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From Crisis to Circularity: A Legal Perspective on E-Waste Management in India

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Abstract

The proliferation of electronic devices in the contemporary digital age has precipitated a parallel rise in electronic waste (e-waste), rendering its management a pressing global environmental and public health concern. This research article undertakes a critical examination of the evolving challenges associated with e-waste governance, with an emphasis on India and other nations within the Global South. E-waste comprises obsolete electrical and electronic equipment embedded with hazardous substances such as lead, cadmium, and brominated flame retardants, which, when mismanaged, result in severe ecological degradation and adverse health outcomes. The predominance of informal recycling sectors employing unsafe methods exacerbates these risks, particularly in low and middle-income countries. Despite the framework established under the Basel Convention to regulate transboundary movements of hazardous waste, the illicit export of e-waste from developed to developing regions remains a persistent issue. In India, although the regulatory landscape has evolved most notably through the E-Waste (Management) Rules, 2016, and the subsequent 2022 amendments emphasizing Extended Producer Responsibility (EPR); compliance gaps, weak enforcement, and limited public awareness continue to hinder effective implementation. The recent introduction of the Battery

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Waste Management Rules, 2022, further demonstrates a legislative shift towards integrated resource recovery and sustainable waste handling practices. The research concludes that an effective e-waste management regime must integrate legislative reform, formalization of the recycling sector, technological innovation, and multi-stakeholder engagement.

Keywords: *E-Waste Management, Extended Producer Responsibility, Batter Waste Management, UN, Electronic Garbage*

1. INTRODUCTION

E-waste has grown at an unprecedented rate in recent years on a global scale. The COVID-19 pandemic further fuelled this increase because of the changing work culture that has made individuals more reliant on their electronic devices than ever before. However, e-waste governance has proven to be a complicated issue, especially in the Global South. Discarded electrical and electronic equipment is referred to as "e-waste" because it frequently contains dangerous substances like lead, cadmium, and flame retardants. When this trash is not correctly managed, harmful substances are released into the environment, posing major threats to human health.

At present, the Global South is leading the way in electronics production to satisfy both their own population's requirements and the expanding wants of the Global North. According to the United Nations' Global E-waste Monitor 2020, the world created an unprecedented 53.6 million metric tons of e-waste in 2019, a 21% increase in just 5 years. That same report states that Asia created 24.9 million tons of e-waste in 2019, with the United States and two Asian economies, such as China and India, contributing 38% of the total.[1]

E-waste is increasing quickly in India, which is made worse by inadequate public awareness and ineffective management techniques. Nearly 92.2% of Indian users are not aware that they contribute to e-waste, even though more than 72.8% of them have already disposed of their electronic garbage.[2] In India collecting, transportation, separation, processing, and recycling of the e-waste are all done by unregulated

1 VANESSA FORTI ET AL., THE GLOBAL E-WASTE MONITOR 2020: QUANTITIES, FLOWS AND THE CIRCULAR ECONOMY POTENTIAL (2020), https://collections.unu.edu/view/UNU:7737 (last visited Apr 08, 2025).

2 Divayana Pawar & Jacinth Dhaya, *A Study To Assess The Effectiveness Of Self-Instructional Module On Knowledge Regarding E-Waste Management Among Mobile Phone Users In Selected City.*, 44 LIBRARY PROGRESS INTERNATIONAL 8126 (2024).

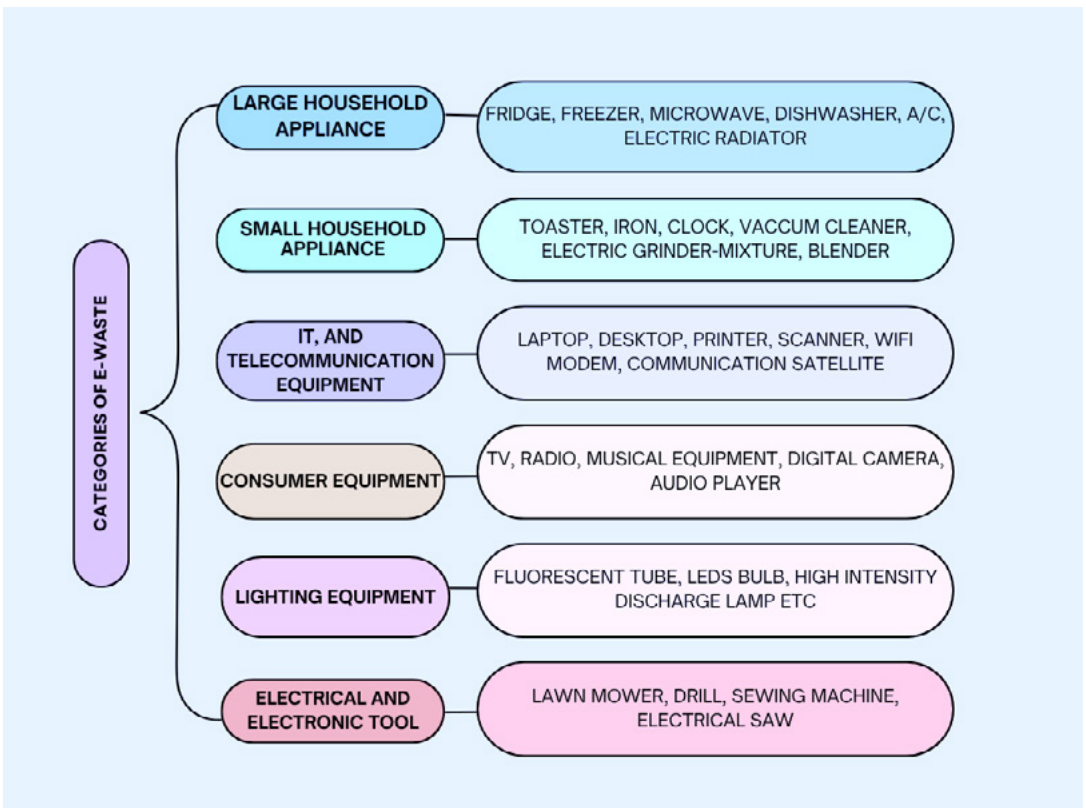
informal sector. This leads to the adoption of hazardous techniques like acid-leaching and open incineration as well as the ineffective recovery of valuable materials.

2. Types of E-Waste Management

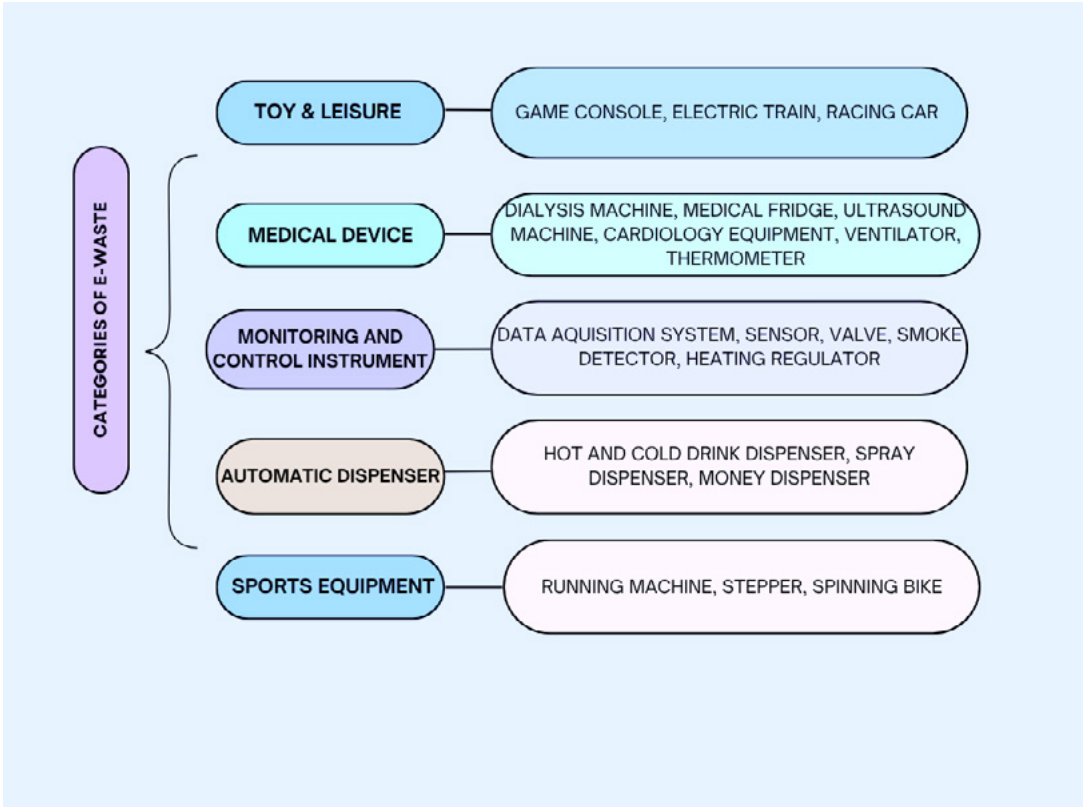
Depending on where electrical devices come from and what they are used for, e-waste can be divided into different categories.[3] Ten distinct categories of e-waste are recognized worldwide (Figure 1). Numerous variables, including as socioeconomic circumstances, consumer behaviour, population density, and the reliance of households and businesses on electrical and electronic devices, can affect the average percentage of each type of e-waste.

Figure 1

Categories of E-waste



3 Waste Electrical and Electronic Equipment recycling (WEEE), https://www.hse.gov.uk/waste/waste-electrical.htm (last visited Apr 08, 2025).



3. Recycling E-waste

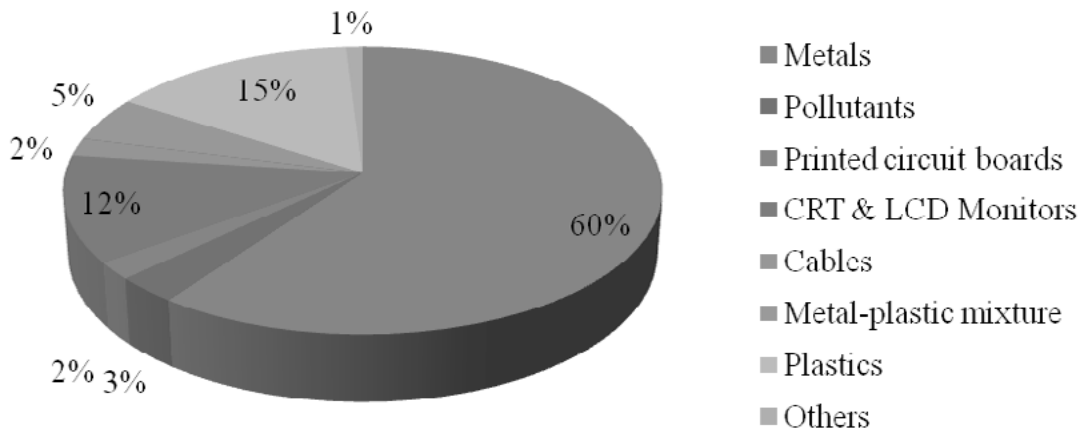
E-waste typically comprises both potentially hazardous and useful items. Electronic device type, model, manufacturer, date of production, and scrap age are some of the major determinants of e-waste composition.[4] A variety of components, including metals, glass, and plastics, are included in e-waste (Figure 2). Recycling e-waste can be challenging since it contains metals with a variety of physicochemical characteristics, including dangerous halogen metals. If substances containing these hazardous compounds are not disposed of properly, they may represent a threat to the environment. In order to lessen the risks to human health and the harm that landfilling brings to the environment, it is now the duty of the entire world to manage trash appropriately and dispose of e-waste responsibly. Only 17.4% of the world's

4 Daniel Mmereki et al., *The Generation, Composition, Collection, Treatment and Disposal System, and Impact of E-Waste*, *in* E-Waste in Transition - From Pollution to Resource (2016), https://www.intechopen.com/chapters/49247 (last visited Apr 08, 2025).

e-waste is collected and recycled due to the challenges of collection and recycling. [5]

Figure 2

Composition of E-waste



Source:- Daniel Mmereki et al., *The Generation, Composition, Collection, Treatment and Disposal System, and Impact of E-Waste*, *in* E-WASTE IN TRANSITION - FROM POLLUTION TO RESOURCE

Acid baths, dioxins, and heavy metals can be produced by e-waste recycling techniques such open burning, metal acid stripping, and incineration.[6] Even though e-waste resource recovery can lead to employment possibilities and business opportunities, insufficient infrastructure and effective scientific technologies may make it more difficult to handle. Because of this, managing e-waste is considered one of the major worldwide issues of the twenty-first century, presenting grave risks to both human health and the environment.

4. INTERNATIONAL LEGAL REGIME

International collaboration is necessary to effectively address the global e-waste issue. As technology advances and e-waste output increases, worldwide collaboration will be vital to maintaining our planet's long-term sustainability. The "*Basel Convention*

5 I. M. S. K. Ilankoon et al., *E-Waste in the International Context – A Review of Trade Flows, Regulations, Hazards, Waste Management Strategies and Technologies for Value Recovery*, 82 WASTE MANAGEMENT 258 (2018).

6 Qingyuan Dai et al., *Severe Dioxin-like Compound (DLC) Contamination in e-Waste Recycling Areas: An under-Recognized Threat to Local Health*, 139 ENVIRONMENT INTERNATIONAL 105731 (2020).

on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal" is an international convention that became effective in May 1992.[7] This convention restricts the transfer of electronic trash from developed to developing nations. Over 180 nations signed the Basel Convention in Switzerland, implementing legalizations that decreased global transportation of the hazardous waste. However, the issue of e-waste has yet to be resolved completely. According to estimates, the European Union (EU) unlawfully exports 352,474 tones of e-waste to underdeveloped countries per year.[8] The US has decided not to ratify the agreement even though it is one of the biggest manufacturers of e-waste worldwide.

The Basel Convention defines Waste Electrical and Electronic Equipment (WEEE) as "*electrical or electronic equipment that is no longer in use, including all components, sub-assemblies, and consumables that were part of the equipment at the time of disposal*". E-waste is one of the world's most rapidly rising waste streams.[9] The Basel Convention distinguishes different types of e-waste as either hazardous or non-hazardous waste. It further classifies e-waste as hazardous, if it contains toxic compounds such as mercury, brominated flame retardants, or lead.

E-waste may also contain certain precious metals like gold, copper, and nickel, and several rare materials with strategic significance like indium and palladium. The said convention further addresses the challenge caused by e-waste by a three-way approach. Firstly, it talks about curbing the e-waste problem by reassuring responsible consumption and also production through policies like Extended Producer Responsibility (EPR).[10]

The convention secondly also advocates "environmentally sound management" (ESM)[11] by promoting a safe treatment of e-waste. This process includes dismantling

7 Basel Convention > The Convention > Overview > Text of the Convention, https://www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx (last visited Apr 08, 2025).

8 EU e-waste "illegally" exported to developing countries: Report, EURONEWS (13:44:46 +01:00), https://www.euronews.com/my-europe/2019/02/07/eu-e-waste-illegally-exported-to-developing-countries-report (last visited April,08 2025).

9 Basel Convention > The Convention > Overview > Text of the Convention, *supra* note 7. Annex II, page no. 39

10 Thirteenth Meeting of the Conference of the Parties to the Basel Convention, https://www.basel.int/TheConvention/ConferenceoftheParties/Meetings/COP13/tabid/5310/Default.aspx (last visited Apr 08, 2025).

11 Basel Convention > Implementation > Country Led Initiative > Environmentally Sound Management > ESM Framework, https://www.basel.int/Implementation/CountryLedInitiative/EnvironmentallySoundManagement/ESMFramework/tabid/3616/Default.aspx (last visited Apr

electronic gadgets to recover treasured materials such as gold and copper, which can be recycled and reused in manufacturing, minimizing reliance on virgin resources. It ensures a proper disposal of hazardous components preventing environmental contamination.

Lastly and thirdly, the Convention implements the "Prior Informed Consent" (PIC)[12] procedure, which requires the exporting countries to obtain written approval from importing countries before shipping e-waste. This measure ensures that recipient countries have the necessary infrastructure to handle e-waste responsibly, promoting transparency and reducing illegal dumping.

In order to continue e-waste awareness and management initiatives, the Partnership for Action on Computing Equipment (PACE)[13] was founded in the same year and ran until 2017. In 2019, the Follow-up Partnership to PACE was introduced. The Parties to the Basel Convention renamed the Follow-up Partnership to PACE as the "Partnership for Action on Challenges relating to E-waste" (PACE II) in decision BC-15/22 Part I[14] reflecting the increased mandate. PACE II, which was initially focused on mobile phones and computing equipment, has expanded to encompass a broader range of e-waste streams like as TV screens (LEDs, LCDs, CRTs), audio and video equipment, and refrigerators, cooling, and heating devices. The alliance keeps pushing for "Environmentally Sound disposal" (ESM) of e-waste, which includes Extended Producer Responsibility (EPR) rules, in order to create guidelines for both efficient trash disposal and the refurbishment and repair of discarded electronics.

Effective e-waste management is closely related to the United Nations 2030

08, 2025).

12 PIC procedure prior to BC COP-16, https://www.basel.int/Implementation/Controllingtransboundarymovements/ImprovingthePICprocedure/tabid/9319/Default.aspx (last visited Apr 08, 2025).

13 Basel Convention > Implementation > Technical Assistance > Partnerships > PACE II > PACE > Overview, https://www.basel.int/Implementation/TechnicalAssistance/Partnerships/PACE/Overview/tabid/3243/Default.aspx (last visited Apr 07, 2025).

14 Overview,https://www.basel.int/Implementation/TechnicalAssistance/Partnerships/PACEII/Overview/tabid/9284/Default.aspx (last visited Apr 07, 2025).

Agenda[15], namely SDGs 3[16], 6[17], 11[18], 12[19], and 13[20]. SDG 12 is supported by India's legislative efforts, such as the E-Waste (Management) Rules, 2022, which promote extended producer responsibility (EPR) and sustainable production practices. Proper hazardous material disposal and regulated recycling help to achieve public health, safeguarding the environment, and climate resilience goals. Aligning national policies with the 2030 Agenda improves the global relevance and influence of India's e-waste management.

The Reduce, Reuse, and Recycle approach should be essential to India's e-waste plan. While recycling has garnered attention, reduction and reuse are still underdeveloped. Strengthening eco-design regulations, incentivizing product longevity, and integrating informal recyclers into formal systems can all help to better implement the 3Rs. This Method not only reduces environmental harm but also promotes the transition to a circular economy that is consistent with global sustainability goals.

5. INDIAN LAWS

There has been a substantial change since the 20th century in India's e-waste management laws which addresses the environmental and health risks caused by mismanaged and discarded electronic and electrical equipment. The initial legislative framework to deal with this menace began in 2011 with the coming of E-Waste (Management and Handling) Rules, establishing basic regulatory measures. The said rules were replaced by the E-Waste (Management) Restrictions, 2016, which expanded the application of area to include producers, retailers, manufacturers, and consumers. These 2016 guidelines further highlighted "Extended Producer Responsibility" (EPR), which made it obligatory for manufacturers to establish collection procedures and satisfy recycling targets.

India's Central Pollution Control Board (CPCB) has produced Implementation Guidelines for Recyclers and Refurbishers under the E-Waste (treatment) Rules,

15 Transforming our world: the 2030 Agenda for Sustainable Development, https://docs.un.org/en/A/RES/70/1 (last visited on June 19, 2025)

16 Ensure healthy lives and promote well-being for all at all ages

17 Ensure availability and sustainable management of water and Sanitation for all

18 Make cities and human settlements inclusive, safe, resilient and sustainable

19 Ensure sustainable consumption and production patterns

20 Take urgent action to combat climate change and its impacts

2016, which establish operational guidelines for environmentally sound e-waste treatment. Recyclers must get authorization from State Pollution Control Boards (SPCBs), set up collection centers, and only source e-waste from recognized vendors. They must also assure proper disposal of hazardous trash produced during recycling. Refurbishers, who are responsible for extending the life of electronic devices, must register on the CPCB's EPR site, keep facility records, and send e-waste generated during refurbishment to registered recyclers or dismantlers. Both recyclers and refurbishers must adhere to occupational safety and environmental compliance standards, which contribute to sustainable e-waste management and resource conservation.

"Guidelines for Determination of Processing Capacity of E-Waste Recycling facilities by State Pollution Control Boards/Pollution Control Committees"[21] which helps in determining the processing capacity of e-waste recycling facilities by State Pollution Control Boards (SPCBs) or Pollution Control Committees (PCCs) are planned to guarantee that these facilities function within organically reasonable and legally allowable boundaries. The maximum quantity of e-waste that a facility can safely and effectively treat, manage, and recycle in a given amount of time is denoted to as its processing capacity.

Extended Producer Responsibility (EPR) is a global initiative that makes producers responsible for the administration of the *"end-of-life disposal"* of their goods. It aims to internalize the environmental costs of garbage disposal by shifting some of the load from local governments to producers.

There were further amendments which were implemented under the newly adopted E-Waste (Management) Rules, 2022[22] that went into force on April 1, 2023, and replaced the previous E-Waste (Management) Rules, 2016, these also included significant elements targeted at enhancing e-waste management practices. By requiring producers, recyclers, refurbishers, and dismantlers to register on the Central Pollution Control Board's (CPCB) online EPR portal, this legislation strengthened the implementation of EPR.

In order to ensure accountability and transparency, the new regulations raise recycling goals and mandate that only certified recyclers be used. India's environment

21 Guidelines Environmentally Sound Recycling E-Waste, https://cpcb.nic.in/uploads/Projects/E-Waste/Guidelines_Environmentally_Sound_Recycling_E-Waste.pdf (last visited Apr 08, 2025).

22 E-Waste (Management) Rules, 2022, https://cpcb.nic.in/rules-6/ (last visited Apr 08, 2025).

legislations, that was well established i.e Environment (Protection) Act of 1986[23], encourages the management of e-waste by creating a legal foundation for penalties in noncompliance cases.

India's e-waste regulations demonstrate the country's commitment to building a circular economy, mitigating environmental degradation, and supporting sustainable development through responsible e-waste management and recycling methods.

Another legislation which aims to resolve e-waste is the Battery Waste Management Rules, 2022[24], which are promulgated by India's Ministry of Environment, Forest, and Climate Change, and are significant regulatory breakthroughs which is aimed at promoting sustainable environmental practices in battery waste management. These guidelines cover a wide range of battery types, such as those found in industrial applications, portable devices, automotive systems, and electric vehicles (EVs).

The regulations provide severe limits on the use of hazardous compounds like mercury and cadmium in battery manufacture, reducing environmental and health risks. The guidelines also require makers, recyclers, and refurbishers to register with the Central Pollution Control Board (CPCB) for regulatory control and the Consumers must return used batteries to authorized collection facilities, while retailers are responsible for ensuring the safe storage and disposal of waste batteries. Battery refurbishing is promoted as a strategic solution to increase product life cycles while minimizing environmental effect. Noncompliance with these statutory regulations incurs fines under the Environmental Protection Act of 1986.

Overall, through extensive regulatory interventions, the Battery Waste Management Rules, 2022, show India's legislative commitment to environmental sustainability and the development of a circular economy. All relevant stakeholders must register with the Central Pollution Control Board's (CPCB) E-Waste EPR Portal.[25]

In charge of compliance, the CPCB can impose annual fees, registration fees, cancel registrations, and impose environmental fines for infractions, thereby creating fines and remedial measures, the Environmental Compensation Guidelines expand the regulatory framework. These policies, which emphasize shared responsibility in reducing environmental and health concerns, are a major step forward in India's

23 Environment (Protection) Act, 1986

24 Battery Waste Management Rules, 2022, https://cpcb.nic.in/rules-5/ (last visited Apr 08, 2025).

25 E-Waste Management System, https://eprewastecpcb.in/#/ (last visited Apr 08, 2025).

efforts to achieve sustainable e-waste disposal.

In *Mahendra Pandey v. Union of India & Others*[26] filed in the National Green Tribunal (NGT) in India. The petitioner voiced concern over improper e-waste disposal and its detrimental effects on the environment, including contaminated soil and water from hazardous substances including lead, mercury, and cadmium. In this case, the tribunal talked about concerns about the improper disposal of e-waste, which causes environmental damage such as soil acidification and groundwater pollution. The tribunal discussed the importance of strict adherence to the E-Waste (Management) Rules, 2016, and said that the authorities must take corrective action to ensure that e-waste is managed environmentally.

In *Illegal E-Waste Units in Delhi (2020)*[27], the National Green Tribunal took suo motu notice of the report[28] which identified about 5,000 illegal e-waste dispensation units operating in and around Delhi-NCR. This study, conducted by the environmental NGO Toxics Link, brought attention to the growth of illegal e-waste processing facilities that break environmental regulations in the Delhi-NCR area. The report also stated that many authorized dismantlers and recyclers were illegally transferring debris to the informal sector, violating legal requirements. In response to the results, the NGT instructed the Delhi Pollution Control Committee (DPCC) and other relevant agencies to take corrective action, such as closing unlawful facilities, enforcing e-waste legislation, and encouraging official recycling infrastructure. In order to lessen environmental contamination and public health issues related to inappropriate e-waste disposal, the tribunal emphasized the importance of closely following the E-Waste (Management) Rules of 2016.

6. DISCUSSION

The proliferation of electronic gadgets over the last decade or so, coupled with a dramatic rise in e-waste, has presented governments, particularly those in poorer countries, with a significant environmental challenge. India's legal reforms have not made much of an impact, indicating the country's challenges in handling electronic waste. This article lists limited awareness, inadequate regulation design

26 Mahendra Pandey v. Union of India & Others OA 621/2018

27 Re: News items – The Indian Express – 5,000 illegal e-waste units being run in capital: study OA 1001/2019

28 Informal E-waste Recycling in Delhi: Unfolding Impact of Two Years of E-waste (Management) Rules 2016, https://toxicslink.org/wp-content/uploads/2022/08/informal%20ewaste%20recycling%20in%20Delhi.pdf (last visited Apr 08, 2025).

and enforcement, and informal sector e-waste practices as some of India's problems. A strong future e-waste management system should be developed with the active participation of all stakeholders.

Global approaches to e-waste management offer instructive contrasts that can inform India's evolving regulatory framework. The European Union exemplifies a structured and legally robust model through its WEEE and RoHS Directives[29], which mandate Extended Producer Responsibility (EPR), enforce high recycling rates, and promote eco-design. Similarly, Japan employs a technologically advanced and decentralized system under its Home Appliance Recycling Law, requiring consumers to contribute recycling fees and manufacturers to recover and process e-waste. These models reflect the successful integration of the 3Rs principle and circular economy ideals.

In contrast, developing countries face distinct challenges. Ghana, despite being a Basel Convention signatory, contends with large-scale informal processing sites such as Agbogbloshie, where unregulated practices like open burning release hazardous pollutants, endangering local communities.[30] The Philippines, guided by the Ecological Solid Waste Management Act, is gradually formalizing e-waste handling, though informal recycling remains prevalent due to limited enforcement and infrastructure.[31] These cases highlight the importance of context-specific strategies. For India, a hybrid model that combines strong legal enforcement with the integration of informal recyclers, public awareness, and international best practices is essential for achieving sustainable and inclusive e-waste governance.

For the upcoming years Indian Legal framework should enact more stringent guidelines for manufacturers and a broader definition of e-waste. The producers should adhere to increased product take-back rates and recently implemented recycling targets. Ambiguities around terms like "producer" and "manufacturer" should be cleared out. It is anticipated that non-compliance costs will rise, indicating increased accountability. Additionally, makers will be requested to submit full

29 Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS)

30 Anuli Njoku et al., *Environmental Injustice and Electronic Waste in Ghana: Challenges and Recommendations,* 21 Int'l J. Env't Res. & Pub. Health 25 (2023), https://doi.org/10.3390/ijerph21010025.

31 Albert P. Aquino, Jamaica Angelica P. Deriquito, and Meliza A. Festejo, Solid Waste Management in the Philippines: Ecological Solid Waste Management Act: Environmental Protection, https://waste-management.pro/WasteManagement/solid-waste-management-in-the-philippines (last visited on June 19, 2025)

Extended Producer Responsibility (EPR) plans that include recycling criteria and quantifiable, verifiable statistics on e-waste collection, in addition to consumer awareness campaigns. It will become crucial to have audited data describing take-back procedures and proof that e-waste is being recycled or used again in manufacturing. At the same time, regulators will probably examine bulk buyers more thoroughly and demand that they exhibit appropriate organizational procedures for handling e-waste.

7. Conclusion and Suggestions

The rapid increase in electronic use and the hazardous waste it generates has made e-waste management a critical global concern. A complex strategy that incorporates innovative technologies, legislative frameworks, and active public participation is required for effective administration.

The findings of this study have critical practical implications for policymakers, industries, and civil society. The growing e-waste burden in India—driven by rapid digitalization and increasing consumer electronics usage—has revealed significant gaps in enforcement, infrastructure, and public engagement. The unregulated dominance of the informal recycling sector continues to pose grave environmental and health hazards due to primitive methods such as open burning, acid leaching, and landfilling of hazardous substances. This results not only in severe soil, air, and water contamination but also in the inefficient recovery of valuable secondary materials such as rare earth metals, gold, and copper. Moreover, the lack of streamlined EPR mechanisms and weak compliance monitoring prevents producers and consumers from fulfilling their legal and ethical obligations. Hence, there is an urgent need to operationalize regulatory mandates through digitized traceability systems, institutionalize environmental audits, and create incentives for industries to invest in eco-innovation and formal recycling networks. The integration of the informal sector into formal value chains—through skills training, registration, and occupational health safeguards—would transform e-waste from an ecological liability into an economic opportunity, fostering employment and resource efficiency.

Looking ahead, India must adopt a systemic and forward-looking approach to e-waste governance that aligns with circular economy models and global sustainability frameworks such as the 2030 Agenda. First, regulatory clarity is paramount: terms like "producer," "manufacturer," and "bulk consumer" must be uniformly defined, and recycling targets should be made progressively stringent

and binding. The Central Pollution Control Board (CPCB) should enhance digital oversight through real-time data reporting, compliance dashboards, and national e-waste registries. Second, investments in scientific research and recycling technologies must be incentivized through tax benefits, innovation grants, and industry-academia partnerships. Third, eco-design and green manufacturing should be made mandatory by integrating sustainability criteria into product standards, enabling products to be easily repaired, refurbished, and recycled. Fourth, large-scale public awareness campaigns—particularly targeting schools, urban households, and corporate offices—must be launched to educate consumers about safe disposal practices and their roles under EPR. Countries should implement Extended Producer Responsibility (EPR), reinforce their regulatory frameworks, and encourage formal recycling infrastructure to lower the hazards to the environment and public health. E-waste collection and proper disposal can be enhanced with the support of public awareness campaigns and corporate accountability. Finally, India should proactively engage in international cooperation by adopting best practices from jurisdictions like the EU, Japan, and South Korea and strengthening its commitment to the Basel Convention. These coordinated interventions will not only mitigate environmental degradation but also position India as a global leader in sustainable electronic waste management.

By encouraging a circular economy built on recycling and resource recovery, societies may turn the e-waste problem into a chance for economic growth, environmental preservation, and sustainable development. A cleaner, safer, and more sustainable future will arise from addressing these issues now.