Factors influencing the adoption of appropriate electronic waste recycling practices in Sub-Saharan Africa: Empirical literature review

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Abstract
The main focus of this paper is to provide a thorough examination of the factors influencing the adoption of appropriate e-waste recycling practices in Sub-Saharan Africa. *Objective:* Specifically, this study assessed global e-waste recycling and policy issues and the factors influencing the adoption of appropriate e-waste recycling practices in sub-Saharan Africa. *Prior work:* This paper is built upon available literature that has been published in the area of e-waste recycling. The paper utilized publications from different developed and developing countries by examining legal and institutional frameworks, infrastructures, recycling practices, etc. *Approach*: This study used a desk review approach to conduct a systematic literature review of research articles collected from various databases. *Implications:* The findings of this study provide insights into the factors influencing the adoption of appropriate e-waste recycling practices by policy makers and all e-waste stakeholders. This provides a path for the implementation of sustainable development goals that aim to protect human health and the environment. *Value:* This study revealed that the absence of policies, regulations and recycling infrastructure are some of the factors affecting the adoption of e-waste recycling in sub-Saharan Africa. However, some countries within the region, such as South Africa, Rwanda and Uganda, have enacted regulatory frameworks for e-waste management, which have enabled them to facilitate the adoption of e-waste recycling practices in their countries. Other factors include economic incentives and market opportunities, which play critical roles in driving the adoption of appropriate e-waste recycling practices. Moreover, factors such as public awareness, education, and technology are fundamental in the region.

Keywords: Electrical and Electronic Equipment (EEE), Waste Electrical, Electronic Equipment (WEEE), e-waste recycling.

1. Introduction
An increase in technology adoption in Sub-Saharan Africa has been accompanied by an increase in the generation of e-waste, yet this growth has occurred in the context of inadequate management systems. This is also driven by consumers' desire for new devices, which leads to the premature dumping of old or broken electronics even before their useful life is spent [1]. The steadily growing Electrical and Electronic Equipment (EEE) sector plays a significant role in aggravating this issue by increasing the levels of electricity usage and disposal of electronic devices. Predictions, admittedly rough, project an annual increase in e-waste generation of more than 74 million metric tons in 2030. These rates remain alarming, and the global management of e-waste is still very poor. This is an indicator of a lack of efficient strategies for managing and recycling e-waste [2] .

The ranking of e-waste generation is led by Asia, followed by America and Europe, where Africa presents a unique challenge. Whereas the rate at which e-waste is generated in Africa, compared with that in developed nations, appears relatively low, this continent is actually very vulnerable to poor e-waste management. Its vulnerability underpins the need for special attention to e-waste management in Sub-Saharan Africa [2]. This challenge is facilitated by the lack of funds and proper technology facilities in many Sub-Saharan countries, and the opportunities for recycling second-hand or used electronics to developed countries remain high. Although products such as refurbished computers and other electronics expand people's access to affordable technologies for education, business, or personal use, the fascination of electronics in the region and, in general, the lack of e-waste management systems have led to the emergence of enormous threats to the environment and public health [3].

E-waste is dangerous because electronic goods contain lead, mercury, cadmium and flame retardants. The disposal of these toxic components into the environment thus affects the soil, water, and air resources, hence deteriorating the environment and posing serious health effects on the public, particularly communities around recycling areas [4].

Sub-Saharan Africa can learn much from developed countries. In most cases, the laws and frameworks that control e-waste management in developed countries are very strict. For example, South Korea has had a legally backed e-waste recycling framework with obligatory recycling endeavors for electronics. This, together with sound collection arrangements, has the added dividends of impressive recycling practices [3]. Likewise, the Japanese experience shows that even legislation, including the Act on the Promotion of Effective Utilization of Resources, can spark success in e-waste recycling. This law has encouraged the establishment of collection centers and centers for the recycling of electronic devices and hence high recycling rates of electronic devices [5].

Even though e-waste recycling practices are considered crucially significant, several challenges hinder successful e-waste recycling practices. A major challenge is the low level of sensitization among the general public to the dangers to the environment and human health caused by the wrong disposal of e-waste. Public awareness formation through education is very important for ensuring that the public understands the importance of proper e-waste management. Additionally, the structure of effective infrastructure collection for e-waste can be daunting for one to undertake, especially in a region that lacks proper dumping facilities for products. Many people cannot easily access collection centres, which greatly affects their ability to recycle. However, costs such as the actual cost of collection, transportation, and processing make e-waste recycling costly [2].

Through recycling, there is a solution since most electronic devices are made of gold, silver and copper, which can be reclaimed from the junk. This helps conserve natural resources and reduces the need for destructive techniques in mining [6]. Additionally, the recycling of electronic waste uses fewer resources that can be used to extract new materials, implying that manufacturing electronics from recycled products is more environmentally friendly than manufacturing electronic products from raw materials. In general, e-waste recycling

provides a positive picture that can be an added advantage to the environment, resources that are preserved, and the provision of a sustainable future in Sub-Saharan Africa [3].

Few studies have focused on the factors that affect the implementation of e-waste recycling practices in sub-Saharan Africa [7]. However, some countries within the region have already developed policies and laws to address the management of e-waste, including South Africa, Rwanda, and Uganda, among others [2]. More developing countries need to adopt such policies in a bid to minimize the impact on the environment and the health of human beings [7].

However, there is a notable lack of research focused on the influencing factors in the adoption of e-waste recycling practices in Sub-Saharan countries, resulting in a scarcity of information on the subject. Previous studies have not thoroughly examined the adoption of e-waste recycling in the region of Sub-Saharan Africa. Therefore, this study seeks to investigate the factors influencing the adoption of proper e-waste recycling practices in sub-Saharan countries.

Two research questions are explored in the literature review:

a) What are the global e-waste generation, recycling trends, and policy issues?
b) What are the factors influencing the adoption of proper e-waste recycling practices?

2. Rational for electronic waste studies

The concept of the environment is at the heart of the Sustainable Development Goals (SDGs), which are set international goals adopted by Member States of the United Nations for eradicating poverty and promoting prosperity and people's well-being [8]. Electronics, which is now a very furious waste stream if not correctly dealt with, has many impacts on the environment and health. Such risks may slow down the attainment of multiple of the 2030 agenda's intended goals, which are depicted by the acronym SDG. Fortunately, effective e-waste management can contribute positively to several SDGs. The study's significance, encompassing environmental, economic and social considerations, is as follows:

Environmentally, e-waste is hazardous, particularly with the constituent materials that are toxic in nature. This results in the release of these toxins into the soil and water, which pollutes the environment and has implications for human health [6]. Sustainable e-waste management focuses on reducing e-waste generation, promoting device reuse and recycling, ensuring the safe disposal of hazardous materials, and directly aligns with SDG 11 (target 6). One of the proposed global goals is sustainable cities and communities, and another similar goal, namely, SDG 12, is responsible for consumption and production.

Economically, e-waste is a potential threat because it contains some toxic materials. The latter, when landfilled and not disposed of properly, causes the release of these toxins into the soil and water, hence becoming hazardous to the ecosystem and human health [9].

Thus, the latter can be argued to be linked directly to SDG 11: Sustainable Cities and Communities and SDG 12: Responsible Consumption and Production by focusing on reducing e-waste generation and emphasizing reuse and safe disposal through recycling of hazardous material devices [2].

Socially, with respect to the impact on the community, poor people or developing countries are usually burdened with e-waste. These regions usually lack facilities and means to dispose of waste effectively, which results in environmental pollution and health impacts for people living in these areas [2, 10]. Proper management also implies a reduction in these hazards in support of SDG 3: good health and well-being.

3. Methodology

Kitchenham [11] coined the phrase Systematic Literature Review, which is widely applied in all academic studies. It is a process used for identifying important academic papers to extract, appraise, and review data relevant to a particular research question or a specific research field. The SLR also enables the researcher to identify the gaps in existing knowledge that need to be filled. Within the SLR, the assessment is conducted in accordance with the PRISMA guidelines on reporting in systematic reviews and meta-analyses to secure an effort toward a deep and unbiased view of the literature [12]. The research questions were answered through critical studies of scientific journals. Publications from January 2016 to 2024 were searched for relevant information. A search was performed in leading databases such as Web of Science, Science Direct, Sage, Springer Link, EBSCO Host, and Sabinet African Journals. The last database was intentionally used for targeting African publications.

In line with Kitchenham, Charters [13] recommended that Boolean operators ("AND" and "OR") are important for maximizing the search for relevant publications. The logical operator "OR" combines keywords, and the "AND" operator combines keywords within a phrase. The original search terms focused on e-waste management in developing nations and alternative words for these terms. The results after the search streamlined 12,300 from the selected databases, indicating the scope of the titles, abstracts and keys, i.e., the topic, to obtain a complete understanding of e-waste management in sub-Saharan Africa.

The Boolean operators "AND" and "OR" were used to improve the search results. The original keywords used were e-waste management search terms in developing countries and their synonyms. These keywords were linked via the "OR" operator in a phrase and combined via the "AND" operator. The search excluded gray literature and white papers because there was already enough cited literature on the topic.

In the second iteration, the search terms were formatted further to increase search precision and include keywords related to e-waste management in Africa. This identified 1,784 research articles. In the subsequent stages, the search criteria were further filtered with the help of precise search strings such as e-waste, e-waste management, e-waste recycling, and e-waste recycling in developing countries and developed countries and factors influencing the adoption of e-waste recycling practices in sub-Saharan Africa, which resulted in the

filtering of 970 articles by reviewing their titles. The basis of further consideration was the discussion of 505 articles that discussed only e-waste or e-waste related issues in Africa or sub-Saharan Africa.

The third step entailed further scrutiny of the articles remaining after the second step of the review. The third step aimed to determine the relevance of the articles to aspects such as e-waste management, policies surrounding the control and governance of e-waste recycling efforts, motives to adopt e-waste recycling technologies that are environmentally sound, and e-waste recycling plants in Sub-Saharan Africa. In total, 462 studies were eliminated. Rayyan was applied, which is a web and mobile application that uses the design of systematic reviews led by the articles [14]. The citation files downloaded from scientific databases were uploaded to the Rayyan platform via the website https://rayyan.qcri.org. Articles were screened via the labels "include," "exclude," and "undecided".

The final phase involved reading the abstract and conclusion of every article to determine how applicable it was to the research questions. In duplicate, the titles were scanned, and up to 43 articles that seemed most relevant were selected for inclusion in the study. Content analysis was used, and the emerging themes were derived from the selected articles in the listing in which the information answered the research questions. Data extracted according to Mayring, [15] are compiled in a content analysis. The main factors analysed as prevalent themes shed light on the status of electronic waste management in Sub-Saharan African countries. Both quantitative and qualitative interpretations of the data were performed, revealing patterns and gaps in dealing with e-waste in Sub-Saharan Africa.

4. Findings and discussion

4.1. Global trends in e-waste generation and recycling

4.1.1. Global e-waste generation

In addition to rapidly developing technology and the increasing rate at which humans replace devices, electronic waste or e-waste has accumulated. As depicted in Figure 1, e-waste generation has consistently increased, indicating a global environmental crisis during these times. The 2014 global e-waste monitor report painted a bleak picture whereby 33.8 million metric tonnes of e-waste were generated in the year 2010. This disturbing trend did not decrease but continued, as this figure ballooned to 43.8 million metric tonnes (Mt) in 2015 [16]. In its recent release, the 2020 Global E-waste Monitor report revealed a staggering 53.6 million metric tonnes of e-waste generation globally in 2019. This undesirable trend is projected to increase to approximately 74.7 million metric tonnes by 2030, translating into a nearly 2 million tonne annual increase. Notably, Asia led the surge in e-waste generation, followed by America, Europe, Africa, and Oceania [2, 6]. Of even more concern, however, is the fact that such e-waste contains some toxic materials. This e-waste is a great danger to the environment and human health if it is not properly disposed of or recycled [17]. In this context, governments, organizations, and individuals must continue to sensitize and adopt proper management strategies and ways of minimizing these wastes to reduce the level of destruction of our planet.

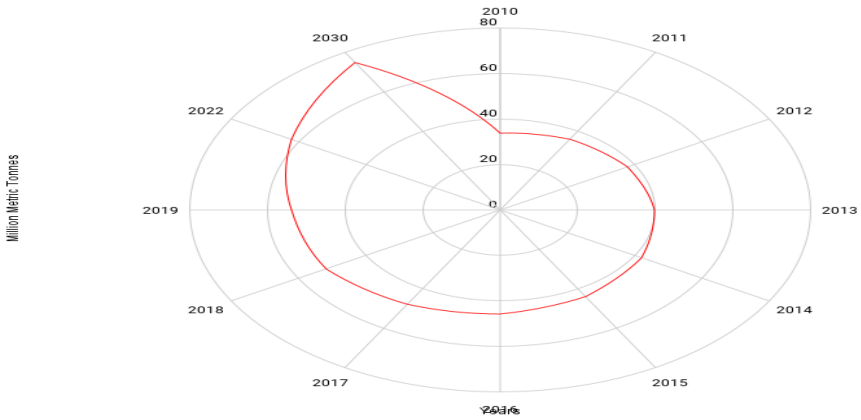

Fig. 1. Global e-waste generation trend
Source: Global e-waste reports from 2017 and 2020 modified by the author

Even though there has been an increase of 1.8 million tons of e-waste that has been recycled since 2014, it still translates to a very poor rate of collection globally. According to a global e-waste monitoring report from 2020, out of the 53.6 million tons produced, only 17.4% were formally collected and recycled (9.3 million tons). Indeed, European countries were at the top of the list in terms of collection and recycling of e-waste, as shown in Figure 2 below. Europe collected and recycled 5.1 million tonnes, whereas Asian countries followed with 2.9 million tonnes, and African countries reached the lowest rate of 0.03 million tonnes [2].

The widening gap between the e-waste generated and the e-waste recycled raises many questions: Where has all the uncollected e-waste gone? What is the current management practice for it? Which global or regional strategies can truly result in better collection and recycling? How can governments at the policy and legislative levels promote e-waste recycling? What are the economic and technical barriers to increased recycling? Can public awareness campaigns attract participation at large?

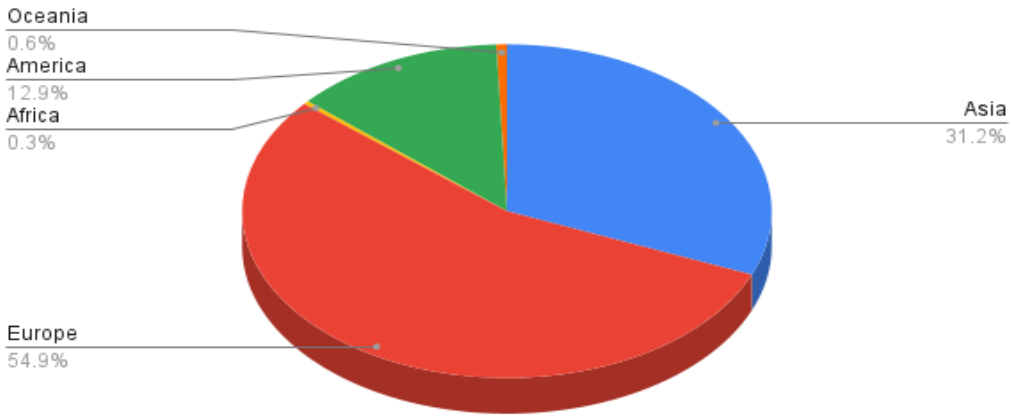

Fig. 2. E-waste recycling percentage by continent
Source: Global e-waste monitor 2020 modified by the author

The answers to these questions are of vital importance. Inventing new technologies, providing appropriate economic incentives, and increasing public awareness are some of the major factors in solving the problem of e-waste worldwide.

4.1.2. Global policy on e-waste

The United Nations Environment Programme takes lead in addressing global environmental issues; hence, it facilitates the adoption of sustainable development regarding e-waste. The UNEP works closely with governments, industries, and relevant stakeholders in setting policies aimed at achieving sustainable management of e-waste through recycling and proper e-waste disposal methods. There are also environmental conventions that focus on e-waste, such as the Basel Convention, which is held under the umbrella of the UNEP [18].

Another cornerstone of global e-waste policy is the Basel Convention, adopted in 1989 and ratified by more than 180 countries, which controls the transboundary movement and disposal of hazardous wastes. This convention aims at protecting human health and the environment by prohibiting the export of hazardous waste from developed nations into developing nations without consent. This ensures that responsible waste management is promoted through guidelines, best practices, and technical assistance [19]. The Basel Convention offers a framework of paramount importance to the global control of hazardous waste trade and disposal, aiming to prevent pollution and protect human health.

Moreover, 2015 was also an iconic year for global sustainability. The United Nations adopted a universal framework called the Sustainable Development Goals, which comprises 17 interlinked objectives oriented at combating poverty, inequality, and environmental degradation. In this context, e-waste management is important for the attainment of several SDGs in the following ways:

- SDG 12 on responsible consumption and production explicitly states that safe management of wastes, including e-waste, is necessary (Target 12.4).
- SDG 11 on Sustainable Cities and Communities seeks to provide a sustainable environment within and between cities and communities. Waste management problems, of which e-waste is a part, must be factored into this goal.
- Finally, SDG 3 on Good Health and Well-being applies because failure to safely dispose of e-waste can harm human beings because of the toxic chemicals that its constituents carry [20].

Effective e-waste management will thus help us reach these key SDGs and ensure the well-being of the planet and society.

4.2. Factors influencing the adoption of appropriate e-waste recycling practices in sub-Saharan Africa

The adoption of e-waste recycling in Sub-Saharan Africa is a complex issue intertwined with various regulatory, economic, social, and infrastructural factors. This section presents an in-depth analysis of these elements.

4.2.1. Regulatory and policy frameworks

4.2.1.1. Regulations and standards

Effective regulatory frameworks are important elements in the management of e-waste in Sub-Saharan Africa. These help arrest the inflow of low-quality electronic products and guarantee the environmentally sound management of e-waste [21, 22, 23, 24, 25]. However, most countries in this region still do not have strong frameworks in place against such irresponsible disposal practices. Notable exceptions, such as South Africa, Uganda, and Rwanda, which have been proactive in e-waste policies, provide examples of the good that strong regulations can do [3].

Although some progress has been made, there is still a wide gap in the implementation of international agreements governing hazardous waste disposal, such as the Basel Convention, of which e-waste is a part. While more than 40 countries in Sub-Saharan Africa have signed up to the Basel Convention, many of them still fail to translate these principles into national legislation, complicating effective e-waste management [26].

However, some countries have done impressively well. For example, Madagascar, Kenya, and Ghana have legislated e-waste management laws, whereas Nigeria is vigorously implementing draft e-waste regulations even without their corresponding legislation [27]. The ability of the Nigerian environmental agency to stem illegal e-waste imports masquerading as used goods is an example of what stringent enforcement of regulations can do [28].

4.2.1.2. Regulatory frameworks

Although there are still disparities in e-waste legislation across most of Sub-Saharan Africa, the following countries are leading from the forefront with respect to regulatory developments:

Kenya: The draft e-waste act, awaiting final endorsement, compels companies to state where their electronic waste shall be disposed of at the stage of manufacturing or import of electrical and electronic equipment. This step contributes to transparency and accountability throughout the entire life cycle of e-waste [2].

Ghana: Ghanaian legislation covers e-waste from various dimensions. This ranges from the prohibition of e-waste imports and exports to stop the country from being a dumpsite, phasing out printed circuit boards in electronics so that there will be an incentive for designing more environmentally friendly boards, and compulsory registration of manufacturers, importers, and distributors of electronics for enhancing monitoring along the e-waste supply chain. The creation of an e-waste management fund financed by funds provided in advance by the industry players themselves provides the resources needed for responsible e-waste management practices [3].

These examples from both Kenya and Ghana demonstrate a growing commitment to addressing e-waste challenges across Sub-Saharan Africa.

4.2.1.3. Towards full e-waste management

An increasing number of African countries are actively looking for ways to overcome the e-waste challenge and do so by adapting comprehensive strategies from successful programs elsewhere [3]. These strategies involve the integration of the informal sector, which presently dominates e-waste processing in most African countries, into formal management structures and the establishment of take-back schemes, extended producer responsibility systems, and producer responsibility organizations [29, 30].

These efforts are increasingly being supported by United Nations agencies, development organizations, the private sector, and alliances of original equipment manufacturers on the African continent [3]. This collaborative approach brings aboard critical guidance, technical expertise, and financial resources that are critical to their implementation.

4.2.2. Economic and market factors

4.2.2.1. Financial incentives

Economic incentives are among the strongest incentives for e-waste recycling. Deposit-refund schemes can form a financial mechanism that motivates consumers to return their electronic products for recycling. These incentives help individuals and businesses have financial motives for proper e-waste disposal [7, 29, 31]. The implementation of financial incentives has started, and South Africa and Nigeria are examples as follows:

- *South Africa:* There are discussions in the South African government and private sector to introduce financial incentives to recycle e-waste. The government and private sector have been exploring deposit-refund schemes and other financial incentives to motivate consumers to return end-of-life electronics for recycling. The Electronic Waste Association of South Africa has, in this context, been pushing for the establishment of a deposit-return scheme, which provides a refund to the consumer upon return of used electronic goods to foster increased recycling rates: https://ewasa.org/epr/epr-fees/.
- *Nigeria:* Given the current domination of informal practices within the e-waste recycling sector, proposals have been made to increase its formalization through the use of financial incentives. Pilot schemes, such as buyback initiatives, have been tested by paying consumers to return old electronic devices in urban areas such as Lagos. The project E-waste Compensation as an International Financing Mechanism in Nigeria, ECoN, went a step further to develop some financial incentives for agents working with local collectors from the informal sector through the employment, income, and training provided to them [32].

4.2.2.2. Market opportunities

Market opportunities influence the current adoption of e-waste recycling practices to a great extent. The profits gained from e-waste recycling through the recovery of precious metals such as gold, silver, and copper are significant enough to drive formal and informal activities [29, 33]. However, for these market opportunities to materialize, there needs to be a properly set-out and regulated market that is missing in Sub-Saharan Africa. Another

incentive measure could be strengthening market structures and ensuring that fair prices are paid for materials derived from waste.

4.2.3. Awareness factors

4.2.3.1 Public awareness and education

A major constraint for e-waste recycling in Sub-Saharan Africa is the low level of public awareness regarding the environmental hazards and health effects caused by unregulated e-waste disposal. Most people in these countries are not informed enough about the benefits of the recycling and hazards associated with the toxic materials in e-waste, as observed by [34, 35]. For example, a study conducted in South Africa and Uganda suggested that the majority of consumers have very minimal knowledge about issues related to e-waste. This is well documented by [9, 36, 37].

4.2.4. Infrastructural and technological factors

4.2.4.1. Recycling infrastructure

Among the fundamental challenges or obstacles to proper e-waste recycling in Sub-Saharan Africa is the lack of adequate infrastructure [38]. This in itself is considered to be a major constraint on the adoption of safer and more sustainable practices since most recyclers are without essential facilities. This shortage, therefore, in most cases leaves most of them stuck between the devil and the deep blue sea, resulting in harmful methods that involve manual dismantling, burning, and acid leaching of harmful substances to recover valuable metals.

A key challenge is the lack of most of the key infrastructure needed, such as collection centers and facilities for recycling. The lack of such facilities has contributed to individuals and organizations not being able to handle their e-waste in an environmentally responsible manner. The majority dispose of their e-waste hazardously or sell it to informal collectors, who, in turn, break them down using equally hazardous means owing to the lack of organized and responsible facilities [38].

The examples from Nigeria and Ghana echo the results of limited infrastructure. For example, at Alaba in Nigeria, e-waste processors recover copper and aluminum by manual dismantling and burning [39]. Similarly, Agbogbloshie in Ghana is well known for its pollution caused by crude methods such as open burning, which are used in extracting precious metals [3].

Furthermore, the lack of e-waste recycling facilities has increased the recycling costs in sub-Saharan Africa [40]. For example, e-waste recyclers in South Africa must transport some e-waste types, such as personal computer boards, for processing in Europe. The extra transportation cost pressures the profit margin, making it challenging for recyclers to maintain profitability [41].

4.2.4.2. Technology and skills

The availability of proper technology and adequately trained labor forces is critical for the proper handling and recycling of e-waste. Technological advances can effectively increase

efficiency and safety in the process of recycling, and skilled labor can ensure that these processes are executed in the proper manner [42]. In this direction, there will be a need to invest in technology and training to develop the capacity required to efficiently manage e-waste within the region.

4.2.5. Environmental and health factors

4.2.5.1. Environmental values

Among the factors influencing household recycling behavior are environmental values and perceived behavioral control. If people are more informed about the impact of e-waste on the environment and if they perceive the ability to do something about it, then they are more likely to recycle [43]. Therefore, such education and a culture with respect to environmental care would support more sustainable ways of managing waste.

4.2.5.2. Health risks

This also exposes the serious health risks associated with informal e-waste recycling practices in the form of toxic exposure to substances such as lead and mercury, thereby placing better protection of workers and safer methods for recycling at the forefront of urgency [44].

5. Conclusions

The global e-waste challenge is mushrooming and has been expanding due to rapid advancements in technology, coupled with a desire by consumers to own the latest models. The global response has failed to rise to this challenge, despite some progress concerning recycling efforts; there is only a small fraction of properly collected and recycled e-waste. Among all the regions, the situation is critical in Sub-Saharan Africa, where proper e-waste recycling practices face a complex array of obstacles at regulatory, economic, and attitudinal levels, with low public awareness and poor infrastructure.

The existing regulatory frameworks have, to an extent, shown potential in reining the harm caused by e-waste. However, for most regions, many countries remain exposed to the threats of unsound disposal practices, with no comprehensive legislation or enforcement in place. For example, South Africa, Uganda, and Rwanda are rare exceptions to those countries with regulations on e-waste. In this context, a stronger regulatory environment that enforces international agreements becomes mandatory, including the Basel Convention, if the region is to better manage its e-waste.

Another factor that influences the adoption of e-waste recycling practices in Sub-Saharan countries is the economic factor. This involves the availability of financial incentives and market opportunities, which often tend to play a critical role in encouraging or motivating users to participate effectively in e-waste recycling programs. Such financial mechanisms have already shown their magic in motivating customers and businesses toward proper means by emphasizing the move's economic importance.

Another key driver is awareness and public education related to the need to adopt recycling practices. In most areas in sub-Saharan Africa, awareness of all issues related to e-waste is very low, and there is a high need for environmental and health awareness to make a case

for specific educational campaigns. These initiatives would therefore sensitize not only the general public but also specific business groups and houses with local communities on the issue of e-waste management in a sustainable manner.

Many countries in Sub-Saharan Africa do not have important infrastructure for e-waste handling and recycling. Improving technologies and infrastructures is equally central in the solution to the e-waste challenge. Harmful means are currently in use by most recyclers due to a lack of proper recycling facilities in place, which are costly to the environment and thus further inflate the recycling cost, making it a less preferred option. Investments in technology, along with developments in the skills of labor, are two key ingredients that can foster a working e-waste management system in this region.

References

[1] C. S. Deche, Factors Influencing an ICT Framework for a circular e-waste economy by Household in Nairobi, Kenya, http://repository.anu.ac.ke/, 2020.

[2] V. Forti, C. P. Baldé, R. Kuehr and a. G. Bel, " The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential," *United Nations University (UNU)/United,* 2020.

[3] V. M. a. M. Maphosa, "E-waste management in Sub-Saharan Africa: A systematic literature review," vol. 7, 2020.

[4] M. N. Bimir, "Revisiting e-waste management practices in selected African countries," vol. 70, p. 659–669, 2020.

[5] S.-W. Chung, R. Murakami-Suzuki and a. M. Kojima, Application of EPR to Recycling Policies in Japan, Korea and Taiwan, 2009.

[6] D. Mmereki, B. Li, A. Baldwin and a. L. Hong, The Generation, Composition, Collection, Treatment and Disposal System, and Impact of E-Waste, 2016.

[7] O. E. Orisakwe, C. Frazzoli, C. E. Ilo and a. B. Oritsemuelebi, "Public Health Burden of E-waste in Africa," vol. 9, p. 1–12, 2020.

[8] UN, "Global Sustainable Development Report," p. 1–69, 2015.

[9] R. I. a. T. S. Hattingh, "Consumer e-waste recycling in South Africa," vol. 31, p. 44–57, 2020.

[10] W. W. R. a. B. C. L. Athapattu, Challenges in E-waste management in Sri Lanka, 2019.

[11] B. Kitchenham, "Procedures for Performing Systematic Reviews," p. 33, 2004.

[12] B. Kitchenham, O. P. Brereton, D. Budgen, M. Turner, J. Bailey and a. S. Linkman, "Systematic literature reviews in software engineering - A systematic literature review," vol. 51, p. 7–15, 2009.

[13] S. Kitchenham and B. a. Charters, Guidelines for Performing Systematic Literature Reviews in Software Engineering, Technical Report EBSE 2007-001, 2007.

[14] M. Ouzzani, H. Hammady, Z. Fedorowicz and a. A. Elmagarmid, "Rayyan-a web and mobile app for systematic reviews," vol. 5, p. 1–10, 2016.

[15] P. Mayring, Qualitative content analysis, 2000.

[16] P. Baldé, C.P., Forti, V., Gray, V.J., Kuehr, R. and &. Stegmann, The global e-waste monitor 2017: Quantities, flows and resources.

[17] C. M. Ohajinwa, P. M. V. Bodegom, M. G. Vijver and a. W. J. G. M. Peijnenburg, "Health risks awareness of electronic waste workers in the informal sector in Nigeria," vol. 14, 2017.

[18] UNEP, ""E-waste Management Manual," *E- waste,* vol. II, 2007.

[19] U. Bob, A. Padayachee, M. Gordon and a. I. Moutlana, "Enhancing Innovation and Technological Capabilities in the Management of E-Waste: Case Study of South African Government Sector," vol. 22, p. 332–349, 2017.

[20] ""Sustainable Development Goals," vol. 148, p. 148–162, 2012.

[21] S. K. a. V. Kumar, Electronic Waste Management: Policies, Processes, Technologies, and Impact, 2024.

[22] V. M. a. P. Mashau, "The Conundrum: Transforming African E-waste Landfills to Urban Mines," p. 1–16, 2023.

[23] B.-Y. Kwabena, A. Clifford and a. K. A. Kwasi, "Stakeholders perceptions on key drivers for and barriers to household e-waste management in Accra, Ghana," vol. 12, p. 429–438, 2018.

[24] N. E. a. S. Herat, "E-waste: A problem or an opportunity? Review of issues, challenges and solutions in African countries," vol. 17, p. 318–339, 2016.

[25] O. O. a. I. C. Nnorom, The Challenge of Electronic Waste (E-waste) Management in Developing Countries, 2007.

[26] GSMA, Connected Women: The Mobile Gender Gap Report, 2020.

[27] O. Odeyingbo, C. P. Baldé and a. V. Forti, "Effect of a modified lifetime model on e-waste generation in Nigeria under defined reuse options," vol. 16, p. 192–206, 2022.

[28] I. C. N. a. O. A. Odeyingbo, Electronic waste management practices in Nigeria, 2020.

[29] D. Faibil, R. Asante, M. Agyemang, M. Addaney and a. C. Baah, "Extended producer responsibility in developing economies: Assessment of promoting factors through retail electronic firms for sustainable e-waste management," vol. 41, p. 117–142, 2023.

[30] H. Mafaranga, "East Africa Invests in Strategies to Manage E-Waste," vol. 101, p. 148529, 2020.

[31] S. Nyeko, S. Mlay, A. Nyero and a. C. Ogen, "Waste Electrical and Electronic Equipment Collection: Challenges and Opportunities in a Developing Country Perspective," vol. 26, p. 1–19, 2023.

[32] GIZ, E-waste Compensation as an International Financing Mechanism in Nigeria, 2023.

[33] P. Marchi, "Assessment of the Awareness Level of E - waste and Factors That Influence Informal Recycling : A Case Study of E - waste Pickers in Local Municipality — Gauteng Province," p. 21435, 2023.

[34] O. A. Addae, H. F. Alomirah, H. F. S. Alkhliefi, R. Rangarajan and a. H. M. Moda, "Exploring Influencing Safety and Health Factors among E-Waste Scavengers in Accra, Ghana," vol. 3, p. 236–247, 2023.

[35] L. Kushi, R. Koch, K. Mcdonough and a. J. M. Fagan, Leaching of E-Waste Pollutants in African Environments, 2013.

[36] W. F. Strydom, "Barriers to household waste recycling: Empirical evidence from South Africa," *Recycling*, vol. 3, 2018.

[37] A. S. A. a. Z. K. Akalu, "E-waste Awareness and Management Among People Engaged in E-waste Selling, Collecting, Dismantling, Repairing, and Storing Activities in Addis Ababa, Ethiopia," *Environ. Health Insights*, vol. 16, 2022.

[38] O. J. Okorhi, E. E. O. E. I. Igbinoba and a. A. N. Nd-Ezuma, "Characterization of e-waste: an inventory from households and the recycling sector in south eastern Nigeria," vol. 22, p. 146, 2018.

[39] V. N. Kyere, K. Greve, S. M. Atiemo and a. J. Ephraim, "Spatial assessment of potential ecological risk of heavy metals in soils from informal e-waste recycling in Ghana," *Environ. Health Toxicol*, vol. 32, p. e2017018, 2017.

[40] T. F. P.-W. Meas, "E-waste it wisely: lessons from Africa," vol. 4, 2022.

[41] T. P. Moyo, S. Lubbe and a. K. Ohei, "Exploring E-waste Management Practices in South African Organisations," vol. 14, p. 12, 2023.

[42] W. Avis, "Responsible E-Waste Value Chains in Africa," p. 19088, 2022.

[43] D. O. a. A. O. Mensah, "Sustainable electronic waste management among households: a circular economy perspective from a developing economy," vol. 33, p. 64–85, 2022.

[44] C. M. Ohajinwa, Environmental and health impacts of informal electronic waste recycling, 2018.