E-Waste Management on Environmental Sustainability: A Case of Universities in Lang'ata Constituency, Nairobi City County, Kenya

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Abstract – The overall objective of this study was to examine the management of electronic waste and environmental sustainability in universities in Lang'ata constituency, Nairobi County, Kenya. The stated overall objective could be achieved through an investigation into; the different types of e-waste generated by Universities in Lang'ata; the current e-waste management mechanisms put in place by universities in Lang'ata; existing measures of collecting electronic wastes in Universities in Lang'ata constituency; and the disposal methods for handling e-waste in the universities in Lang'ata. The study was informed by the waste management theory developed by Pongrácz and the integrated solid waste management framework by UNEP. The study employed the use of descriptive study design, using both qualitative and quantitative research approaches. A sample size of 56 respondents was computed using the slovens sampling formula {n=N/(1+Ne^2)}. Questionnaires, interviews, and observation were used in data collection. The study found out that the e-waste identification methods that were practiced by universities in Lang'ata included tracking hazardous levels of e-wastes, considering e-waste material recyclability, tracking consumption of electronics, and categorization of what was e-waste and what was not. Some of the e-waste produced by the institutions included obsolete cartridges, computers, mobile phones, telephone, radio, cables; uninterruptable power supplies (UPSs), power extension cables, and keyboards among others. Management of e-wastes entailed buying less and durable electronics, use of cloud storage and Extended Producer Responsibility (EPR), recycling, re-use, leasing for a certain period of time instead of purchasing and keeping inventory of all electronics given out to various offices. E-waste collection entailed having a common collection point for e-waste, collection banks, collection footprints and legislation on e-waste collection in various universities. The e-waste disposal strategies identified included recycling, landfilling, Adapt and Re-use method, dismantling and scrap method, use of public dumpsites, burning of e-waste, selling them as second hand at a cheaper price and giving them out as gifts to charitable agencies. The study recommended clear categorization of e-wastes; NEMA recommendations on what electronics were to be acquired by universities; clear records of varieties of e-waste generated; establishment of environmental commissions in universities; subsidized procurement of electronic devices; a common e-waste collection point in universities; assessment of e-waste collected; collaborative action by both the government and NGO sector; seminars and workshops on E-waste management; Environmental conservation and sustainability was to be introduced as a common course in universities. The study recommended further research on the challenges that confront universities in their effort to manage e-wastes; and the effectiveness of e-waste management strategies employed by universities in Kenya.

Keywords: Electronic Equipment, E-waste (Electronic Waste), E-waste identification, E-waste Management, E-waste collection, E-waste Disposal, and E-waste Footprint

1.1 Background to the study

Over the past three decades the electronics industry has become one of the largest and fastest growing manufacturing industries globally. This growth, combined with rapid product obsolescence and creative destruction, e-waste has become a nuisance. E- waste covers a wide and growing range of obsolete electrical and electronic equipment, from household to office equipment like telephones, mobile phones, photocopiers, Laptops and desktops, other appliance includes televisions, refrigerators, washing machines among others. Approximately 20 million PC's which translates to about 7 million tons are estimated to have become obsolete by 1994. It was also estimated that in ten years' time the figure of obsolete PC's will increase to 100 million PCs (Widmer, 2005).

According to Balde (2014), there is an increase in the production of e-wastes, but very little is being recycled. The world population had generated approximately 44.7 million Mt. of e-waste by 2016, of which the amount recycled was 20% (8.94 million Mt.). Almost half of the world's countries have e-waste legislations; hence, the need to bring more countries on board in enforcing, implementing and developing policies.

In America, USA produces the largest volume of e-waste with 6.3 Mt., followed by Brazil with 1.5 Mt. and Mexico comes third with 1 Mt. of e-waste. As observed by the United States Environmental Protection Agency (EPA, 2016), the environment is often fed by toxic substances including mercury, lead, cadmium and arsenic; which pose a threat to human life. These toxic substances are likely to have serious effects on the environment, animals and plants. Land-filling is one of the mechanisms adopted for e-waste management in the US. However, landfilling results to leaching of the hazardous materials into groundwater and surface runoff, hence causing water pollution.

In 2016, an approximate total of 18.2 Mt. of e-waste was generated by Asia. China was the leading in terms of e-waste generation, not only in Asia, but also in the world (7.2 Mt.). The e-waste generated by Japan was 2.1 Mt. while India generated 2 Mt. of e-waste. China has adopted a variety of simple and complex e-waste disposal and disassembly processes that are implemented to tackle the e-waste menace. Some of the e-waste management practices embraced are for instance manual disassembly, melting printed circuit boards to recover solder and using acids for metal extraction from compounds.

In China, rural areas are experiencing increased water pollution that has been facilitated by unscrupulous waste disposal methods; thereby limiting the benefits communities get from their lands. Guiyu China, is the region that is documented as having the with the world's highest levels of cancer-causing dioxins. In this Province discharged water from industries run-off into Lianjiang River, further causing more damage to only human life but to life under water. Among the polluted rivers in China is the Lianjiang River, rated as category 5 river. This is with implication that the river may not be used for agricultural operations and human consumption, as indicated by the Chinese Ministry of Environmental Protection (Leung, 2008).various regulations on waste management, especially on e-waste are being implemented. These measured are aimed towards banning any adverse effects e-waste pose to the environment by reduction of usage environmentally toxic electric gadgets (Xianbing, 2006).

In 2016, Europe generated e-waste totalling to 12.3 Mt, which translated to approximately 16.6 kg in every homestead. Germany, which according to studies, stands out as the highest quantity in Europe, Great Britain and Russia generated 1.6 and 1.4 Mt respectively. In Europe, Norway is the leading in terms of the average e-waste generated in each household (28.5 kg/inh), after which comes Denmark and Great Britain (approximately 24.9 kg/inh each). Europe and the Nordic countries of Switzerland, Norway, and Sweden have the most advanced global e-waste management practices. However, according to Robinson (2009) Northern Europe is far ahead of many other countries, which apparently has the world's highest collection rate of 49% of her total e-waste generated.

In 2016, Africa generated (2.2 Mt) of e-waste with scanty data having been documented on Africa's collection rate. According to the available information, the amount of e-waste documented as having been collected and recycled amounted to 4 kt; which is less than 1% of the total e-waste generated. A major concern of developing countries is that the consignment of admixture of EEE and WEE are not shipped as wastes, but as second hand products. However, many of these products are near their end-of-life, so African countries have the challenge of dealing with these wastes in an environmentally sound manner. Infrastructure for solid waste management is weak and ineffective in Africa as many Countries have neither a well-established system for separation, storage, collection, transportation, and disposal of waste nor the effective enforcement of regulations relating to hazardous waste management. As observed by Asiimwe&Ake (2012), e-waste materials are traded or dumped illegally by criminal gangs. This amounts to between 60 to 90% of e-waste with an approximate value of 19bn dollars. West Africa has been reported by the UN Office on Drugs and Crime (UNODC) to be a major destination for electronic waste, while some Asian countries are also recipients of obsolete e-waste considered as toxic material, sometimes as part of so-called trade free agreements with Western countries (Asiimwe&Ake, 2012).

A wide range of challenges have been brought about by the global growth of WEEE and this include the introduction of effective management practices that are environmentally sound to reduce the negative health impacts and environmental impacts as a result of pollution. Most developing countries have no formal management of WEEE and in these countries, including Kenya, management is carried out through the informal sector and this poses a great challenge. According to a press release by UNEP (2010), Kenya is estimated to generate e-waste that amount to 17350 tonnes per year. In Africa, e-waste is estimated to grow at 20% each year as a result of the increased sales and consumption of electronic goods and as such this poses a major threat in environmental conservation and health risks associated with e-waste.

1.2 Statement of the Problem

In lieu of the need to have framework and policy for regulating recycling and e-waste management in Kenya, NEMA came up with guidelines for e-waste management aimed at assisting learning institutions, private sector, the government and other stakeholders to manage e-wastes effectively and enhance environmental conservation in 2010. These guidelines included approaches to enhance environmental protection; environmental awareness (Asiimwe&Ake, 2012). The rapid economic growth in Kenya and the expected increase in trans-boundary movement of electronic and electrical equipment were expected to generate enormous amount of e-waste. The generated E-waste was likely to pollute the environment by releasing hazardous materials into water, soil and air systems.

Universities in Kenya being among the biggest consumers of electronic equipment mostly through PC's, laptops and photocopiers, were at crossroads on means and ways to dispose-off their e-waste. As a result of obsolesce of e-wastes; universities were facing a task of e-waste management and disposal. This study therefore sought to examine the mechanisms that universities have in place for e-waste collection and management, evaluate existing regulatory and policy measures in Kenya regarding e-waste management and also examine environmental impact of poor e-waste disposal.

1.3 Research Objectives

The overall objective of this study was to examine e-waste management on environmental sustainability in universities in Lang'ata constituency, Nairobi County, Kenya

Specific objectives were as follows:

a) To identify different types of e-waste generated by Universities in Lang'ata
b) To evaluate the current e-waste management mechanisms put in place by universities in Lang'ata
c) Evaluate Existing collection methods of e-waste management in Universities in Lang'ata constituency
d) Explore disposal methods for handling e-waste in the universities in Lang'ata.

1.4 Literature Review

Waste Management Theory

The theory of waste management was developed by Eva Pongrácz in 2004. This theory is an amalgamated body of knowledge that specifically focuses on e-waste and how it is generated and managed. It is founded on the expectation that waste management is to prevent waste to cause harm to the health of human beings, the flora and fauna and promote optimisation of resources that are available. In this context, management of waste is about the generation, collection and disposal of e-waste in ways that minimise the impacts on both the humans and environment.

The waste management theory states that technological appliances were developed, from time to time, without prior considerations of recovering and recirculating the materials. It is important to properly define waste because it's in the clarity of the definition that society is able to come up with a sustainable and effective mechanisms agenda for waste management. Legislation, both existing and that to be implemented will only attend to e-waste as defined. The e-waste peril is brought about by the fact that electronic appliances that enter the waste stream have not been made with considerations of disassembly or recyclability (Popov, 2004).

Pongrácz's waste management theory is critical in understanding the behaviour behind the generation, collection and management of e-waste. The waste management theory is used to describe a targeted prescribed action upon which it implies that sustainable waste management so dependent on how waste is defined and understood. Pongrácz argues that generation of electronic through production, is the biggest contributor to the problem of e-waste management and disposal. She posts that unless producers reign in on their production mechanisms, and then there will be always a huge appetite for electronics which in turn will generate e-waste. In her opinion, manufacturers, through competition, innovation a due creative destruction have failed to look at how they contribute to the problem of e-waste and how their failure to address management and disposal has led to environmental degradation.

How society defines and isolates e-waste is vital in the e-waste management processes that are put in place. The process involves not only the identification and isolation but also how e-waste is disposed. Common perceptions of what developed countries refer to as e-waste have been challenged in developing countries because what is discarded as waste in these countries ends up as functional electronics in developing countries especially in Africa.

Pongrácz's WMT was relevant to this study because it is the only theory that focuses purely on e-waste as an emerging waste category that needs to be isolated from general waste. The theory is especially relevant to developing nations because that is where we have weak practices of e-waste generation, collection and disposal.

The theory fell short because it is still under evolution and hasn't been studied by other scholars. It fails to address all aspects of e-waste especially the aspect of disposal thus the need to complement it with the integrated solid waste management framework.

The Integrated solid waste management framework

The Integrated solid waste management framework has underlying concepts that include; the lifespan-based concept, generation-based concept and management-based concept (UNEP 2007). Its premise is that, no one approach is superior in waste management but their integration yields improved solid waste management. The realisation that there was a lack of a universally adopted method or mechanism of waste management, led to the development. Integrated solid waste management framework sought to consolidate waste management rather that each waste management system to be tailored to the community served (Kollikkathara, 2009; Korfmacher, 1997). Integrated solid waste management framework considers all methods of waste prevention, waste collection, resource recovery and disposal and chooses the best combination of methods to achieve the specific waste management goals of a community (Kollikkathara, 2009; van de Klundert& Anschutz, 1999; Tchobanoglou, 1993).

Integrated solid waste management framework is premised on the foundation of dealing with waste from the aspect of waste generation to disposal or resource recovery. It also advocates for suitable environmentally reuse and recycling to conserve natural resources and energy through systematic segregation, collection and reprocessing (UNEP, 2007). Integration entails different aspects such as integration of scales from household, institutions, neighbourhood, city, region, country urban systems, and different actors (Baritone, 2000). It looks at roles, interest and powers structures prevalent in waste management. McDougall (2001) wrote the objective of ISWM is "achieving environmental benefits, economic optimization and societal acceptability".

The aspects of Integrated Solid Waste management framework are defined as social, environmental and management. The four main principles of Integrated Solid Waste management framework then become social acceptability, environmental sustainability and effective management of e-waste. Considering these principles in unison, the optimal waste management system for universities would be one which minimizes environmental and public health harm, that stakeholders are willing and able to participate in. The social, environmental, and management aspects of the waste collection system in universities in Lang'ata, and the management techniques used to control them, are critical (Baritone, 2000).

The Integrated Solid Waste management framework framework was therefore found to be relevant to this study because it considers all methods of waste prevention, waste collection, resource recovery and disposal and chooses the best combination of methods to achieve the specific waste management goals of a community. It also advocates for suitable environmentally reuse and recycling to conserve natural resources and energy through systematic segregation, collection and reprocessing Integrated Solid Waste management framework has been criticized because of it's a general approach to waste. Critics of this theory feel that due to technological advancements whereby we are seeing new streams of waste, Integrated Solid Waste management framework should focus on isolating especially hazardous e-waste and giving it special attention.

Identification of e-waste and environmental sustainability

Among the critical elements associated with e-waste is the clear identification of what entails e-waste. There exists a relationship between identification of e-waste and how the same is handled from the production to disposal. The higher the toxicity and hazardousness of e-waste the more critical intervention is implied that proper identification of e-waste can mitigate environmental degradation by adopting stricter disposal and handling mechanisms. While bearing in mind the environmental sustainability of such mechanisms.

StEP imitative (2014) refers to e-waste as the electronic and electrical appliances and parts of the same appliances dumped as waste materials without intentions of recycling/ re-using. E-waste has various synonyms around the globe including Waste Electrical and Electronic Equipment (WEEE), e-scrap or electronic waste. This also includes a range of products that can be found in homes or in institutions and that may have circuitry or electrical components with power or battery supply (Baldé, 2015). According to a study by Sinha-Khetriwal (2009), e-waste could be defined as appliances that consume/ are powered by electricity and which have reached the end of their lifespan.

Baldé (2015) further breaks down e-waste into six key categories. These categories are classified as those with Cooling and freezing equipment/ temperature exchange, examples of which include freezers, air conditioners, heat pumps and refrigerators among others. Another category includes Screens, monitors which include televisions, monitors, laptops, notebooks, and tablets. The category that include high intensity discharge lamps, LED lamps and fluorescent lamps among others; Large equipment typically include electric stoves, photovoltaic panels, large printing machines, copying equipment, washing machines, clothes dryers and dish-washing machines among others. Examples of small equipment, which is the sixth category include radio sets, video cameras, electrical and electronic toys, toasters, electric kettles, electric shavers, vacuum cleaners, microwaves, ventilation equipment, scales and calculators among others. In the IT sector, small equipment include pocket calculators, routers, printers, telephones, Global Positioning Systems (GPS), personal computers and mobile phones among others. The six e-waste categories have been classified in different products and these products have a different lifetime profile and thus it means that the life span determines the waste quantities and qualities that are generated (Sinha-Khetriwal, 2009).

Studies that have been carried in identification of e-waste are not necessarily relevant to what is classified as e-waste among many developing countries more so in Africa. In Kenya where this study is being carried out, what has been discarded and shipped as e-waste from developing countries is seen as functional electronics. This can be seen mostly in the number of second hand or refurbished computers that are in the market. Most of these items are sold to academic institutions because of their huge consumption and need for computers and low budgets to afford brand new machines. On the status of e-waste in Kenya, UNEP s Executive Director Achim Steiner (2007) stated that there is likelihood of emergence of e-waste being dumped in Kenya. He pointed out that the dumping is carried out under the guise of donations.

It is therefore important to note that the definition and identification of e-waste greatly differs from the first world to that in the developing world. According to Sinha-Khetriwal (2009) in his study defined e-waste as any electrical powered appliance that has reached its end-of-life. This statement is debatable as end of life doesn't mean that the said equipment cannot be refurbished and re-used, as is the case with electronic equipment penetrating the African market.

E-waste management and environmental sustainability

E-waste management is the management of activities associated with generation, storage, collection, transfer, transport, processing and disposal of e-waste which should be environmentally compatible adopting principles of economy, energy, aesthetics, and conservation. E-waste management incorporates the general management functions including staffing, planning, forecasting, controlling and organizing for the effective and accurate functioning of electrical appliances (Kiogora, 1995). In this study, e-waste management will look at the ways that are put on place to control the generation of e-waste. Management will therefore adopt the meaning of controlling, laws, sustainable sources and tracking. The possible negative health and environmental impacts of waste, as well as the potential use of waste as a resource, make effective waste management prudent. Waste management involves all the activities associated with the control and handling of waste from generation to disposal. Bilitewski et al. (1996) wrote that "waste management encompasses the collection, storage, treatment, recovery and disposal of waste. Management is also associated with the promotion and control of waste reduction and reuse.

According to a baseline study in Kenya by Mureithi&Waema (2008) on e-waste, it Computers, printers and monitors alone generate up to 3,000 tonnes of e-waste annually. Mureithi&Waema's study used a baseline study that focused on general e-waste in Kenya, while this study focuses on e-waste generated by universities in Lang'ata constituency Nairobi, thereby narrowing the scope of the study and findings. Their study findings speculated possible increase in the amount of e-waste generated due to the advancement in ICT that hikes the importation of ICT equipment. The study goes further to indicate the fast growth of the ICT sector globally is driven primarily by national initiatives to enhance competitiveness in the global information society. This has lowered the cost of ICTs in many instances, and in many countries, taxation has been reduced or eliminated altogether. In addition, the move towards information society initiatives such as telemedicine, e-government, and e-education calls for the increased acquisition and use of computers, as well as programmes to increase computer penetration. Against the high growth is the high rate of obsolescence of ICTs due to technological change. This means that there is a need to dispose of large quantities of computers. Globally the United Nations Environment Program (UNEP) estimates that up to 50-millions tons of e-waste are generated annually worldwide (Mureithi&Waema, 2008).

As African countries join the global information society, the volume of ICT equipment in these markets continues to grow rapidly. Most e-waste recycling in developing and transition countries is done informally and there is little regulation in place to safeguard the health of those who dismantle the electronic equipment. Additionally, many developing countries have been caught up in a web of global e-waste dumping. This usually goes unnoticed due to inadequate legislation that governs the importation of non-functional, non-reusable and obsolete electronics into the various countries. (Asiimwe&Ake 2012) in their qualitative study, cited Kenya as one such e-waste dumping spot. In their study, they largely focused on East African Community (EAC) governments, that is, Rwanda, Burundi, Tanzania, Uganda and Kenya. Their study looks at the efforts that governments have in place in relation to e-waste management, whilst this study is specific to institutions and what efforts the said institutions have made and what other policies they have in place when it comes to the e-waste identification, management, generation and disposal menace

Waema&Mureithi (2008), opine that responding to health and safety issues, countries have taken a number of measures. Many European countries banned e-waste from landfills in the 1990s due to the fear that toxic substances will leach and contaminate underground water. In this regard, countries in Europe and Asia have developed a policy framework for e-waste. In the United States (US), similar legislation and policies exist at state level, but are not enacted at national level due to stalled efforts in the US Congress. The key thrust of these efforts is for the manufacturers as well as the consumers to be responsible in the end-of-life disposal. In some systems, a fee/tax is chargeable at the point of sale to cover the costs of disposal. Switzerland and some other OECD countries have established recycling systems which ensure safe disposal and high collection rates. These are partly financed by an Advance Recycling Fee (ARF) added to the sale price of new appliances, permitting consumers to return end-of-life equipment free of cost. However, consumers have to return them to retail outlets or collection points, from where e-waste is sent to specialised recyclers (Waema&Mureithi, 2008)

Currently, of all the nations of the world, 66% have laws regulating e-waste management, which is a positive deviation from the previous 44% in 2014. The management of e-waste is part of the OECD programmes on circular economy, material resources and waste. These guidelines are covered in a number of documents of the OECD, examples of which include Strategic Waste Prevention Environmentally Sound Management of Waste and Extended Producer Responsibility (Balde, 2015). In China, a number of severe effects of e-waste recycling to the environment and human life have been prevalent, and continue to pose a threat; as a result of inadequate waste management strategies (Xianbing Liu, 2006). With e-waste becoming a major worry which is now being widely recognised, it is important to establish and regulate-waste management framework. In China, there are legislations that stipulate e-waste management measures, promulgated by both the central and the local governments.

The study by Xianbing, (2006) was carried out on the website and the number of responders was 1100. The other two surveys carried out in Xian, capital of Shanxi Province and Hangzhou, capital of Zhejiang Province showed that Chinese citizens traditionally look at their obsolete electronic appliances as goods of value that they cannot discard in anyway and they would much rather hoard them or sell them and get some money rather than pay to discard. The study was also carried out on the general population in China. My study on the other hand will be a mixed method study and will be more specific targeting universities and will interview a total of 32 respondents and it will be a purposive sampling. It will also be drop and pick questionnaire. The study by Xianbing, (2006), on the other is purely quantitative desktop study and it used secondary data sources.

Sivakumar&Vidhya (2016) in their study of e-waste and its management, opine that around 20 million electronic household appliances including TV, washing machines, personal computers etc and 70 million cell phones reach end-of-life every year and this does not include electronic devices used in industries and offices. As such there are methods that can be used to dispose of small quantities of e-waste. However, the increase in production of electronics has made disposal much more difficult. In their study, they state that reduction of production can be used as one of the key methods of managing e-waste.

Ozman (2017) carried out a study about life cycle assessment where they indicated that due to the increased global ownership of electric and electronic there is a direct link to the volume of obsolete electronic equipment. Innovation has been shown to be one factor which creates rapid growth of electronic waste. The witnessed increase in the number of machines becoming obsolete is due to electronic manufacturers competing in terms of innovation, and therefore increasing the processing power of computers (Sivakumar&Vidhya, 2016).

According to Shah &Badruddin, (2016), Material Flow Analysis is the tracking of electronics from the production stage right up to the obsolete and disposal stage. Data used to develop the MFA model are the sales data from major distributors of electronics which help in knowing how many units are out in the market. Usage time of computer equipment and transfer coefficients of the electronics from one stage to another is also taken into consideration. The projections of the flows for a period of 15 years also indicated that storage and reuse of computer equipment's would be preferred over direct disposal; and computer equipment would continue to remain in either storage, re-use or gradually disposed of for about 11 years after its inflow (Badiru, 2013)

Extended Producer Responsibility is a domain strategy methodology that credits obligation to producers in retrieval of items when utilization has been done, and is in view of contaminator-compensations standards (Munam&Batool, 2015). According to OECD (2015), Extended Producer Responsibility is a policy highlighting the responsibility to be undertaken by manufacturers in ensuring treatment and/or disposal of e-wastes and other waste products. This obligates them to put in place mechanisms that will allow consumers to return the obsolete electronics back to the manufacturers or put in place mechanisms for sustainable disposal. Giving EPR is essential in providing incentives for waste management among the manufacturers, hence environmental conservation and helping the public manage waste. This means that manufacturers will be forced to cut down on the product's creative destruction, whereby they make a few changes on a product and then reproduce it as a new version.

Kenya's ICT industry is growing fast. The rate at which electrical appliances like mobile phones and computers are being acquired is on the rise. A large percentage of these devices are imported in the country from the European Union countries, USA, and countries in Asia like Malaysia and China. Some of these products come into the country while refurbished as donations to schools, hospitals and other institutions and are channelled through Non-Governmental Organizations as aid. Such devices are brought to favour most people who prefer relatively cheaper products. The 2006-2010 strategic plan in Kenya aimed at legal, regulatory and policy reforms that would create an enabling environment (Waema&Mureithi, 2008). The implementing body of the plan was the Kenyan Ministry of Environment and Natural Resources, and described pollutants and hazardous materials. Most of the awareness created has always focused generally on the environment, and ignores e-wastes; hence the Kenyan government is on its toes to develop e-waste management guidelines (Asiimwe&Åke, 2012). Mader (2011) in her Thesis uses both qualitative and quantitative research methods to outline e-waste management in Mexico and this ties with the researchers study. Most of the studies that have been conducted are geared towards looking at the general e-waste generation and production without isolating particular institutions.

E-waste collection and environmental sustainability

Of all the e-waste generated globally, only 8.9 Mt has been collected and recycled, and this translates to 20% of the globally generated e-waste (Balde, 2017). He further states that only 20% of E-waste generated is documented o be collected and recycled. Out of the total 44.7 Mt of e-waste generated globally, approximately 1.7 Mt in high income countries are either bunt or landfilled. A further 20% (8.9 Mt) of e-waste is collected and effectively recycled, with 80% (35.8 Mt) not having been documented; which apparently is illegally recycled, dumped or traded.

Most of the e-waste generated is not effectively managed. The documentation is as well not done consistently and systematically with the existing systems. A gap exists between the e-waste generated, e-waste that is officially collected and that recycled, due to data that has not been reported for the trans-boundary e-waste movement, especially from the developed and the developing countries. In 2016, approximately 34.1 Mt of e-waste globally generated could not be traced and wasn't reported (Balde, 2017).

The explanation for this low collection rate as compared to the total amounted that is generated can be attributed to the fact that only 41 countries have e-waste statistics that are official. Estimations through research were gathered on e-waste quantities for 16 countries. This therefore leaves a majority of e-waste (34.1 Mt) simply unknown. Countries that do not have national e-waste legislations put in place treat their e-waste like other or general waste. The e-waste is either land-filled or recycled along with other metal or plastic wastes posing the risk of pollutants not being taken care of properly or they run the risk of being taken care of by an informal sector that ends up recycling without proper protection of the workers at the same time emitting toxins that are contained in the e-waste.

Despite the e-waste challenge being on the rise, there is a growing number of countries adopting e-waste legislations. Approximately 66% of the world population is covered by national e-waste management laws as it currently stands which is an increase from 44% in 2014. Anyango (2013), states that with e-Waste Kenya and such recycling activities being on the rise, the need has therefore been felt in all quarters for an efficient and environmentally sound management of e-Waste in the country. The WEEE Centre has been handling e-waste from all sectors, with over 5000 tons of e-waste safely disposed since beginning of operation. Attempts by the government to manage e-waste in Kenya have suffered from a number of draw backs, such as incorrect consumer perceptions of e-waste, lack of e-waste financial management resources and models, lack of appropriate e-waste recycling technology, difficulty in incentivisation, unhealthy conditions of informal recycling, illegal imports, inadequate legislation, laxity in enforcing existing regulations, low awareness and, finally, reluctance on the part of corporate bodies to address the critical issues (Basiye, 2008). The consequences of this situation are that: there is wastage of resources when economically viable resources are dumped; hazardous materials are directed into the water stream without precautionary measures to minimise the effects to human life and the environment; and unhealthy conditions are developed during informal recycling.

According to Waema (2008), the Kenyan Ministry of Information and Communication was proactive regarding e-waste and, in 2006, formulated an ICT policy on e-waste that stated that there was need by businesses and individuals to demonstrate their ability and preparedness in minimizing the effects of their infrastructural development on the environment prior issuance of grant or renewal of licenses. The policy further stated that the report would give suggestions of appropriate waste disposal/ recycling facilities, especially for waste materials that could be toxic. The Communications Commission of Kenya (CCK) has implemented a Universal Licensing Framework that requires telecommunication operators to take responsibility for their discarded technology. However, there was limited capacity to collect and process e-waste, and no mechanism to separate it from solid waste (Amy, 2009).

In studies done, India is shown to possess generated 0.4 million plenty of e-waste in 2010 which was projected to increase to 0.5 Mt. More of those wastes are ending up in dumping yards and recycling centres, posing a replacement challenge to the environment and policy makers as well (Santhanam, Samuel & Chidambaram, 2014).It is estimated that 30,000 to 40,000 computers in the IT industry of Bangalore become obsolete every year. Waste generated annually in Bangalore includes; plastic at 1000 tons, lead at 300 tons, mercury at 0.23 tons, nickel at 43 tons and copper at 350 tons. In South India, there exists only two formal recyclers with one located at Chennai and the other at Bangalore. There currently lacks formal recyclers that operate in the north or the east with over 1 million people being involved in the manual recycling operations. Of those are the urban poor whose literacy levels are very low hence they have little awareness of the hazards associated with e-waste toxins (Santhanam, Samuel & Chidambaram, 2014).

It's is estimated that Bangladesh generates 2.8 million plenty of e-waste per annum, out of which 2.5 million tons comes from ship-breaking yards. Riyad, (2014) observed that in 2014, up to 500,000 computers were being used. Consequently, there have been 15,323 and 10,504 plenty of e-waste generated from PCs and cell phones, respectively, which might be the potential sources of 30,646 plenty of e-waste generated in 2013 (Riyad, 2014). The right management (collecting, storage, recycling, disposing) of those wastes is vital due to hazardous chemicals within the waste released through the ecological food chain can adversely affect human health and ecosystems.

When it's compared to standard municipal wastes, there are certain components of electronic products that contain toxic substances, which may cause a threat to the environment also on human health. An example is that of television sets and computer monitors that contain hazardous materials like lead, mercury and cadmium. Nickel, beryllium and zinc also are found in their circuit boards. The presence of the said substances makes their recycling and disposal a crucial issue (Riyad, 2014). Thanks to the hazardous materials contained by these electronics, placing them in landfills poses health risks. The improper disposal of electronic products results in the likelihood of damaging the environment (Riyad, 2014).

China is that the top e-waste producer with a generation of seven .2 Mt of e-waste consistent with a study administered and therefore the amount is predicted to grow to 27 Mt by 2030 (Zeng, 2017).Most of the e-waste in 2016 was generated in Asia at around 18.2 Mt or 4.2 kg per person and approximately 2.7 Mt were documented to be what was collected and recycled. Together of the world's largest exporters of electrical and equipment (EEE) and importers of waste electrical and equipment (e-waste) worldwide, China plays a crucial role within the life cycle of most of the world's electrical and equipment . China is now facing serious e-waste problems from both growing generation domestically and thru foreign imports as a results of increased Chinese and worldwide consumptions and turnovers of EEE (Feng Wang (UNU-ISP SCYCLE) RuedigerKuehr (UNU-ISP SCYCLE) Daniel Ahlquist (UNU-ISP SCYCLE) Jinhui Li (Tsinghua University. The importing of e-waste was formally banned by the government in 2000 (Zeng, 2017). .

However, administratively invisible flows of e-waste are still thought to be finding their way into the country to satisfy the constant demand for reasonable second-hand products and raw materials for re-manufacturing. As a results of technological and development, domestic generation of e-waste has risen rapidly. the increase from 0.99 million plenty of e-waste imported from developing countries in 1990 to 17.5 million tons in 2000 consistent with the report makes China the most important importer of e-wastes within the world. Its pressure to securely affect such wastes is increased by China being the second largest generator of e-wastes (Zeng, 2017).

US e-waste recycling industry once declared that around 80% of the e-waste they received was exported into Asia, with an estimate of 90% going into China (BAN, 2002). The main channel for e-waste collection was formed by private individual collectors. It's important to notice however that there also are some semi-organized collection networks that exist but they are doing not exclusively collect e-waste. There are some second-hand appliance markets also. These individual collectors don't have business licenses and glued workshops and that they collected all types of e-waste and approximately 60% of the entire e-waste that is discarded is collected by individual peddlers (Beijing Morning News, 2005). In contrast to economies that are industrialized, the consumers are paid by the collectors for the old, used and non-working appliances in China.

In 2014, The United States generated 11.7 million tons of e-waste but the data for 2015 and 2016 are not yet available. According to the EPA, of the over 3.4 million tons of e-waste generated in the U.S. in 2012, only about 1 million tons (29%) was recycled. In 2010 the rate of recycling was 19.6% and in 2011 it was 24.9%. As observed by the Environmental Protection Agency (EPA), every day, we are to get rid of over 416,000 mobile devices and 142,000 computers either by recycling or disposing of them in landfills and incinerators (Leblanc, 2018).

Nnorom&Osibanjo (2008) presuppose that African countries still lag behind when it comes to enacting legislation to deal with electronic waste. This is despite well documented evidence showing that African countries have been the recipients of electronic waste illegally exported from various affluent nations. An observation has been made that informal collection, dismantling and recycling of e-waste has begun to take shape in several countries such as Nigeria, Ghana and Kenya. However, the absence of infrastructure, appropriate collection and recycling services for electronic waste is still a major challenge in addition to scarcity of data on amounts of waste electrical and electronic equipment generated (Nnorom&Osibanjo, 2008).

The collection and treatment of e-waste is undertaken by the so-called 'informal' and 'invisible' backyard/informal recyclers using archaic techniques to cannibalize some useful materials and components (Mmerekiet, 2012). Information on what proportion e-waste is generated and where, and on where it's moving to, is restricted (Mmereki, 2012).This situation is formed worse by the present system of limited up to-date research project work (NCS/GZT, 1996), and scientific understandings about e-waste management (Taye and Kanda,2011).

Using an exploratory survey design, Otieno&Omwenga (2015) conducted a study on the challenges and opportunities of e-waste management in Kenya whereby their results indicated that the demand for, and consumption of second-hand electrical and electronic equipment has increased and as such some of the equipment that is imported or dumped in developing countries are old and are almost reaching their End-of-Life (EoL) usually imported illegally under the pretext of bridging the "digital divide". The most problem is that the storage, collection, transfer and disposal of WEEE in developing countries has not been either streamlined or managed in an efficient manner that ensures re-use; conservation of the environment or the security of the people involved (Otieno&Omwenga, 2015).

In Kenya, Safaricom a top collector of e-waste in the Kenyan private sector. The company has collected and recycled 1072 tonnes of e-waste since 2015. In 2018, Safaricom collected and recycled 217 tonnes and have been managing e-waste with the Waste Electrical and Electronic Equipment (WEEE) Centre based in Embakasi (www.gadgets-africa.com). In their study, Otieno&Omwenga (2015) state that the government has also not streamlined mechanisms for the Local Authorities to separate WEEE from other solid wastes, store, collect, transport and process it during a structured manner. All the solid waste collected by the Local Authorities isn't separated into different streams currently to facilitate separation of WEEE and affect its disposal in effective ways. There's a need to develop a correct waste collection system altogether Local Authorities where waste is separated at the source to effectively address this e-waste challenge (Otieno&Omwenga, 2015).

E-waste Disposal and environmental sustainability

The global economy was now heavily reliant on Electrical and electronic equipment. Due to the current and ongoing technological advancements, most industries have moved towards automation and due to these changes, we are witnessing an increased the use of electrical and electronic equipment. Unfortunately, as is with any new development and changes, the development of new technologies and equipment the life span of electronics products is getting shorter and shorter throughcreative destruction. This results to a lot of outdated electronic wastes to be deposited in the waste streams (Heacock, 2015).

The foremost important objective of appropriate e-waste disposal in developed countries is to guard the environment. Balde (2014) opine that increasing levels of electronic waste, and its improper and unsafe treatment and disposal through open burning or in dumpsites, pose significant risks to the environment and human health. In September 2015, the United Nations and every one Member States adopted the ambitious 2030 Agenda for Sustainable Development which are the 17 sustainable goals (SDGs) and there 169 targets to finish poverty, protect the earth , and ensure prosperity for everywhere subsequent 15 years. Processing of e-waste is often done through the informal sector, and lots of e-waste disposal and recycling jobs are unsafe and not protected by formal regulation (Brett, 2009; Leung, 2008).

In the world, measurement of the foremost common disposal scenarios is done through a standardized framework that is developed by the Partnership on Measuring ICT for Development (Bald, 2015), its most essential features of the e-waste dynamics are therefore captured and measured during a consistent manner. There are ecological, economic and social consequences that result from poor handling and management of e-waste. They include air pollution, especially when e-waste is burnt since most of them are non-biodegradable equipment (Buenker, 2007). The toxicity and radioactive nature of e-waste is dangerous to the humans since they are found in water, soil and animal products in economic terms; substantial public spending on health care goes up when the hard chemicals affect people's health through lead poisoning and cancerous mercury. Ozone depletion has also been cited as a result of poor disposal of e-waste, and can lead to unpredictable weather conditions through prolonged droughts and floods.

E- Waste Recycling

E-waste contains toxic heavy metals, such as lead, mercury and cadmium as well as hazardous chemicals such as bromine flames retardant Land filling or incineration has adverse impacts on the environment and on human health. On the other hand, e-waste also contains a large amount of useful and valuable materials, such as rare metals, copper, aluminium and plastics. However, recycling these wastes involves many technical difficulties and substantial costs. The principle of environmental effectiveness suggests that waste management ought to reduce the negative impact of waste on the environment. This can be done through the promotion of reducing, reusing and recycling waste, and by minimizing the environmental cost of transporting waste (Mader, 2011)

A study carried out by Zhang (2009), indicates that the consequences of these recycling activities for Guiyu's environment and human health were horrendous and that underground water was undrinkable, the air was filled with chemicals, respiratory and renal diseases were prevalent among adults and the lead poisoning rate among children was as high as81.1% (Peng, 2005).The e-waste recycling industry in US declared that around 80% of the e-waste received was exported to Asia, of which about 90% was going to China (BAN and SVTC 2002). Guiyu thus became the destination for a large proportion of this exported e-waste. Within only ten years, Guiyu had become the largest e-waste disassembly site in China. Lianjiang River is fed by cancer causing toxins and is located in Guiyu China, an area believed to be having the world's highest levels of cancer-causing dioxins. Categorised as a level 5 river is the Lianjiang River; meaning that according to the Chinese Ministry of Environmental Protection, the water quality is not safe for human consumption or agricultural function and use (Leung, 2008). There are Management Measures for the Prevention of Pollution from Electronic Products regulations that are aimed at prohibiting the environmentally adverse processing of e-waste and reduction of the utilization of hazardous and toxic substances in electronic appliances (Xianbing, 2006)

Currently there's no U.S. body tasked with the responsibility of e-waste management; however, twenty-five states have enacted legislation requiring state-wide e-waste recycling. It's become illegal for many American businesses to put electronics within the trash with some states prohibiting disposal of electronics within the municipal solid waste stream. More states also are giving requirements to the local governments to offer e-waste recycling for residents through curb side collection, collection events, or take-back programs. Twenty-five states have enacted legislation requiring state-wide e-waste recycling, nineteen of which have bans on disposing e-waste in landfills (Xianbing, 2006).

The National residential recycling rate in Canada between 2004 and 2006 was 22% by mass, and provincial recycling rates ranged from 6.9-40.7% (Statistics Canada, 2008). In Canada, recycling is more formal that that of other countries and to the present end there are several national and provincial organizations handling the gathering and recycling of electronic waste within the country. At the Vancouver centre, individuals and businesses can drop off their end-of-life electronics directly and or request for pick-up service for e-waste (Kumar &Holuszko, 2016). Manomaivibool (2009) asserts that the trend of backyard recycling is very dangerous and it is done without much consideration for environmental degradation (Manomaivibool, 2009). The process would involve heating PWBs over flames to recover lead solders then they undergo an acid bath that will help in recovering gold and copper while polluting the environment with the acid solution.

Most developing countries including Nigeria are still grappling with how to effectively manage electronic waste in their country (Mundada, 2004 in Nnorom and Osibanjo, 2007). They lack formal recycling systems with requisite technology, also absence of regulations and lax enforcement in places where they exist are the order of the day (Nnorom and Osinajo, 2007) hence WEEE is managed through primitive measures such as dump site deposits, backyard recycling and disposal into surface water bodies (Furter, 2004 in NnoromandOsibanjo, 2007). Schluep, (2010) summarizes the major ways that developing countries are affected by the challenge of WEEE

Countries like Kenya and Uganda can recycle a number of the old materials. In Kenya there's lack of a regulatory framework and a policy for recycling e-waste management. NEMA is however tasked with the responsibility of aiding learning institutions, the public and the private sector in waste management and environmental conservation measures. They need included different approaches towards enhancing environmental protection; environmental awareness; e-waste categorization, treatment and disposal (Asimwe& Ike, 2006).

Land filling

One of the foremost commonly used practices round the globe for e-waste disposal is land filling. E-Waste Land filling is one among the foremost commonly used practices round the globe for e-waste disposal. The method involves excavating soil and burying the waste, usually covered with a liner of plastic or clay. Approximately 140,000 plenty of e-waste is disposed into Canadian landfills annually (Shift Recycling). In British Columbia, approximately 85% of residents and 79% of residents in Ontario fall under the jurisdiction where the government banned landfills. Across Canada, the typical landfill tipping fee is CAD 2,100 per ton with an increased tipping fee, recycling, and reuse of end-of-life electronics (Envocare, 2001).

This land filling of e-waste often results in leaching of lead into the bottom water. There are toxic substances contained in these products which will contaminate the environment when burned in incinerators or disposed of in landfills. One mobile phone's battery contains cadmium which is enough to pollute 600 m3 of water (Trick, 2002). The explanation for the inevitable medium and long-term effects of cadmium leaking into the encompassing soil is thru the quantities of cadmium in landfill sites being significant (Envocare, 2001). Thanks to the highly flammable nature of plastics contained in brominated flame retardants of printed wiring board and housings of electronic products, variety of which are clearly damaging to human health and therefore the environment.

Profit organizations like We Recycle and Electronic Recyclers International (ERI) undertake the method of e-waste recycling for a fee. ERI uses a Universal Product Code tracking system which allows customers to trace e-waste in the least stages of the end-processing. Video verification is another service that ERI offers so as to supply assurance that tips is destroyed (Envocare, 2001).

In Nigeria, e-waste generally finishes up in landfills, the most important one being in Agbogbloshie, a billboard district near the centre of Accra (UNEP, 2011). In Kenya, e-waste that cannot be recycled either formally or informally ends up in land-fills which are informal themselves. Dandora dumpsite which is arguably the biggest dumpsite in Kenya plays host to all manner of waste that is disposed by Nairobi residents and institutions. The landfill services both the Nairobi county and its environs. Due to the informal nature of the landfill, there is no sorting or categorising of waste in its proper category and as such extremely hazardous materials and all lumped together with other waste. The proximity of the dumpsite to the Nairobi River, poses a serious environmental and human health risk to those that live around the area. The hazardous materials that leach into the ground seep into the river where they are transported to other parts of the county (Trick, 2002).

Adapt and Re-use

Kuehr, Fitzpatrick &Luepschen (2011), in their study indicate that the Solving the E-waste Problem Initiative is well positioned to form a difference towards the event and practical implementation of sustainable solutions. This Task Force is in support of the event of worldwide consistent re-use practices, principles and standards for EEE products. According to Lu, (2016), there are three channels which will be used for e-waste generation to transfer it to China. This channel is going to be targeted to the agricultural population who the main consumers for such products thank to their lower incomes. Such a channel also extended the life spans of those electronic appliances.

Owners of e-waste sell their obsolescence. Also as ratifying the Basel Convention and banning e-waste imports since 2000, China has several laws in situ prohibiting hazardous waste imports like the 2005 management measure for the prevention of pollution from electronic products legislation (Yang, 2008). Refurbishment or adapting for re-use presents an entrepreneurial opportunity for those with repairing skills. Where wealth inequalities exist, for instance between urban and rural areas, growing demand for reasonable technology also can be a big driver of informal e-waste activities. Within the broader context of manufacture and disposal, diverting e-waste to refurbishment also brings emissions savings.

Laws on E-waste management

In China there are three relevant laws on e-waste management, including; Clean Production Promotion Law; Solid Waste Pollution Control Law; and Circular Economy Promotion Law. These laws don't have detailed stipulations, but provide a legal framework on e-waste management (Zhang et al 2014). One among the foremost important decrees that has been put in situ in china with regard to e-waste management is that the Collection and treatment decree on wastes of electrical and equipment. It’s considered the Chinese like the EU WEEE Directive.

In response to a public outcry following the invention , within the 1980s, in Africa and other parts of the developing world of deposits of toxic wastes imported from abroad (UNEP) the convention was signed by 186 countries and was adopted on 22 March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland. Despite the Basel Convention, the dumping of chemicals remains a drag today, as exemplified by the Probo Koala vessel dumping on August 19, 2006 (Selin, 2011). This Greek owned and Panama-registered ship dumped approximately 500 plenty of toxic industrial waste near the town of Abidjan within the Ivory Coast, which led to several deaths and high health problems for tens of thousands of individuals living nearby (Selin, 2011). Zoeteman, Krikke&Venselaar, (2010) opines that the Basel Convention aims to scale back the quantity of hazardous waste created worldwide also as control its movement especially to 3rd world countries which haven't any proper e-waste legislation.

The treaty of African nations called the Bamako Convention has measures in situ that prohibit the importation of any hazardous waste (including radioactive waste) into the continent. Despite the notice that African governments have of the matter of e-waste, the Basel and Bamako conventions haven’t been domesticated into national laws. The 2006 Nairobi Declaration on e-waste has however marked a crucial milestone that was later followed by the Durban Declaration on e-waste Management in Africa of 2008 that asked of every country to possess its own process that defines its responses and formulation of actions that relate to the growing e-waste problem (Asiimwe&Åke, 2008).

As a result of the previously mentioned initiatives, many governments in African countries have increasingly showed concerns and interests to adopt comprehensive and integrated approaches that will solve the e-waste problem. Such approaches will integrate the informal sector into the official management structures, establish take-back schemes, Extended Producer Responsibility (EPR), and Producer Responsibility Organisations schemes the Government of Kenya through the National Environment Management Authority (NEMA), has developed the draft Environmental Management and Co-ordination (E-Waste Management) Regulations 2013 which will provide appropriate institutional and legal framework and mechanisms that aid in management of E-waste handling, collection, transportation, recycling and safe disposal of E-waste. It also provides for improved legal and administrative co-ordination of the diverse sectorial initiatives in management of E- waste as a waste stream in order to improve the national capacity for the management of the E-waste (https://www.nema.go.ke/).

What makes Kenya's e-waste problem unique is that it is relatively new and the quantities are rapidly growing as technology has become more common. Like other developing countries, Kenya has not yet developed a legal framework and thus, has not established environmentally safe waste management levels to keep in pace with technological change. According to CCK, (2010), Kenya has a broad regulation in EMCA for environmental protection that is not specific to e waste. In view of escalating e waste in Kenya, (Sergon, 2010) notes that the country is trapped in a scenario where there is a need to promote e government by promoting access to ICT.

1.5 Methodology

The study applied a descriptive survey study design. Descriptive survey design is concerned with the what, where, when or how much of a phenomenon (Kothari, 2004). The researcher focused on the phenomenon with little attention on their characteristics. The researcher was fairly knowledgeable about the key aspects of a phenomenon but had little knowledge if any regarding their characteristic nature or details (Munyoki and Mulwa, 2012). Both quantitative and qualitative research approaches were applied by use of questionnaires and interviews to gather data that was to be analyzed and tabulated in numbers, which allowed the data to be characterized by the use of statistical analysis (Hittleman, 1997).Quantitative data was analyzed using frequency distribution tables preceded by explanations of the findings. Frequencies of responses were used to explain meaning of phenomenon from numerical data collected. Content analysis record sheet (CAR) was employed to analyze qualitative data.

The study had therefore targeted a total of 100 respondents comprised of 10 ICT managers, 38 support staffs from ICT departments, 10 Procurement managers and 38 support staffs from procurement department in all the universities of Lang'ata Sub County; 2 officials of NEMA and 2 officials from the county environmental commission. Sample size was computed using Yumane's sampling formula stated as $n = N/(1 + Ne^2)$. This gave a sample size of 56 respondents. The samplewas drawn from the ten universities in Lang'ata constituency, namely Co-Operative University, The Catholic University of Eastern Africa, Strathmore University, Multimedia University, Riara University, Tangaza University, Amref International University and African International University, Marist University and Jomo Kenyatta University Karen Campus. Other samples were drawn from the Nairobi County Government and the NEMA office.

The study adopted probability sampling. This is the process of drawing a portion of a population so that each item in the sample population has a known chance of being selected (Kombo&Tromp, 2011). The probability sampling technique that was used by the researcher was simple random sampling and deliberate also purposive sampling for key informants. The essence of this approach was to aid in the identification of respondents with the requisite information. Deliberate sampling was used to select members of staff from the ten universities. The probability of selection of each department was proportional to their population, so that a department with larger populations had a proportionally greater chance of being included in the sample. Purposive sampling technique was employed in the selection of key informants.

1.6 Discussion of findings

E-waste identification

An investigation into whether or not measures of tracking hazardous levels of e-waste in relation to environmental sustainability gave the findings presented in table 4.7 below. From the findings, 76% (38) of the respondents highlighted that the measures were present in their institutions.This implied that the institutions were sensitive on environmental conservation in terms of e-waste pollution. However, a significant percentage of the respondents (24% (12)) indicated that these measures were not available in their institutions, hence the risk of environmental degradation by e-waste from these institutions were high.

Table 4.1 Presence of the measures of tracking hazardous levels of e-waste

Were present	Frequency	Percent
Yes	38	76.0
No	12	24.0
Total	**50**	**100.0**

Source: *Field Data, 2019*

Study findings on whether or not the respondents' institutions considered recyclability of e-waste materials indicated that most institutions did recycle their e-waste. This was indicated by 82% (41) of the respondents involved in the study. They highlighted that some electronic gadgets could be reused, while others were taken back to manufacturers for recycling. They further indicated that recyclability of e-waste materials was one of the major considerations they made before procuring new electronic gadgets. This was as presented in table 4.8 below.

Table 4.2 Institutions considering recyclability of e-waste materials

Considered	Frequency	Percent
Yes	41	82.0
No	9	18.0
Total	**50**	**100.0**

Source: Field Data, 2019

It was evident from the study that most institutions tracked their consumption of electronic materials. This was indicated by 82% (41) of the respondents involved in the study. Most of them indicated that they had kept records of all electronic gadgets in the institutions that had been purchased and issued out to various departments and offices. They further indicated that some of the gadgets like desktops were serialized, making it easier to track specific appliances. An office/ department had to return/ clear their old spoilt electronic device before they would be given a new one. This ensured environmental sustainability. This was as presented in table 4.9 below.

The respondents further identified the various e-waste materials that were produced by their institutions. Some of them included batteries (UPS), laptops, desktops, storage devices, charging cables and chargers, tonners, mobile phones, telephones, televisions, heaters, printers, photocopying machines and Public Address systems among others. These e-wastes, if not well managed, posed a threat to the environment.

Table 4.3 Institutions tracking the consumption of their electronics

Tracked	Frequency	Percent
Yes	41	82.0
No	9	18.0
Total	**50**	**100.0**

Source: Field Data, 2019

These findings concur with Baldé (2015), who categorised e-waste into six key categories. These categories are classified as those with Cooling and freezing equipment/ temperature exchange, examples of which include freezers, air conditioners, heat pumps and refrigerators among others. Another category includes Screens, monitors which include televisions, monitors, laptops, notebooks, and tablets. The category that include high intensity discharge lamps, LED lamps and fluorescent lamps among others; Large equipment typically include electric stoves, photovoltaic panels, large printing machines, copying equipment, washing machines, clothes dryers and dish-washing machines among others. Examples of small equipment, which is the sixth category include radio sets, video cameras, electrical and electronic toys, toasters, electric kettles, electric shavers, vacuum cleaners, microwaves, ventilation equipment, scales and calculators among others. In the IT sector, small equipment include pocket calculators, routers, printers, telephones, Global Positioning Systems (GPS), personal computers and mobile phones among others. The six e-waste categories have been classified in different products and these products have a different lifetime profile and thus it means that the life span determines the waste quantities and qualities that are generated (Sinha-Khetriwal, 2009).

Methods of E-waste management

The study investigated the various methods of e-waste management that were utilized by universities in Lang'ata constituency using a 5 point Likert analysis, as presented in table 4.13 below. From the findings, most respondents agreed that their institutions bought less and durable goods to ensure that they did not pollute the environment. This was indicated by 64% (32) of the respondents involved in the study. They hence had very little e- wastes to dispose, and if they did, it was after a longer time.

Also, 58% (29) of the respondents indicated that their institutions employed the use of cloud storage. This minimized paper work and more storage devices, as information stored in cloud would be accessed anytime, anywhere. One did not need storage devices to access the files. This reduced to a great deal, the e- wastes that were produced by these institutions.

Furthermore, 46% (23) of the respondents indicated that they were not sure on whether or not their institutions practiced Extended Producer Responsibility (EPR), while 30% (15) indicated that their institutions did not practice EPR. This made it difficult to recycle/ effectively dispose-off some e-wastes, hence putting the environment at a stake. This was as presented in table 4.10 below.

Table 4.4 Percentage Likert analysis of the methods of E-waste management

Method of E-waste management	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
'buying less and durable goods' was effective in environmental sustainability	6	6	24	30	34
Storing information in the cloud contributed to environmental sustainability.	6	18	18	30	28
The institutions/ organizations practiced extended producer responsibility (EPR) strategy	0	30	46	18	6

Source: Field Data, 2019

From the reviewed literature, Waema&Mureithi (2008), opine that responding to health and safety issues, countries have taken a number of measures. Many European countries banned e-waste from landfills in the 1990s due to the fear that toxic substances will leach and contaminate underground water. In this regard, countries in Europe and Asia have developed a policy framework for e-waste. In the United States (US), similar legislation and policies exist at state level, but are not enacted at national level due to stalled efforts in the US Congress. The key thrust of these efforts is for the manufacturers as well as the consumers to be responsible in the end-of-life disposal. In some systems, a fee/tax is chargeable at the point of sale to cover the costs of disposal. Switzerland and some other OECD countries have established recycling systems which ensure safe disposal and high collection rates.

Sivakumar&Vidhya (2016) in their study of e-waste and its management, opine that around 20 million electronic household appliances including TV, washing machines, personal computers etc and 70 million cell phones reach end-of-life every year and this does not include electronic devices used in industries and offices. As such there are methods that can be used to dispose of small quantities of e-waste. However, the increase in production of electronics has made disposal much more difficult. In their study, they state that reduction of production can be used as one of the key methods of managing e-waste.

E-waste collection strategies

Table 4.5 Percentage Likert analysis of e-waste collection strategies

E- Waste collection	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
The collection banks in the institutions were effective in environmental sustainability.	12	6	30	30	22
The collection footprints in the institutions were contributing in Environmental sustainability.	0	24	36	28	12
The legislations guiding E. waste collection in the institutions were effective in environmental sustainability efforts.	6	12	18	36	28

Source: Field Data, 2019

In the analysis of the e-waste collection strategies employed by universities in Lang'ata Constituency, the researcher came up with the findings presented in table 4.11 above. From the findings, it emerged that collection banks that existed in the institutions were effective. This was indicated by 52% (26) of the respondents who agreed that these collection banks were effective. It made it easier for all the worn out electronic gadgets to be assembled for disposal. This minimized the effect to the environment, hence environmental conservation.

Most of the respondents however were undecided on whether or not the collection footprints in their institutions contributed to environmental sustainability. This was indicated by 36% (18) of the respondents involved in the study. They highlighted that they were uncomfortable with the waste collection strategy that was employed by their institutions.

Furthermore, 64% (32) of the respondents agreed that the legislation that guided E-waste collection in their institutions were effective. They were adhered to accordingly. They further indicated that punitive actions would be taken against individuals who violated the legislation. This contributed to environmental sustainability. This was as presented in table 4.11 above.

The respondents identified burning and leasing as another way of waste management in their various institutions, stating that they returned the devices to the seller whenever they were faulty or needed disposal. This was adapted from respondent 014.

> *"Leasing devices. The institution opts to lease electronic devices from various manufacturing companies or sells agents at a manageable cost….especially those that are more expensive, rather than purchase them…..the devices are then returned to the manufacturers before they get faulty, hence limited generation of e-wastes……we also burn some that are non-toxic and can combers"*
>
> Respondent 014
>
> ***Source**: Field Data, 2019*

From the reviewed literature, Extended Producer Responsibility (EPR) is a domain strategy methodology that credits obligation to producers in retrieval of items when utilization has been done, and is in view of contaminator-compensations standards (Munam&Batool, 2015). According to (OECD), (EPR) is an approach that requires manufacturers to be given a significant responsibility for the treatment or disposal of post-consumer products. This obligates them to put in place mechanisms that will allow consumers to return the obsolete electronics back to the manufacturers or put in place mechanisms for sustainable disposal.

Sivakumar&Vidhya (2016), in their study of e-waste and its management, opine that around 20 million electronic household appliances including TV, washing machines, personal computers etc and 70 million cell phones reach end-of-life every year and this does not include electronic devices used in industries and offices. As such there are methods that can be used to dispose of small quantities of e-waste. However, the increase in production of electronics has made disposal much more difficult. In their study, they state that reduction of production can be used as one of the key methods of managing e-waste. This study hence evaluates the effective ways of e-waste management and the impact to environmental sustainability.

When asked on other methods of e-waste collection that were available in respondents' institutions, the respondents identified ferrying them to public dumpsites, burning and burying.

> *"Various methods are utilised to collect e-wastes in this institution. The university has a store, where these wastes are collected, and when full they are ferried to public dumpsites, either in Ngong or Dandora….. Burying of the e-waste materials in large pits dug by the institution………and burning those that can be burnt."*
>
> *Respondent 005*
>
> **Source***: Field Data, 2019*

The respondents however indicated that these methods were ineffective and hence needed better methods of waste collection. They indicated that these alternative methods would be hazardous to the environment, especially thinking of public dumping sites. They indicated that the problem of waste disposal was wide and needed government intervention.

> *"This county has a big challenge in waste disposal……..there is no distinction between solid waste dumpsites and e-waste dumpsite…….in any case, the available dumpsites are very few….. The government should set a budget for more elaborate waste disposal project."*
>
> Respondent 006
>
> **Source***: Field Data, 2019*

E-waste Disposal

In the attempt to understand from the respondents the strategies that were employed by the institutions to dispose off their e-waste materials, the findings presented in table 4.15 below were extracted. It emerged from the findings that recycling of e-waste materials was sometimes practiced. This was indicated by 42% (21) of the respondents involved in the study. They indicated that not all e-waste materials were recyclable, and hence would only recycle those that it was possible to recycle. Furthermore, some respondents stated that most electronic devices in their institutions were leased for some time, after which they would be returned to the seller/ manufacturer.

Most institutions never practiced landfilling in disposing off their e-wastes. This was indicated by 64% (32) of the respondents involved in the study. They indicated that landfilling was an expensive practice, and hence their institutions explored alternative disposal strategies.

The 'Adapt and Reuse' method of e-waste disposal was sometimes practiced by most of the institutions. This was indicated by 66% (33) of the respondents involved in the study. They indicated that some electronic devices would not be reused, as once they got spoilt, it was final. They had to acquire new ones. However, they indicated that they would adapt and reuse those that it was possible to.

Furthermore, 64% (32) of the respondents indicated that their institutions sometimes practiced 'dismantling and scrap' method of e-waste disposal. They indicated that this method disposal method favoured most of them, and hence those that would be dismantled were so done. This was as presented in table 4.12 below.

Table 4.6 Percentage Likert analysis of the e-waste disposal strategies employed

Disposal strategy	Often used	Less often	Never Used
Recycling as a method of E-waste disposal was effective in environmental sustainability	34	42	24
Land filling as a method of E-waste disposal was contributing to environmental sustainability	6	30	64
The 'Adapt & Re-use' method of E-waste disposal was effective in environmental sustainability.	28	66	6
The 'Dismantling and Scrap' method of E-waste disposal was effective in environmental sustainability.	18	64	18

Source: Field Data, 2019

The respondents identified other methods of e-waste disposal including burning, burying, dumping, donation, selling to agents at throw away prices, public procurement and disposal method. They however indicated that these methods were not the best as they exposed the environment to degradation.

> *"The method utilised by the university are not the best method as there could be better ways of disposing wastes…..this is used due to lack of alternatives and machineries to do better"*
>
> Respondent 040
>
> **Source**: *Field Data, 2019*

These findings are intendant with the findings from Xianbing Liu et al (2006) who observed that in China, catastrophic impacts on the environment and human health from e-waste recycling have been identified in the past and continue to occur and this majorly due to a lack of national management strategies With e-waste becoming a major worry which is now being widely recognized, it is important to establish and regulate e-waste management framework.

Furthermore, Anyango (2013), states that with e-Waste Kenya and such recycling activities being on the rise, the need has therefore been felt in all quarters for an efficient and environmentally sound management of e-Waste in the country. The WEEE Centre has been handling e-waste from all sectors, with over 5000 tons of e-waste safely disposed since beginning of operation. Attempts by the government to manage e-waste in Kenya have suffered from a number of draw backs, such as incorrect consumer perceptions of e-waste, lack of e-waste financial management resources and models, lack of appropriate e-waste recycling technology, difficulty in incentivisation, unhealthy conditions of informal recycling, illegal imports, inadequate legislation, laxity in enforcing existing regulations, low awareness and, finally, reluctance on the part of corporate bodies to address the critical issues (Basiye, 2008).

Environmental sustainability

Table 4.13 below presented the findings on the respondents rating of the environmental sustainability measures. From the findings, it was evident that e-waste identification led to long term mechanism for e-waste disposal hence environmental sustainability. This was agreed upon by 82% (41) of the respondents involved in the study. They indicated that environmental sustainability begun with classifying what e-waste was and what was not, before exploring ways of disposing the waste.

Most of the respondents agreed that Methods of E-waste management like storing information in the cloud led to environmental sustainability. This was agreed upon by 54% (27) of the respondents involved in the study. They stated that this minimized paper work and acquisition of more storage devices hence contributing to environmental sustainability.

Table 4.7 Percentage Likert analysis of environmental sustainability measures

Environmental sustainability	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
E-waste identification (recyclability, tracking and hazardous levels) led to long term mechanism for e-waste disposal hence environmental sustainability	6	6	6	58	24
Methods of E-waste management like storing information in the cloud led to environmental sustainability	6	6	24	30	34
E-waste collection led to sustainable development	6	0	18	36	40
Disposal of E-waste led to environmental sustainable development	6	0	6	64	24

Source: Field Data, 2019

It was agreed by 76% (38) of the respondents that e-waste collection led to sustainable development. They shared the sentiments that it facilitated environmental conservation hence minimizing health related hazards to humankind brought about by e-waste. This hence improved productivity thereby fostering sustainable development.

Furthermore, 88% (44) of the respondents indicated that disposal of E-waste led to environmental sustainable development. They highlighted that when poorly disposed, it interfered directly with healthcare by polluting water, soil and air hence putting water bodies, plants and animals at stake. Proper disposal led to environmental sustainability. This was as presented in table 4.13 above.

An investigation into the respondents' opinion on what the university could do towards e-waste management, the respondents indicated that universities were to keep record of wastes generated in the universities within Lang'ata Constituency. They further indicated that the County environment commission would assist in tracking of collected wastes periodically.

> *"Those within the Nairobi County Government to assist in the tracking of collected wastes periodically……..Have a record of wastes generated in the Universities within Lang'ata."*
>
> Respondent 002
>
> **Source**: *Field Data, 2019*

In terms of evaluating the available e-waste mechanisms put in place by universities in Lang'ata, the respondents indicated that universities were to assess e-waste collected and take measures of reducing them. They further highlighted that they would outsource e-waste, zone and dictate dumping sites, and plant trees in dedicated zones. This was adapted from the following verbatim:

> *"E- waste management mechanisms put in place by university include outsourcing of e-waste; zoning and dictating dumping sites; tree planting in dedicated zones…..Assessing e-waste collected and taking measures to reduce them."*
>
> Respondent 014
>
> **Source**: *Field Data, 2019*

In terms of evaluating existing collection methods of e-waste management in universities in Lang'ata, the respondents indicated that universities would examine the current used methods to determine whether they were sustainable. They also indicated that there would have supervision, and that WHO would visit universities in Lang'ata to ensure that the right thing was done. This was according to the following verbatim:

"Have supervision. WHO visit universities in Lang'ata to ensure that the right thing is done………Examine the current used methods to determine whether they are sustainable."

Respondent 020

Source: *Field Data, 2019*

In terms of the methods of e-waste disposal in universities in Lang'ata, the respondents indicated that the Universities would engage the county government or private waste disposal companies. They further insisted on seminars on E-waste management to equip stakeholders with up-to-date methods.

"Engage the county government or private waste disposal companies…Have common Seminars on E-waste management to equip stakeholders with up-to-date methods."

Respondent 019

Source: *Field Data, 2019*

Reviewed literature indicates that Countries such as Kenya and Uganda can recycle some of the old materials. Although the work is by private sector organizations, these organizations are supported by the government which is common elsewhere. In Kenya there is lack of a regulatory framework and a policy for recycling e-waste management. Guidelines were however formulated by the National Environmental Management Authority (NEMA) in 2010. They have included different approaches towards enhancing environmental protection; environmental awareness; categories of e-waste and target groups; e-waste treatment technologies; and disposal procedures.

1.7 Recommendations of the study

E-waste identification

The ICT departments in universities were to come up with a clear categorization of what amounted to electronic wastes and what did not, exploring the possible ways of disposing off each of them. This would facilitate easy e-waste disposal, hence foster environmental sustainability within and without the institutions.

NEMA and County environmental commission of Nairobi County were to collaborate and make recommendations on what electronics (brands and lifespan) to be acquired by universities. They were also to make impromptu visits and audits to universities to ensure that they complied with legislations on e-waste management.

E-waste management

The ICT and procurement departments in universities were to have clear records of e- wastes generated in the Universities, highlighting which electronic gadgets were given to which office, and how long they lasted. This can as well involve serialization of all electronic gadgets procured and issues to ensure easier tracking of specific electronic gadgets.

Environmental commissions were to be established in all universities by the university council, bringing on board all the stakeholders, to help ponder the various ways of e-waste management, and generally, environmental conservation within and without the universities.

Since some universities acquired cheaper electronic devices that would not last long due to budget constraints, the Ministry of Education (MoE) in collaboration with the Commission for University Education (CUE) was to subsidize the procurement of electronic devices, to ensure durability and quality.

There was need to develop e-waste management and general waste management policies in universities by the university management, to ensure that every stakeholder was held responsible.

E- Waste collection

University management was to come up with a common e-waste collection point, preferably a room/store, from where the waste could be sorted out in terms of the disposal methods of each. This would as well call for a taskforce to facilitate the sorting of collected w- waste materials.

There was also need to assessing e-waste collected by the procurement departments, in ensuring that effective measures were taken to reduce them. This could be done by both the universities and environmental conservation agencies like NEMA and CEC.

E-waste disposal

Since Nairobi County is faced with a serious problem when it comes to waste disposal, collaborative action was to be taken by both the government and NGO sector to ensure that a common and effective dumpsite was set, whereby wastes could be sorted, recycled, buried or burnt by waste management expatriates.

Training was key in addressing any challenge. Hence, universities were to hold Seminars and workshops to their staffs and students on E-waste management to equip stakeholders with up-to-date methods of e- waste management. Environmental agencies and the government could be brought on board in these events.

Environmental conservation and sustainability was to be introduced by the university councils as one of the common and compulsory courses for all students in universities to ensure that we have an environment literate generation.

1.8 Areas for further research

The study recommended further investigation in the following areas for individuals interested in furthering knowledge in this subject:

Diversification of the same study in other universities, Counties and Countries.

The challenges that confront universities in their effort to manage e-wastes.

Effectiveness of e-waste management strategies employed by universities in Kenya.

References

1. Asiimwe, D &Åke, G. E-waste Management in East African Community European Commission (2017). Waste Electrical & Electronic Equipment (WEEE). Retrieved from Europa: http://ec.europa.eu/environment/waste/weee/data_en.htm.
2. Asiimwe, E. N., &Grönlund, Å. (2012). E-waste management in east African community. In Handbook of research on E-Government in emerging economies : adoption, e-participation, and legal frameworks (pp. 307–327). Hershey. https://doi.org/10.4018/978-1-4666-0324-0.ch015
3. Badiru, F, Begianpuye, D., Giwa, A., Argungu, Sule, &Okuofu, C. (2013). Material Flow Analysis of Electronic Wastes (e-Wastes) in Lagos, Nigeria. Journal of Environmental Protection. 4. 1011-1017. 10.4236/jep.2013.49117.
4. Baldé, C.P., Wang, F., Kuehr, R., Huisman, J. (2015). The global e-waste monitor – 2014, United Nations University, IAS – SCYCLE, Bonn, Germany
5. Balde, Cornelis P., Forti, Vanessa, Gray, Vanessa, Kuehr, Ruediger and Stegmann, Paul. The Global E-waste Monitor 2017: Quantities, Flows and Resources, (Bonn, Geneva, and Vienna: United Nations University, International Telecommunication Union, and International Solid Waste Association, 2017).
6. Basiye, K. (2008), "Take-back policy implementation for used mobile phones: challenges encountered", paper presented at the National Workshop on E-waste Management, 7 September, available at: www. icwe.co.ke (accessed 9 September 2010).

7. Bouvier, R. & Wagner, T. (2011). The influence of collection facility attributes on household collection rates of electronic waste: The case of televisions and computer monitors. esources, Conservation, and Recycling, 55, 1051-1059
8. Frazzoli, C., Orisakwe, O. E., Dragone, R., &Mantovani, A. (2010). Diagnostic health risk assessment of electronic waste on the general population in developing countries. Environmental Impact Assessment Review, 30, 388-399
9. Heacock, M.; Kelly, C.B.; Asante, K.A.; Birnbaum, L.S.; Bergman, Å.L.; Bruné, M.-N.; Buka, I.; Carpenter, D.O.; Chen, A.; Huo, X.; et al. E-Waste and Harm to Vulnerable Populations: A Growing Global Problem. Environ. Health Perspect. 2015, 124, 550–555. [CrossRef] [PubMed
10. Jecton, A &Waema, T. (2013) "Towards an e-waste management framework in Kenya", info, Vol. 15 Issue: 5, pp.99-113, https://doi.org/10.1108/info-05-2013-0028. Permanent link to this document: https://doi.org/10.1108/info-05-2013-0028
11. Kumar, A,.&Holuszcko, P. Electronic Waste and Existing Processing Routes: A Canadian Perspective Received: 14 September 2016; Accepted: 31 October 2016; Published: 4 November 2016
12. Leung, O. (2008). l"Heavy Metals Concentrations of Surface Dust From E-Waste Recycling and its Human Health Implications in Southeast China," Environmental Science and Technology 42, no. 7 (2008): 2674-80).
13. Liping Zhang 2009); From Guiyu to a nationwide policy: e-waste management in China, Environmental Politics, 18:6, 981-987, DOI:0.1080/09644010903345736
14. Liu, X,. Masaru, T,.:Electrical and Electronic Waste Management In China: Progress and the Barriers to Overcome, Article in Waste Management & Research • March 2006)
15. Liu, X,. Masaru T &Matsui, Y. (2006). Electrical and Electronic Waste Management In China: Progress and the Barriers to Overcome. Waste management (Article)
16. Lu,C,.Zhang,L,. Zhong, Y,.Wanxia, R,. Tobias,M,. Zhilin, M,.Zhixiao, G,.& Xue, B.; An Overview of E-wastes Management in China
17. Mader, J. (2011). Applying the Integrated Solid Waste Management Framework to the Waste Collection System in Aguascalientes, AGS, Mexico. https://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm
18. Manomaivibool, P. (2008). Network management and environmental effectiveness: the management of end-of-life vehicles in the United Kingdom and in Sweden. Journal of Cleaner Production, 16 (18), 2006-2017.
19. Mmereki, M. (2012). Journal of the Air & Waste Management Association 65 (2015) 11–26)
20. National Environment Management Authority (NEMA), 2010. Guidelines for E-Waste Management in Kenya
21. Needhidasan, S,. Samuel, M. & Chidambaram, R. Journal of Environmental Health Science and Engineering201412:36. https://doi.org/10.1186/2052-336X-12-36. 20 January 2014)
22. Niu, X., & Li, Y. (2007). Treatment of waste printed wire boards in electronic waste for safe disposal. Journal of Hazardous Materials, 145 (3), 410-416.
23. Organisation for Economic Co-operation and Development. (n.d). Extended producer responsibility. Retrived from https://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm
24. Othman,N., Nurul, A. O., Shreeshivadasan, C,. &Mohammad,R. Life Cycle Assessment: A Comparison Study on the Various Electronic Waste Management Option. International Journal of Civil Engineering and Technology, 8(8), 2017, pp. 1177– 1185
25. Pongrácz, E. (2004). Evolving the theory of waste management: Defining key concepts. Waste Management and the Environment II. 471-480. (journal
26. Rick Leblanc, 2018 https://www.thebalancesmb.com/e-waste-recycling-facts-and-figures-2878189
27. Riyad, A.S.M. ,. Mahbub, K.H. ,. Iqbal, J,. M. Abdur- Rahim, S.M. ,&Wasi, U.: International Journal of Renewable Energy and Environmental Engineering ISSN 2348-0157, Vol. 02, No. 03, July 2014, pp 193-200, E-waste recycling practices in Bangladesh
28. Robinson, B.H.,: "E-Waste: An Assessment of Global Production and Environmental Impacts," Science of the Total Environment 408, no. 2 (2009): 183-91
29. Sahadat, H,.Sulala, M.Z.F. ,. Toufiqur, R.: Journal of Health & Pollution Vol. 5, No. 9 — December 2015 Enhancing e-waste estimates: Improving data quality by multivariate Input–Output Analysis
30. Shah, M &Rakhshanda B; An Overview of Electronic Waste Management, Practices and Impending Challenges. International Journal of Computer Applications (0975 – 8887) Volume 125 – No.2, September 2015

31. Shah, N., Gautam, P., Badruddin, M,.& , Ng & Ming, Ga. (2015). MATERIAL FLOW ANALYSIS AND AWARENESS ON E-WASTE MANAGEMENT. Malaysian Journal of Civil Engineering. 27. 275-289.
32. Sinha-Khetriwal,DThe management of electronic waste: a comparative study on India and Switzerland, M.S. thesis, University of St. Gallen, St. Gallen, Switzerland, 2009
33. Sivakumar, Vidhya. (2016). Global and Indian e-waste management - Methods & Effects.
34. United Nations Envrionmnetal Programme. (n.d). Turning e-waste into gold: the untapped potentila of African Landfills. Retrieved from https://www.unenvironment.org/news-and-stories/story/turning-e-waste-gold-untapped-potential-african-landfills

