



Extended Producer Responsibility in Practice: Insights from Hyderabad and Bangalore

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ABSTRACT

The rapid increase of electronic waste has, among other things, escalated the concerns of the global community regarding environmental and health effects such that India is one of the top e-waste generators in the world. This research paper, through the analysis of secondary data and two-city level case studies, i.e. Hyderabad and Bangalore, investigates the implementation of Extended Producer Responsibility (EPR) in India. The study reveals that apart from the regulatory progress, the enforcement of the regulation is still very weak; the provision of services is not sufficient, and the governance of the fragmented local government units is still very weak, which together impede the EPR implementation in the area under study. It is necessary to strengthen data systems, integrate informal actors, and elevate institutional capacity if we are to open up the way for India's circular economy.

***Keywords:* Electronic Waste Management; Extended Producer Responsibility (EPR); Policy Implementation; Recykal; Producer Responsibility Organizations (PROs)**



INTRODUCTION

The accelerating advancement of technology and urban growth has resulted in a significant rise in electronic waste (e-waste). E-waste, which is generated from discarded electronic products at the end of their life cycle, is one of the most rapidly expanding waste categories globally (United Nations University, 2024). India ranks among the top five countries producing e-waste (Central Pollution Control Board [CPCB], 2023). This type of waste comprises various valuable metals, rare earth elements, ferrous and non-ferrous metals, as well as plastic, wood, and glass. Unregulated methods of e-waste processing are linked to numerous environmental and health issues (Balde et al., 2024).

According to the Global E-Waste Monitor (2024), a record 62 million tonnes of e-waste was produced in 2022. This marks an 82% increase from 2010, and the amount is expected to rise by another 32% to 82 million tonnes by 2030 (United Nations University, 2024). This highlights the urgent need for sustainable waste management systems.



Image 1: E-waste Status in Asia (2022). Global E-waste Monitor 2024



Extended Producer Responsibility (EPR) is an environmental policy approach that makes producers responsible for the collection, recycling, and disposal of their products after consumer use, promoting eco-design and waste reduction (Organisation for Economic Co-operation and Development [OECD], 2016). Countries like Switzerland and Singapore have set up strong EPR systems with digital traceability and public participation, which has led to high recycling efficiency (Policy Pathways to Sustainable E-Waste Management, 2024).

India, one of the world's largest producers and consumers of electrical and electronic equipment, has developed a legal framework to address e-waste management under the E-Waste (Management) Rules, first notified in 2011 and subsequently amended in 2016, 2018, and 2022. These rules introduced the concept of Extended Producer Responsibility (EPR), assigning producers financial and operational responsibility for collecting and processing their products after use (Ministry of Environment, Forest and Climate Change [MoEFCC], 2022).

The Implementation Guidelines for E-Waste (Management) Rules (Central Pollution Control Board [CPCB], 2016) detail procedures for authorization, collection-target setting, and compliance reporting. Despite the progress, policy enforcement and infrastructure development remain inconsistent. The India e-waste increased by 147% between 2017–18 and 2023–24, with more than half remaining untreated (Centre for Science and Environment, 2024). Weak enforcement, lack of awareness, and the dominance of the informal recycling sector hinder effective implementation. The on-ground execution of EPR faces multiple challenges in India. (White Paper on E-Waste EPR, 2022). Studies reveal that the current model suffers from monitoring inefficiencies, overlapping jurisdictions, inadequate industry participation, and lack of economic incentives for producers (Bhaskar & Turaga, 2018; ScienceDirect, 2024).



Furthermore, the integration between formal and informal sectors remains weak, with informal actors—kabadiwalas and small-scale dismantlers—handling a major portion of e-waste under unsafe conditions (Sengupta et al., 2022). Addressing these issues requires improved data transparency, digital tracking, consumer education, and inclusive policy reforms.

This research paper looks into the implementation of the EPR framework in India for E-Waste Management. The objective of this research is to evaluate the effectiveness of different state-level models of EPR implementation across India. The focus lies on comparing how EPR works in different states, identify best practices, and highlight regional challenges. Using secondary data, it analyzes institutional frameworks and city-level initiatives, focusing on Hyderabad and Bangalore - the IT Hubs of India. Hyderabad's collaboration with Recykal, a Producer Responsibility Organization (PRO), shows progress through digital traceability (Bhadra & Mishra, 2021), while Bangalore presents fragmented but evolving compliance structures (Borthakur & Govind, 2017). Through these cases, the research aims to identify practical strategies for strengthening India's e-waste governance and transitioning toward a more transparent and inclusive circular economy.



LITERATURE REVIEW

Electronic waste (e-waste) has become one of the most rapidly increasing forms of waste worldwide, propelled by swift digital advancement, technological ageing, and growing consumption habits. The Global E-Waste Monitor 2024 reports that nearly 62 million tonnes of e-waste were produced globally in 2022, with less than 25% being formally collected and recycled (United Nations University, 2024). The principle of Extended Producer Responsibility (EPR)—a policy framework in which manufacturers take on financial or physical responsibility for managing products after consumer use—has become a fundamental aspect of contemporary waste management systems around the globe (White Paper on E-Waste EPR, 2022, p. 30).

International Frameworks and Effective Practices

The operation and implementation of EPR vary significantly globally in terms of both scope and efficiency. Countries like Switzerland, Japan and Singapore serve as models of successful EPR systems, showing how effective institutional design and consumer involvement can boost compliance. In Switzerland, over 90% recycling efficiency is achieved through producer-funded collection systems and strong traceability protocols (White Paper, 2022). Singapore's Resource Sustainability Act (2019) mandates that producers meet annual collection targets through Producer Responsibility Organizations (PROs), prioritizing digital traceability and government supervision. These examples demonstrate that accountability, consumer education, and enforcement are crucial to the success of EPR (Policy Pathways to Sustainable E-Waste Management, 2024).

EPR and E-Waste Management in India

The regulatory groundwork for e-waste management in India was established by the E-Waste (Management) Rules, 2016, which were later updated in 2018 and 2022 to introduce targets for producer collection and the registration of PROs.



The Implementation Guidelines for E-Waste (Management) Rules (2016) highlight the processes for authorization, compliance reporting, and setting the targets. However, enforcement of these policies remains weak, and the development of collection systems is insufficient, resulting in discrepancies between policy and practice (Bhaskar & Turaga, 2018).

India's e-waste generation surged by 147% from 2017-18 to 2023-24, scaling up from 0.7 million tonnes to 1.75 million tonnes, with approximately 57% still not being processed (E-Waste Crisis: Lethal Electronic Waste Accumulation in India, 2024). While formal recycling efforts have improved, a notable amount of e-waste continues to circulate within the informal sector, marked by unregulated collection and environmentally hazardous dismantling methods.

Policy and Institutional Shortcomings

Research conducted by Bhaskar and Turaga (2018) indicates that although India's EPR model appears advanced in theory, it faces challenges like monitoring inefficiencies, overlapping authority, and limited industry involvement. In a similar vein, the report Policy Pathways to Sustainable E-Waste Management (2024) points out that there are insufficient economic incentives for producers and inadequate integration of formal and informal systems. The Global E-Waste Monitor (2024) also highlights a lack of infrastructure, consumer awareness, and available financing as major obstacles to the successful implementation of EPR in developing regions.

City-Level Implementation: Insights from Hyderabad and Bangalore

The regional studies provide a glimpse into the impact and application of EPR on ground level, highlighting the practical challenges. The research titled "Extended Producer Responsibility in India: Evidence from Recykal, Hyderabad" delves into how Recykal, a digital PRO platform, enhances compliance by linking producers,



consumers, and recyclers through real-time tracking. Although this platform increases transparency and accountability, it encounters issues such as limited consumer participation and logistical challenges (Recykal Case Study, 2021).

In Bangalore, Borthakur and Govind (2017) analyzed e-waste management techniques among the large consumers in the IT, education, and banking sectors. The compliance is achieved through take-back and auction systems; however, these practices are scattered and poorly monitored, which limits their effectiveness on formal recycling. The authors conclude that institutional inertia and a lack of incentives weaken the impact of EPR in the city. Comparing India's experience with global best practices reveals that while digital innovation offers promise, the absence of harmonized institutional arrangements and consumer awareness limits scalability.

Furthermore, a study by Sengupta et al. (2022) claims that the informal sector—particularly kabadiwalas and small-scale dismantlers—plays a crucial role in improving collection efficiency. They advocate for a hybrid model of the EPR framework that incorporates informal actors through training, certification, and collaborations, facilitating outcomes aligned with a circular economy. This aligns with the broader call for inclusive governance in India's waste management policy landscape.



METHODOLOGY

The introduction of Extended Producer Responsibility (EPR) in India represented a major shift from waste management systems, which are mostly directed by local governments, to producer-led accountability, especially for complicated waste streams such as e-waste. This shift is a reflection of the global concerns over the environmentally sound management of electronic waste and the inherent limitations of the traditional disposal methods.

This research paper adopts a qualitative, exploratory case-study approach and delves into the implementation of the EPR framework in India for E-Waste Management. As the subject is regulatory and policy-focused, it is based on secondary data. The paper aims to comprehend the government and institutional mechanisms, and not quantify the outcomes. Secondary data was collected from government notifications and guidelines, policy reports, industry white papers, and published case studies related to EPR implementation in India. Data was selected on the basis of relevance to e-waste EPR, credibility of the paper or publishing house, and execution at an urban level. The study focuses on two case studies of Hyderabad and Bangalore due to their status as major IT Hubs in India and high levels of e-waste generation.

Hyderabad leans towards a centralized, digitally aided EPR model through a Producer Responsibility Organization (PRO), whereas Bangalore adopts a decentralized and sector-specific approach mainly led by institutional and corporate initiatives. The analytical framework for the case studies dissects EPR implementation along four facets: Institutional arrangements (role of PROs, producers, local authorities), Operational mechanisms (collection, recycling, reporting, traceability), Stakeholder participation (producers, recyclers, informal sector), and Governance and transparency outcomes. The comparison between the



two cities is based on an analysis identifying similarities, differences, and governance gaps, which allows the study to present general insights into the strengths and limitations of India's EPR framework for e-waste management.



CASE STUDIES

Hyderabad- The case of Recykal

EPR for e-waste management has been implemented across India. It mandates producers to collect and recycle e-waste through authorized dismantlers and recyclers (Press Information Bureau, 2022). The policy applies nationwide; however, these operations are more feasible in the major urban centres like Delhi, Pune, Bangalore, Hyderabad, etc., which are responsible for the highest volume of E-waste generation (Press Information Bureau, 2022).

In addition to the EPR waste management guidelines, local governments also have their share of responsibilities in providing necessary infrastructural support for the segregation, collection, storage, transportation, processing and disposal of plastic waste either on their own or using the producers (Bhadra & Mishra, 2021). Central to the framework has been the digitalisation of the process through the establishment of the web portal to ensure viable functioning, managing tasks like registration and monitoring of stakeholders. The onus of responsibility on producers is the striking distinction in the Indian EPR framework. Digital transition aligns with the principles, supporting the decentralised model.

In the case of Hyderabad, Recykal has played a pivotal role in the facilitation and expansion of EPR. Recykal operates as a Producer Responsibility Organization (PRO) in India that enables businesses to comply with Extended Producer Responsibility (EPR) regulations by linking producers, recyclers, and consumers to optimize waste management and promote sustainability (Recykal, 2025). This paradigm, which assigns compliance responsibilities from producers to a specialist intermediary, is an example of a digitally integrated approach to EPR implementation. Its services “help to create a cross value chain alliance and connect



multiple stakeholders that include waste generators (business and household consumers), waste aggregators and recyclers, thereby ensuring transactions among the above take place with greater transparency and traceability” (Bhadra & Mishra, 2021).

Recykal functions as a Producer Responsibility Organization (PRO) that operates through a digital platform connecting firms with customers, waste aggregators, and recyclers. The businesses registered with Recykal are expected to set targets and categorize their waste types. Recykal collects waste from households and bulk generators, storing it at its Material Recovery Facility (MRF). Recykal conforms to the demands of firms to recycle the waste, through this the firms outsource their EPR obligations by giving the responsibility to PROs like Recykal.

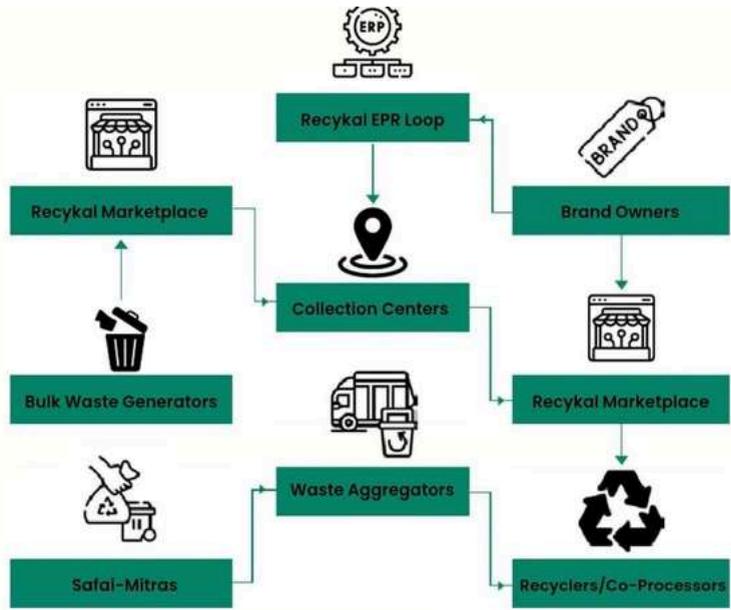


Image 2: Value Chain



One of the main flaws of India's EPR framework, a lack of transparency and traceability, is addressed by Recykal's platform, which permits target setting, waste classification, real-time tracking, and documentation. By managing EPR for multiple firms, Recykal also leverages economies of scale, making the process more cost-effective than individual efforts. It also handles all required documentation for the Central Pollution Control Board (CPCB), including reports and disposal certificates. Real-time tracking ensures transparency, offering firms live updates on progress and geographic data.

An important dimension of Recykal is the Informal Sector App, which attempts to manage the gap between the recycling of waste and unregistered firms and organizations. A sufficient portion of the e-waste goes unprocessed due to low reporting and accessibility. Recykal deals with this challenge by introducing the Informal Sector app, which not only empowers the waste pickers but also connects them to the buyers by optimizing collection routes and facilitating digital payments. Provision of access to healthcare, banking and insurance incentivizes the process. Additionally, Recykal offers sustainability consulting to corporations and governments, helping them improve waste management and comply with environmental regulations.

The model continues to rely on producers and consumers volunteering, and there are still challenges in getting most households engaged. Lack of logistics and uneven awareness also hinder scalability outside the main urban areas. However, the case study reveals that digital platforms and PRO-led coordination can greatly enhance EPR compliance and governance outcomes.

Case Study of Bangalore

Bangalore, known as the 'Silicon Valley of India', houses several Information



Technology (IT) companies, startups and electronics companies. A number of international tech-giants have established their research and development (R&D) centres in Bangalore. The city's IT and electronics sector has benefited from the infrastructure and skills supplied by public sector manufacturing enterprises and laboratories, including telecommunications, aerospace, and defence electronics, located in the nearby regions (Parthasarathy & Aoyama, 2006; Borthakur & Govind, 2017). Karnataka state also houses a huge banking sector, with major national banks having their headquarters in Bangalore (Sharma, 2005; Borthakur & Govind, 2017). The city is also a hub for educational institutions and commercial enterprises. All these industries contribute significantly to the city's economy and e-waste production, making Bangalore India's third-largest generator of e-waste, following Mumbai and Delhi (MoEF, 2008; Borthakur & Govind, 2017).

India's E-waste Management Rules 2011 mention the Extended Producer Responsibility (EPR) framework, which was later strengthened in 2016. It makes the producers responsible for the EEE (Electrical and Electronic Equipment) manufacturing and end-of-life disposal. This can be achieved by various strategies, like take-back and buy-back schemes, and establishing collection centres (MoEF, 2016; Widmer et al., 2005, as cited in Borthakur & Govind, 2017). The EPR compliance in Bangalore varies by sector:

1) Information technology (IT) and electronics :

The IT sector in Bangalore is a major generator of e-waste, discarding about 30000-40000 obsolete computers every year (Needhidasan, Samuel, & Chidambaram, 2014; Borthakur & Govind, 2017). Wipro, the third largest IT company in India, was studied for its e-waste management practices. Every three to four years, Wipro implements a "Tech Refreshing". cycle in which obsolete electronic equipment is methodically replaced, gathered, and discarded. Their 'take-back' program recycles



tonnes of e-waste annually, with reports showing recycling volumes of 241 tons in 2010–11, 247 tons in 2012–13, and 317 tons in 2014–15 (Wipro Sustainability Report, 2015, as cited in Borthakur & Govind, 2017). The company also segregates hazardous materials and maintains its own recycling facilities for lamps. These programs show comparatively high levels of formal recycling and compliance, but they are still corporate-specific practices rather than the results of a coordinated city-level EPR plan.

2) Banking Sector:

Public sector banks frequently store outdated devices in anticipation of yearly tenders and auctions, with little effort put into repair or reuse and a tendency towards quick disposal. Most computers used in these banks have a five-year lifespan and are sent for auction once they become non-operational. Only authorised e-waste recyclers from the state bid in these auctions, and most banks do not seem to care what happens post-auctions, exhibiting an “out of sight, out of mind” approach (Borthakur & Govind, 2017). Karnataka Bank is considered an exception as it operates a ‘buy-back’ policy for computers in partnership with Wipro, though equipment like printers still goes to scrap dealers. Delayed tenders and limited awareness can act as challenges in this sector, resulting in large volumes of e-waste being stored for years and lying unaddressed.

3) Educational Sector:

Indian Institute of Management Bangalore (IIMB) was studied as a major representative of the educational sector. The institute implements various strategies in handling e-waste. A sustainability startup named ‘Binbag’, incubated at IIMB in 2014, deals with e-waste, plastic and paper waste. Their motto is ‘Waste is a resource —only when treated the right way; treated wrongly it is an environmental burden’. Binbag bridges the gap between NGOs and recyclers. Mr. Achitra Borgohain, the



Major Sectors and Institutions Considered for the E-waste Study in Bangalore

| Sector | Key Institutions |
|--|---|
| Information Technology and Electronics | Wipro; A major multinational electronics company (name withheld) |
| Banking | Canara Bank; State Bank of Mysore; Bank of India; Indian Bank; South Indian Bank; Kotak Mahindra Bank; HDFC Bank; ICICI Bank; Karnataka Bank; Apex Bank |
| Education | Indian Institute of Management Bangalore (IIM-B) |

Table 1

Note. Adapted from "How well are we managing E-waste in India: Evidences from the city of Bangalore," by Borthakur and Govind, (2017)

founder of Binbag, reported that Binbag had processed 12 tonnes of e-waste and served 4,000 customers by June 2016 (Borthakur & Govind, 2017). IIMB also tries to maximise the lifespan of its EEE. The educational institute's efforts in e-waste handling showcase waste reduction strategies, innovation and infrastructure.

Despite partial compliance among all the sectors, there is a lack of transparency towards providing relevant information on their E-waste management practices. Lack of awareness, limited knowledge and formal practices contribute to problems in each sector. Much e-waste remains unresolved due to the auctioning of obsolete electronics, the approach of buying new items rather than repairing old items and inadequate policies. Overall, fragmentation, a lack of transparency, and inadequate monitoring systems define Bangalore's EPR implementation. Even though there are some excellent practices, the lack of a centralized reporting or traceability mechanism restricts the efficacy of EPR at the local level and lowers accountability.

The case studies reveal that there are different EPR models implemented across cities, depending on the local governance, institutional capacity and digital



infrastructure. Hyderabad's waste management, operated by Recykal, demonstrates a centralized and digitally integrated approach, thereby strengthening transparency and stakeholder connectivity. Bangalore's approach to the EPR framework in e-waste is decentralized and varies across sectors, but lacks transparency and monitoring. The examination of case studies suggests that coordinated governance structures and digital integration may enhance EPR's efficacy in urban India.



CONCLUSION

The EPR model marked a significant shift in the approach to dealing with the agenda of e-waste management globally. Hyderabad's Recykal model shows how digital tools can simplify EPR implementation by linking producers, recyclers, and consumers. This approach ensures tracking, documentation, and overall transparency in e-waste management. Recykal's Informal app motivates waste pickers and kabadiwallas to contribute by offering digital payments, route optimization, and access to services like banking and healthcare. In the case of Bangalore, companies like Wipro follow structured e-waste cycles. The process involves replacing outdated equipment regularly and recycling through take-back programs. Institutions like IIM Bangalore promote sustainability through startups like Binbag, which focus on awareness and responsible disposal. Hyderabad posits a central digital model, while Bangalore's recycling functioning as decentralised segments show that EPR strategies are tailored to specific regions and industries located within it. Decentralisation does help in building frameworks and models suitable for the specific regions; however, this achievement has not been without challenges. Low participation at the government level and lack of investment result in insufficient and absence of reliable data and statistics. At the policy level, the findings highlight the need for more coherent institutional arrangements, ensuring a system connecting the local governments, producers and PROs, such that their collaboration results in effectivity. The integration of the informal sector through digital tools indicates a replicable policy pathway for bridging formal and informal waste systems, ensuring inclusivity and equity in e-waste management. The challenges for this research consisted of reliance on data and reports put out by private corporations/organisations. This demands active involvement of the local as well as the central government in terms of contributing to the initiatives.



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