The Digital Mandate: How Smart Cities in India are Redefining Solid Waste Management

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1. The Urban Imperative for Sustainable Waste

With the advent of India's growing economy and thus an increase in per capita GDP, urbanization has accelerated in a manner that has completely Changed the face of Indian cities. A major direct impact of such accelerated growth, together with enhanced consumerism and linear commodity supply chain systems, is the emergence of increased waste generation in these cities. Traditionally, for many years, the foremost mode of managing waste in most Indian cities used to be mere dumping. However, mounting scientific evidence regarding the negative environmental consequences of these outdated strategies—such as the formation of leachate and resulting emissions—has necessitated a paradigm shift in urban governance.

In response, waste management in India has seen a complete overhaul from a purely civic function to a "value chain spanning collection, transport, processing including treatment, recycling, and upcycling, to final disposal. The launch of the Clean India Mission (Swachh Bharat) provided the initial impetus, but it is the Smart Cities Mission (SCM), a Central Sector Scheme under the Ministry of Housing and Urban Affairs (MoHUA), that has truly integrated sanitation and efficient Solid Waste Management (SWM) as a core element of holistic urban development.

This study, undertaken by Dr. Ambika's group in Indian Institute of Technology Hyderabad, attempted to gauge the direct and indirect effects of SCM in the SWM sector in India. Our hypothesis was that information technology and 'smart solutions' can prove to be an important means of dealing with intense challenges being faced by Indian cities. The research methodology adopted a two-fold approach. One, a nation-wide theme-based sustainability impact assessment through a thorough questionnaire. Two, a primary sustainability assessment through field research in five purposively chosen cities.

Case Study: The National Impact - Digitalizing the Waste Chain

The national assessment, with responses from all 100 Smart Cities, proved to prove that SCM funds are being used actively towards strengthening the SWM sector, sometimes in a complimenting role to Urban Local Bodies (Municipal Corporations). The statistics show a definitive trend towards a digitally tracked and efficient waste environment:

- **Fleet and Infrastructure Development**: A large portion of the budget for SCM went towards basic infrastructure. A total of thirty-six cities acquired new transport vehicles for waste collection, and another twenty-two cities built waste transfer stations and processing units.
- Intelligent Monitoring: Perhaps the most revolutionary step is the integration of SWM modules into the Integrated Command and Control Centre, which is a project initiated by twenty-six cities. Such integration is very essential for enhancing the level of monitoring concerning waste management and efficiency.
- **Handling Legacy Waste:** Twenty-one cities used SCM funding for dealing with legacy waste sites, which is a major step towards achieving 'Zero Waste City' status.
- **Policy and Vision:** To further prove their commitment over a period of time, cities including Indore, Surat, Gwalior, Chandigarh, Thanjavur, and Belagavi have developed vision documents and policies to become circular and carbon neutral in the SWM sector.

On a broad level, it can be seen from this national assessment that there is a momentum towards enhancing all aspects of SWM, but it is equally evident that a more integrated focus with a desire to improve data management and reporting is indicated.

Field Studies and Insights - A Deep Dive into Smart Cities Mission on SWM

To truly comprehend the practical efficacy and four-dimensional sustainability impact—technical, social, environmental, and economic—of SCM projects, Dr. Ambika's team undertook primary field assessments in five cities: Indore, Surat, Pune, Lucknow, and Cochin as illustrated in Figure 1. The selection was based on the alignment of their projects with the SWM theme, initial project information shared, and geographical representation of the Indian landscape.

3.1 Indore: The Zero-Waste Blueprint

Indore, consistently recognized for its SWM excellence, stood out as the undisputed leader. The city has implemented a best-in-class model where household segregation is enforced into a remarkable six waste streams as shown in Figure 2. This strict adherence to source segregation has enabled the considerable up-scaling of centralized processing facilities.

3.1.1 Key Achievements:

- **Zero to Landfill:** The city government has achieved a total reduction in the waste disposed of in landfill sites by making proper use of all kinds of waste.
- **100% Coverage:** Indore shows a 100% door-to-door waste collection and a 100% level of waste segregation at source.
- **Environmental Benefits:** As a direct consequence of not landfilling, not only have the lifespans of existing landfill sites in this city been extended, but more importantly, serious environmental harm from landfill emissions, groundwater pollution, and soil pollution from leachate have been prevented.

- **Aesthetics and Health**: The technical success has translated into social and environmental benefits; during the field visit, it was observed that there are no community dust bins and transport is done using totally covered vehicles, which prevents spillage and prevents foul odor, thus improving aesthetics and health within the community.

3.2 Surat and Pune: Monitoring Excellence Meets Segregation Challenges

Surat and Pune are examples of Smart Cities where digital technology is playing an intensely active role in ensuring efficiency. In both cities, their respective ICCCs are playing a vital role in ensuring efficient monitoring of waste collection routes and movement. They have developed both centralized and decentralized systems in handling both wet and dry waste.

Despite such technical complexity, both cities face serious challenges which can undermine the sustainability of the model adopted by them. The principal challenge is a lack of awareness among citizens in both cities with respect to waste segregation. In response, mixed waste is being generated in varying proportions, making it difficult for the performance levels of processing plants. Moreover, both cities are facing serious capacity issues due to an increasing boundary and a "floating population," especially in Pune.

3.3 Pune Specific Points and Challenges:

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) as given in Figure 3. The assessment in Pune emphasized an additional challenge of compounding, wherein a major share of construction work and vehicular traffic adds a substantial amount of construction and demolition waste and dust to the existing waste generation. Additionally, awareness programs may be conducted to emphasize in-situ models of composting, including home, community, and institutional systems, which would significantly alleviate the transport challenge associated with taking waste to processing sites and thereby work towards a reduction in fuel consumption and emissions.

3.4 Lucknow and Cochin: Leveraging Technology for Tomorrow

Lucknow and Cochin show how SCM can utilize technology to establish a basis for an enhanced SWM.

- **Lucknow:** The ICCC has spearheaded a number of projects to enhance logistics, including smart fleet management with live tracking and fuel sensors to reduce wastage. It has also ensured regular household waste collection through the installation of bin-level sensors and Near Field Communication (NFC) tags for collection point monitoring.
- **Cochin**: Cochin's efforts are currently focused on a suite of upcoming infrastructural projects under the Cochin Smart Mission Limited (CSML), including the procurement of waste compactors, mechanized street sweeping machines, and the installation of CCTV at dumpsites. However, the city's Integrated Command and Control Centre (IC4) has yet to realize its full potential due to a technical gap: limited availability of standardized datasets from concerned municipal departments required for full system integration. This underscores the broader point that digital infrastructure is only as effective as the data feeding it, requiring enhanced cooperation and skill development within administrative departments.

4. The Human Element and The Road Ahead

The Smart Cities Mission is contributing considerably to the improvement of SWM efficiency and monitoring across India. It is enabling cities to procure smart vehicles, develop crucial infrastructure, invest in digital monitoring systems, and remediate environmental hazards like legacy waste sites. Cities like Indore have demonstrated a replicable best practice model, proving that achieving a 'zero-landfill' status is possible through aggressive source segregation and processing capacity. However, a fundamental gap persists - the limited citizen awareness and sensitization towards waste segregation. This social and behavioral challenge remains the single largest barrier preventing smart cities from maximizing the efficiency of their new civil and digital infrastructure. Future SCM projects must strategically focus on overcoming this challenge through enhanced information dissemination, citizen sensitization, and community-level capacity-building programs, operating in tandem with the development of physical and digital assets. Furthermore, for SCM projects to achieve maximum success, there is a clear need for enhanced cooperation, collaboration, and clear delegation of responsibilities between the City Municipal Corporations (ULBs) and the Smart Cities Special Purpose Vehicles (SPVs).

Ultimately, the findings of this sustainability impact assessment offer a valuable resource for policymakers, city administrators, and technical engineers. By prioritizing the human element of source segregation and leveraging smart technologies for monitoring and processing, Indian Smart Cities can effectively mitigate the challenge of urban waste, paving the way for a truly sustainable and circular urban future.

To read the full report:

https://iith.ac.in/projects/sustainability_impact_assessment_study_on_solid_waste_management/

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Figure 2: Field visit photos from Indore depicting the smart SWM

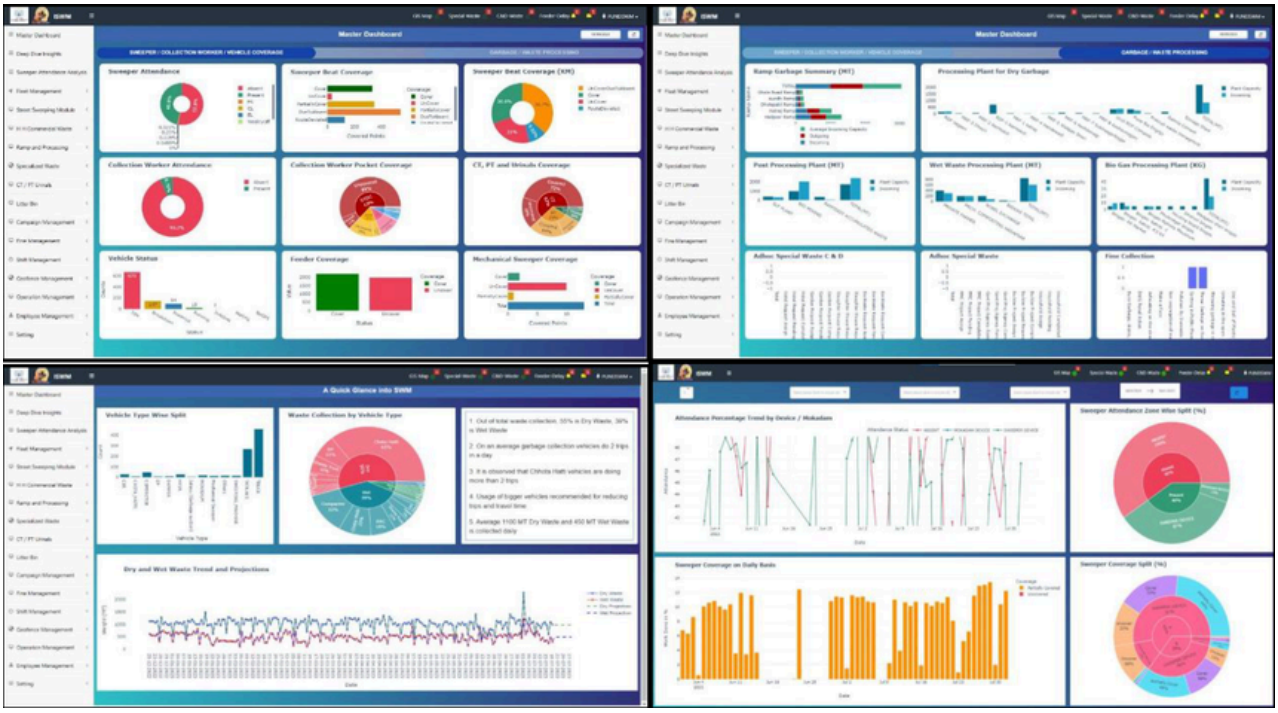

Figure 3: Pune Smart City-ICCC dashboards depicting various parameters related to Solid Waste Management

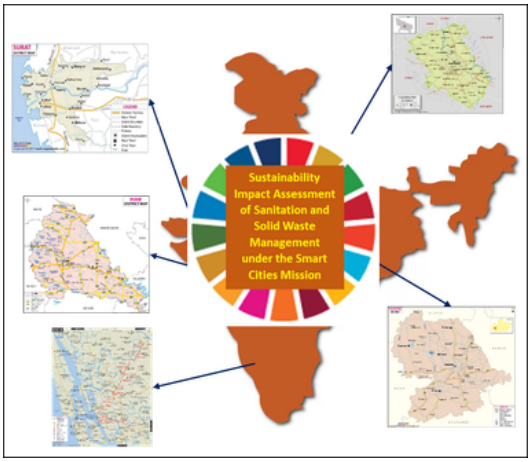

Figure 1: The five cities covered in this study's field visit

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