

Potential for Circular Economy in Developing Countries; Case Study of Kenya's E-Waste Sector

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Abstract :- The world produces close to 50 million tonnes of electrical and electronic waste each year. The likelihood of finding either electric or electronic waste in a typical homestead is irrefutable. In Kenya, only about 1% of the total e-waste generated is properly managed. This review sought to establish the state of Kenya's e-waste sector landscape to inform its potential for circularity. It employed a rapid review approach of documentation on e-waste; policy, strategies, journal papers, and grey literature. Circularity in the e-waste sector is still at a nascent stage with limited players in the space. While the government is cognizant of the challenges in managing e-waste, policy frameworks and preparedness are still nascent. A framework is imperative in not only creating awareness but also establishing the necessary infrastructure to facilitate the collection and management of e-waste. Moreover, government and private sector partnerships will be essential in regulating the e-waste sector, especially with the emerging interest from sector players.

Keywords:- E-waste; Circularity; Recycling; Policy; Developing Nations; Potential; Kenya.

I. INTRODUCTION

The utilization of electrical and electronic devices is on the rise globally (Goodship *et al.*, 2019); in 2019, the world generated close to 53.6 Mt of e-waste (an increase of 21% in only 5 years), an average of 7.3 kg per capita with a projection to grow to 74.7 Mt by 2030 (Forti *et al.*, 2020). In 2019, Africa was estimated to generate about 2.9 Mt (2.5 kg per capita) of e-waste, and only 0.03 Mt (0.9%) of the total e-waste was documented to be collected and properly recycled (Forti *et al.*, 2020). E-waste generation is expected to rise with higher consumption rates of electrical and electronic equipment, short life cycles, and few options for repair (Andeobu *et al.*, 2021). Electrical and electronic devices are always up for improvement and advancements resulting in quick replacements by consumers. According to UNEP estimates, the current e-waste generated in Kenya annually stands at 11,400 tons from refrigerators, 2800 tons from TVs, 2500 tons from personal computers, 500 tons from printers, and 150 tons from mobile phones. (National Environmental Management Authority (NEMA), 2010). Averagely, the country is estimated to be generating close to 17,000 tons of e-waste annually (UNEP, 2014.). This trend is expected to increase exponentially, more advancely in the off-grid sector where the demand for off-grid appliances is increasing hence the production of the same (Magalini *et al.*, 2016).

Kenya has continued to experience an increase in its generation of Electrical and Electronic Equipment (EEE) both at the government and private sector levels over the past decade (MoE, 2019). This increase is attributed to; the elimination of trade barriers in the importation of ICT equipment, liberalization of the telecommunications sector that has increased the use of mobile phones, fax, and telephones; and the development of E-initiatives to improve service delivery (MoE, 2019). The proliferation of e-waste is dependent on the growth of the economy and population, advancement in technology, market penetration, and the rate of obsolescence of a country (Kalana, 2010). However, much of the growth in cheap imported or refurbished second-hand cell phones, computers, solar panels, printers, and other electronic items are gradually contributing to a silent epidemic. This trend will bear huge negative effects on the environment and the health of many Kenyans, and if left unchecked, Kenya will be loaded with e-waste that has been discarded from developed countries. The storage, compilation, transfer, and disposal of e-waste in developing countries have not been structured and handled in an effective way to guarantee reuse, environmental conservation, and the well-being of the people (Muhani, 2012).

The concept of circularity or the circular economy can be defined as the “recirculation of material resources for new product development” (Singh & Ordoñez, 2016) or a combination of reduction, reuse, and recycling activities (Kirchherr *et al.*, 2017). Circular economies are also those that are “regenerative and restorative” as opposed to linear economies that are unsustainable and destructive (Pagoropoulos *et al.*, 2017). There has been a global shift from linear production systems and economies to circular systems to address challenges around the depletion of finite natural resources, the loss of biodiversity, the pollution of the environment, and the exacerbation of climate change impacts (Garam Bel, *et al.*, 2019).

It is reported that circularity has become ubiquitous and widely promoted by government officials, private sector stakeholders, and development finance entities, however, a concrete body of research on the real-world applications and efficacy of the concept in Global South countries is still lacking (Halog & Anieke, 2021; Korhonen *et al.*, 2018; Wong *et al.*, 2019). This is even though developing countries are set to experience the highest rates of urbanization and industrialization with potential increases in waste production (Halog & Anieke, 2021). To partly address this gap, this review seeks to explore the potential for circularity within Kenya, a lower-middle-income country located in Eastern Africa. It specifically explores how circularity can be leveraged and embedded in the

management of Electrical and Electronic Waste (e-waste) in the country.

II. METHODOLOGY

This topical review took an exploratory approach and concentrated on the investigation of policy instruments and programmatic documents related to e-waste in Kenya. The review employed the following steps which are further explained subsequently;

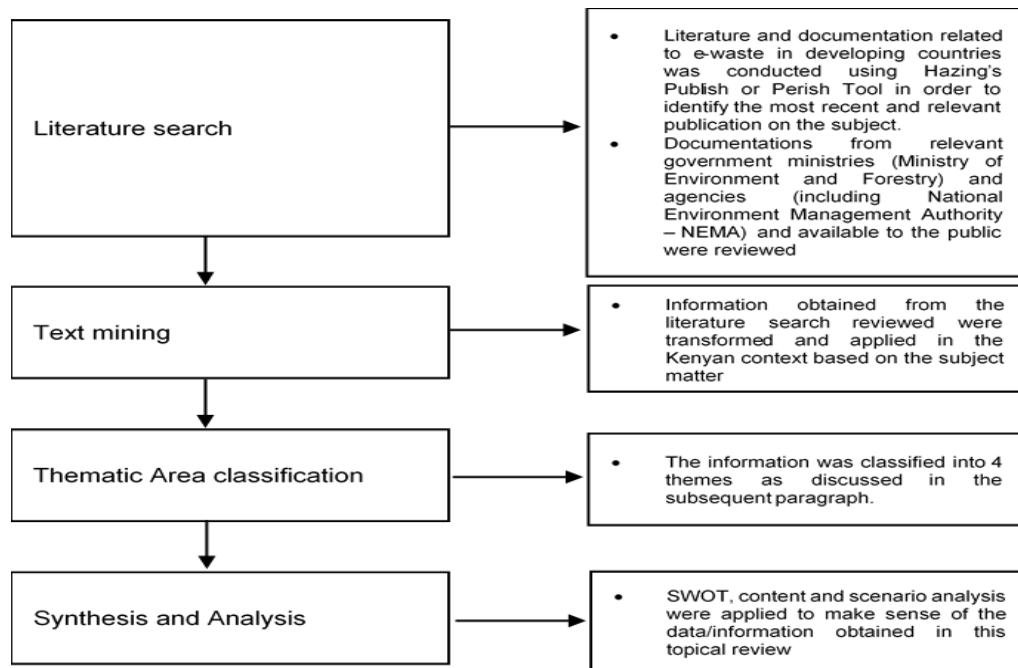


Fig. 1: Steps used in this topical review

The literature search employed a search tool, ‘Harzing’s Publish or Perish’¹ with search terms used including; ‘E-Waste’ AND ‘Kenya’, ‘E-Waste’ AND ‘Circularity’, ‘E-Waste’ AND ‘Potential’. Google Scholar was used as the search engine and attention was paid to the top 20 relevant documents and/or articles. The tool has been identified as important, not only in making citations better but also in providing the most recent and relevant publications on the subject under review (Lamanna *et al.*, 2021; Moosa, 2018). Apart from the peer-reviewed articles, programmatic documents including government policies and strategies were also reviewed. The literature searches were conducted between December 2021 and March 2022, with periodical consultations among the authors to build depth of the review process through screening and eliminating any duplications and irrelevant information.

The rapid review followed systematic searches elaborated previously in Fig. 1 while imposing certain limitations informed by exclusion and inclusion criteria indicated in

¹ Annex 2

. This approach has been employed in previous studies and proved to be efficient in drawing sound conclusions (Watt *et al.*, 2008). Moreover, the method

has been touted as one that simplifies systematic review processes to produce information promptly (Dobbins, 2017; Tricco *et al.*, 2015).

Inclusion Criteria	Exclusion Criteria
Top 20 search findings from google scholar on Hazing's Publish or Perish.	Literature below the top 20 from the search engine.
Publications from the year 2010: These would provide more recent data on the subject	Any publication before 2010: Such literature, albeit relevant, may seem outdated or may have undergone modification over time
Web/Site publications	A newspaper article
Government documents, policies, and strategies	Non-governmental documents, policies, and strategies
Papers/documents/articles in the English language	Papers/documents/articles not in the English language
Peer-reviewed journals/articles	Grey literature and unpublished report
The document/article/paper has component(s) on e-waste, circularity, circular economy, developing nations	The document/article/paper has no component(s) on e-waste, circularity, circular economy, developing nations

Table 1: Inclusion and exclusion criteria used in this review

In line with the most common themes presented in the documents, these contents were categorized into four distinctive themes, namely: (i) Institutional frameworks for circularity in the e-waste sector; (ii) Regulatory frameworks for e-waste; (iii) Barriers to the integration of circularity in the e-waste sector (iv) Opportunities for integration of circularity in the e-waste sector. These were supplemented by the authors' expertise in policy, e-waste, and related issues to provide an understanding of the potential for circularity in the e-waste sector in Kenya. Both SWOT and scenario analytical approaches were employed to synthesize the data and present the potential for circularity in Kenya's e-waste sector. The scenario analysis took three distinct approaches – linear growth, reactive growth, and proactive growth scenarios.

III. E-WASTE SECTOR LANDSCAPE IN KENYA

Kenya, just like other developing nations, is experiencing growth in e-waste generation as a result of the consumption of electronic and electrical equipment. Little attention is given to environmental regulation and enforcement mechanisms (Hansen *et al.*, 2021) and an understanding of the landscape would inform sustainable management of e-waste. It is estimated that in 2020, Kenya produced close to 4 tons of e-waste with only 1% being recycled (Meso, n.d.). Data on e-waste generation and trends is scanty, however, this review establishes that while a number of entities recycle waste of different categories, e-waste recycling industries are limited with concentration majorly in Nairobi as indicated in Fig. 2 below.

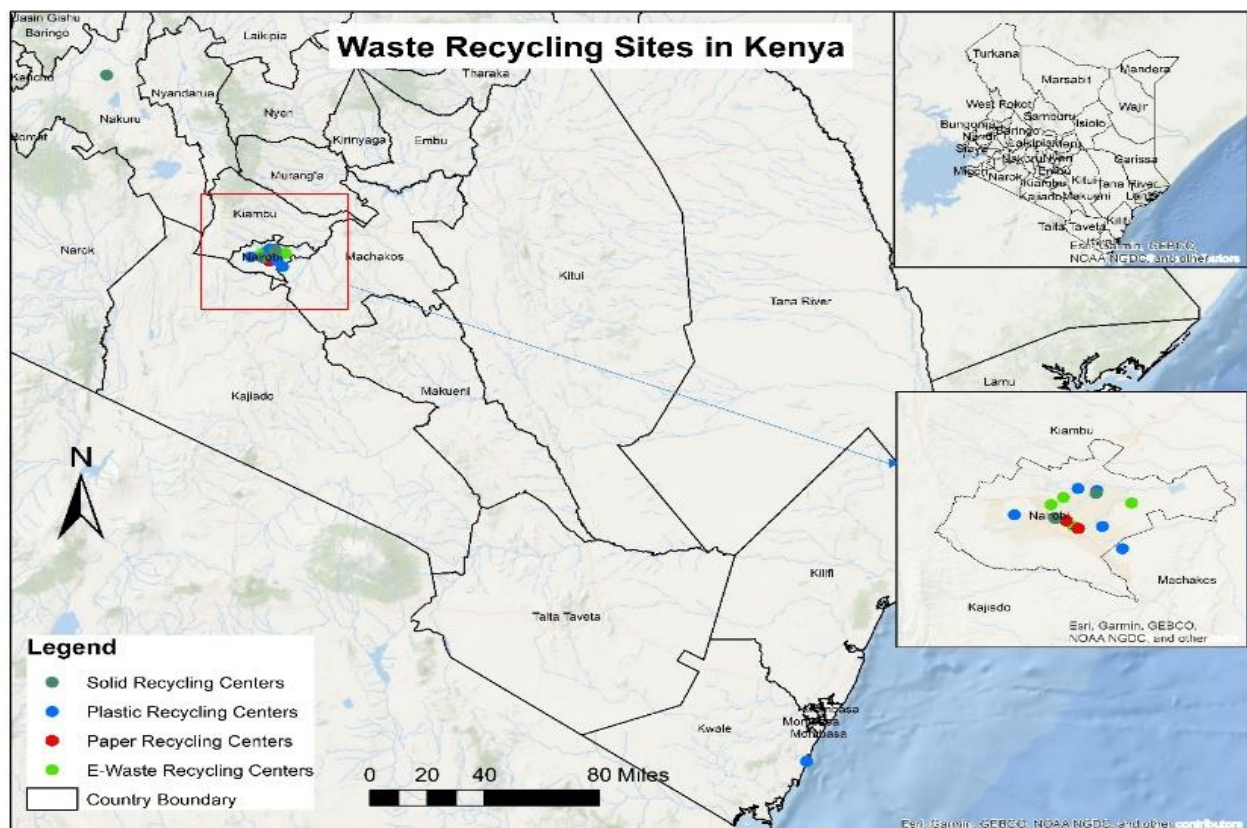


Fig. 2: Location of recycling site in Kenya. Source – Author

Institutional and Regulatory Overview of the E-waste sector in Kenya

A. Institutional Arrangement

The e-waste guidelines of 2010 (NEMA, 2010) highlighted five main stakeholders including the producers (importers, manufacturers, and local assemblers) who introduce new or used electrical and electronic equipment. These stakeholders are required to

register with the authorities; Generators are the downstream users such as households, businesses, and institutions; Recyclers receive and dismantle the electrical and electronic equipment waste into hazardous and non-hazardous components; Refurbishers and repairers and collection centers. In

we present some of the key actors who are presently driving circularity in Kenya’s e-waste sector.

#	Institution	Current Initiative
1	WEEE Centre (WEEE - Waste Electrical and Electronic Equipment)	The centre is owned and operated by local entrepreneurs with sustained support from various local and international partners. It provides E-waste collection, dismantling, and automated processing services in Nairobi and other major cities in Kenya. The valuable materials are sold to local recycling facilities. Its partnership with international partners enables the shipping of dismantled and sorted e-waste fractions such as monitors to international recyclers and smelters.
2	Safaricom Limited	It actively participates in the collection of used phones and other e-waste and safe disposal of the same. It has partnered with local institutions such as the WEEE Centre to receive the collected waste for dismantling and further processing. Safaricom has invested heavily in raising public awareness and runs collection drives to ensure the safe disposal of electronic gadgets. The company uses its network of retail shops across the country as collection centres.
3	Sintmund Group	This is a licensed company operating an advanced recycling facility for e-waste such as bulbs, batteries, fridges, freezers, cartridges, and computers among others.
4	Sinomet Kenya Limited	The company is specializing in waste transportation, treatment/disposal, and transboundary movement of waste with special emphasis on e-waste. Established in 2011, Sinomet has transformed itself into a big transboundary mover of E-waste through its international recyclers and up-cyclers of e-waste while also maintaining close ties with its local scrapping partners.

Table 2: Some of the e-waste handlers in Kenya

The updated draft national e-waste management strategy (MoE, 2019) notes that the informal actors were the main stakeholders in e-waste management in Kenya as of 2019. Fig. 3 presents an overview of the sector actors across the value chain.

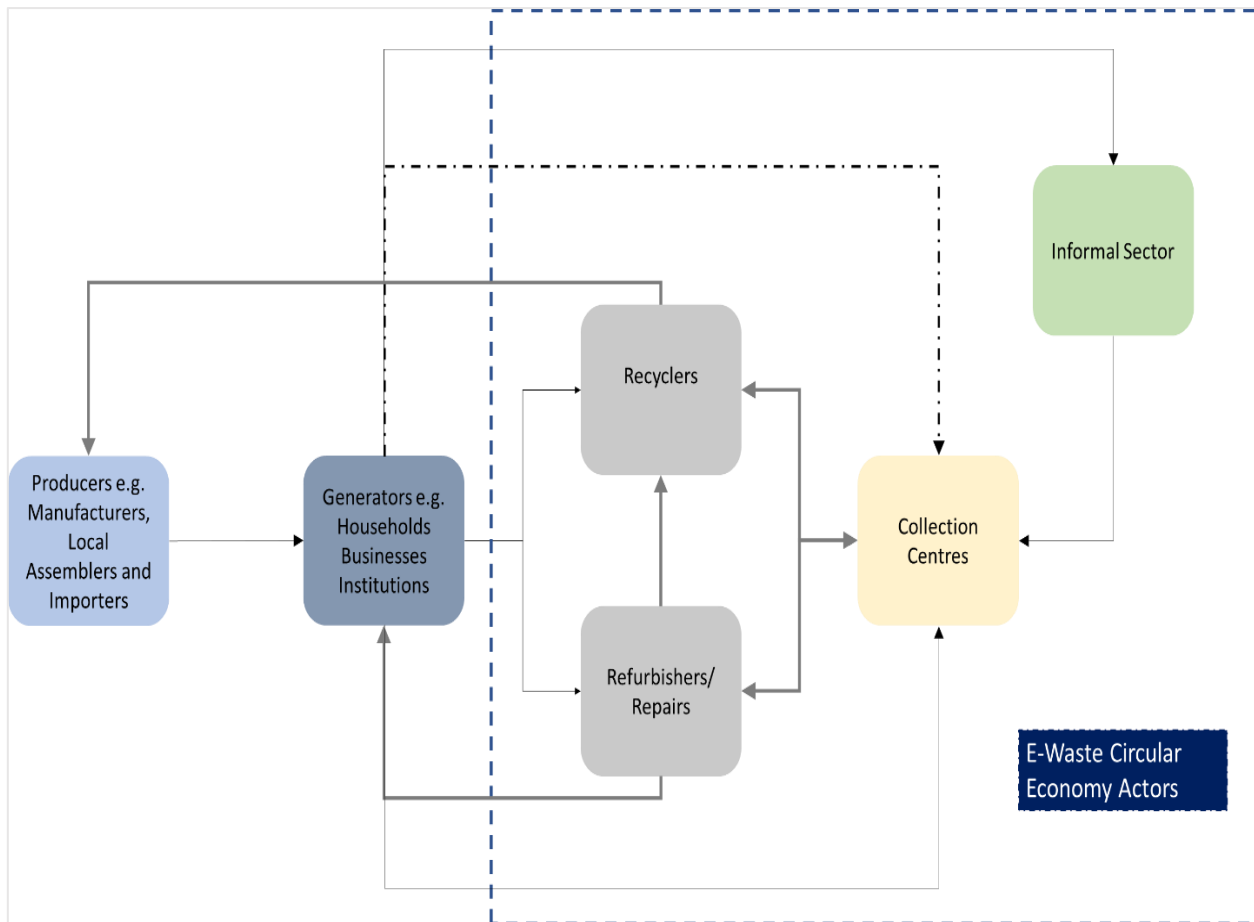


Fig. 3: Main E-Waste Stakeholders (NEMA,2010)

B. Policy and Regulatory Overview

The Sustainable Waste Management Bill introduced in 2021 introduces new measures and actions around extended producer responsibility and take-back schemes. Producers, that is entities that engage in the production, conversion, and importation of products, are required to join an extended producer responsibility (EPR) scheme. With the permission of the authority, they are also required to establish a collective (GoK, 2021). The proposed bill is likely to shift the actors and efforts by introducing structured collectives involved in the recycling and reuse of waste.

Some of the notable actors within the sector include, i) Kenya Extended Producer Responsibility Organization (KEPRO) – a collective implementing the proven EPR, ii) Safaricom which runs the e-waste management project, iii) Waste Electrical and Electronic Equipment Centre (WEEE) which is involved in the treatment of e-waste and iv) E-waste Initiative Kenya (E-WIK), an NGO providing a safe disposable option for the informal sector.

The National E-waste Management Strategy acknowledges the lack of regulation, resources and infrastructure, skills, and inadequate capacity as some of the challenges facing the sector presently (Republic of Kenya, 2020). Further, it goes ahead to report that only about three recyclers have been licensed to handle e-waste in the sector. A lack of disposal mechanism has resulted in poor handling of e-waste as households continue to remain with electrical and electronic equipment which are either damaged beyond repair or non-functional (Anyango & Munyugi, 2018). Consequently, as the world transitions to e-Mobility (Siemens Stiftung, 2020), coupled with increased usage of electronic and electrical devices, policies and laws geared towards sustainable consumption and production will be imperative. E-waste in Kenya is largely handled by the informal sector (Meso, n.d.; Republic of Kenya, 2020; UNEP, n.d.) that lacks the skills and expertise required in the process, as such their activities are characterized by toxicity that impacts both the environment and human health.

#	Name of e-waste policy/regulation/strategy	Year of Publication	Source
1	Draft e-Waste Regulations	2013	National Environment Management Authority (NEMA)
2	National E-Waste Management Strategy 2019-2024	2019	Ministry of Environment and Forestry
3	County e-Waste Acts - Machakos	2015	County Government of Machakos
4	Institutional e-Waste Policy	2015	Jomo Kenyatta University of Agriculture and Technology (JKUAT)
5	Sustainable Waste Management Policy and Bill	2021	Ministry of Environment and Forestry
6	Vision 2030	2006	Government of Kenya (GoK)
7	Constitution of Kenya (2010)	2010	Government of Kenya (GoK)
8	Environmental Management and Coordination Act 1999 (Revised 2015)	2015	Government of Kenya (GoK)
9	Waste Regulations	2006	Government of Kenya (GoK)

Table 3: Summary of e-waste regulations/policies/strategies in Kenya

IV. POTENTIAL FOR CIRCULARITY

In this section, the authors provide the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis of the potential for circularity in Kenya's e-waste sector.

A. SWOT Analysis

Circularity in the e-waste sector in Kenya would require among others, sound policies and regulatory frameworks, proper infrastructural development that meets the current needs, and a robust awareness of the subject. This review establishes that the resources and infrastructure needed to handle e-waste in Kenya are currently either ineffective or non-existent. There are legislative gaps to regulate and deal with the management and recycling of e-waste in the country. While national policies are addressing solid waste in general, there exists no legislation that directly addresses e-waste specifically, including public procurement and disposal laws that do not consider the end-of-life effects of electrical and electronic equipment procured (Otieno & Omwenga, 2016). Although Kenya is a signatory to the two major International Conventions (Bamako Convention whose objective is to introduce preventive measures and to guarantee appropriate disposal of hazardous waste in Africa, and the Basel Convention which regulates the transboundary movement of hazardous waste and its disposal), their implementation is still a challenge as Kenya keeps on receiving refurbished electronics which have hazardous elements from developed countries in form of donations (Forti et al., 2020). Refusal to comply with international e-waste treaties has presented challenges in the regulation of the movement of hazardous waste to developing countries (Perkins et al., 2014).

The institutions authorized to manage waste in the country lack adequate capacity to fulfill their mandate, as they do not have adequate fund allocation from the central government (Muhani, 2012). Further, they do not work in a coordinated manner depicting how disintegrated and nascent the sector is. That notwithstanding, there is an opportunity in the few establishments to form a collective to promote circularity in the sector through public and private partnerships. Also, there are limited employees to discharge the enforcement of regulations that presently exists in drafts except for the e-waste management strategy from the Ministry of Environment and Forestry. The institutions do not conduct frequent environmental reporting where internal and external auditing on the condition of the environment should be carried out to ensure that industries are compliant with the laws and regulations governing the sector (Muhani, 2012).

While piecemeal efforts exist to enhance awareness, especially by WEEE Centre, there is a low level of awareness among people on the dangerous effects of e-waste on their safety, health, and the environment. A study (Ohajinwa et al., 2017) reveals that when burnt or discarded without due diligence, e-wastes could release harmful heavy metals such as lead and mercury which block drainages and causes cancer. Conversely, e-waste has resulted in some benefits including the generation of revenue, creation of employment, and production of bi-products which have been applied to support other local industries. The figure below presents our SWOT Analysis of Kenya's e-waste sector.

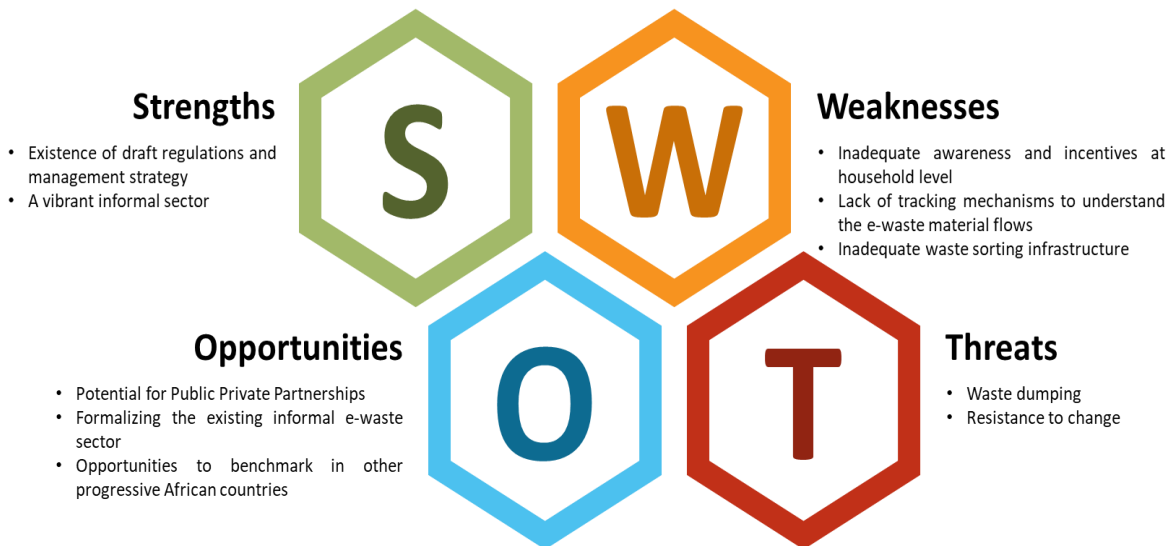


Fig. 4: Kenya's e-waste sector - SWOT Analysis

#	Variable	Element	Description
1	Strengths	Existence of draft regulations and management strategy	The Kenya Constitution 2010, the Vision 2030, the Third Medium Term Plan 2018 -2022 of the Vision 2030, the Environmental Management and Coordination Act 1999 (Revised 2015), the Waste Management Regulations (2006), the National E-waste Guidelines, the National ICT Policy, the Public Procurement and Disposal Act, and the National E-waste Management Strategy all give impetus to e-waste management in Kenya. The development of an e-waste policy is ongoing. Moreover, Kenya recognizes international conventions, protocols, and laws that provide guidance and standards for e-waste management including the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, and the Bamako Convention. By virtue of Article 2(6) of Kenya’s constitution 2010, these international treaties become part of the laws of the country.
		A vibrant informal sector	Recognizing the economic value of electrical and electronic waste, informal recycling and reuse have been an ongoing activity in Kenya (NGETHE, 2021). Due to the lack of e-waste collection infrastructure, the electrical and electronic wastes (EEWs) are collected from mixed dumpsites posing huge health risks and other occupational hazards to the informal waste pickers and recyclers (Hashim <i>et al.</i> , 2020). The informal e-waste industry creates substantial employment opportunities for unemployed youth that can be leveraged by formalization to ensure the occupational health and welfare of these informal workers are improved.
2	Weaknesses	Inadequate awareness and incentives at the household level	The acquisition of quality electrical and electronic waste is dependent on the collection process which starts at the final consumer, i.e., the households and institutions (Goodship <i>et al.</i> , 2019). While it is easier to implement waste collection processes within institutions, household waste collection is more difficult and requires a heightened awareness of the need for waste separation and disposal at designated locations. In Kenya today, individuals hoard the products in stores and homes for a lack of awareness of e-waste management facilities ² . The households also lack incentives for waste separation and disposal in designated locations because the drop-off locations are very few and not conveniently accessible. The lack of awareness by consumers was reported to be the key factor that led to the failure of a take-back initiative by Safaricom PLC in 2012 (Otieno & Omwenga,

² The WEEE Center can handle 200 metric tons of waste per month. However, due to low awareness among the public and almost non-existent laws and regulations encouraging people to recycle their used computers and phones, they are managing 35 to 50 tons a month. Source: <https://www.asme.org/topics-resources/content/turning-e-waste-into-an-opportunity>

			2016).
		Lack of tracking mechanisms to understand the e-waste material flows	Kenya lacks a robust mechanism to track the flow of electronic and electrical products and waste in and out of the country and within the different regions nationally. There are no institutions that have been provided the mandate to conduct material flow analyses on behalf of the government, and as such, there is a lack of oversight and understanding of the absolute potential of e-waste utilization in the country. The possibility to track waste and material flows would inform government agencies of the most appropriate approaches and strategies for e-waste management.
		Inadequate waste sorting infrastructure	Effective e-waste management is dependent on the management of other solid wastes (Goodship <i>et al.</i> , 2019). Waste sorting at the source has not been affected in Kenya and this will negatively affect the plans for the collection of e-waste from households and institutions (Ministry of Environment and Forestry of Kenya, 2019). There is a lack of waste segregation at the source which leads to mixed wastes which are collectively disposed off in the dumpsites (Rosenthal, 2018). However, if sorting would be done, re-mixing of the wastes would still occur down the waste management chain because the transportation and waste treatment infrastructures cannot cater to the treatment of the different waste types. For example, only a few companies exist that utilize e-waste and they lack the capacity to utilize all the available e-waste nationally. The lack of sorting hampers material recovery, reuse, and recycling. The sorting has largely been relegated to the informal waste pickers at the dumpsite locations (National Environmental Management (NEMA), 2010).
		Inadequate financing for e-waste research and innovation	E-waste management will require ongoing research and innovation to be able to meet the changing needs in the sector. In Kenya today, no research centre is primarily dedicated to the advancement of waste or e-waste knowledge. With this, there is also no financial resource mobilization that goes into research and innovation in waste or e-waste management. This means that knowledge of e-waste in Kenya is not aggregated and there is no dedicated body that advocates for the improvement of e-waste based on scientific evidence. There are also minimal government resources being directed towards research and innovation in e-waste and waste in general (Ministry of Environment and Forestry of Kenya, 2019).
3	Opportunities	Potential for Public-Private Partnerships	Due to the increasing interest by the private sector to establish e-waste recycling facilities as well as the existence of the National Waste Management Steering Committee and the national working group on e-waste, there is potential for the commencement of public-private partnerships to leverage each other's resources and capabilities. A potential area for PPP would be county governments giving legal mandates to established private sector players to manage e-waste on behalf of the counties. This, however, would require the right policies and legislation to be put in place to support such endeavors.
		Formalizing the existing informal e-waste sector	As discussed earlier on the existence of the informal e-waste players, there is huge potential in working together with the informal sector players to support their ongoing activities rather than creating alternative systems that could lead to competition and resistance. Interested stakeholders can engage the informal e-waste pickers and the existing e-waste recycling facilities to design fair, safe, and reliable business models that are recognized by the government. The Dandora dumpsite in the capital city Nairobi has more than 3000 waste pickers who are mainly young people from the neighbouring informal settlements (Gall <i>et al.</i> , 2020b). Working with the waste pickers would contribute to national economic developments by improving the livelihood conditions and providing opportunities for gainful employment to the marginalized youth in Kenya.
		Opportunities to benchmark in other progressive African countries	African countries have demonstrated potential for circularity in the e-waste sector (World Economic Forum, 2021) and offer opportunities that Kenya could learn from. These opportunities emanate from innovations and policy initiatives being undertaken in other countries. For example, the Ghanaian government has taken a significant step towards the proper management of e-waste (Hollins <i>et al.</i> , 2017; UNEP, 2018). The construction of an integrated e-waste recycling facility at Agbogbloshie as well as ongoing plans to construct e-waste handover centres to provide a continuous supply of raw materials to sustain the operations of the facility indicate progress in Ghana. Ghana is also investing significantly in e-waste research and innovation as well as training and capacity building (UNEP, 2018).

4	Threats	Waste dumping	The so-called ‘digital dump’ a phenomenon where electronic wastes from developed countries find their way to developing countries in the name of “initiatives to bridge the digital divide”(Ngethe, 2021) poses a huge threat to the management of e-waste in Kenya. The huge demand for digital devices and inefficient oversight in the importation of electronic devices has created a loophole leading to the importation of sub-standard second-hand used equipment into Kenya. Additionally, counterfeit low-quality electronic devices are finding their way into the Kenyan market. These second-hand and counterfeit devices have short lifespans and in most cases are not repairable leading to an increase in e-waste (Rosenthal, 2018). The counterfeit products may also lack information about the type of raw materials used in the production thus making recycling difficult and even dangerous. The Government of Kenya needs to prioritize this issue so as to avoid increasing e-waste problems in the country. “While attempting to close the digital divide, we are opening a digital dump where electronic manufacturers in the richer countries are evading their responsibilities over the ultimate fate of the products in the name of donations”(Gall <i>et al.</i> , 2020).
		Resistance to change	Resistance to formalization processes may be expressed by the informal waste pickers. This is due to the very low trust the low-income communities have towards public agencies because they have experienced marginalization for a long time. The informal waste pickers may perceive formalization processes as strategies to take their livelihood activities and give them to large companies. This will need to be anticipated and strategies put in place to develop trust among the informal waste pickers.

Table 4: Summary of SWOT Analysis

B. Scenario Analysis

The transition to circularity in the e-waste sector would require a critical analysis as well as exploring different scenarios while establishing lessons that can inform the transition process to circularity. The authors present three scenarios adapted from a case study (Parajuly *et al.*, 2019).

The world is already envisioning a proactive pathway approach in the management of e-waste, especially with the desire to be able to produce and consume sustainably in line with the United Nations Sustainable Development Goal #12 (Chan *et al.*, 2018).

#	Scenario	Description
1	Linear Growth Scenario	<ul style="list-style-type: none"> This is a business-as-usual scenario where a standard growth-based economic agenda is the priority. The consumption of e-products and the amount of e-waste grow at the usual rates. Conventional business models remain dominant with e-waste management capabilities continuing to lag behind. The result is increased consumption and a severe e-waste problem.
2	Reactive Approach Scenario	<ul style="list-style-type: none"> In this scenario, strong regulations and monitoring frameworks are in place. Most businesses reluctantly take this approach to comply with the new set of legislations. The end result is - some changes appear in the production and consumption patterns.
3	Proactive Pathway Scenario	<ul style="list-style-type: none"> More sustainable consumption practices are developed along the product's supply chain, which is supported by governments and accepted by users. Stakeholders, including economic actors, are supporting the commitment of producers to take a lifecycle approach to manufacturing and End of Life (EoL) management of e-products.

Table 5: Summary of different scenarios for e-waste circularity

Electrical and electronic waste generation is expected to increase with the advancement in technology and the transition witnessed during the global pandemic (Barapatre & Rastogi, 2021). As a result, Kenya, just like any other developing country has to consider options for ensuring circularity in the sector. From the 3 scenarios presented, this review proposes the proactive pathway scenario (Parajuly *et al.*, n.d.). The country is currently transitioning to e-Mobility, which will translate into more e-waste from the sector, therefore, end-of-life resource recovery should be aligned to meet the need for e-waste. While e-waste

generation increases, stakeholder management capacity has to be strengthened to ensure environmentally-sound practices. Most importantly, the government has to intentionally commit to this process and consumers are expected to embrace the circularity in the sector. Article 69 (2) (National Council for Law, 2010) mandates every citizen to cooperate with the state organs in the quest to provide a clean and safe environment as well as management of the same.

V. CONCLUSION AND RECOMMENDATIONS

Circularity in the e-waste sector in Kenya is still at a nascent stage but with great potential. Already, institutional and regulatory frameworks are being aligned to circularity in the sector. With a growing interest coming from both the public and private sectors, government goodwill and stakeholder coordination will spur circularity in the sector. Initial steps would require the government to give legal mandates to established private sector players to manage e-waste on behalf of the counties. Additionally, the government should consider working together with the informal sector players to support their ongoing activities rather than creating alternative systems that could lead to competition and resistance. Evidently, capacity building on the importance of circularity in the e-waste sector will help in enhancing the citizens' attitudes, perceptions, and knowledge of e-waste. Guided by this review that finds Kenya's e-waste at a nascent stage, taking a proactive pathway approach would be ideal to bring circularity to Kenya's e-waste sector.

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• Data Availability statement:

No new data were created or analyzed in this review.

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ANNEX 1: DISTRIBUTION OF WASTE RECYCLING CENTRES IN KENYA

WASTE CENTRES IN KENYA	Latitude	Longitude
E- wastes		
WEEE Centre	-1.270661089	36.95135
Eastleigh e-Waste Collection Centre	-1.261050399	36.85007
MSDP e-Waste Collection Point	-1.310993253	36.86492
EWIK	-1.273576629	36.83191
Plastics Waste Centres		
Kwale Plastics Plus Collectors	-4.29301047	39.58001
Plastic posts	-1.350352723	36.93753
Vintz Plastics Limited	-1.31156772	36.908
Pure Planet Recyclers Ltd	-1.248755341	36.89976
Romeo & Reuse Recyclers	-1.245341268	36.87179
Kenya PET Recycling Company Limited	-1.291194447	36.77766
Solid waste		
Gioto Dumping Site	-0.21011954	36.04983
Garbage Dot Com Ltd	-1.298049348	36.83817
Pure Planet Recyclers Ltd	-1.253834014	36.89868
Colnet Ltd	-1.29592602	36.83759
Paper Waste		
Tranbiz Solutions Kenya Ltd	-1.314926819	36.87193
Kamongo Waste Paper Kenya Ltd	-1.301121265	36.85434

ANNEX 2: INTERFACE OF THE SEARCH ENGINE (HARZING’S PUBLISH OR PERISH)

Harzing's Publish or Perish (Windows GUI Edition) 7.33.3388.7819

File Edit Search View Help

My searches	Search terms	Source	Papers	Cites	Cites/year	h	g	hI,norm	hI,annual	hA	acc10	Search date	Cache date	Last ...
Trash	"E-Waste" AND "Kenya"	Google Sch...	10	135	10.38	8	10	6	0.46	2	0	10/30/2021	10/29/2021	66

Google Scholar search [How to search with Google Scholar](#)

Authors: Years: 0 - 0

Publication name: ISSN:

Title words:

Keywords: "E-Waste" AND "Kenya"

Maximum number of results: 20 Include citations Include patents

Results	Cites	Per year	Rank	Authors	Title	Year	Publication	Publisher	Type
Publication years: 2008-2020	<input checked="" type="checkbox"/> h 17	2.83	1	I Otieno, E Omwen...	E-waste management in Kenya: ch...	2015	Journal of Emerging Trend...	researchgate.net	PDF
Citation years: 13 (2008-2021)	<input checked="" type="checkbox"/> h 16	2.00	2	JA Tocho, TM Wae...	Towards an e-waste management ...	2013	info	emerald.com	HTML
Papers: 10	<input checked="" type="checkbox"/> h 17	1.31	3	M Mureithi, T Wae...	E-waste Management in Kenya	2008	Nairobi: Kenya ICT Action ...	rds.org.co	PDF
Citations: 135	<input checked="" type="checkbox"/> h 11	1.57	4	P Vanegas, JR Peete...	Synergizing industrialized and dev...	2014	Procedia CIRP	Elsevier	
Cites/year: 10.38	<input checked="" type="checkbox"/> h 8	1.60	5	L Liza, F Mwaura	The variability in the generation, di...	2016	J Environ Pollut Hum Health	researchgate.net	PDF
Cites/paper: 13.50	<input checked="" type="checkbox"/> h 21	1.62	6	M Schluep, D Roch...	Assessing the e-waste situation in ...	2008	... Goes Green 2008+ ...	researchgate.net	PDF
Authors/paper: 2.20	<input checked="" type="checkbox"/> 6	0.46	7	R Wanjiku	Kenya opens first e-waste manage...	2008	Network World Canada	search.proquest.com	
h-index: 8	<input checked="" type="checkbox"/> h 13	1.18	8	M Schluep	E-Waste Management in Developi...	2010	ITU Symposium on ICTs an...	itu.int	PDF
g-index: 10	<input checked="" type="checkbox"/> 5	5.00	9	MN Bimir	Revisiting e-waste management pr...	2020	Journal of the Air & Waste ...	Taylor & Francis	
hI,norm: 6	<input checked="" type="checkbox"/> h 21	2.33	10	EN Asimwe, G Åke	E-waste management in East Afric...	2012	Handbook of Research on ...	igi-global.com	
hI,annual: 0.46									
hA-index: 2									
Papers with ACC >= 1,2,5,10,20: 9,4,1,0,0									