

Assessment of public awareness on e-waste management: A case study of Kigali.

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Abstract. E-waste generation in Kigali has significant increases as economic change, which means a lot of uses of ICT equipment in different domains with high population willingness to use technological materials, the change of technology makes loose of existing equipment value and increased waste electrical and electrical equipment. This study was carried out to determine and comprehend the e-waste awareness and disposal practices among residents of Kigali city. The findings revealed that consumer awareness in Kigali is generally fairly good but low. However, with regard to disposal methods, residents are not informed about e-waste collection facilities, appropriate disposal methods, and electronic waste regulations. As a result, residents most of them store their e-waste in homes and mix some e-waste generated with municipal solid waste, which ends up in dumpsite which is not constructed in an environment protection manner. Respondents had a variety of environmental concerns, but they did not know the consequences, as well as the disposal of electronic waste with municipal waste or stored in homes.

Keywords: environment consciousness; awareness; waste electrical and electronic equipment (WEEE); disposal ; dismantling.

1. INTRODUCTION

E-waste or waste electronic equipment (EEE), is defined as equipment dependent on electric currents or electromagnetic fields to work properly, but also any for the generation, transfer, and measurement of such currents and fields, which is discarded or have reached its end-of-life[1], but there is no standard definition, countries define e-waste with their definitions, interpretations, and usage of the term "e-waste/WEEE[2]. These includes the following categories, temperature exchange equipment, screens and monitors, lamps, large household appliances, small household appliances, IT and telecommunications equipment discarded, missed some part, or reach their end-of-life[3].

Waste generated by EEES is growing rapidly around the world[4], especially in developing countries, people are ready to be transferred to the current trend and those who use more developed and improved technologies of electrical and electronic equipment, make the large portion in degrading EEES before its end-of-life and generate waste electrical and electronic equipment and some transferred in low-class and middle-class income with no knowledge and facilities of e-waste management, example of phones which is upgrade day to day and reduce end of life of phone, and resulting in rising of waste of phones[5].

The irresponsible management of waste electrical and electronic equipment has adverse environmental consequences, in particular, because of the harmful content of devices, including high concentrations of hazardous substances such as mercury (Hg), lead (Pb), cadmium (Cd), hexavalent chromium (Cr), PVC and brominated flame retardants etc.. [6] and contains several parts with different values in feature use that can second resources to manufacture the other needed materials, the EEE's fractions; It contains more than 1,000 different substances in the "dangerous" and "non-dangerous" categories. These include metal, metal, plastic, glass, wood and plate, print circuits, concrete and ceramics, rubber and other elements. e-waste consists of 50% steel, followed by plastics (21%), non-metallic ferrous metals (13%) and other constituents. Ferrous metals consist of copper and aluminium as well as precious metals such as silver, gold, platinum, and palladium[7,8]. The proper treatment of e-waste is vital; ecologically, socially and economically sustainable development for the future. Today, electronic waste management includes formal and informal recycling sectors that attempt to deal with electronic waste, but on the other hand, the informal sector has become part of an adequate economy and is involved in activities illegal. The activity destroyed the environment. There is no national control[9].The formal process of e-waste recycling facilities it's ethical and reliable for environment sustainability, it is regal work with recycling standards begins with sorting, testing, refurbishment and repair of received e-waste, component which can be reprocessed are disassembled and sometimes shredded and sorted by automatic machines or manually[10].

This paper aims to investigate the awareness of the general public in Kigali/Rwanda, forces that leverage and downplay the adoption of e-waste practices. We emphasize that the commitment to responsible waste management, such as recycling, is not just about environmental awareness, positive environmental goals, or a global attitude towards technologies. Instead, it takes a sense of personal effectiveness and social legality to take these steps to effectively involve people. A well understanding of the impact of setting up professional recycling practices can provide valuable information for policy development and help identify key points of contact that governments, businesses, and local initiatives can explore for a fight more effectively against environmental pressures.

As far as the author knows, this is the first study on the public awareness of recycling electronic waste in Kigali / Rwanda. Therefore, we first describe the background of e-waste in Kigali, illustrating the general numbers and public opinion on solid waste issues to characterize this society. Then we review the literature to assess the potential forces that lead to facilitate recycling and recognize the limitations and alternative readings of cumulative evidence. Given the lack of research in developing societies like Kigali, we use as many lessons learned from research based on similar emerging contexts as possible.

2. BACKGROUND

2.1. e-waste in Rwanda

Rwanda is a country in Central Africa, the capital Kigali. Geographically, Kigali is located at 1°57'S 30°4'E. In 2012 [11], Kigali was 10.7% of the country's population, and Kigali is the largest city with 745,261 residents or more million persons living in the well urban area. The garbage portion is about 70% of organic waste, about 13% of non-recycled / imported waste, about 5% of plastics (plastic bottles), about 5% of packaging, 1% of metal and 1% of the waste of **electrical and electronic equipment** and 1% of the hazardous waste. The average waste production is from 1800 to 2000 tons per day[12].

Rwanda faces major challenges in solid waste management[12]. The quantity of waste produced increases and most is disposed of in inappropriate landfills, with negative consequences for the environment and health. Country waste management legislation is implemented and existing efforts to recover and dispose of the waste are properly coordinated and promoted, but the lack of suitable infrastructure rests a major challenge.

Kigali's demand for EEE has increased significantly due to overall economic development and transformation due to the strong demand for various ICT tools as end-user equipment, the increases of EEEs for the side of human health and environment protection needs further treatment strategies of waste from EEEs after end of life of the equipment, and this is very complicated and due to the high price of e-waste collection, facilities are still needed, which can handle e-waste from different sources. According to a survey conducted between November 2014 and January 2015, Rwanda's imports of EEE increased fivefold. The annual growth rate of EEE imports during 2010-2014 is estimated to be approximately 5.95% and had annual generation of 9 417 tons of e-waste; 7 677 tons (81.52%) were from individuals, 1,143 tons (12.14%) were from public institutions, and 597 tons (6.34%) were from private institutions[13], the estimation per capita was 0.9kg/inh[14].

The political and legitimate framework for e-waste management in Rwanda was widely discussed and implemented in 2018, with specific descriptions; (1) National Health Policy - a framework policy for specific policies for the management of e-waste; and (2) National electronic waste policy; The policy guidance and guidance for legal and regulatory tools apply to the management of electronic waste, and (3) The Environmental Law approved by Parliament following the Producer Responsibility Principles (Article 16 - Electronic waste management) provides a legal program of e-waste management. Legal obligations of producers and other institutions, and (4) The Regulation on e-waste accepted by the governing board of the governing body establishes the functions of the various actors, including producers and recyclers, with emphasis on maintenance and renewal and minimum license requirements, as good as sanctions and penalties for violations[14]. However, these legal agreements are largely unknown to consumers (households) and implementation between manufacturers and the informal sector is weak.

E-waste management still presents major challenges. 1) Low consumer awareness: the general public is less aware of the environment, mostly about the challenges and management of e-waste. 2) Legislative and Regulatory Framework: no law obliges consumers and producers to treat and properly recycle electronic waste or compensate the engaged parties. 3) Limited national capacity: currently, the country's capacity to process e-waste is in its infancy and e-waste in developing countries is exacerbated by dumping in the form of donations, second-hand goods or poor quality.

Therefore, it is vital to study the WEEE production model of households considered as an important source of WEEE production. The author claims to be the first to study this questionnaire with topics such as awareness level, WEEE knowledge, reasons for rejection, preferences and WEEE treatment methods. The purpose of this study is to assess the general public awareness, disposal practices and the willingness to contribute to the management of WEEE at the domestic level, and then to imply the results of international regulations and trends in the production of WEEE. This document also provides an opportunity for the accumulation of scientific knowledge from a scientific perspective of developed countries then called for the promotion of the political agenda in the WEEE management system, taking into account international development.

2.2. RWANDA ELECTRONIC WASTE MANAGEMENT INFRASTRUCTURE

The government of Rwanda has set up a dismantling and recycling facility for e-waste which is in provision of helping all e-waste generated in EAC, the dismantling facility has attracted private investment and are currently working in partnership with Enviroserve Rwanda, a subsidiary of Recycling Powerhouse in the United Arab Emirates, in line with the PPP model, and now enviroserve is working forward to sets up collection points/centers across the country[14].

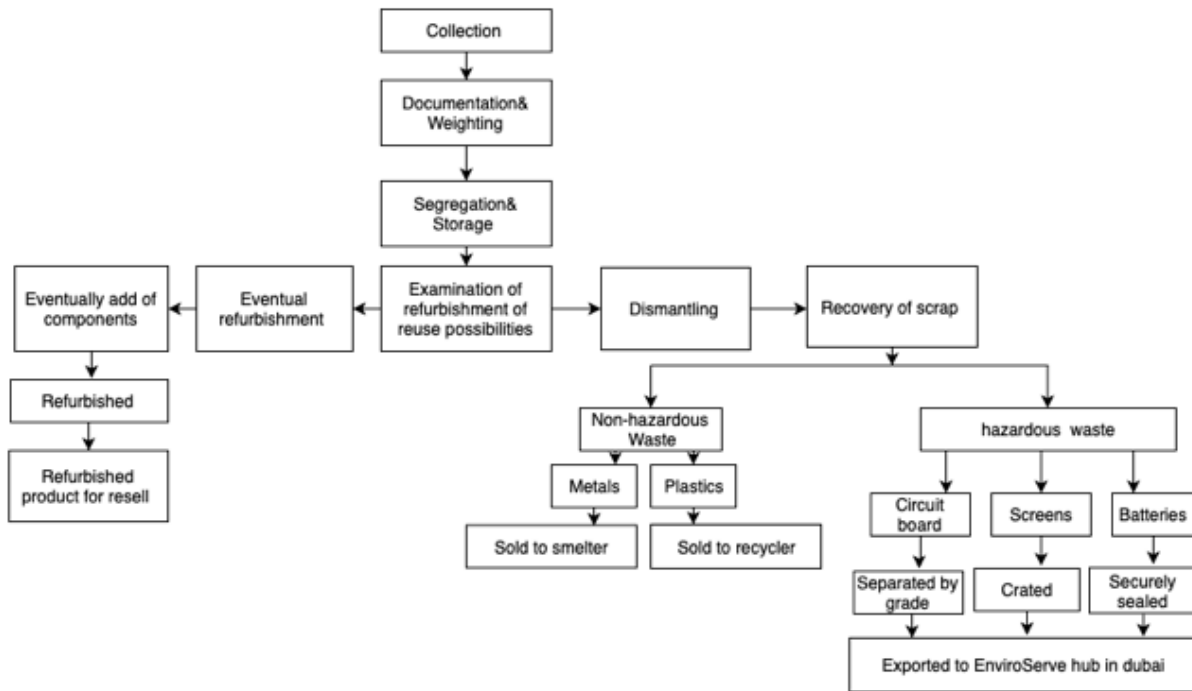


Figure 1: Enviroserve/e-waste dismantling & recycling facility process flow

3. METHODOLOGY

This survey aimed to understand general population behaviors and awareness about e-waste, Public knowledge, and environmental awareness, e-waste management practice disposal method, EEEs utilization, and intention for purchasing new EEEs. The data were gathered using questionnaires, the sample size of the population was calculated using the Slovin’s formula; 200 population samples were used in this study; the distribution of 200 well-structured questionnaires was distributed to the populace with different characteristics; sex, age group, education, and income. 135 responses were received.

Kigali city was selected because it is the capital and biggest city of Rwanda, is located near the geographical center of the country. The city is the economic, cultural and traffic region of Rwanda, it is the first place in a country that uses EEEs, data were collected in 3 different districts within 9 sectors. The study data was analyzing all the answers to each question and comparing demographic information such as gender, age, income, and education. Due to the different demographics of the respondents, the percentages were compared. Data collected from investigations should only be used as a tool to support qualitative information.

Table 1 shows the demographic information of respondents. The factors are grouped as shown in the questionnaire with sex, age, educational qualification and income as factors to be considered. 41.15% of the respondents are male and 51.85% are female. Also, most of the respondents are within the age range of 18-29 was 37.78%, 30-49 was 45.91% and 50 or above was 16.3% which implies all categories were taken into account. In terms of educational qualification, most of the respondents possess; 11.86% was high school, 41.46% was university, and 46.67% was others(Masters and PhD), income status was arranged by 3 categories; >200\$, 200\$-500\$, and 500 and above with the same shared number of respondents.

4. RESULTS AND DISCUSSION

E-waste is the fastest-growing waste streams in the globe due to innovation, due to rapid growth in production and demand for EEE. However, once EEE becomes waste, proper disposal becomes a major problem as it contains many toxic metals. Inappropriate practices in developing countries have negative effects on the environment and human wellbeing. Then they need the most appropriate and efficient technology for the handling of e-waste. Besides, it’s necessary to increase stakeholder awareness and enhance the active participation of individuals in the e-waste management system.

This paper was about to investigate the level of awareness about e-waste in Kigali populace, the focused points were: knowledge about WEEE, willingness to help e-waste facilities, e-waste from household route, motivation for purchasing new EEEs, how EEE currently are in use and changed, and e-waste management policy knowledge.

4.1. EEE UTILIZATION

Table 2 explains how people use the device today. Many respondents noted that PCs, mobile phones, televisions, radios, and air condition are used first and that at least 80.52% of respondents said they owned them and use it often. Other devices such as Internet devices, electrical cooking stoves, water heater system, and cattle are used 53.3% as the remaining EEEs; washing machines, lamps, water dispensers, wires, car battery and electronic iron used at 34.1% shown in table 2. The survey revealed equipment that had been in use for 10 years 60.18%, 35.25% and 23.6 respectively.

4.2. REASON FOR PURCHASING NEW EEES

Many publications showed the different reasons for growing e-waste most are technology and discarded devices. Technology can be the reason for certain devices to lose some functionalities, which is required even on the market use of these devices. These survey findings, 19.3% of respondents their reason for purchasing new EEES were Physical damage, 40% of respondents are loss of function, 20.7% of respondents is needed for greater functionality, and 17.8% of the respondent is the desire for new technology.

4.3. PUBLIC KNOWLEDGE ABOUT WEEES AND THE HARMFUL EFFECTS OF CONTENT.

The survey was administered in households and was responded mainly by one member of household. Questions attempted to access how population consider unused EEE with regarding environmental sustainability, whether (i) can be taken as waste, (ii) discarded but with valuable things that can be removed for another purposes, (iii) not waste as can be repaired or reused and (iv) depend on devices functionality condition.

The respondents were asked to respond to the questions of general awareness about e-waste such as; how they consider unused Electrical & Electronic Equipment to be waste, or to have another purpose! Overall, 54.81% of respondents reported No, can be Repaired and/or Reused, 11.85% of respondents reported Can Utilize Components / Raw Materials, 11.11% of respondents reported Yes, It Is Waste and 22.22% reported that depend on equipment Conditional (dependent on whether the product is functioning) (Fig.1).

And second question about if they perceive any hazards or risks in e-waste, see any hazards or risks to the growing amount of e-waste in Rwanda (Fig.2), Overall, 15.56% of respondents reported No, 37.04% of respondents reported Yes (but no specific information), 9.63% of respondents reported Yes, Toxicity or Safety Hazard, Overall, 22.22% of respondents reported Yes, Environmental Problem, 15.56% of respondents reported Recognition of Both Health and Environmental Hazards. (Fig. 1 and 2).

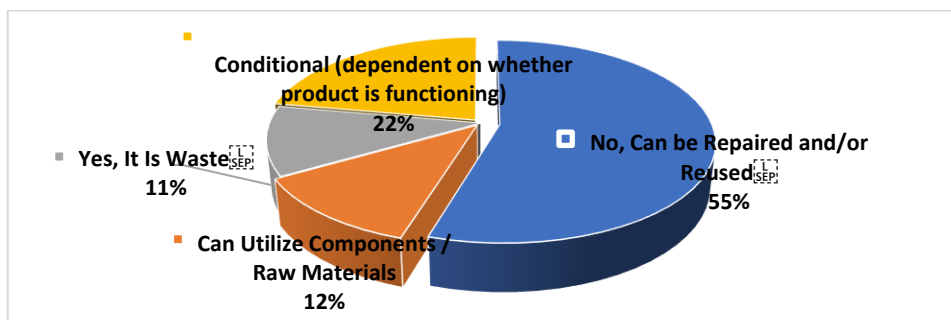


Figure 1: People that consider unused Electrical & Electronic Equipment to be waste, or to have another purpose.

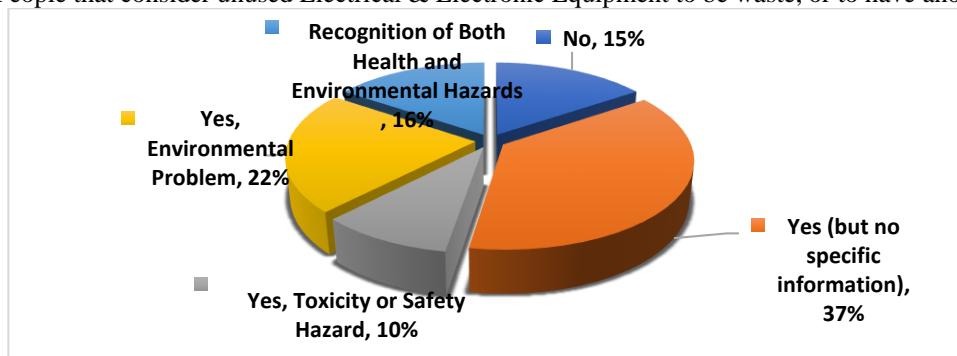


Figure 2: People that perceive any hazards or risks in e-waste, see any hazards or risks to the growing amount of e-waste in Rwanda.

4.4. E-WASTE DESTINATION ROUTE AND RECYCLING FACILITIES

E-waste source has been indicated, it is generated from 3 mains part of the community which is household (individual), public and private institutions, the survey conducted in 2014 shown hug amount of e-waste generated from the individual part which is 81.52%. This survey was about to examine e-waste from an individual since it's helpful in recycling industries to identify strategies for the collection of this e-waste from home. Populace in responses they showed that most of them, 64.4% of respondents keep e-waste in home, 16.3% of respondents give or sell out to any person, 7.4% of respondents sold to informal system, 0% sold to formal system, 4.4% of respondents disposed in trash and 7.4% responded another manner (Fig.5).

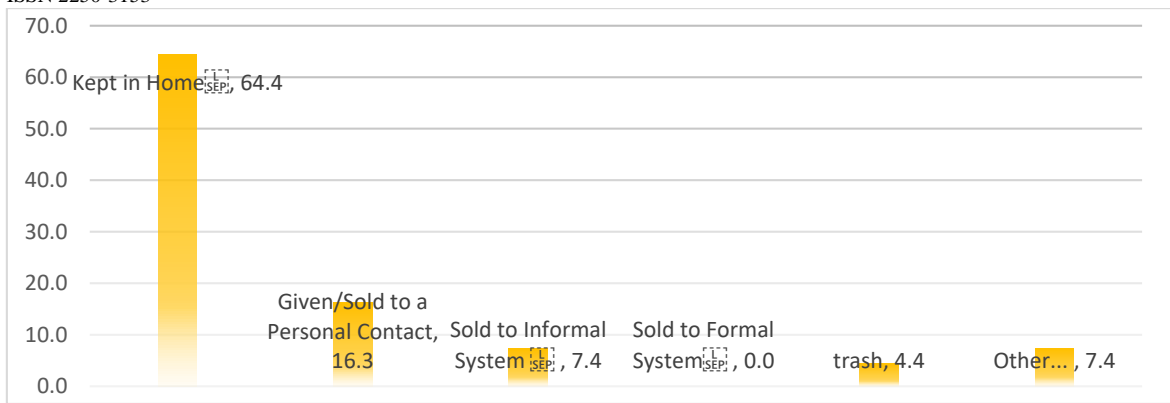


Figure 5: Population perception of EEE that is no longer use.

Recycling facility is compared as the link between users and waste management facilities, and important step toward the other treatment such as recycling, removing valuable materials, dismantling and disposal of residuals. Findings of this survey 67.4% of respondents shown no collection Centre or company collects their e-waste, 17.8% of respondents shown their e-waste collected by the informal sector, while 14.8% of respondents showed their e-waste collected by formal sector (fig.6).

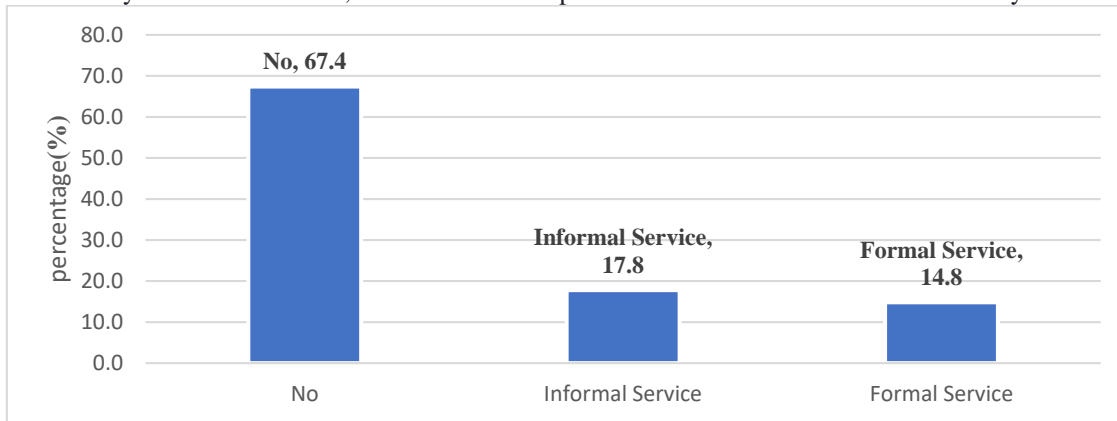


Figure 6: Collection of unused Electrical & Electronic Equipment for reuse, reselling, recycling, or dismantling.

4.5. KNOWLEDGE ABOUT E-WASTE MANAGEMENT POLICY

Rwanda Government established State E-waste Management Policy to tackle E-waste dares, to build awareness of E-waste management, to support capacity building and knowledge in e-waste management, and to avoid an e-waste crisis. We attempted to assess the population knowledge about this policy which is very helpful in e-waste management.

The question was concerned about what people know about any electronic waste management policies currently implemented in Rwanda? If so, what do you know of these policies? 52% stated that they don't know anything about it, 31% stated that no knowledge of policy or governing body and 17% stated that yes, they know any related policy or governing body. These portions illustrate the low awareness about e-waste management policy in the populace.

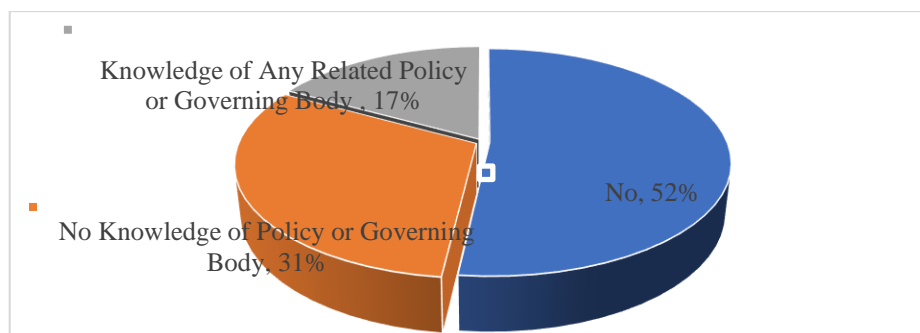


Figure 3: General population knowledge about national e-waste management policy

4.6. WILLINGNESS TO GIVE UNUSED EEES TO FORMAL RECYCLERS FOR FREE OR SELL FOR FURTHER TREATMENT.

Population willingness to give discarded or unused EEES to e-waste facilities is extremely vital for e-waste management as a large stream or source of e-waste, willingness to give out e-waste could be the alternative option of taking back system in

Kigali due to takeback system doesn't work. This survey showed a big part (69%) couldn't give out e-waste to recycling facilities while a small part of people wills to give out e-waste to recycling facilities for free (31%) (Fig 4).

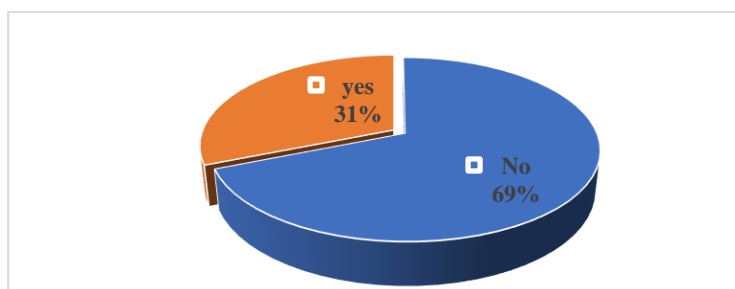


Figure 4: willing to give unused EEs to formal recyclers for free or by selling.

Table 1 demographic data of respondents

Demography variables	N	Percentage(%)
Gender		
Male	65	48.15
Female	70	51.85
Age group		
18-29	51	37.78
30-49	62	45.91
50 or above	22	16.3
Education		
Primary	0	0
High school	16	11.86
University	56	41.49
Others	63	46.67
Income		
>200\$	45	33.33
200\$-500\$	45	33.33
<500	45	33.33

Table2. EEE and utilization in Kigali

variables	Personal computer(laptop)	Mobile Phone	Television set	Internet devices	radio	Car battery	wires	Electronic cooking stoves	Washing machine	lamp	ceiling	Electronic iron	Water dispenser	Water heating system	Air conditions	others
Household use of Electrical & Electronic Equipment	80	100	73.3	53.3	76	27	33.3	53.3	48.1	40	53.3	18.5	37.8	53.3	73.3	0
Household Electrical & Electronic Equipment used frequently	80	100	73.3	53.3	80	27	33.3	53.3	48.1	40	53.3	13.3	30.4	53.3	73.3	0
Devices purchased in the past 10 years	59.3	74	54.3	39.5	59	20	24.7	39.5	35.6	30	39.5	9.9	22.5	39.5	54.3	0

5. CONCLUSION

E-waste management in Rwanda is still in its establishment and e-waste has become a major concern for the environment and human wellbeing all over the world, in developing countries is less compared to developed nations. Therefore, to develop new strategies requires effort of all stakeholders, local authorities approach should be important step to help recycling industries through sensitization of how e-waste should be managed to protect our environment and human wellbeing for the sake of healthier future. The results of this study can help to better understand the state of electronic waste with the general public awareness as to understand the management of electronic waste, in fact general public is immense generation of e-waste. We believe these results will help strengthen the decision-making process to minimize deficient household e-waste management in Kigali City. Besides, the city of Kigali has improved waste management in general but not concerns e-waste from household, its value and the safety of treatment. According to the survey results, it appears that most respondents are ready to be more environmentally conscious, but no knowledge about e-waste in general, regulation and its management. In addition, environmental authorities should adopt more control measures for e-waste management in the city. Moreover, a thorough investigation is needed to improve e-waste management in the city.

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