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E-Waste Management in Rwanda: A Situational and Capacity Need Assessment

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Abstract: This study analyzed e-waste management and capacity need assessment for both the city of Kigali and secondary cities in Rwanda. Questionnaires were used to obtain primary data. Data collected during this study have been analyzed using the Statistical Package for Social Sciences (SPSS v.2020). Using qualitative and quantitative data on e-waste management, this study showed that a large number of respondents used repair and reuse (38.1%) and the main environmental concerns were found to be waste management problems (reported by 77.3% of respondents), water pollution (36.2%), and air pollution (20%), whereas regarding health effects, chronic diseases were the major concern (21.6%). Results showed a significant association between education levels and awareness and dissemination, with respect to Rwanda's e-waste legislation and general e-waste knowledge. This study showed a need for urgency to introduce an extended producer responsibility (EPR) approach. It recommends the introduction of a disposal fee for every sale of electrical and electronic equipment (EEE).

Keywords: city of Kigali; Rwanda; extended producer responsibility; disposal fee; electrical and electronic equipment

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1. Introduction

E-waste is defined as "waste arising from end-of-life (EoL) electrical and electronic product" [1]). E-waste is also referred to as all electrical and electronic equipment (EEE) together with their components that are no longer being used [2], whereas the Government of Rwanda has defined e-waste as "encompassing all discarded and disposed electrical and electronic equipment (EEE)" [3].

Previously, electrical and electronic waste, or e-waste, was classified in ten categories, but it has now been revised and become six major different categories according to the WEEE Directive 2012/19/EU [4]:

- Temperature exchange equipment: fridges, freezers, air conditioning, etc.
- Screens, monitors, and equipment containing screens having a surface greater than 100 cm^2: TVs, computer monitors, etc.
- Lamp bulbs
- Large equipment (any external dimension more than 50 cm): washing machines, dishwashers, cooking stove and oven, cookers, luminaries, large printers, copying equipment, large equipment in general, etc.
- Small equipment (no external dimension more than 50 cm): vacuum cleaners, calculators, video cameras, cameras, wi-fi equipment, watches and clocks, smoke detectors, payment systems, etc.
- Small IT and telecommunication equipment (no external dimension more than 50 cm): mobile phones, tablets, routers, laptops, GPSs, printers, etc.

Recently, a number of researchers have used different methods in conducting e-waste-related studies. Hamdan & Saidan [5] used ArcGIS mapping to acquire, analyse, and quantify data on e-waste generation and disposal techniques in Jordan. Mor et al. [6] cited the relevance of e-waste management methods for environmental sustainability while investigating people's empirical studies conducted in India. Dzah et al [7] assessed the perception and practices of e-waste management among commercial consumers in Ho, Ghana, and [8] proposed the material flow analysis as a method to collect data during a short period in the informal e-waste recycling environment in Ghana.

Researchers have pointed out that the generation of e-waste is considered one of the fastest-growing solid waste streams in the world [9–11]. The development of society has been triggered by the adoption of technology, which requires the use of electronic equipment such as mobile phones and computers [12,13], but due to poor management of this waste from electrical and electronic equipment (EEE) and related materials, the world is now facing associated environmental pollution [14–16] and health-related problems [17,18]. Studies conducted on behalf of the United Nations (UN) showed that anywhere between 20 and 50 million tons of e-waste are generated globally and the growth rate of e-waste is nearly three times the growth rate of the municipal solid waste stream [19]. Due to the current rapid urbanization, economic growth and modernization, and advances in EEE industries, the e-waste generation rate has also significantly increased [20]. This is mostly due to the growing dependency on the use of ICT in all sectors of the economy, including mobile communication, education, health, finance, and service delivery. In its report of 2020, the UN showed that by the end of 2020, e-waste generation increased to more than 44 million metric tons (MT) annually [21].

Proper handling of e-waste is an emerging challenge because e-waste contains more than one thousand substances, and many of them contain toxic and hazardous substances such as lead, mercury, arsenic, cadmium, and selenium [22], among others, which pose severe threats and risks to human health and to the environment if not handled and disposed of properly. E-waste contains hazardous materials such as brominated flame-retardants, beryllium, lead, mercury, and cadmium that pose growing risks to the environment and to human health, but white and brown product waste is less toxic than grey product waste [23]. On the other hand, e-waste also contains some valuable metals such as iron, aluminum, nickel, copper, and some precious metals which include gold, silver, and the platinum-group metals [24]. Therefore, the recovery of various materials from e-waste represents a significant opportunity for the environment and the economy [25], and many researchers have proposed that the circular economy (CE) should replace the linear economy in order to achieve a sustainable environment [26]. The disposal and recycling of grey product waste present a challenge in both developed and developing countries [27]. In a study conducted in 2019, [28]) estimated e-waste generated globally to be about 53.6 Mt.

Recently, the International Communication Union (ITU) published an article which showed that 7000 tons of e-waste is generated annually in Rwanda [29] and the e-waste collecting company in Rwanda, known as "the Enviroserve", was able to collect 553,786 kg of e-waste in 2021.

This study aims to assess both situational and capacity need assessments for e-waste in both the city of Kigali and secondary cities. The main motive to conduct this study is that there have so far been no data provided by research on e-waste management in Rwanda.

2. Current Policies and Legal Framework in Rwanda

Rwanda is among the few African countries that have an electronic waste policy and regulations (Table 1). A report prepared by the International Telecommunication Union (ITU) reported Rwanda to be one of thirteen African countries to have nationally regulated e-waste, along with Egypt, Ghana, Madagascar, Nigeria, South Africa, Cameroon, and Cote d'Ivoire [29]. Policies and regulations are well articulated, but they are not followed in Rwanda. For example, it is stated that auctions for e-waste are prohibited, but during this

study it was found out that in some big organisations, auctions are still being conducted, and this shows that there is a need for regulatory enforcement.

Table 1. National and international frameworks for waste management (WM) in Rwanda (including e-waste).

National Frameworks	
Short Name	**Comment on the Provided Framework**
Legislation and regulation	Rwanda has important WM-related legislation/regulations, including: 1. Rwanda's Constitution of 2003 with Amendments through 2015, Article 53. Protection of the environment. Everyone has the duty to protect, safeguard and promote the environment. The State ensures the protection of the environment. 2. The resultant Environment Law (2018), officially Law N° 48/2018 of 13 August 2018 on Environment, includes Article 20 on e-waste management. The overreaching Law N° 48/2018 of 13 August 2018 on Environment contains restrictions on export for recovery, import for final disposal, import for recovery, and for transit waste. This law is supported by Instruction N° 01/04 of the Rwanda Bureau of Standards related to the issuance of a quality certificate for imported goods. 3. Law N° 39/2001 of 13 September 2001 establishing as utility regulator the Rwanda Utilities Regulatory Authority (RURA). 4. LAW N° 57/2008 of 10 September 2008 prohibiting the manufacturing, importation, use, and sale of polythene bags in Rwanda. 5. Regulation N° 002 of 26 April 2018 Governing E-Waste Management in Rwanda.
Strategy/Policy	1. Relevant strategies and policies include: National Strategy for Transformation (NST1) and Vision 2050, National Strategic Plan, and five-year operational plan for the Management of Healthcare Waste [30]. 2. National Industrial Policy [31]). 3. National Sanitation Policy [32]. 4. Rwanda began policy discussions around how to manage its e-waste in 2008, and that draft e-waste policy was never adopted as a stand-alone policy but was instead incorporated in the National Sanitation Policy (2016). 5. National Strategy for Climate Change and Low Carbon Development. 6. National Environment and Climate Change Policy (2019).
Guidelines and implementation procedures	1. The Ministry of ICT and Innovation, in collaboration with the Rwanda Standards Board (RSB), established Ministerial Guidelines No. 1 of 25 October 2011 Related to Importation of Used Electronics/ICT Equipment. 2. Standards on the Management of Waste Disposal Sites [33]. 3. N° DGO/REG/005 of 7 July 2022 Regulations governing trade of used electrical and electronic equipment.
Standards	DRS 276-2: E-Waste Management Standard. In addition, RSB has developed and published several standards for various EEE and a dedicated standard on e-waste management.
International Conventions Related to E-Waste Management	
Basel Convention	As a signatory to the Convention, the Government of Rwanda, through the Rwanda Environmental Management Authority (REMA), established the National Implementation Plan (NIP) of the Convention in 2013 in order to address issues related to transboundary movement of hazardous wastes and their disposal within the country. The NIP implementation has been underway since 2014 and ran until 2021. It outlines national priorities and targets, including establishment of repair centers for EEE and construction of an appropriate e-waste storage and recycling plant.
The Bamako Convention	Adopted under the auspices of the then Organisation of Africa Unity (OAU), the Convention prohibits hazardous waste imports into Africa and was adopted on 30 January 1991.The Convention also covers waste considered hazardous under the domestic laws of the state of import, export, or transit, including e-waste.

In August 2021, for proper management of hazardous waste including e-waste, the Rwanda Environmental Management Authority (REMA) made a decision on hazardous waste entering the Rwandan market illegally. It was decided that these wastes will be returned to their countries of origin. Companies and all industries involved in the trade

of transboundary movement of those wastes must obtain authorisation from a competent authority for transporting them [34].

3. Study Area and the Secondary Cities Concept

Due to an increase in rural-to-urban migration caused by employment opportunities in Rwanda and especially people moving from rural districts to the city of Kigali (CoK), the Government of Rwanda, through a strategy known as the Second Economic Development and Poverty Reduction Strategy (EDPRS 2), has created a concept of secondary cities. These cities were selected due to their strategic locations for conducive business environments and settlements, and they will thrive and drive the needed urbanisation growth in the respective cities. The Republic of Rwanda through EDPRS 2 wanted to provide a more balanced urban system by creating six secondary cities. This was intended to simulate urban economic development, particularly outside the capital city of Kigali [35]. These cities were Huye, Muhanga, Musanze, Nyagatare, Rubavu, and Rusizi (See Figure 1). Under new national land use and development master plan (NLUDMP 2020–2050) [36] secondary cities have been updated and they are now eight: Huye, Karongi, Kayonza, Kirehe, Musanze, Nyagatare, Rubavu, and Rusizi. Note that this study was conducted before NLUDMP 2020–2050, and therefore the considered secondary cities were only the ones under EDPRS 2.

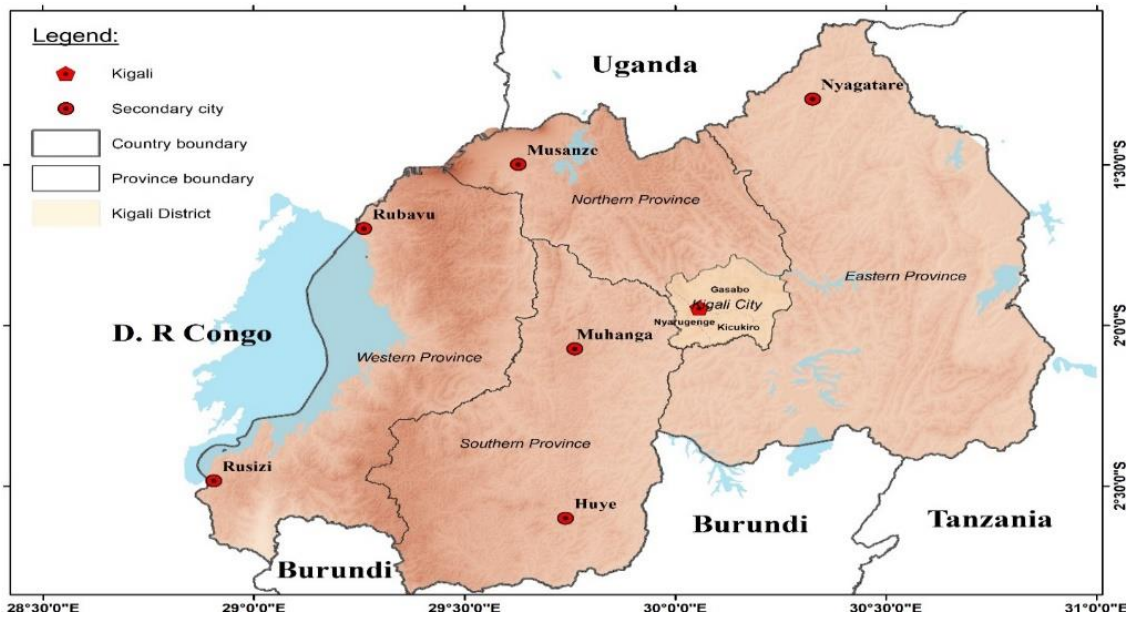

Figure 1. Kigali city and secondary cities.

The table below shows the population of secondary cities and the CoK. Note that the total projected urban population in the secondary cities is equal to 618,988 individuals in 2022 (Table 2).

Table 2. Urbanization rate projection in the city of Kigali and secondary cities.

	Huye	Muhanga	Nyagatare	Rubavu	Musanze	Rusizi	CoK	Total
Population of the district (2012) [37]	328,398	319,141	465,855	403,662	368,267	400,858	1,132,686	3,418,867
Projected urban population	339,236	329,673	481,229	416,983	380,420	414,087	1,608,414	3,970,042
Urban population (2012) [38]	52,768	50,608	47,480	149,209	102,082	63,258	-	-
Projected urban population (2022)	70,181	67,309	63,148	198,448	135,769	84,133	1,608,414	2,227,403

4. Materials and Methods

4.1. Sampling

Questionnaires were used to obtain primary data. To evaluate the sensitivity and local applicability of questions, a pretesting study was used among ten respondents prior to the survey fieldwork. For those with limited English knowledge, questions were translated and asked verbally in Kinyarwanda (the local language), with immediate translation of responses into English at the time of interview.

Five groups of respondents were chosen, namely: (i) corporate organisations, (ii) distributors/retailers, (iii) consumers (general public), (iv) recyclers/refurbishers, and (v) e-waste collectors, and each group was given a questionnaire having a set of open- and closed-ended questions.

For households (general public), the sample size has been calculated using Cochran's formula (1977) [39] for large samples, where, n_o is the sample size, z is the selected critical value of the desired confidence level, p is the estimated proportion of an attribute that is present in the population, $q = 1 - p$, and e is the desired level of precision (Cochran, 1963). The maximum variability was assumed to be equal to 50% ($p = 0.5$), and taking the 95% confidence level with ±5% precision, the calculation for the required sample size will be as follows:

$$n_o = z^2pg/e^2$$

$$p = 0.5 \text{ and hence } q = 1 - 0.5 = 0.5; e = 0.05; z = 1.96$$

$n_o = (1.96)2 \times 0.5 \times (1 - 0.5)/0.05^2 = 384.16 = 384$ people. This sample represents the whole study area. A larger number of interviewees were chosen to be consumers (general public) because they are the ones who largely sell their e-waste to informal e-waste collectors, and they are also the ones who use informal repairs to repair their EEE, whereas for the remaining groups (corporate organisations, distributors/retailers, and recyclers/refurbishers), a convenience sampling approach has been used and 135 people were visited. Five hundred and nineteen (519) respondents in total participated in this study, which was conducted from June to August 2022.

4.2. Data Analysis

Data collected during this study have been analysed using the Statistical Package for the Social Sciences (SPSS v.2020). The Pearson Chi-Square was used to see if there is a relationship between two categorical variables. Here, background information (Gender, Age and Education) and sets of questions were considered.

The sets of questions were:

Questions related to e-waste legislation

- Q1: Have you ever heard about Rwanda's e-waste legislation?
- Q2: Is it good to have legislation on e-waste?

Questions related to e-waste general knowledge

- Q3: Are you aware of the environmental hazards caused by discarded electronic equipment (e.g., computers, mobile phones)?
- Q4: Are you aware that some electronic parts may be profitably recycled?
- Q5: Do you know what e-waste or waste of electrical and electronic equipment is?

5. Results and Discussion

5.1. Limitations of the Study

One major limitation of the present study was the inability to have an exact total number of e-waste quantity because of (i) the informal sector involvement in refurbishing and recycling e-waste, and (ii) lack of e-waste records in both public and public organisations. Another problem was that retailers were reluctant to provide information on their annual sales, saying that it depends on the offers they receive (i.e., they fluctuate).

The methodology used during this study depends on primary data collected from the various stakeholders, especially the quantities of products imported, and in order to address this, data from the Rwanda Revenue Authority were used because, as stated above, most of the institutions lack or do not have easily accessible information on their e-waste stocks and generation.

5.2. Background Information of Respondents

The table below shows the background information of the respondents. The considered sample is composed of 55.9% males and 44.1% females (Table 3). The highest percentage of respondents regarding age was found to be 28.1% (the age between 25 and 34).

Table 3. Background information of respondents.

Variable	Category	Total Number of Respondents	Percentage (%)
Gender	Male	290	55.9
	Female	229	44.1
Age (years)	15–24	135	26
	25–34	146	28.1
	35–44	139	26.8
	45–54	99	19.1
Educational level	No formal education	25	4.8
	Primary	86	16.6
	Secondary	180	34.7
	Tertiary	228	43.9
Occupation	Formal *	221	42.6
	Informal **	171	32.9
	Student	43	8.3
	Unemployed	84	16.2

* Formal: Formal employment is created through contractual arrangements between an incorporated company and an individual employee. ** Informal: the person doing the work has little or no job security, does not have a contract, and might not have the same employer for more than a few weeks or months. The majority (95.2%) of the respondents had some form of education, and the majority (42.6%) of the respondents are also employed in the formal sector.

5.3. Imports of Electrical and Electronic Equipment for the Period 2018–2021

In Rwanda, all imported goods are registered by the Rwanda Revenue Authority. Figure 2 shows some of the EEE which were imported from 2018 up to 2021. There has been an annual increase in importing EEE each year except for 2021, and this may be attributed to the travel restrictions due to the COVID-19 pandemic; it was prohibited to travel to China, for example. The total weights of imported EEE are 5472.15 tons for 2018, 5723.193 tons for 2019, 5858.37 tons for 2020, and 4782.748 tons for 2021. For the considered EEE in this study (computers (desktops and laptops), fully automatic washing machines, printers, copying machines and facsimile machines (fm), dishwashing machines, refrigerators, air conditioning machines, and telephones), the item with the highest weight was telephones in 2019 with 599,167 kg (see Figure 2).

Using the EEE imported in 2018, it was projected that the e-waste potential in 2022 was equal to 5472.15 tons.

For targeted imported EEE, e-waste in 2022 was equal to: 419.997 tons from refrigerators; 120.982 tons from computers; 92.136 tons from printers, copying machines, and facsimile machines; 69.528 tons from air conditioning machines; 14.404 tons from dishwashing machines; and finally, 588.462 tons from telephones; the total is equal to 1305.509 tons (Figure 3).

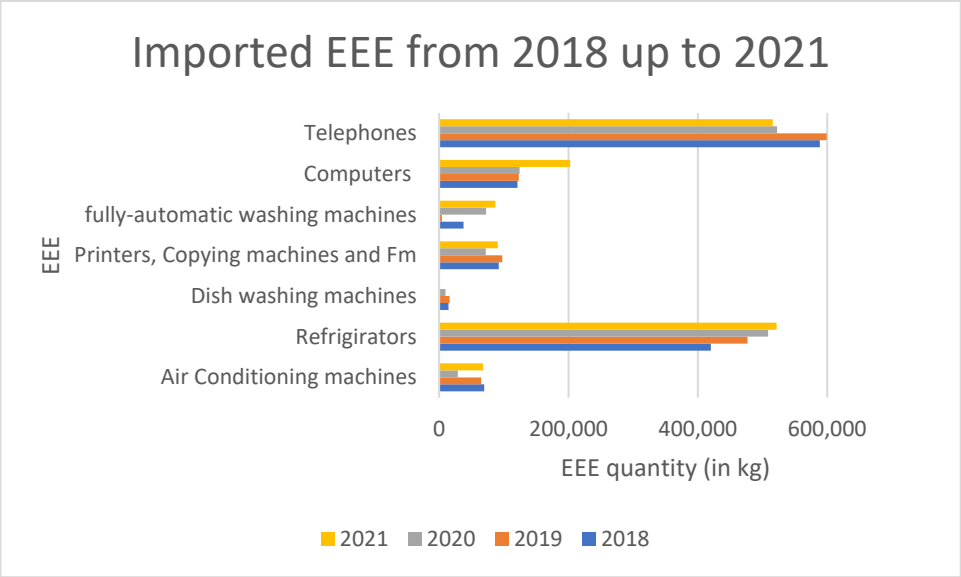

Figure 2. Imports of EEE from 2018 to 2021.

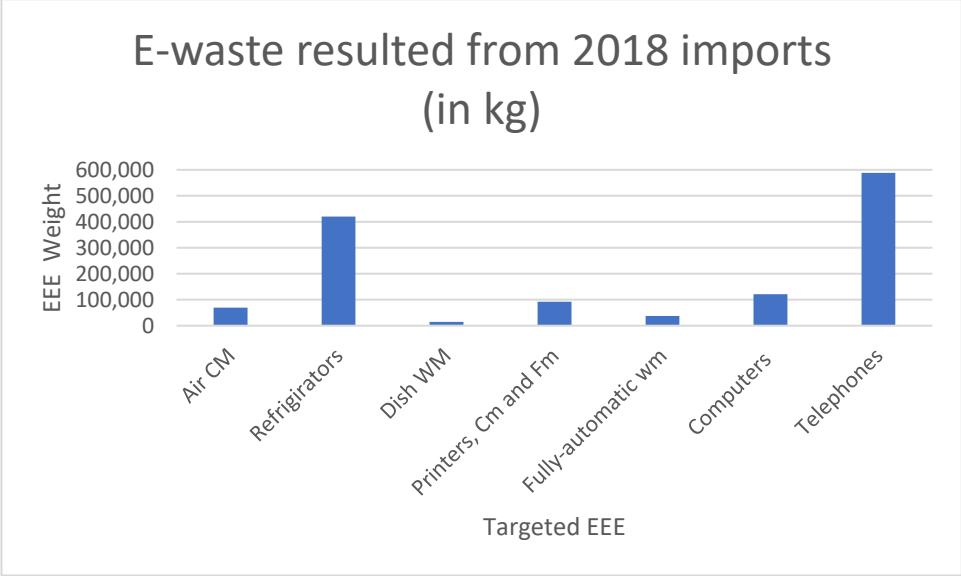

Figure 3. E-waste resulting from 2018 EEE imports.

An increased rate in EEE imports into Rwanda was estimated to be approximately 5.95% in 2016 (REMA, 2016), and it is the one used in this study in order to project e-waste in 2050. Figure 4 shows that Rwanda is projected to import 9379.27 tons of EEE in 2030, 12635.19 tons of EEE in 2040, and 15,891.12 tons of EEE in the year 2050 (Figure 4).

5.4. Electrical and Electronic Equipment (EEE) in Households

High percentages of EEE are found in the city of Kigali (Nyarugenge, Kicukiro and Gasabo districts), and the lowest number is found in the Muhanga district, where only 0.01% of its households have refrigerators (Figure 5).

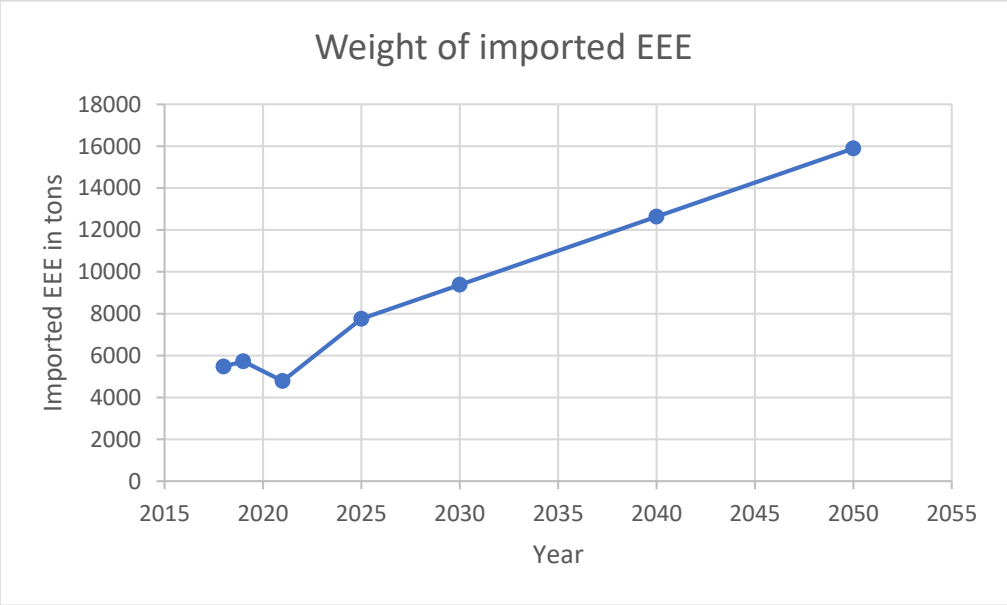

Figure 4. Projected imports for EEE till 2050.

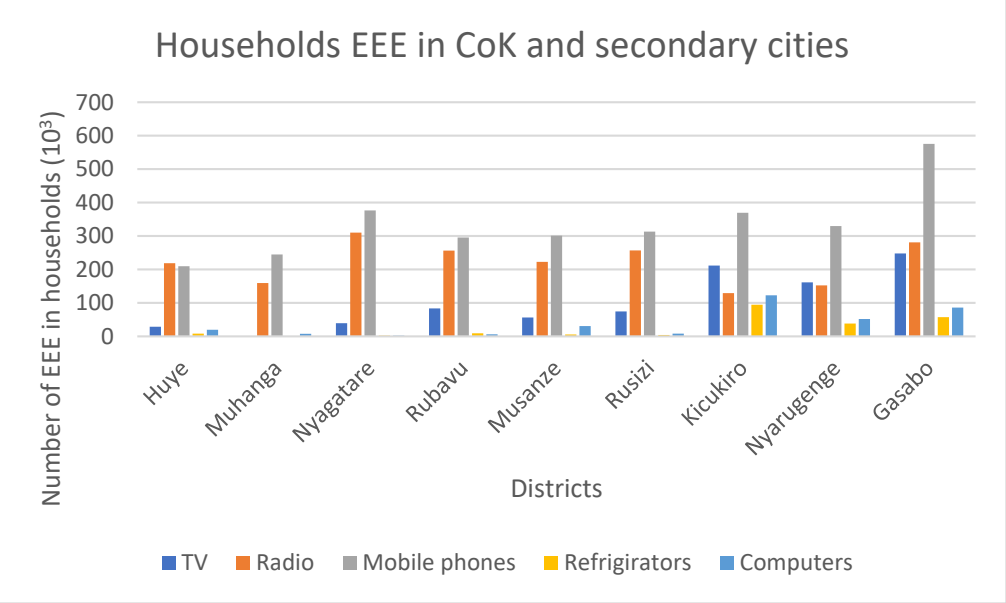

Figure 5. EEE in households in both the city of Kigali and secondary cities.

Figure 6 shows the weight of e-waste to be produced from households at the end of this year. It shows that the highest EEE from households is found in the city of Kigali. Numbers shown in Figure 6 were calculated based on the EEE found in the house and their lifespans.

5.5. Value Chain of EEE in Rwanda

Figure 7 shows the value chain of electronic equipment in Rwanda. After importing electrical and electronic equipment, they are distributed to selling shops, where four big players are visited: Mitsumi Distribution L.L.C., which distributes HP, Dell, Lenovo, and Toshiba laptops and their accessories, and Transsion Holdings Company, which facilitates the importation of Techno, Itel, and Infinix mobile phones.

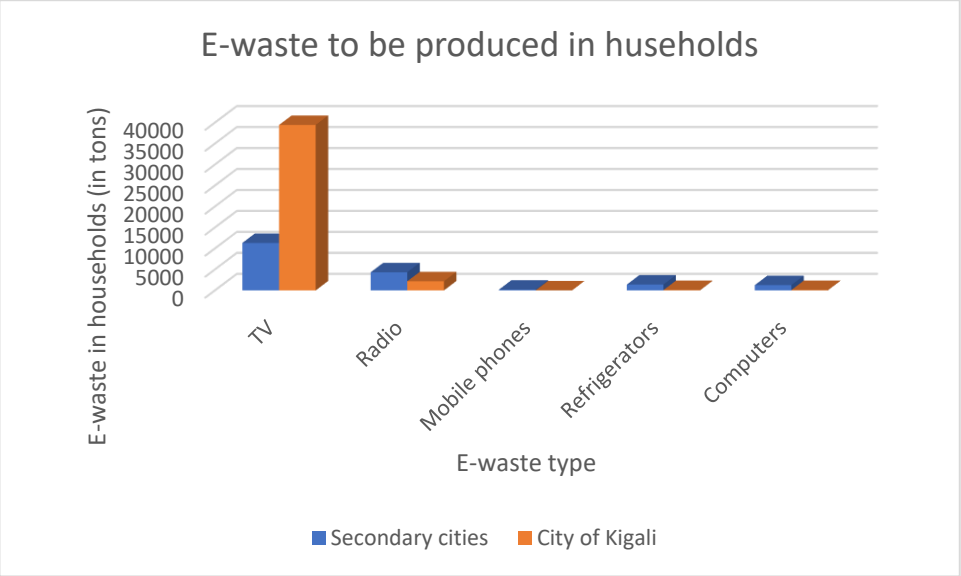

Figure 6. Weight of targeted EEE.

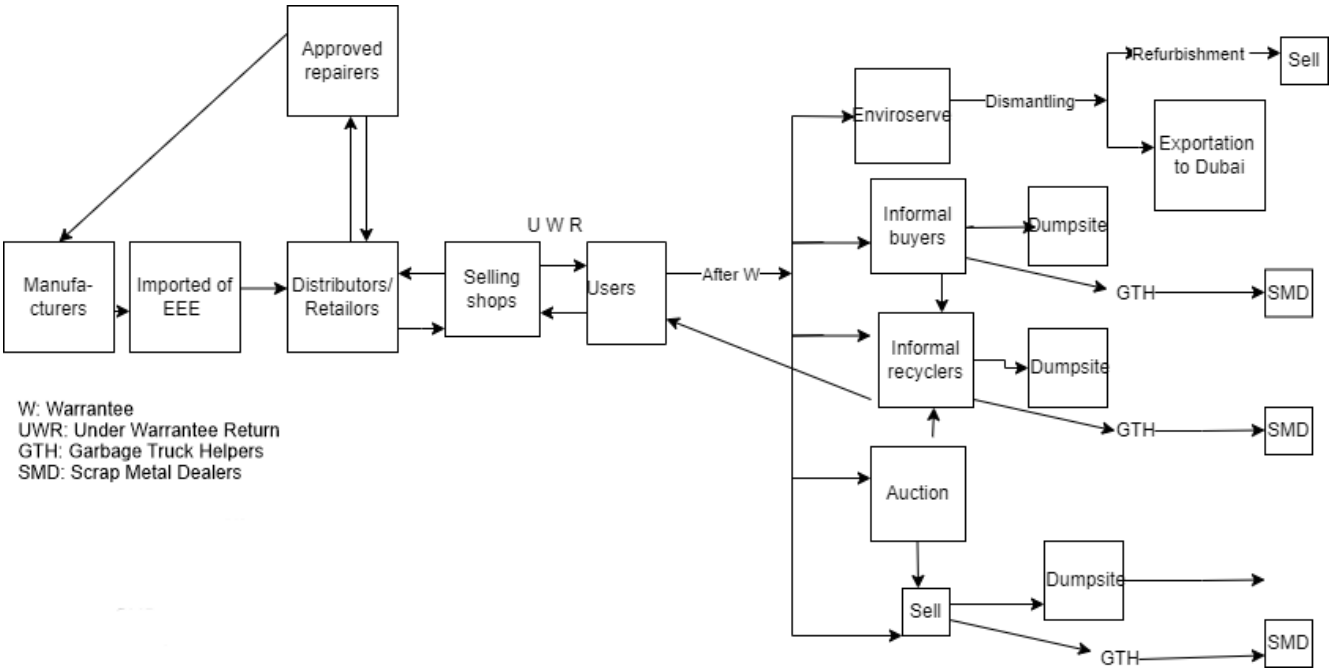

Figure 7. EEE value chain in Rwanda.

For Mitsumi Distribution L.L.C., when its electronic equipment does not function well, it is repaired by Life Solutions Company, but this is done when the equipment is still in warranty period, and when the repairing company fails to repair that equipment, it is then sent to the manufacturer.

For Transsion Holdings Company, the approach is similar to Mitsumi's approach: the damaged equipment is repaired by Carcare Company, and if it fails to repair the equipment, it is also sent back to the industry; in both cases, the consumer receives a new equipment. For other types of mobile phone such as Samsung, Nokia, and iPhone, the company in charge of repairing them is called Shreecom Company, and the process is similar to the previous ones.

The formal collection of e-waste in Rwanda is done by a private company called Enviroserve Rwanda Green Park, which received a permit from the Ministry of Trade and

Industry. Enviroserve Rwanda Green Park started working in 2017. Enviroserve Rwanda Green Park has been granted the permission to collect all e-waste materials from government institutions. After collecting e-waste and dismantling them, refurbished equipment, non-hazardous waste, and scraps are sold (e.g., plastic wastes are sold to a cobblestone-making company), whereas hazardous wastes are sent to Enviroserve Headquarters in Dubai to be recycled or disposed of, and the main dismantling method is manual, with equipment such as screwdrivers. Enviroserve has pursued good initiatives, including the distribution of refurbished computers in secondary schools and the creation of green jobs.

Some e-waste must be paid for in order to be collected. Here, the lithium batteries from solar home systems are good examples.

Enviroserve Rwanda Green Park has drop-off containers in many districts in Rwanda (See Figure 8, which shows the Musanze drop-off container).

Figure 8. Musanze drop-off point.

Apart from Enviroserve, we found a startup called Wastezon 2.0 owned by a company known as Wastezon Ltd., which only repairs electronic equipment. On 18 October 2022, the Wastezon company launched an application called Wastezon 1.0.2 for Android. This app is going to connect Wastezon Ltd. to its customers, and they will be able to use their mobile phones to report their e-waste presence to the Wastezon Company.

5.6. Current Operations and Practices

Regarding the methods used for e-waste disposal, the highest number of respondents were reported to be using repair and reuse methods (38.1% (Table 4)). Figure 9 shows how e-wastes are kept in informal repairing stores, followed by the dumpsites representing 24.9%. Contrary to the previous research conducted in Ghana [8], no one in this study responded that e-waste is burned.

In some informal repairers (this was mentioned by repairers in Musanze District), e-waste is sold to unknown people and they normally buy phone pads. As previously stated, some big distributors have their own repairers, and all e-equipment which are still within the warranty period gets repaired, and if the repairers fail to repair them, they are being sent to the manufacturer.

Almost half of the visited public institutions (8 out of 17: 47%) showed that their e-wastes are collected by the Enviroserve Company. The only concern here was the number of drop-off points in the city of Kigali and the unused ones in secondary cities. In secondary cities those drop-off points are almost empty. When a respondent from the Musanze District office was asked about that drop-off point, he denied using that drop-off point as an e-waste disposal place. This is unfortunate, because this drop-off point is located near the Musanze District.

The main reason for not disposing of e-waste in drop-off points is that people think that their e-wastes still have economic values, and those e-wastes are still being sold through auctions. Some institutions have shown the intention of reusing e-waste (See Figure 10).

One of the informal repairer/recyclers from Kazi ni Kazi (a job is a job) in the city of Kigali testified that he sometimes converts computer screens to televisions, which then become a cheaper option for those who have low incomes and who are not able to afford buying a brand-new TV.

A small percentage (0.5%) of respondents showed that they sell their e-waste through auction. This is unfortunate because it is very hard to know where this sold e-waste will end up (the final disposal).

5.7. General Knowledge on E-Waste

When respondents were asked about their general knowledge on e-waste, 44.5% of the respondents showed they had knowledge on e-waste, and a high number (65.5%) showed they were aware of the possibility of recycling e-waste.

Table 4. E-waste disposal methods.

Management Methods	General Public Consumers (384)	Informal Repairers (64)	Manufacturers/ Distributors/ Retailers (43)	Collectors/Formal Repairers/ Recyclers (4)	Private Higher Learning Institutions and Public Institutions (24)	Total
Bury	-	-	-	-	-	-
Burn	-	-	-	-	-	-
Donate	12 (3.1%)	3 (4.6%)	-	1 (25%)	-	16 (3.1%)
Anywhere	15 (3.9%)	1 (1.5%)	-	-	-	16 (3.1%)
Dumpsite	101 (26.3)	25 (39.1)	-	-	3 (12.5)	129 (24.9%)
Dismantle	5 (1.3%	7 (10.9%)	-	1 (25%)	-	13 (2.5%)
Recycle	20 (5.2%)	5 (7%)		1 (25%)	3 (25%)	28 (5.4%)
Repair and reuse	150 (39.1%)	8 (12.5%)	33 (76.7%)	1 (25%)	6 (25%)	198 (38.1%)
Reselling	69 (17.9)	6 (9.4%)	-	-	-	75 (14.4%)
Storage	12 (3.1%)	6 (14.1%)	-	-	1 (4.2%)	19 (3.7%)
Collected by Enviroserve	-	-	-	-	8 (33.3%)	8 (1.5%)
Auction	-	-	-	-	3	3 (0.5%)
Selling to informal collectors		3 (4.7%)		-	-	3 (0.5%)
Export	-	-	10 (23.3%)	3 *	-	11 (2.1%)

*: The percentage is high because some companies gave more than one answer.

The portion of the respondents who knew that e-waste requires special treatment before disposal was found to be 16% and those who knew the health risk associated with e-waste was approximately equal to 17.8%. Knowledge on the health risk associated with e-waste might be explained by training given to informal repairers/recyclers provided by Enviroserve. Only a small proportion of respondents mentioned that they have been trained on e-waste (17.5%).

Figure 9. EEE in an informal repairing place in the city of Kigali.

Figure 10. A computer case used in a ventilator at Kigali Integrated Polytechnic Regional Center (IPRC).

In order to test respondents' knowledge on e-waste in Rwanda, Table 5 has been prepared. Respondents' knowledge on the existence of e-waste legislation is very limited (87.8% responded no) whereas a great number showed to be in favour of having e-waste legislation in place (93.8%). The knowledge levels of respondents on the impacts of e-waste on public health and environment were tested, and the main environmental concerns

were found to be waste management problems (77.3%), water pollution (36.2%), and air pollution (20%). With regard to the main health effect, chronic diseases were found to be the major concern (21.6%). These findings are consistent with a previous study conducted in Ghana [8]).

Table 5. E-waste legislation in Rwanda.

Variable	Have You Ever Heard about Rwanda's E-Waste Legislation?		Is It Good to Have Legislation on a Legislation on E-Waste?	
	Yes	No	Yes	No
General Public Consumers	50	334	371	13
Informal Repairers	10	54	47	17
Distributors/ Retailers	1	42	41	2
Formal Repairers/Recyclers	1	3	4	0
Private Higher Learning Institutions and Public Institutions	2	22	24	0
Total	64 (12.3%)	455 (87.7%)	487 (93.8%)	32 (6.2%)

In order to know how e-waste management and e-waste recycling in Rwanda can be fostered, results from respondents showed that e-waste recycling, costs, lack of infrastructure, and absence of recycling possibilities are the main obstacles, whereas for proper e-waste management in Rwanda, the following points should be kept in consideration: (i) e-waste collectors should pay for collection; (ii) standards should be prepared regarding e-waste management; (iii) campaigns should be made to increase awareness: physical meetings, media, and/or messages to mobile phones; (iv) technical schools should contribute to e-waste management; (v) ICT students should be trained: ICT students, as people who will work in the sector, should be taught an e-waste management module; and (vi) used electronics should be donated to social programs.

5.8. Needs Identified by the Study

As a result of this study, the following trends, which will serve as a basis for planning capacity development measures, have been identified:

1. Waste pickers, those involved in municipal waste collection and transportation (especially in the city of Kigali where waste collection is well organized), collect some e-wastes which are mixed with municipal waste and they sell them before arriving at the disposal site (the dumpsite). Those waste pickers must be trained regarding e-waste knowledge. They also must be informed about legal and safety requirements for the collection and transportation of this type of waste.
2. Twelve per cent of interviewees are informal refurbishers/recyclers and are engaged in e-waste pretreatment (like dismantling). Residues from these operations, including hazardous wastes, are released into the environment. Even if a high number of them have been trained by Enviroserve, that sector is receiving many new members every time and new EEEs are entering the market; therefore, they should be regularly both trained on how to handle these wastes and be informed about legal requirements related to hazardous waste management.
3. Both waste collectors and informal refurbishers/recyclers must deal with hazardous waste. Thus, skills in handling those hazardous wastes should be developed to avoid their impact (negative) on the health of waste collectors and informal refurbishers/recyclers. It is hereby advised to develop a document containing relevant skills or use an available e-waste training manual which has been developed by GIZ [40].
4. Waste pickers are supposed to wear boots, nose masks, and gloves, but sometimes they do not put them on, claiming that it is very hot, they feel itchy, they lose their sense of

touch, and they have difficulty in speaking, and informal refurbishers/recyclers do not put on personal safety equipment. Therefore, both of them should be informed on occupational safety risks. When asked about being trained, most of them expressed the need. An information booklet containing information on the equipment should be used, and their specifications and safety rules should be developed.

5. Informal e-waste dealers, including informal refurbishers/recyclers, deal with e-waste manually, and in such working conditions, the risks of adverse health effects are likely to be very high. This should be addressed by capacity development measures.
6. All visited organizations except Enviroserve lack a waste management plan, and there is a need to inform them about relevant requirements of legislation.

5.9. The Association between Background Information and Awareness Level on E-Waste

In order to associate background information and awareness level on e-waste, a large number of the participants (who are general public consumers) (n = 384) were considered. Five questions in two groups (awareness of e-waste legislation in Rwanda and general knowledge on e-waste management) were asked. Eight different significant associations were established (Table 6). For the group 1 questions, in six scenarios there was a significant association between questions and all the background information for four scenarios, and in two scenarios there was no significant association between variables (Age with Q1 and Gender and Q2). For the group 2 questions, in nine scenarios, six of them showed a significant association.

Table 6. Pearson Chi square analysis for the association between the background information and awareness level on e-waste.

Background Information	E-Waste Legislation Related Questions		E-Waste General Knowledge Related Questions		
	Q1	**Q2**	**Q3**	**Q4**	**Q5**
Age	0.402	0.005	0.84	0.43	0.002
Education	<0.001	0.001	0.001	0.01	<0.001
Gender	0.025	0.35	0.16	0.01	0.03

p Values < 0.05 are significant.

6. Conclusions and Recommendation

6.1. Conclusions

Finally, the baseline findings show several challenges for Rwanda's management of e-waste. Challenges are especially related to (i) the low level of awareness of Rwanda's e-waste legislation (87.8% of the respondents were not aware of e-waste legislation in Rwanda) and general knowledge on e-waste, (ii) collection strategies (there is only one formal e-waste collector (Enviroserve), drop-off points are insufficient, and for disposal methods a high number of respondents (24.9%) responded that they mixed e-waste and other municipal waste and collected them together with their final destination to the dumpsites. This study found out that those e-wastes are sold to unknown people by waste pickers before arriving at the dumpsites), and (iii) the study found inadequate regulatory enforcement, frictions in markets for end-of life products, and the development of policies for e-waste management in the private institutions, and public institutions will play a big role in enabling better markets for e-waste.

6.2. Specific Recommendations

This study recommends the following:

- To organize awareness campaigns: This should be done through community engagement such as community work "umuganda" (it takes place every last Saturday of every month) mainly at the village level, and through mass media such as radio and television.

- To continue a very good initiative of Enviroserve Rwanda, which conducts training for informal repairers/recyclers.
- To include an e-waste management course in ICT programmes' curricula, both in secondary schools and higher learning institutions.
- To match e-waste management with a 'made in Rwanda' initiative: Integrated Polytechnic Regional Centers (IPRCs) as technical schools should be involved in e-waste management, and as IPRCs are scattered right across Rwanda they will be assisting e-waste management in all districts.
- To look at taking back legislation based on the extended producer responsibility (EPR) principle, thereby legally requiring manufacturers and importers to finance the take back initiative and proper recycling of products placed on the national markets.
- Public institutions and companies should be encouraged to assess their estimated end of life (EoL) stock, as this will help to determine what their EoL strategy will be, and it will also help investors who are willing to invest in e-waste management.
- To provide incentives to encourage engagement with local communities in e-waste management.
- To provide incentives to encourage refurbishment and reuse before sending e-waste to Enviroserve: reuse and refurbishment extend the lifespan of products.
- To provide additional infrastructure for both the disposal and recycling of e-waste.
- To include informal repairers/recyclers in e-waste management initiatives.
- To conduct a study on the impact of e-waste on the economy in Rwanda.
- The GoR is recommended to rethink the policy instruments under the EPR approach.
- A disposal fee (DF) should be proposed on every sold item of EEE, and this generated money can be used to (1) provide subsidies to consumers to depose of their e-waste at designated drop-off points, (2) provide training to informal sector workers, and finally (3) provide subsidies to e-waste collectors/recyclers. A challenge here will be to agree on that disposal fee, and one of the proposals would be the monetary value of that particular e-waste.
- All public and private organizations should record their e-waste quantities.
- Further research could investigate the impact of e-waste on the economy.

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