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Factors Influencing Willingness to Recycle E-Waste in Kisumu City Central Business District, Kenya

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Abstract: **The ever increasing levels of electronic waste (e-waste) and limited capacities for disposal and recycling have worsened e-waste management in Kenya. An understanding of end-user of electronic devices (consumer) participation is fundamental in planning for e-waste management as Kenya has a pending bill on e-waste management since 2013 that stipulates the role of consumers in e-waste management. There is need to understand factors influencing willingness to recycle to inform policy. Various studies suggest socio-economic, demographic and individual preferences influence participation by consumers. Our study relied on Kisumu municipality registry (N = 1,193) to get a sample of businesses and offices to be surveyed in the Central Business District. Using multiple regression model, the authors found factors that influence participation in e-waste drop-off schemes are Income, Education, Gender and Recycling habit but not Age and Awareness levels. Our results suggest that Economic instruments such as deposit and refund programs for e-waste drop-off should be embraced by waste planners to encourage low income earners to participate, there is need for civil education on the benefits.**

Keywords: **E-waste, participation, recycling, socio-economic, demographic, personal factors.**

I. INTRODUCTION

Electronic waste (e-waste) is a generic term encompassing various forms of electronic and electric equipment (EEE) that are old end-of-life or discarded appliances using electricity disposed of by their original users (Fraige *et al.*, 2012 and Qu *et al.*, 2013). E-waste is the fastest growing waste stream globally and this has been attributed to rapid technology development which has led to growth of the electronic industry (Wang *et al.*, 2008). This development has changed the society's purchasing habits and resulted to an increase in production of superfluous electronic and electrical products. According to UNEP (2012), 50 million tonnes of e-waste is produced globally; however, the significant increase in electronic devices has not corresponded to growth in collection, reuse and recycling as a paltry 10% of e-waste produced is properly recycled and recovered due to cost of recycling and limited management options.

Modern electronics contain up to 60 different elements, some valuable such as copper (Cu), gold (Au) and palladium (Pd) that can be recovered and also hazardous elements (Wang *et al.*, 2012; UNEP & UNU, 2009). Toxic elements such as lead (Pb), cadmium (Cd), mercury (Hg) have adverse impact on human health and the environment, therefore, proper management is necessary to not only gather value in health and environmental protection but also resource conservation.

To address the emerging e-waste problem at a global scale, legislations have been formulated through Basel convention as e-waste is classified as hazardous waste. Policy pieces such as the Mobile Partnership Initiative have been adopted through conference of parties to the convention to address the increasing numbers from this device (www.basel.int). In the European Union (EU), there are directives on waste electrical and electronic equipment (WEEE Directive, 2002/96/EC) and also, restriction of the use of certain hazardous substances in EEE (RoHS Directive, 2002/96/EC) which require, heavy metals and flame retardants to be substituted by safer alternatives. However, some EU states have faced challenges complying with the regulations that were enforced in February 2003, but some like Netherlands and Greece have successfully operationalized the directives (Wang *et al.*, 2011 and Kahhat *et al.*, 2008).

Another strategy that has been employed in e-waste management is Extended Producer Responsibility (EPR). This is an environmental policy approach in which it is the producer's responsibility to reduce environmental impact and manage the product across the whole life cycle, from selection of materials and design to its end-of-life, and especially for their take-back, recycling and disposal (www.eprclub.eu). The form of implementation varies from country to country, ranging from mandatory regulations to voluntary agreements between government and industry to voluntary industry initiatives. Switzerland was the first country to apply this principle in e-waste management with setting up of three Producer Responsibility Organizations; SWICO (Swiss Economic Association for the Suppliers of Information, Communication and Organizational Technology), SENS (Swiss Foundation for Waste Management) and SLRS (Swiss Lighting Recycling Foundation) that have transformed collection, transport, recycling, inspections and reporting of the take-back and recycling system (Kahhat *et al.*, 2008).

In the Unites States, e-waste management schemes vary from state to state. In some, there are permanent collection facilities that are collocated with municipal hazardous waste collection programs, drop-off special events, retail collection programs, curb side recycling and non-profit or thrift retail collection (Nixon *et al.*, 2009). The success of these schemes is dependent on participation level in drop-off by consumers. In Asia, e-waste management policy has taken a punitive approach. For instance, in Japan, recycling is enforced through Home Appliance Recycling Law that compels consumers to pay for recycling and transportation costs and also obligates retailers to collect and transfer discarded products from consumers. South Korea has a similar approach with financial consequences placed to ensure producers, distributors and consumers of EEE achieve recycling targets. Consumers pay for collection through the local government collection system. Alternatively, they can pay private collection companies that offer collection services or have a 100% waiver on recycling fee if they return the old equipment to the retailer when purchasing another (Kahhat *et al.*, 2008).

According to Kahhat *et al.*, (2008), the success of one system does not necessarily portend success in another country therefore; the development of a sustainable e-waste system should begin with understanding the culture within which the material flows take place. Nnorom *et al.*, (2009) acknowledged the importance of consumers in e-waste flow and emphasised need to understand factors influencing their participation. Factors such as socio-economic characteristics, environmental attitudes and beliefs influence participation in e-waste recycling programs (Ongondo & William 2011). Other researcher have found demographic factors and individual factors like convenience in recycling influencing participation in recycling (Saphores *et al.*, 2006). In a later study, Saphores *et al.*, (2012) found moral norms, recycling convenience, priori-knowledge of toxicity of e-waste, recycling experience, and demographic factors such as gender and marital status as principal determinants of participation by residents in California. Song *et al.*, (2012) assessment of Macau residents′ found age, education level and income as the significant factors in willingness to pay for e-waste recycling schemes. Nixon *et al.*, (2009) suggest that ignoring environmental attitudes and beliefs leads to biased estimates in participation outcomes by consumers.

Consumer participation outcomes have been explored in developed e-waste systems characterized by strong institutional framework that have facilitated development of e-waste mangement infrastructure (see Darby & Obara, 2005; Nixon *et al.*, 2009; Saphores *et al.*, 2012; Saphores *et al.*, 2007 and Rolls *et al.*, 2009). However, not much is known in developing countries which are in the process of formulating e-waste regulations. Most African countries are currently facing challenges with not only internally generated e-waste, but also importation knock-off EEE and e-waste in guise of donations for charity (Nnorom *et al.*, (2009).

A report by UNEP (2007) posited that businesses, government departments and municipal offices were the earliest adopters of information and communication technology (ICT) and therefore, has the highest penetration of ICT equipment. However, e-waste management system has been assessed from household participation perspective leaving out commercial sources. Participation of organizations and individual consumers in business is not known, especially in developing countries where penetration of EEE is significant within the business community.

Kenya produces 11,400 tonnes from refrigerators, 2,800 tonnes from TVs, 2,500 tonnes from personal computers, 500 tonnes from printers and 150 tonnes from mobile phones per annum and the lack of clear disposal mechanisms has resulted in excessive stocks being held consumers' (NEMA, 2010).There is great need to address this challenge considering technical solutions for e-waste processing are available in Kenya, but a legal framework for collection, logistics, and other services are yet to be implemented. Regulations have been proposed by the National Environment Management Authority that requires participation from all stakeholders, of interest, is participation from consumers who

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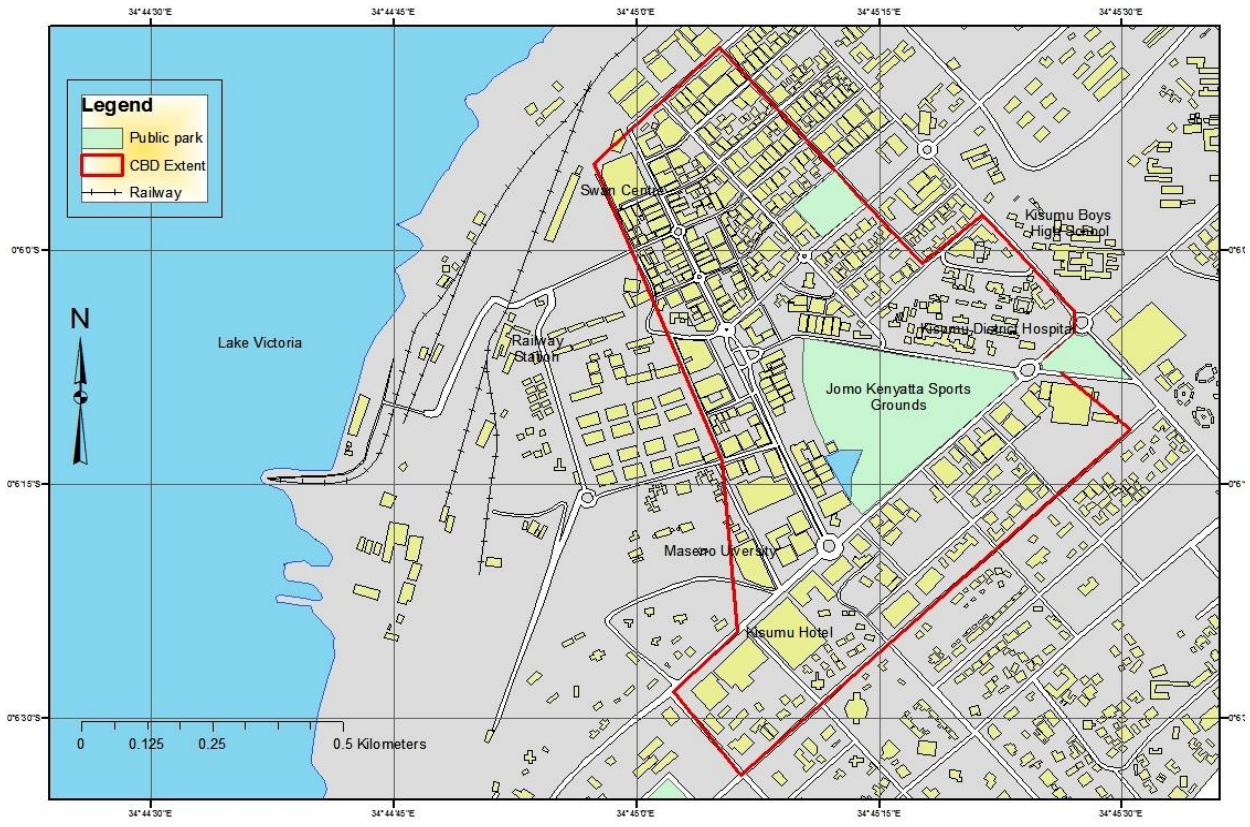
are the nexus between producers and recyclers. The regulations proposes consumers to dump e-waste at the licensed dumping site specified for the e-waste, sell or donate e-waste to licensed refurbishers, take back equipment to the manufacturer, importer or assembler and to separate e-waste from other wastes to facilitate collection. Therefore, there is need to establish factors that will influence participation so that interventions are sensitive in their approach. This paper looks at influence of socio-economic-demographic factors as well as individual characteristics on willingness to participate in e-waste recycling programs.

2. MATERIALS AND METHODS

Kisumu city is the third largest city in Kenya and stands on the eastern shores of Lake Victoria, at an altitude of 1160m above sea level and is situated approximately 00^0 06' South of the Equator and 34^0 45' East of Greenwich. The Central Business District is approximately 69.5 hectares (see Fig.1) and the extent of the CBD was determined through a consultative process involving the Municipal planning officer and the Municipal Council Town manager/clerk. As at 13/7/2013 f, the Kisumu Municipal Council registry had about 1,193 registered businesses operational within the CBD. The distribution of businesses was as follows; Retail and wholesale accounted for 30% of the businesses, professional services 25%, financial services 22%, hospitality 9% construction and transport were 14%.

The study adopted a cross-sectional design where data was collected one-off through questionnaires to assess influence of consumer's socio-economic, demographic and individual factors on willingness to participate in e-waste recycling. The respondents were looked at as individual entities and not corporate entities representing their business. The questionnaires were administered face to face and were pretested on 15 business owners in the CBD, then adjusted appropriately to address reliability and validity of measurements. The pre-test sample was informed by Canell *et al.,* (1989) conclusions that a sample size of 10-100 respondents is sufficient to highlight problematic areas in a survey tool. The pre-test was conducted in June, 2013 and the survey carried out in August, 2013. The respondents were the business owners and representatives.



Source: Author

Figure 1: Kisumu City

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After pre-testing the tool, the survey was conducted. The researchers sought informed consent from business owners, questionnaire-based interviews with business owners were conducted by locally recruited enumerators under the supervision of a researcher. Business owners were asked if they agreed it is their responsibility to drop off e-waste at recycling centres. Preferred Drop-off schemes were also given based on proposal in the NEMA, (2010) e-waste regulations.

A sampling size was calculated using the equation adopted from Fisher *et al* (1983) for finite population. A sample size of 290 businesses was derived from Kisumu Municipal council registry that had 1,193 businesses registered within the CBD. The size was determined at 95% confidence level and the sample was stratified as per the business classes in the Kisumu business registry. The finite population of 1,193 businesses was divided into 5 strata. The strata were retail and wholesale traders; professional services; financial and commerce; hospitality; and Construction and hardware businesses and from the strata, systematic random sampling was done to get n^{th} representative for sampling.

2.1 Modelling participation in e-waste recycling:

This section investigates the effect of socio-demographic characteristics (gender, age and education), socio-economic characteristics (income and occupation type) and individual characteristics (e-waste awareness level and recycling habit) on willingness to participate in e-waste recycling program.

Willingness to participate in e-waste recycling was modelled using linear regression in the form of:

$$Y = \beta_o + \beta_1(X_{1i}) + \beta_2(X_{2i}) \ldots . + \beta_k(X_k) + \varepsilon_i$$

$$Participation = \beta_o + \beta_1 Gender + \beta_2 Age + \beta_3 Education + \beta_4 Income + \beta_5 Occupation + \beta_6 Awareness + \beta_7 Recycling\ habit + \varepsilon_i$$

Where Y is a straight-line function of each of the X variables, holding the others fixed, Y seeks to measure the probability of the respondent being the recycler and the X_s are explanatory variables hypothesized to influence the probability of paying for recycling, β_s are the coefficients of the explanatory variables, and ε represents the stochastic disturbance term.

3. RESULTS AND DISCUSSIONS

3.1 Socio-demographic–economic-individual characteristic of the respondents:

A total of 286 responses were received from the survey. The study was done within the CBD where a population of 1,193 businesses are operational, the response rate represent 98% of the 290 businesses sampled. Table 2 presents the summary of key factors considered in the model for participation in dropping-off e-waste recycling centres. The socio-economic-demographic-individual characteristics of the business owners in the CBD are given and the results show majority of business owners were at college level in terms of education level.

Table 1: Descriptive statistics for variables in the model

Variables	Scale	N	Mean	S.D.
Independent Variables				
Income (x_1)	1=<Kes 10,000 2=Kes 10,001-25,000 3=Kes 25,001-35,000 4=Kes 35,001-50,000 5=Kes 50,000>	286	2.24	1.037
Gender (x_2)	1=male 0=female	286	0.55	0.498
Age (x_3)	1=<18 years 2=18-30 years 3=31-40 years 4=41-50 years 5=50> years	286	2.60	0.774
Education (x_4)	1=secondary 2=college 3=university	286	2.21	0.66
Occupation (x_5)[a]	1=Retail & wholesale 2=Financial services 3=Professional services 4=Hospitality 5=Construction & Hardware	286	-	-
Recycling Habit (x_6)	1=recycles waste 0=no recycling	286	0.12	0.324
Awareness (x_7)	1=Have no idea 2=Know very little 3=Know 4=Know quite well 5=Very familiar	286	1.73	0.35
Dependent variable				
Willing to participate	1. Strongly disagree 2.Disagree 3. Neither disagree nor agree 4.Agree 5.Strongly agree	286	0.78	0.413

(x_5)[a] = 1(29%), 2(22.7%), 3(24.5%), 4(8.7%), 5(15%)

Majority of business owners (n=286) are male and fall between age brackets 18-30 years (M =2.60, S.D. = 0.774). The latest census which found among the economically productive groups, ages 20-30 years form the majority (KNBS, 2009). The income levels shows over half (52%) of the sample fall at middle income class. The predominant occupation the CBD is professional services (25%) and financial services (23%) both accounting for almost has of the sample. Professional services include groups dealing in activities such as accounting, consulting medical practitioners, whereas financial services included those who were in money transfer services and allied activities.

The awareness levels with regards to possible harm and benefits that results from management of e-waste were summarized. The findings show awareness levels is low (M =1.73, S.D =0.35) as less than a quarter of the sample (N = 281) were aware of there is a regulation in place stipulating the responsibility of consumers. Currently, recycling practice is very low with regard to solid waste in general, majority of the respondents do not have a recycling culture and this is evident by the low average on the binary scale (1,0) was 0.12 (*SD* =0.324).

3.2 E-waste management in Kisumu city CBD:

There is no e-waste management infrastructure in Kisumu CBD, all efforts towards e-waste management are informed by current Solid Waste Management practices and in-house strategies developed at organizational level. Results on figure 2 shows end of life management of e-waste. Much of the e-waste from businesses is in storage (61%), e-waste destined for re-use was either sold as second-hand goods (16%) or donated (2%) and few were recycled (3%). Another avenue of management was returning to seller for onward conveyance to recycling facilities and only (1%) of the consumers surveyed had such an agreement with retailers and finally, disassembly for re-use was low (2%) and this can be attributed to some of the WEEE have limited re-usability.

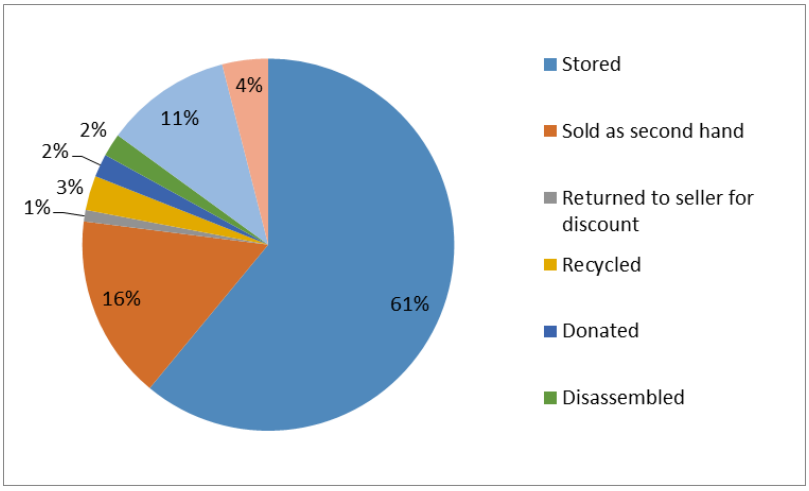

Figure 2: E-waste management practices in Kisumu CBD.

The high frequency of WEEE in storage reflects the situation in Nairobi city where lack of a policy and legislative framework, and the absence of practical e-waste management system has led to huge stockpiles of e-waste (Waema & Mureithi, 2008). The same observation was made by Garcia (2011) findings that established 64% of mobile phone consumers' had them in storage due to lack of recycling opportunities. Lack of e-waste management options for the consumers in Kisumu CBD can be linked to low financial outlays by the municipal council towards waste management in general. There are is no e-waste management infrastructure that addressing collection, transportation, recycling and disposal of e-waste.

3.3 Participation in E-waste Management:

A multiple regression was conducted to assess influence of socio-economic, demographic and personal factors on participation in e-waste recycling. An analysis of standard residuals was carried out, which showed that the data contained no outliers (Std. Residual Min = -2.068, Std. Residual Max = 3.193). Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (Income, Tolerance = .685, VIF = 1.459; Education, Tolerance = .770, VIF = 1.298; Age, Tolerance = .848, VIF = 1.179; Gender, Tolerance = .967, VIF = 1.035; Recycling habit, Tolerance = .903, VIF = 1.108; Awareness levels, Tolerance = .880, VIF = 1.136; Income 1, Tolerance = .953, VIF

= 1.050; Income 2, Tolerance = .966, VIF = 1.036). The data met the assumption of independent errors (Durbin-Watson value = 1.662). The histogram of standardised residuals indicated that the data contained approximately normally distributed errors, as did the normal P-P plot of standardised residuals, which showed points that were not completely on the line, but close and the scatterplot of standardised predicted values showed that the data met the assumptions of homogeneity of variance and linearity.

Using the enter method it was found that some of the independent variables explained a significant amount of the variance in participation in e-waste recycling (F (8, 277) = 15.431, $p < .05$, $R^2 = .55$, $R^2_{Adjusted} = .288$). The analysis shows that of the demographic factors, Age did not significantly predict value of sales per week (β = .050, t(285) = .684, p = .495), however, Gender did significantly predict participation in recycling (β = .281, t(285) = 2.641, p < .05). Among the socio-economic factors, service based occupation (Occupation 1) (β = .003, t(285) = 0.27, p = .978) and retail based occupation (Occupation 2) (β = .184, t(285) = 1.649, p = .100) did not predict participation. Both Income levels (β = .285, t(285) = 1.649, p < .05) and Education levels (β = .430, t(285) = 1.649, p = .05) predicted participation in e-waste recycling. However, from the analysis, Education levels had better predictive power than Income levels. When it came to personal factors, Awareness levels did not predict participation (β = .002, t(285) = .061, p = .951) but Recycling habit predicted participation (β = .479, t(285) = 2.905, p < .05).

Among the demographic factors, our findings showed Age was not a significant factor in predicting participation in e-waste recycling. This contradicts most studies on e-waste recycling behaviour that agree age is a predictor; however differences have been noted by the type of correlation (positive or negative). For instance, Saphores *et al.,* (2012) found positive relationship between recycling behaviour and age whereas Colesca *et al.,* (2014) study had a negative relationship. Colesca *et al.,* (2014) found the young are more inclined to keep up with fashion trends when it comes to ICT products whereas, the older generation (65 and above) use the same fridge for more than 30 years and have never used in their life an ICT product. So, difference between generations regarding the use of technology was deduced to explain that younger are more inclined towards WEEE recycling than elders. This has not been replicated locally as a study by Sije & Achieng' (2013) in Kisumu city found much of e-waste is in storage as consumers have emotional attachment to old electronic equipment and still consider them valuable. Also, since the study was done in the CBD, majority (86%) of the consumers are in the active age group (18-40 years) there is a possibility that participation may be view as an interference with their work schedules as most of the respondent were in full time employment. Gender significantly predicted participation in e-waste recycling. Saphores *et al.,* (2006) found Women were more likely to have pro-environmental behaviour therefore influencing their willingness to drop-off e-waste at recycling centres. However, our findings show that Male were more likely to participate in recycling program. Education was the best predictor for participation, individuals with higher education levels were more likely to participate in recycling. The findings are in agreement with Nixon & Saphores (2007) and Song *et al.,* (2012) studies on willingness to pay for advanced recycling fees. Our findings established that education level do not correlate with awareness levels as individuals with higher levels were found to have low awareness on e-waste issues. Saphore *et al.,* (2012) study concluded that educational attainment is an ineffective proxy for specific knowledge about the public health/environmental consequences of improperly disposing of e-waste.

Income was significant in predicting participation as Individuals with higher income were more likely to participate than lower income groups. This contradicts Saphores *et al.,* (2006), Wang et al., (2011) and Saphores et al (2012) studies that focused on household income though few studies have looked at commercial sources of e-waste. Dwivedy & Mittal (2013) study on willingness of residents to participate in e-waste recycling in India, realised similar results and the authors attributed influence of income on economic benefits that can be accrued from recycling. Households consider it a privilege to explore economic benefits when they dispose their e-waste. Therefore, when economic benefits are not accrued in dropping-off e-waste, participation from lower income groups diminishes. This applies to Kisumu CBD, analysis on the most preferred drop-off scheme (see fig. 2) shows deposit-refund to be the most preferred (58%) in comparison to other schemes. Dropping-off at electronic and electrical equipment (EEE) shops for discount on new EEE had a frequency of 21%. Though drop-off at retail shops offers economic gain, it does not resonate with the residents because valuable waste is usually sold as a good in exchange for cash, this has been the case with scrap metal, some plastics and old newspapers that have ready market within Kisumu city as there is a formal market with licensed waste vendors. Occupation was broadly classified into two, those that are service oriented and those that are retail based. Both classes did not predict recycling.

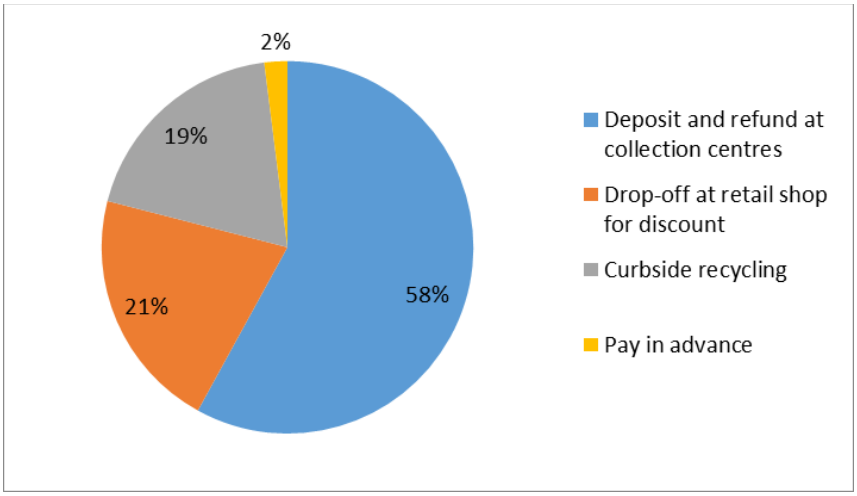

Figure 3: Preferred Drop-off scheme

A look at personal factors shows that only consumers with a tendency to recycle other forms of waste are most likely to participate in in e-waste drop-off program. Awareness levels did not predict participation. This can be attributed to low awareness levels among the consumers (n = 286) averaged 1.73 ± 0.35 on a scale of 5 items. A breakdown of the survey questions showed about 14.1% were aware on e-waste issues and problems concerning e-waste while the remaining have very low understanding of the problem. Waste recycling habit predicted participation; about 12% had waste management plans and sorted their waste for disposal were more likely to participate in dropping off e-waste at recycling centres in Kisumu CBD. Saphores *et al.*, (2012) and Sidique *et al.*, (2010) found familiarity with curbside recycling for conventional household play a minor role in influencing participation however, for our case, recycling habit plays a significant role in predicting participation in e-waste recycling.

The consumer preference toward different modes of e-waste recycling as shown in Fig. 3 reveal that pay in advance for e-waste collection is least favoured (2%). This is unexpected as current practice in solid waste collection entail private waste contractors being paid upfront for waste collection. However, this can be explained from an economical point where e-waste is still viewed as a resource and not a liability. Curbside recycling would work with small EEE that might not be valuable in terms of resale, items such as cartridges, lightbulbs, phone chargers would adequately be collected through this scheme.

4. CONCLUSIONS

The objective of our research was to shed some light on factors influencing consumers' willingness to recycle e-waste in order to inform policies proposed to handle the growing e-waste problem. Studies have shown there is increasing demand for EEE but not capacity and infrastructure to manage this waste stream. Our results show that current e-waste recyclers are more likely to be more educated male with higher income and have had prior experience with recycling other forms of waste. About one-tenth of our respondents have strongly agreed it they ought to drop-off e-waste at recycling centres, close to a half of them agreed to do so. Knowing that e-waste contains toxic materials matters does not influence willingness to participate in e-waste recycling and also, age does show no significant associations with recycling.

The results suggest the fact that significant proportion of the consumers are not aware of the e-waste and the consequences of improper management, this shows that policy implementers should first and foremost carry out a rigorous sensitization program about the potential toxicity of e-waste and the potential public health impacts of its improper disposal. Drop-off recycling facilities should be established and to enhance participation, deposit/refund scheme (where consumers pay a fee when they purchase a product and get it back when they return it at the end of its useful life) should be considered in Kisumu CBD as it's the most preferred by consumers. Since financial outlays are dire in the municipality to set up drop-off facilities, these services can be carried out through a private-public partnership and this could be achieved by contracting existing EEE retail shops as collection centres. Future research could further explore obstacles to e-waste recycling among female and look at how effective deposit refund programs can be implemented.

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