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E WASTE MANAGEMENT IN INDIA: CHALLENGES AND A PATH TO SUSTAINABILITY

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ABSTRACT

Electronic garbage, or "e-waste," which includes outdated or discarded electronic appliances, has increased in tandem with the exponential expansion in the use of electronic devices. Lead, mercury, and brominated flame retardants are among the dangerous materials found in e-waste that can leak into the environment and pollute the soil, water and air while also posing major health concerns to people and wildlife.

At almost 2 million metric tons per year, India is currently the world's third-largest producer of electronic garbage, or "e-waste." Computer machines produce the majority of this waste, followed by telephones and other electronic equipment. Significant geographic differences were highlighted by the approximately 150% increase in e-waste volumes during the six-year period (2017–2024), with the majority of the waste concentrated in about 65 urban areas and 10 states.

Only a small portion of e-waste is collected and recovered by the formal sector, regardless of current legislation. The informal recycling sector in India, which manages more than 95% of e- waste using crude techniques that emit harmful chemicals, makes the e-waste situation worse.

This paper highlights the present scenario of e-waste in various parts of India in comparison to world while highlighting the challenges.

In the end this paper also offers various sustainable strategies aligned with circular economy principles to enhance resource efficiency and practice the sustainable development strategies.

KEYWORDS: Electronic devices, Environment, Sustainable development, EPR, India, Informal Sector, Circular Economy

INTRODUCTION

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E Waste

Electronic trash or E Waste covers everything from outdated electronics like VCRs and CRT monitors to more recent gadgets like smartphones, laptops, and tablets. It also includes any electrical and electronic devices that are broken, outdated, or no longer needed. India is one of the countries that produce the most electrical garbage globally. Every year, outdated laptops, smartphones, home appliances, and even industrial electronics add significantly to the amount of waste produced. Toxic elements including lead, mercury, and cadmium can contaminate the environment and pose serious health hazards if waste is not properly disposed of.

According to the United Nations Environment Programme (UNEP), e-waste covers all components, subassemblies, and consumables of electronic equipment at the point they are designated as waste.

The Step (Solving the E-waste Problem) initiative defines e-waste as: "*items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use*"

According to UN estimates, 53.6 MT of e-waste were produced globally in 2019 and this figue continues to rise. After China and the United States, India is the third-biggest producer of e- waste. The amount of e-waste generated in India has increased by 72.54% in the last five years, from 1.01 million metric tons (MT) in 2019–20 to 1.751 million MT in 2023–24. Recycling rates for e-waste increased from 22% in 2019–20 to just 43% in 2023–24.

Chi et al. (2011) and Dwivedi and Mittal (2013) underrated the significant influence of consumer behavior on patterns of e-waste disposal. Their research found that households generally have low awareness about formal recycling options. Awasthi et. al.(2021) pointed out while recycling creates jobs, it jeopardizes the health of workers and damages the environment. The research recommends incorporating informal workers into official systems.

Balde et al. (2020), in the Global E-waste monitor reported a continuous growth in e-waste generation in worldwide, highlighting that only 17.4% of e-waste is formally recycled worldwide. The study emphasized the importance of circular economy strategies but pointed out weak global enforcement mechanisms.

Objectives of the Study:

- To examine the trends and patterns of e-waste generation in India
- To analyze the environmental and health impacts associated with e-waste.
- To study the role of the informal sector in e-waste recycling

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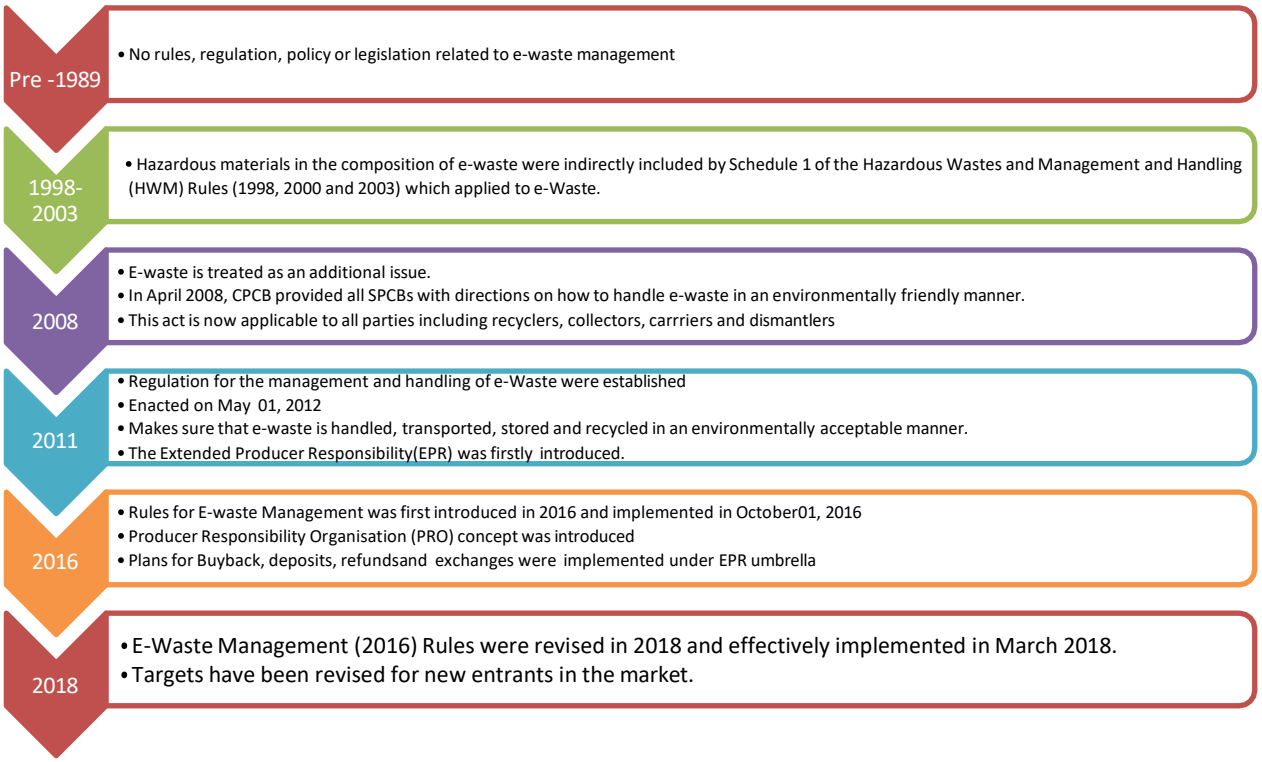
• To critically evaluate the effectiveness of e-waste management policies in India.
• To propose sustainable solutions for effective management.

Evolution of E-Waste Management in India



Who generates E-Waste

E-waste Generator category	Types of Waste
Household/Consumers	The disposal of large equipment such as refrigerators (675 kt), washing machines (630 kt), air conditioners, televisions, cellphones, and computers accounts for almost 70% of the entire amount of e-waste generated.
Business Houses/Institutions	About 30% of the waste produced at businesses and institutions comes from a variety of electronics, including servers, printers, lab tools, medical devices, water dispensers, and more.

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Manufacturers/Producers	Manufacturers indirectly contribute to e-waste, even though they are not as frequently regarded as direct generators. For instance, they must oversee the electronics of their own products at the end of their useful lives in accordance with Extended Producer Responsibility (EPR) laws. This obligation has an indirect impact on the flow of e-waste, particularly from abandoned goods.
Unorganized Sector	A significant amount of e-waste is distributed through unofficial routes, such as dismantlers and scrap dealers, or "kabadiwalas," rather than through official channels. These actors manage
	Collection and recycling, frequently using unsafe and environment hazardous methods.
Imported Waste	Additionally, India imports e-waste from other nations. These are discarded electronics that are coming into the nation, which raises the amount of e-waste.

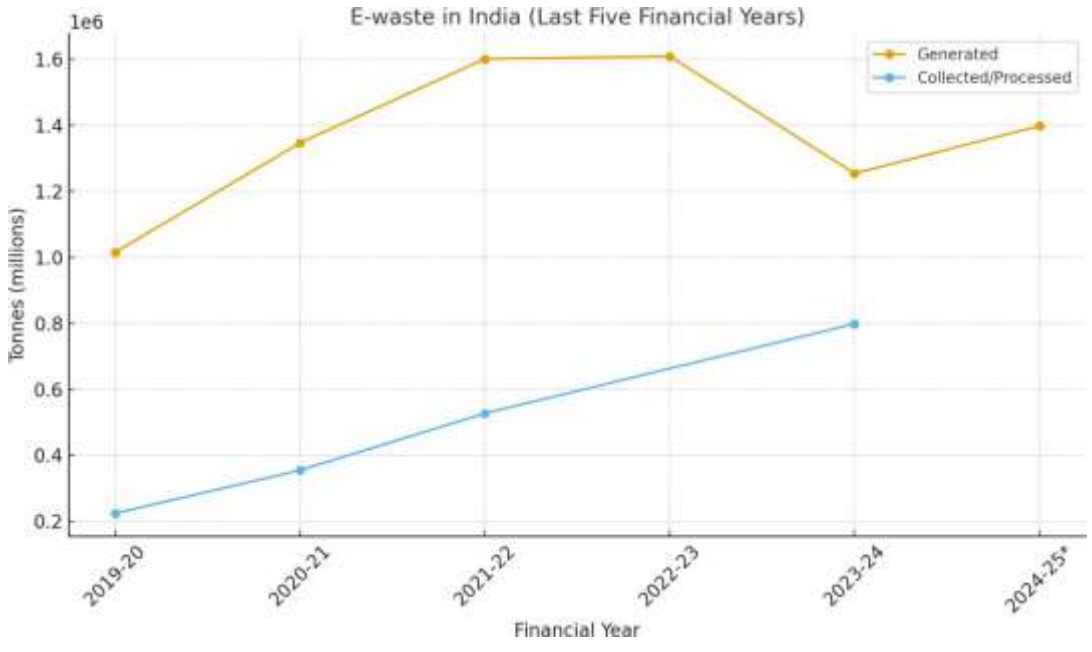

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Table 1 Generation and Collection of E-waste in India (2019–20 to 2024–25*)

Financial Year	E-waste Generated (tonnes)	Collected / Processed (tonnes)	Collection Rate (%)
2019-20	1,014,961.21	224,041.0	22.07
2020-21	1,346,496.31	354,540.7	26.33
2021-22	1,601,155.36	527,131.57	32.92
2022-23	1,609,117.0	n/a	—
2023-24	1,254,286.55	798,493.0	63.66
2024-25*	1,397,955.59	n/a	—

Sources. Press Information Bureau (2022); Rajya Sabha Q. No. 535 (24 July 2025); CPCB report to National Green Tribunal (2024).

Despite regular interventions, e-waste management in India remains inefficient due to structural challenges such as inadequate infrastructure, weak enforcement of policies, and the dominance of the informal sector, which handles nearly 90-95% of recycling activities using unsafe methods.

Factors Calling for E-Waste Management

Effects on the Environment

E-waste from screens, laptops, and telecom equipment increased by 163% between 2010 and 2022 in India. India produces about 2 million tons of e-waste a year, making it the third-largest producer in the world. More than 95% of e-waste is treated informally using dangerous techniques like acid leaching and open burning, which pollutes the air, water, and soil. Water containing high amounts of lead, mercury, and cadmium is contaminated by informal recycling that uses acid to extract valuable metals.

Soil Degradation: Dumped electronics release toxic heavy metals including lead, cadmium, and mercury into the soil, decreasing productivity and affecting food crops.

Water Toxicity: Drinking water and aquatic communities are harmed when pollutants from e-waste landfills mixes with groundwater and rivers.

Air Pollution: Toxic gasses like dioxins and furans are released during informal recycling processes (burning wires, melting plastics), which exacerbate air pollution and global warming.

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Natural Resource Depletion: When electronics are thrown away without being recycled, rare earth elements and precious metals (copper, palladium, silver, and gold) are permanently lost, which puts more pressure on mining operations and negatively impacts the environment.

Contribution to Climate Change: Greenhouse gas emissions and the energy-intensive manufacturing of new gadgets are two factors that contribute to climate change.

Effects of Health on Society:
Lead, cadmium, mercury, chromium, flame retardants, polymers, and other dangerous substances are found in e-waste and can harm the nervous system, reproductive system, kidneys, and cause cancer, among other problems.

Toxic Nature: Workers that are involved in informal recycling are exposed to toxic substances, which can lead to cancer, allergies, kidney damage, and respiratory illnesses. Workers in Bangalore and Chennai have higher amounts of Zn, Cu, Pb, and Mn in their hair, according to analyses.

Impact on Women and Children: Early exposure puts children at higher risk for neurological diseases, defense weakness, and developmental delays. Up to 80% of youngsters at comparable e-waste sites around the world have dangerously elevated blood lead levels. They experience long-term developmental impairment, migraines, respiratory issues, and constant nausea.

Birth complications and birth abnormalities are more likely to occur in pregnant women.

Public Health Burden: The growing number of pollution-related illnesses brought on by exposure to e-waste puts a load on the public health system and raises healthcare expenses.

Occupational hazards: include working without safety equipment, getting hurt when disassembling things, and having a lower life expectancy as a result of long-term exposure.
In Hyderabad, just 16% of informal workers used any protective gear (e.g., goggles), while most couldn't understand associated health risks.

Social and Economic Effects
Only over 5% of e-waste makes it to official recycling facilities; the remainder is left unmanaged, causing risks to human health and the environment. The potential of the circular economy and the preservation of economic value are undermined by the enormous amounts of valuable materials (gold, copper, rare earths) that remain unrecovered.

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Dependency on the Informal Sector: Informal recyclers, who lack infrastructure and scientific expertise, manage almost 90% of e-waste in nations like India. For instance, scrap laborers in Gujarat make about ₹50,000 (~US$580) a month by indiscriminately disassembling equipment.

Poverty & Exploitation: Because of their hazardous working circumstances and extreme social inequalities, informal laborers make relatively little money while taking on the greatest dangers.

Economic Value Loss: Ineffective recycling methods and inappropriate disposal result in the annual loss of recoverable metals valued at billions of rupees.
Barriers to the Circular Economy: Unregulated recycling impede the growth of a sustainable "circular economy," in which resources might be reprocessed to create new goods.

Long-term and worldwide effects
Trans boundary E-waste Movement: Environmental injustice is frequently caused when affluent countries dump their e-waste in developing countries.

Ecological Imbalance: Long-term ecological health and biodiversity are threatened by persistent organic waste and heavy metals that find their way through into food chains. For decades, toxins exist in the environment, posing health and environmental risks to subsequent generations.

Global Inequality: While developed countries profit from technology, developing nations are disproportionately responsible for the health and environmental expenses associated with discarded gadgets. Telangana processed over 119,000 MT of e-waste in 2024–2025—a significant increase from 65,226 MT the year before, according to The Times of India.

Delhi is developing a world-class e-waste facility that is modeled after Norway's Revac model. It will have air scrubbers, water reuse systems, concrete flooring to prevent soil contamination, and mechanical dismantling to reduce pollution—all of which are examples of sustainable recycling infrastructure.

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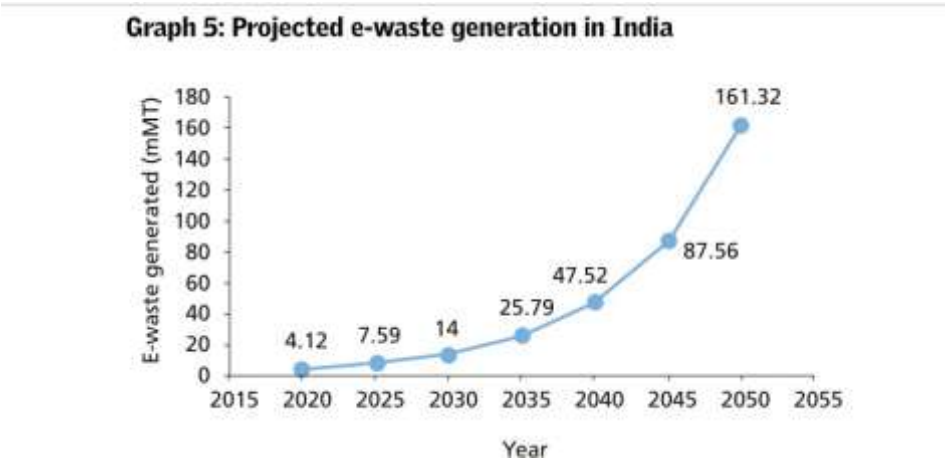

Techniques/ Strategies for E Waste Management

Managing e-waste is a top priority in many wealthy nations. In India, consumers have the solution to improved e-waste management. The goal of programs like Extended Producer Responsibility, Design for Environment, and the 3Rs (Reduce, Reuse, Recycle) technology platform, which connects the market and supports the circular economy, is to increase the rate of reuse and recycling of e-waste and to encourage consumers to adopt sustainable consumption habits.

While e-waste in India is rapidly increasing, processing is getting better, and by 2024–2025, it will reach over 70% of the country's total. Telangana became the third-largest contributor in India in FY 2024–2025 by processing over 1 lakh metric tonnes of e-waste, up from 65,226 MT in FY 2023–2024. To lessen the harm to the environment and public health, it is crucial to properly dispose of electronics through e-waste recycling programs. These initiatives can recycle costly components from electronic devices for future use and safely remove and dispose of hazardous metals.

Donate or Sell Functional Electronics

You can sell your device or give it to someone who might benefit from it if it's still in good working order. You may list and sell secondhand devices on a lot of websites. If they are still usable, you can also give them to local organizations or charity.

The two most prevalent types of e-waste are computers and cell phones. When disposed of properly, the majority of e-waste effectively still operational!

Companies that install new gear and systems annually might have a significant influence on the environment. One great method to reduce this waste and also benefit those in need is to donate computers to nonprofits or educational institutions.

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Understand State Laws Regarding the Disposal of Batteries:
Battery disposal is governed by regulations in several states. When it comes to disposing of solid waste and batteries of any kind, including laptop and cell phone batteries, it's critical to understand your state's laws.

It is against the law in several states to dispose of batteries in the garbage or recycling bin. Batteries should always be returned to the maker or taken to a suitable disposal facility by both individuals and corporations.

Make sure you are abiding by all local battery disposal requirements because improper battery disposal can have disastrous environmental effects. Batteries must be handled carefully since they contain hazardous substances like lead and mercury.

Put your electronics in order:
By keeping everything in its own location and within easy reach, organizing your gadgets can help cut down on e-waste. You can more easily keep track of what works and what doesn't when you have a system in place for organizing your technological equipment. More rapidly, you may decide when something needs to be recycled.

Assume you have several gadgets that you utilize for various tasks. If so, labeling them will help you understand why they're there and when to replace them.

Furthermore, there will be several chargers and accessories because every member of the family now has access to cellphones, PCs, tablets, and other devices. The quantity of e-waste will be decreased by sharing these chargers and accessories.

Pay attention to the three Rs.
The ideal approach to managing e-waste is to follow the three Rs: reduce, reuse, and recycle.

Reduce: Make every effort to utilize fewer devices. This involves buying only what you require and utilizing energy-efficient items.
Reuse: Try to find someone who can use outdated equipment or repurpose them for other use rather than discarding them.
Recycle: Be sure to recycle electronic devices appropriately when it's time to get rid of them. There can be particular rules in your location, so be sure to ask the local authorities how to proceed. Our e-waste problem may be significantly reduced and the environment can be preserved for future generations by consuming less and recycling more.

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Check Your State's E-Recycling Centers:

Recycling is crucial for decreasing down on e-waste. Look for recycling facilities in your state to be sure you're disposing of gadgets the right way. These facilities focus on disposing of electronic trash in a responsible and safe manner. Additionally, they frequently provide collection services and educational resources to help you reduce the amount of e-waste you produce.

One excellent approach to get rid of old gadgets without damaging the environment is to recycle them. Additionally, they assist you in safely and ethically recycling.

Increasing Consumer Knowledge for Appropriate E-Waste Disposal:

It is essential that customers know how to properly dispose of e-waste. To inform people about the risks of inappropriate disposal and the value of recycling, the government and non- governmental organizations must start comprehensive awareness programs. Improving community involvement would be greatly aided by the possibility of including Resident Welfare Associations (RWAs) and Self-Help Groups (SHGs) in raising awareness and directing individuals toward the proper disposal of e-waste. Customers will also be more inclined to adopt sustainable activities if they are informed about the current disposal systems, such as collection locations and secure recycling procedures.

Enhancing E-Waste Recycling via EPR Pricing and Implementation:

A reasonable EPR floor price guarantee that recyclers receive fair reimbursement for the labor, facilities, and technology they have invested in. This will stop unauthorized, deceptive recycling operations and make recycling economically feasible.

Strict penalties for fraud or non-compliance, digitization of EPR certificate tracking, and robust audit systems are essential for effective enforcement.

This would guarantee compliance with appropriate disposal procedures and assist in reducing illicit recycling.

(Sources: CSE 2020)

CONCLUSION:

Resolving India's e-waste problem presents a big chance to promote economic expansion and sustainable development. India can successfully reduce threats to the environment, economic development and human health while also generating economic benefit by improving the regulatory framework, bolstering enforcement tactics, and encouraging innovation in recycling technologies. Addressing these challenges requires a multi- stakeholder’s approach that integrates policy

enforcement, technological innovation and behavioral changes. By turning e- waste into a catalyst for green growth and helping to create a genuinely circular economy, this approach supports SDG 12 (Responsible Consumption and Production).

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