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SOLID WASTE MANAGEMENT

What has been the contribution of Indian Smart Cities in Solid Waste Management sector?

Sustainability Impact Assessment Report by

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

INDIAN INSTITUTE OF TECHNOLOGY HYDERABAD

Smart City
MISSION TRANSFORM NATION

SMART CITIES MISSION
MINISTRY OF HOUSING AND URBAN AFFARIS

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Executive Summary:

Economic growth of India coupled with rise in per capita GDP has led to increase in urbanization with more people settling in urban habitats (cities). This has further led to land use changes, rapid construction, and industrial expansion as well as rise in consumerism. A direct consequence of this has been increase in urban waste generation. The traditional method of waste management in most Indian cities has been dumping followed by incineration/burning or unplanned landfilling. However, there is mounting scientific evidence about the negative environmental consequences about such traditional waste management strategies. Consequently, governance and administrative efforts to include waste management as a critical component of urban development have been on the rise.

Following the launch of the Clean India Mission for efficient and sustainable solid waste management and sanitation in the rural and urban spaces of the country, waste management has transformed into an entire value chain comprising of various stages (collection, transportation, processing (treatment, recycling, upcycling etc.) and disposal with cities developing comprehensive strategies and action plans to improve efficiency and sustainability at every step of the 'waste value chain.' While waste management is the focus of urban local bodies (Municipal Corporations or Nagar Nigams), the Smart Cities Mission (SCM) (Central Sector Scheme launched by the Ministry of Housing and Urban Affairs and focused on holistic development of selected 'smart' cities as drivers of economic growth and good quality life) has 'sanitation and efficient solid waste management' listed as one of its core elements.

The present report therefore focuses on the Impact of SCM in fostering Sanitation and Smart Solid Waste Management (SWM) within cities. Beginning with a general overview of the significance of sustainable urbanization and the role of the Solid Waste Management (SWM) sector in it, the major Aim and Objectives of the study have been detailed. The report then moves on to provide a brief literature review detailing the present status of SWM in terms of administrative regulations and data availability. Section 3 outlines some key national projects implemented under SCM that can guide future action plans related to Smart SWM. Subsequently Section 4 describes the methodology adopted for ascertaining the impact of SCM in the realm of sanitation and SWM which is broadly categorised into two major heads that is National Level Sustainability Impact Assessment and City-visits for Primary Assessment.

Overall analysis of the responses received from Smart Cities for the questions circulated to ascertain the impact of SCM on the SWM sector at the National Stratum revealed that ***several cities have undertaken initiatives for the SWM sector by utilising SCM funds. This has been done through procurement of vehicles for waste collection (reported by 36 cities), development of waste transfer stations and processing units (reported by 22 cities) and 26 cities took up integration of SWM module within the Integrated***

Command and Control Centre (ICCC) for improving monitoring related to waste collection and waste collection efficiency. *Some cities such as like Indore, Surat, Gwalior, Chandigarh, Thanjavur, Belagavi have also developed vision documents and policies for attaining circularity and carbon neutrality within the SWM sector while several other cities have initiated proposals for the same. Additionally,* ***21 cities also reported to have utilized SCM funds for remediation of legacy waste sites*** *which is a major step in transitioning towards 'zero waste city.' Overall, it was evident that while initiatives are underway for improving all aspects of solid waste management, cities need to adopt a more holistic approach for improving efficiency in the municipal waste management sector.*

A total of ***five cities were visited as part of Primary Assessment namely; Indore, Surat, Pune, Lucknow, and Cochin*** *for understanding the solutions/projects implemented by their respective city SPVs for improving management of solid wastes within their cities. Technical project details aside the likely social, environmental, and economic impact of the projects being implemented under the SCM were also ascertained. Overall, Indore was evidently leading in terms of SWM having successfully implemented household segregation into six waste streams and considerably up-scaled centralised processing facilities which has reduced the amount of waste ending in landfill sites to zero. Surat and Pune too are performing extremely well with the ICCC of both cities playing an active role in ensuring effective monitoring of waste collection and waste movement. Both cities have centralized and decentralized facilities for management of wet and dry waste streams, however, lack of awareness for waste segregation and expanding city limits coupled with a large floating population (especially in Pune) prove to be major challenges. ICCC-Lucknow, on its part has implemented a couple of projects for ensuring smart fleet management (live tracking of waste collection vehicles, fuel sensors for reducing fuel wastage) and regular household waste collection (installation of NFC tags and bin-level sensors), while Cochin has several upcoming projects (waste compactors, CCTV installation at dumpsites, mechanised sweeping machines) for improving that status of SWM. The last section lists the major observations from the national assessment and inferences drawn from each of the five field visits followed with some recommendations for making future projects targeting SWM more robust and successful. Overall, limited citizen awareness and sensitization towards waste segregation remains a major challenge for smart cities to overcome and future projects of Smart Cities could essentially focus on improvement of this aspect in addition to development of civil and digital infrastructure projects. The report will prove to be an insightful read for policy-makers, administrators, municipal officers, NGOs, academicians, and individuals interested in the SWM sector as it provides a comprehensive overview of city-specific waste management strategies, challenges and gaps, future focus areas and the role of digital infrastructure and smart SWM management.*

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FOREWORD

It has been a great privilege for **Indian Institute of Technology Hyderabad** to partner with Smart Cities Mission (SCM), Ministry of Housing & Urban Affairs (MoHUA), Government of India, in its unique initiative under SAAR (Smart Cities & Academia towards Action & Research) - Sameeksha Series, aimed at offering an opportunity to the premier institutes of the country to undertake comprehensive, national level independent impact assessment studies. It comprise of 50 national level impact assessment studies by 29 premier institutes of India on various themes. It is focused to bridge the gap between academia and government to document and research new urban initiatives/ models/ projects under SCM, on one hand, and take the learnings to level next on the other.

The **Sustainability Impact Assessment Study on Solid Waste Management"** carried out by Dr. Ambika S, Department of Civil Engineering, IIT Hyderabad delves on **"What has been the contribution of Indian Smart Cities in Solid Waste Management Sector?".** The study meticulously examines the direct and indirect effects of projects and initiatives on enhancing solid waste management practices across 100 smart cities. In this study, detailed city-level case studies were undertaken in Indore (Madhya Pradesh), Surat (Gujarat), Pune (Maharashtra), Lucknow (Uttar Pradesh), and Cochin (Kerala). The observations on the impacts were reported in terms of technical, social, environmental and economic impact assessments. Furthermore, the report offers Replicable Best Practices, Recommendations, and Policy Directives aimed at reinforcing solid waste management in India, serving as a valuable resource for researchers, technical engineers, city planners, and future smart city endeavors.

Dr. Ambika's team express gratitude to the Mission team at MoHUA for offering well-coordinated data support and on-ground facilitation of site visits to the project team, for documenting the learnings which could be bedrock for future urban development policies. Hope the outcome of these impact assessment studies will go long way in improving living standard of its citizens. We would also take this opportunity to wish good luck to SCM, MoHUA in its future endeavours.

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1. Introduction:

1.1 Significance of Sustainable Urban Development:

The level of urbanization is often regarded as a critical parameter for assessing the economic prosperity of a nation as it not only proves to be a yardstick for quantifying the relative access to resources but also helps assess the 'standard of living' based on indicators related to sanitation, education, mobility, and governance. Moreover, mounting anthropogenic pressures has gradually shifted focus towards greater inclusion of ecological and sustainability indicators while measuring city expansion and urbanization. Consequentially, governments world-wide are laying greater emphasis on interventions, frameworks and guidelines that promote 'sustainable urbanization' *(Keith et al. 2023; Takano et al. 2023)*.

1.2 Urbanization and Challenges with Solid Waste Management:

India, a fast-emerging economy categorized by vast regional, cultural, and ecological heterogeneity is making earnest efforts to overcome diverse developmental challenges arising because of urbanization. Moreover, linear commodity supply chains, rise in per capita income, technological upgradation, and lifestyle transitions have further led to an increase in waste generation within Indian cities. Moreover, unplanned migration has considerably increased the population of urban residents living in slums. As evident, effective Solid Waste Management (SWM) is a critical challenge faced by Indian municipalities.

1.3 Hypothesis, Aims and Objectives:

Therefore, it was hypothesized that digital infrastructure and smart solutions can play a significant role in overcoming the challenges faced by Indian cities in SWM. The Aim of the present report was to assess the role and impact of the Smart Cities Mission (SCM) (a Central Sector Scheme) in enhancing effective Sanitation and SWM. Specific objectives include:

- To assess impact of SCM projects in improving sanitation and SWM at the National Stratum.
- To undertake Primary Sustainability Impact Assessment for SWM through field visits to selected Smart Cities.
- To comprehend Gap Areas with respect to SWM and to propose appropriate Recommendations for overcoming them.

1.4 Observed Limitations:

Since Indian urban centres are still evolving and city administrative units are in a state of continuous development, datasets and indicators which allow undertaking a holistic sustainability impact assessment for the SWM sector remain limited in nature. The report therefore tries to establish linkages with social, economic, and environmental sustainability based on the technical information received for the SWM related projects being implemented by the city SPVs under the SCM.

2. Literature Review:

2.1 Administrative Structure for Management of Sanitation and Solid Waste:

At the administrative level the Ministry of Environment, Forests and Climate Changes (MOEF&CC) serves as the nodal agency responsible for planning, co-ordination and implementation of programs and schemes related to environmental management. The ministry is further assisted by the Central Pollution Control Board (CPCB), providing services such as implementation of programs directed towards pollution abatement, guidance to State Pollution Control Boards (SPCBs), training of personnel, pollution related data monitoring as well as preparation of manuals and guidelines related to control of pollution and management of waste (https://cpcb.nic.in/). To effectively tackle the challenge of waste management, the MOEF&CC framed the Municipal Solid Waste Management Rules, 2016 applicable to all urban local bodies of India *(MOEFCC, 2016)*. The rules provide definitions of various terminologies associated with waste as well as outline the duties of the waste generators, various ministries, State Pollution Control Boards and Pollution Control Committees along-with the procedure to be followed in establishing waste treatment and processing facilities. In addition to the MSW rules, there is the Swachh Bharat (Clean India) Mission, which although started in 2014 with a vision to make the country open defecation free and improve access to improved sanitation facilities, was subsequently sub-divided into rural and urban components with the latter being placed under the jurisdiction of the Ministry of Housing and Urban Affairs (MoHUA). The guiding targets of the urban component include improving waste management within cities through promotion of door-to-door collection, processing facilities and remediation of existing dumpsites.

2.2 Status of Solid Waste Management:

State-wise municipal solid waste statistics are significantly influenced by the statistics of the Urban Local Bodies located within them with the average values for a state over-shadow the best and worst performing municipal bodies in terms of sustainable waste management. Therefore, while the state level statistics may serve the purpose in making an overall assessment of waste management at the country level and rank states in various sustainability related metrics, they fail to help in ascertaining gap areas in solid waste collection, segregation, processing, and treatment at the city-scale which is ultimately useful in devising appropriate strategies for management. City or municipal level waste related statistics, however, are not easily available on government data portals in a manner that can be easily assessed for analysis and comparisons. **Table 1** further shows the waste generation statistics for some metro cities and state capitals of India.

Table 1: Municipal solid waste generation in some metro cities/state capitals

City	1999-2000	2004-2005	2010-2011	2015-2016	2018-2019	2019-2020
Mumbai	5,355	5,320	6,500	11,000	7,700	6,000
Delhi	400	5,922	6,800	8,700	10,817	10,470
Bengaluru	200	1,669	3,700	3,700	5,700	6,000
Chennai	3,124	3,036	4,500	5,000	-	-
Hyderabad	1,566	2,187	4,200	4,000	-	-
Ahmedabad	1,683	1,302	2,300	2,500	-	-
Kolkata	3,692	2,653	3,670	4,000	-	-
Surat	900	1,000	1,200	1,680	-	-
Pune	700	1,175	1,300	1,600	3,628	3,300
Jaipur	580	904	310	1,000	-	-
Lucknow	1,010	475	1,200	1,200	-	-
Kanpur	1,200	1,100	1,600	1,500	-	-
Nagpur	443	504	650	1,000	1,595	1,000
Vishakhapatnam	300	584	334	350	-	-
Indore	350	557	720	850	1,010	1,010
Thane	-	-	-	700	1,971	2,120
Bhopal	546	574	350	700	1,060	1,060
Patna	330	511	220	450	770	850
Vadodara	400	357	600	700	-	-
Ludhiana	400	735	850	850	-	-
Coimbatore	350	530	700	850	990	-
Agra	-	654	520	790	-	-
Rajkot	-	207	230	450	-	-
Varanasi	412	425	450	500	-	-
Srinagar	-	428	550	550	450	520
Amritsar	-	438	550	600	-	-
Navi Mumbai	-	-	-	675	711	750
Allahabad	-	509	350	450	-	-
Ranchi	-	208	140	150	-	-
Gwalior	-	-	285	300	606	606
Raipur	-	184	224	230	-	-

Unit-Tonnes Per Day;
Source: MOSPI, (2023) (https://www.mospi.gov.in/publication/test1-0)

While the annual city level data could only be retrieved in terms of solid waste generation, closer analysis of **Table 1** yields two important inferences that is primarily 2015-16 is the year for which most uniform waste generation data is available at the city scale with recent years (2018-19 and 2019-20) having several missing values and secondly waste generation at the city scale witnessed an upward trend over the years. While a major contributing factor in this would be the expanding population base of cities owing to rising

floating populations within major metropolitan cities and new territories being added within the existing municipal boundaries, rising income levels of urban residents leading to unsustainable lifestyles and overconsumption of resources could also be regarded as a major factor responsible for increased waste generation. While national level data monitoring and reporting related to solid waste management may not be very robust, it is conclusive enough to highlight the need of envisaging smart solutions for efficiently mitigating the challenge of SWM.

3. Case Studies for Solid Waste Management-National:

Kakinada Smart City Corporation Limited has incorporated the use of digital technologies to track movement of waste from collection to transportation and disposal. The system includes the collection of wastes from households, and commercial establishments and tracks movement of garbage collection vehicles throughout. The project has ensured real-time monitoring of garbage collection vehicles and considerable improved operational efficiency. Besides, the project also provides a 24*7 helpdesk for resolving citizen grievances, has systems for police surveillance and public announcement systems for increasing public awareness. Overall, the project is a classic example of how education, information technology and digital infrastructure can be used to ensure sustainable waste management *(MoHUA, 2023)*.

Additionally, the Chandigarh Smart City has enabled the provision of SCADA for SWM. Innovative features of the project involve integration of D2D related information onto a single platform, installation of GPS devices in 638 SWM vehicles, route mapping of SWM vehicles, location mapping of garbage transfer stations, citizen App for complaint registration and efficient D2D waste collection and web dashboards. Under the project more than 11,000 Point of Interaction have been created that covers the complete residential properties in 114 Square kilometer area. Post implementation of the project the number of missed points for garbage collection has come down to 192 from 4200 *(MoHUA, 2023)*.

On the other hand, several construction and redevelopment projects undertaken by Smart Cities can also have a direct positive bearing on improving Solid Waste Management related statistics. A major example of this includes the Market Redevelopment of the Chappan Dukan area (Indore) spread over 10000 square kilometers and containing 250 vendors into a smart street food hub. The redevelopment project included creation of 56 stores along a 175-meter-long street in the business district of Indore, known as "*Chappan*". The street is the city's first vehicle-free zone designed as a public space, featuring green spaces, seating and room for various community activities. While the major objectives of the project were to alleviate congestion, provide a pedestrian-friendly environment and offer vendors a well-organized commercial space, field visit taken to the area as part of the primary assessment revealed that the project had also aided the cause of SWM as post project implementation all food waste was ending in dustbins which was directly benefitting the general aesthetics of the place as well as the waste collection process.

4. Methodology:

The basic methodology adopted for undertaking the Sustainability Impact Assessment study for assessing the role of SCM in improving sanitation and solid waste management within Smart Cities has been depicted through the following flowchart:

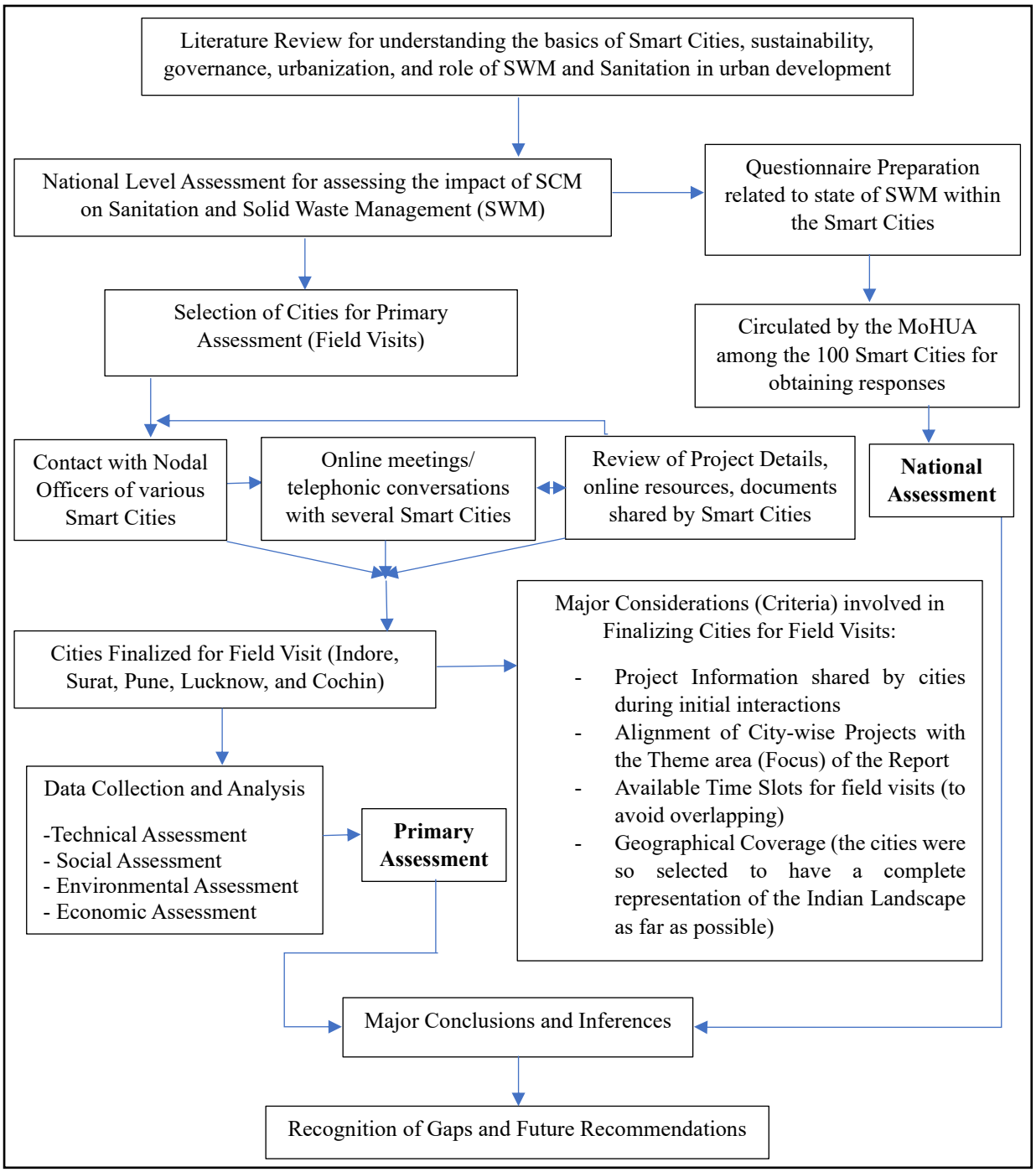

Figure 1: Schematic representation of the Approach adopted for assessing the Impact of SCM in improving Sanitation and SWM within Smart Cities

5. Sustainability Impact Assessment Inferences:

5.1 National Level Theme-based Sustainability Impact Assessment:

All Smart Cities responded to the questionnaire circulated for assessing the status of SWM at the national stratum. The questions were divided into four broad sectors that is waste management related statistics between 2014 and 2023 (for ascertaining waste related trends), utilization of SCM funds for strengthening waste collection, monitoring and processing, contribution of SCM in skill development, informal sector integration, data strengthening for SWM and policy initiatives to enhance circularity and carbon neutrality within the SWM sector. The Box below highlights some major conclusions drawn based on the data provided by smart cities related to SWM statistics.

Between 2014-2023:

- Solid Waste Generation has increased by 6164.58 tonnes (based on cumulation (sum) of data reported by 37 cities).
- Solid Waste Collection has increased by 7291.17 tonnes (based on cumulation (sum) of data reported by 36 cities).
- Average percentage of solid waste being segregated increased by 51.06% (based on cumulation (sum) of data reported by 33 cities).
- Average percentage of households covered under D2D collection increased by 47.99% (based on data reported by 33 cities).
- Average rate of total wet waste processing has increased by 45.87% (based on data reported by 32 cities).
- Average rate of total dry waste processing has increased by 63.33% (based on data reported by 31 cities).
- Several cities (Belagavi, Indore, Tirupati, Solapur, Satna, Jhansi, Aligarh, Thoothukudi, Rajkot, Tiruchirappalli, Shimla) have either considerably reduced or completely removed 'community bins' which could be indicative of improved waste collection and transportation.
- Cities such as Agra (8), Aurangabad (10), Bareilly (2), Belagavi (10), Bhopal (12), Indore (10), Tirupati (2), Aligarh (3), Raipur (9), Tumakuru (9) to name a few also reported development of Garbage Transfer Stations which is reflective of improved infrastructure for SWM.
- Number of sanitary landfills and landfills increased by 18 and 4 based on data reported by 23 and 21 cities respectively.

These figures clearly indicate that while Smart Cities have undertaken development of infrastructure and monitoring facilities for SWM and recognize the significance of enhancing SWM for sustainable urban growth, data management and reporting related to the same needs to be further developed. On the other hand, **Table 2** provides an overview of the diverse heads/parameters under which utilization of SCM funds has been undertaken by the Smart Cities.

Table 2: Overview of Projects undertaken by Smart Cities related to various aspects of SWM and associated utilization of SCM funds for the same.

Parameter (P) for SWM	Cities reporting projects related to (P)	Cities reporting utilization of SCM funds for (P)	Total Cost for Projects against (P)	Avg. Expenditure per City against each (P)
Procurement of waste collection vehicles	38	36	384	10.66667
Monitoring & routing of collection vehicles from ICCC	48	26	111.906	4.304077
Development of waste transfer stations	23	21	291.512	13.88152
Development of waste segregation units, material recovery centres	20	14	163.52	11.68
Development of processing units	22	18	268.17	14.89833
Waste to energy plants (using Bio methanation, incineration, Plasma pyrolysis, gasification, Refuse derived fuel, etc.)	15	10	404.72	40.472
Management of legacy waste	26	21	504.12	24.00571
Any other*	52	52	24.00571	21

*refers to projects such as procurement of waste collection vehicles (Diu), preparation of DPR of SWM (Bhagalpur), purchase of road sweeping machine (Tiruchirappalli), procurement of bins of different sizes (Karnal), improvement of sanitary drains (Puducherry) and development of SWM Museum (Zero Shop) (New Town Kolkata).

In total of the 100 Smart Cities, 89 reported utilization of SCM funds for the purpose of SWM related projects. Besides, cities also reported having future projects or contributing to municipal SWM through development of dry and wet processing (15), decentralized waste management systems (26), improving capacity of centralized waste processing facilities (22), skill development/ training programs (25), worker-welfare programs or integration of the informal sector (22), improvement of data monitoring measures (35), establishment of plastic recycling facilities (12), establishment of glass recycling facilities (4), establishment of e-waste management facilities (9), establishment of C&D waste management facilities (18), restoration of open dumping sites (18), remediation of legacy waste mining sites (24), development of compost facilities within city green spaces (20), development of start-ups exclusively focused on SWM (10). 43 cities also reported having ICT interventions in place for SWM such as tracking of waste collection vehicles, development of mobile applications for citizen tracking of SWM services and grievance redressal, development of smart underground bins etc.

Few cities answered in the affirmative to questions related to development of policy interventions for promotion of circularity (20) and zero waste/carbon neutrality (31) within the SWM sector. Thanjavur, New Town Kolkata and Panaji admitted to preparing the proposals related to it under CITIIS 2.0. Surat mentioned about having a policy on Decentralized Waste Management by 2030. Meanwhile, Lucknow reported development of MRF and covering of open dumping sites in the city while Pune reported development of RRR centres and Waste to Wonder Parks.

5.2 City Visits and Detailed Primary Assessment:

5.2.1 Indore:

- Ease Of Living Index 2020: **Score-58.58; Rank- 9** (million+ municipality)
- Municipal Performance Index 2020: **Score- 66.08; Rank- 1** (million+ municipality)
- Swachh Survekshan 2023 Rank: 1
- Field Visit Undertaken on: 8-9th April, 2024

A. Basic overview of SWM within the Municipality:

The basic process of SWM adopted by the Indore Municipal Corporation (IMC) involves, the 'safai-mitras' (waste collection workers) reaching their designated ward offices in the morning for attendance following which they disperse to their respective sweeping/collection areas. Every ward has around 70 such workers comprising of helpers, driver, waster collectors and area inspectors. Each ward has been allotted around 6 vehicles for door-to-door collection along-with an open vehicle which depends on the ward-size, number of households and the population density of the ward. Moreover, documenting a highly innovative approach to spreading awareness at the grass-root level, every primary collection vehicle has an NGO worker associated with it whose major purpose is related to information and communication. This is a two-way process as the NGO worker not only conveys the regulations and requirements of the IMC and Swachh Bharat Mission (SWM) to the local residents but also listens to their complaints and ensures their timely resolution through appropriate authoritative action. Collected waste is ultimately transferred to the Garbage Transfer Stations (GTS) which receive six different types of waste (wet, dry, plastic, e-waste, sanitary and hazardous) segregated at source from where they go to different sites for processing and management.

Table 3: Overview of the Solid Waste Management Sector of Indore in term of Generation, Collection and Transportation Vehicles

Parameter	Value
Total solid waste generation/ collection	1150 to 1200 TPD
Approximate generation of wet and dry waste	Wet – 650 to 700 TPD; Dry – 450 to 500 TPD
Sanitary, E-waste and Domestic Hazardous Waste	18 TPD
Waste collected by Informal sector	0 TPD
Door to door collection	100 %
At source segregation (approx. percentage)	100 %
Total dry waste processed	450 to 500 TPD
Total wet waste processed	650 to 700 TPD
Waste sent to landfill	0 TPD
Total no. of Community bins	0
Total no. of transfer stations	10
Total no. of dumping yards	0
Total no. of sanitary/engineered landfills	2
Revenue obtained from User Charges	60 to 150 rupees/month from residential units 150 to 300 rupees/month from commercial units

Parameter		Value
Type and No. of Transportation vehicles	Trucks (tipper lorry, compactors, tractors, compartment vehicles)	800 approximately
	Hand-driven carts (pushcarts, tricycles)	108
	Motorized carts	40
	e-vehicles	0
	Other	
Fate of processed waste (market: revenue generated from waste)	Compost	0 (earns money through premium/royalty)
	Recyclables	0 (earns money through premium/royalty)
	Refuse derived fuel	0 (earns money through premium/royalty)
	Electricity generation from waste	(No plant of such technology functional presently)
	Other	

*The infrastructure development for the GTS have been undertaken by Smart City Indore (ISCDL) and handed over to IMC. This was done as part of the infrastructure development for Swachh Bharat Mission.

Table 4: Details of Dry and Wet Waste Processing facilities functional in Indore

Waste	Type	Number	Operational Capacity	Quantity Processed
Dry	Material Recovery Facility	6	544 TPD	450-500 TPD
Wet	Bio CNG	3	585 TPD	491.2 TPD
	Biogas plants			
	Home Composting	56000 approximately	74 TPD	72 TPD
	BWGs with in-situ processing facilities	286	51.5 TPD	27 TPD
	Other	Decentralized Mobile Composting Van – 4 Decentralized Green waste processing units- 371	8 TPD 60.2 TPD	7 TPD 45.3 TPD

*Two centralized MRFs have been developed by Smart City Indore (ISCDL). The tender was by ISCDL.

B. Technical Impact Assessment of Smart Solutions for SWM:

A major contribution of the Smart Cities Indore in SWM has been in enhancing solid waste related monitoring via the ICCC. The major contributing factor in this has been the fact that the parking lots, fuel stations and the amount of fuel for every garbage collection vehicle has been fixed before-hand. Moreover, IMC has a centralized workshop for fixing issues related to breakdown or malfunctioning of vehicles. The number of vehicles going to a particular GTS has also been mapped. A lane-to-lane marking system has been followed for the route mapping of every vehicle (open tippers and partition vehicles) and alerts (route deviation, over-speeding, stoppage-time violation) are generated in case a vehicle fails to comply moving on the designated route. A total of 575 routes have been

mapped for the entire city and the concerned ward officers ensure that the vehicles reach to their specific beginning spots by 6 am (open tippers) and 7 am (compartment vehicles).

C. Social Impact Assessment of SWM:

Changing the perception and behaviour of people towards 'waste' has been the major factor behind Indore's success. People in Indore feel it is their primary responsibility to keep their city clean. Secondly, IMC has played a major role by working at the ground level, building trust and faith of the public in the city's corporation and changing their perception towards waste. For the same area specific planning and city profiling was undertaken by the IMC and in 2016 the IMC began with collecting mixed waste from households to simply build the habit of handing over waste to official authorities instead of discarding it in open spaces or burning it. Moreover, the NGO worker deployed with every waste collection vehicle for capacity-building of citizens created awareness related to holding capacity of bins and the necessity of storing waste within their house premises instead of discarding it. Subsequently, additional achievements such as source segregation, removal of secondary storage bins, provision of waste-bins at subsidized costs, introduction of three-bin system (wet, dry, and domestic sanitary waste in 2017) and introduction of terrace gardening, home composting (to promote in-situ management of waste) were incorporated at the ward-scale. Lastly, in 2021 the six-bin segregation of household waste was introduced and awareness related to the same was spread via the NGO. Several additional strategies adopted by IMC, for improvement of citizen awareness and sensitization include; Ward level Competition, Engagement of Social media Influencers, (Focused Group Discussions) FGD with stakeholders, Brand Ambassadors engagement, Theme based activities as per in-house calendar, Engagement of Volunteers from School and college, Awareness through social, print, and electronic media. IMC has also introduced Aadhar based attendance system and complete online payroll for workers engaged in waste management.

D. Environmental Impact Assessment of SWM:

Indore municipality has been able to completely remove the installation of secondary storage bins owing to robust source segregation and regular collection from household and commercial establishments. Filed visit to the city made this fact apparent as no community dustbins were visible. Moreover, all vehicles being used for waste transportation are completely covered. Such measures directly contribute towards maintaining clean environmental conditions and community aesthetics by reducing foul smell and spilling of waste. Besides, the GTS and waste processing plants visited were also found to be very clean. Interaction with the IMC officials also revealed that owing to improvement in waste metrics the city administration has been able to completely avoid waste being sent to the landfill, which has not only increased the landfill lifespan but also benefitted the surrounding environment as it is common knowledge that landfilling results in emissions and groundwater and soil contamination from leachate formation.

E. Economic Impact Assessment of SWM:

While exact economic benefits by projecting 'waste as a resource' cannot be quantified since IMC runs all its processing facilities in PPP mode and earns revenue through premium/royalty, it is apparent that the model adopted has been a success economically based on the city's performance in the cleanliness rankings. Additionally, the municipal administration has played a major role in ensuring the success of the Indore SWM Model through robust planning, efficient co-ordination between various agencies, correct delegation of responsibilities as well as proper flow and utilization of financial resources being received under various heads.

Figure 2: Field visit photos from Indore depicting household waste collection and segregation into six waste-streams, garbage transfer stations, processing at the wet (Bio-Gobardhan plant) and dry waste processing sites and role of ICCC in improving waste collection efficiency within city.

5.2.2 Surat:

- Ease Of Living Index 2020: **Score- 61.73; Rank- 5** (million+ municipality)
- Municipal Performance Index 2020: **Score- 60.82; Rank-2** (million+ municipality)
- Swachh Survekshan 2023 Rank: 1
- Field Visit Undertaken on: 12th April, 2024

A. Basic overview of SWM within the Municipality:

The basic process for SWM within the Surat municipality involves daily collection of household waste from more than 16 lakh households. Around 100 vehicles deployed for the collection and transportation of waste are GPS/RFID enabled for live tracking. An additional 28 mechanized sweeping machines have been deployed for cleaning of main thoroughfares. Surat has both Centralized and Decentralized facilities for processing of Wet and Dry waste streams. Additionally, Surat Municipal Corporation (SMC) operates separate waste management systems for processing and disposal of plastic waste (200 TPD), E-waste (1 TPD), C&D waste (300 TPD) and bio-medical/domestic hazardous waste (6 TPD).

Table 5: Overview of the Solid Waste Management Sector of Surat in term of Generation, Collection and Transportation Vehicles

Parameter		Value/Number
Total solid waste generation/ collection		2443 TPD
Approximate generation of wet and dry waste		2443 TPD
Waste collected by Informal sector		Yes
Door to door collection		Yes (100 %)
At source segregation (approx. percentage)		Yes (94 %)
Total dry waste processed		1091 TPD
Total wet waste processed		1352 TPD
Waste sent to landfill		100 TPD
Total no. of Community bins		-
Total no. of transfer stations		8
Total no. of dumping yards		-
Total no. of sanitary/engineered landfills		2
Revenue obtained from User Charges		4677967103.12 (FY 2023-24)
Details of Transportation vehicles	Trucks (tipper lorry, compactors, tractors)	187
	Hand-driven carts (pushcarts, tricycles)	-
	Motorized carts	-
	e-vehicles	132
	Other	41
Fate of processed waste (revenue generated from waste)	Compost	Rs. 3.60 Cr. (12000 tonnes/year)

Table 6: Details of Wet and Dry Waste Processing Facilities operational in Surat

Wet Waste Processing	Dry Waste Processing
Total: 2 Centralized, 81 Decentralized	**Total**: 4 Centralized, 8 Decentralized
Centralized 1. Waste to compost plant (Khajod Disposal Site, Khajod) - 1500 TPD 2. APMC Biogas Plant (APMC, Ring Road, Surat) - 50 TPD	**Centralized** 1. Waste to RDF plant - 1000 TPD 2. Plastic Waste Facility - 200 TPD 3. E-Waste Processing Facility - 1 TPD 4. Biomedical/Domestic Hazardous/Sanitary Treatment - 6

Wet Waste Processing	Dry Waste Processing
Decentralized 3. OWC-KOSAD (Kosad Transfer Station, Amroli-Sayan Road) - 1 TPD 4. Vermi-CZ (Chok Bajar, Nr. CNI Church) - 1 TPD 5. Vermi-NZ (Causeway Vermi Compost) - 0.8 TPD	TPD **Decentralized** 5. MRF-ANJANA - 30 TPD 6. MRF-BHATAR - 25 TPD 7. MRF-BHESTAN - 30 TPD 8. MRF-KATARGAM - 35 TPD 9. MRF-KOSAD - 40 TPD 10. MRF-DINDOLI - 30 TPD 11. MRF-PAL - 30 TPD 12. MRF-VARACHHA - 40 TPD

B. Technical Impact Assessment of Smart Solutions for SWM:

The major objectives of the Surat-SMAC Center for Smart Solid Waste Management Vehicle Tracking and RFID project include:

- Real-time monitoring of fleet involved in the SWM activities, to improve per vehicle productivity, reduce non-compliance and optimize fleet utilization
- Real-time information with regards to waste collection activity
- Geocode and geofence stoppages/Point of Interest (POI) and routes
- Route planning and allocation
- Automation of transfer stations and disposal site for daily garbage movement
- Minimize human intervention and to improve waste collection efficiency
- Prevent misuse of manual system, improve transparency and accountability in operations
- Ensure complete coverage of waste collection across Surat city
- Management with dashboard and detailed analysis reports for decision making

Additionally, Surat Smart City (SSCDL) has also developed the AIC SURATi iLAB Foundation which serves as an Innovation, Incubation, Start-up and Trade Facilitation Centre at a cost of 2.54 crores in the Udhna area. Among the various start-ups launched through the centre is the of 'Biofics Private Limited' which is a leading provider of waste management services in Gujarat (waste picking, recycling, development of automated composting machines etc.). The Incubation centre serves as an excellent example of how Smart Cities funds can be directed towards R&D activities for various developmental sectors with SWM being one of them.

C. Social Impact Assessment of SWM:

Surat like Indore has made considerable progress in the household municipal solid waste collection as evident from the fall in the number of citizen complaints and increased coverage of waste collection. However, waste segregation at source (although commendable at 94%) is a sector which can be further improved as interactions with the officers at the C&D processing plant as well as the Plastic waste recycling unit revealed that mixed waste streams was a challenge that needs to be overcome as it would not only improve plant performance but also reduce the amount of non-recyclable materials and

benefit economic metrics associated with the processing facilities. While the SMC in coordination with the SSCDL has undertaken several projects to improve mobility and public transportation related infrastructure of the city, similar projects can be proposed and implemented to improve waste segregation at source. Additionally, the AIC SURAT iLAB can further contribute in this direction by boosting academic-industrial-governance collaborations for SWM, capacity-building for data analysis being generated at the ICCC and improved quantification of indicators and metrics related to SWM.

D. Environmental Impact Assessment of SWM:

The field visit to Surat revealed that the city is well-planned with wide roads with several placemaking and development of open vibrant spaces projects undertaken by the SSCDL showing visible results. While the projects may not directly be related to SWM, they did help in improving the environmental parameters associated with the ABD area of Surat by promoting recreational activities and clean surroundings. To improve the positive environmental impact through Smart SWM further, future project tenders under the SSCDL could concentrate on improved monitoring of waste ending in the landfill which is around 100 TPD. Installation of cameras at the landfill site for real-time detection of fire outbreaks as well as regular monitoring of gas and leachate levels at the landfill site could significantly reduce emissions and contaminants entering the surroundings (air, groundwater, and soil). SSCDL could also assist the SMC in undertaking periodic landfill audits to characterize the waste ending in landfill (indicative of non-recyclable materials in market circulation) and accordingly help devise plans and strategies to reduce their quantity.

E. Economic Impact Assessment of SWM:

Around 12000 tonnes of compost is produced from the wet waste being generated by the city which results in revenue generation of around 3.60 crores. This figure alone unequivocally highlights the economic significance of just one type of waste stream from the Surat city. Additionally, field visits to the C&D waste processing plant and plastic waste recycling facility revealed that both the treatment facilities are dispatching their end products (sand and plastic pellets respectively) to various industrial units based on demand. Economic quantification of this in terms of ‘money saved by industries through usage of recycled products as input resource as compared to raw materials’ especially in the case of plastic recycling can further help estimate the economic impact of the integrated SWM chain. Having a true estimation of the revenue being generated through waste processing and recycling and using those numbers for highlighting the significance of sustainable waste management could potentially motivate citizens towards responsible practices and behaviour towards waste.

Figure 3: Field visit photos from Surat depicting the plastic waste recycling facility, cement processing plant, Swachhta Monitoring undertaken by SMAC centre and the impact of Smart SWM monitoring (reduction in citizen complaints and increase in collection efficiency) as well as the AIC Surat iLab developed by SSCDL. The lower panel depicts the recreational activities underway following the developmental projects of SSCDL.

5.2.3 Pune:

- Ease of Living Index 2020: **Score- 66.27; Rank- 2** (million+ municipality)
- Municipal Performance Index 2020: **Score- 58.79; Rank- 5** (million+ municipality)
- Swachh Survekshan 2023 Rank: 10
- Field Visit Undertaken on: 10th April, 2024

A. Basic overview of SWM within the Municipality:

The municipality comprises of a total of 5 zones which are further sub-divided into 15 wards and 42 prabhags. Furthermore, based on the population density of prabhags, 'Aarogya kothis' (200-250 across the city) have been established within each prabhag which constitute the lowest administrative unit from where waste collectors disperse to their designated locations (households) for daily waste collection. The basic process followed by the Pune municipality in waste collection involves door-to-door collection of waste from residential and commercial properties by informal waste-pickers (Swachh workers) and Pune Municipal Corporation (PMC) workers using push-carts and other primary waste collection vehicles and deposit it at feeder points located across the city. Manual sorting is undertaken at the feeder points and the waste recovered is further recycled at designated sorting sheds (tie-up between SWaCH workers and local scrap dealers). This process not only reduces the amount of waste to be processed by the PMC

but also provides a sustainable source of income to the scrap dealers and SWaCH workers. Secondary waste collection vehicles (bell-trucks and other small vehicles) collect the waste from these feeder points as well as from other public places and chronic waste deposition points and transport it to the Ramp/Transfer Stations. Waste from the transfer stations is then sent to the processing plants and the sanitary landfill site for processing and final disposal. Additionally, waste from Bulk Waste Generators (BWGs) such as hotels and restaurants, educational institutions, public gardens, construction sites etc. is directly collected by designated vehicles and sent over to the processing sites (based on the type of waste collected) for treatment and disposal. The daily generation of waste approximately amounts to 2100-2200 tonnes per day with almost 98 percent segregation.

B. Technical Impact Assessment of Smart Solutions for SWM:

Implementation of Integrated Solid Waste Management essentially falls under the administrative jurisdiction of the PMC with the Pune Smart City Development Corporation Limited (PSCDCL) lending its expertise and technology to improve monitoring, efficiency and data collection related to Solid Waste all along the value chain. This support is being enabled through the ICCC (a smart city project completed in March, 2020 and built at a total cost of 155.10 crore). The features integrated within the ICCC which help Integrated Solid Waste Management include (i). Fleet Management, (ii). Mechanical Sweeper Route Coverage, (iii). Ramp Processing Dashboard, (iv). Collection Worker Attendance, (v). Collection Worker Pockets Map and (vi). Master Dashboard.
Additionally, the project requirements and objectives include:

- **Citizen Grievance Management:** provision of solutions to diverse citizen related problems through integration of the Swachhta and PMC Care Applications.
- **Waste Flee Management:** Real-time Monitoring & Maintenance of Fleet involved in waste collection and integration of weighing bridge with the application.
- **GIS Integration:** Integration of existing GIS data for intelligent location driven decisions like route mapping for Ghantagadis and workers engaged in the waste collection process.
- **Concessionaire Management:** for improving contractor's productivity and billing management system.
- **Manpower Management:** for managing the attendance and payroll of workers engaged in the waste collection through Smart GPS devices or Smart watches.
- **Intelligence driven MIS reporting:** to perform data analysis and generate custom MIS reports based on the requirements of the major stakeholders.

For fulfilment of the project objectives, the measures undertaken include fitting GPS trackers/devices and RFID tags within waste collection vehicles, distribution of GPS devices or smart watches to the waste collection workers, deployment of weight bridges and RFID readers at the garbage transfer stations and integration of citizen grievance applications with the ICCC. Additionally, sweeper routes, door-to-door collection routes, primary and secondary vehicle routes, feeder points, prabhag, ward and zone boundaries, garbage vulnerable points and ramp and dumping points have been geo-

referenced to integrate them within the ICCC system and monitor garbage collection worker and vehicle movement.

C. Social Impact Assessment of SWM:

Pune is a fast-developing city with a large metropolitan area and undergoing major horizontal city expansion with new villages being integrated within the PMC jurisdiction boundary. Moreover, the city also has a high density of floating population. Both these factors prove to be a major challenge in ascertaining per capita daily waste generation which ultimately results in gaps in waste collection, segregation, and processing. Determination of waste generation aside, limited waste segregation (particularly within newly added villages and slum areas owing to lack of awareness initiatives) as well as limited in-situ waste processing is still a challenge being faced by the PMC as residents are hesitant to process waste in their own backyard. However, a positive measure undertaken by the PMC in this regard has been the provision of rebates within property taxes to households engaging in in-situ composting which serves as an incentive to citizens and reduces the solid waste management burden of the corporation. Another major positive initiative undertaken by the PMC has been the integration of the informal waste collectors through the SWaCH NGO for household collection of waste which can prove to be a key case study for other cities having a high proportion of informal waste collectors. The SWaCH model is a self-sustainable model wherein the PMC only provides PPE kits to the workers and some supervisory charges while the workers generate their income through user charges and ground-level waste recycling at the sorting sheds. Awareness drives (Red Dot Campaign) have also been undertaken by the PMC to remove hesitancy surrounding sanitary waste and to improve sanitary waste segregation at the household level.

D. Environmental Impact Assessment of SWM:

PMC has engaged in talks with several vendors to upscale home composting. Successful implementation of these projects would not only improve the much-needed behavioural change towards waste among residents of the city but also have a positive environmental impact by reducing the amount of wet waste being sent to the centralized processing facilities. While PSCDCL has undertaken several green space development and place-making projects, it can particularly prove beneficial in this regard by helping promote home-composting, community composting and institutional composting within the ABD area through awareness campaigns as well as provision of technical guidance and infrastructure (space, equipment etc.). Promotion of in-situ composting models would also reduce the amount of waste transportation to dumpsites and processing facilities (already a challenge faced by PMC owing to traffic congestion), in-turn resulting in lesser fuel consumption and lesser emissions. Interactions with PMC officials has also revealed that dust along-with C&D waste was forming a high proportion of daily waste generation owing to high rate of ongoing construction activities and high vehicular density. Future

projects undertaken by PSCDCL could also focus on sustainable management of this waste-stream.

E. Economic Impact Assessment of SWM:

Visit to the ramp stations (Garbage Transfer Stations) during the field visit to Pune revealed that old infrastructure of these stations can prove to be a major challenge in solid waste collection and storage and these stations need to be modernized. Pune Smart City office can focus on revamping these ramp stations under future projects for pan-city initiatives like the work undertaken by Indore Smart City office who had a tender to develop the infrastructure for 10 garbage transfer stations across the city and then transfer them over to the Indore Municipal Corporation.

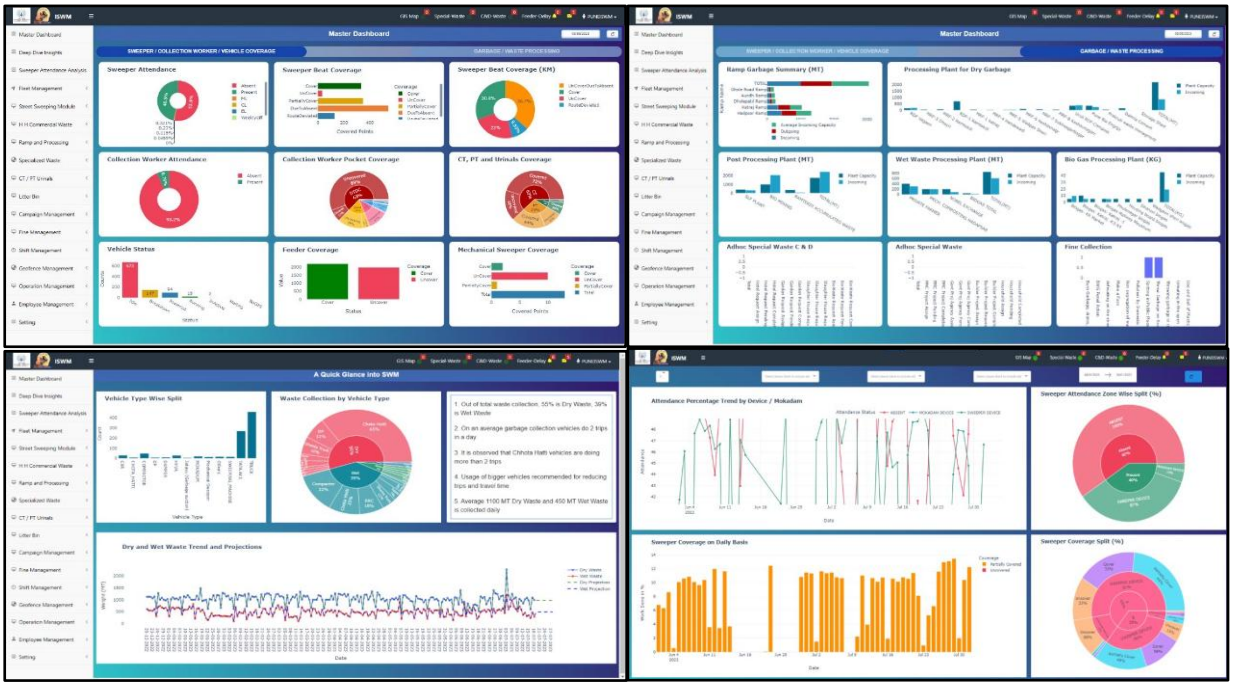

Figure 4: Pune Smart City-ICCC dashboards depicting various parameters related to Solid Waste Management being monitored such as sweeper attendance, sweeper beat coverage, collection worker attendance, feeder point coverage, ramp garbage summary etc. The dashboards in the lower panel depict the 'Deep Dive Insights' feature of ICCC that uses data from various monitoring systems to generate detailed, comprehensive analysis that provide insights related to waste (such as wet and dry waste projections) that help improve waste management efficiency.

5.2.4 Lucknow:

- Ease of Living Index 2020: **Score- 55.15; Rank- 26** (million+ municipality)
- Municipal Performance Index 2020: **Score- 44.76; Rank- 33** (million+ municipality)
- Swachh Survekshan 2023 Rank: 44
- Field Visit Undertaken on: 5-6th April, 2024

A. Technical Impact Assessment of Smart Solutions for SWM:

- **Installation, operation, and maintenance of vehicle tracking system enabled with Fuel Sensor for Fleet of vehicles used in waste transportation by Lucknow Nagar Nigam:** *(Vendor Name: Blackbox GPS Technology (OPC) Pvt. Ltd.)*

The involved installation of GPS tracking devices in all fleet vehicles, installation and calibration of fuel sensors in each vehicle provision of wiring diagrams and documentation of installation procedures, provision of testing and validation reports for ensuring accurate functionality of tracking devices and fuel sensors, provision of training materials for users to enable them to interact with the system, development of fully functional real-time tracking system accessible via web-based or mobile interface, enabling fuel monitoring feature enabled for provision of accurate fuel level readings for each vehicle, maintenance schedule outlining regular inspection and upkeep tasks for the system, procedures documented for sensor recalibration, software updates, and troubleshooting as well as data management protocols established for collecting, storing, and analyzing tracking and fuel consumption data. Improved fleet efficiency, fuel savings and cost reduction, enhanced safety and compliance, data-driven decision making and enhanced customer service are the key project outcomes. The project is being monitored via the ICCC-Lucknow.

- **Installation of NFC/QR Code, Sensor Based Bins:** *(Vendor Name: Convexicon Software Solutions India Pvt. Ltd.)*

A total of 49750 NFC tags have been installed in 49750 household of Zone 1 (approximately 14 wards) falling in ABD Area of Lucknow Nagar Nigam (LNN) to track the garbage collection. The basic feature of the project involves scanning of the NFC tags by the garbage collectors (a total of 110 NFC scanners distributed to primary waste collectors under the project) during daily waste collection. The intended objectives of this project are to improve waste collection efficiency through daily monitoring of door-to-door waste collection and timely redressal of grievances of complaints related to waste collection. Additionally, a total of 250 bins (1.1 cubic capacity) have been deployed with ultra-sonic sensors. The sensors have been further sub-divided into three categories (low (less than 75 percent full), threshold (above 75 percent full) and full) based on the quantity of waste in the bin. The overall objective is to avoid overfilling of bins and spillage of garbage onto the streets which leads to both ecological (soil contamination, creation of insect breeding grounds and garbage consumption by animals) and social (poor aesthetics, foul smell, health hazard) challenges.

B. Social Impact Assessment of SWM:

Use of digital infrastructure for monitoring of public services and dissemination of information (awareness-spreading) can go a long way in benefitting the process of SWM within the city. The Variable Message Systems (VMS) installed at various locations across the city can be used for displaying information related to waste generation and the significance of waste segregation and home composting to inculcate the much-needed

behavioural change towards waste among the residents of Lucknow. Besides, while the ICCC is already monitoring projects related to Smart Fleet Management and Detection of Bin Filling, future projects for the ICCC could also include aspects related to attendance and payment monitoring of workers engaged with the waste collection process as it would further improve the social indicators associated with the SWM process. Awareness and citizen-engagement campaigns and workshops related to waste segregation and in-situ wet waste composting by residential and commercial buildings could also be organized by the Lucknow Smart City (LSCDL) following a PPP model with NGOs and academic institutions wherein the PSCDL could be responsible for the finances and the NGO could be made responsible for material preparation and information dissemination. Additionally, the 'Lucknow One Citizen App' has been integrated with the ICCC for quick redressal of user complaints and help in case of emergency situations. Similarly, the Lucknow Smart City Web Portal (www.lucknowsmartcity.com) has over 3800 registered users and offers various public services (viewing of utility bills and taxes) and news updates.

C. Environmental Impact Assessment of SWM:

LSCDL completed projects with respect to SWM have been related to purchase of vehicles for solid waste collection, procurement of refuse compactor machines as well as procurement of dustbins and road cleaning machines. Digital infrastructure development has similarly focused on monitoring routes of primary garbage collection vehicles, installation of sensors to monitor bin-filling status and installation of NFC tags at households to monitor daily waste collection. Future projects under LSCDL could therefore focus on infrastructure development related to secondary waste collection that is the community transfer sheds or the garbage transfer stations as well as digital monitoring of these stations. This would directly have a positive environmental impact by improving cleanliness of surroundings.

D. Economic Impact Assessment of SWM:

Successful implementation of project related to 'smart fleet management' could have major economic benefits for the LMC by helping monitor route adherence of waste collection vehicles and fuel theft by vehicle drivers both of which would result in improving fuel efficiency and consequently economic savings. LSCDL could further coordinate with the LNN in making economic indicators related to SWM more robust through improved analysis of data being generated by the ICCC as well as future projections related to waste generation trends. This would help LNN in developing future strategies and action plans related to sustainable municipal waste management.

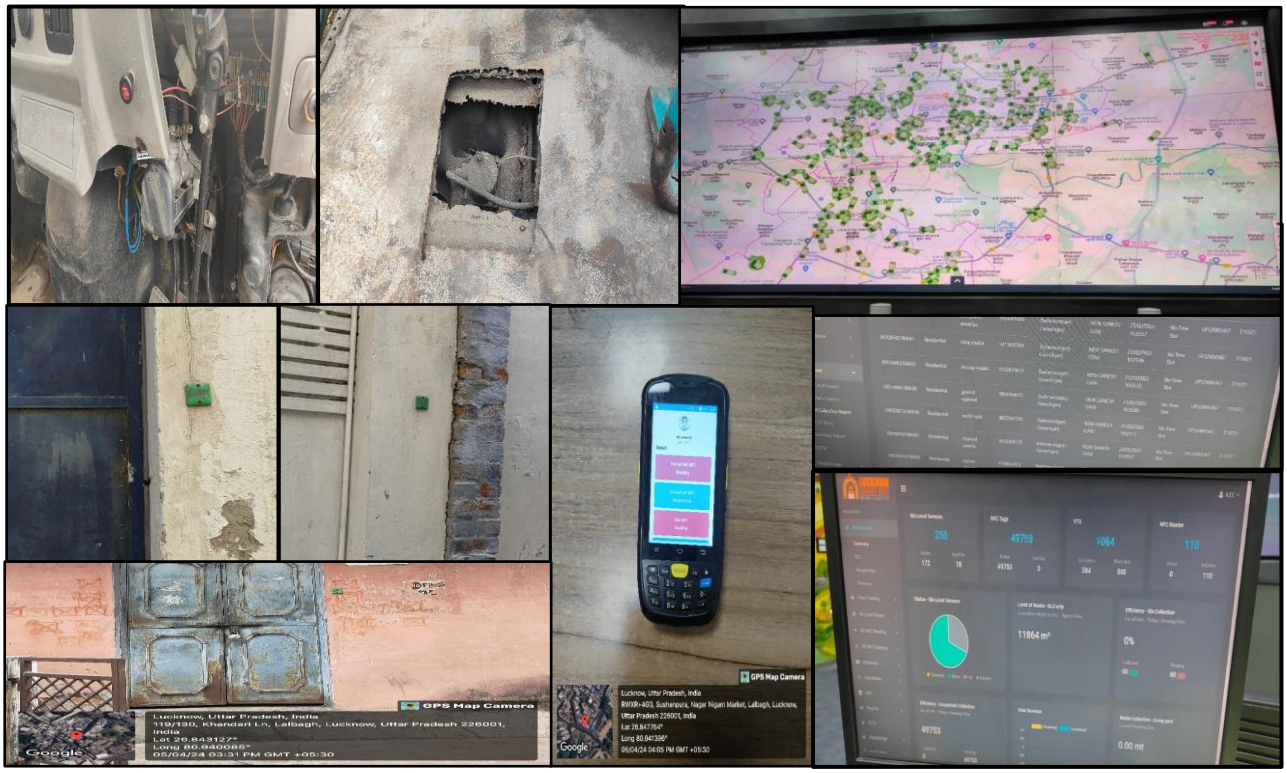

Figure 5: Field visit photos from Lucknow depicting the GPS trackers and fuel sensors installed in waste collection vehicles as well as the NFC tags installed at households and NFC scanner used by waste collectors. The dashboards in the right panel depict the data being generated at the ICCC office for monitoring waste fleet movement, household collection and filling of bins fitted with sensors.

5.2.5 Cochin:

- Ease of Living Index 2020: **Score- 51.41; Rank- 39** (less than million+ municipality)
- Municipal Performance Index 2020: **Score- 46.85; Rank- 12** (less than million+ municipality)
- Swachh Survekshan 2023 Rank: 416
- Field Visit Undertaken on: 19-20th April, 2024

A. Technical Impact Assessment of Smart Solutions for SWM:

- **Distribution of household bins and street litter bins**

The aim of the project (cost 0.61 crore) was to enhance the door-to-door segregation of solid waste originating from households and public places. The implementation strategy involved one-time distribution of a pair of bins (green bins for wet waste and blue bins for dry waste) of 15 litre capacity among households. Approximately 40000 bins were supplied through the project of which 37000 were distributed among the residents. A

total of 35 street bins on the other hand were installed in the Ernakulum and West Cochin area.

- **Supply, Operation and Maintenance of Truck Mounted Sweeping Machines**

With a project cost of 10.98 crores, the salient features of the machines include cleaning approximately 8 kms of road stretch in an hour and having a water storage capacity of 1800 litres that can be sprinkled on road to prevent dust resuspension while cleaning of roads. The sweeping machines come with a five-year operation and maintenance contract while the trucks have been fitted with GPS and CCTV cameras. The first phase of project implementation involves deployment of the machines over a stretch of 35 kms surrounding the Cochin Municipal Area, mostly during night hours.

- **Ernakulum Market Redevelopment**

Proposed as Basement + Ground + three-floors construction project, the Ernakulum Market Redevelopment project is a project having a built-up area of 19990 sq kms with an investment of around 72.69 crores. Construction of the project is being undertaken to provide better working environment for the traders and enhance the convenience of customers and improve ease of accessibility to resources. Tonnes of organic waste generated within the market premises is planned to be collected and compacted using a Compactor and managed effectively under the project. A PPP system is being proposed to operate and handle the entire waste management process under the aegis of the Urban Local Body or the Zonal Management Committee. The main elements proposed under efficient SWM at the market complex include; Mechanically operated waste storage and compaction system, Prime mover with hook loader support and Leachate collection and disposal system.

- **Thuruthy Tower:**

Located in the Fort Cochin area, the Thuruthy Tower has been envisioned as a slum rehabilitation project with the aim to benefit around 195 families residing in two divisions of Fort Cochin. In terms of SWM, Door to Door waste collection (based on outsourced contracts by the Kerela State Government) would be initiated in the completed tower while the CSML would also provide an Organic Waste Convertor for producing compost using the organic waste generated at the premises. An on-site space for segregation of organic and dry waste components would also be provided. The 'Suchitwa Mission' (operating under the Local Self Governance Department of the Kerela State Government) would be responsible for collection and transportation of the recyclable component of the waste to the centralized processing facilities. On the other hand, non-recyclable waste components would be incinerated within the premises using a small capacity incinerator. Hazardous and E-waste management generated within the premises would also be done by the Suchitwa Mission.

B. Social Impact Assessment of SWM:

Ground level awareness among Cochin residents requires improvement when it comes to aspects related to sustainable waste disposal, waste segregation and waste recycling. Therefore, strengthening public awareness related to sustainable solid waste management and changing their perception towards waste is a major task which needs to be achieved to improve SWM related metrics. Undertaking mass awareness campaigns related to SWM would not only make citizens responsible about their purchase, consumption and disposal choices but also reduce the amount of waste ending at the dumping ground. CMC and CSML could work in tandem for achieving this and even form collaborations with NGOs and academic/scientific institutions located within the city that could help with designing activities and materials for such mass public engagement campaigns. However, a particularly positive example of social inclusiveness and women empowerment are the 'Harithra Karma Sena' employed by the CMC for primary waste collection like the SWaCH workers of Pune.

C. Environmental Impact Assessment of SWM:

Owing to its geographic location, Cochin presently enjoys a clean environment with particulate matter concentrations below the prescribed standard limits. However, rising traffic density, urban construction projects and poor solid waste management are a growing threat to the natural environment of the city. With respect to SWM, open waste dumping as well as limited infrastructure development for secondary transfer stations can prove to be potential causative factors responsible for degrading city aesthetics, producing bad odour and negatively impacting the health of stray animals. Interaction with the CSML officials had also revealed that the waste dumping site located at Brahmapuram had witnessed a major fire incident in the recent past which could have potentially caused gaseous and particulate emissions in turn resulting in local air pollution. However, to avert future such incidents, one of the future projects under CSML involves installation of cameras at the dumping yard for improved monitoring of the site. This clearly indicates that the CSML can particularly contribute towards improving environmental aspects related to SWM within the city.

D. Economic Impact Assessment of SWM:

IC4 (Integrated Command, Control and Communication Centre) has been developed under the CSML to enhance the digital infrastructure within the city and integrate various public services (traffic management, solid waste, public grievance) as well as other services (solar lights, street lights, environmental monitoring) onto a single platform. However, the IC4 is yet to realize its full potential within the city owing to limited availability of datasets (from the concerned departments) in the format necessary for integration within the system. Alternatively, CSML could undertake skill development and training programs for officers for improving data acquisition and surveillance infrastructure. Moreover, enhanced cooperation between the CMC and CSML could also

benefit waste data monitoring which would directly improve economic indicators (fuel purchase and consumption, worker payments etc.) associated with the SWM sector.

Figure 6: Future projects awarded to CSML for Solid Waste and Sanitation improvement. These include purchase of 15 waste compactor machines, purchase of mechanized street sweeping machines and procurement of suction sum jetting machine for sewer cleaning.

6. Study Outcome and Conclusions:

The study attempts to undertake a sustainability impact assessment of smart cities in India with respect to sanitation and solid waste management based on survey responses from and field visit to smart cities. Overall, it was evident that SCM is contributing considerably within cities for improvement in SWM efficiency and monitoring. Detailed conclusions and future recommendations have been provided in the sections below:

6.1.1 Major Observations from National Assessment:

SCM is contributing towards improvement of the SWM sector of Smart Cities in some way or the other despite the sector being under the administrative regulation of city municipal corporations. Based on the responses obtained for the questionnaire circulated to all cities, SWM related efforts were found to be more holistic and widespread in certain cities such as Indore, Surat, Pune while certain other cities such as Belagavi, Gwalior, Lucknow were found to be making earnest attempts. Most cities have utilized SCM funds for procurement of collection vehicles, development of infrastructure (waste collection centres, waste segregation/ material recovery facilities, processing units), remediation of legacy waste sites and improvement of SWM collection. The latter has primarily been achieved through fitting GPS trackers in waste collection vehicles and route mapping of SWM vehicles which is monitored by the ICCC. Some cities have also utilized SCM funds for development of worker welfare associations (Belagavi), skill development of sanitary workers (Erode), IEC activities for ULB staff and public (Solapur), loan programme for workers (Salem), skill development for source segregation (Saharanpur), integration of informal sector under 'Ragpickers Shramjivi Arthik Vikas Yojana' (Vadodara). Similarly, Gwalior also organises periodic training sessions for ULB workers and has also integrated the informal waste workers in their transfer stations and MRF centres while Surat has RWAs (Resident Welfare Association) in the city self-operating their wet waste by the Organic Waste Converter (OWC). Overall, it was concluded that better maintenance of solid waste related datasets and enhanced coordination between SCM and ULB offices can further improve efficiency and management of the solid waste sector.

6.1.2 Major Inferences (Achievements and Challenges) from Field Visits:

Indore:

- Changing citizen perception towards waste has been a major factor responsible for the city's success in the SWM sector.
- Strong administrative control of the municipal corporation coupled with effective delegation of responsibilities to various city-based organizations and outsourcing of waste processing projects to private vendors is yet another factor working in the city's favor.
- The role of Smart Solutions (ICCC module on SWM) can be further upscaled to further benefit the ground management of the waste value chain.

Surat:

- In terms of SWM, Surat Smart City presently is mostly helping with strengthening the digital infrastructure and monitoring associated with solid waste collection, transportation and final processing and disposal.
- Interactions with officials at both the C&D waste processing and plastic waste recycling facility during field visit pointed out that the type of waste received proves to be a major factor in ensuring quality of the end-product produced as well as in increasing the operational efficiency and life-span of the machinery involved.

Pune:

- Horizontal city expansion, large floating population, traffic congestions, dust and increasing volume of construction and demolition waste are the major challenges being faced by Pune municipality in terms of Solid Waste Management.
- Intelligence driven MIS reporting feature of the ICCC can prove to be extremely relevant for SWM in Pune as it can help generate future trends related to wet and dry waste generation which can be used to devise appropriate strategies for their sustainable management.

Lucknow:

- LSCDL via the ICCC has implemented several innovative projects for increasing the monitoring efficiency related to primary collection of solid waste from households.
- Being the capital of Uttar Pradesh, the city is witnessing rapid expansion and development which is resulting in increased waste generation of all types (wet, dry, construction) which require upscaling of existing processing facilities for adequate disposal and management.
- Citizen awareness related to waste segregation at source and its significance in improving waste processing, recycling at the waste economy still requires considerable improvement.

Cochin:

- Interactions with the CSML officials revealed that a total of 8 wards/divisions fall within the ABD area of CSML of which division 1 is a tourist area but divisions 2, 3, 4 and 5 are essentially densely populated slum areas facing several socio-economic and environmental challenges. Future projects undertaken/implemented by CSML could concentrate on redevelopment of this area. Additionally, with respect to SWM, pan-city projects could be undertaken by CSML for enhancing the sustainability impact of the solid waste sector.
- Better demarcation of city ward boundaries and municipality boundaries are needed for improving management of waste being received by the Bhramapuram dumping yard. Strengthening of regulations related to waste dumping, weighing and characterization of incoming waste streams would certainly yield a positive impact on waste management at the dumpsite.
- Availability of datasets in the required format would help IC4 better contribute towards city monitoring and surveillance as well as in resolving public grievances and concerns.

6.2 Replicable Best Practices:

Heightened ground level awareness related to waste segregation, regular household waste collection and transportation, provision of segregated waste to the processing facilities as well as cleanliness at the GTS and processing sites are some of the major features of the Indore SWM model which has ensured Rank 1 for the city in the Swachhata Survekshan rankings for six continuous years. Thus, the Integrated SWM Indore Model, especially the initiatives undertaken by them to increase ground-level awareness (*detailed in 5.2.1.1*) towards waste can be adopted by other cities and city SPVs can play a major role in it.

Swachhta Monitoring through CCTV via the ICCC is another major and replicable initiative of the Surat Smart City which is directly benefitting the Integrated Waste Management Chain of the city. Drainage overflow, water leakages, encroachment, illegal hoardings, road digging, road sweeping are some of the major issues identified under the monitoring initiative. Upon identification of an issue, a complaint is raised with the concerned department and ground level employees for compliance and resolution with each complaint having a fixed time for resolution and the issue being escalated to higher activities if the complaint fails to be resolved within the stipulated time-frame.

Besides, the smart projects related to 'fuel sensors' and 'installation of bin level sensors and NFC tags at households' (*detailed in 5.2.4.1*) by Lucknow can also be replicated by other cities. Likewise, the SWaCH initiative *(detailed in 5.2.3.3)* undertaken by PMC to integrate informal workers within the solid waste supply chain is a major initiative having positive implications on worker protection and women empowerment which can be adopted by other cities as well.

6.3 Recommendations and Policy Directives:

While ICCC in most of the cities surveyed is effectively contributing towards smart monitoring of SWM related services it can also be used for information dissemination related to 'best practices for waste management' as well as designing of citizen engagement and awareness campaigns. Moreover, inclusion of SWM as a major focus area of 'Pan-City Initiatives' being implemented via smart city SPVs can yield major positive impacts on the overall sustainability and efficiency of solid waste. Besides, capacity-building and skill development for robust analysis of data being generated at the ICCC is another aspect that can potentially serve as 'future focus direction' for SPVs. Besides, enhanced cooperation and delegation of responsibilities between the city Municipal Corporations and Smart Cities SPVs especially for projects dealing with information dissemination, citizen sensitization and other infrastructural/developmental projects requiring pan-city implementation can greatly help improving sanitation and SWM status of cities.

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8. List of Annexures:

1. Indore SCM Data (word file containing data related to SWM requested from Indore city following field visit)
2. Overview of SWM in Surat
3. Smart Solid Waste Monitoring Surat
4. Additional Information Surat ICCC
5. Lucknow- Project Details - SAAR ICCC LSCL C (details of 'Design, Development, Implementation and Operation & Maintenance of ISWM System for LMC Area')
6. Lucknow- Project Details - SAAR ICCC LSCL B (details of 'Selection of Contractor for supply, installation, operation and maintenance of vehicle tracking system enabled with fuel sensor for Fleet managed by Lucknow Corporation')
7. Cochin-Projects Overview (word file containing small briefs of projects being implemented by Cochin Smart City (CSML))
8. New Project Details (word file containing information on CSML - New Project Details (Electrical, IT and Procurement) related to SWM and Sanitation sector)

Annexure 1

Request for Data against projects related to Solid Waste Management and Local Air Quality Improvement for Sustainability Impact Assessment under the SAAR-Sameeksha Series Initiative of the Smart Cities Mission

- Any observations regarding challenges/barriers faced in implementation of projects under SCM (in terms of finances, administrative rigidity, social acceptance/ reluctance related to specific project implementation etc.) List briefly.

As such no challenges/barriers faced in implementation of projects of Solid waste management under SCM

- Future projects in the pipeline related to Solid Waste Management

Below mentioned are way forwards: -

1. Approach toward Zero Landfill City
2. Promotion of Decentralized waste processing
3. Per capita waste reduction
4. Phasing out single use plastic
5. Creating more zero waste wards in the city

- Any available datasets/ information of Solid Waste Management within the municipality

Parameter		Value
Total solid waste generation/ collection		1150 to 1200 TPD
Approximate generation of wet and dry waste		Wet – 650 to 700 TPD Dry – 450 to 500 TPD
Sanitary, E-waste and Domestic Hazardous Waste		18 TPD
Waste collected by Informal sector		0 TPD
Door to door collection		100 %
At source segregation (approx. percentage)		100 %
Total dry waste processed		450 to 500 TPD
Total wet waste processed		650 to 700 TPD
Waste sent to landfill		0TPD
Total no. of Community bins		0
Total no. of transfer stations		10
Total no. of dumping yards		0
Total no. of sanitary/engineered landfills		2
Revenue obtained from User Charges		60 to 150 ₹/month from residential units 150 to 300 rupees/month from commercial units
Type and No. of Transportation vehicles	Trucks (tipper lorry, compactors, tractors)	800 approximately
	Hand-driven carts (pushcarts, tricycles)	108
	Motorized carts – 40	40
	e-vehicles	0
	Other	
Fate of processed waste (market: revenue generated from waste)	Compost –	0 (earns money through premium/royalty)
	Recyclables –	0 (earns money through premium/royalty)
	Refuse derived fuel-	0 (earns money through premium/royalty)
	Electricity/ power generation from waste	0 (No plant of such technology is functional at present)
	Other	

- Information related to Dry Waste Processing Facilities:

Type	Number	Operational Capacity	Quantity Processed
Waste to Energy/RDF	0	NA	NA
Material Recovery Facility	6	544	450 to 500 TPD
Cement co-processing plants	0	NA	NA
Recycling by Informal sector	0	NA	NA
Other	0	NA	NA

- Information related to Wet Waste Processing Facilities:

Type	Number	Operational Capacity	Quantity Processed
Bio CNG Biogas plants	3	585 TPD	491.2 TPD
Home Composting	56000 approximately	74 TPD	72 TPD
BWGs with in-situ processing facilities	286	51.5 TPD	27 TPD
Other	Decentralized Mobile Composting Van – 4 Decentralized Green waste processing units - 371	8 TPD 60.2 TPD	7 TPD 45.3 TPD

- Citizen engagement/participation/awareness campaigns

Below mentioned strategies being followed for sensitizing citizens: -

1. One to one interaction
2. Political acceptance and involvement
3. Ward level Competition
4. Engagement of Social media Influencers
5. FGD with stakeholders
6. Brand Ambassadors engagement
7. Theme based activities as per in-house calendar
8. Engagement of Volunteers from School and college
9. Awareness through social media, print media, and electronic media, etc.

- Any Collaborative (engagement with municipality/other private companies/ academic institutions) projects implemented or in the pipeline related to Solid Waste Management

  There are certain projects regarding the processing of wet waste, dry waste, and C & D waste implemented on PPP mode. In addition to that, road sweeping is outsourced, and the rest entire operations related to manual road sweeping, O&M of vehicle fleet, and collection & transportation are in-houses and conducted by Indore Municipal Corporation.

General Information about the Municipality:

Total Area: 276 Sq kms
Number of Households: approx. 6 lakhs
Number of Zones: 22
Number of Wards: 85
Total Population: approx. 30 lakhs

Annexure 2

Overview of SWM in Surat (Excel file)

Total solid waste generation/ collection		2443 TPD
Approximate generation of wet and dry waste (percentage/ quantity (tonnes per day)		2443 TPD
Waste collected by Informal sector		Yes
Door to door collection		Yes (100 %)
At source segregation (approx. percentage)		Yes (94 %)
Total dry waste processed		1091 TPD
Total wet waste processed		1352 TPD
Waste sent to landfill		100 TPD
Total no. of Community bins		-
Total no. of transfer stations		8
Total no. of dumping yards		-
Total no. of sanitary/engineered landfills		2
Revenue obtained from User Charges		4677967103.12 (FY 2023-24)
Type and No. of Transportation vehicles	Trucks (tipper lorry, compactors, tractors)	187
	Hand-driven carts (pushcarts, tricycles)	-
	Motorized carts	-
	e-vehicles	132
	Other	41
Fate of processed waste (market: revenue generated from waste)	Compost	Rs. 3.60 Cr. (12000 tonnes/year)
	Recyclables	-
	Refuse derived fuel	
	Electricity/ power generation from waste	-
	Other	-

Total Number of Processing Facilities (Wet and Dry waste)	in terms of location	Wet Waste Facilities: 2 Centralized, 81 Decentralized Dry Waste Facilities: 4 Centralized, 8 Decentralized
	processing capacity of plant	**Wet Waste Facilities:** **Centralized** 1. Waste to compost plant Khajod Disposal Site- 1500 TPD 2. APMC_Biogas Plant (APMC, Ring Road, Surat) - 50 TPD **Decentralized** 3. OWC-KOSAD (Kosad Transfer Station, Amroli-Sayan Road)- 1 TPD 4. Vermi-CZ (Chok Bajar, Nr. CNI Church) - 1 TPD 5. Vermi-NZ (Causeway Vermi Compost) - 0.8 TPD **Dry Waste Facilities:** **Centralized** 1. Waste to RDF plant (Khajod Disposal Site, Khajod) - 1000 TPD 2. Plastic Waste Facility (Beside Bhatar Sewage Treatment Plant, Gokulnagar, Bhatar) - 200 TPD 3. E-Waste Processing Facility (Surat Gabheni, Chourasia, Surat) - 1 TPD 4. Biomedical/Domestic Hazardous/Sanitary Treatment Facility (Nr. Gokulnagar, Opp.Hotmix Plant, Bhatar, Surat) - 6 TPD **Decentralized** 5. MRF-ANJANA (Anjana STP, Mithikhadi Road, Aanjana, Surat) - 30 TPD 6. MRF-BHATAR (Nr. Gokulnagar, Opp.Hotmix Plant, Bhatar, Surat) - 25 TPD 7. MRF-BHESTAN (Nr. Siddharthnagar, Canal, 80 Feet Road, Udhna, Surat) - 30 TPD 8. MRF-KATARGAM (B/s. Singanpore STP, Singanpore, Surat, Gujarat) - 35 TPD 9. MRF-KOSAD (B/s.Kosad Hotmix Plant, Nr. Sriram Crossroad, Amroli-Sayan Road) - 40 TPD 10. MRF-DINDOLI (B/s.Dindoli STP, Dindoli Crossroad, Dindoli) - 30 TPD 11. MRF-PAL (Beside Pal Transfer Station. L.P. Savani Road Surat) - 30 TPD 12. MRF-VARACHHA (B/s. SMC Mun.Workshop, Nr. Bombay Market, Surat) - 40 TPD
	end usage of product/ energy produced from waste processing	- Composting - Biogas (WtE) - Plastic Pellets - Recover Materials (Plastic, Glass, Paper, Cardboard, Metal, etc.) - Incineration - RDF

	basic process involved	Daily MSW collection from more than 16 lakh households, Live tracking of 1000 vehicles for transportation of classified waste through GPS/RFID and 28 mechanized sweeper machines for cleaning of main thoroughfares Bio-Methanation Plant (50 TPD) at APMC Market Bio/Wet Waste Processing in Decentralized Model.81 RWAs in the city self-manage wet waste in their campuses with Organic Waste Converter (OWC) machines. and 2500 TPD capacity centralized waste processing plant at Khajod. Mechanized material recovery facilities have been set up at all transfer stations and dry waste is sent for recycling... Surat Municipal Corporation operates separate waste management systems for processing and disposal of plastic waste (200 TPD), E-waste (1 TPD), C&D waste (300 TPD), bio-medical/domestic hazardous waste (6 TPD).
	some pictures of the plant	        

Annexure 3

Smart Solid Waste Monitoring Components in Surat

Questions	Answer
Smart Solid Waste Monitoring	
Type of data generated through GPS trackers, RFID readers	GPS installed on Vehicle is used to track the movement of the SWM vehicles. It helps to track the actual trip and geo-tagged locations visited by vehicle verses the assigned against it. The RFID tag on each vehicle is mapped with vehicle registration number and once the vehicle reaches the transfer station and stands on the weigh bridge for weight, the RFID reader identifies the vehicle and the integrated weigh bridge captures the weight without requiring any manual intervention.
Route mapping of vehicles which are helping in monitoring and management of solid waste	Each vehicle is assigned the trip/route and various locations which the vehicle is supposed to visit is geo-tagged with time.
Kindly also share screenshots of the same for incorporation in the report	Included in report
Data generated through Smart Solid Waste Monitoring(improvement in D2D coverage, improvement in real-time monitoring of SWM vehicles, data related to type and number penalties levied)	Included in report

Annexure 4

Additional Information Surat ICCC

Swachhta Monitoring through CCTV	
Type of issues identified and strategies used for their resolution	**Type of Civic Issues Identified using CCTV Feed:** - Damaged Footpath / Divider - Road digging by electricity / gas / utility services - Road Sweeping, Night Scraping & Brushing - Water Leakage / Drainage Overflow - Water Logging - Encroachment - Illegal Hoardings **Standard Operating Procedure** – The Command Centre operator identifies the issue though CCTV Camera – A photograph is captured for the issue and a proactive complaint is generated in Complaint Management - System with necessary details – Complaint Management System automatically assigns the complaint to concern officer – After complaint is resolved, the Command Centre operator once again verifies the event using CCTV camera.
Monitoring of Citizen Grievances- data on number and type of complaints received (ward-level data).	– SMC provides a very wide gamut of services that directly touches the citizens on a daily basis. – On a yearly basis over 1.70 complaints are reported by citizens. – These complaints are assigned to different departments and ground level employees for compliance. – Around 1000 employees/officers are assigned complaints pertaining to over 120 civic issues spanning across 9 zones and 138 wards. – Each complaint has fixed time for its resolution. – If complaint remains open beyond stipulated time, it is escalated to higher official. – Complainant is notified on compliance of the complaint, and if s/he is not satisfied with resolution, complaint can be reopened within 48 hours and such reopened complaints are assigned to higher officials. – ICCC is used to monitor the complaint pendency, adherence to SLA, complaint reopening and recurrence of complaints.

Annexure 5

Lucknow Smart City Sanitation And Solid Waste Management details

Project Name: Design, Development, Implementation and Operation & Maintenance of Integrated Solid Waste Management System for Lucknow Municipal Corporation Area

Vendor Name: Convexicon Software Solutions India Pvt Ltd

Date of Completion: Feb 2023

Project Cost: ₹ 03.00 Cr

Project Scope: Convexicon is tasked with monitoring of waste from source to disposal in area under jurisdiction of Lucknow Municipal Corporation. Our solution in Lucknow is a combination of NFC, GPRS and GPS enabled Solid Waste Management System within the existing landscape to achieve an array of objectives.

Deliverables:

Door to Door Collection (NFC Tags Reading)

Bin Level Sensors

Intelligent Fleet Management System

Attendance Management Solution

Grievance Redressal Module

Outcomes:

1. Ensure the cleanliness status and help the citizen to complaint if the garbage is not collected
2. Monitoring of level sensor enabled bins with geo tagged locations for timely clearance
3. Improve operational efficiency
4. Timely resolution of Public related grievance

Key Features:

DOOR TO DOOR COLLECTION:

49750 NFC tags are installed in 49750 household of Zone 1 ABD Area Lucknow Nagar Nigam to track the garbage collection. It ensures the time status. cleanliness status and helps the citizen to complaint if the garbage is not collected. Further it also helps the city authorities know the exact status of cleanliness along with ensuring the user charge collection status.

BIN LEVEL SENSORS

250 Bin Level Sensor are Installed in community bins of Lucknow Municipal Corporation Area When garbage crosses threshold limit Grievance Redressal Module of 75%, an alert is raised to authorities in LMC and further course of action can be taken in shortest possible time.

Achievements:

Lucknow has gone up from 26 in 2020 to 8 in 2022 in Smart Cities rankings released by MoHUA.
As a result of the services provided, the base of user collection charges has widened in Lucknow.

Annexure 6

Details of ICT component of vehicle tracking system project at Lucknow ICCC

Project Name: Selection of Contractor for supply, installation, operation and maintenance of vehicle tracking system enabled with fuel sensor for Fleet managed by Lucknow Corporation including 3 years operation period

Vendor Name: Blackbox GPS Technology (OPC) Pvt. Ltd.

Date of Completion: 27/12/2022

Project Cost: 64,17,984.0/0.

Project Scope: Supply, managed by Lucknow Municipal Corporation. Installation, operation and maintenance of vehicle tracking system enabled with Fuel Sensor for Fleet

Deliverables:

1) Completed installation of GPS tracking devices in all fleet vehicles.
2) Successfully installed and calibrated fuel sensors in each vehicle.
3) Wiring diagrams and documentation of installation procedures provided.
4) Testing and validation reports ensuring accurate functionality of tracking devices and fuel sensors.
5) Training materials for users on how to interact with the system.
6) Fully functional real-time tracking system accessible via web-based or mobile interface.
7) Fuel monitoring feature enabled, providing accurate fuel level readings for each vehicle.
8) Maintenance schedule outlining regular inspection and upkeep tasks for the system.
9) Procedures documented for sensor recalibration, software updates, and troubleshooting.
10) Data management protocols established for collecting, storing, and analyzing tracking and fuel consumption data.

Outcomes:

The outcome of implementing a black box GPS with fuel monitoring system in Lucknow's smart city initiatives would be multifaceted, contributing to various aspects of transportation management, efficiency, and sustainability. Here are some potential outcomes of the project

1. Improved Fleet Efficiency: - With real-time tracking and monitoring capabilities, the GPS system enables better fleet management, leading to improved efficiency in vehicle deployment, routing, and scheduling. This can result in reduced idle time, optimized routes, and enhanced overall productivity.

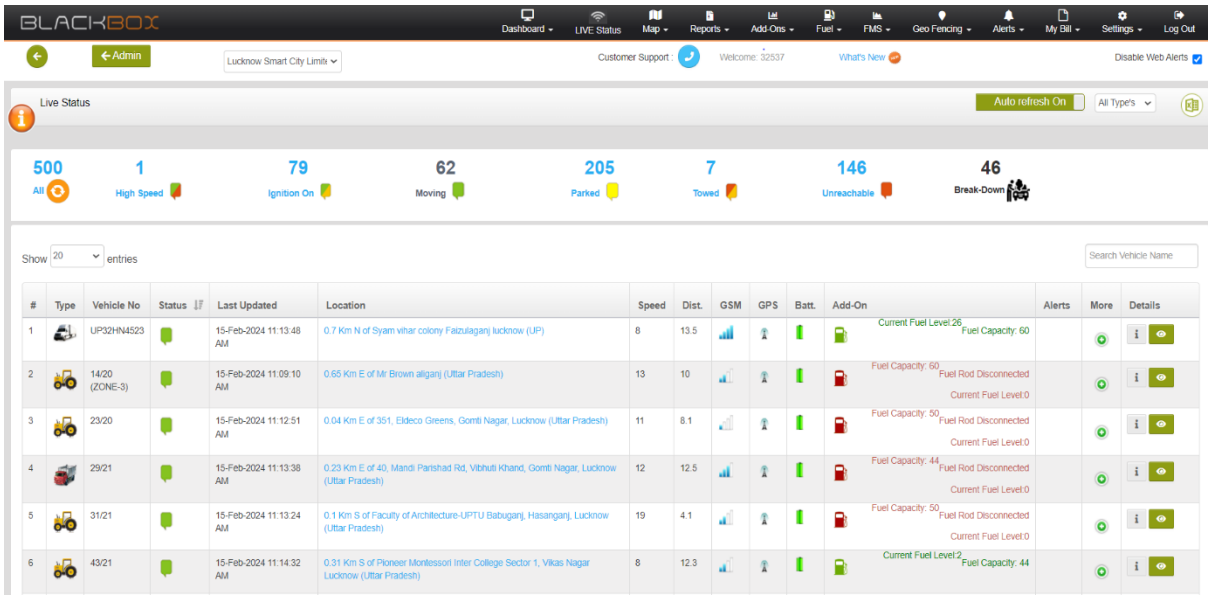
2. Fuel Savings and Cost Reduction: - The fuel monitoring feature allows for the tracking of fuel consumption patterns, identification of inefficient driving behaviors, and detection of fuel theft. By optimizing routes and promoting fuel-efficient driving practices, the system can help reduce fuel costs and achieve significant savings for the city's transportation operations.

3. Enhanced Safety and Compliance: - By monitoring vehicle speed, adherence to traffic rules, and driver behavior, the GPS system contributes to enhanced safety on the roads. It helps reduce the risk of accidents, promotes responsible driving practices, and ensures compliance with safety regulations, ultimately leading to safer transportation for citizens and reduced liability for the city.

Key Features:

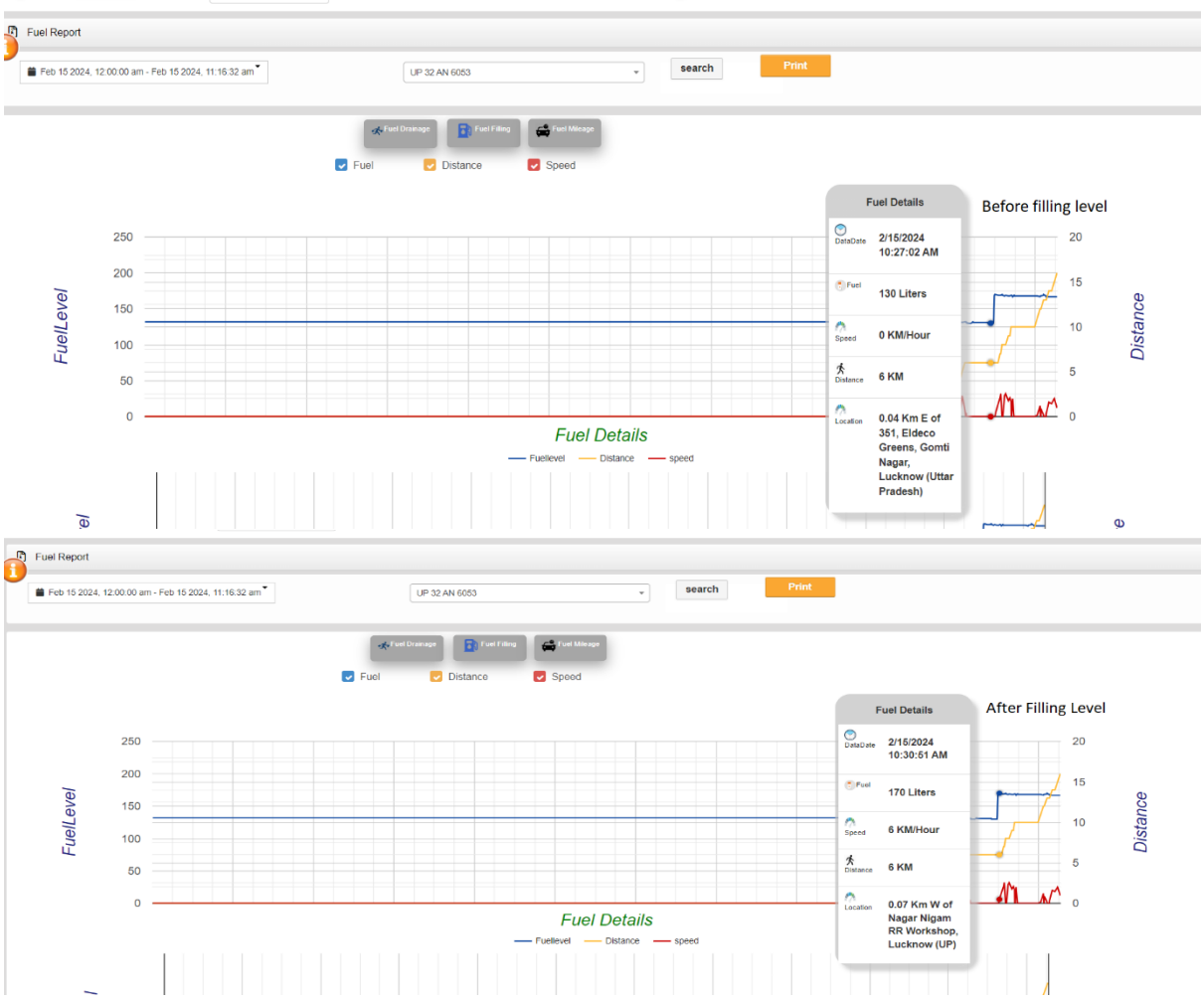
1 GPS tracking and real time vehicle monitoring

Real Time tracking

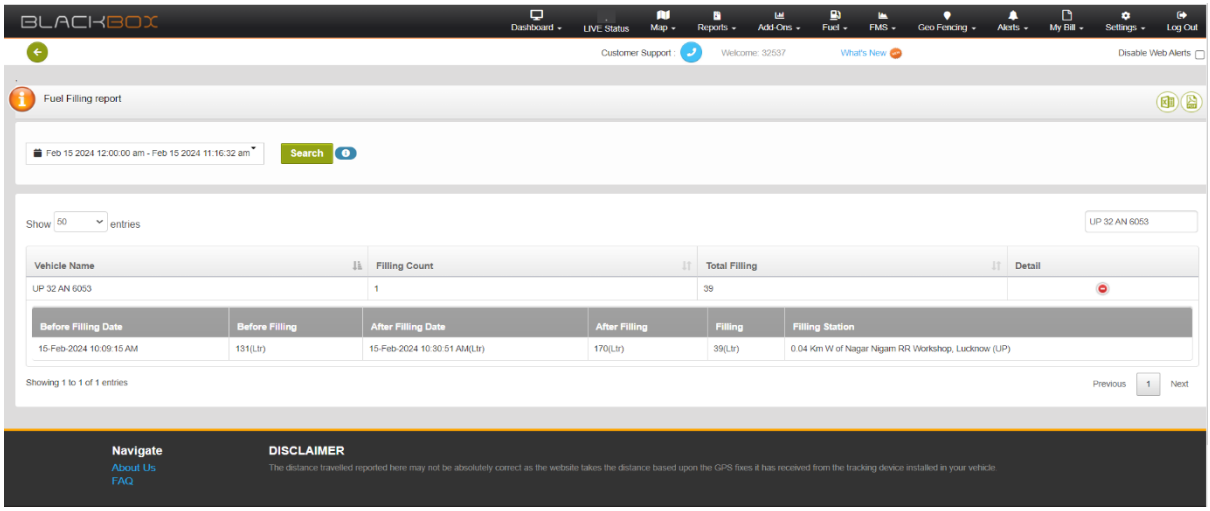


2 Fuel Monitoring like Filling and Theft Report

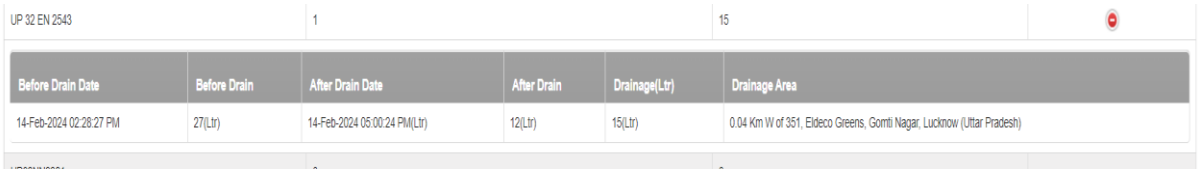
Graphical Report



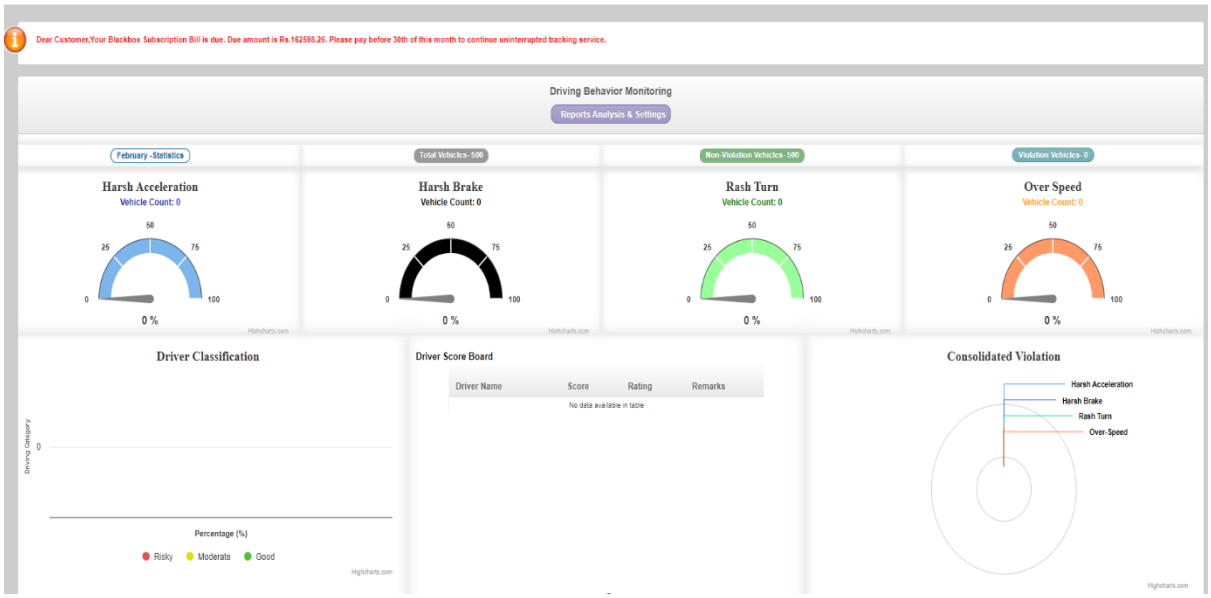
Fuel Filling Report



Fuel Drainage report

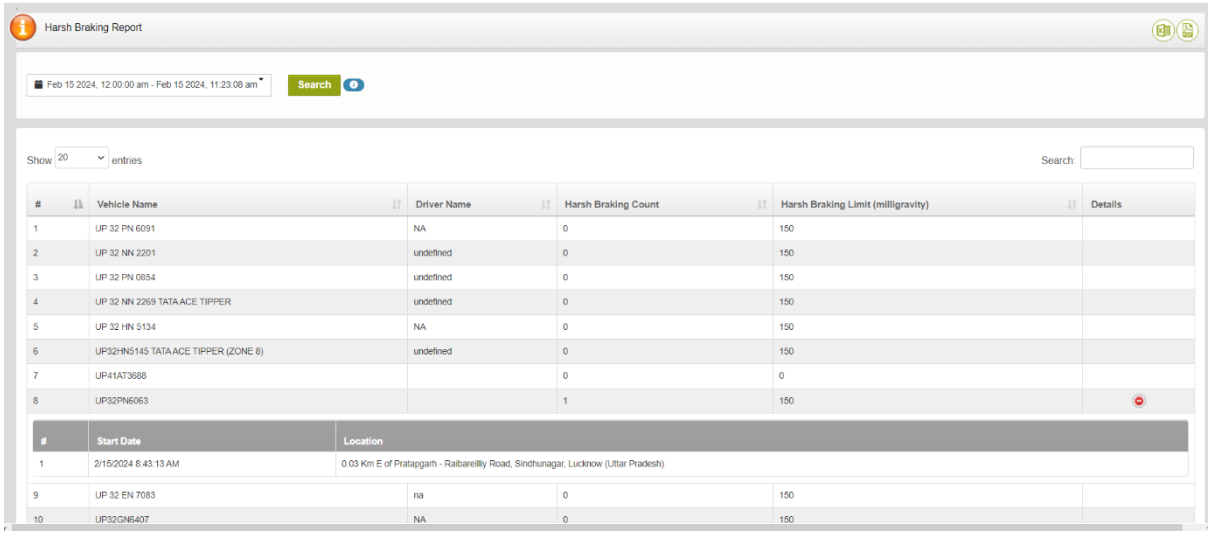


3 Driving behavior

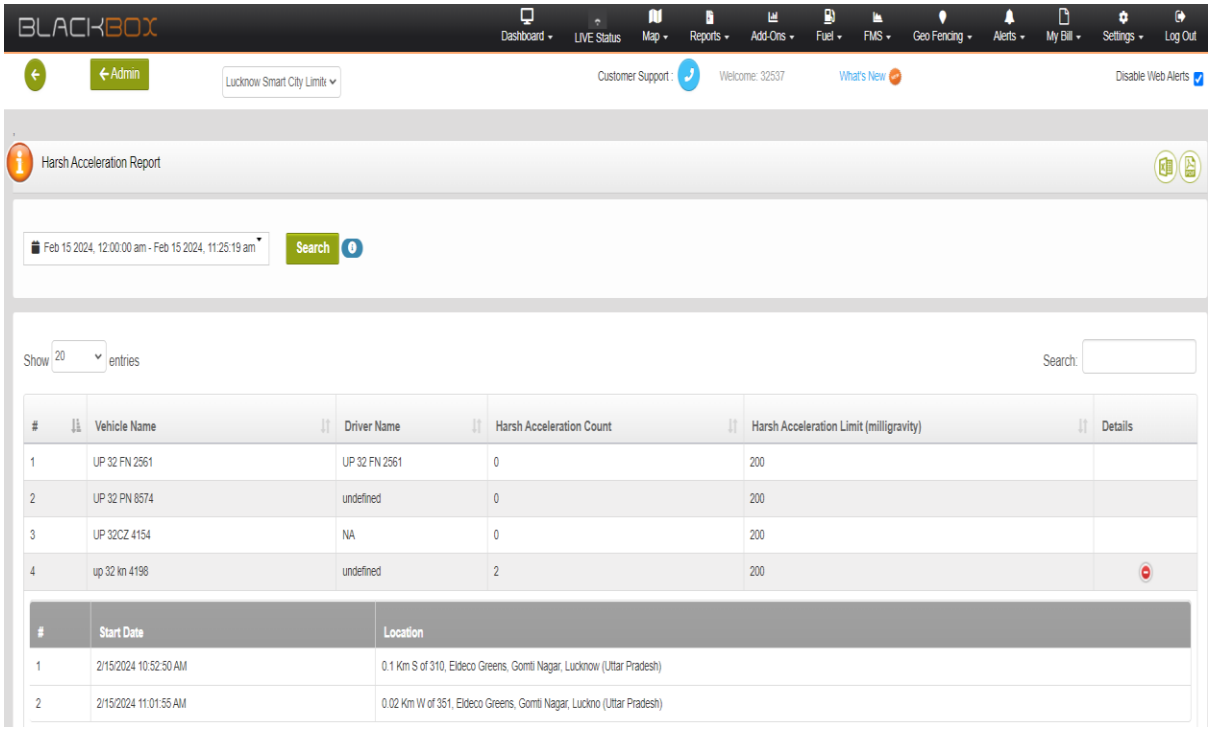


4 Driving pattern of the driver with details

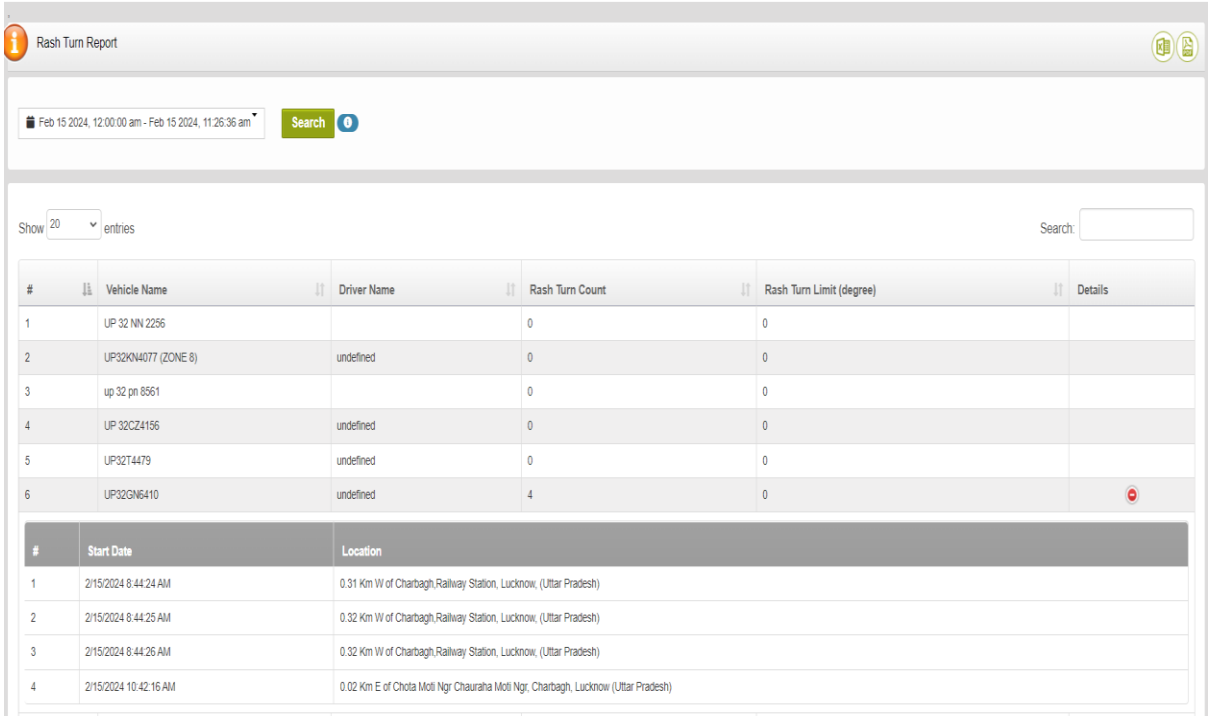
Harsh Braking Report



Harsh Acceleration Report



Rash Turn Report



Achievements:

1) **Improved Fleet Efficiency:** Implemented a comprehensive vehicle tracking system resulting in enhanced fleet efficiency through optimized routes and reduced fuel consumption.
2) **Enhanced Security:** Strengthened fleet security with real-time monitoring, geofencing, and alerts, leading to a decrease in unauthorized vehicle usage and potential theft.
3) **Cost Reduction**: Achieved cost savings through better fuel management, reduced maintenance expenses, and increased operational efficiency.
4) **Data-Driven Decision Making:** Empowered decision-makers with actionable insights derived from data analytics, enabling informed decisions for fleet management and resource allocation.
5) **Enhanced Customer Service:** Improved response times and service delivery to citizens of Lucknow through better fleet coordination and route optimization.

Annexure 7

Cochin Project Overview

Open space DH to Mangalavanam

Aiming at revitalizing all the open/ public spaces, along the western water edge of Ernakulum mainland, by improving the accessibility, introducing various activities and linking the same with each other to create an active corridor for recreational facilities, CSML proposes an integrated continuous open space corridor between Durbar Hall on south of the corridor up till Tata Canal, to the north of the corridor. The project is conceived to upgrade and integrate all the open spaces between Rajendra Maidan and Tata Canal into an open space corridor as public space. The proposed project shall ensure to provide a variety of attractions and recreational activities for all walks of people and thereby transform the area into one of the most visited areas of the city.

The 2.4 km long reconstructed walkway has 120 granite seats. 201 new LED lights enhanced the night views of the Marine Drive walkway. Playgrounds for children and a gym in the common area have been constructed as part of the project. CCTV cameras are being installed as part of the Intelligent City Surveillance System project to ensure the safety of people coming to the Marine Drive Walkway. Dustbins have been installed to prevent littering of public spaces. CSML has also planned to install more dustbins realizing the need in the area. Plants and flowers have been planted as part of beautification. The project cost is Rs.9.52cr

Roof top solar projects in 28 government buildings

Roof top solar plants are installed in 28 government buildings within the Kochi Corporation limits by Cochin Smart Mission Limited. These grids connected solar plants with total capacity of 1Mega Watt will be generating 1.46 million units of green energy in a year. Apart from savings in electricity bill of the Govt. establishments by about 10.2 million rupees per year, the solar plants will assist in reduction of carbon foot print by 1000 tones. This is equivalent to planting 5400 trees. 1Mega Watt (1000kW) roof top solar power project installed by Cochin Smart Mission Ltd is also an excellent example of how a city can generate renewable energy and contribute to the state's vision of achieving 2500Mega Watt solar capacity by 2030. The project cost is Rs.5.80 cr.

Development of Open Spaces, Playgrounds and Museum of Freedom Struggle in West Kochi

Major interventions of the Parks & Playground project include surface paving, landscaping and providing street furniture (such as benches, stone pergola, & post top light), fixing of play equipment, gym equipment, solar panel system, solar tree & repairing/constructing storm water drainage trenches etc. in 4 parks in West Kochi. The project also envisages conceptualisation, design and development of a Museum of Freedom Struggle in the old Fort Kochi Jail premises. The project cost is Rs.4.07cr. The project includes Pattalam ground, T M Muhammad Park, Karipplaam ground,

Distribution of household bins and street litter bins

The project is intended to maintain the efficiency of segregation originating from households & public places by one-time distribution of a pair of green bins for wet waste and blue bin for dry waste of 15 litres capacity each to every household. Approx. 40, 000 bins have been supplied and 37, 000 disturbed to the residents. The project cost is Rs.0.61cr

Public Bike Sharing

To promote non-motorized transport in Kochi City CSML and KMRL together had launched the Public Bicycle Share System in the year 2019 as a PPP model which included 1000 cycles as part of the project

In order to support public in commuting in current conditions the PBS project has been reinitiated jointly by KMRL and CSML to address the problem of first and last-mile connectivity faced by the citizens. In the year 2021 Cochin Smart Mission Limited and Kochi Metro Rail Limited re launched the PBS system in the Kochi. The citizens can now access 900 cycles from 46 docking stations including 21 metro stations around the city. The project cost is Rs.1.21 Cr.

Smart Bus shelter

The Cochin Smart Mission Limited (CSML), as part of its efforts to make the city's roads smart, is all set to build smart bus shelters to aid commuters in the city. As part of the first phase, two bus shelters have been constructed at Abraham Madamakkal (AM). The total cost of the shelters is Rs 0.19 Cr.
The new bus shelters are greener, cleaner, and smarter and the solar-powered bus shelter also have facilities such as an SOS alert switch, charging points, waste bins and CCTV surveillance for enhanced safety.

Implementation of Smart LED Lights
Cochin Smart Mission Limited (CSML) intends to replace existing conventional lights on streetlights and lighting Masts with intelligent LED streetlights with light poles having smart controls. Substantial energy saving can be achieved by replacing the conventional lighting with LED lighting. LED modules have very long life running as high as 50,000 hours, hence by installing LED based lights there is a good scope of reducing maintenance cost. The project cost is of Rs 23.93 Crore. Under this project, CSML has installed 3000 LED lights in the ABD area which helps to reduce the electricity usage and charges to the Kochi Municipal Corporation.

Development of parks and open spaces package: 2
Under this project CSML is developing Pared ground, Ro Ro Jetty, Subhash Park, and open space at Church road and river road. The major components are landscaping, sculptures, ornamental light, Play equipment and heritage architecture will be provided as per the site requirement. The project cost is Rs. 8.80 Cr.

Development of parks and open spaces package: 4
Under this project CSML is developing Rajendra Maidan, Marine Drive balance work, High Court Junction development, Vanchi Square are the open spaces. The major components are landscaping, sculptures, ornamental light, Play equipment and new toilet block will be provided as per the site requirement. The project cost is Rs. 4.90 cr.

Development of P J Antony Cultural Centre and Ground.
Under this project CSML is widening the entrance gate, providing rest room facilities, gym equipment drains, children's play area, new walkways, football and net ball ground. The project cost is Rs. 5. 90 cr.

Supply Operation & Maintenance of Truck mounted Sweeping machine
Cochin Smart Mission Limited has launched a pair of truck-mounted sweeping machines, with an amount of ₹10.98 crore Smart Cities Mission funds to clean roads. The machines that can clean up to 8 km in an hour and each of the 6,000-litre capacity machines can store 1,800 litres of water that can be sprinkled on roads to prevent the emanation of dust when the cleaning process is on. The machines come with a five-year operation and maintenance contract. They can be tracked using GPS and also have a pair of CCTVs. The machines would initially be deployed to cover 35 km of roads in the Kochi Municipal Area under the first phase of the project, mostly during night hours

Pan City Smart LED
In a move to brighten up city roads and reduce energy consumption, Cochin Smart Mission Ltd (CSML) is installing 40,400 LED streetlights by June 2024. The project, implemented at a cost of Rs 40 crore in the corporation limits, will help the local body lower its electricity bill to a large extent and provide well-lit streets. On a pilot basis, CSML has installed LED lights at five locations: Vyttila area, Cochin Shipyard Road, MG Road, Venduruthy bridge, and South over bridge. A total of 2,000 smart meters will be installed as part of the project, and the lights can be monitored at the Integrated Command, Control and Communication Centre (IC-4). They can be operated remotely. As a result of real-time monitoring, IC-4 can identify the malfunctioning lights and replaced within 48 hours. The new LED lights will come up on 2,263 local roads, 102 major roads, 223 minor roads, three state highways, and three national highways. A total of 773km of road will be illuminated under the project. These lights will reduce the monthly electricity bill to Rs 29 lakh, from the previous Rs 1 crore. Apart from that, the corporation can save Rs 2.5 crore in maintenance expenses over the first five years. Based on that calculation, the corporation will be able to save Rs 11.5 crore a year. This will help reduce the financial burden on the corporation. The agreement was signed in November 2023, and the project must be completed within seven months.

Annexure 8

Details of New SWM Projects at Cochin

CSML - New Project Details (Electrical, IT and Procurement)

Supply, Operation and Maintenance of Vehicle Mounted High-Capacity Suction cum Jetting Machine (4000 L) with Recycling Facility

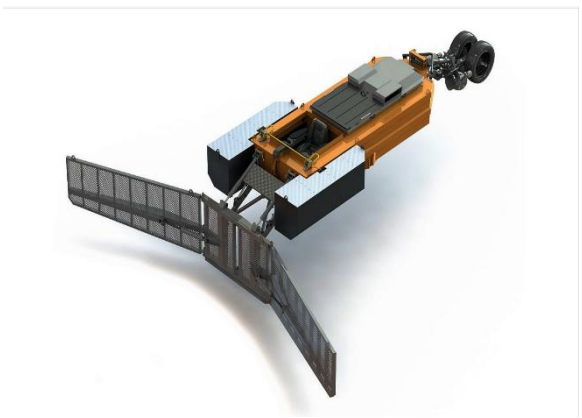
"Elevating Sanitation Standards with Cutting-Edge Technology"

Project Cost: 6.85 Cr

No. of Procurement: 1

Experience the future of sewer cleaning technology with our innovative initiative. Our high capacity suction cum jetting machines, featuring a recycling facility, are poised to revolutionize sanitation practices and promote environmental sustainability. With high-capacity suction cum jetting machines featuring a recycling facility, we are committed to boosting effectiveness, mitigating waterborne diseases, and promoting sustainability. Join us in creating a cleaner, healthier future for all. The machines will have operation and maintenance for a duration of 5 years.

SUPPLY, OPERATION AND COMPREHENSIVE MAINTENANCE OF SILT PUSHER MACHINE FOR A PERIOD OF 5 YEARS



"Enhancing Waterway Navigation"

Project Cost: 13.29 Cr
No. of Procurement: 1
Presenting the comprehensive solution for silt pusher machines by CSML! Our objective is to enhance waterway navigation, reduce flood risks, and improve dredging efficiency through the procurement of state-of-the-art silt pusher machines. With a focus on ensuring navigational channel maintenance, our mission is to create safer and more efficient waterways for all. The machines will have operation and maintenance for a duration of 5 years.

Supply, Operation and Maintenance of Refuse Compactor

"Streamlining Waste Management for Cleaner, Greener Communities"

Project Cost: 36.58 Cr
No. of Procurement: 15
Refuse Compactor machine; revolutionizing waste management! The objective of acquiring compactor machines is to optimize waste management processes by compacting solid waste materials into dense and manageable forms for efficient transportation and disposal. With increased storage capacity and reduced transportation costs, we are minimizing environmental impact and enhancing cleanliness in our communities. Join us in creating cleaner, greener environments for everyone to enjoy. The machines will have operation and maintenance for a duration of 5 years.

Sweeping machine

Project Name	Smart & Improved Mechanized Street Sweeping Machines
LOA Amount (INR Cr)	9.31
Executing Agency	Vaishnavi Infratech Pvt Ltd.
Project Status	Ongoing
Stakeholders	Kochi Municipal Corporation

Solid Waste Management (SWM) is an important infrastructure service that decides the quality of life in a city. An effective SWM system includes four main components - collection, transportation, treatment, and disposal of waste.

It is an integrated process comprising several collection methods, varied transportation equipment, storage, recovery mechanisms for recyclable material, reduction of waste volume and quantity by methods such as composting, WTE and disposal in a designated engineered sanitary landfill.

Kochi Smart City Project has identified improvement of solid waste as one of key components to be designed and implemented under area-based development concept. The Area identified for Area Based Development consists of Wards 1, 2, 3, 4, 5 of West Kochi and 62, 66, 67 of Ernakulam in Kochi.

Project Scope and Objectives

The main aim of the proposed project is to improve the present street and roads sweeping efficiency and improvement of service level delivery in West Kochi & Ernakulam in ABD area. The objectives of project are following:

- To Improve efficiency of street sweeping in main and inner roads of West Kochi & Ernakulam
- Introduce ergonomically better and mechanized sweeping machines for supporting increased work productivity of sanitation staff engaged in daily street sweeping.
- To facilitate separated collection and improved transportation of sweeping waste and silt
- from road side areas.
- To reduce the load of manual street sweeping in major roads of West Kochi & Ernakulam

Proposed System

Suction cum Jetting machine

Smart Green BUS Shelters

Ministry of Housing and Urban Affairs

Government of India