Management Systems of 3R and Sustainability of E-waste management in Kisumu City, Kenya

Amolo Elvis Juma Amolo[1], George G. Wagah, PhD[2*], Leah Onyango, PhD[3*]

[1]*MA Project Planning and Management Student, Maseno University, Kenya*

[2]*Senior Lecturer PhD, Maseno University, School of Planning and Architecture, Kenya*

[3]*Senior Lecturer PhD, Maseno University, School of Planning and Architecture, Kenya*

**Corresponding author*

Abstract: **In spite of the increased use of electronic gadgets which has proportionately increased the accumulation of e-waste, E-waste in Kisumu is informally managed and it is not known whether the informal management of e-waste is sustainable. The purpose of this study was to establish management systems of 3R on sustainability of e-waste management in Kisumu City, Kenya. The research adopted a descriptive survey design and data collected using questionnaires, interview, Focus Group Discussions and observation from a sample size of 425 respondents out of a target population of 148,494 households while analysis involved descriptive statistics. The study concludes that the current e-waste management is not sustainable because: there is no monitoring of the volumes of e-waste generated making it difficult to plan for its disposal, there is a high turnover of e waste at the rate of 78% within 5 years without a corresponding mechanism for reducing, recycling and reusing, policy formulation and enforcement by relevant government ministries remains weak and investors and NGOs are unwilling to invest in this area due to expensive capital infrastructure and technology inadequacy. The study recommends that NEMA e-waste management guideline 2010 should be enforced to ensure proper reduce, reuse, recycling and disposal besides amendments to Public Health Act (1962), Urban Areas and Cities Act No.13 of 2011 (Cap. 265) to comply with the NEMA guideline. MIC should enforce their requirement for Extended Producer Responsibility on ICT Actors. The relevant ministries and the civil society need to create awareness of e-waste and its safe handling. NEMA and the County Government should offer incentives to interested investors. KEBS should train expertise in forensic audit of hazardous components included in electronic equipment's and discourage importation of such substances.**

***Keywords*: Recycling, Reuse, Reduction, sustainable, E-waste management**

I. INTRODUCTION

The growth in electronic equipment production and consumption has been exponential in the last two decades due to urbanization and the growing demand for consumer goods in different regions of the world (Babu *et al.*, 2007); eventually leading to increased volume of e-waste. Financial constraints on acquiring ICT materials in developing regions has led to consumption of second hand products (Nnorom & Odjango, (2007)) besides internal generation or illegal importation of used goods in an attempt to bridge the digital divide.

About 20 to 50 million tones of electronic waste ("e-waste") are generated worldwide every year, much of which has been transported to the developing nations (UNEP 2010). In 2007, Kenya, Morocco and Senegal discarded approximately 17,500 tones of IT e-waste (Hewlett-Packard 2009). South Africa generates 100,000 tons annually (Lombard 2004). In Kenya the total e-waste generated from computers, monitors and printers is about 3,000 tons per year (Mureithi *et al.*, 2008) and likely to increase dramatically as the importation and use of computers increases; a 200% rise was recorded in 2007 (Hewlett-Packard 2009). The e-waste concept came to light as far back as in the 1970s and 1980s following environmental degradation that resulted from hazardous waste imported into developing countries (Shinkuma & Huong, 2009). The Basel Convention on the control of trans-boundary movements of hazardous wastes and their disposal was instituted in 1992 to control the situation. Although "the Basel Convention does not regulate secondhand items and some e-waste scrap" (Shinkuma & Huong, 2009), it has played a role in banning exportation of obsolete products and engineering waste solutions.

E-waste contains toxic substances and creates serious risks to human health and the environment if not handled properly (Chatterjee, 2008; Li *et al.*, 2008). In the e-waste recycling regions, the improvement of disposal systems is the most cost-effective method to reach the objectives of solid-waste management (Brunner & Fellner, 2007) and calls for proper processing and management methods and enactment of timely regulatory and legislative policies. Current technologies are not particularly cost-effective in many developing countries; and many aspects of recycling depend on informal recycling (Babu *et al.*, 2007). Public awareness of the health and environmental threat posed by e-waste is minimal due to failure to provide up-to-date information by the relevant authorities (Brunner & Fellner, 2007). To best protect public health and the environment, policy makers of all developed and developing nations must be willing to fundamentally redesign the approach to e-waste management (Babu *et al.*, 2007). The absence of a policy and legislative framework and a practical management system, means that much e-waste remains in storage or recycled/disposed of in an unsafe and unsustainable manner putting both the recycler and local population at risk (Hewlett-Packard, 2009). Extended Producer Responsibility (EPR) as a policy strategy was first proposed by Thomas Lindhqvist in 1988 for a shared responsibility among relevant stakeholders across the product life cycle (Lifset & Lindhqvist, (2002); Lindhqvist, 2000) and is currently being implemented by Nokia Ltd in Kenya as "a take-back strategy" (Nokia, 2010). National and local governments ensure effective EPR programmes by raising awareness of programme requirements and establishing mechanisms to help prevent free riding and anti-competitive behavior (OECD, 2001).

The first Medium Term Plan (2008-2012) of Vision 2030 stating the government's commitment to improve ICT infrastructure as a foundation for a knowledge economy further raises an alarm because to bridge the digital gap there will occur exponential importation of ICT and Telecommunication equipments which will eventually turn into e-waste but the existing legislative Acts and by-laws do not recognize e-waste in specific and the e-waste management systems are informal. Capacity constraints hindering the disposal of e-waste as well as the collection system and recycling infrastructure are the major challenges facing all the East Africa nations. In Kenya a huge quantity of e-waste is handled by the informal (jua kali) sector. In addition, many developing countries have been caught up in the web of global e-waste dumping (Waema & Muriuki, 2008). The major source of e-waste is the disposal of the hardware and electronic items from Government offices, public and private sectors, academic and research institutes and Household consumers (Chatterjee and Krishna, 2009). Many of these products can however be refurbished, reused, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem and public health i.e. to reduce leaching, radiations and emission of toxic gases (William, 2010).

The generation of solid waste in Kisumu is on the increase due to the rising population and high rates of resource consumption while the handling capacity of the council has been exceeded (KARA, SANA & Ilishe Trust, 2007); the legal framework and the Municipal Council By-laws of 2008 on solid waste management, is held captive by inadequate capacity of the county council resulting in illegal dumping on road reserves (Obera & Oyier, 2002). The dumpsite at Kachok on the Kisumu-Ahero Road, 2 km from the town centre, receives unsorted solid waste mixed with toxic e-waste (Carl Bro Report, 2001; Ecoforum, 2001; World Bank, 1995). People from nearby informal settlements use the dumpsite as a source of income, oblivious of the harmful fumes from waste burning and methane fires in it. Only 17% of households in Kisumu have access to private collection and 47% by county council while the rest are just disposed off roadsides (KARA, SANA & Ilishe Trust, 2007).

In general the consumption of secondhand, cloned and refurbished electronic equipments has led to the generation of e-waste even though locally recording has not been done to track the quantities generated per source. On policy issues, Despite NEMA's development of e-waste management policy guidelines in 2010, the relevant ministries have not amended the necessary Acts and by-laws to comply with the policy guideline i.e. EMCA (1999); Articles 42; 60-70 of the new Constitution; Urban Areas and Cities Act No.13 of 2011 (Cap. 265) and the 2008 city by-laws and Public Health Act (1962) do not specifically address e-waste management since it's a recent phenomenon even though currently the council is considering drafting specific by-laws and also engage in public-private partnership. The inexistence of recycling facilities and the unwilling nature of NGOs and the private sector to cooperate with the City Authority in recycling of e-waste due to the huge capital and technology requirements has left the authorities in a limbo.

The study aimed to contribute valuable knowledge on sustainable e-waste management policy formulation for a healthy environment in general. Policy amendments will ensure formal handling of e-waste because every stakeholder will be held accountable after the ratification of the Acts. The study therefore endeavored to establish appropriate formal systems of e-waste management practices that observe reduction, reuse, recycling through enforcement of Extended Producer Responsibility. Formal e-waste management would ensure recovery of valuable resources such as gold, silver and aluminum; employment creation both formal and informal; revenue generation to the local authorities through taxation of registered recyclers and refurbishers and improved health and environment. The study also provides a reference and vital information to the databank on sustainable e-waste management for other researchers and development agencies interested on the issue. This research provides an insight into the dynamics of e-waste management in Kisumu.

II. LITERATURE REVIEW

2.1 Systems of e-waste management

Key strategies for sustainability include radical improvements in eco-efficiency, eliminating waste and dematerialization (Gertsakis & Lewis, (2003); Tibbs, 1999). Rather than regarding 'rubbish' as a homogenous mass that should be buried, Schall (1992) argued that it was made up of different materials that should be treated differently i.e. reduced, reused, recycled, burnt and buried. The concepts of waste management hierarchy of popularly 3R (reduce, reuse and recycle) is the basic requirement for sustainability in waste management (Smith & Scott, (2005); Gertsakis & Lewis (2003)). A study by Greenpeace in 2008 estimated that, 25% and 20% of the e-waste is recycled safely in Europe and USA respectively while China and India which have the biggest population in the world have 95% informal recycling sectors (Liu, 2009).

Today, land filling remains the most widely used waste disposal option (70% Solid Waste Management) across the European Union but recent changes to the landfill directive in Europe have restricted the types of waste that will be accepted at landfills i.e. landfill are required to have liners and leachate treatment systems. Incineration emissions legislation (Directive 200/76/EC) and the ever-present stigma attached to incineration plants have limited their introduction in most of

Europe to industrial centres. However, locally, state-of-the-art facilities have gained public acceptance; and has provided heat recovery (Copenhagen) (Greenpeace, 2008). In Italy there is significant public concern over incineration as poorly managed incinerators have lead to smoke and ash deposits on surfaces of nearby habitations. Following reported health effects and public pressure, since 1995, dirty incineration technologies in the United States, Germany and Japan have been rapidly phased out but Incinerator manufacturers (US government) are pushing their deadly wares into Africa under the guise of "technology transfers", taking advantage of the less stringent health and environmental regulations in the region (Smith & Scott, 2005). The e-waste recycling and disposal methods in India, China and Pakistan pollute the environment as they do open burning.

In South Africa formal recyclers process approximately 20% while the rest is stored by the owner, recycled informally, added to the domestic waste stream or dumped illegally. There is no specific legislation to deal with e-waste in South Africa, although a National Environmental Management Waste Bill was passed in 2009 to deal with issues such as hazardous waste and to introduce measures such as extended producer responsibility (Chatterjee & Krishna, 2009). Nigeria has 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 (Liu, 2009). As a result electronic wastes are managed through various low-end management alternatives such as disposal in open dumps, backyard recycling and disposal into surface water bodies.

Infrastructure of e-waste recycling is not well-established in Kenya (Smith & Scott, 2005). Due to high costs of recycling and lack of consumer incentives, only a very small fraction of e-waste are being refurbished and resold to consumers or recycled (Smith & Scott, 2005). E-waste collection activities by local governments are still limited because e-waste is commonly viewed as a potentially valuable resource by consumers but in recent years, take-back programs by cellular phone producers and retailers have begun (2007-2008) but have stalled in recent past (Nokia, 2010). The solid waste management scenario in Kisumu is a big challenge. A system of solid waste segregation at household level is lacking and subsequent waste collection rates are low. Several methods of waste disposal are widely used in Kisumu municipality: open dumping, open burning and incineration of medical waste; but the Incineration facilities are limited and where available, they are either broken down or improperly used (Obera & Oyier, 2002). Open dumping or unsanitary land filling is the dominant mode of disposal at Kachok dumpsite which is already full (Obera & Oyier, 2002; KARA, SANA & Ilishe Trust, 2007).

Besides the general advantages of the incineration of wastes such as the hygienic reduction in waste volume to be disposed of, the ability to handle both hazardous and non-hazardous wastes and the possibility to recover energy (Pirrone *et al.*, 2001), it also poses threats due to the release of toxic emissions (dioxins) (Tibbs, 1999) with negative environmental and health effects e.g. Immuno-toxicity, reproductive and developmental effects and cancer (Van Beukering *et al.*, 1999). It is very important to identify both valuable materials and toxic substances in order to develop a cost-effective and environmentally sound recycling (Gertsakis & Lewis, (2003)) for the recovery of valuable materials such as ferrous, aluminum, and copper. Informal recycling of e-waste in developing nations is an environmental challenge due to research scarcity in areas of appropriate planning and infrastructural analysis on best recycling systems (Williams, 2006). Even though recycling approach has been the recommendation of many institutions and experts on waste management (van de Kludert, 2000), in western countries it is economically non-viable due to rising cost of manpower, compelling them to find alternative destinations (developing nations) for disposal, where the labor cost is comparatively low and the environmental laws are not enforced strictly (Gao *et al.*, 2004; Mou *et al.*, 2004; Hanapi & Tang, 2006).

No waste management option can handle all wastes, except land filling (Costner, 1998); however, this would lead to a large loss of recoverable resources (Smith & Scott, 2005). It is therefore best to keep it as a last resort and send each waste streams to the option that allows the highest overall level of recovery possible with an acceptable level of safety and cost (Bontoux & Leone, 1997). The environmental risks from land filling are leaching of toxic metals (cadmium and lead) into soil and ground water and emission of gases (methane explosion, mercury) via the landfill gas combustion plant (Van de Kludert, 2000). According to Lombard (2004), unrefined e-waste dumped on landfills does not pose much of a health risk since registered landfills are reasonably protected to prevent leaching. Re-use as a method of waste control constitutes direct second hand use or use after slight modifications to the original functioning equipment (Waema and Muriuki, 2008), this helps in the conservation of raw materials and maximizes the utility of the equipments. Large companies should purchase the used equipments back from the customers and ensure proper treatment and disposal of e-waste by authorized processes (Gao *et al.*, 2004). Setting up a system where it’s easy to take-back old technology has met resistance due to unwilling nature of big recyclers (Ecroignard, 2005).

III. METHODOLOGY

The study was conducted through descriptive cross- sectional survey design and data collected using questionnaires, interviews, Focus Group Discussions and observation from a sample size of 425 respondents selected through stratified random sampling out of a target population of 148,494 households while analysis involved descriptive statistics of percentages and cross-tabulation at a significance level of 0.05 to establish the relationship between the variables under investigation. A reliability and validity tests were done amongst 10% of the respondents and a coefficient value of 0.87 obtained.

IV. FINDINGS AND DISCUSSION

The questionnaire return rate was 87%. The study investigated the sustainability of e-waste management in Kisumu city. The study assessed the management systems of e-waste. E-waste management systems tend to address issues of reduction, reuse and recycling for resource recovery, job creation, revenue generation and health and environmental enhancement. Rather than regarding 'rubbish' as a homogenous mass that should be buried, it is made up of different materials that should be treated differently. To achieve this objective the following pertinent issues were analyzed: development of downstream market infrastructure; general observation of health and safety standards; possession period of electronic products; equipment status at disposal; market value of end-of-life equipment in relation to its original purchase price; final disposal method and basic management practices. Frequency analysis was done on the above variables and results presented on tables and charts.

4.1 Downstream market infrastructure

The resultant downstream market is not fully developed to address both economic opportunities and safety and environmental concerns raised by e-waste. Field research revealed that KCC does not have the capacity to extract all of the value from e-waste. There is no local e-waste recycling industry while refurbishing and repair are informal leading to loss of valuable resources and related socio-economic gains besides risks posed health and environment. The inexistence of recycling industries locally is different from the conditions of developed countries i.e. Greenpeace (2008) estimated that, 25% and 20% of the e-waste is recycled safely in Europe and USA respectively while China and India which have the biggest population in the world have 95% informal recycling sectors (Liu, 2009). Economically the e-waste sector is an area generating employment both formal and informal. It was noted that repairers are able to make an average of Ksh 2000 daily which is approximately 23 dollars a day. This is twenty three times more than the World Bank poverty benchmark of a dollar a day. But since the business is run informally the City council only charges Ksh 20 daily as operational charges and exempts them of the proprietor taxation which goes to the government thus losing revenue. Some waste practitioners, such as Lombard (2004) similarly see e-waste as an opportunity to significantly scale up local refurbishment processes and a way of developing effective recycling industry offering opportunity for socio-economic development. Similarly Lardinois (1996) concluded that sustainable waste management enables recovery of materials, provision of employment in the informal sector, and reduction of toxic substances for improved health and environment.

Observations of health and safety standards on repairers

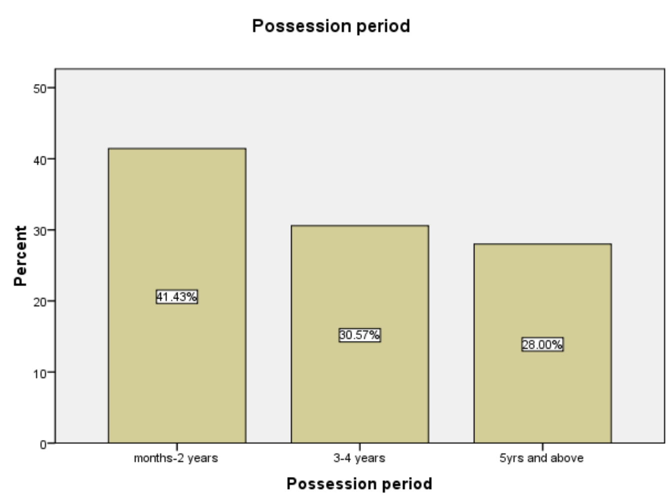
An observation on the health and safety standards of repairers/refurbishers revealed that disassembly was done without wearing protective gears such as gloves, masks and gumboots besides other dangers such as working unsafely with CRT monitors; obvious potential for eye damage, backaches and electric shocks; dangerous objects at the premises (sharp and heavy computer parts placed in the open). Many workers were in a relatively small shop and experienced congestion from dust and poor circulation of air generally. Pollution from burning plastic parts of the equipments and mercury and smells from laser printers that were believed to have a potentially negative health effect could be experienced; however, in some places, the premises appeared organized and clean.

Infrastructure of e-waste recycling is not well-established in Kenya (Smith & Scott, 2005). Due to high costs of recycling and lack of consumer incentives, only a very small fraction of e-waste are being refurbished and resold to consumers or recycled (Smith & Scott, 2005). Informal recycling of e-waste in developing nations is an environmental challenge due to research scarcity in areas of appropriate planning and infrastructural analysis on best recycling systems (Williams, 2006).

4.2 Period of use before disposal

The possession period of the electronic equipments before disposal was short as 41% of the respondents indicated that they only took 3 months-2 years before disposal; 31% possessed the equipments for 3-4 years while only 28% possessed the equipments for 5 years and above. At 72% turnover rate/disposal level in a span of 4 years is an indication of how technology evolution and changing lifestyle can contribute adversely to health and environment if not checked. At this rate the enactment of policies by responsible authorities and awareness creation amongst consumers besides active engagement of other stakeholders in the private sectors such as manufacturers and their downstream vendors for a take-back strategy (EPR) and private public partnership in the establishment of recycling system (plant) is the most amicable solution.

Figure 4.1: A Bar graph showing possession period of electronic products



A similarity is found in research by Yoon & Jang (2006) who identified that East Africa nations import cheap, low quality and short lifespan ICT products while in Kenya the advance development of information technology, change of life style and the growing consumer demand for newer electronic products have resulted in significant amounts of obsolete electronic devices. Difficulty in acquiring ICT materials in developing regions has led to consumption of second hand products (Kleine & Unwin, (2009); Hayford & Lynch, (2003)) with short lifespan as 50% of Kenya's PC market is second hand; 60% of equipment given to beneficiaries is beyond refurbishing when it is donated and should be recycled (Schluep *et al.*, 2008).

4.3 Equipment status at disposal

Of the respondents interviewed 57% discarded the electronic equipments in broken and unfixable condition while 24% discarded the equipments in broken but fixable condition and only 19% discarded the equipments in a working condition. Even though more than half of the respondents disposed obsolete electronic equipments were in broken and unfixable condition, this does not eliminate the existence of valuable materials like gold, copper and silver which are usually used in making the equipments finding their way into the waste stream. The broken but fixable equipments disposed which constitute 24% and the 19% of the electronic equipments disposed of in working condition is a clear waste of resource that would have been repaired to be in the normal working condition. It also leads to the depletion of raw materials that are used to make new equipments instead of recycling the existing ones.

Table 4.1: Equipment status at disposal

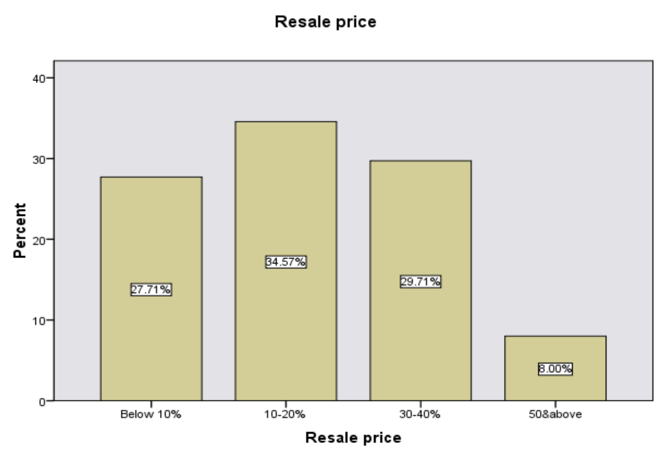
		Percent
Vali d	Brocken-unfixable	57.0
	Broken-fixable	24.0
	Working condition	19.0
	Total	100.0

In the e-waste recycling regions, the improvement of disposal systems is the most cost-effective method to reach the objectives of solid-waste management (Brunner & Fellner, 2007) and calls for proper processing and management methods and enactment of timely regulatory and legislative policies which is lacking in Kisumu. Current technologies are not particularly cost-effective in many developing countries (Kisumu inclusive) and many aspects of recycling depend on informal recycling that leave valuable resources to be disposed (Babu *et al.*, 2007), similar to the situation in Kisumu. According to Hewlett-Packard (2009) the data on e-waste sources are poor and insufficient, limiting our understanding of the issues and therefore solutions.

4.4 Market value of end-of-life equipment in relation to its original purchase price

The respondents were selling their end-of-life equipments at lower price than the original purchase price. Around 35% of the respondents were willing to sell their obsolete equipments at between 10-20% of the original price; 30% were willing to sell them at 30-40% of the original price; 28% were interested in selling the products at below 10% of the original price and only 8% were interested in selling the products at 50% and above. This gives a good impression of the willing nature of the respondents to resale their equipments at the end-of-life or when it does not serve the very purpose for which it was acquired but this does not eliminate the accumulation of the waste downstream (internal generation of waste). The minimum number of respondents indicating the willingness to resell the electronic products above 50% plus of the original price stems from the fact that most of the respondents recognized depreciative nature of electronic equipment's over time.

Fig 4.2: Resale price of electronic product in comparison with initial price



E-waste is both valuable as source for secondary raw material and toxic if discarded improperly (Hayford & Lynch, (2003)). The findings are similar to those of Gertsakis & Lewis (2003) who argued that; it is very important to identify both valuable materials and toxic substances in order to develop a cost-effective and environmentally sound recycling for the recovery of valuable materials.

4.5 Final Disposal method

On the final disposal mechanism 29% of the respondents were keeping in store the e-waste; 15% disposed them as mixed solid waste while 21% were selling them as second hand after repair. Of great concern is that 7% of the respondents burn the e-waste which release toxic fumes that can cause cancerous related diseases and also interfere with the reproduction systems of organisms as per the information provided by the health specialists. Only 5% were taking back end-of-life equipments for subsidy on new products. The 15% of the respondents whose e-waste are disposed as mixed rubbish still finds its way into the disposal sites at Kachok which is already full and overflowing and most times they are burnt openly producing toxic gases risky to health. The 29% of the respondents keeping the e-waste in stores not only experience dust collection in the stores which cause respiratory problems but also occupy a lot of space that would have otherwise been used for other more creative economic activities. About 9% of the respondents indicated that they donated the equipments either to institutions, friends or relatives who in most instances use the equipments shortly before their breakdown.

Table 4.2: Final disposal method

	Percent
Dispose of as mixed rubbish	15.0
Keep in store	29.0
Burn	7.0
Sell as second hand	21.0
Give to recycler	8.0
Donate	9.0
Return to seller for subsidy on new product	5.0
Disassemble for reuse of parts	5.0
Total	100.0

The ability of the respondents to either give the recycler the equipment or subsidy on new product or disassembly of parts for reuse is exercised by 18% of all the respondents. This shows that the respondents are moderately informed on the issue of repair or retake and resale of obsolete equipments (reuse). The resale market is informal and most times exchanged below market price. This in view of research does not only erase genuine value of the obsolete products but also strips the government the revenue which would otherwise been collected. The burnt waste poses real threat due to the chemicals released in form of fumes such as mercury, cadmium and lithium which are toxic. The waste left by respondents at the refurbishers/repairers shop still finds its way into the waste stream.

The findings are similar to that of Liu (2009) who argued that globally only 10% of people have recycled their old mobile phones while the rest are in stores at home. Chatterjee and Krishna (2009) found that in South Africa formal recyclers process approximately 20% while the rest is stored by the owner, recycled informally, added to the domestic waste stream or dumped illegally; and in Nigeria Liu (2009) found that electronic wastes are managed through various low-end management alternatives such as disposal in open dumps, backyard recycling and disposal into surface water bodies. Due to high costs of recycling and lack of consumer incentives, only a very small fraction of e-waste are being refurbished and resold to consumers or recycled similar to findings by Smith & Scott (2005). Re-use as a method of waste control Waema and Muriuki (2008) argue can help in the conservation of raw materials and maximizes the utility of the equipments. Gao et. al. (2004) recommended that large companies should purchase the used equipments back from the customers and ensure proper treatment and disposal of e-waste by authorized processes and large companies like Nokia in collaboration with Safaricom had locally initiated such project but it stalled after 2 years due to lack of cooperation by the consumers. Yet setting up a system where it's easy to take-back old technology has met resistance due to unwilling nature of big recyclers (Ecroignard, 2005); but in the locality even the recycling facility does not exist.

4.6 Management practices

The results suggest that 17% of the respondents are doing household sorting which kills the spirit of waste stream reduction at consumer level. Only 11% of the respondents indicated that they keep record of the electronic equipments they dispose meaning most of the equipments are discarded into the waste stream without recording making it difficult to quantify e-waste generated within the City, thus it would be difficult in establishing the capacity of the recycling plant even if funds were availed for the same purpose. About 29% had ready market for the second hand electronic equipments but this was mostly done in an informal way which results into resale at lower value not commensurate with the actual product market price and the government also loses revenue in the course of black market transaction.

Among the respondents interviewed 19% were willing to pay for the disposal of e-waste they generate provided there was an elaborate method of collection and proper disposal. This implies that if proper advocacy is done then the funding for the recycling infrastructure development is not a great deal as some portion would be generated from the consumers. Only 23% were willing to give their e-waste for free while the remaining felt that there was value attachment to the e-waste and therefore the need for compensation either in the form of new product subsidy or refund on submission of obsolete electronic equipment.

Table 4.3: Basic E-waste management practices

		Responses
		Percent
E-waste management practices	Sorting	17.0%
	Inventory	11.0%
	Ready market	29.0%
	Willingness to pay	19.0%
	Ready to give free	23.0%
	E-waste training	2.0%
Total		100.0%

Only 2% of the respondents (households) had attended e-waste management training meaning the responsible authorities tasked with knowledge dissemination on e-waste management are doing very little to the public (consumer) in terms of awareness creation and this might be attributed to the poor and uncoordinated execution of duties by the relevant agencies regarding e-waste management. The 2% of the sample 425 when extrapolated to the general population is equivalent to 2,970 people.

Rather than regarding 'rubbish' as a homogenous mass that should be buried, Schall (1992) argued that it was made up of different materials that should be treated differently. The concepts of waste management hierarchy of popularly 3R (reduce, reuse and recycle) is the basic requirement for sustainability in waste management (Smith & Scott, (2005); Gertsakis & Lewis, (2003)). Hewlett-Packard (2009) findings concurred that globally; the data on e-waste are poor and insufficient, limiting our understanding of the issues and therefore solutions and given the very limited data on amounts of e-waste collected and treated through "official" e-waste channels, it is clear that the recycling of significant proportions of e-waste currently goes unreported in different parts of the world. Waema and Muriuki (2008) emphasized that awareness and training programmes should be developed and implemented at consumer level. There is no specific structured collection mechanism for the e-waste and instead it's treated like other solid waste. Currently, there is no specialized equipment in the country for handling material fractions like copper, printed circuit boards (PCBs), CRT tubes and other hazardous fractions such as lead, mercury and lithium which make it impossible for recycling to be fully undertaken.

The findings are similar to that of Smith and Scott (2005) who argued that infrastructure of e-waste recycling is not well-established in Kenya due to high costs of recycling and lack of consumer incentives, thus only a very small fraction of e-waste are being refurbished and resold to consumers or recycled. A similar research by Liu (2009) in Nigeria indicated that lack of well-established system for separation, storage, collection, transportation, and disposal of waste has led to electronic wastes being managed through various low-end management alternatives such as disposal in open dumps, backyard recycling and disposal into surface water bodies. Nokia (2010) found out that e-waste collection activities by local governments in Kenya are still limited because e-waste is commonly viewed as a potentially valuable resource by consumers.

V. CONCLUSION

The study sought to establish management systems of reduction, reuse and recycling on e-waste. The findings showed that there is no formal e-waste recycling industry locally. On reduce, only 17% of the respondents are doing household sorting which kills the spirit of waste stream reduction at consumer level. Only 11% of the respondents keep record of the electronic equipments they dispose making it difficult to quantify e-waste generated, thus it would be difficult in establishing the capacity of the recycling plant even if funds were availed. There is no specific structured collection mechanism for the e-waste and instead it's treated like other solid waste. On Reuse, there is informal refurbishing and repair done but this leads to loss of valuable resources and related socio-economic gains besides risks posed to health and environment. The resale market is informal and most times exchanged below market price which does not only erase genuine value of the obsolete products but also strips the government the revenue. Final disposal mechanisms on e-waste involved: keeping in store (29%); mixed solid waste (15%) while 7% were burnt. The mixed rubbish still finds its way into the disposal sites and most times they are burnt openly producing toxic gases. The waste kept by respondents in store still finds its way into the waste stream besides occupying the economic space. Incineration was done in three hospitals (New Nyanza General, District and Aga Khan Hospitals) but only the incinerator in Aga Khan was in good condition.

The study concludes that: There is a high turnover of e waste since 78% of the respondents purchased electronic equipment every 5 years without a corresponding mechanism for reducing, recycling and reusing the e waste making e-waste management unsustainable. Such a scenario indicates that if nothing is done there will be an increasing accumulation of e-waste over time thus endangering the environment and its users. The study also concludes that the current management of e-waste is not sustainable because there is no monitoring of the volumes of e-waste generated making it difficult to plan for its disposal. The study concludes that the current situation on e-waste management and policy formulation and enforcement by relevant government ministries remains weak. The unwilling nature of investors and NGOs to invest in this area due to expensive capital infrastructure and technology inadequacy render the management of e-waste unsustainable. E-waste management therefore remains informal leading to resource wastage and minimal health and environmental safety observation, thus it remains unsustainable.

The study recommends that: At policy level; MENR through NEMA should enforce the e-waste management guideline 2010 to ensure proper sorting, collection, recording, reuse, reduce, recycling and disposal and the licensing of investors along this line. The MPHS should amend the Health Act (1962) to include e-waste management and comply with NEMA e-waste management guideline 2010. MIC through CCK should enforce their requirement for environmental management on ICT infrastructure by ICT Actors to ensure implementation of take-back strategy (Extended Producer Responsibility). The County Government should amend Urban Areas and Cities Act No.13 of 2011 (Cap. 265) to incorporate e-waste management.

The relevant ministries and related stakeholders need to create awareness of e-waste and its safe handling i.e. dispose unusable equipment through sorting of waste at the source, organized collection and disposal system separately from solid waste by e-waste collectors. NEMA should set training standards for personnel handling e-waste to be enforced by the County Government. Awareness and training programmes for consumers and technicians handling e-waste should be developed and implemented after establishing a recycling facility/infrastructure.

MENR, NEMA and the County Government should encourage the growth and expansion of recycling capability in Kisumu through offering incentives to interested investors.

Kisumu city council should endear interested investors to establish a formal e-waste recycling infrastructure. KRA should establish a mechanism to raise funds for e-waste management through charging a fee to the suppliers of old equipment or those who want to dispose large volumes of equipment in the city. KEBS should train expertise in forensic audit of hazardous components included in electronic equipments and discourage importation of such substances.

Consumers should be made aware and encouraged to buy brand new equipments to discourage acquisition of short lifespan equipments. County Government should establish disposal sites far from residential areas due to health concerns. MENR should encourage and acknowledge the role of civil society stakeholders in creating awareness and conducting research on e-waste.

REFERENCES

[1] Babu, B. R., Parande, A. K., & Basha, C., A. (2007): Electrical and electronic waste: a global environmental problem. Waste Management & Research, 25(4), 307-318

[2] Brunner, P. H., & Fellner J. (2007): Setting priorities for waste management strategies in developing countries. Waste Manage Res 25:234– 240. Washington DC.

[3] Bulkeley, H., Watson, M., Hudson, R., & Weaver, P. (2005). Governing municipal waste: towards a new analytical framework. Journal of Environmental Policy and Planning 7 (1), 1–23.

[4] Carl Bro report (2001): Study of the Environmental Situation in Three Urban Centres; New-Delhi India.

[5] Chatterjee, S. & Kumar, K. (2009). Effective electronic waste management and recycling process involving formal and non-formal sectors. International Journal of Physical Sciences, 4(13), 893–905.

[6] Cunmingham, W. P., & Cunningham M. A., (2002): Principles of Environmental Science. Graw Hill, New York.

[7] Davis, G., & Heart, S. (2007): Electronic waste: The local government perspective in Queensland, Australia. Journal of Resources, Conservation and Recycling, 52(8-9), 1031–1039

[8] Fricker & Alan (2001): Measuring up to sustainability – Sustainable Futures Trust http://www.metafuture.org/articlesbycolleagues/AlanFricker/MeasuringSustainability

[9] Gartner Inc. (2007): Worldwide mobile phone sales; Press release 27 February 2007. http://www.gartner.com/newsroom/id/612207. Accessed 26 Jul 2014

[10] Gao Z., Li J., & Zhang H., C. (2004): Electronics and the Environment, IEEE International Symposium pp.234-241. Earthscan, London.

[11] Hall W.J., & Williams P.T., (2007). Separation and Recovery of Materials From Scrap Printed Circuit Board., Resources, Conservation and Recycling, Vol. 51, 2007, pp. 691-709.

[12] Hanapi B. M., & Tang B. S., (2006). Selective Liquid-Liquid Extraction of precious metals from semiconductor wastes, Department of Chemical Engineering Faculty of Chemical and Natural Resources Engineering, University of Technology Malaysia. http://eprints.utm.my /2743 /1 /72157.pdf.

[13] Hewlett-Packard HP, (2010): http://www.hp.com/hpinfo/abouthp/government/us/ewaste.html, Accessed June 15, 2010.

[14] Kenya Alliance of Resident Associations (KARA), Sustainable Aid in Africa (SANA) International, and Ilishe Trust, (2007). Citizens' Report Card on Urban Water, Sanitation and Solid Waste Services in Kenya: Summary of Results from Nairobi, Kisumu and Mombasa. Nairobi, Kenya.

[15] Kathuri, N. J., & Pals, A. D. (1993): Introduction to educational research. Egerton: Egerton University Education Book Series. Kenya

[16] Kleine, D., & Unwin, T. (2009): Technological Revolution, Evolution and New Dependencies: Third World Quarterly, 30(5), 1045 – 1067. Latin- America

[17] Klundert, A., & Anschutz, J. (1999). Integrated Sustainable Waste Management: the selection of appropriate technologies and the design of sustainable systems is not (only) a technical issue.

[18] Kombo D. K., & Tromp D. L. (2006): Proposal and Thesis Writing: Introduction (2006). Nairobi: Paulines Publications Africa.

[19] Kothari C. (2003). Research methodology, methods and Techniques. New Delhi: Wisha Prakshan.

[20] Lardinois, I., & Van de Klundert, A. (1999). Integrated sustainable waste management (ISWM). LARDINOIS, I. and FUREDY, C. Source Separation of Household Waste Materials–Analysis of Case Studies from Pakistan, The Philippines, India, Brazil, Argentina and the Netherlands. Gouda, Urban Waste Series, 7.

[21] Lifset, R., & Lindhqvist T. (2008). Producer Responsibility at a Turning Point? Journal of Industrial Ecology 12(2) 144–147.

[22] Lindhqvist, T. (2000): Extended Producer Responsibility in Cleaner Production; the International Institute for Industrial Environmental Economic; Dissertations 2000:2 Sweden Lund University.

[23] Liu, Q., Li, Q. K., Zhao, H., Li, G., & Fan, Y. F. (2009): The global challenge of electronic waste management. Environmental science and pollution research international, 16(3), 248–249. China.

[24] Lombard R., & Widmer R., (2005). E-Waste Assessment in South Africa, A Case Study of the Gauteng Province. EMPA - Swiss Federal Laboratories for Materials Testing and Research, Switzerland. Available at: http://ewasteguide.info/Widmer_2005_Empa. Last accessed on 7th July, 2008.

[25] Moreno, J.A., Rios F.R. & Lardinois I. (1999): Solid waste management in Latin America: the role of micro- and small enterprises and co-operatives. Latin America

[26] Mou, W., Namara, T. P., Valiquette, C. M., & Rump, B. (2004): Allocentric and egocentric updating of spatial memories. J Exp Psychol Learn Mem Cogn 30(1):142–157

[27] Nnorom, I. C., & Osibanjo, O., (2008): Electronic waste (e-waste): material flows and management practices in Nigeria. Waste Manage 28:1472–1479.

[28] Napoleon Edger (2009): E-waste Management in East African Community. Orebro University, Sweden

[29] Nokia (2010): Nokia Sustainability Report. http://www.nokia.com/corporate-responsibility/ reporting

[30] Obera B. and Oyier M. (2002): Sustainable Solid Waste Management for Kisumu, Kenya in: 28th WEDC Conference Kolkata (Calcutta), India.

[31] OECD (2002): Working Group on Waste Prevention and Recycling; How to Apply Environmentally Sound Management to Small and Medium Size Enterprises. Washington D.C.

[32] Peralta, G. L., & Fontanos, P., M. (2006). E-waste issues and measures in the Philippines. Journal of Material Cycles and Waste Management, 8(1), 34-39

[33] Pirrone F. P., & Peralta, G. L. (2006): E-waste issues and measures in the Philippines. Journal of Material Cycles and Waste Management, 8(1), 34-39. Philippines.

[34] Pirrone, N. & Mahaffey K., R. (2005). Where we stand on mercury pollution and its health effects on regional and global scales. In N. Pirrone and K. Mahaffey (eds.), Dynamics of Mercury Pollution on Regional and Global Scales: Atmospheric Processes, Human Exposure around the World, pp. 1-24. Norwell: Springer Publisher.

[35] Shinkuma, T., & Huong, M., T. (2009): The flow of E-waste material in the Asian region and a reconsideration of international trade policies on E-waste. Environmental Impact Assessment, Review 29(1), 25-31

[36] Smith, T. & Byster, L. (2006). The Electronics Production Lifecycle. From Toxics to Sustainability: Getting Off the Toxic Treadmill,' in T. Smith, D. Sonnenfeld & D.N. Pellow (eds), Challenging the Chip, Labour Rights and Environmental Justice

in the Global Electronics Industry. Philadelphia: Temple University Press.

[37] Streicher-Porte, M., Widmer, R., Jain, A., Bader, H. P., Scheidegger, R., & Kytzia, S. (2005): Key drivers of the e-waste recycling system: Assessing and modeling e-waste processing in the informal sector in Delhi. Environmental Impact Assessment, 25(5), 472-491

[38] Tibbs H. (1999): 'Sustainability', Deeper News, Global Business Network, 10:1 E-waste management in South Africa, Kenya and Morocco: Developing a pathway to sustainable systems

[39] Report commissioned by Hewlett-Packard 2009. St. Gallen, Switzerland.

[40] United Nations Environment Programme (2009): Recycling – From E-waste to Resources. www.unep.org/PDF/PressReleases/E-Waste_publication_screen_

[41] Van-de-Kludert, A and Anschütz J., (2001): Integrated Sustainable Waste Management .Gouda Taiwan.

[42] Waema, T. and Muriuki, M. (2008): E-waste Management in Kenya. Kenya. Nairobi, Kenya.