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Abstract

E-waste is a critical emerging issue in both developed and developing countries as a result of increasing volume and quantity electrical and electronic equipment generated. E-waste contains both valuable and toxic materials, which require special collection and transport systems as first components of the management chain. Current thinking on the best practices dictates that it must be managed in an environmentally sound manner. Consequently, many countries have adopted various collection and transport system options that incorporate best practices with varied degrees of success. However, a search for appropriate collection system options in Ghana has received less scholarly attention. This paper explores e-waste collection and transport system options in an attempt to find management option suitable for Accra from the perspective of households, e-waste workers and institutions. The study throws more light on stakeholders' perception about e-waste collection and transport system options which has the ability to re-direct and re-shape public policy and awareness on household e-waste management. The researcher used questionnaire to collect data from 347 households, 48 e-waste workers and 11 institutions for the study. The findings revealed that stakeholders identified recyclers' or dismantlers' collection system as the most suitable management for Accra. The paper found that key stakeholders have different interests in e-waste collection and transport system options. The study, therefore, draws attention of policy makers and waste planners to understand the nexus between stakeholders' interests in order to adopt strategies that are more inclusive to satisfy varied interests.

Keywords: E-waste, Stakeholders, Households, Collection, Option, Transport, Ghana

1.1 Introduction

The management of e-waste has become an albatross for many countries not only as a result of the volume and rate of waste generation but also because it consists of both hazardous materials and precious metals (Tsydenova & Bengtsson, 2011; Liu et al., 2009; Babu et al., 2007; Lincoln et al., 2007) which require special treatment to avoid environmental and health effects as well as recovery of metals (Robinson, 2009). The dichotomy or contradiction of negative environmental effects and economic value associated with e-waste makes its management a challenging task as it is distinct from other types of waste. Consequently, collection and subsequent treatment of e-waste is an opportunity for counties to extract valuable materials and more importantly to reduce if not avoid environmental harm. E-waste collection and transport system as used in this study refers to the process of collecting or gathering obsolete electronic products or gadgets from consumers.

According to a review of e-waste collection systems, there are three categories of collections globally. These are producer collection, municipal collection and independent collection (Terazono et al., 2010; Yoshida and Yoshida, 2010). However, according to UNEP (2012), the major options of e-waste collection and transport system consist of producers' take-back system, retailers' take-back system, municipal collection and transport system and recyclers' or dismantlers' collection system (UNEP, 2012; UNEP, 2007). As shown in Figure 1, Producers' take-back system covers the complete life cycle of Electrical and Electronic Equipment (EEE). It starts from EEE production and ends at final disposal of e-waste. A retailers' take-back system, which is a subset of the producers' take-back system, begins with EEE sales and ends with e-waste generation. The last two options i.e. municipal collection and transport system and recyclers' or dismantlers' collection and transport systems on the other hand do not include upstream activities of production, sales and consumption. Rather, it begins at the point of e-waste generation and ends at e-waste disposal.

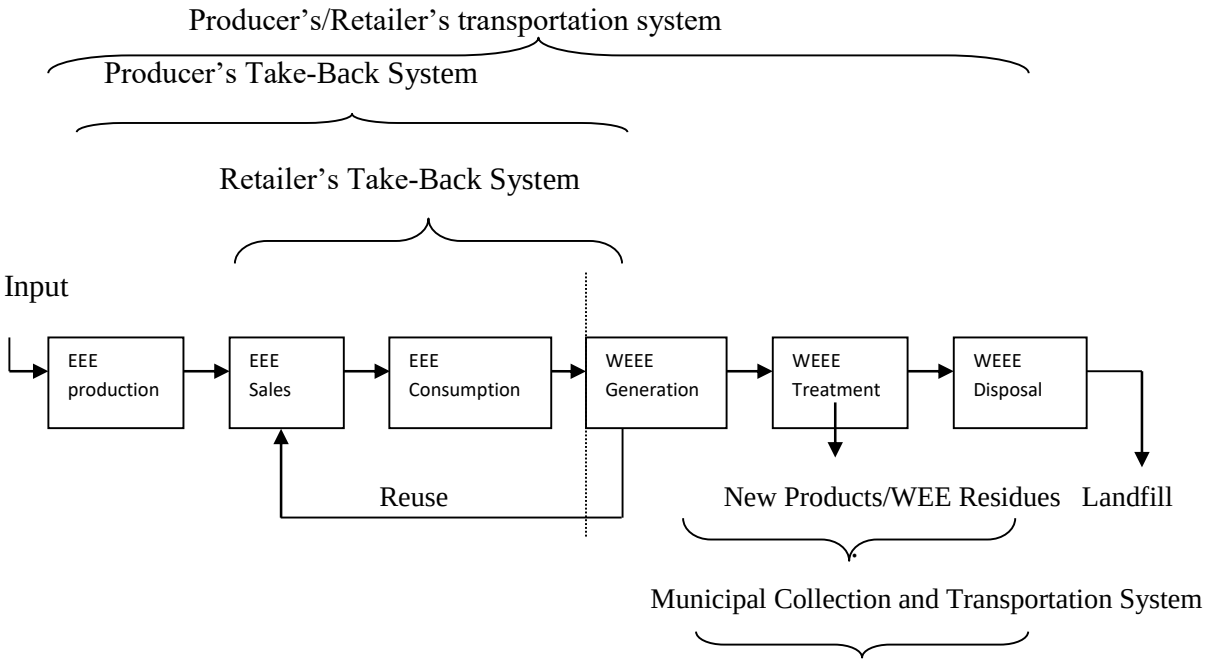

Figure 1: WEEE/E-waste collection systems

Source: UNEP, 2007

In response to the increasing e-waste problem, many countries have adopted collection and transport systems that incorporate best practices to manage it in an environmentally sound manner (ESM). For instance, increasingly it has been recognized by the EU and some other developed countries that the enormity of e-waste problem requires adoption of management practice that will help to achieve sustainable development (Nnorom and Osibanjo, 2008; Peralta and Fontanos, 2006). This has resulted in the adoption of Extended Producer Responsibility (EPR) principle in e-waste laws of EU member states. As a result, several countries have introduced legislation making producers responsible for taking back their products for end-of -life management (Kiddee et al., 2013; Nnorom and Osibanjo, 2008; Khetriwal et al., 2007). The concept of EPR as an environmental policy principle was first proposed by Thomas Lindqvist in 1988 and was introduced by the Swedish Ministry of Environment in 1990 (Linqhqvist, 2000). He defines EPR as "policy principle that promotes total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the product's life cycle, and especially to the take-back, recovery and final disposal of the product" (Linqhvist, 2000:v).

This implies that "a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle" (OECD, 2001:18).

From the definition, it is apparent that the basic principle of EPR among others emphasizes polluter pays principle (Widmer et al., 2005; OECD, 2001). Therefore, EPR as e-waste management option shifts responsibility of waste management "which were traditionally assigned to consumers and" municipal authorities to producers (OECD, 2001; Lindhqvist 2000: 29).

As indicated in the introductory paragraph, e-waste contains both valuable and hazardous materials (Tsydenova and Bengtsson, 2011; Robinson, 2009; Babu et al., 2007; Lincoln et al., 2007). It therefore requires efficient collection and transportation system under controlled condition to avoid damage or break down of components that contain harmful substances, which may adversely affect the environment and human health (UNEP, 2012; Robinson, 2009; UNEP, 2007). To avert the above scenario, UNEP (2007) identified six major factors that are critical to achieve efficient collection and transport system. These include:

- accessible and efficient collection facilities;
- ensure minimal movement of products;
- minimize manual handling;
- aim to remove hazardous substances;
- separate reusable appliances and
- adequate and consistent information to the users (UNEP, 2007:14).

It is imperative that producers, retailers, municipal authorities, recyclers or dismantlers are involved in e-waste collection and transport system. Those involved in the collection and transportation together with importers, traders, scrap dealers and consumers have been identified in the literature as the major stakeholders.

However, regardless of who is responsible for collection, provision of collection facilities that will be accessible to consumers to drop off their e-waste is important (Khaliq, 2014). This will discourage consumers from mixing their e-waste with solid waste but this modality depends on public awareness (Prakash, 2010). Secondly, minimal movement of e-waste will reduce if not eliminate possible leakage of hazardous materials into the environment. As observed by Barba-Gutierrez et al. (2008) distance travelled to transport e-waste is very important when environmental impact of e-waste collection is assessed. By inference, the longer the distance travelled the more likelihood of breakages and possible leakage of toxic substances to

contaminate the environment. Thirdly, manual handling of e-waste should be reduced to the barest minimum to avoid contamination and possible health effects. Fourthly, efficient e-waste collection system should aim at removing portions that contain hazardous substances from the other portions that are non-hazardous. This will facilitate the treatment of the hazardous substances. The segregation will ultimately reduce the volume of e-waste and cost of disposal. The sixth factor is separation of functional appliances from those that are not usable. As opined by Puckett et al. (2005) reuse is the major source of some e-waste in most low-income countries as components that are functional may be separated for reuse. He et al. (2006) corroborated this assertion. Provision of adequate and consistent information on environmental and health impacts of e-waste to users will go a long way to ensure effective collection and transport system as public awareness on special nature of e-waste will inevitably influence collection and disposal practices.

E-waste collection is the essential first stage of e-waste management options. However, a search for appropriate collection system options in Ghana has received less scholarly attention. Though there have been several studies documenting the existing collection systems there are no empirical research investigating assessment of collection options. For instance, in Ghana, prior reviews focused on health and environmental effects of e-waste in the encompassing communities or health consequences (Huang et al., 2014; Asante et al., 2012; Brigden et al., 2008; Puckett et al., 2005), social effects (Heacock et al., 2016; Agyei-Mensah and Oteng-Ababio, 2012; Prakash et al., 2010) and also e-waste scavenging and manual recycling for material recovery as livelihood to the urban poor (Amankwaa, 2014; Owusu-Sekyere, 2014; Oteng-Ababio and Amankwaa, 2014; Oteng-Ababio et al. 2014; Grant and Oteng-Ababio, 2012; Oteng-Ababio, 2011, 2012a and 2012b). However, there has not been any study in Ghana that has examined e-waste collection and transport system as a management option from the perspective of households, e-waste workers and institutions.

This study explores e-waste collection and transport system options in an attempt to find management option suitable for Accra from stakeholders' perspective. The study assesses stakeholders' perception about e-waste collection and transport system that will promote environmentally sound management in line with global best practices. This study, whilst filling the knowledge gap in the literature, contributes to scholarly debate in the search of e-waste

collection system options in Accra using data of households from three selected communities, e-waste workers and institutions.

1.2 Materials and methods

1.2.1 Study Setting

Accra (Accra Metropolitan Area) was selected for the study because it is the capital city of Ghana and also the biggest commercial city in the country. In addition, Accra has been experiencing rapid urbanization with 100 percent of its population living in urban areas as compared to 90.5 and 50.9 percent in Greater Accra and the entire country respectively (Ghana Statistical Service, 2013). As a result, there are many social infrastructural facilities including electronic products in Accra. For instance, according to the 2010 Population and Housing Census, mobile phone ownership by the population above 12 years for Accra was 75.7 percent as compared to 73.5 percent for Greater Accra Region and 47.7% nationwide (Ghana Statistical Service, 2013). In terms of Internet penetration, Ghana Statistical Service (2013) estimated that 20.1 percent of its population use Internet facility as compared to 18.6% for Greater Accra Region. Moreover, 16.8 percent of the estimated 501,956 households in Accra own desktop/laptop computer in Accra (Ghana Statistical Service, 2013). Accra hosts Agbobloshie described by various writers as the hub of e-waste recycling in Ghana (Huang et al., 2014; Agyei-Mensah and Oteng- Ababio, 2012; Grant and Oteng-Ababio, 2012; Amankwaa, 2013, 2014; Oteng-Ababio et al., 2014; Amoyaw-Osei et al., 2011). For instance, Prakash et al. (2010) estimated that Agbobloshie contributes about 40% to 60% of the aggregate e-waste recycled in Ghana. Hence the study was conducted in three selected communities in Accra: Agbobloshie, James Town and Korle Gonno. These communities were selected because they exhibit high concentration of e-waste activities and moreover have been affected by e-waste management practices.

1.2.2 Sample Population and Sampling Procedure

The study population consists of institutions, households and e-waste workers. These were identified as key stakeholders of e-waste management in Accra. Households are consumers of electronic products and ultimately e-waste generators. Therefore, the decision to dispose of an obsolete electronic product is their prerogative. E-waste workers were also considered because they are involved in e-waste collection, recycling and final disposal. The study included

institutions as key stakeholders because they are policy makers, implementers, and regulators or are engaged in waste management activities.

The institutions included policy makers, policy implementers, EEE assembler/importer and executives of Greater Accra Scrap Dealers Association. Policy makers include: Ministry of Local Government and Rural Development, Ministry of Environment Science Technology and Innovation and Ministry of Health. For policy implementers, a representative from Environmental Protection Agency (EPA), Energy Commission, National Youth Authority and Accra Metropolitan Assembly were included. Other stakeholders included: Rlg Company Limited, representing manufacturers/importers, Zoomlion Ghana Company Limited (a private waste management company) and Green Advocacy Ghana (an environmental NGO).

As regards 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 researcher selected a household from a house for the study. In a situation where there were more than one household, accidental sampling was used to select one for the study. In cases where selected household was unwilling to be part of the process, the researcher moved to the next household. After picking the initial household, the researcher picked every third until the sample size was exhausted. Having selected sample size and sampling procedure for the study, the survey method used questionnaire administration. To avoid low return rate and non-responses of questions usually associated with the practice where respondents fill the questionnaire themselves; the researcher adopted direct door stepping questionnaire administration. Using this method, six research assistants were hired to help with the administration of the questionnaires. In all, a total of 347 households with 95% confidence level were used for the study.

For e-waste workers, a total sample size of 48 was used for the study. It must be emphasised that the sample size for the e-waste workers was not calculated, as the sample frame was not known. The researcher was 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. Majority are migrants as observed by Oteng-Ababio (2010a), 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 researcher realized that no new information was emerging. These reasons informed the decision to make use of the 48 respondents. In view of

the limited number of respondents, interpretation of the results at 95% precision must be done with caution.

1.2.3 Data Analysis

Quantitative data that were generated through questionnaire administration were analyzed using Microsoft Excel and IBM Statistical Package for the Social Sciences. Before carrying out the data analysis, data screening was carried out to ensure that data collected were credible. This was to increase confidence in the data. The data were then edited to check clarity and non-responses to questions. After responses had been coded, entry and storage was done in SPSS and Microsoft Excel. Nominal data that were generated were transformed to produce descriptive statistics such as frequencies and percentages to describe various variables for the study. The ordinal data generated from the Likert Scale were subjected to a test of normality to determine whether the data were normally distributed or otherwise.

1.3 Results

1.3.1 Awareness and Assessment of E-waste Collection and Transport System Options

Results of the study showed that the awareness level of the respondents on recyclers or dismantlers collection option is high, while the awareness level on producer take-back option is low. As shown in Table 1, 82.7% of households, 90.9% of the institutions and all the e-waste workers (100%) were aware of recyclers or dismantlers collection system. Across the study communities, majority of households in Korle Gonno (79.6%), James Town (94.9%) and Agbobloshie (76.9%) were found to be aware of this option. The high level of awareness by respondents may be attributed to door-to-door services rendered by scavengers and dismantlers. For e-waste workers, the universal response (100%) is not surprising since e-waste collection is their major source of livelihood as observed by Prakash et al. (2010), Oteng-Ababio (2012a) and Amankwaa (2014). On the other hand, the data showed that only 15.9% of households and 10.4% of e-waste workers were aware of producer take-back option. There were few variations among households in the study communities. In Korle Gonno, only 14.4% of households said they were aware of this option. Similarly, 17.7% of households in James Town and 19.2% in Agbobloshie indicated that they were aware of the option. It appears the absence of any producer take-back system in the country might have accounted for low level of awareness among households and e-waste workers. In the case of the institutions, 72.7%

were aware of this option. This outcome is not surprising since the institutions are made up of policy makers, implementers, and managers of waste or organizations that carry out activities related to waste management.

Table 1: Respondents awareness of e-waste collection and transport system option

Collection and transport option	Korle Gonno (n=216)		James Town (n=79)		Agbobloshie (n=52)		All Communities (n=347)		E-waste Workers (n=48)		Institutions (n=11)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Producer take-back	31	14.4	14	17.7	10	19.2	55	15.9	5	10.4	8	72.7
Retailer take-back	61	28.2	19	24.1	26	50.0	106	30.5	9	18.8	9	81.8
Municipal collection	112	51.9	43	54.4	32	61.5	187	53.9	37	77.1	9	81.8
Recycler or dismantler collection	172	79.6	75	94.9	40	76.9	287	82.7	48	100	10	90.9

Source: Field Survey, 2015

For the municipal collection option, about half of households (53.9%), 77.1% of e-waste workers and 81.8% of the institutions indicated that they were aware of it. The relatively high level of awareness of municipal collection system can be attributed to the general perception that the metropolitan, municipal and the district assemblies are responsible for the collection of waste.

Turning now to the assessment of collection and transport system options, the study revealed that majority of households (83.9%), e-waste workers (97.9%) and the surveyed institutions (81.8%) evaluated recyclers or dismantlers collection system as good. It appears the door-to-door services render by scavengers as well as payment for the e-waste which was formerly given for free as found by Amankwaa (2014) could be possible reasons for the observed pattern. There were small variations across the study communities. As presented in Table 2, majority of respondents in Korle Gonno (84.7%), James Town (89.9%) and Agbobloshie (71.1%) assessed the option as good.

Table 2: Respondents assessment of e-waste collection and transport system options

Collection and transport options	Scale of Assessment	Korle Gonno		James Town		Agbobloshie		All Communities		E-waste Workers		Institutions	
		N	%	N	%	N	%	N	%	N	%	N	%
Producer take-back system	Good	92	42.6	31	39.2	27	51.9	150	43.2	4	8.3	7	63.6
	Don't know	108	50.0	43	54.4	19	36.5	170	48.9	42	87.5	3	27.3
	Poor	16	7.4	5	6.3	6	11.5	27	7.9	2	4.2	1	9.1
	Total	216	100	79	100	52	100	347	100	48	100	11	100
Retailer take-back system	Good	102	47.2	33	41.8	35	67.3	170	49.0	9	18.8	7	63.6
	Don't know	84	38.9	38	48.1	14	26.9	136	39.2	39	81.2	1	9.1
	Poor	30	13.9	8	10.1	3	5.8	41	11.8	0	0.0	3	27.3
	Total	216	100	79	100	52	100	347	100	48	100	11	100
Municipal collection system	Good	98	45.4	29	36.7	20	38.5	147	42.3	9	18.8	2	18.2
	Don't know	45	20.8	21	26.6	5	9.6	71	20.5	10	20.8	2	18.2
	Poor	73	33.8	29	36.7	27	51.9	129	37.2	29	60.4	7	63.6
	Total	216	100	79	100	52	100	347	100	48	100	11	100
Recyclers or dismantlers collection system	Good	183	84.7	71	89.9	37	71.1	291	83.9	47	97.9	9	81.8
	Don't know	17	7.9	5	6.3	8	15.4	30	8.6	1	2.1	1	9.1
	Poor	16	7.4	3	3.8	7	13.5	26	7.5	0	0.0	1	9.1
	Total	216	100	79	100	52	100	347	100	48	100	11	100

Source: Field Survey, 2015

The data showed that majority of households (48.9%) and e-waste workers (87.5%) could not assess producer-take-back system option as they indicated that they do not know about them. This could be attributed to their low level of knowledge about this option as depicted in Table 1. However, majority of the institutions (63.6%) mentioned that it was good. Similarly, 39.2% of households and 81.2% of e-waste workers could not evaluate retailer take-back system as they also indicated that they do not know. On the contrary, majority of the institutions (63.6%) said that the option is good. Some differences were observed in the study communities. For instance, while majority of households in Agbobloshie (67.3%) and Korle Gonno (47.2%) judged retailer take-back option as good, majority of households in James Town (48.1%) indicated that they do not know about the policy. Majority of e-waste workers (60.4%), the institutions (63.6%) and 37.2% of households evaluated municipal collection system option as poor. In the study communities, the data showed that about half of households in Agbobloshie (51.9%), 38.7% in James Town and 33.8% in Korle Gonno perceived this collection system as poor. However, 45.4% or majority of households in Korle Gonno indicated that the option is good. The poor rating of municipal collection system by respondents could be attributed to poor performance of AMA in the collection of solid waste in the city, which has necessitated private sector participation over the past few years. For instance, available data indicate deficiencies in solid waste management by AMA due to population growth, breakdown of waste infrastructure and financial constraint. This led to pile-up of refuse especially in low-income areas. Hence, privatization was conceived as a way forward (Oteng-Ababio, 2010b).

1.3.2 Collection and Transport System Option Suitable for Accra

When respondents were asked to indicate collection and transport system option suitable for Accra, majority of households (59.3%) and all e-waste workers mentioned recyclers or dismantlers collection system (see Table 3). On the other hand, majority of the institutions (45.5%) selected producer take-back system. In addition, the study found that retailer take-back system and municipal collection system are the least preferred options by households and the institutions respectively. Across the study communities, the data showed that majority of households in Korle Gonno (60.6%), James Town (55.7%) and Agbobloshie (59.6%) perceived recycler or dismantler collection and transport option as the most suitable for Accra. In contrast, while both households in Korle Gonno and Agbobloshie considered producer take-back as unsuitable for Accra, households in James Town indicated that retailer take-back system is the least preferred option.

However, during an interview with the respondent of AMA, Waste Management Department, he indicated that all the four options could be adopted by taking into consideration local conditions. He opined that: "The fact that Accra is a heterogeneous city; one option may not be suitable citywide."

Table 3: Respondents perceived e-waste collection and transport option for Accra

Collection and transport option	Korle Gonno		James Town		Agbobloshie		All Communities		E-waste Workers		Institutions	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Producer take-back	24	11.1	15	19.0	5	9.6	44	12.7	0	0.0	5	45.5
Retailer take-back	25	11.6	3	3.8	7	13.5	35	10.1	0	0.0	2	18.2
Municipal collection	36	16.7	17	21.5	9	17.3	62	12.9	0	0.0	1	9.1
Recycler or dismantler collection	131	60.6	44	55.7	31	59.6	206	59.3	48	100	3	27.3
Total	216	100	79	100	52	100	347	100	48	100	11	100

Source: Field Survey, 2015

In Figure 1, various reasons were assigned for the preferred choice of options. Reasons given by the households who perceived recyclers or dismantlers collection and transport system option include the following: they pay for e-waste (21.8%); they are efficient and effective (11.5%); experience and expert knowledge (14.5%); accessible (7.9%); door-to-door services (16.4%); adequately resourced (5.5%) and sources of livelihood (7.3%). It must be noted that there were 15.2% no responses. In the case of e-waste workers, two reasons were given for the preferred choice. First, majority (87.5%) mentioned that it provides livelihood to many people. This finding is in agreement with Oteng-Ababio (2012b) and Amankwaa (2014) who observed that, e-waste management activities serve as livelihood for a substantial number of informal people. Second, 12.5% of respondents said dismantlers and recyclers have experience and expert knowledge about collection.

Figure 1: *Reasons assigned for the choice of recycler or dismantler collection and transport system option by households and e-waste workers*

Source: Author's construct, 2015

The institutions on the other hand, indicated that producers are the primary producers of e-waste equipment (electronic products); therefore, they should be responsible for its end-of-life management in order to lessen the burden on the city authorities.

1.3.3 Perception about E-waste Collection and Transport System that will Promote Environmentally Sound Management

Perception of respondents about e-waste collection and transport system that will promote environmentally sound management in line with global best practices was carried out. Respondents were provided with four different statements with a five-point Likert scale options: strongly disagree, disagree, neutral, agree and strongly agree. The data were analyzed using descriptive statistics such as frequency and percentage and the severity index (SI) was calculated. A composite index of severity index was calculated for the four statements. The essence of this was to assess respondents' perception about the issue under consideration as a whole. The study adapted Al-Hammed and Asaff's (1996) equation for the calculation of the severity index. The rating classification was, however, adapted and modified after Majid and McCaffer (1997) as follows:

a_0 = Strongly disagree (SD)	0 - 20
a_1 = Disagree (D)	21 - 40
a_2 = Neutral (N)	41 - 60
a_3 = Agree (A)	61 - 80
a_4 = Strongly agree (SA)	81 - 100

The results on the assessment of perception of respondents about e-waste collection and transport system that will promote environmentally sound management are presented in Table 4. As shown in Table 4, calculated values of severity indices ranged between 69.0% and 82.3% for households, 50.5% and 85.2% for e-waste workers while that of the institutions ranged between 79.6% and 100%.

Table 4: Perception about e-waste collection and transport system

Item		Households			E-waste Workers			Institutions		
	Scale	No.	%	IS (%)	No.	%	IS (%)	No.	%	IS (%)
To achieve efficient collection and transport systemthere should be provision of accessible and efficient collection facilities	SD	2	0.6	82.3	0	0.0	85.4	0	0.0	100
	D	5	1.4		0	0.0		0	0.0	
	N	36	10.4		0	0.0		0	0.0	
	A	151	43.5		28	58.3		0	0.0	
	SA	153	44.1		20	41.7		11	100	
	Total	347	100		48	100		11	100	
Minimal movement of e-waste will reduce, if not eliminate, possible leakage of hazardous materials into the environment	SD	6	1.7	69.0	6	12.5	50.5	1	9.1	79.6
	D	41	11.8		18	37.5		0	0.0	
	N	60	17.3		3	6.3		0	0.0	
	A	164	47.3		11	22.9		5	45.5	
	SA	76	21.9		10	20.8		5	45.5	
	Total	347	100		48	100		11	100	
Manual handling of e-waste should be reduced to the barest minimum to avoid contamination and possible health effects	SD	0	0.0	77.4	0	0.0	76.0	0	0.0	88.6
	D	6	1.7		3	6.3		0	0.0	
	N	57	16.4		2	4.2		0	0.0	
	A	182	52.4		33	68.8		5	45.5	
	SA	102	29.4		10	20.8		6	64.5	
	Total	347	100		48	100		11	100	
Efficient collection system should aim at removing portions that contain hazardous substances from the other portions that are non hazardous	SD	0	0.0	74.3	0	0.0	71.4	0	0.0	95.5
	D	6	1.7		3	6.3		0	0.0	
	N	81	23.3		12	25.0		0	0.0	
	A	177	51.0		22	45.8		2	18.2	
	SA	83	23.9		11	22.9		9	81.8	
	Total	347	100		48	100		11	100	
Composite Score	SD	8	0.6	80.6	6	3.1	76.7	1	2.3	92.7
	D	58	4.2		24	12.5		0	0.0	
	N	234	16.9		17	8.9		0	0.0	
	A	674	48.6		94	49.0		12	27.3	
	SA	414	29.8		51	26.6		31	70.5	
	Total	1388	100.0		192	100.0		44	100.0	

Severity Index (SI), Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly Agree (SA)

Analysis of the data showed that the essence to provide accessible and efficient collection facilities for e-waste collection and transport system have severity index of 82.3%, 85.4% and

100% by households, e-waste workers and the institutions respectively. These are found within the strongly agreed perception range of 81-100. These findings corroborate Chatterjee and Kumar (2009) and Davis and Herat (2008) assertion that provision of adequate infrastructure for collection, treatment and disposal is very important for e-waste management.

Results on the minimal movement of e-waste in order to reduce, if not to eliminate, leakage of hazardous materials into the environment have severity index of 69.0% and 79.6% among households and the institutions respectively. These results are found within the agreed perception range of 61-80. On the other hand, the e-waste workers had severity index of 50.5%, which is found within the neutral perception range of 41-60. These findings corroborate Barba-Guetierrez et al. (2008) who observed about negative environmental effects on long distance travelled to collect and dispose of e-waste. They recommended minimal movement of e-waste to avoid negative environmental impacts, which may emanate from possible leakage of toxic substances due to breakages.

The study revealed that the general perception that manual handling of e-waste should be reduced to the barest minimum in order to avoid contamination and possible health effects is high among households and e-waste workers but relatively higher among the institutions. Households' severity index of 77.3% and the e-waste workers figure of 76.0% are found within the agreed perception range of 61-80. However, the institutions had a severity index of 88.6%, which is found within the strongly agreed perception range of 81-100. The findings corroborate Amankwaa (2014) who found that about 90% of e-waste workers perceived e-waste management activities as potential threat to the environment. However, it contradicts his assertion that they have little knowledge about the implications of such activities on their health.

The study found that respondents' awareness of the importance of the removal of portions that contain hazardous substances from the other portions that are non-hazardous is high. The results indicate that households had a severity index of 74.3% while the value for e-waste workers is 71.4%. These values are found within the agreed perception range of 61-80. On the other hand, the institutions perception on the statement was found to be higher than that of the households and e-waste workers. The results showed that the institutions had a severity index of 92.7%, which falls within the strongly agreed perception range of 81-100.

The study found that households and e-waste workers had severity index of 76.7% for the composite score. This result is found within the agreed perception range of 61-80. However, households and the institutions had severity indices of 80.6% and 88.6% respectively which are found within the strongly agreed perception range of 81-100. These results suggest that respondents' have good knowledge of elements inherent in the best practices of e-waste collection and transport system.

1.4 Discussion

1.4.1 Options Available for E-waste Collection and Transport System

This study investigated respondents' awareness of four e-waste collection and transport options: producer take-back, retailer take-back, municipal collection and recycler or dismantler collection. The findings show that respondents' awareness level of recycler or dismantler collection option is generally high. For instance, 82.7% of households, 100% of e-waste workers and 90.9% of the institutions were found to be aware of this option. Additionally, this study asked respondents to assess the effectiveness of the collection and transport options and the results were revealing. The findings show that majority of respondents' perceived recycler' or dismantler' collection and transport system as the most efficient option. From the results, majority of households, e-waste workers and the surveyed institutions evaluated this option as good. There are several possible explanations to the observed pattern. Firstly, it appears the important role of scavengers and dismantlers in the collection of e-waste through their door-to-door services, which seems to be convenient to many people, can help to explain the observed pattern. Secondly, recycler' or dismantler' collection system seems to be the most visible and pervasive activity in many communities as they render invaluable services to many households. Payment of an agreed amount of money for unserviceable electronic gadgets after negotiation with owners of e-waste, which formerly was given free, could be the other possible reason. Amankwaa (2014) found similar evidence of emerging livelihood for the urban poor, with studies at Agbobloshie. His study revealed that increasing awareness of the inherent value of e-waste by consumers as well as competition among collectors has caused them to pay for e-waste, which formerly, was given for free. With regard to the e-waste workers, the finding is not surprising because the study found that e-waste collection and related activities is emerging as a livelihood opportunity to them. These findings are very important for policy consideration in the search for e-waste collection and transport system option.

1.4.2 Suitable E-waste Collection and Transport System for Accra

The study found that households and e-waste workers identified recycler or dismantler collection and transport system as the most suitable management option for Accra. The results show that 59.3% of households and 100% of e-waste workers perceived recycler' or dismantler' collection and transport system as the most preferred option. Though households for this option assigned several reasons, three of them are outstanding. These include payment for e-waste, door-to-door services rendered by collectors as well as experience and expert knowledge of recyclers or dismantlers. Majority of e-waste workers on the other hand, indicated that they opted for this option because it provides livelihood to many people, while a smaller number said that recyclers and dismantlers have experience and expert knowledge about collection. This finding is not surprising since previous studies in Ghana (Oteng-Ababio and Amankwaa, 2014; Oteng-Ababio, et al., 2014; Owusu-Sekyere, 2014; Amoyaw-Osei, et al. 2011; Prakash, et al., 2010; Brigden et al., 2008) and China (Streicher-Porte and Geering, 2010;Yang, et al., 2008) have indicated that the informal collection by scavengers and dismantlers is the most significant collection method. The present findings seem to be consistent with other research, which found that 95% of e-waste generated in the country are collected and recycled by scavengers and dismantlers (Amoyaw-Osei, et al., 2011; Prakash, et al., 2010). These findings suggest that informal collection is the fulcrum within which e-waste management in developing countries revolve. This makes the current findings significant as global best practices seems to be gearing towards complete privatization of waste collection services, thereby leaving the city authorities to assume greater responsibilities in supervisory and oversight functions. This implies that, any policy or regulatory framework that attempt to exclude the sector from e-waste management interventions would be counterproductive. Therefore, in the search for e-waste collection and transport system option, it is important for decision makers and waste planners to integrate the informal collection in e-waste management policy and planning as the sector is well established.

On the contrary, majority of the institutions perceived producer take-back system as the most suitable e-waste collection and transport system option for Accra. Reason for the choice of this option is that producers are the manufacturers of the electronic products; therefore, they should be responsible to take-back at the end-of-life for their management. It can be inferred that, the institutions are more concerned with an EPR principle, which promotes formal collection system with establishment of licensed collection agencies than unlicensed informal collectors.

In effect, producer take-back seems to shift the burden of the end-of-life management responsibilities from city authorities (in this case metropolitan assembly) to original producers. This finding is in agreement with previous studies findings which found that formal collection by producers or their agents through various take-back schemes are widely applied in countries like Switzerland, Germany, UK, Canada, USA (Maine) and Japan (see Kiddee et al., 2013; Khetriwal et al., 2007; Wagner, 2009; Yoshida and Yoshida, 2010). In these cases, e-waste are either collected from users or returned to purchasers for free. This implies that owners of the e-waste do not gain financially from the value of the product. Though this strategy might have contributed significantly to the success story of e-waste management in these countries, wholesale importation of these policies, programmes and strategies into the country is likely to fail because this study has established that consumers are aware of inherent value of e-waste, which could be sold. In addition, the appropriate institutions and infrastructure to support this option do not exist. Moreover, identification of producers or importers may be problematic because of poor inventory, orphan and clone products. These realities make the adoption of this option technically not feasible.

These findings also bring to the fore the varied interest of key stakeholders in e-waste management. This implies that in the search for e-waste management option, policy makers and waste planners should understand the nexus between consumers and e-waste workers interest and that of the institutions. These findings, therefore, suggest that the adoption of more inclusive interventions that build on the current collection practices in order to harness the potentials of the informal collection networks which are already in place is critical and relevant.

1.4.3 Respondents' Perspective on E-waste Collection and Transport System

The study also assessed respondents' perception on e-waste transport and collection system that will promote the adoption of an environmentally sound management in relation to global best practices. From the results, respondents expressed their perception on the need to provide efficient and accessible facilities to facilitate e-waste collection. The severity index on the statement "to achieve efficient collection and transport system there should be provision of accessible and efficient collection facilities" which range between 82.3% and 100% are found within the strongly agreed perception range of 81-100. With these perception ranges the respondents affirm the general perception in the literature that provision of collection facilities that will be accessible to consumers is critical to efficient collection and transport system.

Though the perception is relatively high across the three categories of respondents, the results indicate that the perception is stronger among the institutions than the households and e-waste workers. By inference, it appears the institutions are more inclined towards formal collection system than informal collection system where the basic collection infrastructure facilities are required and provided by collectors themselves. This finding is consistent with take-back schemes under EPR where collection facilities are provided at designated points for consumers to return e-waste for proper end-of-life management. This finding corroborates Khaliq (2014), Chatterjee and Kumar (2009), UNEP (2007) and Davis and Herat (2008) assertion that provision of adequate infrastructure for collection, treatment and disposal are very important for e-waste management.

Similarly, the findings indicate that there is a positive agreement on the statement "efficient collection system should aim at removing portions that contains hazardous substances from the other portions that are non-hazardous". The results show that households and e-waste workers had severity index of 74.3% and 71.4% respectively. These results are found within the agreed perception range of 60 - 80. The institutions, on the other hand, have a severity index of 95.5%, which is found within the strongly agreed perception range of 81 - 100. These findings suggest that respondents are aware that e-waste contains hazardous substances, which need to be removed to avoid adverse effects on the environment and human health (UNEP, 2012; Robinson, 2009; UNEP, 2007). These findings corroborate previous studies, which found that detoxification as a management practice promotes good environmental standards and health safety (see Li et al., 2015; Namias, 2013; Wang et al., 2012; ILO, 2012; Salhhofer and Tasar, 2011; Schluep et al., 2011). Policy implications of these findings is that policy makers and waste planners in the search for e-waste management option should institute measures that will make it obligatory for scavengers to carry out detoxification in order to promote sound management practices.

Composite score of the four statements of respondents' on perception on e-waste collection and transport system indicate that e-waste workers had 76.7% of severity index. This result is found within the agreed perception range of 60-80. On the other hand, households and institutions had severity indices of 80.6% and 92.7% respectively which are found within the strongly agreed perception range of 81-100. These results demonstrate the importance of best practices of e-waste collection and transport system to ensure environmentally sound

management from stakeholders' perspective. These findings suggest that public perception could play a critical role in fashioning out e-waste management option, as their opinion would be helpful in decision-making.

1.5 Conclusion

This study has conducted an investigation into stakeholders' perceptions on e-waste collection and transport system options that will promote environmentally sound management in line with world best practices. The study identified recycler or dismantler collection system as the most suitable e-waste collection and transport management option for Accra. The findings indicate that the informal sector is likely to perpetuate its existence for a long time in terms of e-waste collection and transport system, so long as these activities serve as sources of livelihood to them. In addition, the findings indicate that key stakeholders have different interests in e-waste collection and transport system options. Therefore, policy makers and waste planners should understand the nexus between stakeholders' interests. This would go a long way in policy formulation and design of appropriate strategies that are more inclusive to satisfy varied interests. The study therefore recommends that, in the search for e-waste collection and transport system option, it is important for decision makers and waste planners to integrate the informal collection in e-waste management policy and planning as the sector is well established. These findings call for policy response to regulate the informal sector activities and moreover build on their knowledge in best management practices to enable them perform effectively and efficiently in order to accrue optimum benefits from their operations.

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