Vol. 12(11), pp. 429-438, November 2018
DOI: 10.5897/AJEST2018.2409
Article Number: CDDAC9259247
ISSN: 1996-0786

http://www.academicjournals.org/AJEST

African Journal of Environmental Science and Technology

Full Length Research Paper

Stakeholders' perceptions on key drivers for and barriers to household e-waste management in Accra, Ghana

Kwabena Badu-Yeboah*, Clifford Amoako and Kwasi Kwafo Adarkwa

Department of Planning, Faculty of Built Environment, College of Art and Built Environment, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Received 22 August, 2017; Accepted 24 October, 2017

Safe management of e-waste has become a major problem for many countries particularly developing countries. This is because e-waste management in an environmentally sound manner (ESM) is affected by many factors in most African countries. To address this emerging urban waste problem, city authorities are devising management strategies that would be acceptable to key stakeholders. This paper evaluates perceived drivers for and barriers to the adoption of e-waste management option in Accra, Ghana from the perspective of households, e-waste workers and institutions. The paper identified four critical factors that could facilitate the adoption of e-waste management option. These include regulatory framework, public health outcomes, education and awareness on e-waste management and good policies and stricter legislation. In addition, the paper identified poor policy framework, lack of or inadequate legal/regulatory framework, low public education and awareness of e-waste management and unhealthy conditions of informal recycling as the four most critical barriers to overcome in the search of e-waste management option. We draw attention of policy makers and waste planners to critically take into consideration the identified drivers and barriers in the adoption of any management option to ensure sound environmental practices.

Key words: E-waste, stakeholders, drivers, barriers, management option.

INTRODUCTION

E-waste being part of urban waste has become an emerging challenge to city authorities and planners due to the magnitude of volume and quantity generated. The increasing volume generated annually in cities worldwide is attributed to rapid urbanization (Babu et al., 2007), rapid changes in technology (Oteng-Ababio and Amankwaa, 2014) which has resulted in the manufacturing of new designs (Kiddee et al., 2013; Rode, 2012; Tiwari and Dhawan, 2014) and changing lifestyle. Consequently, the management has become an albatross for many countries not only as a result of the volume and rate of waste generation but also because it

*Corresponding author. E-mail: kwabena_yeboah2001@yahoo.com. Tel: +233 20 813 1258.

contains several toxic substances which could lead to adverse health and environmental effects (Robinson, 2009; Peralta and Fontanos, 2006) if not properly handled or disposed of (ILO, 2012).

On the other hand, e-waste also tends to contain substantial quantities of valuable minerals such as gold, silver, copper, platinum and other precious metals (Widmer et al., 2005) which could be lost to the waste stream if it is not recovered early. From the aforementioned discussions, it is imperative that while e-waste is a growing environmental and health concern, it also offers opportunities for many people to earn a living (Herat and Agamuthu, 2012).

Studies have shown that e-waste management in an environmentally sound manner (ESM) has been constrained by many factors in developing countries. These include lack of institutional framework, inadequate or absence of effective legislation (Kiddee et al., 2013; Herat and Agamuthu, 2012), and other regulatory controls. Other factors include lack of proper recycling infrastructure (Oteng-Ababio and Amankwaa, 2014; Namias, 2013; Herat and Agamuthu, 2012) and inadequate knowledge on proper disposal practices by households (Kalana, 2010). These have resulted in the adoption of crude and wasteful recycling methods by informal recyclers in developing countries (Oteng-Ababio and Amankwaa, 2014; Nnorom and Osibanjo, 2008).

In response to the increasing e-waste problem, many countries in Europe, North America and Asia have adopted management strategies that incorporate best practices to manage it in an ESM. However, many developing countries are yet to adopt any management strategy to specifically address the e-waste issue. Although extensive research has been carried out on e-waste management in Ghana, no single study exist which adequately covers appraisal of how key drivers and barriers could affect the adoption of e-waste management option.

The objective of this study is to evaluate perceived drivers for and barriers to the adoption of e-waste management option in Accra, Ghana from the perspective of key stakeholders. This study, therefore, whiles bridging the knowledge gap in the literature, contribute to scholarly debate in the search of e-waste management option in Accra using data of households from three selected communities, e-waste workers and institutions.

LITERATURE REVIEW

Identifying and adopting appropriate policy and management strategies for waste management, especially e-waste, is a challenging task that requires technical expertise. However, policy formulation and management strategy design is not just a technical exercise and it is imperative that policy and management strategies should also reflect the values of the community they serve. An important dimension that is significant to policy formulation is drivers and barriers. Drivers are factors which have a positive influence while barriers are factors which have a negative influence. Integrating key drivers and barriers in a synergetic and reinforcing strategy in policy formulation will serve as a framework for appropriate activities towards sound e-waste management.

Drivers

A review of the literature identified a range of drivers for the adoption of new concepts or policy implementation. Phillips et al. (2002) have identified the main drivers of municipal solid waste management best practice in United Kingdom. According to them, they include policies and legislation, efficient waste institutions, socio-economic factors, education and public awareness as well as various regulatory frameworks established over time.

Similarly, UNEP (2007), Savage et al. (2006) and Babu et al. (2007) observed that public awareness and knowledge of environmental and health impact of e-waste is critical for their management. Additionally, studies by Wilson (2007), Peralta and Fantanos (2006), Zaman (2014), Kiddee et al. (2013), Khetriwal et al. (2007) and Nnorom and Osibanjo (2009) showed that the driving factor for e-waste management best practices in most countries is the formulation of policies and institution of good legislation. Other drivers identified in the literature include community perception, efficient waste management institutions, socio-economic factors, potential market for recycled products, adequate infrastructure for collection, treatment and disposal as well as existence of informal recycling sector (ILO, 2012; Wilson, 2007; Oteng-Ababio, 2012c; Amankwaa, 2014; Oteng Ababio et al., 2014; Chi et al., 2011).

Barriers

There are a number of key factors which normally put a barrier against sound waste management practices. For instance, ILO (2012) identified absence of data on quantity of e-waste generated and disposed of yearly as a hindrance to effective e-waste management. In addition, ILO (2012), UNEP (2007), Kiddee et al. (2013), Herat and Agamuthu (2012) and Kissling et al. (2013) have identified poor policy framework, lack of or inadequate legislation and regulatory framework as barriers to e-waste management. Other barriers found in the literature include low public education and awareness

on e-waste management (Davis and Herat 2008; Hicks et al., 2005), unhealthy conditions of informal recycling (ILO, 2012; Joseph, 2007; Hicks et al., 2005), unstable macroeconomic environment, lack of involvement of stakeholders in decision making, lack of or inadequate funding, weak waste institutions, high cost and inadequate management infrastructure, and limited capacity of state institutions to deal with waste as well as lack of or inadequate funding (ILO, 2012).

METHODOLOGY

Sample population

The population frame for the study consists of electronic assembler/ importer, recyclers/dismantlers (waste scavenging), scavengers, refurbishers (classified as e-waste workers for this study), consumers (households), policy makers and implementers (government officials), city authorities, final disposers and environmental non-governmental organizations (NGO) within the study area.

Three communities namely: Agbobloshie, James Town and Korle Gonno within the Accra Metropolis were selected for the study. These communities were selected because there is high concentration of e-waste activities. In addition, several studies has established that these communities have been affected by e-waste management practices (Oteng-Ababio et al., 2014; Amankwaa, 2014; Huang et al., 2014; Asante et al., 2012; Amoyaw-Osei et al., 2011; Brigden et al., 2008).

For the households, a total of 347 households with 95% confidence level were used for the study. With regards to e-waste workers, a total sample size of 48 was used for the study. It must be emphasized that the sample size for the e-waste workers was not calculated as the sample frame was not known. The researchers were able to collect data from only 48 people due to two main reasons. Firstly, because of the nature of their work, majority are not stationary as they normally scavenge for e-waste.

In addition, majority are migrants as observed by Oteng-Ababio (2010), whose stock of trade is to explore varied opportunities in the city. Secondly, the concept of saturation was detected during the data collection as the researchers realized that no new information was emerging. These reasons informed the decision to make use of 48 respondents. In view of the limited number of respondents, interpretation of the results at 95% precision must be done with caution. The institutional survey covered 11 institutions.

The study adopted both probability and non-probability sampling methods. These include systematic random sampling and purposive sampling techniques. The sample of institutions was purposive as the study targeted people who are policy makers or implementers as well as those involved in e-waste management activities.

Snowball sampling techniques was applied to select respondents of e-waste workers. With regards to households, the three selected communities were stratified into sub areas after which systematic random sampling involving picking a point within the community and moving at a regular interval were used.

In this case, the researchers selected a particular household for the study. In a situation where there were more than one household, accidental sampling was used to select one for the study. Again, in cases where selected household were unwilling to be part of the process, the researchers moved to the next household. After picking the initial household, the researchers picked every third house until the sample size was exhausted.

Data collection

Three sets of questionnaires were developed for the households, e-waste workers and the institutions. This was guided by a 3-point Likert Scale with the following points: “critical”, “not sure” and “not critical” as scale. The questionnaires were self-administered.

RESULTS

Respondents were asked to indicate the extent to which the eleven identified drivers and twelve barriers would facilitate or impede the adoption of effective e-waste management in Accra. Due to limited vocabulary of the local language which was used as a medium of communication for the data collection, a three-point ordinal scale with rating options of 1-not critical, 2-not sure and 3-critical was adopted. Two prong analyses were done. First, percentages for each driver in respect to the scale were calculated to find out the level of effects as perceived by respondents. In the second aspect, the score for “critical” responses were used to rank the drivers in order of importance for the three categories of respondents (Table 1).

Results of the data showed that regulatory framework was identified by households as the most critical issue to consider when adopting e-waste management option. The findings show that 87.0% of households, 95.8% of e-waste workers and all the respondents of the surveyed institutions consider this driver as critical. The findings suggest that this driver is the most critical factor among the eleven to consider when adopting e-waste management option. A possible explanation for the observed patterns may be attributed to the general perception that institution of regulatory controls and safety standards could help to regulate e-waste activities which is currently unregulated. This finding corroborates a study by Khetriwal et al. (2007), Keddee et al. (2013) and Nnorom and Osibajo (2009) who found that the success story of Extended Producer Responsibility (EPR) and the European Union (EU) directives on e-waste have been largely attributed to regulatory framework as the main driver. In addition, Phillips et al. (2002) identified regulatory framework among the main drivers of municipal solid waste management best practices in the United Kingdom (UK).

One striking observation is the assessment of “public health outcomes” especially by e-waste workers. Both the institutions and e-waste workers identified it as the most critical driver as they ranked it 1st while households ranked it 6th. This implies that respondents place high premium on public health over environmental outcomes. In terms of the level of effects, all the surveyed institutions (100%) and e-waste workers (100%) considered this driver as critical, while 83.3% of households indicated same. The finding affirms earlier one by Wilson (2007) who identified public health as an

Table 1. Ranking of key drivers by sample households, e-waste workers and institutions.

S/N	Key drivers	Households (n=347)		E-waste workers (n=48)		Institutions (n=11)	
		No.	Rank	No.	Rank	No.	Rank
1	Good policies and stricter legislation	299 (86.2)	3rd	45 (93.7)	3rd	11(100)	1st
2	Regulatory framework	302 (87.0)	1st	46 (95.8)	2nd	11(100)	1st
3	Education and public awareness	300 (86.4)	2nd	45 (93.7)	3rd	11(100)	1st
4	Environmental outcomes	277 (79.8)	7th	46 (95.8)	2nd	11(100)	1st
5	Public health outcomes	289 (83.3)	6th	48 (100)	1st	11(100)	1st
6	Efficient waste management institutions	292 (84.2)	5th	46 (95.8)	2nd	11(100)	1st
7	Socio-economic factors	223 (64.3)	10th	46 (95.8)	2nd	11(100)	1st
8	Potential market for recycled products	275 (79.2)	8th	46 (95.8)	2nd	11(100)	1st
9	Existence of the informal recycling sector	266 (76.6)	9th	42 (91.6)	5th	10 (90.9)	2nd
10	Community perception	180 (51.9)	11th	9 (18.7)	6th	10 (90.9)	2nd
11	Adequate infrastructure for collection, treatment and disposal	297 (85.6)	4th	43 (89.5)	4th	11(1000	1st

Source: Field survey (2015).
*Figures in brackets are percentages.

important driver in Europe.

Education and public awareness on e-waste management is another factor which is deemed as critical when adopting e-waste management option. As shown in Table 1, 86.4% of households, 93.7% of e-waste workers as well as all the surveyed institutions (100%) evaluated this driver as critical. This driver is perceived by the surveyed institutions as one of the most important factor to consider in e-waste management as they ranked it 1st alongside eight other drivers. On the other hand, both households and e-waste workers ranked it 2nd. The finding supports Wilson (2007) who indicated that education and public awareness are among the main drivers of waste management best practices in the UK. Similarly, UNEP (2007), Savage et al. (2006) and Babu et al. (2007) observed that public awareness and knowledge of environmental and health impact of e-waste is critical for its management.

On driver number one, “good policies and stricter legislation”, majority of households (86.2%), e-waste workers (93.7%) and all the institutions (100%) considered it critical. This finding supports the study by Wilson (2007), Kiddee et al. (2013) and Khetriwal et al. (2007) which showed that the driving factor for e-waste management best practices in most countries is the formulation of policies and institution of good legislation.

Finally, community perception was considered the least factor among the eleven drivers by respondents for the adoption of e-waste management option. The results showed that about half of households (51.9%), nearly one-fifth of e-waste workers (18.7%) and about nine-tenth of the surveyed institutions (90.9%) identified this driver as critical. However, majority of e-waste workers (77.1%) evaluated community perception as not critical. Households ranked it 11th while e-waste workers and the institutions ranked it 6th and 2nd respectively which is last on their ranking.

The varied results highlight two key issues; first, varied perceptions about e-waste management and second how people perceived e-waste collection, treatment and disposal. For instance, if community perceives e-waste management as “resource management” (resource value of e-waste) but not as waste management or consider the management approach from the current paradigm shift from the conventional “end-of-pipe solution” to cradle-to-cradle, then, community perception would be seen as critical driver.

Additionally, societal held beliefs whether positive or negative about e-waste management appears to be critical in fashioning out e-waste management option (Oteng-Ababio, 2012c). However, the results suggest that majority of e-waste workers and some households are of the view that community perception, whether negative or positive, is not critical driver to affect the adoption of e-waste management option. The observed pattern confirms and validates the study of Wilson (2007) who found significant variations in what are perceived as the most important drivers between different spatial entities and also among stakeholders.

On the other hand, the results show that poor policy framework is perceived as the most critical barrier among the twelve to the adoption of e-waste management option. As shown in Table 2, 83.6% of households, 95.8% of e-waste workers and 100% of the institutions considered this barrier as critical. Interestingly, this barrier is ranked 1st by all the three categories of

Table 2. Ranking of key barriers by sampled households, e-waste workers and institutions.

S/N	Key Barriers	Households (n=347)		E-waste workers (n=48)		Institutions (n=11)	
		No.	Rank	No.	Rank	No.	Rank
1	Poor policy framework	290 (83.6)	1st	46 (95.8)	1st	11(100)	1st
2	Lack of or inadequate legal/regulatory framework	267(76.9)	8th	44 (91.6)	3rd	11(100)	1st
3	Low public education and awareness on e-waste management	285 (82.1)	2nd	42 (87.5)	4th	11(100)	1st
4	Unhealthy conditions of informal recycling	241 (69.4)	9th	11(22.9)	6th	9 (81.8)	3rd
5	Nonexistence of data on quantity of e-waste generated and disposed of annually	163 (47.0)	11th	13 (27.1)	5th	9 (81.8)	3rd
6	Weak waste institutions	275 (79.3)	4th	44 (91.6)	3rd	11(100)	1st
7	Unstable macro-economic environment	209 (60.2)	10th	44 (91.6)	3rd	11(100)	1st
8	Lack of involvement of stakeholders in decision making	268 (77.2)	7th	45 (93.7)	2nd	9 (81.8)	3rd
9	Limited capacity of state institutions to deal with e-waste	267 (76.9)	8th	45 (93.7)	2nd	10 (90.9)	2nd
10	Lack of or inadequate funding	283 (81.6)	3rd	45 (93.7)	2nd	11(100)	1st
11	Poor management arrangements and clearly defined responsibilities	274 (79.0)	5th	42 (87.5)	4th	10 (90.9)	2nd
12	High cost and inadequate management infrastructure	273 (78.7)	6th	44 (91.6)	3rd	10 (90.9)	2nd

Source: Field survey (2015).
*Figures in brackets are percentages.

respondents (Table 2). The results affirm findings of an ILO (2011) study that identified poor policy framework as a major constraint to e-waste management in developing countries.

Similarly, “lack of or inadequate legal/regulatory framework” was considered by respondents as critical to affect the adoption of e-waste management. The study showed that majority of households (76.9%), e-waste workers (91.6%) and all the institutions surveyed (100%) considered this barrier as critical. The observed pattern is not unexpected as there is general perception that absence of legislation and regulatory regimes has contributed to the current e-waste management practices. The barrier is ranked 8th by households while e-waste workers and the institutions ranked it 5th and 1st respectively. The finding supports findings of a similar study by Kiddee et al. (2013) and Herat and Agamuthu (2012) who identified inadequate or absence of effective legislation as a major constraint to e-waste management in developing countries.

Additionally, low public education and awareness on e-waste management was perceived as a key barrier that could impede the adoption of e-waste management option in Accra. Households and the institutions ranked this barrier 2nd and 1st respectively, while e-waste workers ranked it 7th. The results showed that majority of households (82.1%), e-waste workers (87.5%) and the institutions (100%) considered this barrier as critical. It appears the increasing awareness of the importance of education and awareness on best management practices account for the observed pattern. This finding corroborates Davis and Herat (2008) who identified low public awareness as key barrier which hinder the Australian local councils’ ability to encourage e-waste collection and recycling. Similarly, Hicks et al. (2005) indicated that lack of public awareness among e-waste collectors, recyclers and consumers has contributed to China’s difficulties in developing financial and environmentally sound e-waste management.

Another barrier that was assessed by respondents during the study was unhealthy condition of informal recycling. The study found that 69.4% of households and 81.8% of the institutions considered it as a critical barrier to the adoption of e-waste management. In contrast, 70.8% of e-waste workers said this barrier is not critical. The evaluation by the e-waste workers is not surprising because as Oteng-Ababio (2012b), Amankwaa (2014) and Oteng-Ababio and Amankwaa (2014) observed, e-waste management activities serve as livelihood for a substantial number of informal people.

Therefore, it would be suicidal for them to perceive this as impediment to the adoption of e-waste management. This barrier is ranked 9th by households while e-waste workers and the institutions ranked it 10th and 3rd

respectively as a barrier likely to affect the adoption of e-waste management option. This barrier was identified by Joseph (2007) and Hicks et al. (2005) as a critical hindrance to e-waste management in India and China respectively.

Finally, non-existence of data on quantity of e-waste generated and disposed of annually was perceived by respondents as the least critical barrier to the adoption of e-waste management. It was ranked 9th (last but one) by e-waste workers while households and the institutions ranked it 11th and 3rd respectively. The results suggest that respondents perceived the barrier as the least among the twelve that could impede the adoption of e-waste management option.

As shown in Table 2, majority of e-waste workers (64.6%) considered this barrier as not critical. In addition, 25.9% of households and 18.2% of the institutions assessed it as not critical. By inference, respondents do not consider data on quantity of e-waste generated and disposed of annually as important factor to determine the adoption of appropriate management option in terms of capacity and sustainability in event of waste diversion. However, 47% of households, 27.1% of e-waste and 81.8% of the institutions evaluated the barrier as critical. The finding contradicts results from study of ILO (2012) that identified this barrier as key factor to affect safe e-waste management.

DISCUSSION

The study revealed that regulatory framework was identified as the most critical factor to consider in the adoption of e-waste management option. The results indicate that 87.0% of households, 95.8% of e-waste workers and 100% of the surveyed institutions perceived this driver as critical. This finding demonstrates the importance of regulatory framework as a key element of global best practices in sustainable e-waste management option as suggested in the literature. For instance, this finding is consistent with those from the previous studies that show that the success story of EPR and the EU Directives on e-waste have been attributed to regulatory framework as key driver (Keddee et al., 2013; Nnorom and Osibajo, 2009; Cahill et al., 2011). Similarly, Phillips et al. (2002) identified regulatory framework among the key drivers of municipal solid waste best practices in the UK. It is apparent from this finding that, institution of regulatory framework could help to sanitize the e-waste sector. This is critical in the search of e-waste management option as currently e-waste collection and transport, treatment and disposal activities are unregulated resulting in poor management by the informal dismantlers.

Related to regulatory framework is good policies and stricter legislation as an important factor that will facilitate the adoption of e-waste management option. The results show that 86.2% of households, 93.7% of e-waste workers and all the institutions surveyed perceived this driver as critical. This finding corroborates several studies which found that global best practices of e-waste management are driven by good policies and stricter legislation (Wilson, 2007; Kiddee, et al., 2013; Wagner, 2009). These studies have shown that e-waste management is driven by the EU's policy of EPR legislation and their Directives on Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances Directive (RoHS. For instance, Switzerland which is acknowledged as the pacesetter in e-waste management legislation introduced the Ordinance on "The Return, the Taking Back and Disposal of Electrical and Electronic Equipment" (ORDEEE) in 1998 by the Swiss Federal Office for the Environment (FOEN) to regulate e-waste management (Kiddee et al., 2013; Khetriwal et al., 2007; Nnorom and Osibanjo, 2008).

Similarly, Japan regulates e-waste by two main laws. These are the Specified Home Appliances Recycling (SHAR) Law promulgated in 1998 and entered into force in 2001 to take back four large household appliances: TV sets, refrigerators, air conditioners, washing machines and the Promotion of Effective Utilization of Resources (LPUR), while LPUR was passed to deal with personal computers and used batteries (Chug and Murakami-Suzuki, 2008; Ogushi and Kandikar, 2007). This finding is significant as it demonstrates the compelling need to formulate good policies that improve collection and transport, treatment and disposal standards. Similarly, enactment of specific legislation to govern e-waste collection and transport, treatment and disposal is also critical. By inference, the legislative framework will be very effective if it define roles and responsibilities of the major actors clearly as well as prescribe rewards and sanctions which can be enforced to the letter. This is very important because in the absence of legislation, removal of hazardous substances before processing may not be carried out. In addition, there is likelihood that, recyclers will focus on electronic and electrical appliances, and components that will yield maximum returns to their investment as observed by Wang et al. (2012) and Oteng-Ababio (2012c). This makes the formulation of good policies and enactment of stricter legislation, and their enforcement to promote compliance which has been the trump card of global best practices indispensable in the search for e-waste management option.

Another finding that was revealing was identification of public health outcomes by respondents as a critical driver for the adoption of e-waste management option. The results show that all the surveyed institutions (100%) and e-waste workers (100%) as well as 83.3% of households identified this driver as critical. This finding signifies respondents' awareness of the negative health effects of

e-waste management practices if it is not handled properly. This result confirms extensive literature review that has established that improper recycling by the informal sector has resulted in negative health effects on e-waste workers and people from the hosting as well as surrounding communities (Asante et al., 2012; Ha et al., 2009; Sepúlveda et al., 2010; Xing, et al., 2009; ILO, 2012). This finding clearly suggests that health implications of various management options are helpful and crucial for an environmentally sound management that will be socially acceptable and economically viable. This implies that policy makers and waste planners in their search for e-waste management option should, as a matter of priority, evaluate the possible health outcomes of different management scenarios to promote global best practices.

Moreover, education and public awareness on e-waste was also identified by respondents as equally important factor to consider when adopting e-waste management option. The results show that 86.4% of households, 93.7% of e-waste workers and 100% of the institutions perceived this driver as critical. This finding affirms earlier ones by UNEP (2007), Savage et al. (2006) and Babu et al. (2007) who indicated that public awareness and knowledge of environmental and health impact of e-waste is critical for its management. Similarly, this finding confirms and validates the findings by Wilson (2007) which identified education and public awareness among the main drivers of waste management best practices in the UK. These findings are indicative that successful management of e-waste that are in consonance with global best practices is contingent on public education and awareness on e-waste content, proper mechanism for collection and transport, appropriate treatment options and safe disposal practices. For instance, as indicated in the introduction, extensive literature review has found that e-waste contains both valuable and hazardous materials (Tsydenova and Bengtsson, 2011; Robinson, 2009; Babu et al., 2007; Lincoln et al., 2007). Therefore, public education and awareness on this contrasting threats and opportunities will be critical to guide material recovery to avoid adverse environmental and health effects (UNEP, 2012; Robinson, 2009).

In addition, extensive studies have documented adverse health impact of improper e-waste management practices (Kiddee et al., 2013; ILO, 2012; Asante et al., 2012; Lepawsky and McNabb, 2010; Osuagwu and Ikerionwu, 2010; Robinson, 2009; UNEP, 2007). Evidence from these studies makes this finding significant in the search for e-waste management option. By inference, public education and awareness on environmental and health impacts of e-waste and how to properly deal with it could be critical to reduce, if not eliminate, the adverse effects (Aizawa et al., 2008; Andreola et al., 2007). This implies that policy makers and waste planners in formulating e-waste policies and strategies need to incorporate an educational component to raise awareness about the inherent hazardous nature of e-waste and best management practices in order to convince them to adopt safe collection, treatment and disposal methods.

Turning now to the barriers, the study found that poor policy framework is considered as the most critical barrier to the adoption of e-waste management option. The results show that 83.6% of households, 95.8% of e-waste workers and 100% of the institutions identified this barrier as critical. One striking observation is the ranking of the barrier by respondents. Interestingly, households, e-waste workers and the institutions ranked it as the most critical barrier to overcome in the adoption of e-waste management option. This finding suggests that respondents are aware of the effects of absence or poor policy framework on e-waste management. The finding also reflects the current management situation in the country which shows that there is no specific policy to govern e-waste collection and transport, treatment and safe disposal. These results corroborate previous studies that found poor policy framework as a major constraint to e-waste management in developing countries (ILO, 2012, Nnorom and Osibanjo, 2007).

Similarly, Oteng-Ababio (2012c) and Amoyaw-Osei et al. (2011) have demonstrated in their studies on e-waste management in the country that absence of specific policies to govern end-of-life management of obsolete electronic gadgets has resulted in the adoption of primitive practices by the informal recyclers and collectors. This revelation makes formulation of appropriate policy framework that will be inclusive and tailored along global best practices indispensable. The findings also suggest that the search for e-waste management option that will stand the test of time is contingent on the fashioning out a good policy framework that addresses the needs and aspirations of the major stakeholders.

Similarly, the findings of the study show that lack of, or, inadequate legal/regulatory framework could impede the adoption of e-waste management option. The results show that 76.9% of households, 91.6% of e-waste workers and all the institutions surveyed (100%) considered this barrier as critical. The finding highlights two key issues. First, the important role of legislation and regulatory framework in sustainable e-waste management and second, the adverse effects of absence or inadequate laws and appropriate regulatory framework to control, regulate and manage e-waste in an environmentally sound manner. This finding is consistent with many studies that have shown that e-waste management in an environmentally sound manner has been constrained by inadequate or absence of effective legislation in developing countries (Kiddee et al., 2013; Herat and Agamuthu, 2012; Nnorom and Osibanjo, 2008; Amoyaw-Osei et al., 2011, Oteng-Ababio, 2012c).

Consequently, nonexistence and laxity in the enforcement of existing regulations have resulted in the use of crude and inefficient recycling techniques by the informal recyclers to recover valuable materials without recourse to environmental and health safety measures (Oteng-Ababio and Amankwaa, 2014. The implication of this finding is significant as it suggests the institution of appropriate legal regime to manage e-waste.

Low public education and awareness on e-waste management was perceived by respondents as another critical factor that could hinder the adoption of e-waste management option. The study found that 82.1% of households, 87.5% of e-waste workers and 100% of the institutions perceived this barrier as critical. The finding could help to explain the general perception in the literature that poor knowledge and low level of public awareness of e-waste content as well as best management practices have invariably resulted in poor collection and transport, treatment and disposal. This finding corroborates earlier study by Davis and Herat (2008) who identified low public awareness as major barrier which impedes the Australian local councils' ability to encourage e-waste collection and recycling. Similarly, this finding confirms and validates Hicks et al. (2005) study that found that lack of public awareness among e-waste collectors, recyclers and consumers have contributed to China's difficulties in developing financial and environmentally sound e-waste management. This finding is significant as it suggests that public policy that incorporates education and awareness could play an important role in sustainable e-waste management in the search for management option.

Finally, one contrasting finding of the study by the three categories of respondents is the identification of unhealthy conditions of the informal recycling as a barrier to overcome in the adoption of e-waste management option. The results show that 69.4% of households and 81.8% of the institutions considered this barrier as critical factor that could constraint e-waste management. This corroborates other results from e-waste management studies in India and China that identified this barrier as a critical hindrance to e-waste management (Joseph, 2007; Hicks et al., 2005). This finding suggests that households and the institutions perceive the informal recycling activities as possible impediment to the formalization of the e-waste sector. By inference, abolishing or outlawing informal recycling will open the gateway for the establishment of formal recycling. Despite its policy significance, extensive literature has shown that the informal recycling is currently the dominant management option in many developing countries and emerging economies (Amoyaw-Osei et al., 2011; Oteng-Ababio, 2010; Oteng-Ababio et al., 2014; Laissaoui and Rochat, 2008; Waema and Mureithi, 2008).

For instance, studies by Oteng-Ababio et al. (2014), Amankwaa (2014) and Amoyaw-Osei et al. (2011) found that about 95% of e-waste generated and collected annually in the country are processed by scavengers and dismantlers. On the contrary, 70.8% or majority of e-waste workers perceived this barrier as not critical. This finding is not unexpected since several studies have shown that e-waste collection and transport, treatment as well as various activities associated with the value chain serve as livelihood to a significant number of people including e-waste workers (Oteng-Ababio, 2012b; Amankwaa, 2014; Oteng Ababio et al., 2014; Sinha and Mahesh, 2013; Chaturvedi et al., 2011).

This dichotomy or contrasting findings is a challenge to policy makers and waste planners in the search for e-waste management option. In that, the informal sector is perceived as a threat on one hand and on the other hand as a potential. This implies that, policy formulation and management planning should be inclusive by harnessing the potentials of the informal recyclers and attempt to address their shortcomings. This should be seen as the best policy option since it can be inferred from the discussions that any attempt to exclude the informal sector would be counterproductive due to their unique role in collection and transport. Meanwhile, they have one of the best networks that are well-established for e-waste collection and transport which can be built upon.

This section sought to discuss the findings of the study. The study identified four critical factors that could facilitate the adoption of e-waste management option. These include regulatory framework, public health outcomes, education and awareness on e-waste management and good policies and stricter legislation. On the other hand, the results show that poor policy framework, lack of or inadequate legal/regulatory framework, low public education and awareness of e-waste management and unhealthy conditions of informal recycling as the four most critical barriers to overcome in the search of e-waste management option.

A close evaluation indicates the drivers and barriers are interrelated which has direct implications on environmental protection and waste management in general. This implies that the planning of efficient management option requires specific policies, regulations, environmental legislation and clearly articulated strategies for the realization of global best practices aim of environmentally sound manner.

Conclusion

This study has identified critical drivers for and barriers to the adoption of household e-waste management option. The study findings were based on analysis of empirical data from 347 households, 48 e-waste workers and 11 institutions. The results showed that all the drivers were identified as very important to influence the adoption of e-waste management. However, regulatory framework,

public health outcomes and education and public awareness of e-waste management are perceived as the three most critical factors that could facilitate the adoption of e-waste management option, while community perception is considered as the least driver. Similarly, the 12 barriers were identified as critical to impede the adoption of e-waste management. The study found that poor policy framework, lack of, or inadequate legal/regulatory framework and low public education and awareness on e-waste management are considered as the most critical barriers, with non-existence of the quantity of e-waste generated and disposed of annually as the least critical factor perceived to constrain the adoption of e-waste management. Secondly, the findings also indicate that key stakeholders have different interests in e-waste management. This makes e-waste management difficult. Therefore, policy makers and waste planners should understand the nexus between consumers (households), e-waste workers and the institutions' interests. This will help in the formulation of appropriate policies and strategies that are more inclusive to address the needs and aspirations of the major actors. We conclude that these drivers and barriers need to be considered in any e-waste management to ensure environmentally sound management practices.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Aizawa H, Yoshida H, Sakai S (2008). Current results and future perspectives for Japanese recycling of home electrical appliances. Resources, Conservation and Recycling 52:1399-1410.

Amankwaa EF (2014). E-waste Livelihoods, Environment and Health Risks: Unpacking the Connections in Ghana. West African Journal of Applied Ecology 22(2):1-15.

Amoyaw-Osei Y, Agyekum O, Pwamang J, Mueller E, Fasko R, Schluep M (2011). *Ghana e-waste country assessment*, SBC e-waste Africa Project. Dubendorf, EMPA.

Andreola F, Barbieri L, Corradi A, Ferrari AM, Lancellotti I, Neri P (2007). Recycling of EOL CRT glass into ceramic glaze formulations and its environmental impact by LCA approach. The International Journal of Life Cycle Assessment 12(6):448-454.

Asante KA, Agusa T, Biney CA, Agyekum WA, Bello M, Otsuka M, Itai T, Takahashi S, Tanabe S (2012). 'Multi-trace element levels and arsenic speciation in urine of e-waste recycling workers from Agbogbloshie, Accra in Ghana'. Science of the Total Environment 424: 63-73.

Babu BR, Parande AK, Basha CA (2007). Electrical and Electronic Waste: A Global Environmental Problem. Waste Management Resources 25:307-318.

Brigden K, Labunska I, Santillo D, Johnston P (2008). Chemical contamination at e-waste recycling and disposal sites in Accra and Koforidua, Ghana. Greenpeace Laboratories Technical Note 10:1-23.

Cahill R, Grimes SM, Wilson DC (2011). Review Article: Extended producer responsibility for packaging wastes and WEEE-a comparison of implementation and the role of local authorities across Europe. Waste Management Resources 29(5):455-479.

Chaturvedi A, Arora R, Kilguss U (2011). E-Waste Recycling in India– Bridging the Formal–Informal Divide. Environmental Scenario in India: Successes and Predicaments, London: Routledge.

Davis G, Herat S (2008). Electronic Waste: The Local Government Perspective in Queensland, Australia. Resources, Conservation and Recycling 52(8-9):1031-1039.

Herat S, Agamuthu P (2012). E-waste: a problem or an opportunity? Review of issues, challenges and solutions in Asian countries. Waste Management Resources pp. 1-17.

Hicks C, Dietmar R, Eugster M (2005). The recycling and disposal of electrical and electronic waste in China-legislative and market responses. Environmental Impact Assessment Review 25:459-471.

Huang J, Nkrumah PN, Anim DO, Mensah E (2014). E-Waste disposal effects on the aquatic environment: Accra, Ghana. In: Reviews of environmental contamination and toxicology, Springer International Publishing pp. 19-34.

ILO (2012). The global impact of e-waste: Addressing the challenge. Geneva 112. SAGE Publications.

Joseph K (2007). Electronic waste management in India–issues and strategies. In Eleventh International Waste Management and Landfill Symposium, Sardinia.

Kalana JA (2010). Electrical and Electronic Waste Management Practice by Households in Shah Alam, Selangor, Malaysia. International Journal of Environmental Science and Technology 1(2):132-144.

Khetriwal DS, Kraeuchi P, Widmer R (2007). Producer responsibility for e-waste management: key issues for consideration – learning from the Swiss experience. Journal of Environmental Management 90:153-165.

Kiddee P, Naidu R, Wong MH (2013). Electronic waste management approaches: An overview. Waste Management 33:1237-1250.

Kissling R, Coughlan D, Fitzpatrick C, Boeni H, Luepschen C, Andrew S, Dickenson J (2013). Success factors and barriers in re-use of electrical and electronic equipment Resources, Conservation and Recycling 80:21-31.

Lepawsky J, McNabb C (2010). Mapping International Flows of Electronic Waste. The Canadian Geographer 54(2):177-195.

Lincoln JD, Ogunseitan OA, Shapiro AA, Saphores JDM (2007). Leaching assessments of hazardous materials in cellular telephones. Environmental Science andTechnology 41(7):2572-2578.

Mureithi M, Waema T (2008). E-waste Management in Kenya. Nairobi: Kenya ICT Action Network (KICTANet).

Namias J (2013). The Future of Electronic Waste Recycling in the United States: Obstacles and Domestic Solutions. Thesis submitted to Columbia University.

Nnorom IC, Osibanjo O (2008). Electronic waste (e-waste): Material flows and management practices in Nigeria. Waste Manage. 28:1472-1479.

Nnorom IC, Osibanjo O (2009). Toxicity characterization of waste mobile phone plastics. Journal of Hazardous Materials 161:183-188.

Ogushi Y, Kandlikar M (2007). Assessing extended producer responsibility laws in Japan. Environmental Science & Technology 41(13):4502-4508.

Osibanjo O, Nnorom IC (2007) The challenge of electronic waste (e-waste) management in developing countries. Waste Management & Research 25:489-501.

Osuagwu OE, Ikerionwu C (2010). E-cycling e-waste: The way forward for Nigeria IT and electro-mechanical industry. International Journal of Academic Research 2(1):142-149.

Oteng-Ababio M (2010). E-waste: an emerging challenge to solid waste management in Ghana. International Development Planning Review 32(2):191-206.

Oteng-Ababio M (2012a). The legal and the reasonable: Exploring the dynamics of e-waste disposal strategies in Ghanaian households. Journal of US-China Public Administration 9(1):38-52.

Oteng-Ababio M (2012b). When necessity begets ingenuity: E-waste scavenging as a livelihood strategy in Accra, Ghana. African Studies Quarterly 13(1,2):1-21.

Oteng-Ababio M (2012c). Is trading in used computers creating a digital dump? Reflections from tertiary institutions in Ghana. Journal of

Geography and Regional Planning 5(8):222.
Oteng-Ababio M, Amankwaa EF (2014). The e-waste conundrum: Balancing evidence from the North and on-the-ground developing countries' realities for improved management. African Review of Economics and Finance 6(1):181-204.
Oteng-Ababio M, Amankwaa EF, Chama MA (2014). The local contours of scavenging for e-waste and higher-valued constituent parts in Accra, Ghana. Habitat International43:163-171.
Peralta GL, Fontanos PM (2006). E-waste issues and measures in the Philippines. Journal of Material Cycles and Waste Management 8(1):34-39.
Phillips PS, Holley K, Bates MP, Freestone NP (2002). Corby Waste Not: an appraisal of the UK's largest holistic waste minimization project. Resources, Conservation and Recycling 36(1):1-31.
Robinson BH (2009). Review: E-waste: An assessment of global production and environmental impacts. Science of the Total Environment 408:183-191.
Rode S (2012). E-waste Management in Mumbai Metropolitan Region: Constraints and Opportunities. Theoretical and Empirical Researches in Urban Management 7(2):89-103.
Savage M, Ogilvie S, Slezak J, Artim E, Lindblom J, Delgado L (2006). Implementation of waste electric and electronic equipment directive in EU 25. European Commission, Brussels.
Sepúlveda A, Schluep M, Renaud FG, Streicher M, Kuehr R, Hagelüken C, Gerecke AC (2010). A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipment during recycling: Examples from China and India. Environmental Impact Assessment Review 30(1):28-41.
Sinha S, Mahesh P (2013). Environment and livelihood hand in hand. Toxics Link, Delhi.
Tiwari D, Dhawan NG (2014). E-waste Management: An Emerging Challenge to Manage and Recover Valuable Resources. International Journal of Environmental Research and Development 4(3):253-260.
Tsydenova O, Bengtsson M (2011). Chemical hazards associated with treatment of waste electrical and electronic equipment. Waste Management. 31(1):45-58.
UNEP (2007). E-waste-Volume I: Inventory Assessment Manual. United Nations Environmental Programme.
Wagner TP (2009). Shared responsibility for managing electronic waste: A case study of Maine, USA. Waste Management 29(12):3014-3021.
Wang F, Huisman J, Meskers CE, Schluep M, Stevels A, Hagelüken C (2012). The Best-of-2-Worlds philosophy: Developing local dismantling and global infrastructure network for sustainable e-waste treatment in emerging economies. Waste Management 32(11):2134-2146.
Widmer R, Oswald-Krapf H, Sinha-Khetriwal D, Schnellmann M, Boni H (2005). Global Perspectives on E-waste. Environmental Impact Assessment Review 25:436-458.
Wilson DC (2007). Development drivers for waste management. Waste Management Research 25(3):198-207.
Xing GH, Chan JKY, Leung AOW, Wu SC, Wong MH (2009). Environmental impact and human exposure to PCBs in Guiyu, an electronic waste recycling site in China. Environment International 35(1):76-82.
Zaman AU (2014). Measuring waste management performance using the 'Zero Waste Index: the case of Adelaide, Australia. Journal of Cleaner Production 66:407-419.