Exploring the Dynamics of E-waste Disposal Strategies in Tamale, Ghana

Ebenezer Owusu-Sekyere

Department of Development Studies, University for Development Studies, Wa Ghana

Email: oseturbo@yahoo.com

Kenneth Peprah

Department of Environment and Resource Studies, University for Development Studies, Wa Ghana

and

Raphael Mawiako Demuyakor

Department of Planning Nanton District Assembly, Ghana

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Abstract

Globalised inter-connected world; changing patterns of world standards and norms; and the emergence of consumerism have all drastically shaped the generation and management of e-waste. Cities in developing countries are grappling with developing sustainable strategies to dealing with e-waste and therefore households are compelled to fashion their own disposal strategies. This article examined some of these disposal strategies and the factors that influenced their adoption in Tamale, a growing city in northern Ghana. Data for the study were collected using different techniques including questionnaire survey and key informant interviews. The predominant disposal strategies that emerged were selling e-waste as scrap; donating to other people as gifts; selling as second hand product; disposing with other domestic wastes or combination of any of the strategies. These informal management strategies were influenced by respondents' age, education level and income. It is recommended that the observed disposal strategies can be articulated in Ghana's search for definitive e-waste management policies that are environmentally friendly, socially acceptable and economically viable.

Keyword: E-waste, Disposal strategy, Ghana, Recycling, Legislations

Introduction

Globalisation, neoliberalism and changing patterns of consumerism have all collectively shaped Ghana's linear development – the start of nationwide accumulative growth and broad access to a global consumer society (UN Habitat, 2010; GSS, 2012). This free-market ideology has set the population on an endless course of advancement and perfection to effectively and efficiently improve in all aspects of socio-economic life (Alias et al., 2014). The pursuit of socio-economic growth is driven by the information communication technology (ICT) revolution, thus increasing the consumption of electrical and electronic equipment (EEE). In theory, the ICT boom should result in human advancement by stimulating socio-economic development while at the same time offering an opportunity for the upgrading of technical skills and know-how (technology transfer) by majority of Ghanaians (Oteng-Ababio & Chama, 2012).

The unprecedented demand for consumer electrical and electronic equipment has led to the importation of both used and newer electronic equipment like personal computers, mobile phones and television sets among others with limited lifespan. Available statistics from the Ghana Statistical Service (GSS) in 2014 indicate that on average, Ghana imports about 2,141,300 tons of EEE annually, out of which 64,000 tons are new and 149,000 are slightly used (GSS, 2014). It is further estimated that about 30% arrives as 'dead' devices (Grant et al., 2012; Oteng-Ababio & Chama, 2012). In 2004, used computers imported into Ghana amounted to USD 23.7 million (Grant & Oteng-Ababio, 2012) and by 2009, it had increased to USD 59 million. Other scholars indicate that not only are some used EEE useless, they also present serious challenges to human and environment health (Bridgen et al., 2008). The continuous importation of slightly used or 'dead' EEE has implications for e-waste generation and its management.

Studies show that e-waste offers a set of significant challenges to city authorities in developing countries as most of them lack modern infrastructure for environmentally sound management (Annez et al., 2010; Owusu-Sekyere, 2014; Oteng-Ababio, 2014). Electronic waste is regarded as the fastest growing waste in Ghana and accounts for almost 5% of all municipal solid waste each year (Amoyaw-Osei et al., 2011, Oteng-Ababio, 2012). This quantity has largely been blamed on some government policies such as "One Laptop per Child" initiative for primary school children (Oteng-Ababio, 2012) and the 2003 ICT for Accelerated Development Policy; of which one specific policy objective seeks to "create the necessary enabling environment to facilitate deployment, utilisation and exploitation of ICT within the economy and the society". Such an objective according to Oteng-Ababio (2010), abetted unprecedented reductions in taxes and duties on EEE in the country and

consequently aided the generation of such massive quantities of e-waste. Velis et al. (2009), observes that unlike developing countries, countries of the developed North have developed proper e-waste management systems that are service oriented; carried out by private enterprises and tailored to suit the local conditions. These countries already have well laid structures and proper financing schemes such that the cost of disposal is normally charged upfront or is invisibly embedded in the purchase price, a regime residents have become accustomed to (Streicher-Porte, 2011). More importantly, policies in such societies are not only enforced, but penalties are charged for dissent. This makes e-waste management cost-effective (Streicher-Porte, 2011).

The situation in Ghanaian cities and their counterparts in sub-Sahara Africa are utterly different. These cities are yet to come to terms with the enactment of appropriate legal regimes, policies and strategies to deal with the problem (Osibanjo and Nnorom, 2007; Oteng-Ababio, 2010). The over-burning desire to join the ICT world in the midst of chronic poverty seems to have overshadowed the lingering problems of e-waste management which revolves round an integrated system of collection, transportation and proper disposal. Till date, official channel or policy for the disposal of e-waste is not well defined. This has compelled e-waste generators to fashion out their disposal choices which at best may not be environmentally friendly, socially acceptable or economically viable. The objective of this study is to examine e-waste disposal strategies in Tamale and the factors that influenced the adoption of these desired strategies.The study is an attempt at building a first step towards documenting the overall characteristics of e-waste disposal strategies in Ghanaian cities. It is divided into six sections: the introduction is followed by the conceptual framework which discusses the Integrated Solid Waste Management Framework is presented in the second section. This followed by the research methodology. Section four presents the results while section five discusses the results from the field. Section six presents the conclusion and makes recommendations for policy consideration.

Theoretical Framework

Theoretically, an environmentally sustainable waste disposal is conceivably the most important step to achieving a clean environment devoid of health and environmental risks. The thorough understanding of the factors that influence the choice of method of waste disposal is a necessary step to designing a waste management system that would be suitable to the culture of a community in order to achieve a sustainable system (Whiteman et al., 2001). This paper is housed in the Integrated Sustainable Waste Management (ISWM) framework (UNEP,

2009). Integrated Sustainable Waste Management refers to a strategic initiative for sustained management of solid waste through the use of a comprehensive integrated format generated through sustained preventive and consultative approach to the complimentary use of a variety of practices to handle solid waste in a safe and effective manner.

In Figure 1, the ISWM system comprises three sub-systems: types of waste (core cycle), waste management processes (mantle cycle) and the sustainability triad of economy, environment and society (peripheral cycle). The sub-systems contain various elements such as municipal solid waste (MSW), construction and demolition waste (C&D) waste, bio-medical waste, hazardous waste and e-waste – the subject matter of this study for the core cycle sub-system. The mantle sub-system has elements of waste generation, segregation, recycle and reuse, collection, decentralised treatment, transportation as well as reuse, disposal and treatment. Finally, the peripheral sub-system deals with the elements of sustainable development as economic, environmental and social pillars. Managing solid waste sustainably involves a complex interaction among environmental, economic, and social dimensions. Environmental sustainability means extracting resources for business purposes without overburdening the environment, while sufficiently maintaining the functions of society and the overall economy (Giljum et al., 2005). Spangenberg (2005) explains economic sustainability as improving living standards without diminishing productive resources. Lastly, social sustainability refers to meeting the basic needs of all people in a just and efficient manner. Balancing these concepts is at the very core of ISWM (Meletis & Campbell, 2009).

The first pre-requisite for a well-functioning waste management system is governance; an all-inclusive system which provides all stakeholders the enabling environment to contribute as users, enablers and providers; and in planning, implementation and monitoring (Wilson et al., 2013). The second is that there should be the need for financial sustainability to make services cost-effective and affordable. Finally, there should be a strong and transparent institutional framework and policies that are proactive (UN-HABITAT, 2010). The quest for sustainable system goes beyond technical considerations; it extends to political, economic, institutional, financial and social aspects (Schubeler et al., 1996). These strategic components must be integrated to ensure efficient system and this is what the framework represents. Integrated Sustainable Waste Management takes a comprehensive approach across all types of solid waste streams and involves the use of a range of different options. It is a system developed from generation to disposal and builds around the other management steps encompassing all types of solid wastes.

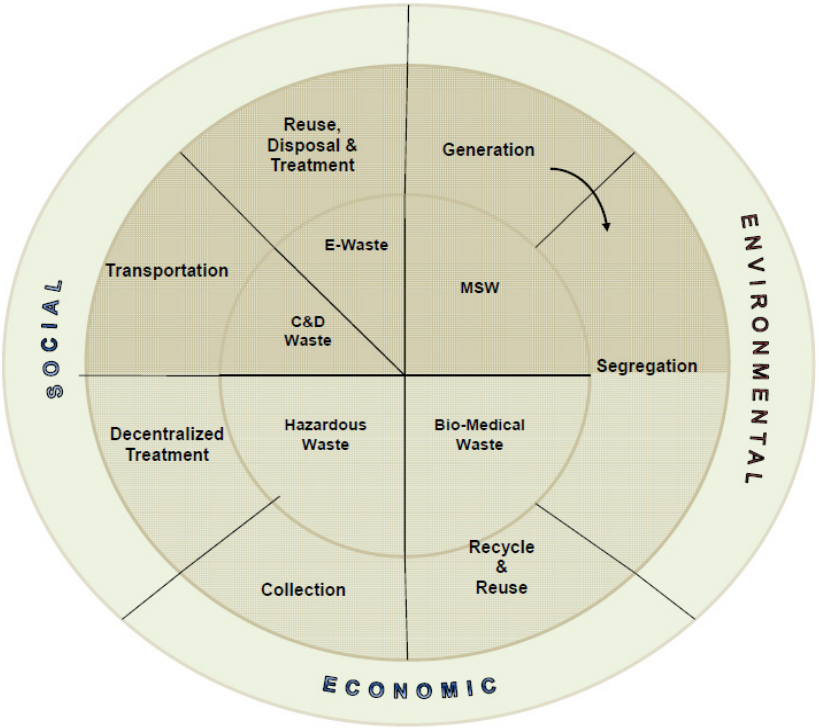


Figure 1: Integrated solid waste management framework

Adopted from UNEP, 2009

In the implementation of ISWM, three important dimensions are recognised – stakeholders, elements and aspects. The stakeholders are individuals (users of the waste management service including households, offices and so on) and organisations (local authority, government ministries and private companies) that have a stake in waste management. There are also often unrecognised stakeholders including street sweepers; workers on collection trucks; waste-pickers some of whom may actually live on or at the edge of the dumpsite and family-based businesses that live from recycling (Oteng-Ababio, 2010). The elements which are the second dimension involve the identification of the various stages in the management of e-waste from the cradle to the grave. It highlights elements such as collection, transfer and disposal or treatment of e-waste while advocating the 3Rs (reduction, reuse, recovery and recycling). The reduction encourages all actions aimed at ensuring that disposers minimise waste creation through the culture of maintenance among other efforts aimed at reducing the rate at which EEE becomes e-waste. Reuse encourages selling or giving away old but workable EEEs to be reused instead of entering the waste stream. This delays EEE from being consigned

as e-waste. In the context of recycling, e-waste is further processed into new products. It also involves removal and safe disposal, as well as the valorisation and composting operated by a variety of stakeholders at various scales.

The third level (Aspects) provides a series of analytical "lenses" which can be used for assessing the situation, determining feasibility, identifying priorities or setting adequacy criteria. "Integrated" in ISWM refers to the linkages and interdependency between the various activities (elements), stakeholders and "points of view" (sustainability aspects). Moreover, it suggests that technical but also legal, institutional and economic linkages are necessary to enable the overall system to function (UNEP, 2009). The discussions so far indicate that as an assessment tool, the ISWM model addresses waste management issues holistically by grouping influencing factors into three as alluded to earlier. The assessment process for the disposal of e-waste shall be conducted by employing the framework to determine the influencing factors that fundamentally inform disposal choices in Tamale. For a solid waste management system to be sustainable, it needs to consider all aspects – operational, financial, social, institutional, political, legal and environmental (third dimension of the framework).

Methodology

Study Area

The study was conducted in Tamale, the most urbanised and the largest city in the northern ecological zone of Ghana (Figure 2). It shares boundaries with the Sagnarigu District to the west and north, Mion District to the east, East Gonja to the south and Central Gonja to the south-west with an estimated land size of 646.90180km^2 (GSS-2014).

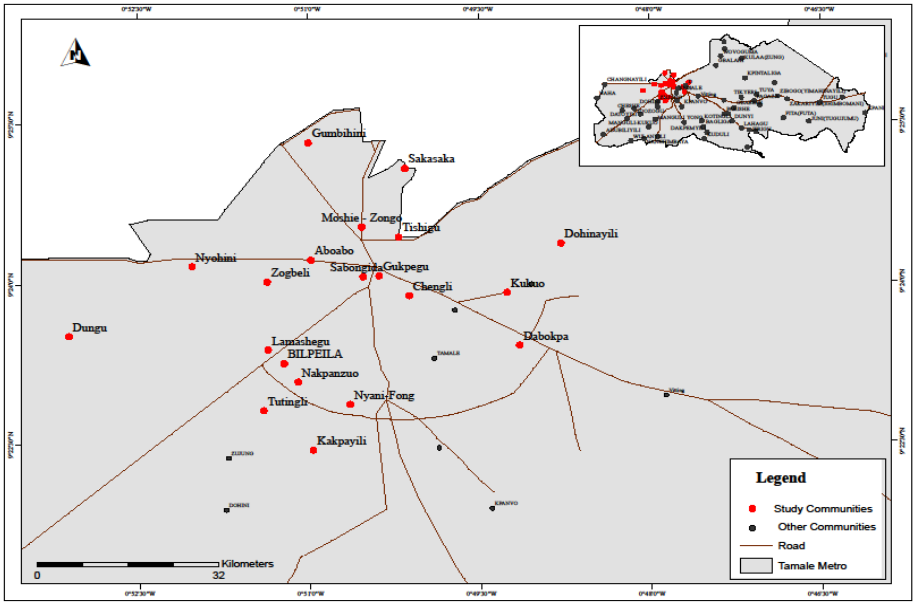


Figure 2: Map of Ghana showing Tamale Metropolitan Area

The Metropolis is estimated to have a population of 223,252 (GSS, 2012) with an urban population of 80.8%. This phenomenal urban growth is due to the strategic location within the West African sub-region. The city serves a transiting point for vehicles and passengers from countries like Burkina Faso, Niger, Mali and the northern part of Togo and has thus added to the booming economic activities. Statistics indicate that the over 35,408 households live in 19,387 houses in the Metropolis and generate 810 tons of solid waste daily out of which over 6% constitute e-waste (TaMA, 2013).

Data Collection

As part of the data collection process, the 10 largest communities in the Metropolis (Figure 2) were selected taking into account the fact that they generate over 80% of the total e-waste in the Metropolis (TaMA, 2013). Multi-stage sampling technique was employed to select 300 study participants as follows: at the first stage, the number of households in the ten communities was obtained from the Ghana Statistical Service (Table 1). Secondly, a proportional sample of thirty was assigned to each of the communities. Proportional sampling was adopted because of the seemingly less differences in the number of households in the communities and also to reduce the bias in over representation.

Table 1: Sampling size distribution

Community	No. of Households	Quota of Sample
Lamashegu	3257	30
Nyohini	2627	30
Tishigu	2564	30
Moshie Zongo	2257	30
Zogbeli	2189	30
Chengli	1706	30
Gumbihini	1746	30
Aboabo	1951	30
Dabopkpa	1470	30
Gukpegu	1530	30
Total	**21297**	**300**

At the third stage, simple random sampling was used to select thirty household heads from each community for the study. The study adopted multiple data collection methods including questionnaire survey, key informant interviews, non-participant observation and a comprehensive review of official documents. The fieldwork which spanned January to October, 2016, saw each key researcher, handling three assistants fluent in the dominant local language and being assigned to a locality with a comparative advantage in terms of local knowledge and social links. The questionnaire was used for the household survey. For each house, the household head was contacted for an interview. In the absence of a household head, the eldest in the household who was relatively informed on e-waste disposal strategies of the household was called upon for the interview. Of particular concern to the researchers was that participants understanding of what factors influenced a disposal choice. In determining the factors that influence the choice of a particular disposal choice, the study employed the multinomial logit model, which theoretically assumes that a household would choose a disposal strategy among different alternatives that yields maximum utility. Cameron and Trivedi (2005), for example indicates that the utility obtained can be separated into observed and unobserved components as expressed in equation (1a).

$$U_{ij}(X_{ij};Z_{ij}) \qquad \textbf{(1a)}$$

Where:

U_{ij} denotes the utility of an *i*th household respondent choosing alternative ***j*** strategy

(X_{ij}) consisting of observed components

(Z_{ij}) components

However, the observed component of household behaviour in its appropriate form is as seen:

$$V_j(X_{ij};\beta)+\mu_i \qquad \textbf{(1b)}$$

Where:

V_j is a function for the deterministic component of the utility**,**

(X_{ij}) consists of the observed components,

β is the estimated coefficient

μ_i is the margin of error

Equation (1a) is however equal to equation (1b)

$$U_{ij}(X_{ij};Z_{ij}) = V_j(X_{ij};\beta)+\mu_i$$

The dependant variable of interest, that is 'e-waste disposal strategies' takes different categories; hence conventional ordinary least squares regression will not be appropriate. Cameron and Trivedi (2005), indicate that such a response variable has a multinomial distribution and can therefore be analysed using the Multinomial Logit Model. The conditional probability of the Multinomial Logit Model is specified in equation (2) as:

$$Prob\left(Y_{ij} = {}^{j}/_{X_i}\right) = \frac{exp(X_i\beta_j)}{\sum_{j=1}^{k} exp(X_i\beta_j)} \qquad \textbf{(2)}$$

Where j = 1, 2 . . . k. The first choice (base) strategy is used to compare other choices by restricting the parameters of the base category to all zero (β_1=0). The first choice category is households who disposed their e-waste by selling as scrap. The other strategies are: sale as second hand, pay for a sustainable disposal and donation. The empirical specification of the multinomial model is:

$$prob(Y_{ij})=\beta_0 + \beta_1 SEX + \beta_2 AGE+\beta_3 INCOME+\beta_4 EDU + \beta_5 AWARE + \mu_i \qquad \textbf{(3)}$$

j = 1, 2 . . .k. The definition of variables, unit of measurement and expected signs are shown in Table 2.

Table 2: Variable definition and hypothesised relationships

Variable	Definition	Unit of measurement	Sign
Dependent Variable			
Y_{ij}	Disposal strategy	Categorical (if method j then 1 ; else 0)	
Independent Variable			
SEX	Sex	Dummy (male = 1; female = 0)	+/-
AGE	Respondent's age	Years	+/-
INCOME	Income	Monthly income of respondent	+/-
EDU	Education	Years spent at School (Tertiary =1;otherwise = 0)	+/-
AWARE	Awareness of Hazard	Dummy (Yes =1; otherwise = 0)	+/-

Six key informant interviews were conducted with officials from the waste management department of TaMA, Environmental Protection Agency and Zoomlion Ghana Limited through the use of semi structured interview guide. The main issues discussed included policy implementation, challenges and the way forward. The authors analysed secondary data collected from various sources: reports from state agencies and civil society groups, workshop and conference proceedings.

Results

Socio-Demographic Characteristics of Respondents

The socio-demographic characteristics that were covered by the study were sex, age and educational background of respondents (Table 3). Since the target population of the study was household heads, majority of the respondents were middle aged and older people who were well informed about e-waste disposal practices. From Table 3, majority of respondents were between 26-35 years of while respondents between 66-75 years recorded the lowest. It can also be observed that the percentage of respondents decreased with the increase in age. Again 70% of respondents were males while 30% were females confirming the position of GSS (2014) that in Tamale household heads who are the target population of the study are predominantly males.

Table 3: Socio-demographic characteristics of respondents

Variable	Category	Percentage
Sex	Male	70
	Female	30
Age	26-35	46
	36-45	28
	46-55	18
	56-65	7
	66-75	1
Education	None	15
	Primary	41
	Secondary	10.9
	University	32.7

The study further revealed that 15% respondents had not had any form of formal education. Forty-one percent of them had either completed or attained formal education to some point at the basic level while 11% of them indicated they had completed a second cycle institution. Thirty-three percent of respondents had attained formal education to the tertiary level. Data on the income of respondents were also collected to help determine the relationship between income level and the choice of disposal method (Figure 3).

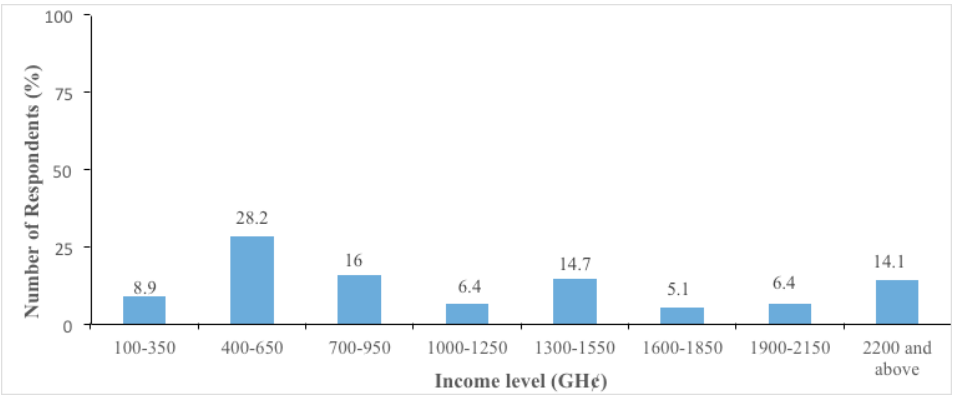


Figure 3: Estimated income level of respondents

Figure 3 shows that 28.2% of the respondents earned between GH¢400 and GH¢650 monthly. A good number of 14.1% also earned GH¢2200 or more in a month.

Majority of respondents (76.3%) were self-employed in the informal sector such as welding, hairdressing, food vending, dressmaking and trading among others.

The Composition of E-waste in Tamale

The Ghana Statistical Service indicates that composition of e-waste helps to determine the disposal strategy to be adopted (GSS, 2014). Available data from the Waste Management Department of the Tamale Municipal Assembly indicates that the major electrical wastes generated by households in the Municipality are television sets, rice cookers, refrigerators, hair dryer, air-conditioner, desktop computers, printers and sewing machines among others. This is a reflection of the general level of economic development within the country where according to the World Bank, employment rate is low. In the circumstances, majority of the people's scale of preference for electrical products is always skewed towards those appliances that have wider social impact. The study further revealed that state policies also influenced electronic products that are used by the population and how they are disposed when they reach their end of life usage. In an interview with a key informant at the Waste Management Department of TaMA, he explained the link between government policies and the type of e-wastes that are generated frequently:

> *The frequent disposal of television may be due to the change in government policy where old analog television sets (CRT technology) is being replaced with digital Liquid Crystal Display (LCD) in line with the digital revolution worldwide. For Cell phones, the reason is due to the proliferation of Android technology that has made cell phones multifunctional in nature. The reason for the high disposal rate of refrigerators is due to the Refrigerating Appliance Rebate Program through the Energy Commission of Ghana which is aimed at retrieving old refrigerators from households by discounting the prices of fridges to buyers who turned-in their old but functional fridges*.

The Refrigerating Appliance Rebate Program, according to the Ghana Energy Commission is to help reduce the release of CFCs into the atmosphere because CFCs have been implicated in the depletion of the ozone layer and thus supporting the fight against climate change. The gadgets that recorded least disposal rates were laptop and microwave oven. The study showed that this was largely because a relatively small number of households indicated they had ever used these gadgets.

Identified E-waste Disposal Choices

The research identified seven different e-waste disposal strategies usually adopted by e-waste generators (Table 4).

Table 4: Description of e-waste disposal strategies

Disposal Channel	Description
Sold as scrap	Informal dealers in metals move door-to-door to buy e-waste from households. Their activities do not however have a routine and so transactions are done at the pace of the buyer
Donated to other people	e-waste is given out to family and friends without any financial compensation
Sold as second hand product	Unwanted (e-waste) but workable EEE is given out to family, friends or even strangers for a financial compensation.
Disposed with other household waste	Some e-waste are disposed along with 'conventional' households waste
Dumped somewhere	Some e-waste are also left at open spaces that are not necessarily refuse dumps
Stored in the house	E-waste is left somewhere in the house. This may be due to some sentimental attachment to the gadget, for future use, in hope to repair it later or even for decoration
Permanently left with repairers	Some e-waste is left at repair shops for good because it is perceived as waste and so unwanted at home. Time and transportation cost sometimes also account for such practices

A disposal strategy employed by respondents was highly dependent on the size, weight and metallic content of a gadget in question. Heavy and bulky products like fridges were seldom stored in the house due to the want of space. Blenders, DVD players, telephones and other small e-waste were fast forgotten in corners of the home due to the limited space they occupy. It was also revealed that scrap dealers preferred collecting gadgets like fridges, desktop computers, air conditioners among others to blenders, telephones, DVD players and other small e-waste due to their high content of recoverable materials (metals). Again, e-wastes that were relatively smaller and light in weight were easily thrown into dustbins together with other domestic waste. The foregoing analysis shows that respondents did not employ a single strategy in disposing all e-waste (Table 5).

Table 5: Disposal strategy by e-waste type

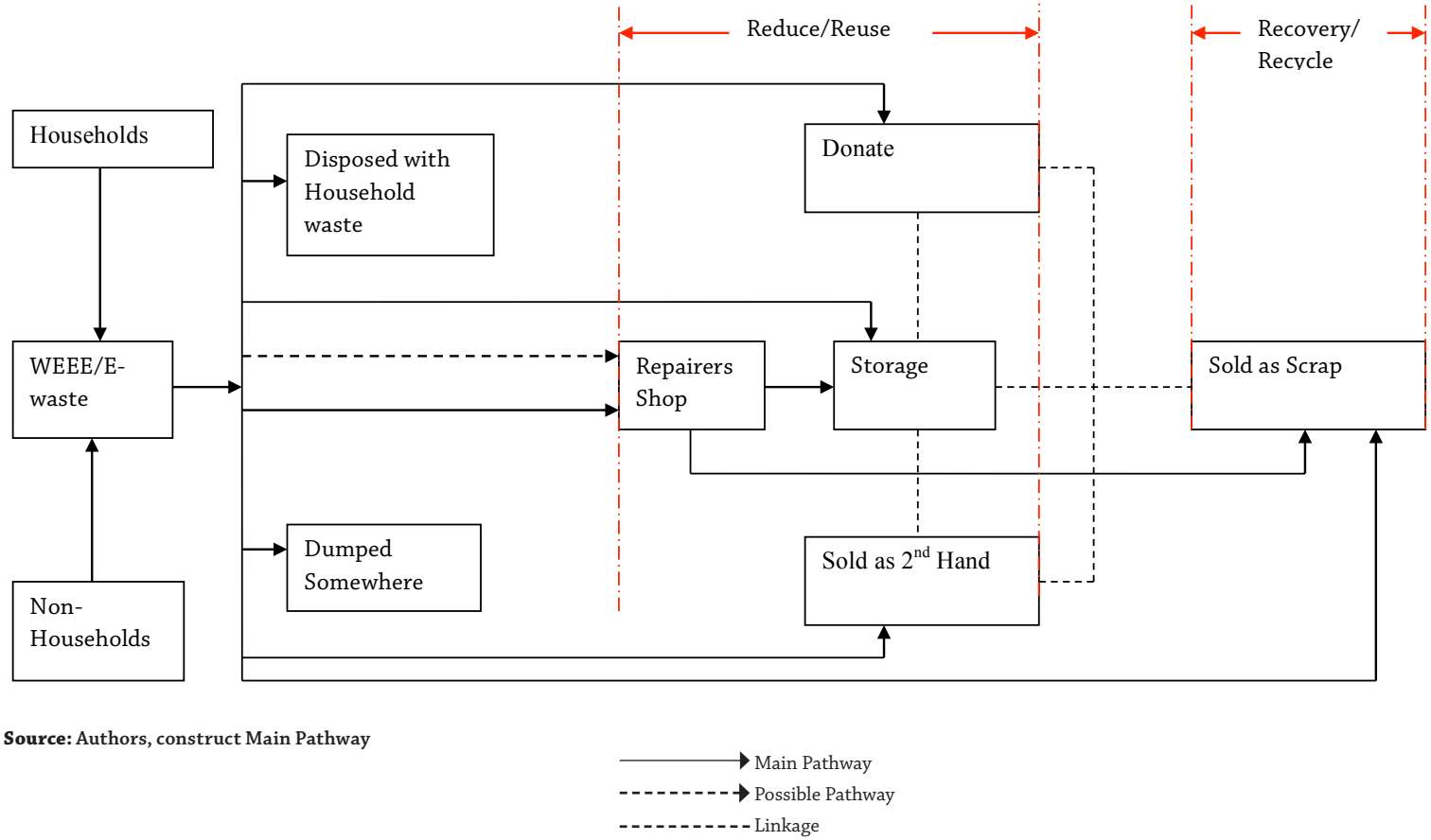
EEE	Donated to other people	Sold as second hand product	Stored in the house	Permanently Left with repairer	Sold to scrap dealers	Disposed with other household waste	Disposed somewhere
Fridge	√		√	√	√		
Desktop PC	√		√		√	√	
Cell phone	√	√	√		√		
Blender	√				√		
Kettle	√				√	√	
DVD player			√	√	√		
Satellite decoder	√				√	√	
Laptop PC			√		√		
Portable radio			√		√	√	
TV	√	√	√	√	√		√
microwave					√		
Portable heater					√	√	√
Sound system	√	√	√		√		
fan			√	√	√		
iron				√	√	√	

The survey revealed that overall, the most widely practiced disposal strategy was sold to scrap dealers followed by stored somewhere in the house, donation, disposed with other household waste, sold as second hand gadgets to other users, dumped somewhere and permanently left with repairers (Table 5). Respondents gave various reasons for employing their disposal strategies. For instance, a forty-two year old explained that he donates to charity as a way of helping the less privileged to own some gadgets they could not have afforded financially. For respondents who sold their e-waste to scrap dealers, it was a way of making some savings which eventually becomes a top-up cash for a new purchase. As one respondent puts it: "It is better than just throwing it away and is thus a way of recouping some of the money used to purchase it".

Implicitly, the strategy helps in ridding the city of piles of e-waste through the way scrap dealers facilitated the access of iron rod manufacturers to their raw material. Gadgets such as desktop computers (CPU), air conditioners and television sets made up the majority of their e-waste purchased. This same reason (cash-back) was adduced by respondents who sold their e-waste as used commodity to other users

at a relatively low price. Our study further showed that for some other respondents, leaving the e-waste anywhere was a disposal strategy. For example 5.1% of respondents dump their e-waste indiscriminately. For some 32.1%, e-waste was treated as part of the normal household waste and was therefore disposed without segregation. A fifty-one year old household head for instance, wondered why e-waste ought to be treated separately when he asked: **"**What is so special about my spoilt water heater that I have to throwaway specially, is it not like any other waste**"**

Disposing e-waste with household waste perhaps shows the understanding and contextualisation of what constitute waste among some people. Figure 4, presents a schematic representation of the pathway of e-waste disposal in Tamale.



Source: Authors, construct Main Pathway

Figure 4: Summary of e-waste disposal pathways in Tamale

Factors that Influenced the Adoption of E-waste Disposal Strategies

The study revealed that the disposal strategies were largely dependent on other characteristics of the household head. In an effort to identify the factors influencing a household's desired disposal strategy; a multinomial logit model was formulated. Since 'sell as scrap' was the most preferred disposal strategy among households as indicated in Table 6, the regression model was run with 'sell as scrap' as the base/reference strategy to be able to determine the relative effect of each specific predictor on a particular disposal strategy. The predictors included sex (SEX), age (AGE), education (EDU), income (INCOME) and awareness of the hazard of e-waste (AWARE). Table 6 shows the Multinomial Logit estimates of the determinants of household desired e-waste disposal strategy relative to the base strategy (sell as scrap). The likelihood ratio statistics is significant at 1% and this implies that at least one of the independent variables in the model has a significant influence on household's desired e-waste disposal strategy. From Table 6; sex, education and awareness of the hazards of e-waste were found not to have any significant influence on disposal strategy. However, age and income were found to have significant relationships with desired disposal strategy.

Table 6: Multinomial logit estimation of determinants of e-waste disposal choice

Variable	Sell as Second Hand	Disposed with other waste	Donate
Constant	3.598(0.98)	-19.600(-0.02)	-6.454(-4.22)
SEX	1.329(1.12)	0.657(0.75)	-0.0477(-0.07)
AGE	-0.250(-2.10)**	-0.0248(-0.65)	0.042(1.32)
EDU	0.532(0.39)	17.834(0.02)	0.680(0.92)
INCOME	0.0004(0.56)	0.002(3.36)***	0.002(4.84)***
AWARE	1.251(00.98)	-1.058(-0.17)	0.296(0.39)
Number of observation = 156 LR chi^2(15)= 135.14, Prob> chi^2 = 0.00 Pseudo R^2 = 0.44 Log likelihood = – 86.89			

*** = significant at 5% and *** = significant at 1%. Figures before parenthesis are coefficients and those in parenthesis are Z-values.*

The results of the model provided that the coefficient of age was negative and significant at 5% for selling as used commodity. This implies that the older the household head, the less likely he/she was to sell e-waste as used commodity compared to selling it as scrap. Conversely, younger household heads were more likely to sell their e-waste as used commodity than selling it as scrap compared to their elderly counterparts. The field interviews confirmed the multinomial

analysis. A 37 year old participant explained why he sold his slightly used mobile phone to his brother's friend:

> *These days hardly would a day passed-by without an advert on fashionable phones. But you cannot buy all of them so what I do is to sell the old one to raise some money to buy new ones. This is about the fourth time I have sold my old mobile phone which I intend not to use again to buy a new one and am not the only person, all my friends do the same.*

Age was however positive for donation; implying that older household heads were the more likely to donate their e-waste than to sell them as scrap though a significant relationship was not established. This finding is in sync with the Ghanaian culture where older people generally feel responsible for the wellbeing and comfort of younger ones and would typically give out such gadgets in working condition to younger family members or friends without accepting any monetary reward. Further, age recorded a negative coefficient for payment for a sustainable disposal of e-waste though not in significant terms. This means that older household heads would often not pay for a sustainable disposal of e-waste relative to selling it as scrap compared to younger household heads. This is most probably because, waste management has until the 1970s been the responsibility of city authorities and for that matter older folks who enjoyed this in the past for free still find it absurd to pay for the same services (Owusu-Sekyere et al., 2015).

The income of respondents was also observed to have a strong influence on the preferred choice of e-waste disposal strategy. The coefficient of income in Table 6 is positive for all disposal strategies. This suggests that higher income earners were more likely to choose other disposal strategies to selling the e-waste as scrap (base/reference strategy). The effect of income on dispose with other household waste was observed to be significant at 1% but not significant for selling as used commodity. These findings imply that high income earners will often pay for a sustainable disposal of e-waste or donate it. The possible explanation for this is that, higher income earners as observed by Owusu-Sekyere et al. (2017) are already used to paying for the disposal of their household waste through the door-to-door services and so find no problem in paying for sustainable disposal of their e-waste. With respect to donation, it is probably due to their capacity to purchase new versions without necessarily needing support from the proceeds of the old ones. Besides, some people simply want to show kindness to the less privileged that otherwise may not be able to acquire such gadgets. Others are also just expected to give out their old gadgets to family members and friends. The model further revealed that, the likelihood of a respondent selling e-waste as used commodity compared to selling as scrap was weak since no significant relationship was established.

Other variables in the model such as sex, education and awareness of e-waste disposal strategy were found not to be significant determinants. The signs of their coefficients however, suggest that male respondents were more likely to sell e-waste as used commodity than to sell as scrap. On the other hand, such male respondents will only prefer selling e-waste as scrap to donation. The education variable was positive for all categories relative to the base though it was found not to be significant. This however, suggests that people with tertiary education would prefer to sell e-waste as used commodity, pay for a sustainable disposal or donate it to selling it as scrap. Their counterparts with no tertiary education would prefer the vice versa. Awareness of the hazardous nature of e-waste had no significant influence on choice of disposal strategy. However, the signs of its coefficients suggest that household heads that were even aware of the hazardous nature of e-waste still did not wish to pay for a sustainable disposal of e-waste given the option of selling as scrap. Such category of respondents would often sell their e-waste as used commodity or simply donate them.

Discussion

The findings of the study indicate that e-waste is growing in Tamale due to the increasing use of used electronic devices that easily become outmoded within a short period of time. As observed by Widmer et al. (2005) for instance, in 1994, it was estimated that approximately 20 million computers became outmoded and by 2004, about 500 million computers reached the end of their service lives. As indicated by Culver (2005), the fast growing e-waste in the waste stream is accelerating because the global market for EEE is far from saturation and the average lifespan is decreasing rapidly — for instance, the lifespan for a computer has reduced from 6-4 years in 1997 to 2 years in 2005. Apart from computers, statistics further indicate that in 2005 approximately 130 million mobile phones were retired from the market because they had reached their end of service life. And so were other kinds of portable electronic devices such as PDAs, MP3 players, computer games and peripherals (Widmer et al., 2005).

The nature, characteristics and components of e-waste means that the wholesale application of conventional waste management strategies designed to handle traditional domestic waste types cannot be applied in the case of the e-waste stream. The current waste disposal practice clearly defeats the tenets prescribed by ISWM which has been the bedrock of many successful MSWM practices in developed economies. This is because the ISWM is based on coordinated efforts under an institutional responsibility but the current disposal strategies are based on individual characteristics of household heads and not a collective prescription

of city authorities. These findings mean that there is the need to develop a definitive or even a more sustainable management practices beyond existing disposal practices in Tamale. The findings further established that not only were the disposal choices among households varied, they were rudimentary. The current disposal strategies also appeared to be poorly organised, uncoordinated and pose health and environmental threats. Clearly, there is a compelling need to rethink the formalisation of the reuse (sold as second hand product and donation) and recycle (sold as scrap) strategies as they are in sync with tenets of ISWM approach in dealing with waste.

The situation in Tamale may not be an isolated case, as most cities countrywide lag behind in terms of policy and practice. Donating outdated electronic and electrical gadget to individuals and institutions is not a novelty (Oteng-Ababio, 2012; Tocho & Waema, 2013). The findings from the study indicated that donation was an important disposal strategy that gave the less privileged the opportunity to join the digital revolutionary process. People showed compassion by giving away old but workable EEEs to the under privilege. This was in line with the e-waste reduction strategy espoused by the ISWM framework. At the international level, developed countries dispose of their outdated electrical gadget to developing countries as aide with the aim of making the technology to these countries which are financially constrained to import brand new ones (Wei & Liu, 2012). The exportation of e-waste to the Global south has received a great deal of attention in the literature (UN Habitat, 2010; GSS, 2012) because it is in contravention with the Basel Convention Agreement which does not allow the cross border trade of hazardous waste including e-waste. The Tamale situation points to the fact that in the absence of disposal channel, society is compelled to enact their own disposal standards, irrespective of the consequences.

Of the disposal strategies, selling to peddlers, scrap dealers and used markets for the recycling industry pre-dominates. In Ghana, the lack of formal recycling regimes has led to the emergence of a flourishing informal e-waste recycling sector which has reconfigure livelihood opportunities in many informal settlements. Selling e-waste to informal recyclers has become a lucrative business because Oteng-Ababio (2012) for example, indicates e-waste contains valuable raw materials with high economic value when recovered. Other studies also indicate that e-waste contains many base metals with over 90% recovery rate while precious metals can be recovered to an extent of 97%-98% (Hischier et al., 2005; Khetriwal et al., 2007). These benefits, therefore, tend to overshadow the health and environmental implications associated with the poor handling of e-waste. While e-waste recycling is hugely acknowledged as a better disposal strategy because of the value chain

involved in the process (from the owner of obsolete electronic equipment to the steel industry) recycling process may also impair on the health of the recyclers (Oteng-ababio & Chama, 2012). This is because there are problems of grading since the presence of some metals (As, Br, Cd) can be hazardous. They also argue that the cost of dissembling and pre-treatment can be prohibitive, therefore, the process demands applying appropriate recycling technology which at the moment is unavailable.

While many countries are constantly developing safe and sustainable disposal methods, Ghana is still wobbling in an experimentation stage in trying to figure out what could be the best option. Countries in the developed world are implementing policies that are in tandem with the ISWM like the Extended Producer Responsibility (EPR) which is an environmental protection strategy (peripheral cycle of Figure 1) that makes the manufacturer of the product responsible for the entire life cycle of the product and especially for the take back; recycling and final disposal of the product in an environmentally friendly manner (Lindhqvist, 2000). As aptly captured by Khetriwal et al. (2007:3), "the emergence and evolution of the concept of EPR reflects several aspects of the ISWM which include, inter alia; a shift from so-called end-of-pipe approaches to preventative environmental strategies; life cycle approach; and wider use of non-prescriptive policy instruments" a view that is also shared by Tojo (2004).

In other jurisdictions such as China (UNEP, 2009), the responsibility of e-waste management is fairly shared among all stakeholders. The government, through its agencies at the national and the local level plays the role of an overseer, framing the basic guidelines through legislation and monitors the activities of the private sector. On their part, manufacturers/Importers carry the economic and physical responsibilities of their products (Khetriwal et al., 2007). They manage the day-to-day operations of the system, including setting the recycling fees, as well as licensing and auditing recyclers. Distributors and retailers are obligated to take back products in categories they have on sale, irrespective of whether the product was sold by them, or whether the consumer purchases a similar product as replacement. The retailers are similarly responsible for alerting the consumer on how much of the cost component is reserved for the product recycling should it reach the end-of-service life. The implication here is that part of the cost of recycling is borne by the consumer right from the point of purchase. The existing legislations mandate the consumer to return discarded appliances to retailers or designated collection points for recycling because an advance fee for such purpose has been made. This chain of responsibility reflects the integrated approach. Giving the fact that e-waste in Ghana is growing exponentially and the fact that

it contains ozone depleting substances, such as chlorofluorocarbons and hydro chlorofloro carbons, which may have a direct relationship with global warming (Schramm et al., 1992), the country cannot ill afford to develop sub-standard unintegrated measures in dealing with this emerging urban menace. But as it is now, policy makers, producers and consumers are grappling with the dilemma over who should take the first step. While state agencies are looking at the society to voluntarily adopt proper disposal practices, the society is looking up to government to develop appropriate channel of disposal. The fact is that Ghana needs to develop an integrated e-waste management strategies that can harnessed the resource potential embedded in it while at the same time reducing the health and environmental consequences.

Conclusion

The study is significant in Ghana's pursuit for legitimate sustainable framework for e-waste management. It identified some disposal channels and the factors that determined their adoption. The uncoordinated e-waste disposal and the absence of specific laws and channels of approved disposal compelled the population to device these disposal strategies. There is every indication that e-waste generation is not going to take nose-dive as demand for electronic equipment is increasing due to economic globalisation and population growth. This means that there is the need to develop definitive or even more sustainable management practices that are environmentally friendly, socially acceptable and economically viable. Such a policy must seek to integrate all aspects, elements and stakeholders. This can be done if city authorities begin to institute an integrated approach with emphasis on reuse, servicing, remanufacturing, recycling, upstream reduction of e-waste generation and final disposal in environmentally friendly manner. While emphasis is being laid on recycling, it is still an informal activity and comes with complex social and environmental costs as well. The integrated approach that emphasises formalising informality in e-waste management may be a starting point. While the EPR which is considered to be one of the most powerful policy mechanisms in dealing with this issue in developed countries may be unworkable due to differing economic conditions, a suggested approach that may tap into local wisdom may be ideal. There would be the need for complementing and/or integrating the activities of the informal e-waste management sector and the formal sector in a mutually beneficial relationship in order to ensure environmental sustainability and poverty alleviation. The role of the informal sector is critical because in a developing country city where finance and access route is a challenge, the informal sector fills the vacuum. This means that the notion among city authorities that the challenges

accompanying the massive urbanisation process are numerous and therefore singling out e-waste is not a top-most priority should be discarded.

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