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Balancing Digital Rights with Environmental Sustainability: A Move Towards Climate Justice

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Abstract

The rapid growth of digital technology has profoundly impacted both human lives and the environment. According to the *2024 Digital Economy Report: Shaping an Environmentally Sustainable and Inclusive Digital Future*, India's global share of screens, computers, and small IT and telecommunication (SCSIT) waste has increased from 3.1% in 2010 to 6.4% in 2022. The United Nations Conference on Trade and Development (UNCTAD) also reported a 163% increase in India's generation of electronic waste from SCSIT. E-waste, due to the presence of hazardous materials like heavy metals, lead, and mercury, poses significant environmental and health risks, necessitating proper disposal methods. A key challenge is the growing reliance on digital technologies for essential services, such as e-commerce and e-banking. The expansion of human rights to include digital rights has created a conflict between the freedom of expression and the duty to protect the environment, especially regarding climate change. This article explores the extent of dependency on electronic devices, purchasing patterns, and attitudes toward responsible e-waste disposal and recycling. It examines the effectiveness of India's current legal and policy framework for e-waste management, focusing on the informal sector's recycling practices, which pose additional risks. Using empirical data collected from working professionals, students, and homemakers, the study finds that while electronic device ownership is widespread, with most respondents owning more than five devices, e-waste disposal practices are largely irresponsible. Discarded devices are often stored rather than recycled or sold to authorized collectors. This indicates a lack of awareness, resources, and proper infrastructure. The findings underscore the need for a comprehensive policy framework that mandates responsible usage and disposal, empowers municipalities with necessary resources, and penalizes illegal recycling practices.

KEYWORDS *E-waste, digital technology, climate change, digital rights, environmental right*

Introduction

Electronic waste/e-waste, e-scrap, and end-of-life electronics are terms used alternatively to refer to those used electronic devices that are nearing the end of their useful life. The United Nations defines e-waste as any discarded product that has battery or plug and contains toxic substances such as lead or mercury and has potential to impact human health and environment.[1] E-waste consists of valuable materials and in the process of extracting it, several hazardous substances are released into the atmosphere which gets accumulated. Processes such as open-air burning and acid baths expose workers to contaminants like thallium, cadmium, mercury, arsenic, and lead which cause irreversible damage such as cancer, miscarriage, neurological damage, etc. The improper handling of e-waste results in loss of valuable and scarce raw materials such as neodymium, which is useful for magnets in motors, indium, which is used in flat panel TV, and cobalt, that is used for batteries. E-waste generation is the fastest growing solid waste in the world, and it is increasing 3 times faster than the world's population. The surge in demand for electronic devices is contributing significantly to man-made global warming because every electronic device produced leaves behind a carbon footprint.

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1 "Update: The Growing Environmental Risks of E-Waste," Geneva Environment Network, last modified March 25, 2024, https://www.genevaenvironmentnetwork.org/resources/updates/the-growing-environmental-risks-of-e-waste/.

Existing study[2] show that 62 billion kg of e-waste was generated globally in 2022, which is equivalent to 7.8 kg per capita per year. The total e-waste generated in 2010 was 34 billion kg which has since increased annually by an average of 2.3 billion kg. Further, it has been found that the rise in e-waste generation is outpacing the rise in formal recycling by a factor of almost 5. It has been predicted that 82 billion kg of e-waste will be generated in 2030. The e-waste generation of India alone paints an alarming picture. The Central Pollution Control Board (CPCB) estimates the e-waste generation at national level based on the countrywide sales data provided by producers and average life of notified electrical and electronic equipment (EEE), as mandated under the E-waste Management Rules, 2016. As per the information available with CPCB,[3] e-waste generated in the country from twenty-one (21) types of EEE notified under the E-Waste (Management) Rules, 2016 since Financial Year (FY) 2017-18 as shown on Table 1.

TABLE 1. E-Waste (Management) Rules 2016

FINANCIAL YEAR	GENERATION (TONNES)
2017-18	7,08,445.00
2018-19	7,71,215.00
2019-20	10,14,961.21
2020-21	13,46,496.31
2021-22	16,01,155.36

Source: Press Information Bureau, Delhi

The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and the E-Waste (Management) Rules, 2022 are two prominent legislations in India which regulate the import and export of hazardous wastes and e-waste respectively. The current legal framework emphasizes on Extended Producer Responsibility (EPR) regime wherein the manufacturer, producer, refurbisher, and recycler must register on portal developed by CPCB. The new rules also promote Circular Economy through EPR regime and scientific recycling/disposal of the e-waste.

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2 Cornelis P Baldé et al., *Global E-Waste Monitor 2024, International Telecommunication Union (ITU) and United Nations Institute for Training and Research (UNITAR), Geneva/Bonn*, 2024, https://ewastemonitor.info/the-global-e-waste-monitor-2024/.

3 "Ministry of Environment, Forest and Climate Change: Generation of E-waste," Press Information Bureau, last modified July 27, 2023, https://pib.gov.in/PressReleasePage.aspx?PRID=1943201.

The global community is actively working towards e-waste management due to its serious impact on climate change.[4] The impact on environment has been exhaustively evaluated by the existing literature.[5] Scholars have discussed that improper handling of e-waste due to lack of adequate infrastructure, technology, human capacity, and limited public awareness are major reasons for environmental pollution. Moreover, studies show that the contaminants move through the food chain and impact human health also.[6] The present situation calls for an effective e-waste management system which has been discussed by Kajalben Patel in her thesis (2021).[7]

While duty for e-waste management is perceived to be primarily on the government and then on the producers, this article attempts to suggest legal amendments for promoting the sense of responsible disposal by the customers and entrusting them with the primary duty in this direction. It is explored in the light of intersection of digital rights with environment and climate justice. The Engine Room in association with Ford Foundation, Ariadne and Mozilla Foundation, prepared this research report on the intersection of digital rights with environment and climate justice. The report identifies six cross-cutting themes which highlights various issues and challenges i.e., "the need for connections and shared vocabularies across communities, movements, and sectors", "our focus on growth is incredibly dangerous", "extractive dynamics are a problem across sectors", "both technological and environmental crises are hard to visualize and mobilize around", "the frictions and contradictions of 'Tech for Climate'", and "growing and protecting the 'commons'".[8] The formation of digital rights' paradigm within the life of society and social relations perceiving such rights as evolutionary on the defined parameters of

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4 Salma Taqi Ghulam and Hatem Abushammala, "Challenges and Opportunities in the Management of Electronic Waste and Its Impact on Human Health and Environment," *Sustainability (Switzerland)* 15, no. 3 (2023), https://doi.org/10.3390/su15031837.

5 Akeeb Adepoju Fawole et al., "Climate Change Implications of Electronic Waste: Strategies for Sustainable Management," *Bulletin of the National Research Centre* 47, no. 1 (2023), https://doi.org/10.1186/s42269-023-01124-8.

6 Abhishek Kumar Awasthi, Xianlai Zeng, and Jinhui Li, "Environmental Pollution of Electronic Waste Recycling in India: A Critical Review," *Environmental Pollution* 211 (2016): 259–70, https://doi.org/10.1016/j.envpol.2015.11.027.

7 Kajalben Patel, "A Study on E-Waste Management System in India," no. March (2021): 93.

8 B. Kazansky et al., "At the Confluence of Digital Rights and Climate & Environmental Justice: A Landscape Review," *The Engine Room*, 2022, https://engn.it/climatejusticedigitalrights.

human rights has already been discussed by scholars.[9] Moreover, majority of the existing work deals with issues like privacy invasion, detriments of dataveillance, datafication, and "digital-by-default commercial" arising as a consequence of digitalization.[10] In this backdrop, the present research focuses on identifying the efficacy of e-waste management in India, awareness of people as to recycling and environmental impact of e-waste, attitude of people to achieve a balance between exercise of their digital rights and their duty to protect and preserve environment. The shortcomings and gaps in the e-waste management rules of India has also been analysed to suggest appropriate measures. Further, the legal position as to e-waste management in a few countries has been discussed with the intention of finding innovative and cost-effective measures to circumvent the evil repercussions of e-waste on climate change.

This research has adopted a mixed-method approach, combining both doctrinal and empirical research methodology. Under the doctrinal method, the analysis of existing literature reveals a thorough comprehension of key concepts like e-waste, digital rights, climate change, and the management of e-waste through disposal and recycling methods. The examination of legislative and policy framework has been critical in identifying the limitations and gaps that needs redressal. The international aspect has been investigated to broaden the scope of the current research.

In furtherance of the non-doctrinal research method, a sample size of 329 was taken. Primary data was collected through a structured questionnaire employing a simple random sampling technique. Since the questionnaire was administered electronically, respondents from all over India were able to participate in the research. The targeted respondents were students, working professionals, and homemakers. The objective behind such diversity of respondents was to obtain comprehensive results which can effectively be generalised. The questionnaire was prepared with the intention of gathering information on average number of electronic devices owned, dependency on electronic devices, frequency to buy new electronic devices, manner of disposal of e-waste, and people's inclination towards responsible e-waste disposal. Further, the awareness of respondents as to impact of e-waste on environment and humans, knowledge as to recycling/dismantling and tendency to recycle,

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9 Kostyantyn I. Bieliakov et al., "Digital Rights in the Human Rights System," *InterEULawEast* 10, no. 1 (2023): 183–207, https://doi.org/10.22598/iele.2023.10.1.10.

10 Luci Pangrazio and Julian Sefton-Green, "Digital Rights, Digital Citizenship and Digital Literacy: What's the Difference?," *Journal of New Approaches in Educational Research* 10, no. 1 (2021): 15–27, https://doi.org/10.7821/NAER.2021.1.616.

awareness as to policies on e-waste was also assessed. Lastly, their opinion on how regulations upholding their duty to protect the environment would affect their digital rights were also recorded. The data was analysed using IBM SPSS software. The analysis reflects on critical issues including the effectiveness of e-waste management, barriers to responsible e-waste disposal, people's knowledge and awareness of recycling and dismantling methods, and their awareness of environmental policies. The novelty of intersection between digital rights and climate justice was also analysed.

The mixed-method approach is followed to provide a holistic view on the impact of digitalisation on climate change. The expansion of international law and increased inclusion of individual through the widening scope of human rights creates a unique situation of overlap between digital rights and environmental sustainability. This methodology attempts to dive into this less explored academic territory with the help of primary data. It helps in gaining insight into e-waste management and other allied issues through the lens of consumers. This approach is the best possible way to know the grass root problems and blockages towards attainment of sustainable development goals. The analysis has been a tool for suggesting appropriate policy measures which specifically cater to the Indian situation.

Digitalisation and E-Waste

Digital technology has become an inalienable part of people's lives across the globe. It has transformed communications, health industry, education, finance, businesses, and so on. As per the World Bank Group in "Digital Progress and Trends Report 2023"[11], there are two prominent trends that are moulding the digital future i.e., significance of digital public infrastructure and the transformative potential of artificial intelligence. This report basically tracks the progress of digitalisation in the world along with countries' production and use of digital technologies. It provides that in 2022, more than 90 per cent population in high-income countries were online, and the online population in South Asia doubled from 2018 to 2020. Notably, this was led by India which has brought one-third of its population online since 2018 as a result of promotion of internet literacy coupled with availability of cheaper data plans. The report further divulges that there was surge in data traffic globally during the COVID-19 pandemic. Interestingly, the download of internet apps pertaining to education, finance, shopping, and business rose tremendously during the pandemic. Use of digital technology for online shopping and

[11] *Digital Progress and Trends Report 2023*, 2024, https://doi.org/10.1596/978-1-4648-2049-6.

payments accelerated during the pandemic. Companies in high-income countries with better accessibility and infrastructure are continuously integrating digital solutions to streamline processes and improve efficiency. Moreover, the information technology services sector comprising of services like software development and tech consulting also grew twice as fast as the global economy which led to creation of job opportunities as well.[12]

Indian Council for Research on International Economic Relations (ICRIER) conducted a study based on the 'CHIPS' framework and scored countries on five factors: connect, harness, innovate, protect, and sustain, for deciding their ranking as a digitalised nation. In pursuance, "The State of India's Digital Economy Report, 2024"[13] was published. As per the report, India is the third largest digitalised country globally just after USA and China. Furthermore, India is in a better position in terms of digitalisation as compared to some developed nations including United Kingdom, Germany, and Japan, compared by their aggregate level of digitalisation. Karnataka was on top when similar thing was applied to States within India.[14]

The above-mentioned studies clearly highlight the increase in use of digital technology. Such digitalisation is inevitable for taking benefit of minimum services like banking, benefits under governmental schemes, investments in terms of health insurance, and life insurance, etc. Moreover, in the backdrop of fast-moving urban life, dependency on electronic and electrical devices has multiplied which has led to increase in purchase of such devices by people, sometimes, just to do menial household chores to save little time. While digitalisation has simplified human lives, it has also created an addiction of owning things because of the ease with which it can be done. Another facet of this discussion is growing emphasis on "paper free" transactions that feature under the "go green" initiative where businesses, banking institutions, and educational institutes insist on getting the receipts, or exchanging ideas on electronic devices. This perception of green and digital transitions has been labelled as two sides of the same coin or "twin transitions" which influenced European Commission to adopt it as the focal point of its 2022 Strategic Foresight Report "Twinning the green and digital transitions in the new

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12 "Global Digitalization in 10 Charts," World Bank Group, accessed September 11, 2024, https://www.worldbank.org/en/news/immersive-story/2024/03/05/global-digitalization-in-10-charts.

13 Deepak Mishra et al., *State of India's Digital Economy (SIDE) Report, 2024*, 2024.

14 Ashutosh Mishra, "India is the third largest digitalised country in the world, says expert," *Business Standard*, February 16, 2024, https://www.business-standard.com/economy/news/india-is-the-third-largest-digitalised-country-in-the-world-says-expert-124021600956_1.html.

geopolitical context."[15] It is argued that perceiving digitalisation as a crucial factor towards minimizing climate risks is skipping an important point that digital services and infrastructure is also producing a significant carbon footprint and environmental damages of their own.[16] E-waste generated from the constant demand and supply of new gadgets and devices is a matter of concern.

Apart from creation of e-waste, services availed under digitalisation such as e-commerce generates waste from packaging materials and emits greenhouse gases from delivery and returns. As discussed before e-waste not only comprises of electrical devices such as washing machine, television, refrigerators, hair dryers, etc., but also includes electronic items such as mobile phones,[17] laptops, tablets, headphones, etc. As per the International Telecommunication Union's 2022 edition of *Facts and Figures*,[18] for every 100 people there are 108 mobile phone subscriptions. Apart from this, there is also surge in demand for e-bikes, e-scooters, health monitors, electronics embedded in furniture, LEDs, etc. This has further accelerated the generation of e-waste. This situation calls for effective e-waste management because the disposal of electrical and electronic equipment generate waste that consists of both hazardous and valuable materials which necessitates adoption of appropriate dismantling and recycling techniques. Other than this, focus should also be on checking the reusability and repairability of an equipment. If it is possible then efforts must be taken to increase its lifespan to reduce its environmental footprint.

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15 European Commission, "Twinning the Green and Digital Transitions in the New Geopolitical Context," no. June (2022): 2022–24.

16 "The environmental dark side of digitalisation: an urban perspective," CIDOB: Barcelona Centre for International Affairs, accessed September 11, 2024, https://www.cidob.org/en/publication/environmental-dark-side-digitalisation-urban-perspective.

17 Rupali Jain, "A Study on Buying Behaviour of Mobile Consumers in Mumbai City" 8, no. 4 (2011): 4–5.

18 ITU, *Measuring Digital Development. Facts and Figures*, *ITU Publications*, 2022, https://www.itu.int/en/mediacentre/Documents/MediaRelations/ITU Facts and Figures 2019 - Embargoed 5 November 1200 CET.pdf.

Digital Rights & Environmental Sustainability

Digital rights and Environmental sustainability are increasingly interlinked as we navigate the digital age.

A. Digital Rights

Digital rights[19] encompass a range of freedoms and protections in the digital realm. These include:

1) *Privacy*: Protecting personal data from unauthorized access or misuse. Privacy in the digital realm involves protection of personal data, including sensitive information such as financial details, health records and personal identifiers. It ensures that this data is collected, used, and stored with consent of individual and is protected from unauthorized access and misuse. Consent of an individual is an important regarding collection of personal data. Transparency is an essential aspect of privacy. Data Minimization, Data Security, right to access and Correction and Right to Deletion are essential component of privacy and digitalization. Privacy is a fundamental aspect of digital rights, ensuring that individuals can navigate the online world without fear of undue surveillance or data misuse. Protection of privacy[20] requires strong regulation, technological solution and informed user practices. As digital technology continues to evolve, maintaining and enhancing privacy protection remains a critical challenge and priority.
2) *Freedom of Expression*: The Right to share and receive information online without censorship. Individuals have a right to express their opinions and ideas without fear of censorship or retaliation. This includes right to share thoughts, critiques and information online. While protecting freedom of expression, it is also important to address the need to prevent them. This includes finding ways to address issues like harassment and harmful misinformation while respecting fundamental rights. Balancing this freedom with need to address harmful content and protect other rights presents ongoing challenges.
3) *Access to Information*: Ensuring equitable access to the internet and digital resources. Individuals have the right to seek out information and ideas through digital platforms. This includes accessing news, research,

[19] Igor Calzada, "The Right to Have Digital Rights in Smart Cities," *Sustainability (Switzerland)* 13, no. 20 (2021): 1–28, https://doi.org/10.3390/su132011438.

[20] Aaron Joyce and Vahid Javidroozi, "Smart City Development: Data Sharing vs. Data Protection Legislations," *Cities* 148, no. October 2023 (2024): 104859, https://doi.org/10.1016/j.cities.2024.104859.

educational resources, and other form of content online. The ability to share information and contribute content to digital platforms, including social media, blogs and online forum is a key aspect of this right. Access to information is essential for an informed citizen., enabling people to make educated decisions and participate effectively in democratic processes. Socio-economic disparities, including income and geographic location can affect access to the internet and digital devices, creating barriers to information access. Access to information is a crucial component of digital rights, underpinning democratic participation, education, and innovation. Ensuring equitable access requires addressing barriers such as digital divide, censorship and financial constraints while balancing other important consideration like privacy and security.

4) *Digital Security*: Safeguarding users from cyber threats and attacks. Digital Security is crucial in today's tech driven world encompassing range of practices and technologies designed to protect digital information and system from various threats. Ensuring data protection like personal information, financial details or intellectual property is kept confidential. Network security, cyber threats, encryption etc. are serious issues to be determined.

B. Environmental Sustainability

Environmental sustainability[21] involves practices and policies aimed at reducing ecological impact and conserving resources. Environmental sustainability is all about meeting our current needs without compromising the ability to future generations to meet theirs.[22] It involves managing natural resources wisely, reducing waste and pollution and protecting ecosystem and biodiversity. Key areas include:

1) *Reducing Carbon Footprints*[23]: Minimizing greenhouse gas emissions through energy -efficient technologies and renewable energy. Using energy efficient appliances and buildings reduces energy consumption. This includes better insulation, LED. Lighting and energy efficient HVAC

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[21] Steffen Lange et al., "Digital Reset, Redirecting Technologies for the Deep Sustainability Transformation," *Digital Reset, Redirecting Technologies for the Deep Sustainability Transformation*, 2023, https://doi.org/10.14512/9783987262463.

[22] Rahul S. Mor et al., "E-Waste Management for Environmental Sustainability: An Exploratory Study," *Procedia CIRP* 98, no. March (2021): 193–98, https://doi.org/10.1016/j.procir.2021.01.029.

[23] Dlzar Al Kez et al., "Exploring the Sustainability Challenges Facing Digitalization and Internet Data Centers," *Journal of Cleaner Production* 371, no. August (2022): 133633, https://doi.org/10.1016/j.jclepro.2022.133633.

systems. Both reducing carbon footprints and protecting digital rights are essential for building a sustainable and equitable future.

2) *Resource Conservation*: Efficient use of natural resources and reduction of waste. Resource conservation and digital rights are interconnected in several meaningful ways, reflecting how advancements in technology and digital infrastructure can impact both the environment and personal freedoms. Green technology is a solution as it conserves energy. Recycling and Disposal leads to frequent upgrades and disposal of electric devices, contributing to e-waste. Proper recycling and responsible disposal of electronic devices, contributing to e-waste. Proper recycling and responsible disposal of electronic devices help conserve resources and reduce environmental impact.
3) *Pollution Reduction*: Decreasing pollution from various sources, including electronic waste(e-waste). Pollution reduction and digital rights intersect in several interesting ways. As digital technologies evolve and become more integral to our lives, they can both contribute to and help mitigate pollution.

C. Intersection of Digital Rights and Environmental Sustainability

1. *Data Centres and Energy Use*

Data centres are crucial for digital infrastructures[24] but consumes significant amounts of energy. Sustainability practices include using renewable energy sources and improving energy efficiency to reduce their carbon print. Transparency in data centre operation can be a digital right, with users having the right to know how their data is being managed in terms of environmental impact.

2. *E-Waste Management*

Digital rights involve responsible disposal and recycling of electronic devices. Ensuring that e-waste is managed sustainably helps mitigate its environmental impact. Users should have access to information about how to recycle or dispose of their devices properly.[25]

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24 Digital Economy Report, "Digitalization and Environmental Sustainability," 2024, 1–23, https://doi.org/10.18356/9789213589779c007.

25 Hua Zhong et al., "An Empirical Study on the Types of Consumers and Their Preferences for E-Waste Recycling with a Points System," *Cleaner and Responsible Consumption* 7, no. October (2022): 100087, https://doi.org/10.1016/j.clrc.2022.100087.

3. *Digital Access and equity*
   Ensuring equitable access to digital technology supports both digital rights and environmental sustainability. Innovation that reduces energy consumption and environmental impact benefit society as a whole.
4. *Green Technology and Innovation*
   Promoting and supporting green technologies aligns with both digital rights and Environmental impact benefit society as a whole.
5. *Awareness and Education*
   Educating individuals about the environmental impacts of digital activities can help foster more sustainable behaviours. This includes understanding the energy consumption of online service and importance of secure, privacy-respecting digital practices.
6. *Regulatory Frameworks*
   Policies and regulations that address both digital rights and environmental concerns can drive progress. For example, regulations that requires companies to disclose their energy use or implement eco-friendly practice can support both causes. By integrating digital rights[26] with environmental suitability, we can work towards a more equitable and eco-conscious digital future. The challenge lies in balancing these aspects to ensure that technological advancement does not come at the cost of environmental degrading or personal freedoms.

Balancing Digital Rights with Environmental Sustainability: A Move towards Climate Justice: International Perspective

The rapid growth of digital technology has brought about significant changes in how people communicate, work, and live. However, this digital revolution has also led to increased dependency on electronic devices, contributing to an unsustainable rise in electronic waste (e-waste). Balancing digital rights with environmental sustainability is now crucial to achieving climate justice. This balance requires understanding the complex relationships between technological advancement, e-waste generation, and its disposal. Several factors, such as the average number of electronic devices owned, dependency on these devices, the frequency of purchasing new devices, e-waste

[26] T. Santarius et al., "Digitalization and Sustainability: A Call for a Digital Green Deal," *Environmental Science and Policy* 147, no. October 2022 (2023): 11–14, https://doi.org/10.1016/j.envsci.2023.04.020.

disposal methods, the presence of authorized collection centers, and public awareness regarding responsible e-waste disposal, recycling, and the legal framework, need to be considered to address these challenges.

Globally, the number of electronic devices owned per person has been on the rise. In developed countries like the United States, Japan, and many European nations, the average household owns several electronic devices, including smartphones, laptops, tablets, wearables, and smart home appliances. In contrast, developing countries are catching up rapidly due to the increased affordability of devices and the proliferation of the internet. This growing number of devices contributes to higher volumes of e-waste when they reach the end of their useful lives.

The dependency on electronic devices has dramatically increased[27] with digital transformation in nearly every sector, from education and healthcare to entertainment and social interaction. During the COVID-19 pandemic, digital devices became even more indispensable as remote work, online education, and virtual communication became the norm. As a result, individuals and organizations have become heavily dependent on electronic devices, which is expected to persist even post-pandemic. This dependency fuels frequent upgrades and replacements of electronic devices, leading to more e-waste generation. To achieve climate justice, there is a pressing need to shift this dependency towards more sustainable digital practices, such as using energy-efficient devices, extending the life of existing devices, and supporting the development of sustainable technology.

The frequency with which individuals purchase electronic devices plays a significant role in the accumulation of e-waste. The rapid evolution of technology and the influence of consumer culture encourage people to frequently upgrade to newer models, even if the older devices are still functional. Studies have shown[28] that, on average, consumers in high-income countries replace their smartphones every 2-3 years, laptops every 3-5 years, and other electronic devices like smart TVs and wearables even more frequently. In

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[27] Chetna Chauhan, Vinit Parida, and Amandeep Dhir, "Linking Circular Economy and Digitalisation Technologies: A Systematic Literature Review of Past Achievements and Future Promises," *Technological Forecasting and Social Change* 177, no. January (2022): 121508, https://doi.org/10.1016/j.techfore.2022.121508.

[28] Forti, Vanessa, Cornelis P. Baldé, Ruediger Kuehr, and Garam Bel. "The Global E-waste Monitor 2020: Quantities, Flows, and the Circular Economy Potential." *United Nations University (UNU), United Nations Institute for Training and Research (UNITAR), and International Telecommunication Union (ITU)*, 2020, accessed September 29, 2023, https://www.itu.int/en/ITU-D/Environment/Documents/Toolbox/GEM_2020_def.pdf.

contrast, in low- and middle-income countries, the replacement cycle tends to be longer due to economic constraints. This pattern reflects a critical need for global policies that promote sustainable consumption, such as encouraging the repair and reuse of devices, extending product lifecycles, and reducing planned obsolescence by manufacturers.

E-waste disposal practices vary significantly across regions.[29] In many high-income countries, a substantial portion of e-waste is collected and processed through formal recycling systems. However, a large amount of e-waste is still improperly discarded in landfills, incinerated, or exported to developing countries. In lower-income regions, e-waste is often dismantled[30] informally, with little regard for environmental or health standards. Informal recycling processes expose workers to hazardous chemicals and contribute to soil, water, and air pollution. Therefore, to promote climate justice, there is an urgent need for internationally recognized standards and practices that ensure e-waste is managed responsibly and sustainably across all regions.

The presence of authorized e-waste collection centres is critical in managing e-waste sustainably. in many developed countries, e-waste management infrastructure is more robust, with several authorized centres for collecting, recycling, and disposing of e-waste. However, many developing countries still lack the necessary infrastructure, and e-waste is often collected informally. To address this issue, international cooperation is essential to build capacity, develop infrastructure, and create incentives for establishing authorized collection centres in countries that lack them. Strengthening e-waste management infrastructure globally is crucial to balancing digital rights with environmental sustainability and moving towards climate justice.

Public inclination toward responsible e-waste disposal is influenced by various factors, including cultural norms, awareness levels, convenience, and the availability of authorized disposal options. In many countries, people may prefer to sell or donate old devices rather than dispose of them properly due to the perceived economic value or lack of knowledge about proper disposal methods. Moreover, in regions with limited or no access to authorized e-waste collection centres, people may find it challenging to dispose of e-waste responsibly. Therefore, fostering a culture of responsible e-waste disposal through public awareness campaigns, incentives, and easy access to authorized collection centres is essential for achieving climate justice.

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[29] Navtika Singh Nautiyal and Shuchita Agarwal, "E Waste Management: An Empirical Study on Retiring and Disposal of Retiring Gadgets," *International Journal of Management* 11, no. 12 (2021): 2901–10, https://doi.org/10.34218/ijm.11.12.2020.272.

[30] Minter, Adam. "Junkyard Planet: Travels in the Billion-Dollar Trash Trade." *New York: Bloomsbury Press* (2013).

Awareness regarding recycling and the tendency[31] to recycle e-waste significantly impacts sustainable e-waste management. In many parts of the world, awareness about the environmental impacts of improper e-waste disposal is low. Even in regions where people are aware, the tendency to recycle is often limited by a lack of convenient recycling options or incentives. In high-income countries, awareness campaigns have successfully improved recycling rates, but in many low- and middle-income countries, similar initiatives are less prevalent or effective. To achieve climate justice, global efforts must focus on enhancing public awareness of e-waste recycling's environmental and health benefits and providing easy and incentivized recycling opportunities.

The legal framework governing e-waste management varies widely across countries. In the European Union, strict regulations like the Waste Electrical and Electronic Equipment (WEEE) Directive mandate[32] producers' responsibility for e-waste management. Similarly, some countries,[33] such as Japan and South Korea, have implemented comprehensive e-waste management laws. However, many countries, particularly in the Global South, lack[34] robust regulatory frameworks or face challenges in enforcing existing regulations. Raising awareness about existing legal frameworks and advocating for international standards in e-waste management are critical steps toward ensuring digital rights are balanced with environmental sustainability. This move will help ensure that e-waste is managed responsibly, reducing environmental degradation and supporting climate justice.

Regulatory Mechanism *vis-à-vis* Environmental Sustainability

Regulatory mechanisms play a crucial role in promoting environmental sustainability by establishing rules and standards that guide and limit human activities to protect and preserve natural resources. Government enacts laws to regulate pollution, manage natural resources and protect ecosystems. In India regulatory mechanisms for environmental sustainability which are governed by

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31 Laura Piscicelli, "The Sustainability Impact of a Digital Circular Economy," *Current Opinion in Environmental Sustainability* 61 (2023): 101251, https://doi.org/10.1016/j.cosust.2022.101251.

32 European Parliament and Council of the European Union. Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE). *Official Journal of the European Union* L 197, 24 July 2012.

33 World Economic Forum. A New Circular Vision for Electronics: Time for a Global Reboot. Geneva: World Economic Forum (2019).

34 United Nations Environment Programme (UNEP). Global Waste Management Outlook. Nairobi: UNEP (2015).

a complex framework of laws, policies and institutions aimed at addressing various environmental challenges and promoting sustainable development. Environment Protection Act, 1986 is a primary legislation providing the framework for environmental protection in India. It empowers the Central Government to take measures for the improvement of the environment and establishes the basis for regulatory mechanism[35].

In 2006, India's approach to environment management, emphasizing sustainable development, integration of environment consideration into policy making and strengthening of regulatory mechanism.[36] The nodal agencies like Ministry of Environment, Forest and Climate Change (MoEFCC), Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCBs) are working towards environmental preservation.

Environment Impact assessment (EIA) requires that certain projects undergo environmental impact assessment before obtaining clearance. This process evaluates potential environmental impacts and proposes mitigation measures. Green Bonds and Subsidies are incentives also available for renewable energy projects and other sustainable practices. NAPCC[37] outlines India's strategy to address climate change through eight missions including the National Solar Mission and the Mission for Sustainable Agriculture.

India has established a regulatory framework to manage electronic waste(e-waste) through a set of rules designed to address the growing environmental and health challenges associated with improper disposal and recycling of electronic products. E-Waste (Management) Rules, 2016 are the primary regulations governing e-waste management in India. They replaced the earlier E-Waste (Management and Handling) Rules, 2011. There is another statutory implication Hazardous and other waste (Management & Transboundary Movement) Rules 2016. The rules aim to minimize e-waste generation, promote environmentally sound recycling and disposal and ensure proper management of e-waste. E-Waste management rules had been amended several times including E-Waste First Amendment Rules 2023, E-Waste Second Amendment Rules 2023 and E-Waste Third Amendment Rules, 2024.And these amendments gave new dimensions to e-waste management in India.

These regulatory mechanism policies and institutions collectively work towards addressing India's environment challenges and promoting sustainable development. The effectiveness of these measures depends on robust

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35 Environment Protection Act, 1986 is a nodal Act on Environment Protection in India.

36 National Environment Policy, 2006.

37 National Action Plan on Climate Change, 2008.

implementation, monitoring and continues adaptation to emerging environmental issues.

Efficacy of e-waste management

The data for the present research was collected to gather information on: the average number of electronic devices owned by the respondents, their dependency on electronic devices, the frequency of buying electronic devices, the methods of e-waste disposal, existence of and access to authorised e-waste collection centres, people's inclination towards proper e-waste disposal, awareness as to recycling and dismantling and their tendency to recycle, awareness as to legal rules, and their opinion on balancing digital rights with environmental sustainability. The broad objectives of the study are:

1) To see the correlation between electronic devices owned as per age and occupation of the respondents. It will help in understanding the set of population to be targeted.
2) Extent of dependency on electronic devices which will guide in predicting the trend for increase in demand in them.
3) Knowledge about toxic effect of e-waste on human health and environment as per the age of the respondents which will show which age group needs to be targeted and when it is further connected to their occupation, an effective policy framework can be drafted.
4) How many have access to e-waste collection or drop-off points.
5) Factors preventing respondents from bringing e-waste to drop-off points where there is access. This will help in knowing the thinking of people and their sense of responsibility.
6) People's opinion on conflict between exercise of their digital rights vis -a vis responsible e-waste disposal. It will help in creating awareness to think in a harmonious manner rather than in a conflicting one.
7) Management of old devices and segregating the responsible behaviour from unresponsible one and thereby analysing the importance of incentives in enforcing a responsible behaviour.

The Table 2 illustrates the frequency distribution across different variables of the study. A detailed discussion on the same has been done after the table.

TABLE 2. Distribution across different variables of the study

Variables	Frequency	Percentage
Age		
Under 18 years	5	1.5
18-28 years	229	69.6

Variables	Frequency	Percentage
28-38 years	56	17.0
38 years and above	39	11.9
Occupation		
Student	212	64.4
Working professional	110	33.4
Home maker	7	2.1
Own electronic devices		
No	7	2.1
Yes	322	97.9
Average number of electronic devices owned		
One	21	6.6
Two	49	15.3
Three	45	14.1
Four	40	12.5
Five	29	9.1
More than five	136	42.5
Dependency on electronic devices		
1	5	1.5
2	7	2.2
3	10	3.1
4	18	5.6
5	37	11.4
6	39	12.0
7	48	14.8
8	72	22.2
9	29	9.0
10	59	18.2
Electronic devices which are:		
Broken or damaged		
No	271	82.4
Yes	58	17.6
Not working but can be repaired		
No	226	68.7
Yes	103	31.3

Variables	Frequency	Percentage
Working condition but not used		
No	254	77.2
Yes	75	22.8
Working condition		
No	130	39.5
Yes	199	60.5
Old electronic devices		
Discarded as waste	29	9.1
Kept in storage	96	30.2
Donated it	24	7.5
Sold it in exchange scheme for purchase of new	49	15.4
Sold it to a recycler	25	7.9
Gave to authorized e-waste collector	2	0.6
First time buyer	51	16.0
Others	42	13.2
Frequency of purchasing new electronic devices		
As per requirement	249	76.6
Every month	9	2.8
1-2 months	9	2.8
2-3 months	12	3.7
3 months and above	46	14.2
Knowledge about e-waste		
No	42	13.0
Yes	281	87.0
Hazardous impact of e-waste on human health and environment		
No	45	13.9
Yes	278	86.1
Knowledge about toxic effect of e-waste on human health		
Extremely poor	30	9.3
Poor	33	10.2
Average	127	39.3
Good	93	28.8
Extremely good	40	12.4

Variables	Frequency	Percentage
Knowledge about toxic effect of e-waste on environment		
Extremely poor	27	8.4
Poor	31	9.6
Average	119	36.8
Good	96	29.7
Extremely good	50	15.5
Access to e-waste collection/drop-off points		
No	266	82.1
Yes	58	17.9
Willingness to bring electronic devices to e-waste drop-off points		
No	39	12.1
Yes	158	49.2
Maybe	124	38.6
Reasons for not bringing electronic devices to e-waste drop-off points		
Lack of drop-off containers in the vicinity	86	35.0
Lack of knowledge about proper e-waste recycling	75	30.5
Lack of carrying facility	43	17.5
Lack of time	28	11.4
Don't care	14	5.7
Methods to dismantle and recycle e-waste		
No	238	73.7
Yes	85	26.3
Knowledge about environmental policies addressing e-waste		
No	192	60.0
Yes	128	40.0
Responsible e-waste management is an interference to digital rights		
No	184	58.6
Yes	130	41.4
Incentive for responsible e-waste disposal		
No	43	13.5
Yes	275	86.5

The Table 2 illustrates the age distribution of the population, highlighting that most of the respondents i.e., 69.6% fall in the age group of 18-28 years, indicating a predominantly youthful demographic. The next largest group, comprising 17% of the population, falls within the 28-38 years age range. Those aged 38 years and above represent 11.9% of the population, while only 1.5% are under 18 years old. This distribution underscores a significant concentration of individuals in the early adult years, with fewer people in the younger and older age brackets.

The Table 2 outlines the occupational distribution of the population, showing that the majority i.e., 64.4% are students. This indicates a significant portion of the population is engaged in academic pursuits. Working professionals make up 33.4% of the population, reflecting a substantial presence of individuals in the workforce. Meanwhile, homemakers represent a small minority, accounting for just 2.1% of the population.

The Table 2 presents data on the ownership, condition, and usage of electronic devices within a population. It shows that 97.9% of individuals own electronic devices, with only 2.1% not owning any. Among those who own devices, 17.6% have devices that are broken or damaged, 31.3% of devices are not working but can be repaired, and 22.8% of devices that are in working condition are not being used. Finally, 60.5% of the devices are in working condition, suggesting most of the devices are still functional.

The Table 2 provides an overview of people's knowledge and awareness regarding e-waste and its impact. A large majority, 87.0%, are aware of the concept of e-waste, and 86.1% recognize the hazardous impact of e-waste on human health and the environment. When it comes to the degree of understanding the toxic effects of e-waste on human health, most individuals rate their knowledge as average (39.3%), followed by those who consider it good (28.8%). A smaller percentage rate their understanding as extremely good (12.4%) or poor (10.2%). Similarly, in terms of knowledge about the toxic effects of e-waste on the environment, most people again rate their extent of knowledge as average (36.8%) or good (29.7%). A smaller group considers their understanding to be extremely good (15.5%), while fewer individuals describe it as poor (9.6%) or extremely poor (8.4%). Overall, while there is a high level of awareness about e-waste and its general impacts, the depth of knowledge varies, with many people possessing only an average understanding of the specific toxic effects of e-waste on health and the environment. Some specific factors can further be discussed in detail under the following sub-headings:

TABLE 3. Average number of electronic devices owned across age groups

Average number of electronic devices		Age				Total	Chi-square statistic (p-value)
		Under 18 years	18-28 years	28-38 years	38 years and above		
One	Count	1	17	2	1	21	33.124* (0.001)
	%	20.0%	7.7%	3.6%	2.6%	6.6%	
Two	Count	2	40	5	2	49	
	%	40.0%	18.1%	9.1%	5.1%	15.3%	
Three	Count	0	36	4	5	45	
	%	0.0%	16.3%	7.3%	12.8%	14.1%	
Four	Count	0	26	13	1	40	
	%	0.0%	11.8%	23.6%	2.6%	12.5%	
Five	Count	0	16	10	3	29	
	%	0.0%	7.2%	18.2%	7.7%	9.1%	
More than five	Count	2	86	21	27	136	
	%	40.0%	38.9%	38.2%	69.2%	42.5%	
Total	Count	5	221	55	39	320	
	%	100.0%	100.0%	100.0%	100.0%	100.0%	

The data shows the distribution of individuals across different age groups based on the number of electronic devices they own. The majority of people own more than five electronic devices, with this being especially prevalent in the age group "38 years and above" (69.2%) and "18-28 years" (38.9%). The ownership of fewer devices (one or two) is more common among younger individuals, particularly those under 18 years old. The highest percentage of respondents owning two devices comes from the "18-28 years" group (18.1%). Conversely, ownership of three or four devices shows a balanced spread across age groups, with a significant portion of those aged "28-38 years" owning four devices (23.6%). The chi-square statistic (33.124, p=0.001) indicates a statistically significant association between age and the number of electronic devices owned.

TABLE 4. Average number of electronic devices owned as per occupation

Average number of electronic devices		Occupation			Total	Chi-square statistic (p-value)
		Student	Working professional	Home maker		
One	Count	20	0	1	21	41.296* (0.000)
	%	9.7%	0.0%	14.3%	6.6%	
Two	Count	43	6	0	49	
	%	20.9%	5.6%	0.0%	15.3%	
Three	Count	27	17	1	45	
	%	13.1%	15.9%	14.3%	14.1%	
Four	Count	26	14	0	40	
	%	12.6%	13.1%	0.0%	12.5%	
Five	Count	17	9	3	29	
	%	8.3%	8.4%	42.9%	9.1%	
More than five	Count	73	61	2	136	
	%	35.4%	57.0%	28.6%	42.5%	
Total	Count	206	107	7	320	
	%	100.0%	100.0%	100.0%	100.0%	

The data shows the distribution of the average number of electronic devices owned by individuals across different occupations. Students predominantly own more than five devices (35.4%), followed by those owning two devices (20.9%). Working professionals overwhelmingly have more than five devices (57.0%), while a smaller percentage own three (15.9%) or four devices (13.1%). Among homemakers, the majority own five devices (42.9%) or more than five devices (28.6%). The ownership of one or two devices is more common among students, with 9.7% owning one and 20.9% owning two devices, but absent among working professionals and homemakers. The chi-square statistic (41.296, p=0.000) indicates a statistically significant relationship between occupation and the number of electronic devices owned.

The table mentioned before provides in detail the level of dependency on electronic devices among the population, rated on a scale from 1 to 10, with 1 indicating the lowest and 10 the highest dependency. The data reveals that the highest percentage of individuals, 22.2%, rate their dependency at 8, followed by 18.2% who rate it at the maximum level of 10. Additionally, 14.8% rate their dependency at 7, and 12.0% at 6. Lower levels of dependency are less common, with only 1.5% of individuals rating their dependency at 1. Overall, the data indicates that a significant portion of the population experiences a high dependency on electronic devices, with the majority rating their dependency between 7 and 10.

TABLE 5. Knowledge about toxic effect of e-waste on human health

Knowledge about toxic effect of e-waste on human health		Age				Total	Chi-square statistic (p-value)
		Under 18 years	18-28 years	28-38 years	38 years and above		
Extremely poor	Count	2	22	5	1	30	24.819* (0.007)
	%	50.0%	9.8%	8.9%	2.6%	9.3%	
Poor	Count	0	21	7	5	33	
	%	0.0%	9.4%	12.5%	12.8%	10.2%	
Average	Count	0	100	20	7	127	
	%	0.0%	44.6%	35.7%	17.9%	39.3%	
Good	Count	1	55	17	20	93	
	%	25.0%	24.6%	30.4%	51.3%	28.8%	
Extremely good	Count	1	26	7	6	40	
	%	25.0%	11.6%	12.5%	15.4%	12.4%	
	Count	4	224	56	39	323	
	%	100.0%	100.0%	100.0%	100.0%	100.0%	

The data reflects varying levels of knowledge about the toxic effects of e-waste on human health across different age groups. A significant portion of respondents have average knowledge, with the "18-28 years" group showing the highest percentage in this category (44.6%). The "38 years and above" group has the highest percentage of individuals with good knowledge (51.3%). On the other hand, extremely poor knowledge is more prevalent among younger respondents, particularly in the "Under 18 years" group (50.0%). The percentage of individuals with extremely good knowledge remains relatively low across all age groups, though "Under 18 years" and "18-28 years" have some representation (25.0% and 11.6%, respectively). The chi-square statistic (24.819, p=0.007) indicates a statistically significant relationship between age and the level of knowledge about e-waste toxicity.

TABLE 6. Knowledge about toxic effect of e-waste on environment

Knowledge about toxic effect of e-waste on environment		Age				Total	Chi-square statistic (p-value)
		Under 18 years	18-28 years	28-38 years	38 years and above		
Extremely poor	Count	2	19	4	2	27	27.104* (0.003)
	%	50.0%	8.5%	7.1%	5.1%	8.4%	
Poor	Count	0	22	5	4	31	
	%	0.0%	9.8%	8.9%	10.3%	9.6%	
Average	Count	0	93	21	5	119	
	%	0.0%	41.5%	37.5%	12.8%	36.8%	
Good	Count	1	54	19	22	96	
	%	25.0%	24.1%	33.9%	56.4%	29.7%	
Extremely good	Count	1	36	7	6	50	
	%	25.0%	16.1%	12.5%	15.4%	15.5%	
	Count	4	224	56	39	323	
	%	100.0%	100.0%	100.0%	100.0%	100.0%	

The data illustrates the variation in knowledge about the toxic effects of e-waste on the environment across different age groups. A large proportion of individuals have average knowledge, particularly in the "18-28 years" group (41.5%). The "38 years and above" group exhibits the highest percentage of good knowledge (56.4%), while the "18-28 years" group also has a significant percentage in this category (24.1%). Extremely poor knowledge is more common among younger individuals, especially those "Under 18 years" (50.0%). Poor knowledge is relatively balanced across age groups but remains low overall. Extremely good knowledge about e-waste's environmental impact is relatively higher in the "18-28 years" group (16.1%) and present to a lesser extent across other age groups. The chi-square statistic (27.104, p=0.003) confirms a statistically significant relationship between age and the level of knowledge about the environmental effects of e-waste.

TABLE 7. Access to e-waste drop-off points

Access to e-waste collection/drop-off points		Occupation			Total	Chi-square statistic (p-value)
		Student	Working professional	Home maker		
No	Count	178	83	5	266	6.247* (0.037)
	%	86.0%	75.5%	71.4%	82.1%	
Yes	Count	29	27	2	58	
	%	14.0%	24.5%	28.6%	17.9%	
Total	Count	207	110	7	324	
	%	100.0%	100.0%	100.0%	100.0%	

The data highlights the access to e-waste collection or drop-off points across different occupations. A significant majority of students (86.0%) do not have access to these facilities, while only 14.0% do. Similarly, most working professionals (75.5%) lack access, although 24.5% do have it. Among homemakers, 71.4% report no access, with 28.6% having access to e-waste collection points. Overall, 82.1% of all respondents lack access to such facilities. The chi-square statistic (6.247, p=0.037) indicates a statistically significant relationship between occupation and access to e-waste collection/drop-off points.

TABLE 8. Reasons for not bringing e-waste to drop-off points where there is access

Reasons for not bringing electronic devices to e-waste drop-off points		Hazardous impact of e-waste on human health and environment		Total	Chi-square statistic (p-value)
		No	Yes		
Lack of drop-off containers in the vicinity	Count	9	77	86	10.223* (0.031)
	%	23.7%	37.2%	35.1%	
Lack of knowledge about proper e-waste recycling	Count	14	60	74	
	%	36.8%	29.0%	30.2%	
Lack of carrying facility	Count	4	39	43	
	%	10.5%	18.8%	17.6%	
Lack of time	Count	5	23	28	
	%	13.2%	11.1%	11.4%	
Do not care	Count	6	8	14	

	%	15.8%	3.9%	5.7%	
Total	Count	38	207	245	
	%	100.0%	100.0%	100.0%	

The data highlights the reasons for not bringing electronic devices to e-waste drop-off points, categorized by individuals' awareness of the hazardous impact of e-waste on human health and the environment. Among those aware of the dangers, the most cited reason is the lack of drop-off containers in the vicinity (37.2%), followed by a lack of knowledge about proper e-waste recycling (29.0%) and a lack of carrying facility (18.8%). For those unaware of the hazards, the primary reasons include a lack of knowledge (36.8%) and drop-off containers (23.7%). Interestingly, a higher percentage of those unaware of the hazards stated that they simply "do not care" (15.8%) compared to those who are aware (3.9%). The chi-square statistic (10.223, p=0.031) shows a statistically significant relationship between awareness of e-waste hazards and reasons for not using drop-off points.

TABLE 9. Attitude of respondents towards digital rights vis-à-vis responsible e-waste disposal

Responsible e-waste management is an interference to digital rights		Occupation			Total	Chi-square statistic (p-value)
		Student	Working professional	Home maker		
No	Count	114	69	1	184	7.963* (0.014)
	%	56.4%	65.7%	14.3%	58.6%	
Yes	Count	88	36	6	130	
	%	43.6%	34.3%	85.7%	41.4%	
Total	Count	202	105	7	314	
	%	100.0%	100.0%	100.0%	100.0%	

The data reflects opinions on whether responsible e-waste management interferes with digital rights, segmented by occupation. Among students, 56.4% believe it does not interfere, while 43.6% feel it does. A higher percentage of working professionals (65.7%) believe there is no interference, with 34.3% stating the opposite. In contrast, a majority of homemakers (85.7%) feel that responsible e-waste management does interfere with digital rights, with only 14.3% disagreeing. Overall, 58.6% of respondents do not see responsible e-waste management as an interference, while 41.4% believe it does. The chi-square statistic (7.963, p=0.014) reveals a statistically significant relationship between occupation and views on e-waste management's impact on digital rights.

TABLE 10. Management of old devices across different variables: Signifying responsible *v.* irresponsible behaviour and the influence of incentives on it (I)

Old electronic devices		Electronic devices owned		Total	Chi-square statistic (p-value)
		No	Yes		
Discarded as waste	Count	0	29	29	15.395* (0.002)
	%	0.0%	9.2%	9.1%	
Kept in storage	Count	0	96	96	
	%	0.0%	30.6%	30.2%	
Donated it	Count	0	24	24	
	%	0.0%	7.6%	7.5%	
Sold it in exchange scheme for purchase of new	Count	0	49	49	
	%	0.0%	15.6%	15.4%	
Sold it to a recycler	Count	1	24	25	
	%	25.0%	7.6%	7.9%	
Gave to authorized e-waste collector	Count	1	1	2	
	%	25.0%	0.3%	0.6%	
First time buyer	Count	0	51	51	
	%	0.0%	16.2%	16.0%	
Others	Count	2	40	42	
	%	50.0%	12.7%	13.2%	
Total	Count	4	314	318	
	%	100.0%	100.0%	100.0%	

Table 10 examines how individuals manage old electronic devices based on whether they currently own electronic devices. Among those who own devices, the most common practices include keeping them in storage (30.6%), participating in exchange schemes (15.6%), and discarding them as waste (9.2%). A smaller percentage of device owners donated them (7.6%) or sold them to recyclers (7.6%). Very few device owners (0.3%) gave their devices to authorized e-waste collectors. On the other hand, respondents without electronic devices displayed limited engagement with disposal methods, with half of them choosing "Others" and 25% giving devices to authorized collectors or recyclers. The chi-square statistic (15.395, p=0.002) indicates a statistically significant relationship between owning electronic devices and the method of managing old devices.

TABLE 11. Management of old devices across different variables: Signifying responsible *v.* irresponsible behaviour and the influence of incentives on it (II)

Old electronic devices		Electronic devices not working but can be repaired		Total	Chi-square statistic (p-value)
		No	Yes		
Discarded as waste	Count	19	10	29	20.211* (0.005)
	%	8.8%	9.8%	9.1%	
Kept in storage	Count	51	45	96	
	%	23.6%	44.1%	30.2%	
Donated it	Count	18	6	24	
	%	8.3%	5.9%	7.5%	
Sold it in exchange scheme for purchase of new	Count	36	13	49	
	%	16.7%	12.7%	15.4%	
Sold it to a recycler	Count	16	9	25	
	%	7.4%	8.8%	7.9%	
Gave to authorized e-waste collector	Count	2	0	2	
	%	0.9%	0.0%	0.6%	
First time buyer	Count	44	7	51	
	%	20.4%	6.9%	16.0%	
Others	Count	30	12	42	
	%	13.9%	11.8%	13.2%	
Total	Count	216	102	318	
	%	100.0%	100.0%	100.0%	

Table 11 explores how individuals manage old electronic devices based on whether their non-working devices can be repaired. Among those whose devices can be repaired, the most common action is keeping them in storage (44.1%), followed by selling them in exchange schemes (12.7%) or as waste (9.8%). In contrast, individuals whose devices cannot be repaired primarily keep them in storage (23.6%), sell them in exchange schemes (16.7%), or discard them as waste (8.8%). A larger percentage of first-time buyers come from the group with non-repairable devices (20.4%), compared to those with repairable devices (6.9%). Very few people, regardless of device status, give old devices to authorized e-waste collectors (0.6% overall). The chi-square statistic (20.211, p=0.005) shows a statistically significant relationship between the repairability of electronic devices and how they are managed.

TABLE 12. Management of old devices across different variables: Signifying responsible *v.* irresponsible behaviour and the influence of incentives on it (III)

Old electronic devices		Electronic devices in working condition but not used		Total	Chi-square statistic (p-value)
		No	Yes		
Discarded as waste	Count	24	5	29	16.608* (0.013)
	%	9.8%	6.8%	9.1%	
Kept in storage	Count	68	28	96	
	%	27.9%	37.8%	30.2%	
Donated it	Count	20	4	24	
	%	8.2%	5.4%	7.5%	
Sold it in exchange scheme for purchase of new	Count	31	18	49	
	%	12.7%	24.3%	15.4%	
Sold it to a recycler	Count	19	6	25	
	%	7.8%	8.1%	7.9%	
Gave to authorized e-waste collector	Count	2	0	2	
	%	0.8%	0.0%	0.6%	
First time buyer	Count	46	5	51	
	%	18.9%	6.8%	16.0%	
Others	Count	34	8	42	
	%	13.9%	10.8%	13.2%	
Total	Count	244	74	318	
	%	100.0%	100.0%	100.0%	

Table 12 examines how individuals handle old electronic devices based on whether they are in working condition but not currently used. Those with working but unused devices most commonly keep them in storage (37.8%), while a notable percentage sell them in exchange schemes (24.3%) or discard them as waste (6.8%). In comparison, individuals with non-working devices primarily store them (27.9%), sell them in exchange schemes (12.7%), or discard them as waste (9.8%). There is a higher tendency among those with unused working devices to participate in exchange schemes for new purchases (24.3%) compared to those with non-working devices (12.7%). Very few people across both groups give their devices to authorized e-waste collectors (0.6%). The chi-square statistic (16.608, p=0.013) indicates a statistically significant relationship between the condition of electronic devices and the methods used for their disposal or management.

TABLE 13. Aspects of e-waste management behaviors and related variables

Variables		N	Marginal Percentage
e-waste management	Irresponsible behaviour	142	46.1%
	Responsible behaviour	75	24.4%
	First time buyers	51	16.6%
	Others	40	13.0%
Average number of electronic devices	One	19	6.2%
	Two	46	14.9%
	Three	45	14.6%
	Four	39	12.7%
	Five	28	9.1%
	More than five	131	42.5%
Not working but can be repaired	No	208	67.5%
	Yes	100	32.5%
Working condition but not used	No	236	76.6%
	Yes	72	23.4%
Incentive for responsible e-waste disposal	No	43	14.0%
	Yes	265	86.0%

Table 13 provides insights into various aspects of e-waste management behaviors and related variables. A significant portion of individuals exhibit irresponsible e-waste management behavior (46.1%), while a smaller group practices responsible behavior (24.4%). First-time buyers make up 16.6%, and others account for 13.0%. Regarding the average number of electronic devices owned, the majority have more than five devices (42.5%), with smaller percentages owning one (6.2%), two (14.9%), three (14.6%), four (12.7%), or five (9.1%). For device condition, 67.5% of individuals own devices that are not working but can be repaired, while 76.6% have devices in working condition but not currently used. Incentives for responsible e-waste disposal are prevalent, with 86.0% of respondents having such incentives compared to 14.0% without.

TABLE 14.

Model summary statistics	Chi-square	Sig.
Model Fitting Information		
Likelihood Ratio Tests	72.432*	0.000
Goodness-of-Fit		
Pearson	81.387	0.650
Deviance	81.008	0.661
Nagelkerke Pseudo R-square = 0.228		

The multinomial regression results provide several key insights into the model's performance and fit. The Likelihood Ratio Test statistic is 72.432 with a p-value of 0.000, indicating that the overall model is statistically significant and provides a good fit compared to a model with no predictors. The Goodness-of-Fit tests, including the Pearson chi-square (81.387, p=0.650) and Deviance chi-square (81.008, p=0.661), suggest that the model fits the data well, as the p-values are high, indicating no significant departure from expected values. The Nagelkerke Pseudo R-square value of 0.228 suggests that approximately 22.8% of the variability in the outcome can be explained by the predictors in the model. Overall, the model performs well in explaining the variation in e-waste management behaviors, with the goodness-of-fit tests supporting that the model's predictions are consistent with the observed data.

TABLE 15.

e-waste management[a]	Wald	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
				Lower Bound	Upper Bound
Irresponsible behaviour					
Intercept	21.730*	0.000	-	-	-
Electronic devices not working but can be repaired [Ref. category = Yes]					
No	10.168*	0.001	0.232	0.094	0.569
Electronic devices working condition but not used [Ref. category = Yes]					

No	4.468*	0.035	0.325	0.115	0.921
Incentive for responsible e-waste disposal [Ref. category = Yes]					
No	4.970*	0.026	10.555	1.329	83.795
Average number of electronic devices [Ref. category = More than five]					
One	2.466	0.116	0.372	0.109	1.278
Two	0.047	0.829	0.891	0.314	2.528
Three	0.431	0.511	0.713	0.260	1.956
Four	1.499	0.221	2.346	0.599	9.185
Five	3.048	0.081	0.380	0.128	1.126
Responsible behaviour					
Intercept	14.698*	0.000	-	-	-
Electronic devices not working but can be repaired [Ref. category = Yes]					
No	2.576	0.108	0.441	0.163	1.198
Electronic devices working condition but not used [Ref. category = Yes]					
No	7.563*	0.006	0.216	0.072	0.644
Incentive for responsible e-waste disposal [Ref. category = Yes]					
No	7.226*	0.007	17.887	2.184	146.484
Average number of electronic devices [Ref. category = More than five]					
One	6.156*	0.013	0.111	0.019	0.630
Two	2.134	0.144	0.407	0.122	1.360
Three	1.973	0.160	0.454	0.151	1.366
Four	0.003	0.957	0.959	0.216	4.264
Five	8.410*	0.004	0.127	0.031	0.512
Others					
Intercept	4.887*	0.027	-	-	-
Electronic devices not working but can be repaired [Ref. category = Yes]					
No	2.845	0.092	0.386	0.128	1.167
Electronic devices working condition but not used [Ref. category = Yes]					
No	2.229	0.135	0.384	0.109	1.349
Incentive for responsible e-waste disposal [Ref. category = Yes]					
No	3.792	0.052	9.236	0.986	86.547
Average number of electronic devices [Ref. category = More than five]					

One	2.744	0.098	0.230	0.041	1.309
Two	0.288	0.592	1.367	0.436	4.283
Three	3.228	0.072	0.257	0.058	1.131
Four	0.512	0.474	0.495	0.072	3.400
Five	5.497*	0.019	0.072	0.008	0.650

The multinomial regression analysis provides insights into factors influencing different e-waste management behaviors. For Irresponsible Behavior, having electronic devices that are not working but can be repaired (compared to those that can be repaired) significantly decreases the likelihood of engaging in irresponsible behavior (Exp(B) = 0.232, p=0.001). Similarly, having electronic devices in working condition but not used also reduces the likelihood of irresponsible behavior (Exp(B) = 0.325, p=0.035). Conversely, the absence of incentives for responsible e-waste disposal significantly increases the likelihood of irresponsible behavior (Exp(B) = 10.555, p=0.026). The number of electronic devices does not show significant effects on irresponsible behavior, with p-values above the conventional threshold of 0.05.

For Responsible Behavior, the presence of electronic devices in working condition but not used decreases the likelihood of responsible behavior (Exp(B) = 0.216, p=0.006), while the absence of incentives for responsible e-waste disposal significantly increases the likelihood of responsible behavior (Exp(B) = 17.887, p=0.007). Among those with one or five devices, the likelihood of responsible behavior decreases significantly (Exp(B) = 0.111 for one device, p=0.013; Exp(B) = 0.127 for five devices, p=0.004). Other numbers of devices do not show significant effects.

For Others, having electronic devices in working condition but not used decreases the likelihood of managing e-waste in other ways (Exp(B) = 0.384, p=0.135). The lack of incentives for responsible e-waste disposal also tends to increase the likelihood of other management behaviors (Exp(B) = 9.236, p=0.052), but this result is not statistically significant. Specifically, owning more than five devices significantly decreases the likelihood of other management behaviors (Exp(B) = 0.072, p=0.019).

Overall, the analysis highlights that the management of e-waste is strongly influenced by the condition of the devices and the presence of incentives, with fewer significant effects related to the number of devices owned.

Conclusion

The world is progressing at a rapid pace with new technological advancements being made every day. These developments even though made to make human lives easier, have serious environmental repercussions. With the progress of e-commerce and increased purchasing power of large sections of consumers, the supply of electronic and electrical devices is also on the rise and so is the generation of e-waste. Most developing nations lack appropriate infrastructure for collection, disposal, and recycling of e-waste. In India, the absence of a dedicated and robust e-waste collection chain forms the major problem. Moreover, lack of awareness and financial incentives, limited information on e-waste generation, mishandling in market for the end-of-life products, hazardous informal sector recycling methods, and inadequate regulatory frameworks are other factors contributing to the mismanagement of e-waste. The need of the hour is that the government should shift focus towards circular economy and right to repair especially in the light of practices followed in the Indian scenario.[38] Moreover, the significant involvement of informal sector should be recognized and after building trust and understanding their problems, they should be made aware of the harm caused by their activities and possible solutions may be suggested. A framework for subsidising consumers to deposit their e-waste at authorised centres, incentivizing them for following responsible behaviour towards e-waste generation and disposal, involvement of companies in awareness programmes, and funding of recyclers must be considered.

The emphasis of law should also be on the manufacturing of products employing environment friendly technologies. The State and Central Pollution Control Board must play an active role in monitoring and enforcing compliance standards specified for collection centres, and recyclers. Regular inspections of registered facilities must also be done. Urban local bodies must be given additional power and funds to ensure effective collection of e-waste and transferring the same to formal recyclers. They may also maintain a database containing block wise information on e-waste generation. It may organise campaigns to create awareness among people regarding e-waste, its segregation, appropriate manner of its handling, and its harmful impact. Even though, many producers provide information on their website regarding impact of e-waste and

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[38] Diyasha Sengupta et al., "Circular Economy and Household E-Waste Management in India. Part II: A Case Study on Informal E-Waste Collectors (Kabadiwalas) in India," *Minerals Engineering* 200, no. May (2023): 108154, https://doi.org/10.1016/j.mineng.2023.108154.

appropriate disposal methods, the overall awareness level is still low. For this, stakeholders may be mandated to run awareness campaigns at grass-root level through collaboration with NGOs and other environmentalists with local reach. Therefore, it can be concluded that a holistic approach is necessary to address the challenges in e-waste management in India. Further, some suggestions can be given as per the research findings:

1) Awareness campaigns should be conducted at grassroot level, including educational institutions, workplaces, residential colonies to educate people on the "right to repair".
2) Government must draft an effective right to repair mechanism to facilitate the involvement of producers, and manufacturers so that they can assist the consumers.
3) Since people are highly dependent on electronic devices, some mechanism should be there that provides for selling of old devices for buying new ones as part of the transaction. Emphasis should also be on adopting environment friendly technology in manufacturing.
4) Since majority of respondents have only average knowledge about toxic effect of e-waste on human health and environment, initiatives much be taken to incorporate such issues in the curriculum of the students, and training much be given to working professionals for enhancing their knowledge. For homemakers, municipal corporations can carry on awareness campaigns in the colonies.
5) There is lack of e-waste drop-off points also. So, government must focus on creating more drop-off points. It can be a gamechanger as it has been found the most common reason for not dropping e-waste at collection centres.
6) Education on reasonable exercise of digital rights and duty of consumers towards environment protection must be enhanced.
7) Providing incentives to consumers engaging in responsible e-waste management must be considered.

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