JOURNAL OF ENVIRONMENTAL LAW & POLICY | 05(01) APRIL 2025
Published by The Grassroots Institute in partnership with Asia Pacific Academy of science Pte Ltd. Website: https://grassrootsjournals.org/jelp
Main Indexing: SCOPUS, EBSCO, HEIN ONLINE

ISSN 2564-016X | April 2025

M – 00535 | Analytical Article | Open Access

TOWARDS AN EFFICIENT E-WASTE MANAGEMENT REGIME IN NIGERIA

Sylvanus Gbendazhi Barnabas
Faculty of Law, Nile University of Nigeria, Abuja, Nigeria.
Email: barnabas.sylvanus@nileuniversity.edu.ng, mailsylvanus@gmail.com
ORCID: https://orcid.org/0000-0001-8299-0818

Received: 06 February 2025 | **Reviewed:** 24 March 2025 | **Revised:** 30 March 2025
Accepted: 07 April 2025 | **Published:** 14 April 2025

ABSTRACT

Electronic waste (e-waste) management has emerged as a critical environmental and public health challenge in Nigeria, driven by increasing digitalisation, high importation of used electronics and inadequate disposal practices. Despite existing regulatory efforts, the country continues to struggle with informal recycling, unsafe dismantling methods and limited enforcement of e-waste policies. This article explores the deficiencies in Nigeria's current e-waste management framework and proposes a regulatory blueprint for a more sustainable approach. Drawing on global best practices, the study advocates for a comprehensive regulatory regime that includes Extended Producer Responsibility (EPR), stricter import controls, improved formal recycling infrastructure, and strengthened enforcement mechanisms. It also highlights the importance of public awareness campaigns, private-sector collaboration, and policy incentives to encourage responsible e-waste disposal. By transitioning to a structured and legally enforceable e-waste management system, Nigeria can mitigate environmental risks, safeguard public health, and unlock economic opportunities through resource recovery and job creation. Through doctrinal and critical analysis, this paper underscores the urgent need for a multi-stakeholder approach that aligns regulatory frameworks with sustainability principles, ensuring Nigeria's readiness to tackle the growing e-waste crisis effectively.

Keywords: E-waste Management; Sustainable development; Nigeria; Recycling; Circular Economy; Environment

How to cite this paper: Sylvanus Gbendazhi Barnabas, 'Towards an Efficient E-Waste Management Regime in Nigeria' (2025) 05 (01) Journal of Environmental Law & Policy 117-147, <https://doi.org/10.33002/jelp050105>

1. INTRODUCTION

Nigeria faces significant challenges with e-waste management. In 2019 alone, the country generated approximately 461,300 tonnes of e-waste, leading the West African region in this regard.[1] The informal sector appears to be playing a substantial role in e-waste processing in Nigeria, with estimates from the Global Environment Facility (GEF) suggesting that up to 100,000 individuals are involved in activities such as collection, dismantling and recycling, as it has been reported that annually, over half a million tonnes of discarded electronics are processed in Nigeria.[2] It appears that a significant portion of e-waste in Nigeria originates from imported used electrical and electronic equipment (EEE), as reports indicate that approximately 15,700 tonnes of damaged EEE enter the country annually, despite international treaties like the Basel Convention that discourage such practices due to environmental and health risks.[3]

Propitiously, the Nigerian government has recognised the severity of the e-waste problem in the country and has taken steps to address it. For example, in January 2023, revised environmental regulations were announced to strengthen the Extended Producer Responsibility (EPR) program, making producers accountable for the end-of-life management of their products.[4] Despite the above efforts, the majority of e-waste management remains within the informal sector, where unsafe practices such as uncontrolled dumping and open-air burning are common. These methods pose significant health risks, including respiratory issues and exposure to toxic substances, as well as environmental hazards like soil and water contamination.[5] The generation of e-waste in Nigeria is driven by a combination of factors, including rapid technological innovation, poor waste management systems, growing consumer demand for electronics, and weak regulatory enforcement. Addressing Nigeria's e-waste challenges requires comprehensive strategies, including strengthening regulatory frameworks, enhancing formal recycling infrastructure and promoting public awareness about the dangers of improper e-waste disposal.

---

1 Ife Ogunfuwa, 'Nigeria Generated 461, 300 tonnes of e-waste in 2019-UN' *The Punch* (Abuja, 14 July 2020). Available at: <https://punchng.com/nigeria-generated-461300-tonnes-of-e-waste-in-2019-un/> accessed 04 February 2025.

2 Global Environment Facility (GEF), 'Nigeria Turns the Tide on Electronic Waste' (GEF, 19 June 2019) <www.thegef.org/newsroom/news/nigeria-turns-tide-electronic-waste?> accessed 04 February 2025.

3 Jennifer Ugwa, 'How Toxic Waste from High-Income Countries Booms in Nigeria Markets' (International Centre for Investigative Reporting (ICIR), 10 November 2021) <www.icirnigeria.org/how-toxic-e-waste-from-high-income-countries-booms-in-nigerian-market/> accessed 4 February 2025.

4 United Nations Environment Programme (UNEP), Nigeria Acts to Fight Growing E-Waste Epidemic' (UNEP, 5 January 2023) <www.unep.org/gef/news-and-stories/press-release/nigeria-acts-fight-growing-e-waste-epidemic?> accessed 4 February 2025.

5 Mansur Ibrahim and Jemilat Nasiru, 'LIVING ON BORROWED TIME (I): How Nigeria's E-Waste is Poisoning Residents, Environment' (International Women Media Foundation (IWMF), 2 December 2024. <www.iwmf.org/reporting/living-on-borrowed-time-i-how-nigerias-unchecked-e-waste-is-poisoning-residents-environment/> accessed 4 February 2025.

This combination of disciplines, such as environmental law and policy, e-waste management, sustainable development as well as equity and justice, will through doctrinal and critical analysis, argue that by focusing on a comprehensive approach that includes regulatory policies, technological innovations, consumer behaviour, and global collaboration, Nigeria can create a more sustainable and equitable system for managing e-waste. It will also be demonstrated that by creating a viable and effective e-waste management regime, Nigeria will enjoy several benefits such as environmental protection, social equity, economic opportunities, and public health.

The rationale for this paper is to explore the deficiencies in Nigeria's current e-waste management framework and to propose a regulatory blueprint for a more sustainable approach. The paper aims to draw upon global best practices, in order to advocate for a comprehensive regulatory regime that includes Extended Producer Responsibility (EPR), stricter import controls, improved formal recycling infrastructure, and strengthened enforcement mechanisms. The paper also aims to highlight the importance of public awareness campaigns, private-sector collaboration, and policy incentives to encourage responsible e-waste disposal in Nigeria. The overarching objective of this paper is to suggest several viable pathways that Nigeria should adopt towards a more sustainable and effective management of digital and electronic waste (e-waste).

2. DRIVERS OF E-WASTES IN NIGERIA

In line with the trends in other developing countries, Nigeria is being buffeted with several challenges in the context of generating e-waste. Several factors are responsible for these challenges, which are mainly due to the socio-economic circumstances in the country.[6] The technological and regulatory situation in Nigeria also contributes to this disturbing trend. A good grasp and examination of the causes of the increasing rate of irresponsible e-waste disposal in Nigeria are very significant to identifying and developing robust e-waste management strategies. One of the main causes of the increasing rate of e-waste in Nigeria is the rather rapid rate of advancement and obsolesce of digital and electronic products.[7] The increasing rate of innovation in the technological industry leads to a shortened lifespan of most digital and electronic products because consumers are then constantly upgrading their digital and electronic products and, in the process, discarding old models. It has been argued that in Nigeria consumers tend to discard old devices such as televisions, smartphones, computers and other digital and electronic devices as new ones

6 Ejiogu A. Rajesh, 'E-Waste Economics: A Nigerian Perspective' (2013) 24(2) Management of Environmental Quality: An International Journal 199. <https://doi.org/10.1108/14777831311303083>.

7 Innocent Chidi Nnorom and Oladele Osibanjo, 'Electronic Waste (E-Waste): Material Flows and Management Practices in Nigeria' (2008) 28(8) Waste Management 1472. <https://doi.org/10.1016/j.wasman.2007.06.012>.

emerge in the market.[8] A related factor is that in contemporary times, manufacturers in the global arena are in the habit of deliberately designing and manufacturing digital and electronic products, with short lifespans, whilst deliberately making them incompatible with older models, thereby instigating consumers to discard old models that should ordinarily be reused or repaired.[9]

Another cause is the increasingly high demand for consumer digital and electronic products, which is spurred by Nigeria's growing middle class.[10] Thus, as the middle class in Nigeria grows, the demand for digital and electronic products such as televisions, smartphones and computers also increases. Indeed, a lot of the digital and electronic devices being used are imported from other countries,[11] leading to a high turnover of these products even as consumers are replacing old devices more frequently. It has been demonstrated that there is a growing penetration of smartphones in Nigeria because they are very popular with Nigerians as users demand more advanced and recent models.[12] The affordability of these products has also contributed to high consumption and disposal levels.

Poor waste management system is another factor that seems to be exacerbating the environmental challenges posed by indiscriminate e-waste disposal in Nigeria.[13] Nigeria's waste management apparatus is weak and is still developing, this implies that there is no effective and efficient e-waste collection and recycling infrastructure. The effect is that most e-waste ends up disposed of through improper means like disposing in landfills, they are burnt or discarded in a manner that leads to environmental pollution and degradation.[14] Associated with this challenge is the dearth of proper disposal channels. Thus, businesses and consumers do not have access to safe and legitimate digital and electronic waste disposal avenues or recycling services. Many Nigerians are unaware of where to properly discard their electronic and digital waste, and this situation drives them to dispose of it in normal waste streams. Another associated challenge is the problem of the informal

8 Victor Ndako Adama and others, 'The Nigerian E-Waste Problem: Way Forward' in Kohei Arai, Rahul Bhatia and Supriya Kapoor (eds), *Intelligent Computing: Proceedings of the 2019 Computing Conference, Volume 2* (Springer, 2019) 368-385.

9 Suphichaya Suppipat and Hu H Allen, 'A Scoping Review of Design for Circularity in the Electrical and Electronics Industry' (2022) 13 Resources, Conservation & Recycling Advances 200064. <https://doi.org/10.1016/j.rcradv.2022.200064>.

10 Felix John Eze and others, 'Entry-Level Export Strategies in Developing African Countries: Evidence from Nigeria' (2024) 14(1) African Journal of Humanities and Contemporary Education Research 173.

11 Ayokunle Olumuyiwa Omobowale, 'Tokunbo ICT: Symbolic-Rationality of Second-Hand ICT Utilization in Nigeria' (2013) 33(7/8) International Journal of Sociology and Social Policy 509. <https://doi.org/10.1108/IJSSP-05-2012-0042>.

12 Ivan Forenbacher and others, 'Determinants of Mobile Phone Ownership in Nigeria' (2019) 43(7) Telecommunications Policy 101812. https://doi.org/10.1016/j.telpol.2019.03.00>.

13 Akinola Peluola, 'Investigation of the Implementation and Effectiveness of Electronic Waste Management in Nigeria' (2016) 2 Modelling Earth Systems and Environment 1. <https://doi.org/10.1007/s40808-016-0155-1>.

14 Innocent C. Nnorom and Olusegun A. Odeyingbo, 'Electronic Waste Management Practices in Nigeria' in Meththika Vithanage, Anwesha Borthakur, Majeti Narasimha (eds), *Handbook of Electronic Waste Management* (Butterworth-Heinemann 2019) ch 14.

e-waste recycling sector. It has been shown that several e-waste recyclers in the informal sector are involved in handling digital and electronic waste in an unsafe manner. For example, some of the stakeholders in the informal sector are involved in open-air burning to enable them to recover valuable metals such as copper, gold and aluminium.[15] The effects of such practices are environmental pollution and health hazards.[16]

There is also the challenge of inadequate regulatory, policy and enforcement mechanisms. Although Nigeria has designed some legal and policy frameworks such as the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act 2007 and associated regulations, the enforcement of these laws and regulations remains rather weak.[17] The result is that people have continued to import substandard, non-recyclable digital and electronic devices, whilst adopting very improper disposal means.[18] Even though Nigeria has signed and ratified the Basel Convention on the Transboundary Movement of Hazardous Waste,[19] there is inadequacy of national legislations and regulations that specifically seek to enhance responsible e-waste management.

Many Nigerians have also continued to import second-hand and obsolete digital and electronic devices. This has made Nigeria a large market for second-hand products, most of which are either near or at the end of their lifecycle.[20] A lot of these second-hand digital and electronic products are mainly imported from Asia, Europe and North America and in most cases they are dysfunctional and outdated. It has been shown that although some of these used products are usually refurbished and reused, a large quantity end up as digital and e-waste either upon arrival into the country or within a short period of time thereafter.[21] This problem of importing second-hand products is compounded by the lack of effective screening at ports, so several digital and electronic devices that are imported into Nigeria are improperly

---

15 Alayande, S. O., Akinlabi, A. K. and Adewale Omosalewa, 'E-Waste Burning: Impact on Metal Components of Dumpsites Around Alaba Market, Lagos, Nigeria' (2015) 40(1) Journal of Chemical Society of Nigeria 1.

16 Ahmed Abubakar and others, 'Pollution of Heavy Metal Threat Posed by E-Waste Burning and its Assessment of Human Health Risk' (2022) 29(40) Environmental Science and Pollution Research 61065. <https://doi.org/10.1007/s11356-022-19974-6>.

17 Aniefiok Okposin, 'Curbing E-Waste Menace in Nigeria: Assessing the Regulatory Framework' (2020) 2(1) Chukwuemeka Odumegwu Ojukwu University Journal of Commercial and Property Law 1.

18 Innocent C. Nnorom and Oladele Osibanjo, 'Overview of Electronic Waste (E-Waste) Management Practices and Legislations and their Poor Applications in the Developing Countries' (2008) 52(6) Resources, Conservation and Recycling 843. <https://doi.org/10.1016/j.resconrec.2008.01.004>.

19 Basel Convention on the Transboundary Movement of Hazardous Waste, United Nations Treaty, signed 22 March 1989, Basel, Switzerland, entered into force 5 May 1995.

20 Kaustubh Thapa and others, 'Ultimate Producer Responsibility for E-waste Management–A Proposal for Just Transition in the Circular Economy Based on the Case of Used European Electronic Equipment Exported to Nigeria' (2023) 6(1) Business Strategy & Development 33. <https://doi.org/10.1002/bsd2.222>.

21 Onokpise Amos Kome, 'Management and Recycling of Secondhand Electronic Devices Case of Nigeria' (PhD thesis, Walden University 2022).

screened for their recyclability or lifespan, resulting in a large quantity of these second-hand products becoming e-waste upon entry into the country.[22]

Just like the challenges posed by the importation of second-hand devices, the illegal exportation of e-waste is also a problem. Like many other developing countries, Nigeria is a known destination for digital and electronic waste exported from developed countries.[23] This illegitimate business which is illegal under international law such as the Basel Convention, this illegal business still persists as a result of the lack of enforcement mechanisms. A substantial quantity of illegal exports from developed countries end up as waste in Nigeria because they are either not usable or recyclable.

There is also the issue of low consumer awareness, as many Nigerians are still unaware of the dangers of e-waste. Thus, a large percentage of Nigerians are not cognisant of the health and environmental risks that are associated with improper disposal of e-waste like the consequences of exposure to toxic substances such as mercury and lead as well as soil degradation.[24] This unawareness then leads to improper disposal practices that in turn, lead to avoidable health and environmental consequences. Similarly, there appears to be very limited awareness of recycling avenues or options, and even where consumers seem to be knowledgeable about the dangers of e-waste, most people are unaware of how and where to recycle their e-waste.[25]

From an economic point of view, the relative affordability of digital and electronic devices such as smartphones seem to have increased Nigerians' ability to have access to Information and Communication Technology (ICT). This affordability then leads to regular incidences of improper disposal of old digital and electronic devices by consumers in favour of newer and upgraded models.[26] A related economic factor is also the issue of digital and electronic waste as a source of income.[27] In this sense and the context of Nigeria's informal sector, e-waste has become a major source of income and means of livelihood for many stakeholders who are in the business of discarding e-waste.[28] Likewise, in the process of extracting some valuable materials like gold, copper and aluminium, these actors in the

---

22 Ibid.

23 Odeyingbo, A. O., Nnorom, I. C. and Deubzer, O. K., 'Used and Waste Electronics Flows into Nigeria: Assessment of the Quantities, Types, Sources and Functionality Status' (2019) 666 Science of the Total Environment 103. <https://doi.org/10.1016/j.scitotenv.2019.02.102>.

24 Josiah Miner Kangyang and others, 'Survey on Household Awareness and Willingness to Participate in E-Waste Management in Jos, Plateau State, Nigeria' (2020) 12(3) Sustainability 1047. <https://doi.org/10.3390/su12031047>.

25 Patrick Azodo Adinife, Peter Unor Ogban and James Okpor, 'Knowledge and Awareness Implication on E-Waste Management among Nigerian Collegiate' (2017) 21(6) Journal of Applied Sciences and Environmental Management 1035. <https://doi.org/10.4314/jasem.v21i6.6>.

26 Amanze Rajesh Ejiogu, 'E-Waste Economics: A Nigerian Perspective' (2013) 24(2) Management of Environmental Quality: An International Journal 213. <https://doi.org/10.1108/14777831311303083>.

27 Ibid.

28 Jack Sullivan, 'Trash or Treasure: Global Trade and the Accumulation of E-waste in Lagos, Nigeria' (2014) 61(1) Africa Today 89. <https://dx.doi.org/10.2979/africatoday.61.1.89>.

informal sectors end up utilising methods that are detrimental to public health and the environment.[29]

The challenges associated with the establishment of an effective and functional e-waste recycling industry and infrastructure in Nigeria are significant. Where recycling infrastructures are available, they remain underdeveloped, as such while Nigeria has a few recycling centres and facilities, it has been argued that the formal recycling sector is still inchoate.[30] The result is that there is heavy dependence on the informal sector, which remains unregulated leading to use of improper recycling methods that lead to environmental damage and health hazards.[31] This inadequacy of a functional and effective e-waste infrastructure and industry results in a lack of effective recovery of valuable materials.[32] The effect is that valuable materials contained in e-wastes such as precious metals and rare earth metals are lost, thereby compounding the problem of effective and efficient e-waste management.

Nigeria has a growing population and this comes with rapid urbanisation and growth. Consequently, as more people relocate from rural to more urban areas in search of 'greener pastures', the use of digital and electronic devices increases. The phenomenon has led to the emergence of urban centres in Nigeria, including Lagos, Kano, and Abuja, as significant nodes for the trade and distribution of digital and electronic devices. Consequently, this surge in electronic consumption has been accompanied by a notable increase in the generation and turnover of electronic waste (e-waste) within these regions.[33] Nigeria's population growth is indeed a big challenge, as the country has been recognised as one of the countries with increasing growth in population in the world today,[34] and this naturally comes with an increasing demand for digital and electronic devices, leading to higher levels of e-waste generated year after year.

Globalisation is increasingly leading to digitisation and Nigeria is no exception. Thus, with globalisation comes an incremental usage of digital and electronic devices. The increase in global connectivity and usage of digital devices is encouraging Nigerians to acquire more digital and electronic gadgets like laptops, tablets and smartphones. Although these devices have now become an inevitable and integral part of daily life across the world generally and in Nigeria particularly, this increasing usage is contributing in a significant way to the amount of e-waste in Nigeria, as

---

29 Nnorom and Osibanjo (n 7).

30 Kingsley Nduneseokwu Chibuike, Ying Qu and Andrea Appolloni, 'Factors Influencing Consumers' Intentions to Participate in a Formal E-Waste Collection System: A Case Study of Onitsha, Nigeria' (2017) 9(6) Sustainability 881. <https://doi.org/10.3390/su9060881>.

31 Ibid.

32 Ibid.

33 Edwin C. Arum and others, 'Strategies for E-Waste Management in West Africa: A Comparative Study of Nigeria and Ghana' (2024) 13(5) International Journal of Development and Sustainability 367. <https://doi.org/10.1080/10962247.2020.1769769>.

34 Sani Yahaya Nura, Mustapha Hussaini, and Abubakar Baba Bashir, 'Population Growth and Environmental Degradation in Nigeria' (2020) 6(1) Academic Journal of Economic Studies 31.

Nigerian consumers replace and upgrade old models of their devices.[35] The result is an increment in the amount of e-waste that is generated in Nigeria.[36] Indeed, the emergence of social media and the connectivity that it enhances leads to higher demands for digital devices in Nigeria.[37] The desire to 'keep up with the Jones' and to stay afloat with the continued advancements in technology, is contributing to the amount of e-waste in Nigeria as consumers discard of functional old devices.[38] These myriad of factors that are exacerbating the challenges of e-waste in Nigeria, demonstrates that Nigeria urgently needs to drastically improve its e-waste management strategy, in order to combat the negative environmental, health, social and economic impacts of e-waste.

3. IMPROVING E-WASTE MANAGEMENT IN NIGERIA

Efficient e-waste management is significant in the context of reducing environmental pollution and the negative social impacts of poor e-waste management. For Nigeria to improve its e-waste management system, it will have to adopt several strategies. There is a need to incorporate the idea of Extended Producer Responsibility (EPR) into relevant domestic laws in Nigeria. This will go beyond the mere inclusion of EPR in Nigeria's NESREA regulation, as legislations carry more legal weight. Through this approach, local manufacturers would be mandatorily required to take responsibility for the entire life cycle of their digital and electronic products. This requirement will include legally binding obligations on manufacturers for the collection, recycling and proper as well as safe disposal of digital and electronic products at the end of their lifecycle. This strategy will legally shift the burden or responsibility for e-waste from consumers and local authorities to the producers.[39] A complimentary strategy about the enactment of EPR laws is the provision of incentives for local manufacturers.[40] In line with this, official regulators should provide financial and regulatory incentives to producers to facilitate their design and production of devices with longer lifespans, modularity and recyclability.

---

35 Okay Benedict Agu, 'Exploring the Linkages between E-Waste Trade, Globalisation, and Protection of the Environment in Nigeria' in Maria Ochwat (ed), *Economic and Cultural Aspects of Selected Global Problems* (The Poznan School of Banking Press 2014) 115-140.

36 Ibid.

37 Elvira Bolat, 'The African New Media Digital Revolution: Some Selected Cases from Nigeria' in ND Taura, E Bolat and NO Madichie (eds), *Digital Entrepreneurship in Sub-Saharan Africa: Challenges, Opportunities and Prospects* (Palgrave Macmillan 2019) 67-87.

38 Bola Abogunrin-Olafisoye and others, 'Sustainable Waste Electrical and Electronics Equipment Recycling in Nigeria, Policies and Emerging Technologies' (2025) 34(3) Environmental Quality Management e70020. <https://doi.org/10.1002/tqem.70020>.

39 See Stéphanie H. Leclerc and Madhav G. Badami, 'Extended Producer Responsibility: An Empirical Investigation into Municipalities' Contributions to and Perspectives on E-Waste Management' (2024) 34(2) Environmental Policy and Governance 111. <https://doi.org/10.1002/eet.2059>.

40 Harri Kalimo and others, 'Greening the Economy through Design Incentives: Allocating Extended Producer Responsibility' (2012) 21 European Energy & Environmental Law Review 274. <https://doi.org/10.54648/eelr2012023>.

Nigeria also needs to improve its e-waste collection and recycling infrastructure. To achieve this, regulatory authorities in Nigeria should create convenient collection points across all the Local Government Areas in the country. Through establishing more accessible and widespread collection centres for consumers to drop off their old digital and electronic devices, the collection and recycling of such wastes will be easier.[41] This initiative should also be supported by public awareness campaigns about the existence of such centres and their locations. Another supporting strategy will be to establish certified recycling facilities to ensure that e-waste is processed at approved and certified recycling centres that follow best practices like R2 certification and e-Stewards certification.[42] Additionally, in rural and underserved areas, regulatory authorities should also create mobile collection units in order to improve accessibility to people living in such isolated areas.

Furthermore, regulatory authorities in Nigeria should be encouraging manufacturers to design their products in a manner to enhance longevity and reparability. This can be achieved through encouraging companies and businesses to designing digital and electronic products that are durable, repairable and upgradable, thereby reducing the chances of premature disposal of products.[43] Likewise, the modular design of devices should be encouraged to increase the production of easy-to-replace parts such as batteries, screens and other internal components.[44] This would lead to an extension of the lifespan of products and make repairing more accessible to consumers. In this connection, there is need for advocacy for the 'right to repair' laws that will grant consumers and technicians the right to access parts, tools and repair manuals for the digital and electronic devices that they purchase.[45]

Promoting consumer education and awareness is another way of enhancing effective e-waste management in Nigeria. To achieve this, there is a need to run awareness campaigns to educate consumers on the significance of responsible e-waste disposal, through recycling and positive environmentally impactful handling.[46] One other helpful way to achieve this

41 Yigit Kazancoglu and others, 'A Proposed Sustainable and Digital Collection and Classification Center Model to Manage E-Waste in Emerging Economies' (2021) 34(1) Journal of Enterprise Information Management 267.

42 Kang Liu and others, 'A Global Perspective on E-Waste Recycling' (2023) 2(1) Circular Economy 100028. <https://doi.org/10.1016/j.cec.2023.100028>.

43 Swathi, B. G. and others, 'Sustainable E-Waste Reduction Methods and Models' in KV Rajesh Kumar and others (eds), *Sustainable Solutions for E-Waste and Development* (IGI Global 2024) 239-253.

44 Guedes Barbosa Victor, Renato Ribeiro Siman, and Luciana Harue Yamane, 'Standardization of Portable Electronic Devices as a Strategy for Preventing E-Waste Generation' (2025) Journal of Cleaner Production 144822. <https://doi.org/10.1016/j.jclepro.2025.144822>.

45 Christopher Boniface, Lachlan Urquhart and Melissa Terras, 'Towards a Right to Repair for the Internet of Things: A Review of Legal and Policy Aspects' (2024) 52 Computer Law & Security Review 105934.

46 Sirage Ali Adane and Zelalem Kibert Akalu, 'E-Waste Awareness and Management among People Engaged in E-Waste Selling, Collecting, Dismantling, Repairing and Storing Activities in Addis Ababa, Ethiopia' (2022) 16 Environmental Health Insights 11786302221119145. <https://doi.org/10.1177/11786302221119145>.

is through enhancing compulsory labelling and certification of products.[47] Thus, there is a need to develop clear labels and certifications for products that seem easier to repair, recycle and reuse, thereby assisting consumers to make prior and informed choices. Incentive programs through offering discounts and rebates for consumers who recycle their digital and electronic devices responsibly, would also help to encourage environmentally sound disposal ways of used products.[48]

The significance of investing in green and safe technologies as a strategy of improving Nigeria's e-waste management methodology cannot be overemphasized. Through investments in advanced recycling methods, Nigeria can develop more efficient as well as environmentally sound recycling technologies that will help in the recovery of rare earth materials and precious metals from e-waste.[49] This will also reduce the negative environmental impacts of improper disposal of such wastes. In line with this, there is an urgent need to enact legislation and policies that impose obligations on the stakeholders in the e-waste management sector, to reduce the toxicity associated with e-waste through the development and implementation of processes and procedures that reduce and possibly eliminate harmful substances such as lead and mercury used in the production of digital and electronic devices,[50] thereby enhancing safer disposal and recycling procedures.

To reduce the improper handling of e-waste in the informal sector, it will be necessary to support and integrate stakeholders in that sector. Indeed, like Nigeria, in many other developing countries, informal workers are involved in the collection and recycling of e-waste in dangerous and environmentally harmful ways.[51] Through formalising and integrating this sector, workers can be provided with training that can improve safety and efficiency in the management of e-waste.[52] There is also an additional need to create safe working conditions in the informal sector, by ensuring that informal workers have easy access to Personal Protective Equipment (PPE) and training in proper disposal ways, whilst simultaneously assisting them

47 Ida Gåvertsson, Leonidas Milios and Carl Dalhammar, 'Quality Labelling for Re-Used ICT Equipment to Support Consumer Choice in the Circular Economy' (2020) 43 Journal of Consumer Policy 353. <https://doi.org/10.1007/s10603-018-9397-9>.

48 Debabrata Das and Pankaj Dutta, 'Product Return Management through Promotional Offers: The Role of Consumers' Loss Aversion' (2022) 251 International Journal of Production Economics 108520. <https://doi.org/10.1016/j.ijpe.2022.108520>.

49 Balaram, V., 'Sustainable Recovery of Rare Earth Elements by Recycling of E-Waste for a Circular Economy: Perspectives and Recent Advances' in Majeti Narasimha Vara Prasad (ed), *Environmental Materials and Waste: Circular Economy and Pollution Abatement* (2nd edition, Elsevier 2024): 499-544.

50 Siyi Lin, and others, 'Toxic Chemicals from Uncontrolled E-Waste Recycling: Exposure, Body Burden, Health Impact' (2022) 426 Journal of Hazardous Materials 127792. <https://doi.org/10.1016/j.jhazmat.2021.127792>.

51 Dipsikha Dasgupta and others, 'Environmental Impact of E-waste Management in Indian Microscale Informal Sectors' (2023) 30(11) Environmental Science and Pollution Research 29581. <https://doi.org/10.1007/s11356-022-23700-7>.

52 Dhyeya Pandya, 'A Path to Formalization: Exploring the E-Waste Informal Sector's Integration amid the Transition to Circular Economy' (PhD thesis, University of Ottawa 2024).

to transit towards environmental sustainable practices in the disposal and recycling of e-wastes.[53]

Nigeria needs to create more legislation at federal, state and local government levels that specifically create viable standards for e-waste management. In this regard, relevant authorities need to make greater efforts towards enacting and enforcing comprehensive laws that will effectively regulate e-waste collection, recycling and enforcement including banning the importation of such wastes into Nigeria in the absence of proper treatment facilities.[54] The relevant regulatory authorities need to collaborate with international organisations, to harmonise and implement standards and guidelines in line with international best practices for effective management of e-waste, while ensuring that dangerous wastes do not end up in Nigeria due to weak domestic regulations.

The idea of Public-Private Partnership (PPP) has been proven to be successful in other sectors of the Nigerian economy. In the context of managing e-waste, PPP is needed to foster collaboration between government, businesses, non-government organisations (NGOs) and consumers.[55] This will facilitate the holistic development of comprehensive digital and electronic waste management systems, as such collaborations can help in the funding of relevant infrastructural facilities and projects for the collection and recycling of such wastes. As part of a PPP agenda in this context, regulators such as the National Environmental Standards and Regulatory Enforcement Agency (NESREA), should find more viable path-ways to make Corporate Social Responsibility (CPR) in this context, a mandatory legal requirement for companies and businesses in their periodic reporting obligations to relevant statutory bodies.[56] Companies and businesses that refuse to implement effective and proper e-waste management in their practices as well as demonstrating this in their periodic reports should be fined and black-listed.

Creating a circular economy around digital and electronic products through closed-loop systems will help create an environment in Nigeria where such products or devices are designed for reuse, remanufacturing and recycling instead of single-use products that will end up disposed of improperly in landfills. Through the creation of a culture of repair and refurbishment which are essential features of a circular economy, companies, businesses and manufacturers should be encouraged to adopt the culture of

---

53 May Ohajinwa Chimere and others, 'Prevalence and Injury Patterns among Electronic Waste Workers in the Informal Sector in Nigeria' (2018) 24(3) Injury Prevention 185. <https://doi.org/10.1136/injuryprev-2016-042265>.

54 Thakur, P. and Kumar, S., 'Evaluation of E-Waste Status, Management Strategies and Legislations' (2022) 19(7) International Journal of Environmental Science and Technology 6957. <https://doi.org/10.1007/s13762-021-03383-2>.

55 Mohamad K. Khawaja, Marwa Ghaith and Ammar Alkhalidi, 'Public-Private Partnership versus Extended Producer Responsibility for End-of-Life of Photovoltaic Modules Management Policy' (2021) 222 Solar Energy 193. <https://doi.org/10.1016/j.solener.2021.05.022>.

56 Ruchi Lal, Smriti Singh Chauhan and Bhupendra Kumar Gautam, 'An Analysis of the Role of Corporate Social Responsibility in E-Waste Management in India' (2023) 12 European Chemical Bulletin 13725.

refurbishment of old digital and electronic devices as well as the sale of used products.[57] This will facilitate reduction in e-wastes and provide consumers with more affordable options whilst creating a safer and healthier environment in Nigeria.

All the above recommended strategies for improving Nigeria's management of e-wastes will be further strengthened through research and innovation. Investing in research and innovation will more specifically help in the improvement of recycling efficiency and the recovery of more valuable materials like rare metals and thereby reduce the negative environmental footprints of e-waste in Nigeria.[58] More so, research and innovation will lead to the development of alternative materials in the manufacturing of digital and electronic products, through the use of less dangerous materials by replacing risky substances with safer alternatives.[59]

To complement the above general recommendations for improving Nigeria's e-waste management strategies, it is argued that Nigeria needs to adopt more specific and targeted solutions in three main areas: innovative strategies in e-waste collection, sorting and recycling; integrating Nigeria's informal digital and electronic waste management sector; and encouraging Nigerian consumers to adopt more sustainable practices to extend the lifespan of their digital and electronic devices in the specific ways suggested below.

4. EFFECTIVE E-WASTE COLLECTION, SORTING AND RECYCLING

Through technological development and recent trends in digital and electronic waste collection, sorting and recycling, there is now an emergent sustainable way of managing e-waste. With the growth in the volume of e-waste globally[60] and in Nigeria in particular, Nigeria can leverage on technological advancements to improve its management of e-waste, whilst adopting more profitable ways of recovering valuable materials from such waste, enhancing recycling and reducing the environmental impacts of such wastes through adopting the following suggested innovative strategies.

4.1. E-Waste Collections Innovations

This can be achieved through the establishment of smart collection points and drop-off locations, by creating automated collection stations. Automated collection machines can be developed to enable consumers to

[57] Rosita Moradi and others, 'Sustainable Resilient E-Waste Management in London: A Circular Economy Perspective' (2024) 10(13) Heliyon 13. <https://doi.org/10.1016/j.heliyon.2024.e34071>.

[58] Gordon Akon-Yamga and others, 'Transformative Innovation Policy Approach to E-Waste Management in Ghana: Perspectives of Actors on Transformative Changes' (2021) 48(3) Science and Public Policy 387. <https://doi.org/10.1093/scipol/scab005>.

[59] Ibid.

[60] It was reported that in 2022, the world generated a record 62 million metric tonnes (Mt) of e-waste, marking an 82% increase from 2010 and projections indicate that this figure could rise by another 32%, reaching 82 million tonnes by 2030. See, Cornelis P. Balde, *The Global E-Waste Monitor 2024* (2nd edition, United Nations Institute for Training and Research (UNITAR) 2024).

drop off their used digital and electronic devices. These are machines that weigh and issue receipts and in some cases rewards such as loyalty points and discounts to encourage citizen participation as has been practiced in some countries and cities.[61] These collection stations can then be integrated into recycling projects which will make it a lot easier for consumers to dispose their e-waste in more environmentally friendly ways.[62] Similarly, Nigeria can leverage on Internet of Things (IoT) technology to create e-waste collection bins that enhance notification of waste management authorities and agencies when such bins are full, thereby enhancing efficient pickups whilst drastically reducing the dangers associated with overflowing and improper disposal ways.[63] E-waste collection could also be made more efficient in Nigeria through establishing mobile collection units in rural areas that lack formal recycling facilities. Such mobile collection units should be equipped with appropriate sorting and simple processing technology that can travel to rural communities and isolated areas to collect e-waste.[64] This will enable such communities to have easy access to recycling facilities.

4.2. E-Waste Sorting Technologies

Nigeria can use Artificial Intelligence (AI) and machine learning systems to improve its sorting processes of e-waste. In some countries, AI and machine learning algorithms are being utilised to enable efficient sorting at recycling centres.[65] AI has been shown to help analyse and categorise various components of e-waste like metals, plastics and circuit boards through their visual and material properties that facilitate more accurate sorting of such wastes.[66] In addition, computer vision could be utilised through the use of advanced cameras and image recognition software that will help in identifying specific components of e-waste like cables, screens and chips as well as help direct them into proper recycling machines.[67] This sort of technology will increase the speed and accuracy of sorting and in the process minimise manual labour as well as reduce human errors. In this context, the use of automated dismantling machines can also be handy.

[61] Erhan Ada and others, 'Smart Technologies for Collection and Classification of Electronic Waste' (2024) 41(9) International Journal of Quality & Reliability Management 2434.

[62] Jenifa Latha, C. and others, 'Dynamic Convolutional Neural Network Based E-Waste Management and Optimized Collection Planning' (2022) 34(17) Concurrency and Computation: Practice and Experience e6941. <https://doi.org/10.1002/cpe.6941>.

[63] Dean Kang Kai and others, 'Electronic Waste Collection Systems Using Internet of Things (IoT): Household Electronic Waste Management in Malaysia' (2020) 252 Journal of Cleaner Production 119801. <https://doi.org/10.1016/j.jclepro.2019.119801>.

[64] Shailender Singh, Mani Sankar Dasgupta and Srikanta Routroy, 'Evaluation of Sustainable E-Waste Collection Method for Urban and Rural Region of India' (2022) 40(5) Waste Management & Research 545. <https://doi.org/10.1177/0734242X211018512>.

[65] Madhav Shreyas, A. V. and others, 'Application of Artificial Intelligence to Enhance Collection of E-waste: A Potential Solution for Household WEEE Collection and Segregation in India' (2022) 40(7) Waste Management & Research 1047. <https://doi.org/10.1177/0734242X211052846>.

[66] Zahid Ali and others, 'Classification of E-Waste Using Machine Learning-Assisted Laser-Induced Breakdown Spectroscopy' (2024) Waste Management & Research 0734242X241248730. <https://doi.org/10.1177/0734242X241248730>.

[67] Philipp Kranz and others, 'Towards Recycling E-Waste Using Vision and Robotic Manipulation' (Australasian Conference on Robotics and Automation (ACRA), Sydney, November 2023).

Indeed, automated systems are increasingly helping to disassemble digital and electronic devices by removing components such as screens, batteries and circuit boards which can subsequently be processed separately.[68] An advantage of such automation systems is a reduction in the costs of employing staff and enhancing safety by eliminating the need for manual work by humans through hazardous ways of handling materials such as cadmium, lead and mercury.

4.3. E-Waste Recycling Innovations

Innovative e-waste recycling techniques such as the use of advanced chemical and hydrometallurgical processes have proven to be effective. Through hydrometallurgical recovery processes, metals such as gold, silver, copper and other rare earth elements can be efficiently extracted from e-wastes.[69] In comparison with conventional smelting, hydrometallurgical procedures have proven to be more environmentally sound means because such hydrometallurgical processes tend to generate less toxic emissions and have also been proven to use lower temperatures.[70] It has been argued in this sense, that the use of environmentally friendly solvents and lixiviates in hydrometallurgy improves sustainability in the sorting of e-waste.[71] In a similar vein, Nigeria can also use bio-leaching as a technique which uses micro-organisms to separate valuable metals from e-wastes.[72] Through these techniques, fungi and bacteria are used to dissolve metal compounds in e-waste.[73] It has been argued that bioleaching is an environmentally friendly means of extracting metals from e-waste and the process helps to dispense with the use of very harsh substances or high-power inputs.[74]

Physical separation techniques such as Eddy Current Separators can also be used to separate non-ferrous metals like copper and aluminium from e-waste.[75] These techniques produce magnetic fields that repel nonferrous metals by efficiently sorting from other materials.[76] This methodology has

---

68 Emmanuel A Oke and Herman Potgieter, 'Discarded E-Waste/Printed Circuit Boards: A Review of their Recent Methods of Disassembly, Sorting and Environmental Implications' (2024) 26(3) Journal of Material Cycles and Waste Management 1277. <https://doi.org/10.1007/s10163-024-01917-7>.

69 Deblina Dutta and others, 'A Review on Recovery Processes of Metals from E-Waste: A Green Perspective' (2023) 859 Science of the Total Environment 160391. <https://doi.org/10.1016/j.scitotenv.2022.160391>.

70 Manivannan Sethurajan and others, 'Recent Advances on Hydrometallurgical Recovery of Critical and Precious Elements from End of Life Electronic Wastes-A Review' (2019) 49(3) Critical Reviews In Environmental Science and Technology 212. <https://doi.org/10.1080/10643389.2018.1540760>.

71 Ibid.

72 Isiaka Adetunji Adegoke, Paul Johan Oberholster and Mariana Erasmus, 'Bioleaching of Metals from E-Waste Using Microorganisms: A Review' (2023) 13(6) Minerals 828. <https://doi.org/10.3390/min13060828>.

73 Ibid.

74 Ibid.

75 Ruan Jujun, Qian Yiming and Xu Zhenming, 'Environment-Friendly Technology for Recovering Nonferrous Metals From E-Waste: Eddy Current Separation' (2014) 87 Resources, Conservation and Recycling 109. <https://doi.org/10.1016/j.resconrec.2014.03.017>.

76 Ibid.

been used in e-recycling centres to recover metals such as aluminium from circuit boards and casings.[77] Other physical separation methods such as shredding and air classification can be adopted by mechanically shredding and breaking down e-waste into small portions, this process facilitates separation through the use of air streams that separate lighter materials like plastics from heavier metals.[78] In addition, the physical separation techniques suggested above can be complemented by the use of X-ray fluorescence (XRF) for the analysis of materials. This method is gradually being used in some countries to identify and analyse the contents of e-waste.[79] It has been shown that this process can result in quick and faster determination of the presence or otherwise of critical and valuable metals, thereby enhancing a more targeted recovery process.[80]

4.4. Sustainable Recycling Innovations

Nigeria could also adopt sustainable recycling innovative methods such as closed-loop recycling systems,[81] which are designed to increase the reuse of materials from e-waste, by creating a circular economy that creates a society where digital and electronic devices are constantly recycled into new products.[82] An example is through the recovery of rare earth materials which can be sent back to manufacturers for the production of new digital and electronic products, to reduce the necessity for mining and enhance the conservation of natural resources. Nigeria could also encourage a culture of zero-waste policies to encourage companies to imbibe a habit of encouraging the creation of an environment where every component of e-waste like glass, metals and plastics recycled, reused and converted into renewable energy.

Other eco-friendly recycling techniques such as the use of biodegradable materials and production of biodegradable digital and electronic devices using bio-based plastics, which have been shown to break down easily at the end of their life cycle should be encouraged.[83] Similarly, the use of green chemistry in the manufacturing of digital and electronic devices could be used and encouraged in the industry. Green chemistry

---

77 Ibid.

78 Kathirvel Brindhadevi and others, 'E-Waste Management, Treatment Options and the Impact of Heavy Metal Extraction from E-Waste on Human Health: Scenario in Vietnam and Other Countries' (2023) 217 Environmental Research 114926. <https://doi.org/10.1016/j.envres.2022.114926>.

79 Dennis S. Ferreira and others, 'Electronic Waste Analysis Using Laser-Induced Breakdown Spectroscopy (LIBS) and X-Ray Fluorescence (XRF): Critical Evaluation of Data Fusion for the Determination of Al, Cu and Fe.' (2024) 1303 Analytica Chimica Acta 342522. <https://doi.org/10.1016/j.aca.2024.342522>.

80 Ibid.

81 Hark Hwang and others, 'A Closed-Loop Recycling System with a Minimum Allowed Quality Level on Returned Products' (2009) 5(6) International Journal of Services and Operations Management 758. <https://doi.org/10.1504/IJSOM.2009.026773>.

82 A circular economy refers to a model where waste is eliminated and materials are used, re-used and recycled continually, to reduce environmental degradation and maximise resource efficiency.

83 Pillai H. P. Jai Shanker and others, 'Innovative Approaches to Sustainable E-Waste Management Through Bio-Based Products' in Jayaseelan Aru, N. Nirmana and S. S. Dawn (eds), *Environmental Applications of Carbon-Based Materials* (IGI Global 2024) 380-407.

techniques require the use of recyclable and non-toxic materials in the manufacturing of digital and electronic products, and the method has been proven to reduce negative environmental impacts when devices created through these processes reach the end of their lifecycle.[84]

4.5. Data Destruction and Security Initiatives

An often-ignored aspect of managing e-waste is data protection.[85] As such it is important that Nigeria adopts effective data protection strategies in the management of its e-waste. While Nigeria has enacted the Data Protection Act 2023, the Act does not contain any specific provisions on data protection in the context of e-waste. So, there is a need to ensure that in practice, secure data-wiping technologies such as data-wiping software are used to securely wipe out personal and sensitive data before reusing or recycling e-waste.[86] It is recommended that innovative data-erasing software should be used to effectively remove data from smartphones, hard drives and other storage devices to ensure that no sensitive or personal information is recovered in the process of reuse and recycling. The use of physical data destruction machines like shredders and crushers is hereby recommended for devices that cannot be effectively erased through the use of software. This process can be adapted for e-waste such as memory chips, SSDs and hard drives to avoid breaching privacy and data protection rights and laws.

4.6. Consumer Engagement through Technology

A good way to enhance efficient e-waste recycling in Nigeria is by engaging consumers through the use of mobile technologies such as mobile apps for e-waste recycling. The use of recycling apps could be helpful as many apps are already in use in other countries for encouraging consumer participation in e-waste recycling.[87] It has been shown that such apps enable users to locate e-waste collection points, schedule pick-ups and track recycling activities.[88] In some instances, some apps have been used to provide incentives like discounts and points to consumers who recycle old digital and electronic products, thereby encouraging participation as well as creating awareness.[89]

---

84 Malhotra, P. and Jain, A., 'Chemical methods for the treatment of e-waste' in Padeep Singh and others (eds), *Waste Management and Resource Recycling in the Developing World* (Elsevier, 2023) 181-204.

85 Burkhard Schafer, 'D-Waste: Data Disposal as Challenge for Waste Management in the Internet of Things' (2014) 22 The International Review of Information Ethics 101. <https://doi.org/10.29173/irie122>.

86 Krumay, B., 'The E-Waste-Privacy Challenge: A Grounded Theory Approach, in *Privacy Technologies and Policy: 4th Annual Privacy Forum (APF)* (APF 4th Annual Forum, Frankfurt/Main, September 2016).

87 Odwa Gazana and Thembisa Grace Ngqondi, 'Co-Design, With Two South African Villages, of a Prototype for an E-Waste Management Mobile App' (2024) 33 The African Journal of Information and Communication1. <https://doi.org/10.23962/ajic.i33.17267>.

88 Ibid.

89 Sonal Thukral, Deep Shree and Shakshi Singhal, 'Consumer Behaviour Towards Storage, Disposal and Recycling of E-Waste: Systematic Review and Future Research Prospects' (2023)

To enhance transparency in the efficient management of e-waste in Nigeria, blockchain technologies can be deployed to trace e-waste recycling processes.[90] Blockchain technologies can track the entire lifespan of e-waste, from the collection points, through transportation to recycling and disposal centres, thereby enhancing responsible and ethical recycling practices by stakeholders.[91] In addition, Radio Frequency Identification (RFID) tags can be utilised in tracking digital and electronic devices throughout their lifecycle. The RFID can, therefore, help ensure a transparent flow of e-waste and reduce illegal disposal while ensuring that precious materials are recovered properly.[92]

4.7. Recycling Business Models

Recycling e-wastes through the use of creative refurbishment technologies provide opportunities for businesses to efficiently repair and upgrade old digital and electronic products, by extending the life of these products and reducing the amount of e-waste that they generate.[93] In this way, companies and businesses can very easily increase their focus of refurbishing devices such as smartphones and computers, which they can then resell or donate and in the process contribute the creation of a circular economy in Nigeria.[94] In line with this business context, companies and businesses are encouraged to explore more innovative means to upcycle e-wastes into new products like furniture, art and fashion. The effect will be the creation of more environmentally friendly solutions for the efficient disposal of e-wastes in Nigeria.

5. INTEGRATING NIGERIA'S INFORMAL E-WASTE SECTOR

In this section, several strategies specifically targeted at integrating Nigeria's informal e-waste management sector into the formal sector will be examined and suggested. Indeed, integrating Nigeria's informal sector in this context, into formalised collection and processing sectors would demand

30(3) Benchmarking: An International Journal 1021. <https://doi.org/10.1108/BIJ-12-2021-0774>.

90 Usman Rais Mohammad, 'Smart E-Waste Tracking and Monitoring Model: A Modern Approach to Counter E-Waste Management Issues' in Prem Kumar Chaurasia and others (eds), *Technology Innovation in Mechanical Engineering: Select Proceedings of TIME* 2021(Springer Nature Singapore, 2022) 757-765.

91 Swagatika Sahoo, Arnab Mukherjee and Raju Halder, 'A Unified Blockchain-Based Platform for Global E-Waste Management' (2021) 17(5) International Journal of Web Information Systems 449. <https://doi.org/10.1108/IJWIS-03-2021-0024>.

92 Geethan Arun Vasantha and others, 'The State-of-the-Art Reverse Logistics for e-Waste Management: A Scenario Specific to India' in J. Aravind, M. Kamaraj, S. Karthikeyan (eds), *Strategies and Tools for Pollutant Mitigation: Research Trends in Developing Nations* (Springer 2022) 181-198.

93 Xin Tong, Dongyan Tao and Reid Lifset, 'Varieties of Business Models for Post-Consumer Recycling in China' (2018) 170 Journal of Cleaner Production 665. <https://doi.org/10.1016/j.jclepro.2017.09.032>.

94 Tasbirul Islam, M. D., Usha Iyer-Raniga and Sean Trewick, 'Recycling Perspectives of Circular Business Models: A Review' (2022) 7(5) Recycling 79. <https://doi.org/10.3390/recycling7050079>.

a myriad of approaches, that will balance the special circumstances of the informal sector on the one hand and the need to enhance environmental sustainability, health and safety as well as efficiency in resource use on the other hand. It is in this broad context that the following strategies for integrating Nigeria's informal e-waste management sector are proposed.

5.1. Inclusive Laws, Policies and Regulations

One avenue through which the informal e-waste sector can be integrated into the formal sector in Nigeria is through the enactment of laws, policies and regulations that grant formal recognition to the stakeholders in the informal sector, such as informal recyclers as key players in the national e-waste management strategy. The adoption of laws and regulations that build inclusiveness can be achieved by providing subsidies, tax breaks and other financial incentives to encourage informal workers to join formal e-waste networks.[95] This can then be complimented through a gradual introduction and enforcement of environmental and health standards, by ensuring that informal workers are not penalised but rather supported during the period of transition. Another strategy is through capacity building and skills development, by offering training to informal workers on safe dismantling techniques, hazardous waste handling and recycling methods.[96] In addition, informal workers should be provided with access to better tools and technologies for efficient and safe e-waste processing.

5.2. Aggregation and Collection Centres

Furthermore, Nigeria needs to create aggregation and collection centres by establishing community-based collection hubs, where informal workers in e-waste can drop off e-waste for some fair compensation.[97] These centres can then be integrated into formal recycling networks while ensuring that they have consistent and transparent access to buyers.[98] Through PPP and the already recognised principle of EPR, the regulatory authorities in Nigeria such as NESREA can through regulations and policies, impose obligations on manufacturers to collaborate with both formal and informal recyclers for e-waste collection and recycling.[99] Similarly, companies and businesses should be encouraged to form cooperatives and PPPs with

---

95 Xin Tong, Tao Wang and Yanguang Chen, 'Towards an Inclusive Circular Economy: Spatial Flows of E-Waste through the Informal Sector' in Sabastien Bourdin, Andre Torre and Evelyn van Leeuwen (eds), *Regions, Cities and the Circular Economy* (Edward Elgar Publishing 2024) 183-202.

96 Eva Ignatuschtschenko, 'E-Waste Management in China: Bridging the Formal and Informal Sectors' (2017) 2(4) Journal of Chinese Governance 385. <https://doi.org/10.1080/23812346.2017.1379629>.

97 Shailender Singh, Mani Sankar Dasgupta and Srikanta Routroy, 'Evaluation of Sustainable E-Waste Collection Method for Urban and Rural Region of India' (2022) 40(5) Waste Management & Research 545. <https://doi.org/10.1177/0734242X211018512>.

98 Ibid.

99 Arora G. Mehra, Prakash, R. and Banerjee, A., 'Approaches to Improving the Circular Economy Paradigm in E-waste Management in India through Informal–Formal Sector Integration' in Gautam Mehra and others, (eds), *Development in E-Waste Management* (CRC Press2023) 209-222.

informal recyclers to bridge the gap between informal collection and formal processing.[100]

5.3. Financial Inclusion

Another strategy that can facilitate the integration of the informal e-waste sector with the formal sector, is through financial inclusion and microcredit support. By providing microloans and grants to informal workers, Nigeria will be encouraging informal workers to invest in safer tools, PPE and small-scale processing units.[101] To build the trust of informal workers, digital payment platforms such as mobile bank apps and electronic transfers should be used for timely compensation of informal recyclers. This would enhance transparency as well. Through creating awareness and encouraging behaviour change, informal recyclers can be educated about the health and environmental dangers associated with improper recycling techniques.[102] Likewise, relevant authorities and stakeholders in the formal e-waste management sector in Nigeria could also run campaigns to inform households about e-waste disposal, whilst simultaneously encouraging them to direct their e-waste to certified centres that are in collaboration with informal collectors.[103]

5.4. Pilot Projects

Through pilot programmes, Nigeria could incrementally formalise the informal e-waste sector by initiating pilot projects that demonstrate the economic and social benefits of integrating informal workers into formal systems.[104] This will help in gradually scaling up successful models to ensure a smooth and sustainable transition. In this context, it will be very helpful if there is an effective data collection system that is also transparent, as through that collection, a system can be developed that monitors and records informal recycling activities in order to understand the scale and impact of those activities better.[105] The data obtained can then be used to design, measure

[100] Ibid.

[101] Woggsborg, A. and Schröder, P., 'Nigeria's E-Waste Management: Extended Producer Responsibility and Informal Sector Inclusion' (2018) 1(1) Journal of Waste Resources and Recycling 1. <https://doi.org/10.15744/2766-5887.1.102>.

[102] Vishwanath Vighnesh Nanjangud, Balachandra Patil and Deepak Chandrashekar, 'Evolving a Conceptual Framework for Sustainable E-Waste Management: A Consumer Typology Based on Environmental Behavior' (2024) 16(1) Journal of Indian Business Research 55; Osei Asibey Michael, Anne Mette Lykke and Rudith Sylvana King, 'Understanding the Factors for Increased Informal Electronic Waste Recycling in Kumasi, Ghana' (2022) 32(2) International Journal of Environmental Health Research 305. <https://doi.org/10.1080/09603123.2020.1755016>.

[103] Wenhua Wang and others, 'Barriers for Household E-Waste Collection in China: Perspectives from Formal Collecting Enterprises in Liaoning Province' (2017) 153 Journal of Cleaner Production 299. <https://doi.org/10.1016/j.jclepro.2017.03.202>.

[104] Jinglei Yu, Eric Williams, Meiting Ju and Chaofeng Shao, 'Managing E-Waste in China: Policies, Pilot Projects and Alternative Approaches' (2010) 54(11) Resources, Conservation and Recycling 991. <https://doi.org/10.1016/j.resconrec.2010.02.006>.

[105] Karoline Owusu-Sekyere and others, 'Assessing Data in the Informal E-Waste Sector: The Agbogbloshie Scrapyard' (2022) 139 Waste Management 158. <https://doi.org/10.1016/j.wasman.2021.12.026>.

and implement targeted intervention strategies as well as ascertain the progress that is being made over a period of time.[106]

5.5. Lessons from other Jurisdictions

Nigeria can also benefit from studying how other developing countries such as Ghana.[107] China and India,[108] where informal recyclers have been integrated into formal e-waste systems through supportive policies, capacity-building programs, and partnerships with Non-Governmental Organisations (NGOs) and private companies.

6. CONCLUSION

As Nigeria grapples with the growing challenges of electronic and digital waste (e-waste), a robust and well-regulated management framework is crucial for mitigating environmental and health risks while harnessing economic opportunities. The current informal handling of e-waste poses significant hazards, from toxic emissions to resource wastage. To transition towards a sustainable and efficient e-waste management regime, Nigeria must strengthen its regulatory framework, enforce compliance with international standards, and invest in formal recycling infrastructure. A successful legal and regulatory regime should integrate EPR, PPP and community engagement to ensure effective and efficient e-waste collection, recycling and disposal. Additionally, raising public awareness about the dangers of improper e-waste handling and promoting circular economy principles will be instrumental in reducing the country's e-waste footprints. By implementing a structured, forward-thinking policy framework, Nigeria can move from reactive e-waste disposal to a proactive, sustainable e-waste management system—one that not only protects public health and the environment but also fosters economic growth through job creation and resource recovery. The time to act is now, ensuring a cleaner, safer and more sustainable future for generations to come.

REFERENCES

Ahmed Abubakar and others, 'Pollution of Heavy Metal Threat Posed by E-Waste Burning and its Assessment of Human Health Risk' (2022) 29(40) Environmental Science and Pollution Research 61065. <https://doi.org/10.1007/s11356-022-19974-6>

Akinola Peluola, 'Investigation of the Implementation and Effectiveness of Electronic Waste Management in Nigeria' (2016) 2 Modelling Earth

[106] Ibid.

[107] Kwayie Bimpong and others, 'Ghana's Recently Introduced E-Waste Regulatory Policy: A Hope for a Better E-Waste Sector?' (2024) 42(11) Waste Management & Research 1031. <https://doi.org/10.1177/0734242X231204457>.

[108] Diyasha Sengupta and others, 'Circular Economy and Household E-Waste Management in India: Integration of Formal and Informal Sectors' (2022) 184 Minerals Engineering 107661. <https://doi.org/10.1016/j.mineng.2022.107661>.

Systems and Environment 1. <https://doi.org/10.1007/s40808-016-0155-1>

Alayande, S. O., Akinlabi, A. K. and Adewale Omosalewa, 'E-Waste Burning: Impact on Metal Components of Dumpsites around Alaba Market, Lagos, Nigeria' (2015) 40(1) Journal of Chemical Society of Nigeria 1

Amanze Rajesh Ejiogu, 'E-Waste Economics: A Nigerian Perspective' (2013) 24(2) Management of Environmental Quality: An International Journal 213. <https://doi.org/10.1108/14777831311303083>

Aniefiok Okposin, 'Curbing E-Waste Menace in Nigeria: Assessing the Regulatory Framework' (2020) 2(1) Chukwuemeka Odumegwu Ojukwu University Journal of Commercial and Property Law 1

Arora G. Mehra, Prakash, R. and Banerjee, A., 'Approaches to Improving the Circular Economy Paradigm in E-waste Management in India through Informal–Formal Sector Integration' in Gautam Mehra and others, (eds), *Development in E-Waste Management* (CRC Press2023) 209-222

Ayokunle Olumuyiwa Omobowale, 'Tokunbo ICT: Symbolic-Rationality of Second-Hand ICT Utilization in Nigeria' (2013) 33(7/8) International Journal of Sociology and Social Policy 509. <https://doi.org/10.1108/IJSSP-05-2012-0042>

Balaram, V., 'Sustainable Recovery of Rare Earth Elements by Recycling of E-Waste for a Circular Economy: Perspectives and Recent Advances' in Majeti Narasimha Vara Prasad (ed), *Environmental Materials and Waste: Circular Economy and Pollution Abatement* (2nd edition, Elsevier 2024): 499-544

Bola Abogunrin-Olafisoye and others, 'Sustainable Waste Electrical and Electronics Equipment Recycling in Nigeria, Policies and Emerging Technologies' (2025) 34(3) Environmental Quality Management e70020. <https://doi.org/10.1002/tqem.70020>

Burkhard Schafer, 'D-Waste: Data Disposal as Challenge for Waste Management in the Internet of Things' (2014) 22 The International Review of Information Ethics 101. <https://doi.org/10.29173/irie122>

Christopher Boniface, Lachlan Urquhart and Melissa Terras, 'Towards a Right to Repair for the Internet of Things: A Review of Legal and Policy Aspects' (2024) 52 Computer Law & Security Review 105934

Cornelis P. Balde, *The Global E-Waste Monitor 2024* (2nd edition, United Nations Institute for Training and Research (UNITAR) 2024)

Dean Kang Kai and others, 'Electronic Waste Collection Systems Using Internet of Things (IoT): Household Electronic Waste Management in Malaysia' (2020) 252 Journal of Cleaner Production 119801. <https://doi.org/10.1016/j.jclepro.2019.119801>

Debabrata Das and Pankaj Dutta, 'Product Return Management through Promotional Offers: The Role of Consumers' Loss Aversion' (2022) 251 International Journal of Production Economics 108520. <https://doi.org/10.1016/j.ijpe.2022.108520>

Deblina Dutta and others, 'A Review on Recovery Processes of Metals from E-Waste: A Green Perspective' (2023) 859 Science of the Total Environment 160391. <https://doi.org/10.1016/j.scitotenv.2022.160391>

Dennis S. Ferreira and others, 'Electronic Waste Analysis Using Laser-Induced Breakdown Spectroscopy (LIBS) and X-Ray Fluorescence (XRF): Critical Evaluation of Data Fusion for the Determination of Al, Cu and Fe.' (2024) 1303 Analytica Chimica Acta 342522. <https://doi.org/10.1016/j.aca.2024.342522>

Dhyeya Pandya, 'A Path to Formalization: Exploring the E-Waste Informal Sector's Integration amid the Transition to Circular Economy' (PhD thesis, University of Ottawa 2024)

Dipsikha Dasgupta and others, 'Environmental Impact of E-waste Management in Indian Microscale Informal Sectors' (2023) 30(11) Environmental Science and Pollution Research 29581. <https://doi.org/10.1007/s11356-022-23700-7>

Diyasha Sengupta and others, 'Circular Economy and Household E-Waste Management in India: Integration of Formal and Informal Sectors' (2022) 184 Minerals Engineering 107661. <https://doi.org/10.1016/j.mineng.2022.107661>

Edwin C. Arum and others, 'Strategies for E-Waste Management in West Africa: A Comparative Study of Nigeria and Ghana' (2024) 13(5) International Journal of Development and Sustainability 367. <https://doi.org/10.1080/10962247.2020.1769769>

Ejiogu A. Rajesh, 'E-Waste Economics: A Nigerian Perspective' (2013) 24(2) Management of Environmental Quality: An International Journal 199. <https://doi.org/10.1108/14777831311303083>

Elvira Bolat, 'The African New Media Digital Revolution: Some Selected Cases from Nigeria' in ND Taura, E Bolat and NO Madichie (eds), *Digital Entrepreneurship in Sub-Saharan Africa: Challenges, Opportunities and Prospects* (Palgrave Macmillan 2019) 67-87

Emmanuel A. Oke and Herman Potgieter, 'Discarded E-Waste/Printed Circuit Boards: A Review of their Recent Methods of Disassembly, Sorting and Environmental Implications' (2024) 26(3) Journal of Material Cycles and Waste Management 1277. <https://doi.org/10.1007/s10163-024-01917-7>

Erhan Ada and others, 'Smart Technologies for Collection and Classification of Electronic Waste' (2024) 41(9) International Journal of Quality & Reliability Management 2434

Eva Ignatuschtschenko, 'E-Waste Management in China: Bridging the Formal and Informal Sectors' (2017) 2(4) Journal of Chinese Governance 385. <https://doi.org/10.1080/23812346.2017.1379629>

Felix John Eze and others, 'Entry-Level Export Strategies in Developing African Countries: Evidence from Nigeria' (2024) 14(1) African Journal of Humanities and Contemporary Education Research 173

Geethan Arun Vasantha and others, 'The State-of-the-Art Reverse Logistics for e-Waste Management: A Scenario Specific to India' in J. Aravind, M.

Kamaraj, S. Karthikeyan (eds), *Strategies and Tools for Pollutant Mitigation: Research Trends in Developing Nations* (Springer 2022) 181-198

Global Environment Facility (GEF), 'Nigeria Turns the Tide on Electronic Waste' (GEF, 19 June 2019) <www.thegef.org/newsroom/news/nigeria-turns-tide-electronic-waste?> accessed 04 February 2025

Gordon Akon-Yamga and others, 'Transformative Innovation Policy Approach to E-Waste Management in Ghana: Perspectives of Actors on Transformative Changes' (2021) 48(3) Science and Public Policy 387. <https://doi.org/10.1093/scipol/scab005>

Guedes Barbosa Victor, Renato Ribeiro Siman, and Luciana Harue Yamane, 'Standardization of Portable Electronic Devices as a Strategy for Preventing E-Waste Generation' (2025) Journal of Cleaner Production 144822. <https://doi.org/10.1016/j.jclepro.2025.144822>

Hark Hwang and others, 'A Closed-Loop Recycling System with a Minimum Allowed Quality Level on Returned Products' (2009) 5(6) International Journal of Services and Operations Management 758. <https://doi.org/10.1504/IJSOM.2009.026773>

Harri Kalimo and others, 'Greening the Economy through Design Incentives: Allocating Extended Producer Responsibility' (2012) 21 European Energy & Environmental Law Review 274. <https://doi.org/10.54648/eelr2012023>

Ida Gåvertsson, Leonidas Milios and Carl Dalhammar, 'Quality Labelling for Re-Used ICT Equipment to Support Consumer Choice in the Circular Economy' (2020) 43 Journal of Consumer Policy 353. <https://doi.org/10.1007/s10603-018-9397-9>

Ife Ogunfuwa, 'Nigeria Generated 461, 300 tonnes of e-waste in 2019-UN' *The Punch* (Abuja, 14 July 2020). Available at: <https://punchng.com/nigeria-generated-461300-tonnes-of-e-waste-in-2019-un/> accessed 04 February 2025

Innocent C. Nnorom and Oladele Osibanjo, 'Overview of Electronic Waste (E-Waste) Management Practices and Legislations and their Poor Applications in the Developing Countries' (2008) 52(6) Resources, Conservation and Recycling 843. <https://doi.org/10.1016/j.resconrec.2008.01.004>

Innocent C. Nnorom and Olusegun A. Odeyingbo, 'Electronic Waste Management Practices in Nigeria' in Meththika Vithanage, Anwesha Borthakur, Majeti Narasimha (eds), *Handbook of Electronic Waste Management* (Butterworth-Heinemann 2019) ch 14

Innocent Chidi Nnorom and Oladele Osibanjo, 'Electronic Waste (E-Waste): Material Flows and Management Practices in Nigeria' (2008) 28(8) Waste Management 1472. <https://doi.org/10.1016/j.wasman.2007.06.012>

Isiaka Adetunji Adegoke, Paul Johan Oberholster and Mariana Erasmus, 'Bioleaching of Metals from E-Waste Using Microorganisms: A

Review' (2023) 13(6) Minerals 828. <https://doi.org/10.3390/min13060828>

Ivan Forenbacher and others, 'Determinants of Mobile Phone Ownership in Nigeria' (2019) 43(7) Telecommunications Policy 101812. <https://doi.org/10.1016/j.telpol.2019.03.00>

Jack Sullivan, 'Trash or Treasure: Global Trade and the Accumulation of E-waste in Lagos, Nigeria' (2014) 61(1) Africa Today 89. <https://dx.doi.org/10.2979/africatoday.61.1.89>

Jenifa Latha, C. and others, 'Dynamic Convolutional Neural Network Based E-Waste Management and Optimized Collection Planning' (2022) 34(17) Concurrency and Computation: Practice and Experience e6941. <https://doi.org/10.1002/cpe.6941>

Jennifer Ugwa, 'How Toxic Waste from High-Income Countries Booms in Nigeria Markets' (International Centre for Investigative Reporting (ICIR), 10 November 2021) <www.icirnigeria.org/how-toxic-e-waste-from-high-income-countries-booms-in-nigerian-market/> accessed 4 February 2025

Jinglei Yu, Eric Williams, Meiting Ju and Chaofeng Shao, 'Managing E-Waste in China: Policies, Pilot Projects and Alternative Approaches' (2010) 54(11) Resources, Conservation and Recycling 991. <https://doi.org/10.1016/j.resconrec.2010.02.006>

Josiah Miner Kangyang and others, 'Survey on Household Awareness and Willingness to Participate in E-Waste Management in Jos, Plateau State, Nigeria' (2020) 12(3) Sustainability 1047. <https://doi.org/10.3390/su12031047>

Kang Liu and others, 'A Global Perspective on E-Waste Recycling' (2023) 2(1) Circular Economy 100028. <https://doi.org/10.1016/j.cec.2023.100028>

Karoline Owusu-Sekyere and others, 'Assessing Data in the Informal E-Waste Sector: The Agbogbloshie Scrapyard' (2022) 139 Waste Management 158. <https://doi.org/10.1016/j.wasman.2021.12.026>

Kathirvel Brindhadevi and others, 'E-Waste Management, Treatment Options and the Impact of Heavy Metal Extraction from E-Waste on Human Health: Scenario in Vietnam and Other Countries' (2023) 217 Environmental Research 114926. <https://doi.org/10.1016/j.envres.2022.114926>

Kaustubh Thapa and others, 'Ultimate Producer Responsibility for E-waste Management–A Proposal for Just Transition in the Circular Economy Based on the Case of Used European Electronic Equipment Exported to Nigeria' (2023) 6(1) Business Strategy & Development 33. <https://doi.org/10.1002/bsd2.222>

Kingsley Nduneseokwu Chibuike, Ying Qu and Andrea Appolloni, 'Factors Influencing Consumers' Intentions to Participate in a Formal E-Waste Collection System: A Case Study of Onitsha, Nigeria' (2017) 9(6) Sustainability 881. <https://doi.org/10.3390/su9060881>

Krumay, B., 'The E-Waste-Privacy Challenge: A Grounded Theory Approach, in *Privacy Technologies and Policy: 4th Annual Privacy Forum (APF)* (APF 4th Annual Forum, Frankfurt/Main, September 2016)

Kwayie Bimpong and others, 'Ghana's Recently Introduced E-Waste Regulatory Policy: A Hope for a Better E-Waste Sector?' (2024) 42(11) Waste Management & Research 1031. <https://doi.org/10.1177/0734242X231204457>

Madhav Shreyas, A. V. and others, 'Application of Artificial Intelligence to Enhance Collection of E-waste: A Potential Solution for Household WEEE Collection and Segregation in India' (2022) 40(7) Waste Management & Research 1047. <https://doi.org/10.1177/0734242X211052846>

Malhotra, P. and Jain, A., 'Chemical methods for the treatment of e-waste' in Padeep Singh and others (eds), *Waste Management and Resource Recycling in the Developing World* (Elsevier, 2023) 181-204

Manivannan Sethurajan and others, 'Recent Advances on Hydrometallurgical Recovery of Critical and Precious Elements from End of Life Electronic Wastes-A Review' (2019) 49(3) Critical Reviews In Environmental Science and Technology 212. <https://doi.org/10.1080/10643389.2018.1540760>

Mansur Ibrahim and Jemilat Nasiru, 'LIVING ON BORROWED TIME (I): How Nigeria's E-Waste is Poisoning Residents, Environment' (International Women Media Foundation (IWMF), 2 December 2024. <www.iwmf.org/reporting/living-on-borrowed-time-i-how-nigerias-unchecked-e-waste-is-poisoning-residents-environment/> accessed 4 February 2025

May Ohajinwa Chimere and others, 'Prevalence and Injury Patterns among Electronic Waste Workers in the Informal Sector in Nigeria' (2018) 24(3) Injury Prevention 185. <https://doi.org/10.1136/injuryprev-2016-042265>

Mohamad K. Khawaja, Marwa Ghaith and Ammar Alkhalidi, 'Public-Private Partnership versus Extended Producer Responsibility for End-of-Life of Photovoltaic Modules Management Policy' (2021) 222 Solar Energy 193. <https://doi.org/10.1016/j.solener.2021.05.022>

Odeyingbo, A. O., Nnorom, I. C. and Deubzer, O. K., 'Used and Waste Electronics Flows into Nigeria: Assessment of the Quantities, Types, Sources and Functionality Status' (2019) 666 Science of the Total Environment 103. <https://doi.org/10.1016/j.scitotenv.2019.02.102>

Odwa Gazana and Thembisa Grace Ngqondi, 'Co-Design, With Two South African Villages, of a Prototype for an E-Waste Management Mobile App' (2024) 33 The African Journal of Information and Communication1. <https://doi.org/10.23962/ajic.i33.17267>

Okay Benedict Agu, 'Exploring the Linkages between E-Waste Trade, Globalisation, and Protection of the Environment in Nigeria' in Maria Ochwat (ed), *Economic and Cultural Aspects of Selected Global Problems* (The Poznan School of Banking Press 2014) 115-140

Onokpise Amos Kome, 'Management and Recycling of Secondhand Electronic Devices Case of Nigeria' (PhD thesis, Walden University 2022)

Osei Asibey Michael, Anne Mette Lykke and Rudith Sylvana King, 'Understanding the Factors for Increased Informal Electronic Waste Recycling in Kumasi, Ghana' (2022) 32(2) International Journal of Environmental Health Research 305. <https://doi.org/10.1080/09603123.2020.1755016>

Patrick Azodo Adinife, Peter Unor Ogban and James Okpor, 'Knowledge and Awareness Implication on E-Waste Management among Nigerian Collegiate' (2017) 21(6) Journal of Applied Sciences and Environmental Management 1035. <https://doi.org/10.4314/jasem.v21i6.6>

Philipp Kranz and others, 'Towards Recycling E-Waste Using Vision and Robotic Manipulation' (Australasian Conference on Robotics and Automation (ACRA), Sydney, November 2023)

Pillai H. P. Jai Shanker and others, 'Innovative Approaches to Sustainable E-Waste Management Through Bio-Based Products' in Jayaseelan Aru, N. Nirmana and S. S. Dawn (eds), *Environmental Applications of Carbon-Based Materials* (IGI Global 2024) 380-407

Rosita Moradi and others, 'Sustainable Resilient E-Waste Management in London: A Circular Economy Perspective' (2024) 10(13) Heliyon 13. <https://doi.org/10.1016/j.heliyon.2024.e34071>

Ruan Jujun, Qian Yiming and Xu Zhenming, 'Environment-Friendly Technology for Recovering Nonferrous Metals From E-Waste: Eddy Current Separation' (2014) 87 Resources, Conservation and Recycling 109. <https://doi.org/10.1016/j.resconrec.2014.03.017>

Ruchi Lal, Smriti Singh Chauhan and Bhupendra Kumar Gautam, 'An Analysis of the Role of Corporate Social Responsibility in E-Waste Management in India' (2023) 12 European Chemical Bulletin 13725

Sani Yahaya Nura, Mustapha Hussaini, and Abubakar Baba Bashir, 'Population Growth and Environmental Degradation in Nigeria' (2020) 6(1) Academic Journal of Economic Studies 31

Shailender Singh, Mani Sankar Dasgupta and Srikanta Routroy, 'Evaluation of Sustainable E-Waste Collection Method for Urban and Rural Region of India' (2022) 40(5) Waste Management & Research 545. <https://doi.org/10.1177/0734242X211018512>

Shailender Singh, Mani Sankar Dasgupta and Srikanta Routroy, 'Evaluation of Sustainable E-Waste Collection Method for Urban and Rural Region of India' (2022) 40(5) Waste Management & Research 545. <https://doi.org/10.1177/0734242X211018512>

Sirage Ali Adane and Zelalem Kibert Akalu, 'E-Waste Awareness and Management among People Engaged in E-Waste Selling, Collecting, Dismantling, Repairing and Storing Activities in Addis Ababa, Ethiopia' (2022) 16 Environmental Health Insights 11786302221119145. <https://doi.org/10.1177/11786302221119145>

Siyi Lin, and others, 'Toxic Chemicals from Uncontrolled E-Waste Recycling: Exposure, Body Burden, Health Impact' (2022) 426 Journal of Hazardous Materials 127792. <https://doi.org/10.1016/j.jhazmat.2021.127792>

Sonal Thukral, Deep Shree and Shakshi Singhal, 'Consumer Behaviour Towards Storage, Disposal and Recycling of E-Waste: Systematic Review and Future Research Prospects' (2023) 30(3) Benchmarking: An International Journal 1021. <https://doi.org/10.1108/BIJ-12-2021-0774>

Stéphanie H. Leclerc and Madhav G. Badami, 'Extended Producer Responsibility: An Empirical Investigation into Municipalities' Contributions to and Perspectives on E-Waste Management' (2024) 34(2) Environmental Policy and Governance 111. <https://doi.org/10.1002/eet.2059>

Suphichaya Suppipat and Hu H Allen, 'A Scoping Review of Design for Circularity in the Electrical and Electronics Industry' (2022) 13 Resources, Conservation & Recycling Advances 200064. <https://doi.org/10.1016/j.rcradv.2022.200064>

Swagatika Sahoo, Arnab Mukherjee and Raju Halder, 'A Unified Blockchain-Based Platform for Global E-Waste Management' (2021) 17(5) International Journal of Web Information Systems 449. <https://doi.org/10.1108/IJWIS-03-2021-0024>

Swathi, B. G. and others, 'Sustainable E-Waste Reduction Methods and Models' in KV Rajesh Kumar and others (eds), *Sustainable Solutions for E-Waste and Development* (IGI Global 2024) 239-253

Tasbirul Islam, M. D., Usha Iyer-Raniga and Sean Trewick, 'Recycling Perspectives of Circular Business Models: A Review' (2022) 7(5) Recycling 79. <https://doi.org/10.3390/recycling7050079>

Thakur, P. and Kumar, S., 'Evaluation of E-Waste Status, Management Strategies and Legislations' (2022) 19(7) International Journal of Environmental Science and Technology 6957. <https://doi.org/10.1007/s13762-021-03383-2>

United Nations Environment Programme (UNEP), Nigeria Acts to Fight Growing E-Waste Epidemic' (UNEP, 5 January 2023) <www.unep.org/gef/news-and-stories/press-release/nigeria-acts-fight-growing-e-waste-epidemic?> accessed 4 February 2025

Usman Rais Mohammad, 'Smart E-Waste Tracking and Monitoring Model: A Modern Approach to Counter E-Waste Management Issues' in Prem Kumar Chaurasia and others (eds), *Technology Innovation in Mechanical Engineering: Select Proceedings of TIME* 2021(Springer Nature Singapore, 2022) 757-765

Victor Ndako Adama and others, 'The Nigerian E-Waste Problem: Way Forward' in Kohei Arai, Rahul Bhatia and Supriya Kapoor (eds), *Intelligent Computing: Proceedings of the 2019 Computing Conference, Volume 2* (Springer, 2019) 368-385

Vishwanath Vighnesh Nanjangud, Balachandra Patil and Deepak Chandrashekar, 'Evolving a Conceptual Framework for Sustainable E-

Waste Management: A Consumer Typology Based on Environmental Behavior' (2024) 16(1) Journal of Indian Business Research 55

Wenhua Wang and others, 'Barriers for Household E-Waste Collection in China: Perspectives from Formal Collecting Enterprises in Liaoning Province' (2017) 153 Journal of Cleaner Production 299. <https://doi.org/10.1016/j.jclepro.2017.03.202>

Woggsborg, A. and Schröder, P., 'Nigeria's E-Waste Management: Extended Producer Responsibility and Informal Sector Inclusion' (2018) 1(1) Journal of Waste Resources and Recycling 1. <https://doi.org/10.15744/2766-5887.1.102>

Xin Tong, Dongyan Tao and Reid Lifset, 'Varieties of Business Models for Post-Consumer Recycling in China' (2018) 170 Journal of Cleaner Production 665. <https://doi.org/10.1016/j.jclepro.2017.09.032>

Xin Tong, Tao Wang and Yanguang Chen, 'Towards an Inclusive Circular Economy: Spatial Flows of E-Waste through the Informal Sector' in Sabastien Bourdin, Andre Torre and Evelyn van Leeuwen (eds), *Regions, Cities and the Circular Economy* (Edward Elgar Publishing 2024) 183-202

Yigit Kazancoglu and others, 'A Proposed Sustainable and Digital Collection and Classification Center Model to Manage E-Waste in Emerging Economies' (2021) 34(1) Journal of Enterprise Information Management 267

Zahid Ali and others, 'Classification of E-Waste Using Machine Learning-Assisted Laser-Induced Breakdown Spectroscopy' (2024) Waste Management & Research 0734242X241248730. <https://doi.org/10.1177/0734242X241248730>

AUTHOR'S DECLARATION AND ESSENTIAL ETHICAL COMPLIANCES

Author's Contributions (in accordance with ICMJE criteria for authorship)

This article is 100% contributed by the sole author. He conceived and designed the research or analysis, collected the data, contributed to data analysis & interpretation, wrote the article, performed critical revision of the article/paper, edited the article, and supervised and administered the field work.

Funding
No funding was available for the research conducted for and writing of this paper.

Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals not even indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has not involved any Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge are only indirectly covered, through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment or field studies. The contexts of plants are only indirectly covered through literature review. Yet, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

(Optional) Research Involving Local Community Participants (Non-Indigenous)
The author(s) solemnly declare(s) that this research has not directly involved any local community participants or respondents belonging to non-Indigenous peoples. Neither this study involved any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people are only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards. It is not relevant in case of this study or written work.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

Attribution and Representation
All opinions and mistakes are the author(s)' own and cannot be attributed to the institutions they represent. The publisher is also not responsible either for such opinions and mistakes in the text or graphs or images.

Declaration of the Use of AI
During the preparation of this work, the authors used ChatGPT to assists the script translation and proof reading. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Rights and Permissions

***

To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Ethical Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/jelp050105.