Towards an e-waste management framework in Kenya

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Abstract

Purpose – *The purpose of this paper is to provide an overview of e-waste management practices in Kenya and selected countries. It develops an ideal regulatory framework for e-waste management in Kenya.*

Design/methodology/approach – *The methodology adopted for this paper includes collecting data using interviews, direct observation and literature review. Both qualitative and quantitative methods are used.*

Findings – *Waste is an emerging stream of solid waste in Kenya. It has become a major concern due to the high volumes generated, its hazardous fractions and the lack of policies applicable to its disposal. Gaps are identified in the areas of awareness levels, e-waste management technology, financing, collection, disposal, monitoring, and stakeholder collaboration.*

Research limitations/implications – *The study area is limited to Nairobi and its environs. With regard to product, the paper focuses on ICT equipment.*

Practical implications – *The proposed framework has direct practical policy implications to manufacturers who ought to reduce e-waste from production, consumers who should adopt safe disposal practices, recyclers/informal actors who ought to use environmentally friendly methods and government agencies that enforce e-waste policies.*

Social implications – *Adoption of the proposed framework has positive socio-economic impacts on job creation, reduced crime and sound environmental management.*

Originality/value – *This paper adds to the body of knowledge on the e-waste problem from the perspective of developed as well as developing countries. It points out best practices for socio-economic development and fronts arguments for sustainable environmental management.*

Keywords *Kenya, Information technology, Communication technologies, Computers, Computer peripheral equipment, Computer hardware, Legislation, Waste management, Communication Commission of Kenya, Stakeholders, Basel Convention, E-waste*

Paper type *Research paper*

Introduction

This paper highlights associated issues and strategies to address the emerging e-waste problem, in the light of initiatives in Kenya. Electronic and electrical waste is one of the topical environmental issues of the twenty-first century. It has been identified as the fastest growing waste stream in the world. Forecasts indicate that it will soon reach 50 million tons per year, while its generation is estimated at three times the rate of municipal solid waste. According to Aniyie (2009), electronics waste or e-waste are electronics that have outlived their usefulness or have exceeded their shelf life. Such waste includes fridges, air conditioners, personal computers and cellular phones.

The time has come for research, dissemination and advocacy programmes in Africa and Asia towards the advancement of evidence-based policy-making and regulation in the emerging information and communication technology (ICT) economy to ensure greater participation in ICTs in the context of a more integrated world economy.

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The paper presents findings from a survey conducted in Nairobi between January 2011 and September 2011 on the e-waste situation in Kenya. Of particular interest to this paper is the development of an e-waste policy and regulatory framework. With the global debate on this emerging stream of solid waste gaining momentum, and given the negative human and environmental impacts and the presence of recoverable precious metals in e-waste, recent years have witnessed numerous attempts by African governments to develop guidelines, regulatory frameworks and policies to deal specifically with e-waste.

In Kenya, the government's current disposal mechanisms through procurement pose a challenge. Not all government institutions follow the required disposal procedures during procurement (Bitange, 2010). Basiye (2008) estimated that Nairobi generated 1500 tons of solid waste daily but that only 25 per cent of this waste was collected and sent to Dandora, an open dumpsite covering 27 hectares.

Attempts by the government to manage e-waste in Kenya have suffered from a number of drawbacks, 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 inventorisation, 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: toxic materials enter the waste stream with no special precautions to avoid the known adverse effects on the environment and human health; resources are wasted when economically valuable materials are dumped; and unhealthy conditions are developed during informal recycling.

According to Waema *et al.* (2008), the Kenyan Ministry of Information and Communication was proactive regarding e-waste and, in 2006, formulated an ICT policy on e-waste that states:

> As a prerequisite of grant or renewal of licenses, applicants must demonstrate their readiness to minimize the effects of their infrastructure on the environment. This should include provision for appropriate recycling /disposal facilities for waste that may contain toxic substances.

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).

National Environmental Management Authority (National Environmental Management Authority (NEMA)/Ministry of Environment and Mineral Resources, 2010) guidelines for e-waste management in Kenya identified producers, manufactures, importers, assemblers, distributors, consumers, government institutions and refurbishers or recyclers as target groups for managing e- waste. On collection, the guidelines proposed the following as mechanisms for consideration when coming up with an e-waste legislative framework:

- municipal collection;
- designation of collection centres;
- producer take-back schemes;
- producer responsibility organisation (PRO);
- storage on site or off site;
- transportation;
- training of handlers; and
- licensing of collection centres.

It was further suggested in these guidelines that, in terms of storage facilities, e-waste take-back, municipal transfer stations, sorting (streams), technical specifications and capacity to handle e-waste should be taken into consideration. Furthermore, there was a need for the establishment of a treatment facility that encompasses operational

requirements, treatment and disposal unit, storage, dismantling and segregation, recycling and recovery, disposal sites and licensing requirements (Magari, 2010).

According to Basiye (2008), in Kenya no funds or resources are set aside for managing e-waste. Additionally, there is no financial infrastructure for e-waste recycling. The financial model in Europe is based on ''extended producer responsibility'', with the producing organisations bearing responsibility for waste electronic and electrical equipment (WEEE) take-back and treatment. Conceptual guidance for e-waste collection, transportation and treatment schemes has been provided by European Union (EU) directive. The guidance features in the EU directive include the following:

- Producers are responsible for the costs of picking up e-waste from collection facilities and for refurbishing waste products for reuse or for recycling and recovery.
- For ''historical products'' (i.e. those put on the market before 13 August 2005), the costs of waste management are to be shared by all producers in existence at the time those costs are incurred. These producers may impose a separate ''visible fee'' (one that is explicitly designated, perhaps on the price tag) to cover these costs for eight years (ten years for large household appliances).
- End-users other than households may be made partly or totally responsible for financing the management of historical products.
- For new products (i.e. those put on the market after 13 August 2005), producers have ''individual responsibility'' (i.e. they must pay the cost of managing their own products). This can be done through programmes set up by individual companies or through participation in collective schemes.
- No visible fees are permitted to fund the management of waste from new electrical and electronic products.
- When producers put a new product on the market, they must provide a financial ''guarantee'' that waste management of the product will be paid for. This guarantee can be waived where producers participate in a PRO, pay recycling insurance or set up a special bank account for this purpose.

According to Schluep *et al.* (2009), South Africa and China have been identified for sustainable e-waste recycling technologies by applying the United Nations Environmental Programme technology-transfer framework. South Africa was implementing a national e-waste recycling compliance scheme, which would ensure that framework conditions would be favourable for a successful technology transfer. This programme is supported by a Swiss e-waste programme, Hewlett Packard, Dell and Nokia. Kenya, Uganda, Senegal and Peru are placed together in Group A, and are classified as promising for the introduction of pre-processing technologies with strong capacity-building support.

Setting up state-of-the-art recycling infrastructure without considering the economic and social boundary conditions cannot meet the aims of technology transfer for e-waste recycling. Technology transfer without taking into account the amount of e-waste to be processed in recycling plants, social and cultural boundary conditions and the role of the existing informal sector hampered and resulted in the failure of pilot projects in the case of China (Schluep *et al.*, 2009).

Aim and purpose of study

The aim of this research was to develop an ideal regulatory framework for e-waste management to handle the collection, transportation, processing, recycling, disposal and monitoring of the new stream of solid waste.

Problem and objective

There is a silent accumulation of e-waste in Kenya, and yet there is no policy framework to address the collection, transportation, treatment, safe disposal and monitoring of its flows in

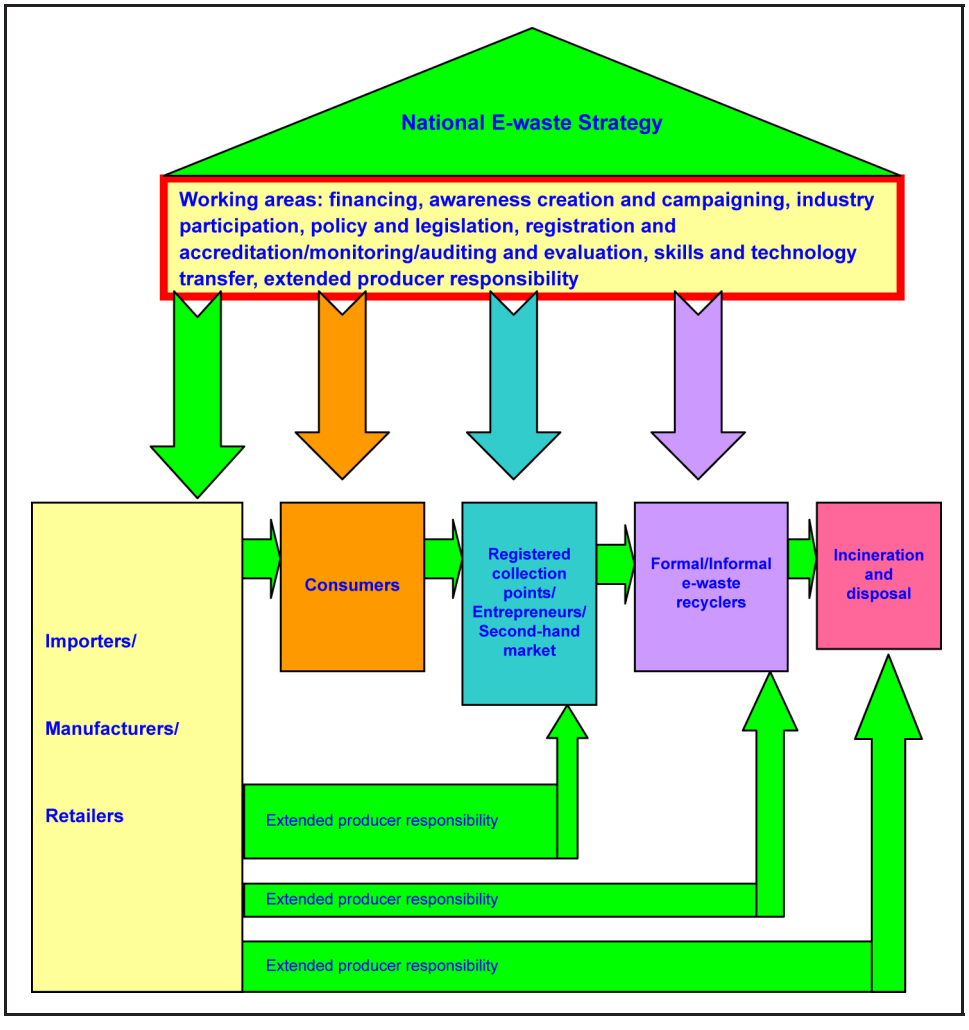
Kenya. Due to an inadequate regulatory framework, various stakeholders do not take up their responsibilities with regard to e-waste management; consequently, there is a problem with disposal. This poses serious danger to both human health and the environment.

In this paper we seek to identify the responsibilities of various e-waste stakeholders in Kenya, and to investigate their e-waste disposal practices and the challenges they face. Additionally, we analyse how other countries manage e-waste and identify what lessons Kenya could learn from them. Finally, we propose an ideal e-waste management framework for Kenya.

Conceptual framework

The research framework for this study (see Figure 1) was obtained from a review of related literature. The study used a conceptual framework derived from the Swiss Federal Laboratories for Materials Testing and Research (EMPA). The generic model describes the manufacturer or importers of e-waste, the consumers and recyclers, as well as the downstream informal markets that provided data for the survey. In the EMPA generic model, the consumer gets a computer from the importer or manufacturer who directly supplies it to the market or through a retailer (Waema *et al*. 2008). When a computer reaches the (EOL), the disposal process begins. In well-established frameworks, formal or informal collection

Figure 1 Conceptual framework



systems are used to collect the computer. The computer may then be fed into the secondary market, which extends its life cycle by refurbishing it. Once it has been repaired, the computer is resold as second-hand to a consumer and the cycle is repeated. A computer that is beyond repair is dismantled to recover the e-waste component material. Incineration can be used to recover energy from e-waste material.

According to Schluep *et al.* (2009), the following information should be collected when using the generic methodology of the Hewlett Packard-Empa project, ''e-Waste Management in Africa'':

1. *E-waste related policies and legislation information*:
   - general environmental legislation applying to air, water, solid waste, hazardous wastes, etc.;
   - specific legislation applying to e-waste, if any;
   - social legislation/policies applying to workers in the recycling chain (e.g. regulating child labour, freedom of association, programmes fostering employment in the informal sector, etc.; and
   - international treaties and conventions, such as the Bamako Convention and the Basel Convention.
2. *Institutional framework information*:
   - organisation of the legislative, executive and judicial systems, with a special emphasis on environmental management; and
   - governmental bodies related to environmental management and e-waste at national and, if important, at local level, such as ministries, administrations, etc.

Another framework used in this study was the EMPA two-stage strategy for implementing clean e-waste channels in India's large cities:

1. Clean e-waste channels for corporate consumers are implemented while EMPA helps to gather experiences for setting up and running a clean e-waste channel. At the same time, the informal sector is trained to handle the critical recycling process.
2. Private households and small and medium enterprises (SMEs) are linked to the established clean e-waste channels. The informal recyclers are integrated in the formal recycling processes for labour intensive manual operations such as dismantling and material segregation.

Both frameworks have clear responsibilities, well-defined financing, adequate monitoring and e-waste regulations. In the conceptual framework, the government's role is to look into areas such as the following: e-waste policy and legislation creation; enforcement; financing; awareness creation and campaigning; industry participation; e-waste recycler registration and accreditation; monitoring, auditing and evaluation; skills development; and technology transfer. In implementing the national e-waste strategy, public government agencies responsible for environmental issues, such as the National Environmental Management Authority (NEMA), Ministry of Local Government, Ministry of Health and Ministry of Environment and Natural Resources, are responsible for formulating and enforcing e-waste management policies for the producers, distributors, recyclers/refurbishers and consumers.

The conceptual framework used in this study looks into the legal and regulatory framework, which includes measures against illegal dumping, mandatory take-back, disposal bans and restrictions, and material bans and restrictions. Information instruments and public awareness measures, such as environmental labelling, product hazard warnings, product durability warnings and energy efficiency labelling, are also an integral part of the framework. Finally, the conceptual framework considers technological dimensions to address the need for building national e-waste handling capacity.

Methodology

Both qualitative and quantitative methods were used in the study. The study was limited to Nairobi and its environs with regard to geographical coverage. Nairobi was chosen because it is argued that Nairobi is the heaviest consumer of ICT products and, consequently, has more challenges related to e-waste (Waema *et al.*, 2008). With regard to product, it focused on ICT equipment, and specifically personal computers, laptops and notebooks, flat-panel monitors, cathode ray tubes, printers and other computer-related accessories. According to Waema *et al.* (2008):

> [. . .] the e-waste ''universe'' in Kenya comprised of stakeholders ranging from importers, assemblers, retailers, consumers, refurbishers, recyclers, downstream vendors, final waste disposers to policy-makers and selected households located near dumpsites.

A working list was developed for the research, since the licensing framework did not disaggregate ICTs from general trade. This means that no definitive list of stakeholders was available from the Ministry of Trade, Ministry of Industrialisation or professional associations.

Primary data were collected by means of questionnaires, interviews and direct observations, which lasted three weeks during field visits. Secondary data were collected from a review of documents and literature. General observations were also made during field visits to map activities going on at scrap dealers, repair and refurbishing shops, government agency offices and collection centres. Photographs and, where appropriate and necessary, videos helped fill information gaps. The target respondents were policy-makers, regulators and enforcers, suppliers, manufactures, consumers, collectors and refurbishers of electronic and electrical equipment.

Among those interviewed were government agencies, producers, consumers, recyclers and e-waste collectors. Government agencies included two compliance officers from the NEMA waste unit, two standards-development officers from the Kenya Bureau of Standards, one senior health policy administrative officer from the Ministry of Public Health and Sanitation, one senior ICT officer from the Ministry of Information and Communication Technology and one senior officer from the solid waste department of the Nairobi City Council. The questions asked were in relation to issues of policy and e-waste regulations, public awareness and consumer education, e-waste strategy, implementation, monitoring and standards.

Consumers included 15 ICT officers from government ministries, ten procurement officers from government ministries, one IT operations and maintenance officer from Kenya Post and Telecommunications (KPLC), 14 secondary school laboratory technicians and 20 secondary school computer studies teachers. The consumers were asked questions related to the issues of e-waste separation at source, return of equipment deemed to have reached EOL, e-waste disposal practices, e-waste management financing, awareness and challenges they faced in e-waste management.

Among the producers interviewed were one waste management officer from Safaricom, two telecommunication officers from Orange Telkom Kenya, and ten computer retail shop agents. The type of question raised with this group revolved around themes such as extended producer responsibility (EPR), establishing collection and take-back centres, extended producer organisations (EPOs), e-waste financing, awareness creation, e-waste inventorisation, and the challenges faced in e-waste management.

The last group interviewed consisted of the e-waste recyclers and collectors, and included six e-waste recycling staff from CFSK, six computer repair shop technicians, and one informal recycler from Kibera slums.

The information gathered through questionnaires, personal observations, discussions, interviews and photographs was analysed thematically, presented and discussed as per research study questions, and then grouped in accordance with the different e-waste stakeholder categories and aspects. During the survey, for ethical and legal reasons, permission was sought from relevant authorities and persons before the photographs included in this study were taken.

Findings

E-waste is an emerging stream of solid waste in Kenya, as it is the world over. It has become a major concern in Kenya due to the high volumes in which it is generated, its hazardous fractions (such as chromium, lead, cadmium, beryllium, brominated flame retardants and mercury) and the lack of policies and regulations applicable to its disposal or recycling. The main sources of these forms of waste were educational and government institutions, manufacturing industries, business organisations and individual users of technology.

This paper presents results of a field survey conducted in Nairobi on e-waste management practices and policy in Kenya.

E-waste management policy and regulations

It was revealed that no policies and procedures were in place to enable proper management of electronic waste in Kenya. However, CFSK was doing good work in trying to deal with the problem and it had established an e-waste recycling facility in Nairobi.

This study revealed that 90 per cent of consumers did not have any e-waste disposal policy, while only 10 per cent indicated that they had some framework. The respondents who said that they had a framework were drawn mainly from government agencies that followed the Public Procurement and Disposal Act of 2005. However, they were quick to point out that it had failed because of lack of enforcement. Commenting on whether they had computers that they felt had reached EOL, a majority (80.95 per cent) of the respondents agreed that they did, while only 19.05 per cent indicated that they did not.

There were no specific national environmental laws or guidelines for e-waste (National Environmental Management Authority (NEMA)/Ministry of Environment and Mineral Resources, 2010). None of the existing environmental laws made any direct reference to handling of e-waste; however, provisions made for environmental management and co-ordination (Waste Management Regulations of 2006) may apply to e-waste where it can be classified as hazardous.

According to NEMA (National Environmental Management Authority (NEMA)/Ministry of Environment and Mineral Resources, 2010), existing policy was drawn from international instruments that included many agreements and conventions on environmental management to which Kenya is a signatory, such as: the Rio Declaration of 1992 on Environment and Development; the Basel Convention on Trans-boundary Movements of Hazardous Wastes and their Disposal; and the Nairobi Declaration on the Environmentally Sound Management of E-waste, adopted at the Conference of Parties (CoP 8) meeting in Nairobi in 2007, focusing on the needs of developing countries and countries with economies in transition. Another policy instrument was the Sessional Paper No. 6 of 1999 on Environment and Development, which identified areas requiring action for the development of a comprehensive waste management policy, guidelines and standards.

The Environmental Management and Co-ordination Act of 1999 provided for the establishment of an appropriate legal and institutional framework for the management of the environment. The Waste Management Regulations of 2006, the government's legal instrument for dealing with waste management in Kenya, applies to e-waste by virtue of its hazardous composition. The Environment Management and Co-ordination (Controlled Substances) Regulations of 2007 deal with substances that deplete the ozone layer, and provide a list of hazardous substances, but do not detail how they ought to be handled with relation to e-waste management.

E-waste management technology

During the survey, it was observed that most of the machines were rudimentary and were inadequate for recovery of precious metals and separation of hazardous parts. This confirmed revelations on lack of adequate technology and machines, as well as trained e-waste personnel in Kenya (Basiye, 2008). Cartons and containers of computers donated for recycling and onward distribution to schools were observed. Sacks of shredded plastic computer casings were also observed.

E-waste institutional framework

This paper identified the institutional framework on e-waste management in Kenya as: the Ministry of Environment and Mineral Resources, responsible for the environment at policy level; NEMA, the principal government instrument for the implementation of all policies relating to the environment; the Ministry of Local Government; the Communications Commission of Kenya; the Ministry of Information and Communication; the Kenya Bureau of Standards; the Kenya Revenue Authority; the Ministry of Education; and the Nairobi City Council.

E-waste management initiatives

According to NEMA (National Environmental Management Authority (NEMA)/Ministry of Environment and Mineral Resources, 2010), efforts towards development of an e-waste policy in Kenya included the following:

- the Ministry of Information and Communication included a clause that addressed e-waste in the 2006 National ICT policy[1];
- the Communications Commission of Kenya was working on the enforcement of the Unified Licensing Framework; and
- the City Council of Nairobi was developing an integrated solid waste management strategy in conjunction with the United Nations Environmental Programme.

E-waste disposal practices

An assessment of e-waste disposal practices by consumers revealed that a significant proportion of consumers (52 per cent) stored e-waste due to lack of awareness of where to take it or what to do with it. This was followed by 24 per cent who auctioned it, 20 per cent who donated it and 4 per cent who took it to a registered collection centre or recycling plant (CSFK).

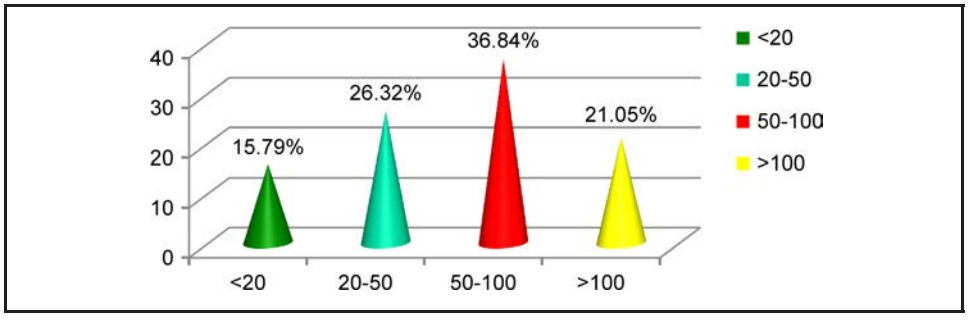
Although contributions from individual households are currently relatively small, they are likely to grow appreciably in the future. The government and learning institutions are also an important source of e-waste in the country; however, it has proved extremely difficult to capture the exact quantity of waste generated by this group because there is no national registry.

In this study, approximately 36.8 per cent of the consumers interviewed had between 50 and 100 computer units in store or at home, 26.3 per cent had between 20 and 50 units, 21.0 per cent had more than 100 units and 15.8 per cent had fewer than 20 (see Figure 2).

E-waste quantities stored by consumers

Respondents who had more than 20 computer units in storage or at home were drawn largely from government agencies and secondary schools offering computer studies at Kenya Certificate of Secondary Education level in Nairobi. It seems, therefore, that learning institutions and government agencies are a major source of e-waste in Kenya. In this study,

Figure 2 Number of computer units stored by consumers



direct observations made during the survey revealed an accumulation of e-waste in government offices and learning institutions.

A similar finding reported in a previous study (Finley, 2005, in Anahide, 2007) estimated that ''about 70 per cent of South Africa's e-waste is thought to be in store – by the government''. In Kenya, this study, through an interview conducted with procurement officers in government institutions, showed that most of the e-waste (98 per cent) sold at auction was inoperative and that the revenue from the auctions was trivial (nominal). The inference could be made that government agencies are prone to selling obsolete electrical and electronic equipment on auction in an attempt to escape financial responsibility for historic waste. Hence, it might be concluded that the vendor is an illegal recycler, and that the system of auction stimulates illegal dumping of e-waste in Kenya.

E-waste financing

In terms of what financing model would be sustainable in Kenya, the study found out that 100 per cent of the respondents were convinced that a model that gave consumers incentives would be the best; however, they were doubtful about its practicability. The implication, therefore, was that a sustainable and suitable framework ought to reward consumers of electronic and electrical equipment by paying a fee for any waste equipment returned. The cost of financing the model could be shared between manufactures, consumers and the government.

Responsibilities of various stakeholders

The study revealed that it was the responsibility of the producers to establish collection centres in Kenya. Additionally, they were responsible for forming producer responsibility organisations, receiving all returned e-waste and safely disposing of it, creating awareness and advocating for the design of products with minimal negative impact on health and the environment. Extended producer responsibility is a strategy that has worked well in the EU but has failed in Kenya. The main reason is lack of collaboration. It is established in this paper that two separate take-back schemes had been organised by two mobile phone communication operators in Kenya, namely Safaricom and Nokia. However, both schemes failed because individual manufacturers were competing amongst themselves, which hindered collective responsibility and a collaborative policy approach on e-waste management by producers. One may conclude that it is difficult to enforce collective responsibility through producer responsibility organisations in Kenya, without collective responsibility and collaboration, consequently making extended producer organisations ineffective.

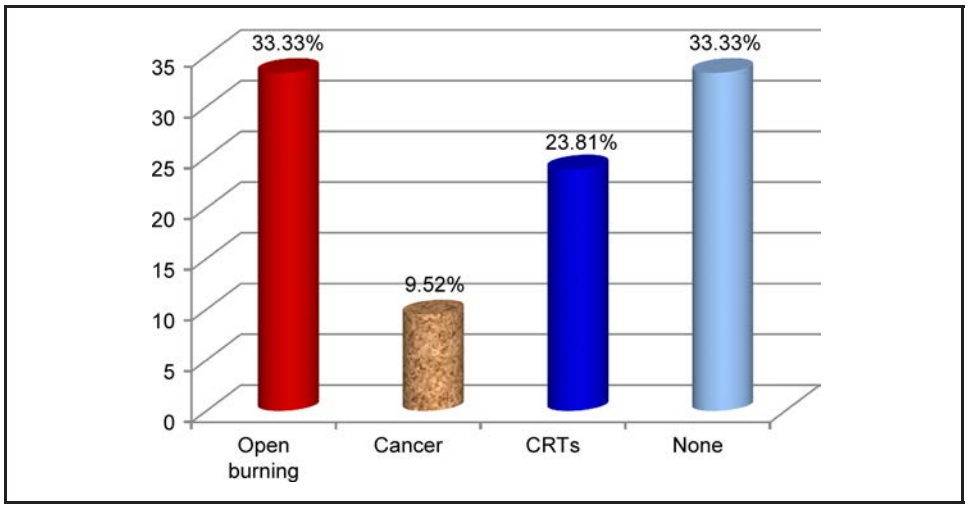
Impact of e-waste on health

With regard to health issues and careless disposal or handling of e-waste that consumers had encountered in the recent past, and which could have a negative impact on the environment or constitute a health hazard, the following was revealed (see Figure 3): 23.8 per cent of respondents interviewed had seen carelessly dumped computer components, such as cathode ray tubes, system units, motherboards and keyboards and 33.3 per cent had seen open burning of computer parts, while 33.3 per cent said that they were not aware of any negative health or environmental impacts that could result from improper handling of e-waste. It was noted that only 9.5 per cent of the respondents were aware of health hazards such as cancer, eye sores and breathing complications that may be caused by e-waste.

A section of the consumers reported that they were aware that cadmium could leach into soil, that sulphur could cause liver damage and that mercury could cause sensory impairment and memory loss.

According to UNEP (2010), hazardous substances such as heavy metals contained in most discarded electronic items pose a serious risk to the environment and human health. Such metals include cadmium, lead and sulphur.

Figure 3 Health issues related to e-waste



A recent study (Institute of Physics, 2011) in China revealed that samples of pollutants caused significant increases in both Interleukin-8 (IL-8) and Reactive Oxygen Species (ROS) levels – indicators of an inflammatory response and oxidative stress respectively. Tests of local air pollution and its impact on human lung cells revealed inflammatory responses and oxidative stress, which could lead to DNA damage, cardiovascular disease or cancer. The authors concluded by saying:

> From these results it is clear that the ''open'' dismantlement of e-waste must be forbidden with more primitive techniques improved. As the results show potential adverse effects on human health, workers at these sites must also be given proper protection. Furthermore, one must consider the initial manufacturing process of electrical goods and look to utilise more environmentally and human friendly materials in their production.

According to the chief executive officer of CFSK, the mercury, lead, cadmium and polycyclic aromatic hydrocarbons are potentially toxic chemicals found in computers (Mshindi, 2010).

Socio-economic benefits of e-waste

This paper presents findings from Kibera, the largest slum in Africa, comprising of a large percentage of very poor inhabitants, with the observation that there was inadequate technology and skill to manage e-waste in Kenya, but that there was potential for job-creation in the e-waste management sector. Informal recycling of e-waste took place in Kibera, and this had turned into a gainful source of income. The survey carried out in this study revealed that an informal recycler raised an estimated income of KShs150.00 (US$1.50) per system unit metal case sold to ''*jua kali*'' (informal metal workers) who bought them to make ''*jikos*'' (charcoal stoves). It was further found that one mother board was sold at KShs40.00 (US$0.50) to electronics repair shops.

Calculating the profit margin, the authors of this paper estimate that, on average, earnings of KShs5,500.00 could be realised from the sale of the metal cases and mother boards alone in a month (see Table I).

It can be argued that e-waste could be a source of income to the informal sector in Kenya, if well managed. It can be argued further that the profit margin shown in Table I of KShs5,425 (approximately US$54.25) could easily be doubled to KShs10,850 (approximately US$108.50), or even tripled to KShs16,275 (approximately US$ 162.75) in two weeks, implying almost double the amounts in a month given a sound mechanism for e-waste collection and an incentive system. Therefore, in a month, informal e-waste recyclers could earn a minimum of Kshs21,712 (approximately US$217.12) and a maximum of KShs32,550 (approximately US$ 325.50). Such an income is certainly higher than the amount currently

Table I Analysis of profit margins in Kenya shillings

E-waste item	*Quantity*	*Buying price*	*Selling price*	*Total*
System unit	35	185.00		6,475.00
System unit metal case	*35 × 2*		150.00	10,500.00
Mother board	35		40.00	1,400.00
Total sales				11,900.00
Profit margin (11,900 – 6,475)				5,425.00

earned by casual labourers from Kibera working in industrial areas, whose daily pay rate is KShs350.00, aggregating to KShs8400 (approximately US$84.00) in a month.

Schluep (2006, in Anahide, 2007) reports that in South Africa collectors bring scrap metal, paper, glass and e-waste to buy-back centres, using of various means of transportation, including pulling or pushing trolleys. It, therefore, seems that one of the key issues that the ideal e-waste management framework ought to address is safe e-waste transportation logistics. The mode of transport is a critical issue, as it has a bearing on the safe handling of e-waste during transportation.

Given the above scenario, it is the view of the authors of this paper that the informal sector is currently playing a key role in solid waste management in Kenya. However, its full potential in creating gainful employment in the informal sector and promoting sound environmental management practices, especially on e-waste, has not been fully explored. Assuming a clear policy on e-waste collection, and given the proof of silent e-waste accumulation as documented in this study, the authors are convinced that the informal sector could play a pivotal role in the collection and downstream recycling of e-waste in an environmentally friendly manner, while, at the same time, creating gainful employment opportunities for thousands of youths in Kenya (and, similarly, in other African countries).

It is pointed out above that the accrued electronic and electrical waste in Kenya is dismantled and sorted manually into its various parts, such as printed wiring boards, cathode ray tubes, cables, plastics, metals, condensers and other materials like batteries. E-waste is a source of livelihood for informal recyclers, but due to lack of awareness, they are risking their health and the environment as well. There is also a lack of technology for separating hazardous waste from the valuable metals.

Experiences from other countries

In Switzerland, there is clear policy, adequate skill and technology to deal with e-waste (UNEP, 2007). In spite of the challenges faced, South Africa has taken great strides towards developing policies, procedures, strategies and legislation for the management of e-waste (Schluep *et al.*, 2009). The conclusion can be made, therefore, that given proper e-waste management in Kenya there is a great economic potential, which will also improve environmental management.

Lessons

Findings from this study reveal that Kenya and Africa at large could benefit from the following:

- The adoption of a model where consumers take e-waste to waste collectors who pay them. Then the collectors could sell to recyclers who, in turn, could sell to producers. This could drive e-waste collection, transportation and its treatment, as is the case in India.
- The adoption of an advance recycling fee, (ARF) charged on all new appliances coming onto the market after the new e-waste policy. The ARF could be used to finance the collection, transportation, storage, recycling and safe disposal of e-waste generated, as is done in the EU.

- The e-waste system in Kenya could make producers both legally and operationally responsible, and a technology transfer strategy could be adopted to develop e-waste management skills in Kenya and Africa, in general.
- The existing informal waste management sector, consisting of collectors, traders and recyclers, could be incorporated in the formal e-waste management system. This could create jobs for thousands of unemployed youth.

The recommended e-waste management framework

It is hoped and believed that the e-waste management framework suggested in this paper presents a unique and ideal solution to the e-waste problem in Kenya and, by extension, would be suitable for adoption in other local African contexts. The proposed framework (Figure 4) has the following components:

- a clearly defined e-waste collection system;
- universities, NGOs and investors;
- clearly defined transport logistics;
- producers and manufacturers of electrical and electronic equipment;
- the informal sectors;
- collaboration; and
- monitoring of illegal imports and dumping.

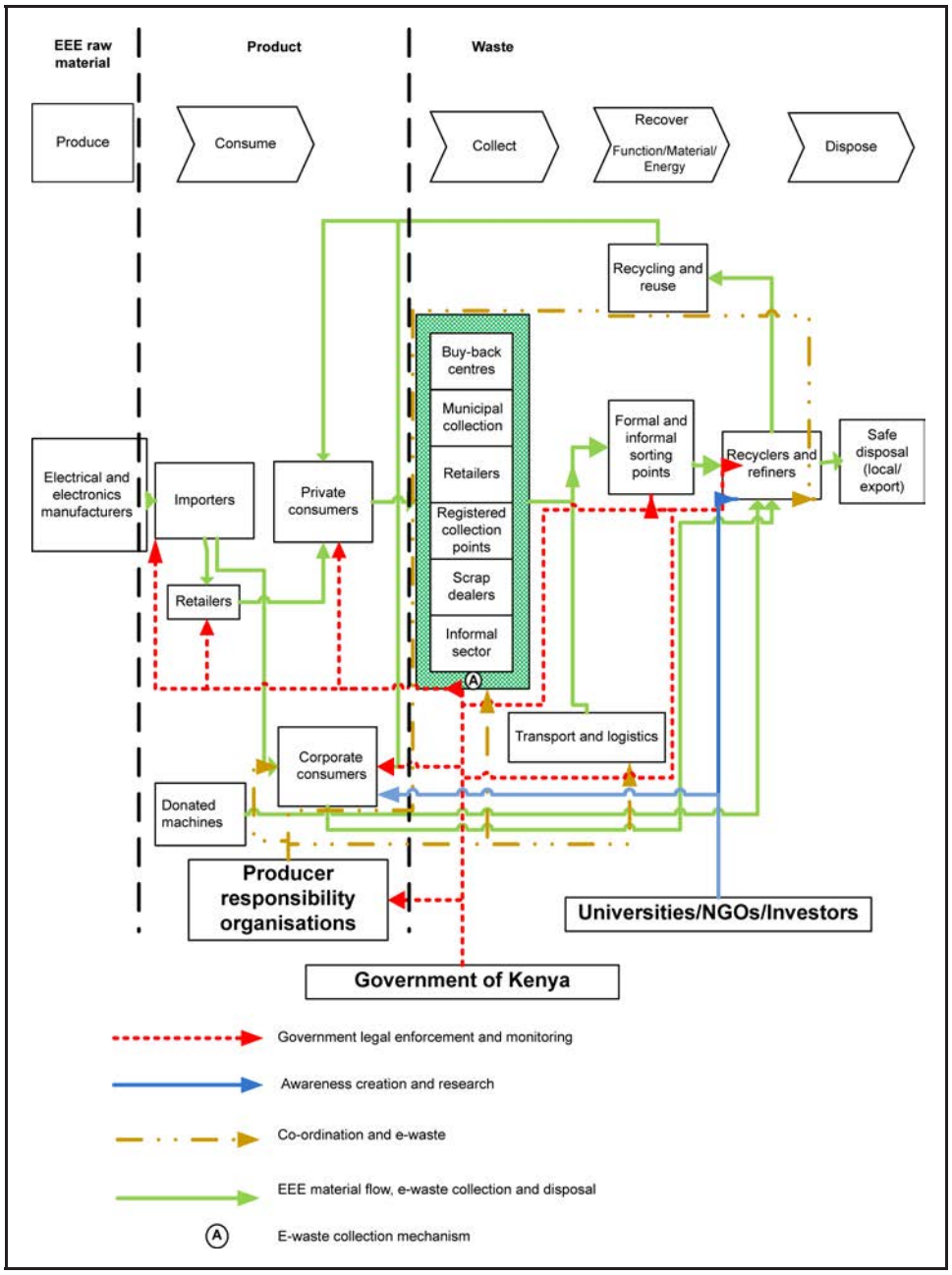
This paper identifies the following stakeholders who ought to take up their responsibilities and form part of the proposed framework:

- consumers;
- collectors and collection points;
- refurbishers;
- processors or dismantlers;
- final disposers;
- the government;
- academics;
- NGOs; and
- producer responsibility organisations.

Producer responsibility organisations provide the managerial component of the framework's logistics and e-waste processing. Buy-back centres would probably be one of the viable avenues for collecting e-waste in Kenya. These could be set up by entrepreneurs who must be registered and trained in e-waste handling. Universities have a great role to play in e-waste research and technology transfer. The informal sector is already established and plays an active role in solid waste management in Kenya. Perhaps what is lacking and is now proposed in this framework is an organised infrastructure of how to co-opt the informal players into the e-waste management mainstream. As a matter of principle, the proposed framework recognises that national systems should be run and managed by industry/recyclers/producers within a sound legislative framework established in a collaborative and consultative process with all e-waste stakeholders. The framework proposes the inclusion of a clause that empowers the Kenya Revenue Authority and Kenya Bureau of Standards to come up with policy and enforce and monitor trans-boundary movement of hazardous waste, as contained in the Basel Convention.

A summary of the cost implications of implementing the framework is presented in Table II.

Figure 4 The ideal e-waste management framework for Kenya



The framework implementation costs provide the key elements to be considered in working out the financial implications of implementing the proposed framework, but do not include the actual amounts.

Conclusion

This paper has presented and proposed an ideal e-waste management framework for Kenya from a variety of perspectives – policy, e-waste management practices, e-waste industry structure, and stakeholder responsibilities – drawing on concepts and models from elsewhere, especially the European Union and South Africa. The emergence of e-waste has further complicated the already complex task of solid waste management in Kenya. The

Table II Cost of framework implementation

Framework element	*Cost implication*
E-waste collection system	Incentives for collection Storage costs
Universities, NGOs and investors	Trainers, training tools, training venue Trainee costs(allowances, cover at work place) Technology transfer
Transport logistics	Transportation from retail points, scrap dealers, informal collectors Municipal collection
Producers and manufacturers	Collection points set up costs Incentives for collection costs
Informal sector	Incentives for collection
Illegal imports and dumping monitoring	Monitoring and enforcement overhead costs

paper advocates for the urgent establishment of an ideal e-waste collection system, monitoring, exchange and recycling centres, and an effective take-back system that provides incentives to consumers. Institutional infrastructure for e-waste collection, transportation, treatment, storage, recovery and disposal needs to be established at national and/or regional levels for the environmentally sound management of e-waste. Strong collaboration is required among all stakeholders in tackling the e-waste problem. Criteria ought to be developed for the recovery and disposal of e-waste. Policy-level interventions ought to include the development of e-waste regulations, control of the import and export of e-waste, maintaining a national e-waste registry and facilitating the development of infrastructure. Universities and other academic institutions should play an active role in awareness creation, training, e-waste research and technology transfer. Additionally, there is an urgent need to set targets for collection and reuse/recycling, to impose reporting requirements and include enforcement mechanisms and deposit/refund schemes through producer responsibility organisations.

Note

1. Kenya Regulatory Framework, E-waste Provisions, ICT Policy of 2006: ''As a prerequisite for grant or renewal of licences, applicants must demonstrate their readiness to minimize the effects of their infrastructure on the environment. This should include provision of appropriate recycling/disposal facilities for waste that may contain toxic substances.''

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