• Allocation of land area under the ULB jurisdiction for sanitary landfill in the master plan of the city
	Getting approval/ clearance for land	Policy and governance	Incorporating sanitary landfills in town planning	• Allocation of land area under the ULB jurisdiction to establish sanitary landfills in the master plan of the city

			Environmental impact assessment (EIA)	• Conducting an EIA for the project/facility under Item 7 (i) Common Municipal Solid Waste Management Facilities as per EIA notification and its amendments (MoEFCC 2006)
	Not finding the right concessionaire	Policy and governance	Transparent tenders/proposal	• Clear definition of responsibilities, key performance indicators, and timelines in the contract
Fire at the disposal facility	Poor design of the facility	Infrastructure	Layout plan of the disposal site	• Development of a fire prevention and protection plan
	Dumping of mixed waste	Training and capacity building; attitude and awareness	Pre-processing of waste	• Use of trommels for segregating mixed waste
			Supervision	• Allocation of personnel to supervise the site
			Layout plan of the disposal site	• Layout plan to include dedicated storage areas for wet and dry waste at the integrated treatment and disposal facility
	Lack of monitoring and supervision	Data and information; technological	Supervision	• Allocation of personnel to supervise the site • CCTVs installed to assist in supervision

			Monitoring using IoT	• Usage of drone cameras and sensors for supervising
	Non-compliance with safety guidelines	Health and safety	Norms on OHS /EHS to be followed	• Safety equipment to be used at the site • Emergency contact details to be displayed prominently at the facility
	Lack of stabilisation of waste	Training and capacity building	Prevention/ stabilisation of waste	• Usage of bioculture and regular turning of waste
			Controlling the breakout of fire	• Usage of soil/inert waste to cover the fire • Wet soil to be kept ready to plug excavated holes immediately • Training of earthmover drivers to undertake fire control operations
	Negligent attitude of workers	Attitude and awareness; health and safety	Regular training	• Developing a plan for fire-safety training • Organising fire drills • No-smoking zone in the facility • Drivers and operators of heavy earth equipment to be trained to handle the quantities, types, and variability of material they are likely to encounter

			Supervision	• Managers/supervisors at the facility to supervise workers
Foul odour at the disposal facility	Dumping of mixed waste	Training and capacity building; attitude and awareness	Pre-processing of waste	• Trommels to be used to segregate mixed waste
			Stabilisation of waste	• Usage of bioculture and proper turning of waste
	Poor design of the facility	Infrastructure	Proper storage design for untreated waste	• Separate area for storage of different types of waste • Development of a green belt around the site
			Odour controlling measures	• Use of bioculture • Development of a green belt around the site
	Poor leachate management	Infrastructure	Rain sheds	• Installation of rain sheds to prevent rain from getting mixed with rainwater
			Leachate treatment plant	• Functional leachate collection and treatment plant at the facility
O&M of disposal facility	No proper road to the facility	Infrastructure	Development of approach road	• Construction of a proper approach road at the time of facility set up

	Poor data management of waste	Data and information	Infrastructure to measure incoming reject	• Weighbridge for measuring the incoming waste at the site • Maintenance of logbooks for data-keeping
			Data analysis for effective operation	• Data collection to track the quantity of waste actually processed at the facility as opposed to the installed capacity • Development of additional infrastructure at the facility based on the data
	Electricity/power cuts	Infrastructure	Mechanism for reporting power cuts	• Communication channels/groups and radio set to inform officials
			Backup plan /alternative strategy	• Establishment of alternate power-generating sources
	No AMCs	Policy and governance	Transparent tenders/proposal	• Clear definition of responsibilities, key performance indicators, and timelines in the contract
Remediation of legacy waste	Not finding the right concessionaire	Policy and governance	Transparent tenders/proposals	• Clear definition of responsibilities, key performance indicators, and timelines in the contract

	Electricity/power cuts	Infrastructure	Mechanism for reporting power cuts	• Communication channels/ groups and radio set to inform officials
			Backup plan /alternative strategy	• Use of diesel-operating machinery for running trommels
	Obsolete technology for remediation	Technological	Customisation of existing machinery	• Customisation of machinery based on the assessment of legacy waste and desirable end products
			Adoption of new technology	• Adoption of state-of-the-art technology based on data assessment
	Destination for end products	Policy and governance	Collaborating with potential partners	• The end product from waste to be sold in local markets or sold to the municipal corporation in agreement with them • Inert can be used in highways
	Lack of data/study about the composition of legacy waste	Data and information	Pre-feasibility study on legacy waste site	• Conducting a pre-feasibility study to assess the status of legacy waste
Accidents at the disposal facility	Non-compliance with safety guidelines	Health and safety	Layout plan of the disposal site	• Fencing and locking the facility and provision of adequate lighting in sensitive areas

	Negligent behaviour of workers	Attitude and awareness	Norms on OHS /EHS to be followed	• Safety equipment to be used at the site • Emergency contact details to be displayed prominently
			Supervision	• Managers/supervisors at the facility to supervise the workers • CCTVs to be installed to facilitate supervision
	Slope instability and erosion	Training and capacity building; attitude and awareness	Norms on OHS /EHS to be followed	• Safety equipment to be used at the site • Emergency contact details to be displayed at the site
Environmental monitoring	Lack of monitoring technology	Technological	Collaborating with solution providers	• Collaborating with start-ups and social enterprises working on environmental monitoring
	Lack of assistance for monitoring	Policy and governance; training and capacity building	Involving experts	• Partnerships with experts and consultants
			Collaborating with solution providers	• Collaborating with start-ups and social enterprises working on environmental monitoring

			Capacity building of ULB officials	• Dedicated training modules and workshops on the role of environmental monitoring • Training of employees at the ICCC
Source: Authors' compilation				