International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 5S, 2025
https://www.theaspd.com/ijes.php

From Toxic Trash to Green Governance: Legal and Policy Dimensions of E-Waste Regulation in India

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Abstract
The exponential rise in electronic waste (e-waste) has emerged as one of the most pressing environmental challenges of the 21st century. India, as the world's third-largest e-waste generator, faces complex regulatory, infrastructural, and socio-economic hurdles in managing this toxic stream. This paper provides a comprehensive analysis of India's evolving legal framework governing e-waste management, tracing its development from the 2011 Rules to the landmark E-waste (Management) Rules, 2022 and its recent amendments. It critically examines the efficacy of the Extended Producer Responsibility (EPR) regime, evaluates the persistent dominance of the informal sector, and identifies systemic gaps in enforcement, infrastructure, and public awareness. Drawing upon policy reports, legal instruments, and empirical estimates, the study reveals that despite regulatory advances, formal recycling processes account for less than half of total e-waste management. The paper illustrates key compliance gaps and environmental risks posed by informal recycling methods. In conclusion, the paper proposes a multi-pronged approach encompassing stronger enforcement, sectoral formalization, public education, and investment in green technologies to achieve a more sustainable, inclusive, and effective e-waste governance framework in India.

Key words: E-waste, Electronic Waste Management, E-Waste (Management) Rules 2022, India, Toxic Waste, Informal Sector, Environmental Law, Public Health, Sustainable Development

INTRODUCTION

The rapid proliferation of electronic waste—commonly referred to as e-waste—has emerged as a pressing global environmental concern and is now acknowledged as one of the fastest-growing waste streams worldwide. This exponential increase is largely attributed to swift technological innovations, the widespread use of electronic gadgets, and their diminishing product lifespans. India, currently ranked as the third-largest generator of e-waste globally, faces a formidable challenge in managing this expanding burden of discarded electronics. Effective e-waste management is essential to safeguard the environment, as these devices often contain toxic substances capable of polluting air, water, and soil if not appropriately treated. Additionally, the informal handling and disposal of e-waste present serious public health risks, particularly for vulnerable communities engaged in unregulated recycling operations. This research article seeks to undertake a critical and comprehensive examination of India's e-waste management regime—tracing its legislative evolution, assessing the current legal and institutional framework, identifying systemic enforcement challenges, evaluating its efficacy in promoting safe recycling and environmental sustainability, and engaging with ongoing policy debates. Finally, it offers strategic recommendations aimed at strengthening the regulatory architecture to achieve more sustainable and equitable outcomes.

Objectives of the Study

1. To examine the magnitude and growth trajectory of e-waste generation in India.
2. To explore the legal and regulatory framework addressing the e-waste crisis.
3. To critically analyse the efficacy and limitations of the existing legal system governing e-waste.
4. To suggest policy and institutional measures for improved management and control of e-waste.

METHODOLOGY

This paper follows a doctrinal legal research methodology, relying on qualitative analysis of statutes, rules, and policy frameworks governing e-waste regulation in India. Primary sources include the E-Waste (Management and Handling) Rules, 2011; the E-Waste (Management) Rules, 2016 and 2022; and relevant provisions under the Environment (Protection) Act, 1986. These instruments are critically examined to trace the evolution of

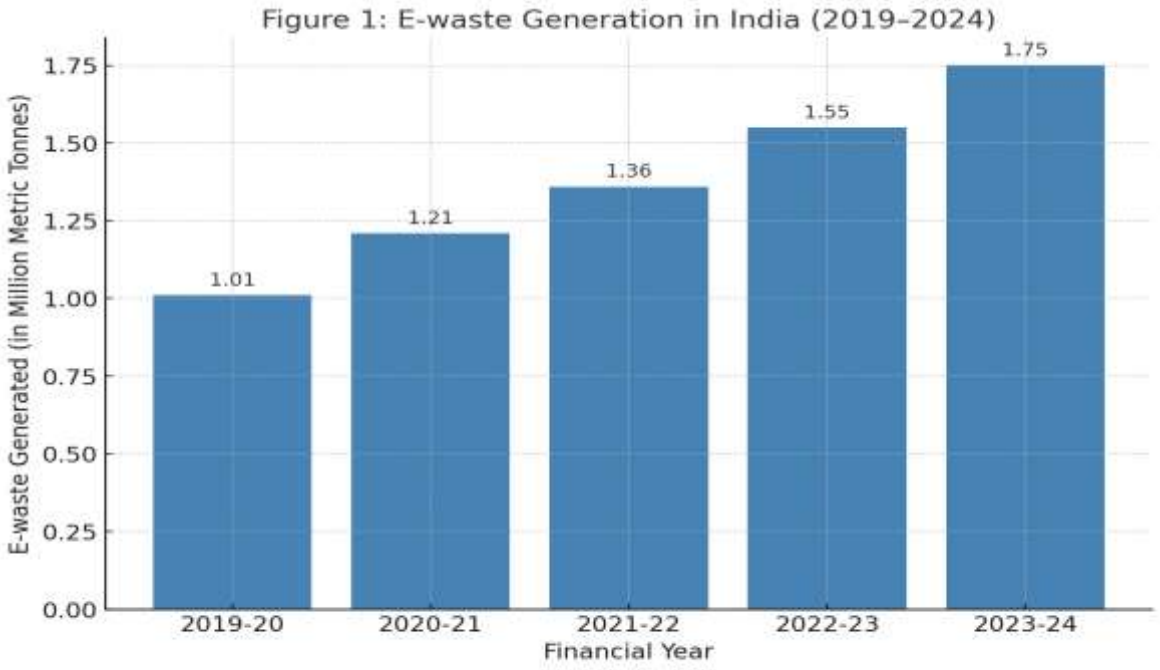
legal responsibilities, assess regulatory mechanisms such as Extended Producer Responsibility (EPR), and evaluate their effectiveness in addressing the e-waste crisis.

The research also incorporates official data and government reports, particularly from the Central Pollution Control Board (CPCB) and the Ministry of Environment, Forest and Climate Change (MoEFCC). Parliamentary data—specifically Rajya Sabha Unstarred Question No. 2384 (December 16, 2024)—provides quantitative insights into the rise in e-waste generation. To complement the legal analysis, literature including scholarly articles, policy papers, and global reports (such as UNEP and Basel Convention documentation), is reviewed to situate India's approach within an international context.

This methodology facilitates a critical, evidence-based appraisal of India's regulatory regime and enables the formulation of grounded recommendations for sustainable and inclusive e-waste governance.

The Escalating E-Waste Challenge in India

With the increasing quantity of e-waste generated and the presence of both toxic and valuable materials within electronic products, the management of e-waste has emerged as a significant global environmental concern. In India, the problem is particularly acute due to the rapid expansion of the digital economy and the exponential growth of consumer electronics.



Source: Rajya Sabha Unstarred Question No. 2384, Session 266, 16 December 2024

India has witnessed a significant surge in electronic waste (e-waste) generation over recent years, positioning itself as the third-largest e-waste producer globally, following China and the United States.[1] According to data presented in the Rajya Sabha, India's e-waste generation increased from 1.01 million metric tonnes (MT) in 2019–20 to 1.751 million MT in 2023–24, marking a 73% rise over five years.[2]

This upward trend is attributed to rapid technological advancements, increased consumption of electronic devices, and shorter product life cycles.[3] The proliferation of affordable electronics and the digitalization of various sectors have further accelerated this growth.

Despite the implementation of the E-Waste (Management) Rules, 2022, which emphasize Extended Producer Responsibility (EPR), challenges persist in effectively managing e-waste. In the fiscal year 2023–24, only 43% of the generated e-waste was formally recycled, leaving approximately 57%—equivalent to around 990,000 MT—unprocessed.[1] This unprocessed waste often ends up in landfills or is handled by the informal sector, leading to environmental and health hazards.[4]

The informal sector plays a significant role in e-waste management in India, with estimates suggesting that over 80% of e-waste is processed by unregulated entities.[5] These operations often lack proper safety measures,

leading to the release of hazardous substances like lead, mercury, and cadmium into the environment, posing severe health risks to workers and surrounding communities.

The government has initiated measures to address these challenges, including setting minimum prices that producers must pay to recyclers to encourage formal recycling practices.[5] However, these policies have faced opposition from manufacturers due to increased compliance costs.

These figures underscore the escalating scale of the e-waste problem in India. The lack of an integrated and enforceable policy, combined with insufficient institutional mechanisms and public awareness, has led to environmental degradation and health hazards associated with improper disposal practices. Addressing this crisis necessitates the development of a robust legal and regulatory infrastructure supported by effective implementation, stakeholder accountability, and a transition towards sustainable circular economy models.

Historical Evolution of E-waste Management Regulations in India

The initial steps towards regulating environmental pollution in India indirectly touched upon e-waste management through the enactment of the Hazardous Wastes (Management and Handling) Rules in 1989.[6] These early regulations provided a framework for managing hazardous substances, but e-waste was not explicitly categorized as hazardous unless it was proven to contain higher concentrations of certain toxic substances. This meant that the unique challenges posed by the growing volume and specific composition of electronic waste were not adequately addressed in the early stages of environmental regulation.

A significant turning point in the formal management of e-waste in India came with the notification of the E-waste (Management and Handling) Rules, 2011, which came into effect in May 2012.[7] These rules marked the first direct legislative effort to address the burgeoning issue of e-waste in the country. A key feature of these rules was the introduction of the concept of Extended Producer Responsibility (EPR), which placed the onus on manufacturers and importers of electronic goods to develop plans for managing the electronic waste generated from their products, including establishing collection centers or implementing take-back systems. The 2011 rules also mandated that sellers of electronic goods provide consumers with information on proper disposal methods and required companies producing electronics to make consumers aware of the hazardous materials present in their products. Specific responsibilities were assigned to various stakeholders involved in the production, disposal, and management of electronic waste, including producers, collection centers, consumers, dismantlers, and recyclers. Furthermore, commercial consumers and government departments were required to maintain records of their electronic waste. However, these rules had limitations, notably the inadequate coverage of the large unorganized sector that dominated e-waste handling in India and the absence of a comprehensive strategy for their integration or rehabilitation.[8]

Recognizing the shortcomings of the 2011 rules, the Ministry of Environment, Forest and Climate Change notified the E-waste (Management) Rules, 2016, which came into effect in October 2016. These rules expanded the scope of the regulatory framework to include dealers, e-retailers, and refurbishers, thereby clarifying the duties of a wider range of stakeholders. The 2016 rules also introduced more stringent regulations on e-waste production and clarified the definition of e-waste. A significant aspect was the reinforcement of the Extended Producer Responsibility (EPR), requiring producers to obtain EPR authorization from the Central Pollution Control Board (CPCB) and to achieve specific collection targets. The rules also mandated authorization for manufacturers, dismantlers, and recyclers from the State Pollution Control Boards (SPCBs). To further refine the regulatory landscape, the E-waste Management Rules were amended in 2018.[9] These amendments relaxed the e-waste collection targets by 10% annually for the initial years and empowered the Central Pollution Control Board (CPCB) to randomly select electronic equipment on the market for testing compliance, with the financial cost of testing being borne by the government.

The most recent and comprehensive iteration of the e-waste management regulations in India is the E-waste (Management) Rules, 2022, which came into force on April 1, 2023. These rules represent a significant revision of the previous framework, aiming to manage e-waste in an environmentally sound manner through an improved Extended Producer Responsibility (EPR) regime. Key provisions of the 2022 rules include mandatory registration on the CPCB portal for all manufacturers, producers, refurbishers, and recyclers, an expanded product coverage including 106 items under seven categories, a focus on recycling targets as EPR obligations in terms of end products, and the introduction of provisions for environmental compensation and verification & audit. These rules also promote the circular economy through the EPR regime and scientific recycling/disposal of e-waste. Subsequent amendments in 2023 further refined the regulatory landscape. The E-Waste (Management) Second Amendment Rules, 2023, issued on July 24, 2023, focused on ensuring the

implementation of approved destruction technologies for managing refrigerants generated during the manufacture and end-of-life of refrigeration and air-conditioning equipment. These amendments also addressed exemptions under the Restriction of Hazardous Substances (RoHS) rules.[10]

Analysis of the Current Legal Framework: The E-waste (Management) Rules, 2022

The E-waste (Management) Rules, 2022, establish a comprehensive framework for the environmentally sound management of electronic waste and apply to every manufacturer, producer, refurbisher, dismantler, and recycler involved in the lifecycle of electrical and electronic equipment (EEE) listed in Schedule I. This includes their components, consumables, parts, and spares that make the product operational. At the core of the 2022 rules lies the Extended Producer Responsibility (EPR) framework.[11] This framework mandates that producers of electrical or electronic equipment listed in Schedule I are responsible for meeting recycling targets as per Schedule III and Schedule IV, solely through registered recyclers of e-waste. A key requirement under the EPR framework is the mandatory registration of producers on the online portal developed by the Central Pollution Control Board (CPCB). The annual recycling targets for producers are specified in Schedules III and IV and are based on the quantity of EEE placed in the market in previous years and the average lifespan of the products.[1] Producers fulfill their EPR obligations by purchasing EPR certificates online from registered recyclers and submitting them quarterly.[1] The quantity of EPR certificates eligible for generation by recyclers is calculated based on the quantity of the end product and a conversion factor determined by the CPCB. The rules also incentivize refurbishing through the concept of refurbishing certificates, which allow producers to defer their EPR obligation for the extended life of the product.

In line with international efforts to restrict the use of hazardous substances in electronics manufacturing, the 2022 rules incorporate provisions for the reduction of hazardous substances (RoHS compliance). Producers of EEE listed in Schedule I must ensure that new equipment and their components do not contain Lead, Mercury, Cadmium, Hexavalent Chromium, polybrominated biphenyls, and polybrominated diphenyl ethers beyond specified maximum concentration values. Schedule II provides exemptions from these limits for certain applications or specifies particular limits.

The 2022 rules also lay down regulations for the entire process of e-waste management, including collection, storage, transportation, dismantling, and recycling. Manufacturers, producers, refurbishers, and recyclers are permitted to store e-waste for a period not exceeding one hundred and eighty days, with a possible extension up to three hundred and sixty-five days by the CPCB under specific circumstances. All entities involved in the handling of e-waste are required to obtain authorization from the relevant State Pollution Control Boards (SPCBs) or Pollution Control Committees (PCCs) and must adhere to the guidelines issued by the CPCB.

To ensure compliance and deter violations, the 2022 rules include provisions for environmental compensation to be imposed by the CPCB for non-compliance, non-fulfilment of EPR obligations, and the use of false EPR certificates. The funds collected as environmental compensation are to be kept in a separate Escrow account and utilized for various e-waste management initiatives. Additionally, the rules specify that providing incorrect information for obtaining EPR certificates, using false certificates, willfully violating directions, or failing to cooperate in verification and audit proceedings can lead to prosecution under Section 15 of the Environment (Protection) Act, 1986.

Challenges in Implementation and Enforcement of E-waste Management Laws in India

Despite the progressive nature of the e-waste management laws in India, their effective implementation and enforcement face several significant challenges. A primary obstacle is the overwhelming dominance of the informal sector in the collection and recycling of e-waste.[12] This sector, handling over 90% of the collection and 70% of recycling, typically employs rudimentary and hazardous methods such as open burning and acid leaching to extract valuable materials.[13] These practices lead to significant environmental pollution, including contamination of air, water, and soil, and pose severe health risks to the workers involved, who often lack basic protective equipment and awareness of the dangers. The sheer scale and decentralized nature of the informal sector make it exceedingly difficult to monitor their activities and enforce formal regulations effectively.

Another significant challenge is the inadequate infrastructure and insufficient financial investment in the formal e-waste recycling sector. While the number of authorized recyclers has increased, their overall capacity remains limited compared to the volume of e-waste generated.[14] Furthermore, many existing authorized recycling facilities operate at underutilized capacities, often struggling to secure sufficient quantities of e-waste due to the dominance of the informal sector and a lack of robust collection mechanisms. The high upfront

costs associated with establishing and operating environmentally sound recycling facilities also deter greater investment in the formal sector.

Low levels of awareness and participation among consumers and bulk consumers regarding the importance of proper e-waste disposal and the availability of formal channels further impede the effectiveness of the regulations. Many individuals and organizations are either unaware of the environmental and health consequences of improper disposal or lack the knowledge about where and how to properly dispose of their electronic waste.[12] The absence of convenient and accessible collection points, particularly in rural areas, also contributes to improper disposal practices.

Weak enforcement of the existing regulations by the relevant authorities poses another significant challenge. Limited resources and personnel within regulatory agencies often hinder their ability to effectively monitor compliance, especially within the vast and dispersed informal sector. The lack of stringent penalties for non-compliance and the unwillingness to publicly share information on compliance and regulatory actions further exacerbate the issue.[15]

Legal Determinants of E-Waste Recycling Efficiency and Environmental Quality in India

Government data indicates a positive trend in the proportion of e-waste being processed in India, rising from 22% in 2019-20 to 43% in 2023-24.[1] However, a substantial amount, approximately 57%, still remains unprocessed.[14] Notably, some sources report significantly lower formal recycling rates, around 5% of the total e-waste generated. This discrepancy in reported figures suggests challenges in accurately quantifying e-waste recycling rates in India, potentially due to the significant role of the informal sector and variations in data collection methodologies.

Despite the regulatory framework, the environmental impact of e-waste management practices in India remains a serious concern. Improper handling and disposal, particularly within the dominant informal sector, continue to pose significant environmental risks.[12] The burning of e-waste and crude smelting processes release harmful pollutants into the air, including dioxins, furans, and particulate matter. The leaching of heavy metals and other toxic substances from landfills and unscientifically managed recycling sites contaminates water sources, including groundwater and rivers. Soil contamination from the dumping and improper processing of e-waste further degrades ecosystems and poses risks to human health through the food chain.

The effectiveness of the current e-waste management laws in mitigating these environmental and health hazards is limited by the persistent challenges in their implementation and enforcement. While the regulations aim to promote environmentally sound practices and increase recycling rates through the EPR framework and other provisions, the continued dominance of the informal sector, coupled with inadequate infrastructure, low public awareness, and weak regulatory oversight, hinders the achievement of the intended outcomes. Addressing these fundamental challenges is crucial to realizing the full potential of the legal framework in safeguarding the environment and public health from the adverse impacts of electronic waste.

Ongoing Trends Related to E-waste Management in India

The effectiveness of the Extended Producer Responsibility (EPR) framework in India is a subject of ongoing discussion and concern. While the EPR mechanism aims to make producers responsible for the end-of-life management of their products, debates persist regarding the ambition of the recycling targets and the practical challenges faced by producers in achieving them. Legal clashes between the government and electronics manufacturers concerning recycling costs further underscore the complexities and tensions surrounding the implementation of the EPR framework.[16]

The role and integration of the informal sector in e-waste management are also subjects of significant debate.[12] While some argue for leveraging the informal sector's extensive network and expertise in collection, others raise concerns about their unsafe and environmentally damaging recycling practices and lack of regulatory compliance. Finding effective ways to formalize and regulate the informal sector while ensuring environmental protection and worker safety remains a critical challenge.

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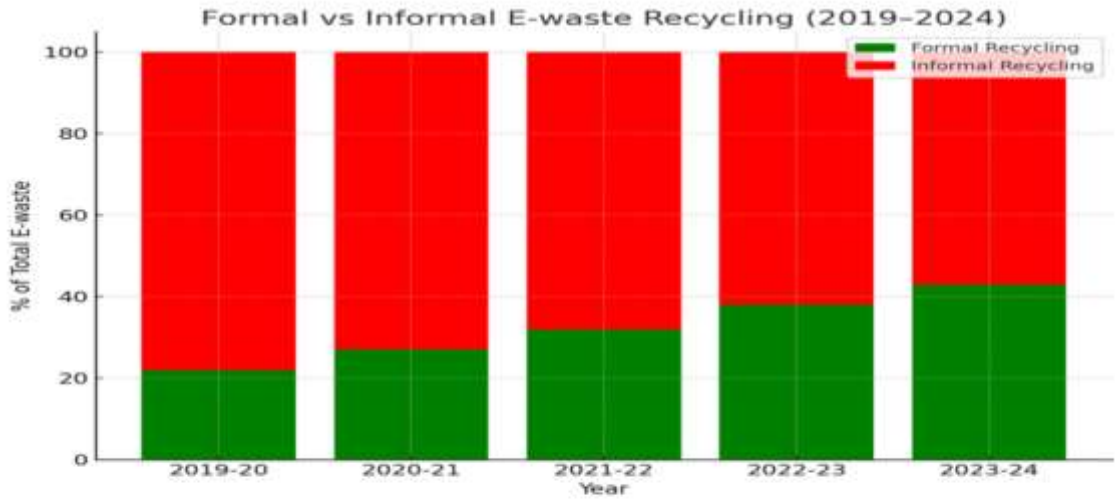

Figure 2: Formal vs Informal E-waste Recycling in India (2019–2024)
Source: Estimated from official CPCB data (Annual Reports on E-Waste Management, 2020–2024)

The increasing volume and complexity of e-waste generation, driven by rapid technological advancements and shorter product lifecycles, also pose significant issues for e-waste management in India. This rapid obsolescence leads to a continuous increase in the amount of e-waste generated, while the increasing complexity of electronic devices, with their diverse materials and intricate designs, makes recycling processes more challenging and necessitates continuous updates to the regulatory framework.

Finally, the illegal import and transboundary movement of e-waste into India, often disguised as donations or reusable equipment, further complicate the e-waste management efforts in the country.[12] This influx of e-waste from other countries adds to the domestic burden and can undermine national management strategies, as the imported waste may not always be accounted for or treated under the existing regulatory framework.

Way Forward for Improving the E-waste Management in India

To enhance the effectiveness of e-waste management in India, several key areas require focused attention and strategic interventions. Strengthening the enforcement and monitoring mechanisms for the existing e-waste management laws is paramount. This involves increasing the capacity of regulatory bodies to conduct regular inspections, track compliance by all stakeholders, and take stringent action against violations, particularly within the informal sector.

Promoting greater investment in research and development (R&D) of environmentally sound and cost-effective recycling technologies is crucial for improving material recovery rates and reducing the reliance on hazardous recycling methods. Encouraging innovation in recycling processes can lead to more efficient extraction of valuable materials and minimize the environmental footprint of e-waste management.

Developing effective strategies for the formalization and integration of the informal e-waste sector is essential. This can be achieved by providing training and capacity building to informal workers on safe and environmentally sound recycling practices, facilitating their access to better technologies, and ensuring their integration into the formal system with proper regulations and safeguards.

Enhancing public awareness and education campaigns is vital to inform consumers and bulk consumers about the hazards of improper disposal and the importance of utilizing formal collection channels. Effective awareness programs can motivate behavioral change towards responsible e-waste disposal practices.

Exploring the implementation of economic incentives, such as deposit-refund schemes and tax benefits for recycling, as well as disincentives like penalties for improper disposal, can further promote formal recycling and discourage environmentally harmful practices.

Finally, continuous policy revisions and updates are necessary, drawing upon international best practices, lessons learned from the implementation of the current rules, and the evolving challenges in the e-waste sector.

The regulatory framework should be dynamic and adaptive to ensure its long-term effectiveness in managing the growing e-waste challenge in India.

CONCLUSION

The e-waste management laws in India have evolved significantly over the years, culminating in the comprehensive E-waste (Management) Rules, 2022, which incorporate key principles like Extended Producer Responsibility and aim to align with international standards. However, despite these advancements, the effective management of e-waste in India continues to be hampered by challenges such as the dominance of the informal sector, inadequate infrastructure, low public awareness, and weak enforcement mechanisms. While there has been some progress in increasing recycling rates, a substantial gap remains between the e-waste generated and the amount formally recycled, and improper practices persist, posing significant environmental and health risks. Addressing these challenges requires a concerted and multi-faceted approach involving stricter enforcement, greater investment in technology and infrastructure, the formalization of the informal sector, enhanced public awareness, and the implementation of effective economic incentives. Continuous learning from international best practices and regular updates to the regulatory framework are also essential to ensure a sustainable and environmentally sound future for e-waste management in India, ultimately protecting the environment, safeguarding public health, and promoting a circular economy for electronics.

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