

Original Research Article

Adult and Non-Formal Education and E-Waste Policies and Management: A Framework for Lifelong Learning, Public Awareness and Sustainable Electronic Waste Governance in Nigeria

Ja'afar M^{1*}, Abdulkadir B¹, Binta L.Y¹, Halima L.M¹, Hadiza Z.M¹, Ibrahim H², Lablatu M.K³, Khalifa M.U⁴, Yusuf S.M⁵, Sabi'u A.K⁵

¹ Department of Social Sciences (Geography Unit), Kano State College of Education and Preliminary Studies, Kano, Nigeria

² Department of Adult and Non-Formal Education, Kano State College of Education and Preliminary Studies, Kano, Nigeria.

³ Department of Political Science, Kano State College of Education and Preliminary Studies, Kano, Nigeria.

⁴ Jigawa State College of Remedial and Advanced Studies, Babura

⁵ Department of Geography, Rabi'u Musa Kwankwaso College of Advanced and Remedial Studies, Tudun Wada

ORCID:  **JM** 0000-0003-0472-6354^{1*},  **AB** 0000-0002-9580-9632¹

Correspondence should be addressed to Ja'afar Muazu: mujaaf555@gmail.com

Article No: 026 | **Accepted:** 29 September 2026 | **Published:** 10 October 2026

Abstract: Electronic waste (e-waste) is a rapidly expanding environmental, economic and public-health challenge. Effective management requires more than legislation and physical recycling infrastructure; it also depends on the knowledge, attitudes, skills and participation of households, informal collectors, repairers, traders, community leaders, educators and producers. This paper examines the relationship between adult and non-formal education and e-waste policy and management, with particular attention to Nigeria. The paper adopts a qualitative documentary review approach, drawing on international reports, Nigerian environmental regulations, policy documents and relevant scholarly literature. The review indicates that adult and non-formal education can strengthen e-waste governance by translating technical regulations into locally understandable practices; developing occupational safety competencies among informal-sector actors; promoting repair, reuse, segregation, collection and responsible disposal; improving community participation; and creating pathways for green livelihoods. Nigeria has established an important regulatory foundation, including the National Environmental (Electrical/Electronic Sector) Regulations, 2022 and an extended producer responsibility approach, but persistent challenges include limited formal collection, inadequate recycling infrastructure, weak

traceability, informal processing and gaps in awareness and enforcement. The paper proposes an integrated Adult and Non-Formal E-Waste Education Framework built around policy literacy, environmental literacy, occupational health and safety, technical skills, entrepreneurship, community mobilization, digital learning and monitoring. It concludes that adult and non-formal education should be treated as a core implementation instrument within e-waste policy rather than as an auxiliary awareness activity. Such an approach can support circular-economy transitions while improving livelihoods and reducing environmental and health risks.

Keywords: Adult Education; Non-Formal Education; E-Waste; Electronic Waste; Environmental Policy; Extended Producer Responsibility; Circular Economy; Nigeria; Lifelong Learning; Waste Management.

Introduction

The rapid diffusion of information and communication technologies, household appliances, digital devices and other electrical and electronic equipment has generated substantial social and economic benefits. At the same time, shorter product cycles, technological change, consumer demand and device replacement contribute to growing quantities of discarded electrical and electronic equipment. The resulting waste stream, commonly described as e-waste or waste electrical and electronic equipment (WEEE), contains both recoverable resources and hazardous substances. The Global E-waste Monitor reported that 62 million tonnes of e-waste were generated globally in 2022, while only 22.3% was documented as formally collected and recycled. WHO similarly identifies e-waste as one of the fastest-growing solid-waste streams and highlights risks associated with unsafe dismantling, burning, dumping and recycling practices.

The challenge is especially significant in low- and middle-income countries, where formal waste-management systems may coexist with extensive informal collection, repair, dismantling and recycling activities. Nigeria has an established policy and regulatory foundation for e-waste management, including environmental regulations administered by the National Environmental Standards and Regulations Enforcement Agency (NESREA), an extended producer responsibility (EPR) approach and rules governing electrical/electronic equipment. Nevertheless, the effectiveness of policy depends on implementation capacity, stakeholder cooperation, infrastructure, financing, enforcement and public understanding.

Adult and non-formal education is relevant because e-waste management is fundamentally a human behaviour and skills issue as well as a technical and regulatory issue. Adult education encompasses structured and purposeful learning for adults, while non-formal education includes organized learning that occurs outside the conventional formal-school system. These modes of learning can reach groups that are central to e-waste management but may not be adequately served by conventional schooling: informal collectors, repair technicians, scrap dealers, artisans, market associations, community

groups, householders, unemployed youth, women, local government personnel and small businesses.

This paper, therefore, examines how adult and non-formal education can support e-waste policy implementation and management in Nigeria. It focuses on the conceptual relationship between learning and environmental governance, the current policy context, the roles of adult and non-formal education, implementation barriers and a proposed framework for integrating lifelong learning into e-waste management.

Objectives of the Study

The objectives of the paper are to:

- examine the conceptual relationship between adult and non-formal education and e-waste management;
- review major international and Nigerian policy principles relevant to e-waste management;
- identify the knowledge, skills and behavioural competencies required by key e-waste stakeholders;
- analyse barriers to using adult and non-formal education as an e-waste policy implementation instrument; and
- propose an integrated framework for adult and non-formal education in sustainable e-waste governance in Nigeria.

Research Questions

- What is the relationship between adult and non-formal education and sustainable e-waste management?
- What policy and regulatory principles shape e-waste management in Nigeria?
- What educational competencies are required by households, informal-sector workers, businesses and public officials?
- What factors constrain adult and non-formal education for e-waste management?
- What framework can integrate adult and non-formal education into e-waste policy implementation in Nigeria?

Methodology

The paper adopts a qualitative documentary-review design. Relevant evidence was identified from peer-reviewed scholarly literature, official policy and regulatory documents, international organizations and institutional reports. The documentary sources were examined thematically under five categories: (1) the scale and risks of e-waste; (2) e-waste policy and governance; (3) informal-sector practices; (4) adult, non-formal and lifelong learning; and (5) educational interventions for environmental and occupational sustainability. The analysis is interpretive rather than statistical and does not claim to provide primary field measurements. The purpose is to synthesize existing evidence and develop a policy-oriented framework that can guide future empirical research and programme design.

For Nigeria, particular attention was given to NESREA's regulatory materials and the National Environmental (Electrical/Electronic Sector) Regulations, 2022, together with international evidence from WHO, ITU, UNITAR and related sources. The analysis also considers the implementation gap between the existence of policy instruments and the capacity of stakeholders to understand, adopt and operationalize them.

Conceptual Review

Adult Education

Adult education refers broadly to organized learning opportunities designed for adults after the initial cycle of schooling, including continuing education, literacy, vocational learning, community education, professional development and learning for social participation. Its defining strength is its responsiveness to adults' lived experiences, occupational needs and immediate social environments. In environmental management, adult education can connect abstract policy objectives to practical decisions made in households, workplaces and communities.

Non-Formal Education

Non-formal education occupies the space between formal institutional education and informal learning. It may be delivered through community workshops, apprenticeship schemes, short courses, extension programmes, association-based training, workplace instruction, public campaigns and digital learning. Because e-waste is generated and handled across diverse settings, non-formal education is particularly useful for reaching populations whose learning needs are occupationally specific or geographically dispersed.

E-Waste and Sustainable Management

E-waste includes discarded electrical and electronic equipment and components. It may contain valuable materials such as copper, aluminium, iron, gold and other recoverable resources, alongside hazardous substances. Sustainable management, therefore, requires a life-cycle perspective: prevention and reduction, durable design, repair, reuse, refurbishment, separate collection, safe transportation, environmentally sound recovery and final disposal. Circular-economy approaches emphasize keeping products and materials in productive use for as long as possible while reducing waste and pollution.

Education as an Environmental Governance Instrument

Environmental regulations establish standards and responsibilities, but people must understand and operationalize those standards. Education can improve policy implementation by increasing awareness, developing practical competencies, changing routines and strengthening participation. In e-waste management, policy literacy can help stakeholders understand producer responsibility, collection requirements, licensing and prohibited practices, while technical education can promote safer dismantling, storage and transport. Education can also help communities distinguish legitimate recovery activities from unsafe burning or uncontrolled dumping.

Global E-Waste Situation and Implications for Education

The global growth of e-waste creates an urgent need for coordinated action across production, consumption, collection and recycling. WHO reports that unsafe e-waste recycling can release numerous chemical substances and that children and pregnant women are particularly vulnerable to exposure. The health implications make community education and occupational safety training central to prevention. The educational requirement is not simply to tell people that e-waste is dangerous; learners need actionable knowledge about identification, segregation, storage, personal protection, safe transport, take-back systems, repair and approved recycling routes.

International guidance also emphasizes identifying e-waste streams, formalizing and regulating waste management and recycling, developing recovery facilities and using appropriate technologies. These measures require trained personnel and informed communities. Education can therefore be understood as enabling infrastructure: without the knowledge and skills necessary to use physical infrastructure and comply with regulations, collection centres, recycling plants, and policy instruments may remain underutilized or poorly managed.

E-Waste Policy and Management in Nigeria

Nigeria's environmental governance architecture includes NESREA, which administers a range of environmental regulations. NESREA identifies the National Environmental (Electrical/Electronic Sector) Regulations, S.I. No. 79 of 2022, as a key instrument designed to prevent and minimize pollution from electrical/electronic-sector operations and to cover new and used electrical/electronic equipment. The 2022 framework incorporates an extended producer responsibility orientation across the life cycle of equipment.

The policy framework places responsibilities on producers and other actors and uses the polluter-pays principle. The International Energy Agency's policy summary notes that the 2022 regulations apply to both new and old equipment across their life cycle, require relevant producers and importers to participate in take-back arrangements, and include registration and producer-responsibility mechanisms. Nigeria also has an earlier regulatory history: the National Environmental (Electrical/Electronic Sector) Regulations, 2011, addressed pollution prevention, e-waste control, recycling obligations, permits and enforcement.

The existence of regulations, however, does not automatically guarantee environmentally sound management. ITU describes Nigeria as having a policy and regulatory foundation but notes continuing limitations in formal collection and recycling, with informal collection and treatment remaining influential. Recent scholarship likewise identifies inadequate infrastructure, limited awareness and enforcement difficulties as continuing concerns. These conditions demonstrate the need to treat education as a component of implementation rather than as a peripheral public-relations exercise.

The Role of Adult and Non-Formal Education in E-Waste Management

Policy Literacy and Regulatory Compliance

Adult and non-formal programmes can translate regulatory provisions into simple operational guidance for different stakeholder groups. A collector needs to know where and how to register, store and transport equipment; a household needs to know how to separate and return obsolete devices; a producer needs to understand take-back responsibilities; and a local official needs to understand monitoring and referral procedures. Training materials should therefore be role-specific rather than generic.

Occupational Health and Safety

Informal e-waste workers can face exposure to hazardous substances through dismantling, open burning and other unsafe practices. Training can cover hazard identification, safer dismantling, ventilation, personal protective equipment, hygiene, fire prevention, first aid, battery handling and procedures for hazardous components. Such programmes should be designed with workers rather than imposed on them, recognizing existing knowledge and livelihood realities.

Repair, Reuse and Refurbishment Skills

Adult vocational education can support the higher levels of the waste hierarchy by developing repair, maintenance, refurbishment and component-recovery skills. Extending product life can reduce premature disposal while creating employment opportunities. Training can include diagnostics, component replacement, quality control, data protection, testing and safe preparation of irreparable equipment for recycling.

Community Environmental Literacy

Community-based education can promote household segregation, discourage burning and dumping, and increase participation in collection programmes. Adult educators can work through community associations, religious and civic organizations, markets, cooperatives, local governments and media platforms. Participatory approaches are especially important because waste practices are embedded in local economic and social systems.

Green Entrepreneurship and Livelihoods

E-waste contains recoverable materials and can support legitimate livelihoods when managed under environmentally sound conditions. Non-formal entrepreneurship education can cover business planning, bookkeeping, cooperative formation, collection logistics, market information, quality standards and compliance. The objective should be to shift livelihoods from hazardous extraction practices toward safer repair, refurbishment, collection and formal recycling value chains.

Digital and Mobile Learning

Because mobile-phone access is widespread, short digital modules can complement face-to-face instruction. Micro-learning can provide illustrated lessons on e-waste

identification, safe handling, collection points, emergency procedures and regulatory responsibilities. Digital platforms can also support refresher training, assessment and communication between local authorities, producer-responsibility organizations and workers.

Stakeholder-Specific Competency Framework

Stakeholder	Priority knowledge	Priority skills	Delivery approach
Households/consumers	Hazards; segregation; take-back options	Sorting, safe storage, responsible disposal	Community workshops, radio, mobile learning
Informal collectors/recyclers	Hazardous components; regulations; health risks	Safe collection, dismantling, PPE use, referral	Apprenticeship, association training, demonstrations
Repairers/refurbishers	Product life extension; safety; data protection	Diagnostics, repair, testing, refurbishment	TVET/non-formal vocational centres
Producers/importers/retailers	EPR duties; take-back; reporting	Collection logistics, compliance, record keeping	Workplace training and professional seminars
Local government/environment officers	Regulations; inspection; community engagement	Monitoring, enforcement, education, data management	In-service training
Educators/NGOs/community leaders	Environmental literacy; behaviour change	Facilitation, campaign design, participatory learning	Training-of-trainers

Proposed Adult and Non-Formal E-Waste Education Framework

The proposed framework, termed the Adult and Non-Formal E-Waste Education Framework (ANF-EWEF), integrates six mutually reinforcing components: policy literacy, environmental and health literacy, technical and occupational skills, green entrepreneurship, community participation, and monitoring and evaluation.

Component 1: Policy literacy

Develop simplified guides explaining e-waste responsibilities, EPR, collection, prohibited practices, permits and reporting. Materials should be translated into locally relevant languages and adapted to literacy levels.

Component 2: Environmental and health literacy

Teach the sources, hazards and consequences of e-waste, including risks from open burning, unsafe dismantling and uncontrolled disposal. Emphasize practical prevention behaviours.

Component 3: Technical and occupational skills

Provide hands-on training in safe collection, segregation, storage, dismantling, repair, refurbishment, battery handling, PPE and emergency procedures.

Component 4: Green entrepreneurship

Build competencies in business management, cooperative organization, logistics, customer relations, market development and environmentally compliant recovery services.

Component 5: Community participation

Use participatory learning, local associations, media and community campaigns to establish collection routines and strengthen trust in formal management systems.

Component 6: Monitoring and evaluation

Measure knowledge gains, behavioural change, participation in take-back schemes, safe-work practices, quantities collected and referrals to authorized recyclers.

Implementation Strategy

Implementation should occur in phases. The first phase should map stakeholder groups and learning needs at the national, state and local levels. The second should develop competency-based curricula and train facilitators. The third should pilot programmes in major e-waste hubs and selected communities. The fourth should evaluate outcomes and integrate successful approaches into local government, vocational and adult-learning systems.

Partnerships are essential. NESREA and other responsible agencies can provide regulatory content; producer-responsibility organizations and industry can support collection and financing; adult-education institutions can develop and deliver programmes; technical and vocational institutions can provide skills training; local governments can mobilize communities; NGOs can facilitate participatory learning; and formal recyclers can provide practical demonstrations and safe referral pathways.

Financing should combine public environmental funds, producer responsibility contributions, industry partnerships, development assistance and community-level enterprise models. Education activities should be incorporated into EPR implementation plans rather than treated as temporary campaigns. Training materials should also be updated as technologies, regulations and hazards change.

Challenges

- Low awareness and varying literacy levels among stakeholders.

- Fragmentation between environmental regulation, education, local government and informal economic systems.
- Limited funding for sustained community and occupational training.
- Insufficient formal collection and recycling infrastructure in many locations.
- Economic dependence on informal e-waste activities, which can make rapid formalization difficult.
- Weak data systems for tracking e-waste quantities, flows and training outcomes.
- Limited availability of qualified trainers with both technical e-waste and adult-learning competencies.
- Potential mismatch between regulatory requirements and the practical realities of small-scale operators.

Policy Recommendations

- 1) Institutionalize adult and non-formal education within national and state e-waste implementation plans.
- 2) Develop competency-based e-waste curricula for informal collectors, repairers, recyclers, households, businesses and public officials.
- 3) Use multilingual, low-literacy and practical teaching materials, including visual guides and demonstrations.
- 4) Integrate occupational health and safety training into programmes targeting informal e-waste workers.
- 5) Strengthen repair, refurbishment and reuse training as part of circular-economy policy.
- 6) Use producer-responsibility financing mechanisms to support public education, training and collection awareness.
- 7) Create partnerships between adult-education centres, technical institutions, local governments, recyclers and producer organizations.
- 8) Develop digital and mobile learning resources for refresher training and public awareness.
- 9) Establish measurable education indicators within e-waste monitoring systems, including knowledge, safe practices, and participation and collection outcomes.
- 10) Conduct state- and city-level empirical studies to identify local learning needs and evaluate the effectiveness of education interventions.

Conclusion

E-waste management is not solely a problem of waste technology or environmental regulation. It is also a problem of knowledge, skills, behaviour, institutional coordination and participation. Nigeria has developed a regulatory foundation for managing electrical and electronic equipment and e-waste, including extended producer responsibility and life-cycle principles. However, the continuing importance of informal collection and treatment, limitations in formal infrastructure and gaps in awareness demonstrate that policy implementation requires stronger human-capacity systems.

Adult and non-formal education provides a practical mechanism for building that capacity. Through policy literacy, environmental-health education, occupational safety, repair and refurbishment skills, entrepreneurship, community participation and digital learning, adult education can help translate regulatory principles into everyday practices. The proposed ANF-EWEF provides a structure for integrating these functions into e-waste governance. Future research should test the framework empirically across Nigerian cities and e-waste value chains, using indicators that capture not only knowledge but also changes in work practices, collection rates, recycling pathways, livelihood outcomes and environmental risk reduction.

Limitations of the Study

The paper is based on documentary analysis and therefore does not provide primary survey or experimental evidence on the effectiveness of specific adult-education interventions. The proposed framework should be treated as a policy and research framework requiring empirical validation. Local conditions also vary considerably across Nigerian states and e-waste hubs; therefore, implementation should be adapted to local regulatory, economic, cultural and infrastructural contexts.

References

1. Balde, C. P., Kuehr, R., Yamamoto, T., McDonald, R., D'Angelo, E., Althaf, S., Bel, G., Deubzer, O., Fernandez-Cubillo, E., Forti, V., Gray, V., Keber, M., Khetriwal, D. S., Krüger, C., Law, R., Nnorom, I., Okolovitch, L., Pavao, A., Persin, J., Wagner, M., & Wang, F. (2024). *The Global E-waste Monitor 2024*. International Telecommunication Union (ITU) and United Nations Institute for Training and Research (UNITAR).
2. International Energy Agency. (2025). *National Environmental (Electrical/Electronic Sector) Regulations, 2022*. IEA Policies Database.
3. International Labour Organization. (2021). *Child labour: Global estimates 2020, trends and the road forward*. ILO.
4. International Telecommunication Union & United Nations Institute for Training and Research. (2024). *The Global E-waste Monitor 2024*. ITU/UNITAR.
5. International Telecommunication Union. (2024/2026). *Nigeria: E-waste country profile*. ITU E-waste Monitor/Country Information.
6. National Environmental Standards and Regulations Enforcement Agency (NESREA). (2011). *National Environmental (Electrical/Electronic Sector) Regulations, S.I. No. 23 of 2011*. Federal Republic of Nigeria.
7. National Environmental Standards and Regulations Enforcement Agency (NESREA). (2022). *National Environmental (Electrical/Electronic Sector) Regulations, S.I. No. 79 of 2022*. Federal Republic of Nigeria.
8. National Environmental Standards and Regulations Enforcement Agency (NESREA). (2024). *Extended Producer Responsibility (EPR) Guidance Document for the Electrical/Electronic Sector*. Federal Republic of Nigeria.
9. Nnorom, I. C., & Faluyi, I. (2026). Informal e-waste management in Nigeria: A comprehensive analysis of practices, challenges, and opportunities for sustainable solutions towards a circular economy. *Waste Management & Research*. <https://doi.org/10.1177/0734242X261435297>
10. Ozavize, E. J., & Olaniyi, A. A. (2026). Policy pathways for integrating adult and non-formal education into Nigerian school curricula. *UniJos Journal of Contemporary Studies in Education*, 4(1).
11. United Nations Environment Programme. (2019). *E-waste and its environmental and health impacts*. UNEP.

12. World Health Organization. (2024). *Compendium of WHO and other UN guidance on health and environment: 2024 update*. WHO.
 13. World Health Organization. (2024). *Electronic waste (e-waste)*. WHO Fact Sheet, 1 October 2024.
 14. World Health Organization. (2024). *Electronic waste: Digital dumpsites and children's health*. WHO Questions and Answers, 2 October 2024.
-



© 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by-nc-sa/4.0/>).