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A Critical Evaluation of the Environmental Effects of the Existing E-Waste Management Practices in Kenya

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Abstract**—** *Information Communication Technology (ICT) gadgets and other electronics are extensively being used in the health, industries, education, homes, communication and trade sectors. With the expected introduction of use of laptops in primary schools in Kenya, the use of these electronics is expected to drastically increase, thus, leading to an increase in electronic waste. Although e-waste has parts and components of value, they contain many toxic components, which prompt a potential need of this research to assess the contents, qualities and impact of e-waste material. The purpose of this paper is to evaluate the environmental implications of the existing e-waste management practices. The study adopted survey research design. The sample population included 18 policy officers in County Government of Bungoma, 28 electronic shop repairs, and 61 institutions and collectors of e-waste material. The study is expected to provide guideline on Green ICT practices and e-waste management as a platform for evaluation, policy enforcement, guidelines and further research on electronic waste management*.

Keywords**—** *E-waste management, environmental effects, Green ICT*.

I. BACKGROUND INFORMATION

There has been an exponential growth in use of technology in the recent past, more so, in the production and purchase of electronic devices. Some of these include; television sets, mobile phones, computers, printers and their respective associated components among others. The emerging concern is how to use these devices and how to discard them when they are out of service. There is need for a sustainable way of tackling the environmental, economic, and social aspects of the current situation without compromising the survival of upcoming generations.

Environmental sustainability refers to the rates of renewable resource harvest, non-renewable resource depletion and pollution formation that can be continued forever [1]. This involves meeting human needs without necessarily compromising the healthiness of the ecosystems. Environmental sustainability is important to ensure the provision of clean water, air and clean productive land [7].

Environmental dilapidation is amongst major threats formally cautioned by the High Level Threat Panel of the UN [8]. This is the practice where the environment including, land, water and air, are subjected to continuous contamination, damage and wrecking. It is also the weakening of the environment through exhaustion of resources such as air, water, soil and forest and the damage to the eco-systems [2].

The overwhelming use ICT devices in learning institutions, both private and public offices, is attributed to affordability of the devices and spontaneous obsolescence of electronics hence increased creation of electronic waste. To this end, it is worth noting that electronic waste contains chemicals that are destructive both to the environment and to life of organisms.

E-waste generation in Africa is growing very fast each year. This is attributed to rising importation of electronic goods, legal and illegal importation of second hand and near end of life electronics [3].

Examining e-waste state of affairs in East Africa, examination of the available literature indication that Tanzania, for example, lack defined regulation or policy related to management of electronic waste [4].

Technology is inevitably increasing spontaneously making EEE become outdated in an alarming speed [2]. In Kenya, this condition is made worse since the country is a favourable dumping zone for second hand or refurbished computers which are cheap and easily available [5], a practice that has led to faster generation of e-waste. Electronic waste management is typically practiced by informal sector, also known as the *Jua Kali* sector, majority of who are workers in electronic repair shops. They have insufficient skills, are neither registered nor authorized [5]. They dismantle and discarded electronics to obtain important usable parts, e.g., scrap metals and electronics. Whatever remains is disposed off alongside other domestic waste thus poses one of the greatest environmental challenges in the country [5].

E-waste components have poisonous materials that have likelihood to harm the environment. Availability of dumping space is reducing which has also escalated costs of getting rid of e-waste [2]. The presence of toxic substances including cadmium, mercury and lead, among others in e-waste require critical intervention. The current structures in place to collect and process recyclables was designed for traditional solid wastes, most of which are decomposable.

A unique way is necessary for handling requirements needed to collect and process electronic waste. Consumers and other electronic waste generators desire suitable recycling and disposal opportunities. Kenya corresponds to other African countries that lack or do not implement specific policies and regulations for electronic waste management [5]. This research investigated the existing electronic waste policies and management practices with the sole aim of providing a model towards effective control of e-waste products before they complicate the situation.

II. METHODOLOGY

The study used the survey research design including both descriptive and exploratory researches. Data was collected

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through document review of policies and legislation, interviews with stakeholders and observation. Primary data was obtained through administration of three sets of questionnaires and an interview schedule. The instrument for data collection were pre-tested (piloted) and readjusted to ensure accurate capturing of required data. The study was conducted in Bungoma County, which is located on the Southern part of Mount Elgon. It neighbours Trans-nzoia to the east, Uganda to the North, Kakamega County to the South and Busia County to the West. The study population comprised of stakeholders i.e. county government officers (the Ministry of Education, Science and Technology and Ministry of Health, Ministry of Water and Sanitation), electronic repair shops, e-waste dealers, secondary and tertiary learning institutions.

III. TOOLS

Research instruments are the tools and techniques used in the process of collecting data on the phenomenon underpinning the study [6]. For this study, content analysis, questionnaires and interview schedules were used.

Content analysis involves analysing contents of documented resources such as magazines, books, journal articles, newspapers and the contents of all other verbal materials, which can be either printed, or spoken [6]. [6] Describes secondary data as raw information gathered by others and found by the researcher in censuses, ethnographies and histories. This method was used to analyse existing policy frameworks, e-waste management practices and their challenges. Hence, the method was used to collect and analyse literature on previous research in the study area to establish strengths, weaknesses and trends in e-waste management. The approach of using both primary and secondary data was to improve the credibility of the study results.

Both open ended and closed questionnaires were designed, pre-tested and finally administered respondents which included member of electronic repair shops, e-waste dealers, County government offices, dump sites tertiary institutions and secondary schools. Questionnaires were used due to their ease of administration and their capability to collect large amount of data using the same questions within a short period. This technique was used to collect data that was quantitative in nature from the respondents.

Interview method involved gathering data from the respondent through face-to-face interaction. The technique was used to collect data from officers of county government Bungoma. It was used as a complimentary tool to questionnaires. It aimed at getting deep insight what the questionnaires did not capture by observing and providing clarification on unclear responses.

To evaluate the environmental implications of the existing e-waste management practices	Primary Secondary	Literature review, Interviews	Books, Journals, Interview guides, Questionnaires

IV. RESULTS

The instrument response rate represents the percentage of the sample that contributed in the study as planned in the research procedures. Among the 107 questionnaires administered, 87 were completed and given back for analysis as indicated a return rate of 81.3%. A response rates of 50% is considered acceptable to analyse and publish.

There are potential adverse effects posed by increased use of electronics, especially the products thrown away or scorched, they present health risks due to the toxic material they contain. This goes a long way to damage the environment. This sub-section sought to gather and analyse data regarding the implications of the existing E-waste management practices. To understand various environment challenges exposed, the following guiding question was posed "What are the environmental risks associated with improper e-waste disposal and handling". Table 1 summarizes the findings on environmental risks associated with existing e-waste management practices.

TABLE 1: Environmental Risks

		Frequency	Percent
Valid	Pollution	49	56.3
	environmental hazards	37	42.5
	Others	1	1.1
	Total	**87**	**100.0**

Table 1 reveals that 56.3% of the respondents pointed out pollution as a major environmental risk, with majority mentioning lead, mercury, cadmium, chromium and beryllium as the main chemicals in the e-waste. There was a 42.5% who indicated that e-waste expose them to environmental hazards such as injuries during repair or on landfills and breeding ground of harmful vectors. While 1.1% mentioned other implications including accumulation of chemicals in the soil and water that find their way into the food chain and altering soil and water P^H.

Health Implications of the Existing Management Practices of E-Waste

To understand various health risks exposed due to poor management of e-waste materials, the following guiding question was posed. "What are the health risks associated with poor e-waste disposal and handling?" The findings on this question are tabulated in Table 2.

TABLE 2: Health Risks

	Type of Health Implication	Frequency	Percent
	Carcinogenic	26	29.9
	Respiratory problems	15	17.2
Valid	Cardiovascular problems	16	18.4
	Not aware	30	34.5
	Total	**87**	**100.0**

Table 2 indicates that, 34.5% of the respondents were not aware of any health risk associated with poor e-waste management and disposal. A 29.9% indicated that, e-waste is carcinogenic thus causing various types of cancer, while, 18.4% indicated that it causes cardiovascular problems. Those

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who reported that e-waste causes major health problems more so, respiratory system was at 17.2%.

Challenge Involved in E-Waste Management

The study also tried to determine some of the challenges experienced by respondents in Bungoma County on management and disposal of electronic waste. To get the data, respondents were required to respond to the question, "What challenges do you face in management and disposal of e-waste?" Their responses are summarised in Table 3.

TABLE 3: E-Waste Management Challenges

	Type of Challenge	Frequency	Percent
Valid	Funding	57	65.5
	lack of awareness	17	19.5
	lack of infrastructure	11	12.6
	policy enforcement	2	2.3
	Total	**87**	**100.0**

Table 3 indicates that lack of funds, which is represented by 65.5%, is the major challenge. This is followed by lack of awareness at 19.5% while 12.6% represents those respondents who believed the challenge is lack of infrastructure. A minority 2.3% indicated that the challenge is due to lack of policy enforcement. This implies that e-waste management and disposal has not been given any priority in the in Bungoma County.

Possible Solutions to e-waste Management Challenges

The study sought to examine if the respondents could suggest solutions to the challenges of electronic waste management and disposal by posing the question, "what do you propose as solution to e-waste management challenges". The summary of the findings is presented in Table 4, on solutions to e-waste management challenges.

TABLE 4: Solutions to e-waste Management Challenges

		Frequency	Percent
Valid	e-waste management institutions	36	41.4
	e-waste management programs	32	36.8
	Extended producer responsibility (ERP)	13	14.9
	Others	6	6.9
	Total	**87**	**100.0**

From Table 4, it is revealed that 41.4% of respondents are of the view that institutions exclusively deal with e-waste management should be set up and funded. A 36.8% indicated that e-waste management programs should be set up within the existing departments to manage e-waste, 14.9% indicated that extended producer responsibility (ERP) should be used where e-waste is collected and send back to producers for recycling. A minority, 6.9% of the respondents gave other solutions like setting up legislations that ban importation of e-waste, tax incentives for scrap dealers, disposal fee for manufactures and consumers, subsidy on disposal and recycling industries along with promotion of awareness of e-waste dangers.

Electronic Sources

The study sought to find out the source of electronic materials. Table 5, gives a summary of the findings.

TABLE 5: Electronic Sources

	Source	Frequency	Percent
Valid	Retail Shop	12	13.8
	General Distributors	14	16.1
	Leased Items	5	5.7
	Refurbished	34	39.1
	Not Aware	22	25.3
	Total	**87**	**100.0**

From Table 5, majority of the respondents (39.1%) indicated that most of electronic material are obtained from refurbished centres. An average (16.1%), marked general distributor, 1.38% indicated retail shops as the sources while 5.7% leaned towards leased item. Notably, 25.3% of respondents were not aware of the source of the electronic material they use. This implies that most electronic material used in are from refurbishing centres thus pointing out concern of the lifetime of such material.

Electronic Equipment

The study also sought to understand the type of electronic equipment mostly used by the respondents. This data is given by Table 6, which summarizes the findings.

TABLE 6: Electronic Equipment

	Electronic Equipment Mostly Used	Frequency	Percent
Valid	Computer System	30	34.5
	Photocopier and Printers	20	23.0
	Television and Radio	10	11.5
	Mobile Phones and Tablets	17	19.5
	Others	10	11.5
	Total	**87**	**100.0**

From Table 6, most respondents recorded computer system as the major electronic equipment they use at 34.5%. Another significant number indicated photocopier and printers at 23.0%, mobile phones and tablets at 19.5%, television and radio at 11.5% while other electronic equipment such as fridges, iron box, projectors etc. accounting for by 11.5%. This implies that majority of electronic equipment or devices used in the study domain were computer system, photocopier and printers accounting for 57.5% of electronic devices.

Protective equipment

The researcher sought to find out if the respondents use protective equipment when using or dealing with sensitive electronic equipment. Their data is shown in Table 7 as summary of findings.

TABLE 7: Protective Equipment

	Type of Protective Gear	Frequency	Percent
Valid	Gloves	10	11.5
	Face Masks	5	5.7
	Boots	1	1.1
	Overalls	20	23.0
	Goggles	10	11.5
	Ear Muffs	41	47.1
	Total	**87**	**100.0**

Table 7 reveals that most protective equipment used are ear muffs at 47.1%, wearing an overall was at 23.0%, while using cloves and goggles tallied at 11.5% each. Facemasks had 5.7% while boots recorded the lowest percentage of 1.1%.

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This implies that majority of respondent use protective equipment when working with the electronic materials hence this goes along way describing the safety of the respondents from the harm that are associated with the electronic equipment when in operation.

Hazardous Material

The study sought to find out if the participants were aware of hazardous material caused by e-wastes. Table 8 summarizes the findings.

TABLE 8: Hazardous Material

	Type of hazardous Material	Frequency	Percent
Valid	Mercury	10	11.5
	Cadmium	5	5.7
	Lead	19	21.8
	PVC	2	2.3
	Chromium IV	4	4.6
	Others	47	54.0
	Total	**87**	**100.0**

Table 8 indicates that general materials referred to as others had the highest percentage at 54.0%, while mercury, Cadmium, lead. PVC and chromium IV had an overall of 46.0%. This also raised mixed reaction whether the respondents were sure of the hazardous materials of e-wastes.

Role of Government

The study collected data on the role of the government towards management of e-waste and policy enforcement. Table 9 summarizes the findings.

TABLE 9: Role of Government in E-waste Management

	Government's Role	Frequency	Percent
Valid	Funding	11	12.6
	Creating of Awareness	24	27.6
	Providing Infrastructure	5	5.7
	Policy Enforcement	47	54.0
	Total	**87**	**100.0**

According to Table 9, most of participants were for the idea that the government should be on the forefront in enforcing policy supported by 54.0%. Those who advocated for the government creating awareness was at 27.6%, funding at 12.6% and those who advocated for the government to provide infrastructures was supported by 5.7%. This implies that the government has much to be done towards e-waste management through funding, creating awareness, providing infrastructures, also creating, and enforcing policies regarding electronic waste Material.

V. Conclusion

Based on the outcome of this study, it is concluded that, most people are not aware of policies and frameworks governing e-waste products in Bungoma County and seems to be ignorant about their existence. The government needs to increase efforts towards e-waste management in terms of policy creation, enforcement, infrastructural development and human capacity training. Additionally, e-waste institution need to be created and information about their existence should be published for various companies, institutions, and electronic dealers to make use of such for the purpose of e-waste management process and environmental sustainability process. Finally, there is need for, training of staff and electronic users on matters related to management and the associated effect of e-waste, green ICT practice.

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