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ADDRESSING PLASTIC POLLUTION IN INDIAN CITIES: LEGAL AND GOVERNANCE PERSPECTIVES

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Abstract: *Plastic pollution has emerged as one of the most persistent urban environmental governance challenges in India. Indian cities generate complex streams of plastic packaging waste, much of which is lightweight, difficult to segregate, and economically unattractive to formal recycling systems. In response, India has developed a layered regulatory framework under the Environment (Protection) Act, 1986 through the Plastic Waste Management Rules, 2016 and subsequent amendments, including the 2022 changes that (i) refine definitions such as "biodegradable plastics," "end-of-life disposal," "plastic waste processors," and "reuse," (ii) strengthen the compliance architecture through registration requirements across State Pollution Control Boards (SPCBs) and the Central Pollution Control Board (CPCB), and (iii) introduce "Environmental Compensation" explicitly anchored in the polluter-pays principle.*

A pivotal governance shift is the 2022 insertion of Schedule-II "Guidelines on Extended Producer Responsibility (EPR) for Plastic Packaging," which operationalizes producer, importer, and brand-owner obligations through measurable targets, a centralized portal, certificate-based compliance mechanisms, and mandatory recycled content requirements. The EPR regime introduces phased targets (25% → 70% → 100%) and later-year minimum recycling thresholds by packaging category, alongside recycled-content mandates that increase over time for rigid and selected flexible/MLP categories.

Despite this normative sophistication, evidence in the literature reviewed indicates that urban implementation remains uneven due to fragmentation between municipal bodies, SPCBs/PCCs, and producer-side compliance systems, compounded by limited enforcement capacity, data deficits, and socio-economic realities, especially the central role yet limited recognition of informal waste pickers and aggregators in city recycling economies. Studies on Indian cities highlight chronic gaps in household segregation, collection logistics, and the mismatch between policy intent and everyday urban waste practices.

This paper argues that sustainable reductions in urban plastic pollution require governance integration: harmonizing statutory compliance across levels, aligning fiscal incentives to EPR targets, formalizing partnerships that include informal recyclers, and embedding circular-economy design (reuse, recycled content, and high-quality recycling) into procurement and urban service delivery. Using doctrinal legal analysis combined with structured synthesis of the published empirical and conceptual literature, the paper evaluates India's legal architecture, identifies implementation bottlenecks, and proposes actionable reforms for city-focused plastic governance.

Key words: *Urban Plastic Pollution, Extended Producer Responsibility (EPR), Circular Economy, End of life disposal, Plastic waste processors.*

INTRODUCTION

Indian cities are at the frontline of plastic pollution. Dense consumption patterns, growth in packaged goods, and the spread of multilayered and flexible packaging have increased the volume and complexity of plastics entering municipal solid waste streams. Urban systems struggle not only with collection and disposal, but also with upstream prevention, source segregation, and the creation of reliable, high-integrity recycling and recovery pathways. The governance problem is multidimensional: it is legal (rules and obligations), administrative (institutions and inter-agency coordination), economic (costs and incentives across the value chain), and social (behavioral compliance and livelihood dependence on informal recycling).

India's legal response has progressively shifted from a primarily municipal-waste lens to a shared-responsibility model that places enforceable obligations on producers, importers, and brand owners. The Plastic Waste Management Rules 2016 recognized that plastic waste is part of solid waste, and therefore both plastic and solid waste management rules apply to plastics governance; it also articulated duties for local bodies and other stakeholders. The 2022 amendments deepen this approach: they link EPR compliance directly to Schedule-II guidelines, clarify critical terms such as "end-of-life disposal" and "reuse," expand and define the category of "plastic waste processors," and incorporate an explicit Environmental Compensation mechanism for non-compliance based on the polluter-pays principle.

The insertion of Schedule-II EPR Guidelines in 2022 is especially significant because it moves India's plastic governance toward measurable performance regulation. EPR targets are structured in phases and are "category-wise," requiring obligated entities to register on a CPCB-developed centralized portal, submit action plans, and demonstrate compliance through verified certificates issued by registered processors (with special rules for road construction). The regime also introduces minimum recycling levels over time (by packaging category) and mandates minimum recycled plastic content requirements, thereby connecting downstream waste outcomes with upstream material choices.

Yet, the literature reviewed consistently indicates that rule design alone does not guarantee urban outcomes. City implementation is shaped by fragmented governance between municipalities and pollution control institutions, uneven enforcement, and socio-economic barriers—particularly the partial integration of informal recyclers and the scarcity of affordable substitutes for certain plastic applications. This paper therefore evaluates India's legal framework through an "urban governance" lens and proposes reforms aimed at closing the persistent gap between robust legal architecture and ground-level reductions in plastic pollution.

HYPOTHESIS

Plastic pollution in Indian cities persists despite robust legal frameworks because of fragmented governance structures, weak enforcement, and socio-economic barriers—such as exclusion of informal recyclers and lack of affordable alternatives which undermine effective waste management. Therefore, only an integrated approach that strengthens statutory compliance, harmonizes governance across levels, and addresses socio-economic realities through fiscal incentives and circular economy innovations can achieve sustainable reductions in urban plastic waste.

OBJECTIVES OF THE STUDY

1. Analyze India's Legal Framework for Plastic Waste Management (with emphasis on PWM Rules and EPR guidelines).
2. Assess Current Strategies and Challenges in urban implementation, including governance and socio-economic constraints described in the reference literature.
3. Recommend Policy and Governance Improvements to enable measurable reductions in urban plastic waste.

SCOPE AND LIMITATIONS

Scope:

This paper focuses on urban plastic pollution in India, emphasizing:

- The 2022 amendments to the Plastic Waste Management Rules (definitions, registration architecture, and Environmental Compensation).
- The EPR Guidelines (Schedule-II) inserted in 2022 including targets, recycling thresholds, recycled-content mandates, registration and portal systems, certificate mechanisms, and environmental compensation logic.

- City governance challenges reflected in the literature reviewed, including informal sector dynamics, municipal capacity constraints, and implementation gaps.

Limitations

- The analysis is primarily doctrinal and secondary-data based; it does not include new primary fieldwork or city-level audits.
- "Indian cities" are diverse; findings therefore generalize governance patterns rather than ranking specific cities. Literature-based city illustrations are used only where available in the referred sources.
- Quantitative visuals in the Analysis section rely on regulatory target data (EPR schedules) rather than measured municipal tonnage datasets.

METHODOLOGY

This study uses a mixed doctrinal–analytical legal research methodology comprising:

1. Doctrinal legal analysis: Close reading of the Plastic Waste Management (Second Amendment) Rules, 2022 and the EPR Guidelines inserted via the 2022 amendment notification, to identify: (i) definitions and regulated entities, (ii) compliance pathways (registration, portal, returns), (iii) performance obligations (targets, recycling thresholds, recycled-content mandates), and (iv) enforcement tools (Environmental Compensation/polluter-pays).

2. Institutional/governance mapping: Using the literature and publications on urban waste governance and plastic management in Indian cities to map how responsibilities distribute across CPCB, SPCBs/PCCs, Urban Local Bodies (ULBs), producers/brand owners, and waste processors, and to identify fragmentation points.

3. Comparative synthesis of scholarly literature: The literature review synthesizes studies addressing municipal waste management, plastic governance, public participation, and informal sector roles, and then links these findings to legal design choices in the 2022 framework.

4. Regulatory data visualization: The analysis constructs tables and graphs using the EPR schedule values (targets and thresholds) to assess the feasibility and governance implications of compliance trajectories in cities.

LITERATURE REVIEW

The reviewed literature presents a consistent theme: plastic pollution in India is not merely a technical waste problem but an institutional and socio-economic governance challenge. Across studies that examine Indian waste systems, a recurring diagnosis is that policy ambition often outpaces local capacity—especially at the municipal level—where collection, segregation, and processing infrastructure remains uneven, and where enforcement is constrained by limited staff, weak monitoring, and unstable financing. The paper on "solid waste management in India: a brief review" emphasizes that municipal solid waste systems face systemic stressors, including rapid urbanization and inadequate infrastructure, which directly affects plastic management because plastic waste is embedded in the broader MSW stream.

A second key theme is that effective plastic governance depends on segregation at source and public participation, yet many Indian cities experience persistent segregation deficits. The reviewed work on solid waste in Kolkata underlines how municipal arrangements struggle to translate policy expectations into routine household compliance; it highlights the practical limitations of urban service delivery systems where mixed waste collection is still common, thereby reducing the quality and market value of recyclables and increasing landfill leakage. Similarly, the reviewed study on "plastic waste management in India: challenges and opportunities" frames the problem as a chain of failures—from product design to disposal—arguing that without systemic interventions, plastic continues to accumulate in drains, landfills, and informal dumping sites, amplifying environmental and public health risks in dense urban settings.

Third, the literature recognizes the central role of the informal sector in Indian recycling ecosystems. Waste pickers, itinerant buyers, aggregators, and small recyclers often provide the backbone of collection and preliminary sorting, particularly for high-value plastics. Yet these actors frequently lack formal recognition, social protection, and integration into municipal contracts. This exclusion can weaken policy outcomes: if formal systems fail to collaborate with informal recyclers, cities may lose efficient collection networks that already function at scale, while also creating livelihood insecurity and compliance gaps. The published works that discuss governance and sustainable approaches stress that informal-sector inclusion is not simply a social policy choice but a functional necessity for urban recycling performance.

Fourth, several sources discuss the limitations of end-of-pipe approaches and advocate circular economic strategies. The circular-economy-oriented literature emphasizes redesign, reduction, reuse, and recycled-content integration as core pathways. It argues that focusing only on downstream cleanup or disposal cannot keep pace with rising plastic consumption; instead, regulatory frameworks must shift incentives upstream so that producers internalize waste management costs and redesign packaging to be recyclable or reusable. This aligns with the conceptual thrust behind EPR, which extends responsibility beyond municipal boundaries and assigns obligations to producers, importers, and brand owners across the product lifecycle.

Fifth, the literature suggests that regulatory success is strongly shaped by governance coherence—the extent to which mandates, monitoring, and accountability are aligned across levels. One of the works on plastic pollution management as an environmental governance challenge describes the problem as one of fragmented institutions and overlapping responsibilities. It underscores that when multiple bodies share partial mandates, enforcement can fall through gaps, and regulated actors can exploit jurisdictional ambiguity. This observation is highly relevant to India's plastic governance architecture, where responsibilities are distributed among CPCB, SPCBs/PCCs, local bodies, and obligated producers/brand owners.

Sixth, the literature points to behavioral and market barriers: consumers may lack affordable non-plastic alternatives; small retailers rely on low-cost packaging; and recycling markets are vulnerable to price swings that affect collection incentives. The paper on "consumer perspective on plastic waste generation" highlights that awareness does not always translate into behavior change, and that consumer preferences, convenience, and availability of alternatives shape plastic use patterns. Such findings are critical because urban plastic pollution control depends partly on citizen behavior (segregation, littering avoidance) and partly on systemic market shifts induced by regulation.

Seventh, some city-oriented papers stress that drainage blockage, flooding, and localized pollution hotspots are common consequences of unmanaged plastic waste. This urban ecology framing is important for governance because it supports a risk-based enforcement approach: cities can prioritize high-leakage zones, commercial districts, transport nodes, and water-adjacent areas where plastic litter externalities are disproportionately high. Such operationally targeted governance can complement broad legal obligations by focusing on municipal action where it yields the greatest environmental return.

Finally, the literature indicates that reforms must be judged not only by legal completeness but by implementability: clarity of obligations, measurability, monitoring capacity, financing mechanisms, and fairness. EPR regimes can fail if targets are unrealistic, if data systems are weak, or if certificate markets become vulnerable to fraud. At the same time, well-designed EPR can unlock investment in material recovery facilities, expand recycling capacity, and drive packaging redesign, provided governance integration and enforcement credibility exist. The EPR Guidelines inserted into India's plastic rules emphasize measurable targets, registration, audit, and certificate-based compliance, demonstrating a move toward performance regulation. Yet the literature warns that without addressing municipal and informal-sector realities, even sophisticated producer-focused regulation may not translate into cleaner cities.

Synthesis and gap addressed by this paper –

Taken together, the studies show that urban plastic pollution is a governance problem where legal rules must work through municipal capacities, market structures, and social systems. What remains under-discussed in

many city studies is how recent 2022 legal instruments (EPR schedules, recycled-content mandates, environmental compensation) can be operationalized in urban governance terms. This paper fills that gap by reading the 2022 amendments as governance design—mapping how compliance tools can (or cannot) address the urban bottlenecks identified in the literature, and proposing reforms that integrate statutory compliance with socio-economic and circular economy strategies.

ANALYSIS

1) The 2022 Legal Architecture: What Changed and Why It Matters for Cities

The Plastic Waste Management (Second Amendment) Rules 2022 refine the definitional and compliance scaffolding that city institutions must implement. The insertion/clarification of key definitions—such as "biodegradable plastics" (complete degradation without microplastics/toxic residues, aligned to BIS standards and CPCB certification), "end-of-life disposal" (waste-to-energy, co-processing, waste-to-oil, and road construction subject to guidelines), and "plastic waste processors" (recyclers plus entities engaged in waste-to-energy/waste-to-oil/co-processing)—matters because ambiguous terms often weaken enforcement and allow regulated actors to classify activities strategically to avoid stricter obligations.

In governance terms, definitional clarity directly affects municipal contracting, SPCB/PCC authorizations, and compliance verification. For example, when "end-of-life disposal" is defined to include co-processing and waste-to-oil (with carve-outs where feedstock chemicals are used back in plastic production), regulators can more clearly distinguish recycling from disposal pathways and reduce greenwashing risk.

Crucially, the 2022 amendments also strengthen the enforcement toolkit by introducing an explicit Environmental Compensation provision (Rule 18 inserted after Rule 17), to be levied on entities not complying with the rules, anchored in the polluter-pays principle, and guided by CPCB-issued guidelines. This is a governance signal that plastic compliance is not merely procedural (registrations/returns) but also sanction backed.

2) EPR as Performance Regulation: Targets, Timelines, and Compliance Instruments

The 2022 EPR Guidelines (Schedule-II) inserted into the rules fundamentally reframe plastic governance by operationalizing responsibility at the production/import/brand-owner level and linking it to quantifiable performance targets and verified reporting. The guidelines apply to obligated entities including Producers, Importers, Brand Owners (with specified coverage), and Plastic Waste Processors. They require registration on a CPCB-developed centralized portal, prohibit business without registration, and prohibit dealing with unregistered

entities—an attempt to "clean" the compliance ecosystem by controlling entry points into the plastic packaging value chain.

2.1 EPR Target Trajectory (Collection/Management Performance)

The EPR target is set as a percentage of an "eligible quantity" (Q1/Q2/Q3) computed from averages of packaging introduced/sold and pre-consumer waste, with adjustments. The target trajectory is phased as: 25% (2021–22), 70% (2022–23), and 100% (2023–24).

Governance interpretation: such a sharp ramp-up is ambitious and implies that by 2023–24 obligated entities must have accounted for the entire eligible plastic packaging quantity through collection and compliant processing pathways. This makes the integrity of data systems, certificate verification, and processor capacity central to success. It also creates pressure on cities because a large share of post-consumer packaging is physically recovered through municipal collection systems (formal or informal), so producer-side compliance is inevitably coupled to city-side collection realities.

2.2 Minimum Recycling Levels by Packaging Category (2024–25 onward)

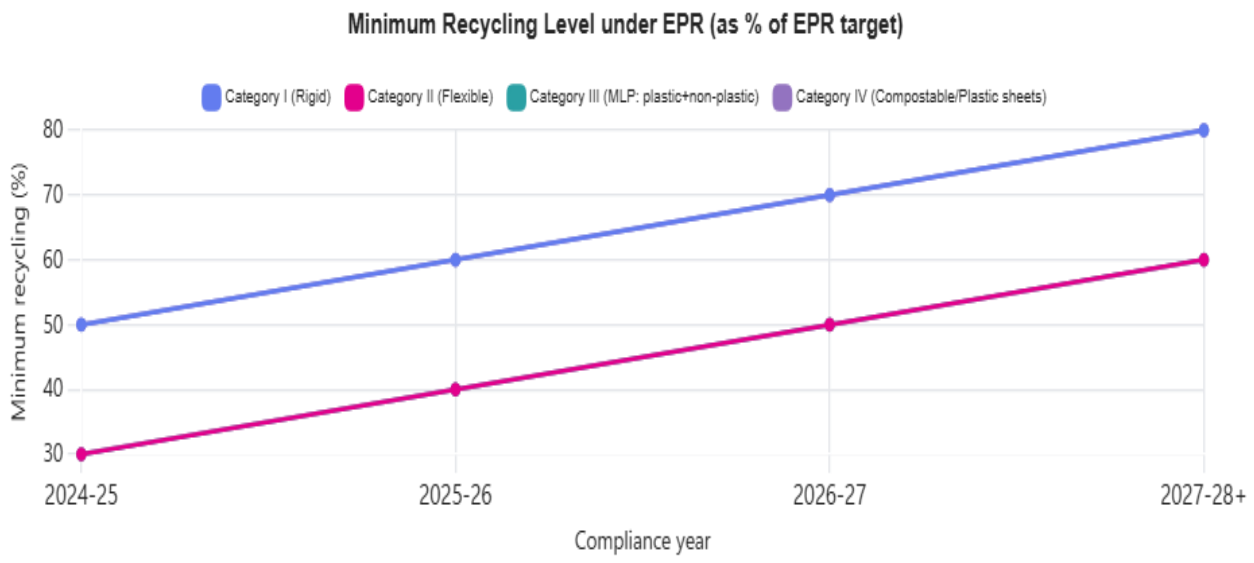
The EPR framework distinguishes "recycling" from "end-of-life disposal," specifying minimum recycling thresholds by packaging category over time. This is particularly relevant for cities, where a common failure mode is to treat mixed plastics as fuel or road-fill substitutes without building higher-order recycling loops.

Table 1. Minimum level of recycling under EPR (excluding end-of-life disposal)

Plastic Packaging Category	2024–25	2025–26	2026–27	2027–28 & onwards
Category I (Rigid)	50%	60%	70%	80%
Category II (Flexible)	30%	40%	50%	60%
Category III (MLP: plastic + non-plastic)	30%	40%	50%	60%
Category IV (Compostable plastics / plastic sheets used for packaging)	50%	60%	70%	80%

This table demonstrates a regulatory preference for progressively higher recycling shares rather than disposal. In city terms, it implies that municipal and private systems must expand segregation quality, MRF capacity, and registered recycling throughput in order to generate verifiable recycling certificates at scale.

Graph 1. Minimum recycling levels by category under EPR



The graph visualizes that rigid and Category IV packaging face the highest recycling expectations over time, rising to 80% by 2027–28+. This is governance-significant because rigid packaging is often easier to collect and recycle compared to many flexible formats; the regulation appears to reflect relative recyclability. However, Category IV includes compostable plastics, and the rules clarify that "recycling" for Category IV means processing through industrial composting facilities, which are limited in many cities.

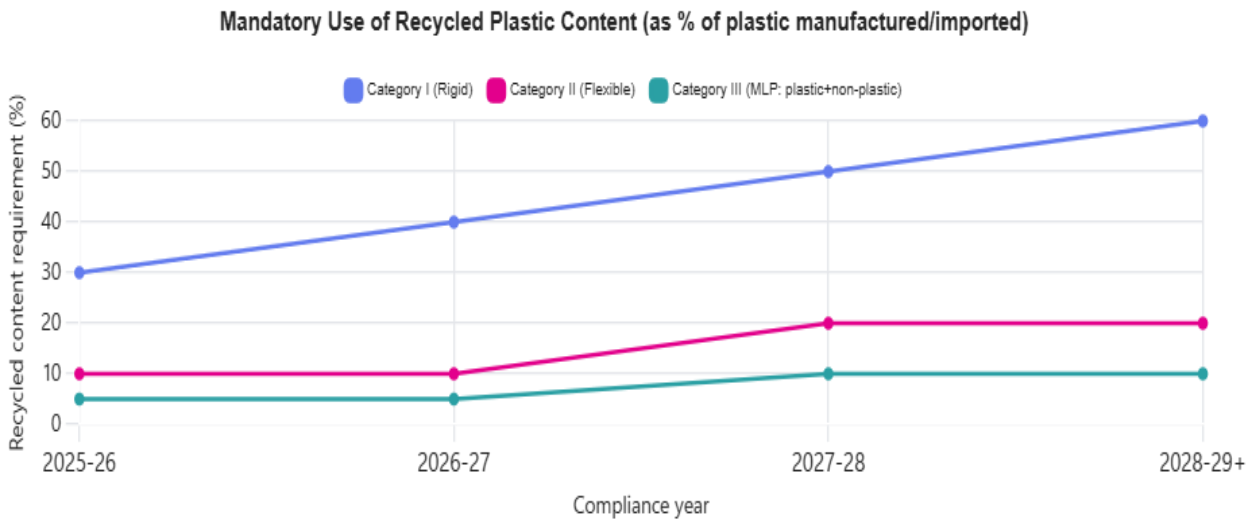
2.3 Mandatory Recycled Content: Linking Upstream Material Choice to Downstream Outcomes

A major circular-economy lever is the requirement of mandatory use of recycled plastic content in packaging, by category, rising over time. This is designed to create stable demand for recycled polymers, reducing market volatility that often undermines recycling economics.

Table 2. Mandatory recycled plastic content requirements.

Category	2025–26	2026–27	2027–28	2028–29 & onwards
Category I (Rigid)	30%	40%	50%	60%
Category II (Flexible)	10%	10%	20%	20%
Category III (MLP: plastic + non-plastic)	5%	5%	10%	10%

Graph 2. Recycled content requirements over time



From an urban governance viewpoint, recycled-content mandates can have downstream benefits: if more packaging is made from recycled content, demand increases for city-recovered plastics—potentially incentivizing better collection systems. Yet this depends on the integrity of recycling certification and on reducing contamination in city waste streams, which the literature highlights as a chronic urban challenge.

3) Enforcement and Compliance Integrity: Registration, Portals, Certificates, and Environmental Compensation

The EPR Guidelines create a compliance pipeline: registration → action plan → annual returns → certificate verification. Obligated entities must register on the centralized portal; registration can be revoked for false information or deviations, and entities cannot deal with unregistered entities. This "gated ecosystem" approach is governance-relevant because it attempts to reduce the informalization of compliance (e.g., paper-only claims) and encourages auditable transactions.

The rules also specify that only registered plastic waste processors may issue processing certificates for EPR compliance, except for road construction where a self-declaration certificate format is contemplated. This

design reflects an enforcement trade-off: certificate systems can improve traceability but also introduce risks of market manipulation or fraudulent certificates if audit capacity is weak.

Environmental Compensation is established as a sanction mechanism both in the PWM 2022 amendment and within the EPR Guidelines. The PWM 2022 amendment inserts an "Imposition of Environmental Compensation" rule grounded in polluter-pays and linked to CPCB guidelines for non-compliance with the rules. The EPR Guidelines further specify that payment of compensation does not absolve obligations; shortfalls are carried forward for three years and partial returns of compensation are possible if compliance is achieved later (75% within one year, 60% within two, 40% within three).

Governance implication: This is a hybrid of deterrence and correction—penalize shortfalls while still allowing future compliance. It can incentivize long-term investment in collection and recycling capacity rather than treating penalties as a cost of doing business. However, its effectiveness hinges on enforcement credibility and the ability of CPCB/SPCBs to levy, collect, and transparently deploy funds (the guidelines contemplate escrow accounts and utilization for collection/recycling of uncollected waste).

4) Why Urban Plastic Pollution Persists: Fragmentation, Weak Enforcement, and Socio-economic Barriers

Literature reviewed strongly supports the hypothesis that legal strength is not enough. The core reasons include:

4.1 Fragmented governance across levels

Plastic governance intersects municipal service delivery (collection/segregation), state environmental regulation (SPCBs/PCCs), and national-level compliance architecture (CPCB portal and EPR verification). This multi-node system can create gaps: municipalities may not coordinate effectively with producer-run collection systems; SPCBs may have uneven capacity; and data flows between actors can be inconsistent. Literature describing plastic pollution as a governance challenge highlights such fragmentation as a primary barrier to effective management.

4.2 Weak enforcement and monitoring capacity

The rules anticipate audits, verification, and reporting, but implementation in many cities is constrained by limited manpower, limited laboratory/testing infrastructure for claims like biodegradability, and limited monitoring of illegal dumping and littering. Studies on SWM in Indian cities show persistent administrative and logistical constraints that reduce the effectiveness of otherwise comprehensive policies.

4.3 Socio-economic barriers and informal sector exclusion

The EPR framework is designed as a formal compliance system—registration, certificates, audited processors. Yet Indian cities rely heavily on informal recycling networks. If the system does not create channels for informal actors to participate legally (through aggregators, cooperatives, contracted MRF roles, or verified collection partnerships), then a large share of actual collection may remain outside the compliance accounting system, producing two distortions: (i) cities may still be cleaned by informal workers without receiving financial support from EPR flows, and (ii) producer compliance may undercount real recovery or shift toward easier certificate procurement rather than investment in inclusive collection systems. The referred literature repeatedly identifies informal sector dynamics as central to plastic management outcomes.

4.4 Market and technology constraints

The rules progressively push higher recycling and recycled-content use. But recycling capacity and quality differ by plastic type. Flexible and multilayer packaging is often harder to recycle into high-value applications, and contamination from mixed waste further reduces viability. The literature on challenges and opportunities stresses that market development and technological capability are decisive for effective plastic management.

5) Governance Integration: How the Legal System Can Work with Cities Rather than Parallel to Them

A key insight from combining the legal text with literature is that the EPR system cannot be effective as a parallel compliance universe detached from municipal reality. The EPR Guidelines explicitly contemplate that producers/brand owners may build collection points and MRFs, offer collection from ULBs and other entities, and develop a separate waste stream (deposit-refund or buyback models) to prevent mixing with solid waste. This indicates the law's recognition that segregation and collection are the bottleneck.

Urban governance can therefore operationalize EPR by:

- Structuring municipal contracts and by-laws that require segregation, facilitate producer-funded MRF infrastructure, and define service-level outcomes aligned with EPR targets.
- Creating inclusive mechanisms to integrate informal collectors into formal recovery systems, improving traceability and livelihoods while strengthening city recycling performance.
- Using Environmental Compensation funds transparently for gap-filling: collection in underserved areas, upgrading MRFs, and building verification capacity.

The 2022 framework is conceptually strong: it defines roles, sets targets, creates measurable performance obligations, and introduces enforcement. But the literature cautions that unless governance is integrated and socio-economic realities are addressed, compliance may become a paperwork exercise rather than a driver of cleaner urban environments.

6) Swachh Survekshan 2024–25 as an "Implementation Mirror" for Urban Plastic Governance

Swachh Survekshan (SS) 2024–25 provides a nationally standardized, outcomes-focused lens for observing how high-performing ULBs operationalize plastic waste management within broader solid waste systems. The 9th edition toolkit (theme: **Reduce, Reuse, Recycle**) emphasizes measurable parameters—**visible cleanliness, segregation, collection and transportation, processing, landfill management, dumpsite remediation, and citizen feedback**—and requires periodic MIS updates, validated through citizen input and third-party assessment.

Governance interpretation: SS 2024–25 functions as a pragmatic "stress test" for the same urban implementation constraints identified in this paper—segregation quality, logistics, processing capacity, and accountability—thus offering a structured proxy for whether legal architecture can translate into street-level plastic leakage reduction.

6.1 The Super Swachh League (SSL) and city categorization as governance instruments

The SS 2024–25 framework introduced **population-based categories** and a "Super Swachh League" to recognize consistent top performers. Official parliamentary documentation specifies that SSL cities are those ranking among the **top 3 in at least two of SS21–SS23**, are assessed against additional aspirational indicators, and must maintain a high-performance threshold (reported as **85% or higher**) to remain in the league.

SSL "best cities" list (official annexure):

- **Million Plus Cities:** Navi Mumbai, Indore, Surat
- **Big Cities (3–10 lakh):** Noida, Chandigarh
- **Medium Cities (50,000–3 lakh):** Ambikapur, Tirupati, NDMC
- **Small/Very Small Cities:** Vita, Sasvad, Panchgani, Patan

Governance interpretation: SSL constitutes a policy-relevant set of cities where routine operational capacity (segregation discipline, processing outcomes, visibility standards, citizen engagement) appears sufficiently mature to satisfy repeated third-party validation—making them illustrative "implementation models" for plastic governance.

7) What High-Performing SS Cities Are Doing Differently: Plastic Waste Practices Mapped to SS/GFC Indicators

7.1 Segregation at source as the first control point for plastic leakage

National messaging accompanying SS awards reiterates that **source segregation is the first and most important step** in the waste management value chain and explicitly identifies plastic waste control as a major challenge requiring systematic effort.
Governance interpretation: consistent segregation at source increases the quality and market value of plastic fractions, reduces contamination, and is foundational for traceable processing—directly aligning with the paper's argument that EPR-style performance regulation cannot succeed without municipal segregation capacity.

7.2 Door-to-door collection discipline and service-level accountability
SS 2024–25 institutionalizes performance monitoring via periodic MIS reporting and third-party validation, strengthening municipal incentives to maintain consistent collection discipline.
Governance interpretation: high-performing cities treat door-to-door collection and segregation compliance as routine service standards (not episodic drives), reducing mixing and enabling plastics to reach sorting and processing systems—thereby reducing leakage into drains and open dumping.

7.3 MRFs/dry-waste processing as the backbone of plastic capture
The Garbage Free Cities (GFC) protocol and related toolkits embed plastic waste management within a broader outcomes chain that includes **dry waste processing** and evidence-backed assessment (desktop and field evaluation).
Governance interpretation: MRF-anchored sorting converts household-level segregation into auditable material streams, enabling higher integrity recovery and supporting verifiable channelization to authorized recyclers/processors—an operational prerequisite for producer-side compliance systems.

7.4 Plastic management as a scored and inspectable compliance domain

The GFC protocol explicitly lists **plastic waste management** among the drivers of garbage-free status; the toolkit-based approach treats it as an evidence-supported performance domain rather than a discretionary activity.
Governance interpretation: where plastic management is scored and verified, ULBs are incentivized to institutionalize enforcement, routing, and processing capacity rather than relying on symbolic compliance.

7.5 Drain and water-body protection: targeting high-leakage urban pathways

The GFC toolkit includes conditions relating to **no visible solid waste in water bodies** and **screening of storm water drains/nallahs**, recognizing drainage systems as high-impact leakage pathways for plastics. This supports the paper's risk-based governance logic: targeted interventions in drains, markets, transport hubs, and water edges yield disproportionate reductions in urban plastic externalities such as flooding and localized pollution hotspots.

7.6 Dumpsite remediation and landfill management as indicators of system maturity

SS 2024–25 emphasizes **landfill management and dumpsite remediation**, and national announcements link the SS cycle to accelerated dumpsite remediation initiatives.

Governance interpretation: top-performing cities typically combine upstream segregation and dry waste processing (reducing plastic inflows to dumpsites) with remediation strategies, reflecting a shift from disposal dependence to scientific, circular waste systems.

8) Linking SS 2024–25 "Best City" Practices to the Paper's EPR Governance Argument

The SS 2024–25 framework helps operationalize this paper's core claim: legal sophistication alone does not produce clean-city outcomes unless municipal systems deliver the physical prerequisites of credible plastic management—segregation, collection discipline, dry-waste processing capacity, leakage control, and landfill diversion/remediation.

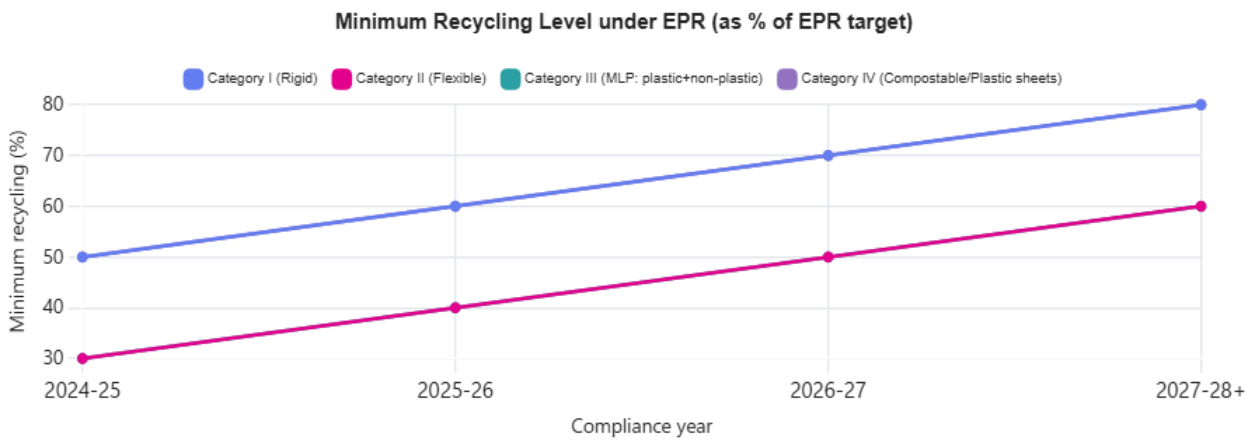
By recognizing consistent high performers through the SSL and validating outcomes through periodic reporting and third-party checks, SS provides an implementation benchmark for the "governance integration" recommended in this paper—where municipal service outcomes and producer-side compliance must be aligned rather than operating in parallel.

RESULTS

1. Legal framework is robust and increasingly performance oriented. The 2022 legal instruments significantly strengthen India's plastic governance architecture by providing clearer definitions, expanding regulated actor categories, and formally embedding enforcement through Environmental Compensation. The EPR Guidelines (Schedule-II) represent a mature regulatory model: they require registration, standardized reporting, and measurable targets, and they design a digital compliance infrastructure through a CPCB-developed centralized portal.

2. EPR introduces a clear compliance trajectory but creates implementation pressure. The phased EPR targets (25% → 70% → 100%) and later-year minimum recycling thresholds by category create a forward compliance pathway. The data visualization shows that the policy expects rapid scaling of recycling performance, culminating in high recycling shares (up to 80%) for rigid and Category IV packaging by 2027–28+.

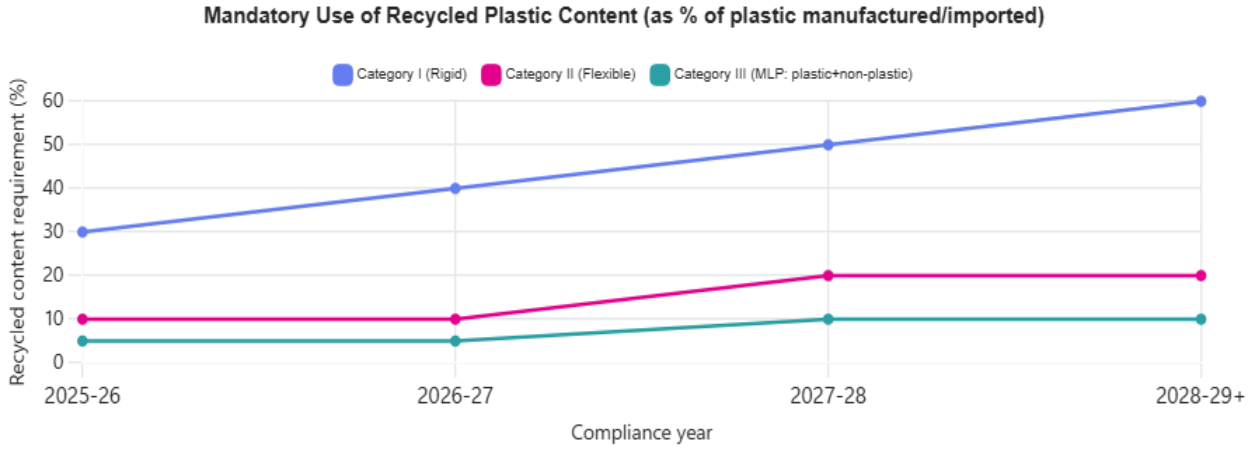
Graph 3. Minimum recycling level under EPR



These targets can drive investment and redesign but also risk non-compliance where municipal and processing capacities remain insufficient.

3. Recycled-content mandates deepen circularity but depend on traceable recovery. Mandatory recycled content (e.g., Category I rising from 30% to 60% over time) is a strong circular-economy lever because it creates stable demand for recycled polymers and can shift producer behavior upstream. The graph indicates a clear upward trajectory for rigid packaging, with more modest requirements for flexible and MLP categories.

Graph 4. Mandatory use of recycled plastic content



However, this mechanism relies on reliable certification and high-quality recycling outputs, which are difficult when city waste streams are contaminated due to poor segregation.

4. Urban outcomes are constrained by fragmented governance and enforcement limits. The literature consistently indicates that Indian urban waste management suffers from governance fragmentation (multiple institutions with partial responsibilities), uneven enforcement capacity, and persistent deficits

in segregation and collection systems. These constraints directly affect EPR's feasibility because post-consumer packaging recovery occurs mainly through city systems (formal or informal). Without alignment between producer compliance mechanisms and municipal service delivery realities, EPR may not translate into visible reductions in plastic leakage in streets, drains, and landfills.

5. Socio-economic realities, especially informal recycling—are decisive. The literature highlights that informal waste pickers and aggregators remain essential to plastics recovery in Indian cities. Yet EPR compliance is built around registered entities and certificate-based accounting. This creates a risk that informal recovery is either excluded from formal compliance credit or incorporated through intermediaries without fair compensation or protection. If informal actors are not integrated via contracts, cooperatives, or verified partnerships, the system may underperform; collection may remain high where informality is strong, but environmental outcomes and compliance integrity may still lag due to weak traceability and insufficient investment in city infrastructure.

6. Enforcement tools exist but require credible implementation. Environmental Compensation under both the PWM 2022 amendment and the EPR Guidelines provides a deterrence-and-correction mechanism, including carry-forward of obligations and partial refund of compensation if shortfalls are addressed within three years. This design can incentivize compliance investments, but only if levies are predictable, audits are robust, and funds are transparently used to strengthen collection and recycling where gaps exist.

Overall, the research supports the hypothesis: the legal framework is strong, but persistent urban plastic pollution is best explained by fragmented governance, enforcement capacity constraints, and socio-economic barriers. Sustainable reductions are most likely under an integrated model that aligns municipal operations, producer compliance obligations, and inclusive recycling economics.

CONCLUSION

India's approach to plastic pollution control has evolved from a predominantly municipal waste management issue into a lifecycle governance model that assigns responsibility across the value chain. The 2022 amendments to the Plastic Waste Management Rules underscore this evolution: they clarify key definitions that shape enforcement boundaries, expand and define regulated actors, and explicitly introduce Environmental Compensation based on polluter-pays principles—thereby strengthening the compliance backbone.

Most importantly, the insertion of Schedule-II EPR Guidelines in 2022 transforms plastic regulation into performance regulation. The EPR framework sets measurable targets, establishes category-wise obligations, and introduces a centralized portal and certificate-based verification architecture. It also goes beyond collection targets by specifying minimum recycling levels (excluding end-of-life disposal) and mandating recycled plastic

content in packaging. In principle, these tools can drive upstream design changes and downstream recycling investments, aligning India's plastic governance with circular economy principles.

However, this paper demonstrates that legal sophistication does not automatically translate into cleaner cities. Urban plastic pollution persists because implementation depends on governance coherence: how effectively municipalities, SPCBs/PCCs, CPCB, producers/brand owners, and waste processors coordinate, share information, and enforce obligations. Where municipal segregation is weak, waste streams are contaminated and recycling becomes less viable; where enforcement is inconsistent, regulated entities may treat compliance as a reporting exercise; and where financing is inadequate, cities may lack the infrastructure necessary for collection, sorting, and material recovery.

Socio-economic realities form a critical part of the explanation. The informal recycling sector remains a major engine of plastic recovery in India yet often operates without formal recognition or stable integration into municipal and producer-led systems. If EPR compliance mechanisms do not create accessible pathways for informal collectors and aggregators to participate in traceable, compensated collection systems, then both environmental performance and social equity can be undermined.

Therefore, the strongest inference from this study is that sustainable reductions in urban plastic pollution require integrated governance: statutory compliance must be linked to operational municipal systems, enforcement must be credible and data-driven, and socio-economic inclusion must be built into the compliance economy. The 2022 legal architecture provides the tools—targets, thresholds, portal systems, and environmental compensation—but the success of these tools in cities will depend on coordinated implementation strategies that bridge institutional fragmentation and align incentives across the entire urban plastic value chain.

RECOMMENDATIONS

1. Harmonize governance across CPCB–SPCB–ULB levels through city EPR coordination cells
   Create City EPR Coordination Cells housed in ULBs but jointly staffed/linked with SPCBs/PCCs, to align municipal collection operations with producer compliance requirements (collection points, MRF planning, reporting formats, and verification protocols). This directly responds to the EPR Guidelines' expectation that producers/brand owners may build collection points and MRFs and offer collection arrangements with ULBs.
2. Convert EPR obligations into municipal service-level outcomes

ULBs should translate EPR trajectories (e.g., category-wise recycling thresholds) into service-level agreements in waste contracts: segregation performance, MRF throughput, contamination limits, and traceable handover to registered processors. This reduces the risk that EPR becomes a parallel compliance market disconnected from city waste realities.

3. Integrate informal recyclers into formal compliance pathways

Design "verified collection partnership models" were waste picker collectives, SHGs, or informal aggregators can operate as recognized collection partners (directly or via licensed aggregators), enabling traceability without displacing livelihoods. The literature shows informal actors are essential to recovery; excluding them undermines both outcomes and equity.

4. Strengthening enforcement credibility using Environmental Compensation strategically

Operationalize Environmental Compensation (polluter-pays) as a predictable deterrent while ensuring funds are transparently allocated to close city infrastructure gaps (MRF upgrades, route optimization, enforcement staff, and audits). The EPR Guidelines already contemplate escrow accounts and utilization for collection/recycling of uncollected waste; cities should publish annual utilization statements to build legitimacy.

5. Invest in verification and anti-fraud capacity for certificate markets

Because EPR compliance relies on certificates issued by registered processors and portal-based accounting, CPCB/SPCBs should strengthen third-party audit capacity, introduce risk-based inspections, and deploy digital traceability (batch IDs, GPS-tagged movement, weighbridge integration) to prevent certificate inflation.

6. Use fiscal incentives to accelerate compliance and innovation

Introduce targeted fiscal measures aligned with the EPR schedules: reduced GST or rebates for packaging meeting recycled-content thresholds; municipal fee rebates for producers funding MRFs; and viability-gap support for industrial composting where Category IV obligations require such facilities. This addresses the "affordable alternatives" and market constraints emphasized in the literature.

7. Prioritize "high-leakage" urban hotspots with risk-based enforcement and infrastructure

Cities should deploy hotspot mapping (drains, markets, transport hubs, water edges) and focus enforcement and infrastructure there. This operational approach complements legal obligations by targeting the most environmentally damaging leakage points described in urban waste studies.

8. Institutionalize public participation and segregation compliance

Adopt ward-level segregation monitoring, feedback loops, and behavior nudges (including differential user fees based on segregation). The literature and consumer-focused work indicates that awareness alone is insufficient; governance must create routine incentives and accountability for households and commercial establishments.

Implementation logic: These recommendations operationalize your hypothesis: they strengthen statutory compliance (through enforceable service standards and audits), harmonize governance (through coordination

cells and aligned contracts), and address socio-economic realities (informal sector inclusion and fiscal incentives), thereby making sustainable reductions in urban plastic waste feasible under the 2022 legal regime.

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