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AN ANALYSIS OF ELECTRONIC WASTE MANAGEMENT IN THE ERA OF DIGITAL TRANSFORMATION

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ABSTRACT

The rapid pace of the use of digital technologies resulted in the rapid growth of electronic waste and it has become one of the most urgent environmental and regulatory challenges of the 21st century. The article aims to analyse the normative and legal provisions with regard to e-waste in the context of the Indian and international environmental law. The main research question is the insufficiency of the current legal framework and the mandate of international conventions that seek to control transboundary flows of hazardous electronic waste, especially between the developed and the developing countries. This paper examines common e waste disposal methods and various legal principles that are entrenched in the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, and the Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movements and Management of Hazardous Wastes within Africa, and the various E-waste Management Rules using a doctrinal research approach. The research design is a systematic review of treaties, interpretative tools, as well as applicable case laws to evaluate the enforcement processes, and normative development of international e-waste regulation. Scholarly articles, United Nations Environment Programme (UNEP) reports, and policy papers which fill gaps in compliance and implementation will also be reviewed. The Basel Convention, though globally applicable, its operation is undermined by the ambiguity of the aspects associated with the definition of used electronics as second-hand goods, which allows formal dumping in developing nations. The Bamako Convention, albeit in a regional approach, is treated as a progressive legal tool that supplements the Basel framework by its stricter ban on the imports of hazardous waste into Africa. It is proposed in the paper that there should be a way of harmonizing these legal regimes to a broader paradigm of the circular economy, which focuses on producer responsibility, long life cycles of products, and the creation of green digital infrastructure. The paper concludes that there is need to have a legally consistent international system which is backed by binding obligations and cooperation to promote sustainable and fair digital revolution.

Keywords: E-waste, Environmental Sustainability, Basel Convention, Bamako Convention, SDGs.

INTRODUCTION

The digital revolution has fundamentally restructured global socio-economic interactions, fostering unprecedented connectivity and efficiency. However, this revolution bears a heavy ecological footprint. The rapid acceleration of technological innovation, coupled with the systemic shortening of product lifecycle has catalysed a crisis of electronic waste.¹ As of 2024, the Global E-waste Monitor reported that the world generates over 62 million tonnes of e-waste annually, a figure projected to rise by 33% by 2030². This phenomenon represents not only a waste management crisis but a profound challenge to the principles of environmental sustainability and international law.

E-waste is uniquely hazardous, comprising of heavy metals such as lead, mercury, and cadmium, alongside persistent organic pollutants. When mismanaged, these substances leach into the pedosphere and hydrosphere, causing irreversible bioaccumulation in the food chain. Despite these risks, the high concentration of precious metals creates a perverse economic incentive for the transboundary movement of waste. This often results in toxic colonialism, where hazardous discarded electronics flow from the Global North to developing nations under the guise of second-hand goods or donations.

From a legal perspective, these flows are governed by the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). While the Basel Convention remains the bedrock of international waste law, its efficacy is frequently undermined by regulatory loopholes such as the distinction between waste and non-waste for repairable items. In response to these perceived inadequacies, regional instruments like the Bamako Convention (1998) have emerged. This convention has adopted a more stringent stance against the import of hazardous waste into Africa.

In the Indian context, the E-Waste (Management) Rules, 2022, signify an evolution toward

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¹ Shanti Quinto, *Exploring the E-Waste Crisis: Strategies for Sustainable Recycling and Circular Economy Integration*, Apr. 8, 2025, <https://www.mdpi.com/2313-4321/10/2/72>.

² *Electronic waste (e-waste)*, Oct. 1, 2024, [https://www.who.int/news-room/fact-sheets/detail/electronic-waste-\(e-waste\)](https://www.who.int/news-room/fact-sheets/detail/electronic-waste-(e-waste)).

Extended Producer Responsibility. However, the implementation gaps persist due to the dominance of the informal recycling sector, which handles nearly 95% of the nation's e-waste. This article seeks to analyse whether the current international and domestic environmental laws are robust enough to transition from a linear take-make-dispose model to a circular economy. Achieving a sustainable digital future requires more than technical recycling; it demands a harmonized, legally binding international regime that ensures the digital revolution does not come at the cost of ecological integrity.

UNDERSTANDING E- WASTE: DYNAMICS & EMERGING THREATS

The rapid electrification of the global economy has transformed the nature of municipal solid waste, elevating e-waste to the world's fastest-growing waste stream. It is currently increasing at an estimated rate of 2.6 million metric tonnes annually.³ E-waste is characterized by a dense and complex material composition, often containing over 60 different elements. While many of these are valuable critical minerals, such as gold, silver, and copper which are inextricably bound with hazardous substances that require sophisticated technical interventions for safe separation. The primary technical threat is posed by neurotoxic heavy metals including Lead, Mercury, and Cadmium. Lead is ubiquitous in printed circuit boards and cathode ray tubes, where its concentration often exceeds permissible environmental safety thresholds. Mercury, utilized in liquid crystal display backlights, is a potent neurotoxin capable of bioaccumulation in aquatic food chains following environmental leaching.⁴ Apart from heavy metals, in the category of Persistent Organic Pollutants, Brominated Flame Retardants are used in plastic casings to prevent combustion. This represents a systemic threat. During informal recycling processes like open-air burning, these substances release highly toxic dioxins and furans into the atmosphere, which are known endocrine disruptors and carcinogens.⁵

A pivotal emerging threat identified in contemporary research is the proliferation of Lithium-Ion batteries. The transition to mobile digital infrastructure and electric vehicles has catalysed an annual surge of approximately 5–6% in the volume of Li-ion batteries entering the waste stream.⁶ Unlike traditional lead-acid batteries, Li-ion cells contain flammable and toxic

³ UNITAR, The Global E-waste Monitor 2024, at 15 (2024), <https://ewastemonitor.info/>.

⁴ *Id.* at 22.

⁵ UNEP, Technical Guidelines on the Environmentally Sound Management of Persistent Organic Pollutants, (2015), <https://www.unep.org/>.

⁶ NITI Aayog, *Advanced Chemistry Cell Battery Reuse and Recycling Market in India*, at 26 (2022), https://www.niti.gov.in/sites/default/files/2022-07/ACC-battery-reuse-and-recycling-market-in-India_Niti-Aayog_UK.pdf.

electrolytes, such as lithium hexafluorophosphate. If breached during manual dismantling or crushed in non-specialized waste facilities, these cells can undergo thermal runaway. This thermal runaway can lead to fires releasing hydrogen fluoride gas in the atmosphere. This gas when released in the atmosphere is lethal even in low concentrations.⁷ It is observed that despite the economic value of lithium and cobalt, current global recycling rates for these batteries remain disproportionately low due to the technical difficulty of recovering high-purity materials from diverse and non-standardized battery chemistries.

Toxins from e-waste undergo environmental migration. Through leaching and runoff, heavy metals enter groundwater and the soil, eventually appearing in local food supplies. Recent studies in e-waste hubs have documented hazardous levels of lead and mercury in eggs and livestock, indicating a total breakdown of local food safety.⁸ The children and pregnant women are disproportionately affected by these technical failures. Lead dust from informal dismantling sites is linked to stunted growth, reduced lung capacity, and irreversible neurodevelopmental damage in infants.⁹ This biological reality underscores the insufficiency of current legal frameworks, which often focus on trade volumes rather than the intricate technical and biological pathways of toxic exposure.

GOVERNMENT INITIATIVES & THE INDIAN LEGAL PARADIGM

The evolution of India's e-waste regime represents a shift from a skeletal, "command-and-control" system to a digitized, market-centric ecosystem. The journey began with the E-Waste (Management and Handling) Rules, 2011, which introduced Extended Producer Responsibility (EPR). This was followed by the E-Waste (Management) Rules, 2016, which expanded the scope to include mercury-containing lamps and introduced Producer Responsibility Organizations (PROs).¹⁰ The 2016 framework relied on a decentralized authorization model where producers submitted EPR Plans to the Central Pollution Control Board (CPCB). However, the system lacked a real-time verification mechanism. This led to the emergence of Paper Trading, where PROs issued fake collection certificates while the actual waste remained in the hazardous informal sector. The failure of these rules demonstrated that procedural law,

⁷ *Supra note 3* at 42.

⁸ World Health Organization, *Electronic Waste (E-waste) Fact Sheet*, (Oct. 2024), [https://www.who.int/news-room/fact-sheets/detail/electronic-waste-\(e-waste\)](https://www.who.int/news-room/fact-sheets/detail/electronic-waste-(e-waste)).

⁹ *Ibid.*

¹⁰ E-Waste (Management) Rules, 2016, G.S.R. 338(E), Ministry of Environment, Forest and Climate Change (2016), https://hspcb.org.in/uploads/laws/Ewaste_Rules.pdf.

without technological oversight, facilitates corporate greenwashing rather than environmental remediation.¹¹

There was a paradigm shift in 2022 with the regulation of The E-Waste (Management) Rules, 2022. The primary objective is to replace plans with verifiable results through a centralized portal. There is a mandate Mandates that every manufacturer, producer, and recycler must register on the CPCB portal. No entity can perform business without this digital identity. In addition to this Rule 15 which deals with EPR Certificate Generation is considered as the "brain" of the new law. Compliance is no longer measured by the weight of waste collected but by the weight of recovered end-products. Further, Schedule II establishes aggressive year-on-year targets, aiming for an 80% recycling rate by 2025-26¹² By recognizing only four precious metals for certificate generation, the law inadvertently devalues the recycling of non-profitable hazardous components like leaded glass and plastics. This suggests a shift toward a Resource Recovery model, which potentially overlooks the "indirect harm" caused by the hazardous residues that do not generate certificates. Furthermore, by strictly forbidding formal recyclers from sourcing waste from unregistered aggregators, the law risks alienating the informal sector rather than integrating it.¹³

In late 2025, the National Critical Mineral Mission reframed e-waste as a strategic asset. The approved ₹1,500 crore CapEx subsidy marks a departure from pure environmental law into Industrial Policy.¹⁴ Addressing the 5–6% annual increase in battery waste, the Union Budget 2025-26 eliminated customs duties on battery scrap to make India a global hub for secondary minerals. The Ministry of Electronics and Information Technology has launched a specialized scheme to provide financial assistance for the establishment of state-of-the-art e-waste recycling plants that focus on printed circuit board recycling, which contains high concentrations of gold and palladium. These initiatives create a legal paradox. While they strengthen the circular economy, they risk making India a subsidized destination for the world's battery waste. For this to be sufficient, customs law must now integrate a "Functionality Test"

¹¹ *Critical Analysis of EPR Implementation in India*, 14 J. ENVIRON. L. & POL'Y 204, 210 (2024).

¹² E-Waste (Management) Rules, 2022, MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE (Nov. 2, 2022), https://eprewaste.cpcb.gov.in/assets/PDF/E-Waste_Management_Rules_2022.pdf.

¹³ *Id.* at Rule 4; See also "The Shadow Economy of E-Waste," *Economic and Political Weekly*, Vol. 60, No. 4 (2025).

¹⁴ PIB, *A strong push for critical mineral extraction from recycling*, MINISTRY OF MINES (Oct. 24, 2025), <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2182108>.

to ensure we are importing resources, not just toxic liabilities.¹⁵

Under the federal structure of the Environment Protection Act, 1986, State Governments and State Pollution Control Boards have launched localized initiatives to bridge the last-mile collection gap. The Delhi Government is currently developing India's first E-waste Eco-Park in Holambi Kalan. This initiative aims to provide a centralized hub for dismantling, refurbishing, and recycling in a formal environment, specifically targeting informal workers to bring them into the legal fold.¹⁶ The Tamil Nadu Pollution Control Board has mandated that all state-run departments and educational institutions must dispose of their EEE through registered recyclers only, setting a state-level precedent for institutional responsibility. While central laws provide the framework, these state initiatives serve as the facilitator to achieve the long-term goal of e-waste management. The success of Delhi's Eco-Park model will likely dictate whether the 2022 Rules can successfully integrate the informal sector without destroying the livelihoods of those at the bottom of the value chain.

The Indian judiciary has transitioned from an advisory role to an Environmental Auditor, filling the gaps left by legislative insufficiency. In the case of *Atul Singh Chauhan v. MoEFCC*¹⁷ right to a clean environment was recognised as a fundamental right under Article 21 of the Constitution. The Tribunal ruled that the polluter pays principle must include the cost of environmental restoration, not just a nominal fine. In the case of *Shailesh Singh v. State of UP & Ors.*¹⁸ the NGT demanded that the CPCB use CAGR methodologies to predict waste levels. This case marks a move toward algorithmic governance. The Court held that the failure of a State to maintain an accurate inventory of generated e-waste is itself a violation of the 2022 Rules. Further, the case of *Devidas Khatri v. Union of India*¹⁹ challenges the digital-first approach of the 2022 Rules. The applicant argued that the CPCB grants registrations without physical site inspections. This case represents a judicial pushback against paper-only compliance. The Tribunal's focus here is on ensuring that Technical Compliance i.e., digital registration does not replace physical Compliance i.e., actual recycling infrastructure.

The Indian framework is technically robust but socio-economically insufficient. The 2022

¹⁵ Supra note 11, at 215.

¹⁶ Delhi Government, *Environment Department Annual Report 2024-25*, <https://environment.delhigovt.nic.in/>.

¹⁷ Original Application No. 219/2023 (I.A. No. 108/2023) 06-04-2023.

¹⁸ O.A. No. 512/2018 (Orissa/NGT)

¹⁹ O.A. No. 88/2025.

Rules assume a level of formalization that the Indian shadow economy has not yet reached. For the law to move from insufficient to sustainable, it must evolve from a system of blocking the informal sector to a system of providing a legal pathway for informal workers to become registered collection points.

TOXIC COLONIALISM & TRANSBOUNDARY FLOWS

The digital paradox is sustained by a globalized trade in hazardous waste. While India has fortified its domestic rules, it remains a frontline destination for toxic colonialism. The Basel Convention (1989) is the primary global treaty governing hazardous waste movement. However, its effectiveness is fundamentally undermined by the Repairables Loophole.²⁰ Exporters often claim that non-functional equipment is destined for refurbishment rather than disposal. This allows shipments to bypass the Prior Informed Consent procedure which is considered as the heart of the Convention. The concept of Prior Informed Consent requires that there should be explicit agreement from the importing country. This loophole de-hazardousizes toxic waste through a simple contractual claim. In 2024–2025, up to 80% of "second-hand" electronics arriving in developing nations were found to be non-functional, shifting the cost of hazardous residue management to the importer.²¹

African nations negotiated the Bamako Convention as a direct response to the "permissive" nature of Basel. Unlike Basel, Bamako imposes an absolute prohibition on the import of all hazardous wastes from non-signatory nations.²² While India is not a party to Bamako, the treaty is academically significant due to the waste displacement effect. As Bamako makes it legally riskier to dump waste in Africa, illegal syndicates often divert these toxic flows toward Asian nations like India, where the enforcement of functionality tests has historically been more negotiable.²³ This shift highlights a geopolitical hierarchy in waste law. When one region strengthens its barriers, the waste does not disappear instead it follows the path of least legal resistance, targeting nations with emerging but not yet fully sealed urban mining infrastructures.

²⁰ BAN (Basel Action Network), *The Repairables Loophole*, (2025), <https://www.ban.org/>.

²¹ Nivedita Chaudhary, *Norms and Challenges in the Global Movement of E-Waste*, 5 J. ENV'T L. & POL'Y 258 (2025).

²² Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa art. 4, Jan. 30, 1991, 2101 U.N.T.S. 177.

²³ *Transboundary Movement: Comparison between Basel and Bamako*, 15 Arno UVT 45, 52 (2025).

India's Hazardous and Other Wastes Second Amendment Rules, 2025, represent a rigorous attempt to close these gaps by mandating physical functionality tests at major ports like Mundra and Nhava Sheva.²⁴ Despite these rules, illegal waste is frequently laundered through legal scrap shipments. Criminal networks mislabel hazardous waste as mixed metal or lithium-ion scrap which is incentivized under India's National Critical Mineral Mission to bypass oversight.²⁵ This creates a systemic environmental injustice. The Global North enjoys clean digital benefits, while the biological costs are externalized to the Global South. This demonstrates that even technically advanced domestic laws like the 2022 Rules are insufficient if the international trade regime allows the functionality loophole to persist. The transboundary flow of e-waste is a systemic failure of the Polluter Pays Principle. Current international law allows the polluter to pay a middleman to export the problem, rather than paying for actual environmental remediation. India's 2022 and 2025 Rules are technically robust but operationally isolated. As long as the repairable loophole exists in the Basel Convention and second-hand goods are exempt from EPR targets, India's borders will remain porous. The transition from Toxic Colonialism to Resource Sovereignty requires not just domestic enforcement, but a fundamental renegotiation of the global definitions of "Functionality" and Waste.

COMPARATIVE JURISPRUDENCE: EUROPIAN UNION, CHINA & JAPAN

A comparative analysis of the European Union, China, and Japan provides a spectrum of regulatory philosophies ranging from human-centric 'right to repair' frameworks to rigid state-controlled 'circular economy' systems. For the Indian legislator, these jurisdictions offer a roadmap for transitioning from a waste-disposal mindset to a resource-sovereignty model. The European Union's approach is governed by the WEEE Directive and the more recent Circular Economy Action Plan. The EU philosophy is rooted in the extended producer responsibility model, but with a degree of transparency that the Indian system currently lacks. Under the WEEE Directive, Member States must achieve a minimum collection rate of 65% of the average weight of electrical and electronic equipment (EEE) placed on the market in the three preceding years.²⁶ In 2025, the EU finalized the Right to Repair Directive, which mandates that

²⁴ Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules, 2025, G.S.R. 512(E), *Gazette of India*, pt. II, sec. 3(ii), July 1, 2025 (India).

²⁵ NITI Aayog, *Advancing Circular Economy of E-waste*, (Jan. 22, 2026), <https://niti.gov.in/>.

²⁶ Council Directive 2012/19, of the European Parliament and of the Council of 4 July 2012 on Waste Electrical and Electronic Equipment (WEEE), 2012 O.J. (L 197) 38.

manufacturers provide repair tools, manuals, and spare parts for up to 10 years after a product is removed from the market.²⁷ Unlike the Indian 2022 Rules, which focus on the "back-end" (recycling), the EU focuses on the front-end (longevity). By legalizing repairability, the EU addresses the indirect harm of e-waste by preventing it from being generated in the first place. China's legal evolution is a mirror to India's. After decades of being the world's e-waste destination, China shifted its paradigm through the Circular Economy Promotion Law (2008) and the Administrative Measures on the Collection and Use of E-Waste Disposal Fund (2012). Unlike India's certificate-trading market, China uses a State-managed fund. Producers pay a levy into the fund, which is then used to subsidize licensed recyclers.²⁸ In response to the Lithium-Ion surge, China's National Development and Reform Commission (NDRC) issued new guidelines in late 2024, mandating a 95% recovery rate for high-value metals (cobalt, lithium) in EV batteries.²⁹ China's model is heavily centralized. While this ensures high recovery rates, it has historically led to the total erasure of the informal sector. It is observed that China's State-Led approach is efficient for resource security but lacks the socio-economic flexibility required in a high-informality economy like Indian economy.

Japan is governed by the Law for the Recycling of Specified Kinds of Home Appliances (2001) and the small WEEE Act, 2013. Japan utilizes a visible fee system. Unlike the EU and India, where recycling costs are hidden in the product price, Japanese consumers pay a direct recycling fee at the point of disposal.³⁰ Japanese law mandates "Environmentally Conscious design. Manufacturers must ensure that products can be dismantled using standard tools within a specific timeframe."³¹

The primary point of divergence between India and these global leaders lies in the socio-legal structure of enforcement. While the EU and Japan have successfully formalized their systems through "Right to Repair" laws and "Visible Recycling Fees" that integrate the consumer, the Indian framework specifically remains focused almost exclusively on the manufacturer's backend logistics. Unlike China, which utilizes a State-managed fund to provide financial

²⁷ Directive 2024/01 of the European Parliament and of the Council on Common Rules Promoting the Repair of Goods, 2024 O.J. (L 84) 1.

²⁸ *Administrative Measures on the Collection and Use of E-Waste Disposal Fund*, (promulgated by the Ministry of Finance, May 21, 2012, effective July 1, 2012) (China).

²⁹ National Development and Reform Commission [NDRC], *Guidelines for Improving the Circular Economy of New Energy Vehicle Batteries* (2024), https://en.ndrc.gov.cn/policies/202412/t20241220_1365421.html.

³⁰ Law for the Recycling of Specified Kinds of Home Appliances, Law No. 97 of 1998 (Japan).

³¹ Ministry of Economy, Trade and Industry [METI], *Handbook on the Home Appliance Recycling Law* 12-14 (2024), https://www.meti.go.jp/english/policy/mono_info_service/recycle/appliance/index.html.

stability to recyclers, India relies on a volatile, market-driven EPR Certificate trading system. Furthermore, while Japan and the EU have the luxury of a negligible informal sector, India’s Digital Panopticon approach risks alienating the millions of informal workers who currently handle 95% of the nation's waste. This creates a "Formalization Gap" where the Indian law is technically sophisticated but socio-economically detached from the ground reality of its waste-management workforce.

Feature	European Union (EU)	China	Japan	India
Primary Legislation	WEEE Directive 2012/19	Circular Economy Law 2008	Home Appliance Law 2001	E-Waste Rules 2022
EPR Mechanism	Weight-based collection targets	State-managed subsidy fund	Visible fee paid by consumer	EPR Certificate trading market
Key Innovation	Right to Repair (10-year spare parts)	"Dual-Carbon" strategy for EV batteries	Design for Disassembly (DfD) mandates	"Urban Mining" via CPCB portal
Informal Sector	Negligible/ Fully integrated	Aggressively displaced	Non-existent	Dominant (95%) but legally excluded

This comparative analysis highlights that India’s missing link is "Consumer Incentives" and "Informal Sector Integration."

THE FUTURE PARADIGM: SDGS, CIRCULAR ECONOMY, AND RESOURCE GOVERNANCE

The Digital Paradox is not a vacuum of policy but a failure of doctrinal alignment. Under the UN Sustainable Development Goals (SDGs), e-waste management is the nexus where environmental law meets human rights. mental law meets human rights. SDG 12 requires the

"environmentally sound management of chemicals. In Indian jurisprudence, this must translate into Material Neutrality. This doctrine suggests that for every gram of virgin material extracted, an equivalent gram must be recovered from the waste stream. The 2022 Rules initiate this via EPR certificates, but the future law must mandate Recycled Content Minimums in new electronics to create a closed loop demand.³² Following the 2022 UN General Assembly resolution declaring access to a clean environment a universal human right, the Indian informal sector's exposure to toxins becomes a constitutional violation under Article 21. The future paradigm requires a just transition framework where informal workers are legally upskilled into green technicians. This aligns with the SDG8 and the Right to Clean Environment.

The Right to Repair is evolving from a consumer protection clause into a fundamental environmental mandate. In the European Union it is a statutory right. However, in India it is currently a series of voluntary circular economy guidelines. Legally, Planned Obsolescence should be treated as a form of environmental fraud. If a manufacturer intentionally bricks a device via software updates, they are essentially creating Forced Waste. Future legislation must require a repairability rating on every Electrical and Electronic Equipment (EEE) label. This rating would be legally binding, where a low score results in a higher environmental compensation levy on the producer. A critical legislative proposal involves banning Part-Pairing which is called the digital locking of components. By making parts interchangeable, the law can lower the cost of repair, thereby diverting functional devices from the shredder.

The Digital Product Passport is the primary technological solution to the information asymmetry between producers and recyclers. Every laptop or phone should carry a decentralized blockchain-based ledger containing its material composition. This allows a recycler to know the exact location of high-value elements like Neodymium and Dysprosium. The DPP solves the Toxic Colonialism issue. At the customs frontier, if a shipment's DPP does not show a Functional Health Score above 60%, it would be automatically categorized as hazardous waste rather than second-hand goods.³³ This removes the discretionary power of customs officials and replaces it with an Algorithmic Enforcement mechanism.

As India moves toward its Net Zero 2070 goal, the demand for EV batteries is creating a new

³² United Nations Environment Programme [UNEP], *E-waste and the SDGs: A Roadmap for Circularity* 12-14 (2024), <https://www.unep.org/resources/report/e-waste-and-sdgs>.

³³ *The Digital Product Passport: A New Tool for the Circular Economy*, 20 J. CIRCULAR ECON. 88 (2025).

category of waste that is, Industrial-Scale Lithium-Ion scrap. India lacks significant domestic reserves of Lithium and Cobalt. Domestic e-waste is therefore our primary mine. The 2026 NITI Aayog report identifies that a 90% recovery rate from EV batteries could meet 25% of India's battery demand by 2035.³⁴ Unlike the 2022 E-waste Rules, which group batteries with consumer electronics, the future law must separate them. EV batteries require a chain of custody mandate where the manufacturer (OEM) is legally responsible for the battery throughout its entire life, including its Second Life applications, such as, using old car batteries for solar grid storage. The current Indian legal regime is a Top-Down model that ignores the 95% of the market handled by the informal sector. A Hybrid Integration Model is the proposed solution. Small-scale informal collectors i.e., the kabaadiwalas should be granted micro-enterprise status. This would allow them to sell their collected waste to formal recyclers at a GST-exempt rate, incentivizing them to move away from illegal burning. Borrowing from Japan, India should mandate a refundable deposit scheme. When a consumer buys a phone, they pay a 2% circular deposit. This deposit is returned with interest only when the device is handed over to a certified collection point. This creates a circular incentive that drives the waste toward the formal sector.

By 2030, the circular economy will not be an environmental niche but a billion-dollar industrial sector. A proposed shift from taxing labour to taxing virgin resource extraction. If the cost of mining new ore is higher than the cost of recycling, the market will naturally gravitate toward circularity. The producer's role must change from being a Seller of Products to a Provider of Services. In a Product-as-a-Service (PaaS) model, the consumer never owns the device instead they lease the function. When the device fails, it automatically returns to the producer for remanufacturing. This eliminates the very concept of waste from the legal dictionary.

The Digital Paradox which is the toxic underside of a clean digital revolution, is a solvable governance crisis. The 2011 and 2016 Rules were the draft phase whereas the 2022 Rules are the infrastructure phase. The 2026-2030 era must be the integration phase.

A truly sustainable e-waste regime must be Material-Neutral, Human-Centric, and Strategically Sovereign. The law must finally recognize that a discarded circuit board is not garbage to be

³⁴ NITI Aayog, *Advancing Circular Economy of Waste Electronic and Electrical Equipment (E-waste) and Lithium-Ion Batteries in India* 102-115 (2026), <https://niti.gov.in/sites/default/files/2026-01/Advancing-Circular-Economy-of-Waste-Electronic-and-Electrical-Equipment-Ewaste-and-Lithium-Ion-Batteries-in-India.pdf>.

hidden, but a 'Fragment of the National Resource Commons' to be recovered with the same dignity and precision as any other mineral wealth. It can therefore be said that the circular economy is the only legal pathway where industrial growth does not necessitate ecological suicide.

WAY FORWARD

The resolution of India's Digital Paradox cannot be achieved only through increased initiatives on the part of the Government. It requires a fundamental shift in the laws regulating waste. The StEP Initiative is a kind of Best of Both World's model represents a critical intersection between labour law and environmental regulation. The analysis of the E-Waste (Management) Rules, 2022, reveals a compliance barrier wherein the high capital requirement for recycling licenses affects informal aggregators in a considerable way. This creates a legal vacuum where the most efficient collection network is forced to operate without any authority. The law should be amended to recognize a Dual-Track Licensing system. Under this model, the collection and non-toxic dismantling should be deregulated to allow for Registered Informal Collectives. However, the chemical leaching and smelting must be strictly reserved for high-tech refineries. This aligns with the principle of environmental justice. By legally partitioning the value chain, the state protects the livelihood of the informal worker while centralized chemical recovery protects the community's right to a clean environment envisaged under Article 21 of the Indian Constitution.

The current Indian legal framework attracts legal liability only once the product is discarded. There is a necessity of upstreaming the liability wherein the responsibility should be imposed on producers and manufacturers for the environmental impact of their electronic products before they become waste. Planned Obsolescence, is a form of environmental fraud. Manufacturers design products with a finite lifespan to drive repeat consumption, thereby externalizing the cost of waste onto the public. Like the European Union's Right to Repair Directive, an Act or Regulation must be brought as a constitutional extension of the Consumer Protection Act, 2019. There should be explicit mandate on prohibition of software bricking. In addition, there should be a mandate for producers to maintain an inventory of parts for at least 10 years post-sale. By elevating 'repair' to a statutory right, the law shifts the burden of proof. If a product fails prematurely, it becomes a defective product in environmental terms. This allows the State to recover environmental compensation not just for disposal, but for the lost lifecycle value of the device.

India's transition to a green economy is currently hindered by mineral dependency. Currently, virgin minerals such as lithium/ cobalt are often cheaper than recycled ones because the social and environmental cost of mining is not included in the price. This creates a market failure where recycling is sidelined. The National Critical Mineral Mission must adopt a Statutory Recycled Content Mandate. By 2028, all EEE (Electrical and Electronic Equipment) sold in India should contain a minimum of 5% recycled critical minerals. This creates a Secondary Material Mandate. It forces producers to invest in urban mining infrastructure, effectively turning every discarded circuit board into a domestic mineral reserve. This is not merely an environmental policy rather it is a Strategic Resource Security imperative.³⁵

The biggest weakness in Indian e-waste law is the information asymmetry between the producer and the regulator. The 2022 Rules rely on self-reported data, which is prone to manipulation. Evidence suggests that EPR certificates are often traded without any physical recycling taking place. This paper compliance mechanism undermines the entire legal regime.³⁶ There should be a requirement of Mandatory Digital Product Passports. Utilizing blockchain technology, a DPP would act as a legal identity for every electronic device. It would contain the device's chemical fingerprint and its functional health score. For transboundary flows, the DPP would eliminate the Repairables Loophole. If a shipment of second-hand laptops arrives at the port of Mumbai without a verified DPP showing 80% functionality, the law should mandate automatic re-exportation. This removes the human discretion that currently facilitates toxic colonialism.³⁷

The collection rate for e-waste in India remains poor because the consumer has no financial benefit. The current take-back mechanisms are friction-heavy. Consumers prefer selling to the informal street vendors because they receive immediate cash. There should be an initiative of a visible recycling fee and a refundable deposit. At the point of sale, a small, transparent deposit is collected. This deposit is held in a statutory escrow account.

By integrating the StEP Initiative's scientific rigor with Blockchain-based transparency and Statutory Repair Rights, India can move from being a waste recipient to a resource sovereign.

³⁵ NITI Aayog, *Advancing Circular Economy of Waste Electronic and Electrical Equipment (E-waste) and Lithium-Ion Batteries in India* 122 (2026).

³⁶ <https://www.thehindu.com/sci-tech/energy-and-environment/6-lakh-fake-pollution-trading-certificates-unearthed-in-three-states/article68401068.ece>

³⁷ *The Digital Product Passport: A New Tool for the Circular Economy*, 20 J. CIRCULAR ECON. 88 (2025).

The law must finally recognize that in a finite world, there is no "away" to throw things to. Every discarded phone is a fragment of the national commons, and its recovery is a matter of both ecological survival and economic independence. Utilizing the Unified Payments Interface (UPI), the deposit is instantly refunded to the consumer's bank account when the device is scanned at a certified Collection Point. This aligns the consumer's financial interest with the state's environmental goals, effectively crowdsourcing the collection of toxic waste.

CONCLUSION

The digital anomaly that characterizes India's technological ascent is a rapid transition to a digitally empowered society underscored by a burgeoning, toxic e-waste crisis. It represents one of the most significant jurisprudential challenges of the twenty-first century. The evolution of India's e-waste governance from the nascent 2011 Rules to the sophisticated, market-driven 2022 framework reflects a maturing understanding of environmental liability. However, the statutory intent and ground-level implementation remain wide. E-waste is no longer a localized pollution concern but a strategic national asset. The current Polluter Pays model, while effective for penalizing negligence, is insufficient for incentivizing resource recovery. The legal system must internalize the Resource Stewardship principle, where electronic devices are viewed as temporary vessels for finite critical minerals such as Lithium and Cobalt. By adopting the Solving the E-waste Problem (StEP) Initiative's standardized recommendations, India can harmonize its data with global standards, ensuring that "Urban Mining" becomes a primary driver of the domestic economy.

A critical conclusion of this analysis is that any legal regime that ignores the informal sector is doomed to operational failure. The 95% of e-waste currently managed by the informal economy represents a massive, yet hazardous, logistical triumph. The proposed Hybrid Integration Model provides a legally sound pathway to formalize this workforce. By partitioning the value chain to allow informal actors to lead collection and manual dismantling while reserving hazardous chemical recovery for licensed, high-tech facilities, the state can uphold the constitutional mandate of Environmental Justice under Article 21. This approach ensures that the Green Revolution does not come at the cost of the health and livelihoods of the most vulnerable.

The investigation into "Toxic Colonialism" and the "Repairables Loophole" highlights the urgent need for algorithmic enforcement at India's borders. The current reliance on manual

customs inspections has proven inadequate against the sophisticated "waste laundering" tactics of the Global North. The implementation of Digital Product Passports (DPP) and blockchain-verified functionality logs represents the "Way Forward." By ensuring that every imported device has a verifiable "Chemical Fingerprint" and functional score, India can protect its soil from becoming a dumping ground while simultaneously securing its domestic critical mineral reserves.

The legal analysis of Extended Producer Responsibility (EPR) suggests that the era of Paper Compliance and ghost certificates must end. The future of EPR in India must be Outcome-Based. This requires a shift toward Mandatory Recycled Content targets. When producers are legally required to use a specific percentage of secondary materials in new products, the market for recycled e-waste will stabilize, making formal recycling economically competitive with primary mining. Furthermore, by enacting a statutory Right to Repair Act, the law can finally curb Planned Obsolescence, extend product life-cycles and reduce the sheer volume of waste generated.

Finally, the digital paradox cannot be resolved without the active participation of the 1.4 billion Indian consumers. The transition from a passive buyer to a proactive steward requires a financial nudge. The recommendation to implement a UPI-linked Refundable Deposit Scheme (RDS) and a Visible Recycling Fee (VRF) addresses the psychological and economic barriers to responsible disposal. By gamifying circularity and integrating it with the LiFE (Lifestyle for Environment) movement, India can foster a culture of shared responsibility where the return of an old smartphone is seen as a civic duty rather than a burden.

In conclusion, the digital revolution is only as sustainable as its residues. The journey from the toxic alleys of Seelampur to a digitized, circular economy requires more than just administrative updates; it requires a radical reimagining of the relationship between technology, labour, and nature. By integrating the scientific rigor of the StEP Initiative, the transparency of blockchain, and the socio-legal compassion of Informal Sector Integration, India can transform its e-waste crisis into a multi-billion-dollar opportunity. The law must transition from a 'Waste Watcher' to a 'Resource Guardian,' ensuring that the minerals extracted today are never lost to the landfills of tomorrow. Only then can India truly claim to lead a digital revolution that is as clean as the silicon on which it is built.