# Evolution of Waste Management Policies in India (2000–2024): A Narrative Review

Elakiya M[1], Jailapdeen S[2]
[1]*Research scholar,* [2]*Assistant Professor,*
[1,2]*Department of Social Work,*
[1,2]*PSG college of arts and science, Coimbatore, Tamil Nadu, India*
[1]*elakiyamanivannan@psgcas.ac.in,* [2]*drjailapdeen@psgcas.ac.in*
[1]*ORCID ID - 0009-0004-3078-2338,* [2]*ORCID ID - 0000-0002-8036-0537*
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**Abstract- This narrative review examines the evolution of waste management policies in India between 2000 and 2024, a period marked by rapid urbanization, rising consumption, and increasing waste complexity. Drawing on government policy documents, national reports, international assessments, and peer-reviewed literature, the review traces regulatory developments across municipal solid waste, plastic waste, biomedical waste, e-waste, construction and demolition waste, and hazardous waste. The analysis highlights a clear shift from fragmented, disposal-oriented approaches to integrated frameworks emphasizing segregation, Extended Producer Responsibility (EPR), circular economy principles, and digital monitoring systems. Despite sophisticated reforms particularly after 2016 implementation challenges persist due to limited municipal capacity, inadequate funding, weak enforcement, and insufficient inclusion of informal waste workers. The review identifies recurring gaps and synthesizes policy evolution into a conceptual understanding of governance, stakeholder responsibilities, and implementation outcomes.**

**Index-Terms: Waste Management Policy, Informal Waste Sector, Implementation Challenges, Governance.**

## I. INTRODUCTION

India has undergone rapid urbanization, significant population growth, and extensive industrial diversification over the past two decades, resulting in a substantial increase in municipal solid waste (MSW) and other waste forms, such as electronic waste, plastic waste, biomedical waste, and construction and demolition debris. Estimates of India's annual MSW generation vary widely,

with figures ranging from approximately 62 million tonnes during 2011–2014 to around 58 million tonnes per year in 2021 (about 160,000 tonnes per day). Projections anticipate that MSW generation could reach between 277 and 300 million tonnes by 2047 and escalate to as high as 436 million tonnes by 2050, driven primarily by ongoing urban population growth and increased per capita waste production (Pal & Bhatia, 2022; Shahab & Anjum, 2022). According to the World Bank (2018), India generated over 277 million tonnes of municipal solid waste annually, underscoring the pressing need for effective waste management policies. Poorly managed waste significantly contributes to environmental degradation, including air and water pollution, greenhouse gas emissions, soil contamination, and increased incidences of vector-borne diseases. These impacts disproportionately affect vulnerable urban populations, particularly the urban poor (Abubakar et al., 2022; Kitole et al., 2024; Ferronato & Torretta, 2019).

In response to these challenges, India's policy landscape has evolved to reflect changing governance priorities, advances in technology, and alignment with global sustainability frameworks. The foundational legal framework began with the Municipal Solid Waste (Management and Handling) Rules of 2000, which focused largely on waste collection, transportation, and disposal. While these early rules established a basis for urban waste governance, they lacked enforcement rigor and failed to incorporate effective strategies for recycling, source segregation, or community participation. Subsequent legislation, including the Plastic Waste Management Rules (2011), the E-Waste (Management and Handling) Rules (2011), and the revised Solid Waste Management Rules (2016), progressively incorporated extended producer responsibility (EPR), emphasized waste segregation at source, encouraged decentralized waste processing, and integrated circular economy principles. Despite these progressive policy reforms, implementation challenges remain formidable. Urban local bodies often grapple with limited financial and technical resources, and insufficient capacity-building initiatives constrain effective execution. Additionally, informal sector workers, who contribute significantly to recycling and material recovery, continue to be marginalized within formal governance structures. Compliance with EPR frameworks is uneven, hindered by systemic governance deficiencies and behavioural barriers.

This narrative review critically examines the evolution of waste management policies in India from 2000 to 2024, emphasizing regulatory milestones, policy shifts, implementation gaps, and emerging governance trends. It seeks to provide a comprehensive understanding of how waste governance is adapting amid rising waste volumes and increasingly complex waste streams, with implications for sustainable development.

## II. METHODOLOGY

This narrative review synthesizes India's waste management policy evolution from 2000 to 2024 using scholarly literature. Key materials included peer-reviewed articles from Scopus, and selected for relevance to municipal solid waste, plastic, e-waste, biomedical waste, construction debris, and hazardous materials.

Inclusion criteria encompassed English-language documents published 2000–2024 addressing policy frameworks, governance, or implementation; exclusions comprised local circulars, non-official commentary, and non-peer-reviewed opinions. Data extraction focused on thematic codes such as regulatory shifts, Extended Producer Responsibility (EPR), decentralization, stakeholder roles, and challenges, aligned with the review's emphasis on urbanization-driven waste growth. An iterative narrative synthesis identified policy milestones, patterns, and gaps ensuring evidence-based insights into transitions from dump-centric to integrated, circular economy models.

## III. RESULTS

Early Phase (2000–2010): Foundational Policies and Fragmented Governance

The period from 2000 to 2010 established the foundational architecture of India's waste management governance amid escalating municipal solid waste (MSW) generation, estimated at approximately 62 million tonnes annually, driven by early urbanization trends (Pal & Bhatia, 2022; Mani & Singh, 2016). This phase was characterized by fragmented, sector-specific regulations that prioritized basic collection, transportation, segregation, and landfilling, with minimal attention to waste reduction, recycling, or circular economy principles (Sharholy et al., 2008).

The cornerstone policy, the Municipal Solid Waste (Management and Handling) Rules, 2000, represented India's first comprehensive national framework, mandating urban local bodies (ULBs) to implement source segregation into biodegradable and non-biodegradable fractions, construct sanitary landfills, develop composting and vermicomposting facilities, and progressively eliminate open dumping practices. Despite these progressive stipulations, the Rules suffered from critical shortcomings: absence of stringent enforcement mechanisms, financial penalties for non-compliance, Extended Producer Responsibility (EPR) provisions, or incentives for resource recovery. Consequently, compliance remained nominal, with most ULBs continuing reliance on inadequate landfills and open dumps

Parallel sector-specific regulations operated in silos, lacking integration with municipal systems. The Biomedical Waste (Management and Handling) Rules, 1998 (amended 2003), introduced categorized treatment, segregation, and incineration protocols for healthcare waste to mitigate infection risks, while the Hazardous Waste (Management and Handling) Rules, 2008, regulated industrial effluents and hazardous substances through treatment, storage, and disposal facility requirements. Implementation faltered due to ULB chronic capacity deficits technical expertise, infrastructure, and funding shortages compounded by the absence of monitoring technologies or centralized data systems

Urban disparities were stark: metropolitan areas like Delhi, Mumbai, and Bengaluru struggled with collection inefficiencies and legacy waste accumulation, while smaller cities and towns faced existential resource constraints (Sharholy et al., 2008). Public engagement was negligible; source segregation mandates were largely ignored by households, and informal waste pickers who recovered 20-30% of recyclables operated outside formal governance, unrecognized and

unsupported. Technological interventions were virtually absent, perpetuating linear waste flows toward landfills.

| Year | Policy | Key Provisions | Limitations |
|---|---|---|---|
| 2000 | MSW (Management & Handling) Rules | Source segregation, sanitary landfills, composting mandates | Weak enforcement, no EPR, no recycling incentives |
| 1998/2003 | Biomedical Waste Rules | Categorized treatment, incineration protocols | Siloed from MSW systems, compliance monitoring gaps |
| 2008 | Hazardous Waste Rules | TSD facilities for industrial waste | ULB capacity deficits, no tracking tech (CPCB reports) |

This phase embedded accountability and sustainability but revealed nascent gaps in scalability and enforcement, setting the stage for further refinements. (UNEP, 2020; World Bank, 2018).

Key Reforms (2011–2016): Toward Segregation, Recycling, and Producer Responsibility

The 2011–2016 period signified a transformative transition in India's waste management policies, evolving from landfill-centric models to multi-stakeholder frameworks emphasizing segregation, recycling, and Extended Producer Responsibility (EPR), amid MSW generation reaching ~58 million tonnes annually by 2021 (Shahab & Anjum, 2022).

Key interventions included the Plastic Waste Management Rules, 2011 (amended 2015), which banned thin carry bags, set recycling targets, mandated labelling and producer collection responsibilities, and aligned with global plastic pollution concerns. The E-Waste (Management and Handling) Rules, 2011 (revised 2016) introduced India's inaugural EPR regime, obligating producers to establish collection centres, meet recycling quotas, and ensure authorized disposal, though enforcement lagged due to inconsistent reporting and monitoring deficits. The Solid Waste Management Rules, 2016 consolidated advances by mandating household source segregation (wet/dry/reject), decentralized composting/biogas, EPR for bulk generators, user fees, and legacy waste remediation, integrating circular economy norms (Mayanti, B., & Helo, P., 2023; Szamek, G. 2024)

Municipal awareness campaigns under state authorities and National Green Tribunal pilots promoted citizen duties, yet behavioural uptake faltered in smaller towns due to infrastructure gaps and low mobilization. Advances encompassed decentralized processing and informal sector linkages, but challenges persisted: uneven compliance, technological silos, and persistent landfilling.

| Aspect | Pre-2011 (MSW Rules 2000) | Post-2016 Reforms |
|---|---|---|
| Segregation | Recommended | Mandatory (wet/dry/reject); fines |
| Producer Role | Absent | EPR (plastics/e-waste/bulk) |
| Processing | Centralized landfills | Decentralized recovery/biogas |
| Citizen Engagement | Minimal | Awareness campaigns, penalties |

This phase embedded shared accountability but exposed scalability gaps, informing 2016's comprehensive overhaul.

Reform Phase (2016): Comprehensive Overhaul of Waste Rules

The year 2016 marked a watershed in India's waste governance, transitioning from fragmented policies to integrated, sustainability-driven regulations. The Ministry of Environment, Forest and Climate Change (MoEFCC) comprehensively revised the Solid Waste Management (SWM) Rules, Plastic Waste Management Rules, E-Waste (Management) Rules, Biomedical Waste Rules, and Construction & Demolition (C&D) Waste Rules, embedding accountability, technological monitoring, decentralization, and circular economy principles.

The SWM Rules, 2016 mandated source segregation (biodegradable/recyclable/hazardous) for households and institutions, promoted decentralized composting, bio methanation, and material recovery facilities (MRFs), integrated informal waste workers, introduced user fees, and encouraged waste tracking technologies. Parallel reforms expanded Extended Producer Responsibility (EPR): Plastic Waste Rules (amended 2018–2022) imposed phased single-use plastic reductions, centralized reporting, and recycling mandates; Biomedical Rules incorporated barcode tracking; C&D Rules required recycling facilities and debris reuse.

| Rule (2016) | Key Innovations |
|---|---|
| SWM | Segregation, MRFs, informal integration, user fees |
| Plastic | EPR expansion, single-use phase-out |
| Biomedical/C&D | Tracking/barcodes; 100% reuse mandates |

Consolidation Phase (2017–2024): Digital Integration and Circular Economy Advancement

The 2017–2024 period consolidated the 2016 reforms amid MSW projections of 277–436 million tonnes by 2050, emphasizing digital transformation, universal Extended Producer Responsibility (EPR), and circular economy operationalization (Pal & Bhatia, 2022; Ferronato & Torretta, 2019). Key Policy Advancements included targeted amendments: Construction & Demolition (C&D) Waste Rules (amended 2017/2022) mandated 100% reuse/recycling through dedicated processing

sites; Hazardous & Other Wastes Rules (2019 update) enforced pretreatment and transboundary controls; Plastic Waste Management Rules (2022/2024 amendments) universalized EPR across all producers with phased recycling targets (50–80% by 2027–28), microplastic prohibitions, and mandatory digital compliance portals; E-Waste Rules (2022) established centralized record-keeping for end-to-end tracking. Swachh Bharat Mission (Urban) 2.0 catalysed innovations GPS-enabled vehicles, mobile apps for citizen reporting, AI waste sorting, waste-to-energy plants, and formal cooperatives for informal recyclers directly supporting SDG 11 (sustainable cities) and 12 (responsible consumption) (Fang et al. 2023; Miranda et al. 2020; Kasinja, C., & Tilley, E. 2018) Citizen and Behavioural Progress saw sustained awareness campaigns yield segregation rates exceeding 50% in metro cities with active monitoring (e.g., Indore model), alongside circular economy embedding through bio methanation, compostable alternatives, and material recovery facilities (MRFs), reducing landfill dependency.

## IV. DISCUSSION

The evolution of India's waste management policies from 2000 to 2024 demonstrates a clear progression from fragmented, disposal-centric regulations toward integrated and sustainability-driven governance aligned with global frameworks such as SDG 11 and SDG 12. Early policies (2000–2010) relied heavily on landfilling and basic collection systems, revealing gaps in enforcement, institutional capacity, and producer accountability. Fragmented rules for plastic, biomedical, and hazardous waste, combined with limited technological infrastructure, constrained coordinated implementation (Sharholy et al., 2008). A transitional shift occurred between 2010 and 2016, marked by the introduction of recycling-oriented provisions, source segregation, and the initial adoption of Extended Producer Responsibility (EPR) through the 2011 Plastic Waste and E-Waste Rules. While these policies initiated shared responsibility and multi-stakeholder engagement, compliance was inconsistent, largely due to municipal capacity deficits and weak monitoring mechanisms. The 2016 reforms represent the most transformative phase, offering a comprehensive overhaul across all major waste streams. Mandatory segregation, decentralized waste processing, strengthened EPR frameworks, inclusion of informal recyclers, and the introduction of digital tracking mechanisms signalled a paradigm shift toward circular economy governance (Murthy, V., & Ramakrishna, S. 2022; Srivastav et al. 2023; Fiksel et al. 2021). Between 2017 and 2024, policy consolidation further expanded digital compliance portals, encouraged material recovery facilities, promoted bio methanation, and strengthened reuse mechanisms for construction and demolition waste. Despite significant regulatory advancement, persistent challenges hinder full realization of policy intent. Urban local bodies continue to face financial, human resource, and infrastructural constraints, limiting enforcement and service delivery. Integration of informal waste workers central to India's recycling ecosystem remains partial, affecting both equity and operational efficiency. EPR compliance gaps, limited data transparency, and uneven citizen participation in segregation further restrict systemic effectiveness.

Strengthening India's waste governance therefore requires a multipronged approach: enhancing municipal capacity, formalizing and supporting informal waste workers, expanding technology-enabled monitoring systems, and fostering sustained behavioural change among citizens. Future research should investigate effective models of informal sector integration and examine the socio-technical impacts of EPR and digital monitoring across diverse urban contexts.

Overall, India's waste management trajectory reflects substantial policy modernization aligned with global sustainability principles, yet underscores the continuing need for stronger governance, institutional coherence, and inclusive partnerships to fully achieve circular economy objectives.

## V. RECOMMENDATIONS

To bridge identified policy-implementation gaps, targeted interventions are essential across governance levels. Allocate dedicated funding streams for urban local bodies (ULBs) to establish material recovery facilities (MRFs), bio methanation units, and waste-to-energy infrastructure, prioritizing smaller municipalities. Implement mandatory training programs for ULB staff on digital tracking tools, EPR compliance, and decentralized processing. Formalize waste picker cooperatives through legal recognition, social security provisions, and priority access to recyclables, enhancing recycling efficiency (>50% national recovery potential). Develop public-private partnerships linking informal workers to EPR supply chains. Strengthen centralized portals with AI-driven audits and real-time verification to curb under-reporting, mandating 80% compliance by 2027. Scale Swachh Bharat Mission ICT innovations (GPS, apps) nationwide for transparent waste monitoring. Launch sustained behaviours change campaigns integrating schools, RWAs, and digital nudges to achieve >70% source segregation, modelled on Indore's success.

## VI. CONCLUSION

From 2000 to 2024, India's waste management policies underwent substantial transformation, evolving from foundational, disposal-centric rules to comprehensive frameworks emphasizing segregation, recycling, Extended Producer Responsibility, circular economy principles, and digital monitoring. The 2016 reforms represent a watershed moment, consolidating fragmented rules into integrated governance structures with clear responsibilities for municipalities, producers, and citizens. Subsequent amendments and consolidation efforts have strengthened EPR compliance, encouraged circular economy adoption, and enhanced monitoring through digital technologies. Despite these advancements, implementation gaps remain a critical concern. Municipal capacity limitations, insufficient infrastructure, uneven citizen participation, partial inclusion of informal waste workers, and inconsistent EPR compliance continue to impede the realization of policy objectives. Addressing these challenges will require coordinated action, including institutional strengthening, technological adoption, behavioural change initiatives, and inclusive engagement of the informal sector. Overall, India's experience demonstrates that regulatory sophistication must be complemented by robust governance capacity and multi-stakeholder collaboration to achieve

sustainable, SDG-aligned waste management outcomes. The lessons from this 24-year period provide valuable insights for other low- and middle-income countries grappling with urban waste challenges, highlighting the critical interplay between policy evolution, implementation capacity, and stakeholder engagement in achieving environmental sustainability.

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