Chapter

Wastes from Industrialized Nations: A Socio-economic Inquiry on E-waste Management for the Recycling Sector in Nigeria

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Abstract

An "assessment of waste electrical and electronic equipment (WEEE or e-waste) management strategies in Southeastern Nigeria" was conducted towards suggesting appropriate implementable measures. This submission presents a key outcome of a socioeconomic study on factors influencing the paths of e-waste generation and control with a view to suggesting innovative measures and market potentials for firms in the recycling sector. The concept of the study highlighted strategic features in-line with the socioeconomic assessment of e-waste management. Potentials for innovation in e-waste recycling were discussed in-line with elements of sustainability. The research introduced investigative methods by questionnaire administration. Purposive selections of local government areas were made from five mutually exclusive states. Data were analyzed using descriptive statistics. Results revealed the reasons limiting e-waste management trends to include cheap pricing, availability, quality, as well as superiority of obsolete e-devices to newer EEE. Sustainable benchmarks for evaluating and adopting e-waste recycling technologies were recommended.

Keywords: waste electrical and electronic equipment (WEEE or e-waste), recycling, socioeconomic, innovation, southeastern Nigeria, sustainability, technologies

1. Introduction

As one of the main growing waste streams globally [1, 2], a phenomenal increase in the quantities of disposed waste electrical and electronic equipment (WEEE or e-waste) was globally recorded in more than a few parts [3, 4], therefore, seeking for interventions from policy makers and practitioners, as well as the scientific community. The quantity of disposed electrical and electronic equipment (EEE) has been described to increase at a high rate, especially in industrialized countries where markets are flooded with large volumes. Today, the short product lifecycles and rapid innovation in EEE production have resulted in large number of rather new products been thrown away [5, 6]. Estimations places the annual globally volume of generated e-waste to be between 20 and 50 million tonnes [1, 3, 7]. There

have been substantial media reports on transboundary movement of WEEE in Nigeria [8]. Records in 2011 shows that Nigeria imported 1.2 million tonnes of new e-devices and generated e-waste of 1.1 million tonnes [9]. With these mounting quantities of WEEE, focus attention is now extended from how WEEE is managed to include reasons for the rising volume and avenues for it to be avoided [10].

Many nations are now faced with the task of handling e-waste that are internally generated and those imported from abroad. Findings revealed that many used electrical and electronics equipment (UEEE) shipments into developing nations are combinations of nearly 25% of disused or end-of-life (E.o.L) e-devices and more than 75% of e-waste [9]. On the contrary, e-waste, though a take on problem, could be an important and alternate source for manufacturing materials whenever it is collected, dispersed and reprocessed properly [10–12]. An entirely new business opportunity is developing with the merchandising, recycling and reprocessing of WEEE [12, 13]. Subjective evidences suggest that there are insufficient actions of management functions for WEEE activities in most emerging nations [7, 9, 14]. Modern trends in recycling of WEEE, still fall short of global practice. Hence, the slow and steady upsurge in the volume of WEEE generated thereby strengthening the concern for waste recovering to protecting valuable materials and safeguarding human health and the environment [1, 13].

Nigeria's approach to WEEE management is seen as considering such emerging waste more on a basis of socioeconomic benefits instead of a long-term human health and environmental effects [7]. Reports by several authors including those by the Öko-Institut and Green Advocacy Ghana in 2010 [15] and Osibanjo and Nnorom [4] revealed that this is driven by an approach to catch-up with the "digital divide" through imports of low-priced near E.o.L EEE from industrialized countries. Many E.o.L e-devices are reasonably stockpiled instead of direct disposal with everyday household refuse [16]. Policy regulators and monitors at the local government areas (LGAs), whose mandates covers solid waste management [17], have unsuccessful establish workable management policy for e-waste management [10]. In several industrialized countries with workable policy frameworks for e-waste, there have raised new businesses revolving around tradeoff, reprocessing and repairs of E.o.L EEE [18]. Primarily, this has been linked to the huge volume of precious metals found inside e-waste. The ratio of prized metals to waste in various E.o.L EEE (especially iron, aluminum, copper, gold etc.) is found to supersede its associated pollutants, therefore encouraging recycling in the e-waste sector [19]. Therefore, the study assessed the socioeconomic factors swaying the paths of e-waste generation and control in Southeastern Nigeria with a view to suggesting innovative measures and market potentials for firms in the recycling sector.

2. WEEE streams: The trail to developing nations

The main sources for WEEE inflow into Nigeria is mapped out to include the container market and RoRo market [18]. It is estimated daily that 500 containers of used laptops, computers, televisions and other e-devices are imported into Nigeria Ports [9]. The 2011 Basel Report noted that e-waste comes to Africa predominately from Europe (majorly through the ports of Felixstowe, Amsterdam and Antwerp). The Nigerian counterpart, Belgian Customs estimates that nearly 90% of these prohibited shipments influx Nigeria environment from co-loaded automobiles with E.o.L EEE [7, 18]. On inspection, many of the exports have problematic contents or are in fact mislabeled for ease of shipment of what are in fact illegal goods. In 2008, the inspection of containers by the Nigeria Customs led to the discovery of 127 e-waste containers, from which 47 of them considered hazardous were reversed and

shipped to the origin sources abroad. Up to 2011, the National Environmental Standards and Regulations Enforcement Agency (NESREA) had impounded five vessels carrying WEEE destined for Nigeria [9].

2.1 Bearings of the WEEE value-chain in Nigeria

e-Waste management in Nigeria is now been tackled not only by relying on prohibiting illegal imports, but by embracing other management strategies through the processes of generation, collection, handling, recovery, recycling and towards final disposal. In this regard, e-waste is considered with the idea of evaluating consumer's behavioral and its socioeconomic implications [15, 18]. Following the Basel Report on e-waste for 2011, a well-coordinated cluster of e-waste recyclers in some regions across West Africa focused their collection activities mainly on UEEE (or end-of-life EEE) and discarded e-waste. These traders source the items from locally generated and foreign imports which is based on categories of items been savaged [7]. The report showed that those in the recycling sector are engaged in recovering e-waste from waste streams, worked on these items and recovered several types of components and materials. Such recovered components from disassembled devices sometimes sever as sources for repair spare-parts. In another report, Lagos, Nigeria has two main recycling clusters located at Alaba International Market and Ikeja Computer Village employing nearly 15,000 technicians and traders with more than 5000 registered enterprises [10]. These two locations were characterized with high patronage by Nigerians, as well as West and Central African nationals in the sales and professional repairs of refurbished EEE.

Furthermore, it is on record that the collection, handling and refurbishing of e-waste in Nigeria take place mainly in the informal sector of recycling by inexperience, low-class, illiterate and undocumented-business individuals. Some of these scavengers, with no prior training and little investment, move around neighborhoods and waste dumps with their handcarts to collect (or in some cases buy) disused e-devices and related metal scraps that contain valuable like aluminum, copper, brass, iron, etc. [7]. These items recovered are then sold directly to cottage recycling businesses (engaged in dismantling to recover valuable components) or to secondary traders that organize large-scale sales to local and foreign recycling firms [10]. The remnant from the dismantled items is often subjected to indiscriminate disposals - including burning (especially plastics coated materials) [8, 16]. Besides, these scavengers are guaranteed of steady access to daily pay, as the proceeds from each day's scouting immediately materialize on sales of the recovered components.

2.2 Pathways for e-waste generation and recycling of the households and traders

The transboundary movement of UEEE/WEEE in industrialized nations varies from one country to another. In certain instances, private households organize their e-waste disposal by requesting either government service or private service, usually for a price [1]. More often, the scheduled bulky waste pick-up service is managed by private collectors who are often concerned with the afterward segregation of the collected wastes towards recovery and recycling. Whereas, the measures used during "recycling" in Nigeria are comparably considered crude and unstandardized. Recovered components are sometimes sold for export to other places in Africa and Asia [7].

The transboundary movements of e-waste in West Africa countries is found to be driven by a craving for UEEE/WEEE owing to its cheap pricing, quality and durability [7, 8]. The brokers and traders of WEEE have been identified as some of the key players in this trade. This sector ranges from household-arrangement to a

bulky and well-arranged distributing syndicates. They are well organized and linked from their point of shipment (Europe) to destination (Africa). Another influence in the collection and handling of UEEE/WEEE is the recurrent visits of WEEE traders to designated formal collection centers to request certain useful items for free with a view to process them for export outside Europe [1, 20]. In this vein, some amount of e-waste somehow finds its way into informal arrangements. Consequently items originally designated for recycling plants are diverted from the formal value-chain into the informal sector. The Basel Report of 2011 stressed that this trail of UEEE from the formal recyclers to informal recyclers is the deviation orchestrated by some registered middlemen to illicit traders (or informal recyclers). These brokers act as logistic firms or sub-contractors in scheduling pick-up services for WEEE, and in many instances consent certain items requested by WEEE traders from the waste streams [7]. In turn losing track of what becomes of such items at the end.

2.3 The nexus of e-waste and the SDGs

As e-waste recycling scheme is gaining more attention, there remains slow competitiveness for the adaptation of innovative technologies in the preprocessing of WEEE. Hence, there is a strong need for the adoption of frontier technologies in recycling. Consequently, the problems of WEEE could be linked to the sustainable development goals (SDGs) in areas of building strong businesses, promoting inclusive and sustainable industrialization and fostering innovation (goal-9); justifiable economic growth, complete and productive employment with decent working environment for everyone (goal-8); as well as maintaining sustainable resources usage and production patterns (goal-12) [21]. Therefore, sustainable management of e-waste in Nigeria and its possible recycling is of high relevance to the SDGs—the planet goals—especially to the prosperity goals, and particularly to goal-12.

2.4 Theories and concepts for the socioeconomic evaluation of e-waste management

The old perception of waste disposal—"dilute and disperse" is no longer tenable, rather a novel model of "concentrate and contain" has paved way to an idea referred to as the "Integrated Waste Management Scheme" [16, 22]. Generated waste is now deliberated as wealth out of place. Numerous waste items can now be collected, refurbished, and reused in the industries, agricultural, construction and building sectors etc. thereby safeguarding natural resources and energy in production of new items. Such measures also minimize environmental effects and relative health issues that could arise from the continuous exploitation of natural resources [10, 23]. This study is driven by the Pongrácz "theory of Waste Management" which is grounded on an agreed expectation that waste management can prevent waste to safeguard man and his environment. It assumes that the practice of waste management would avoid resources losses by turning waste to resources and conserving natural resources. Hence, the theory suggests that "we shall prevent waste from being produced by producing useful products (non-wastes) primarily" [11].

Hence, a conceptual framework (**Figure 1**) was developed to address the socio-economic factors for the sustainable management of WEEE in the Recycling Sector. The fundamental aspects in this e-waste framework include the "Political, Institutional, Social, Financial, Economical and Technical". There are four contextual concerns raised in WEEE management which are namely: "Environmental, Socio-cultural, Political and Economic" [10, 16, 24].

Individuals' behavior and approach to managing their generated wastes differs owing to their social and cultural traits. For example, people living in a fast

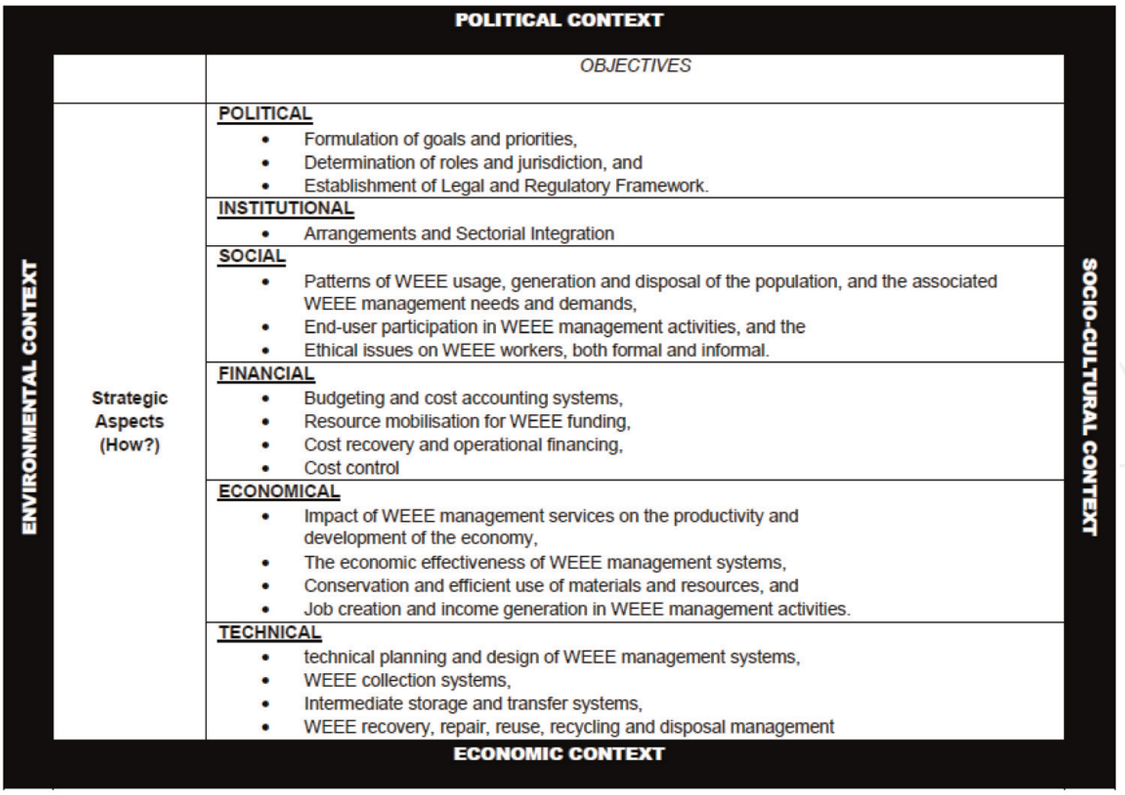

Figure 1.
Conceptual framework for WEEE management strategies (Adapted from Okorhi [9], assessment of WEEE management strategies in South Eastern Nigeria).

developing low-income community have been found to constitute a majority of diverse indigenous group with social difference gap. With such gap of the populace, organizing a thorough e-waste management at such places would be challenging. Secondly, the concern of lobbyists, interest groups and political parties would definitely affect to a large extent the kind of management strategies that is finally put in place for managing e-waste in a community [24]. Therefore, there is a need to incorporate in every stage of the policy making process individuals' views and participation. Lastly, the purpose of e-waste management, its technical and organizational scheme would depend in general on both the economic context of the inhabitants and the economy of the town. For example, in some fast developing towns like Enugu, Onitsha and Aba in Southeastern Nigeria, there are renowned specialized markets boosting informal trade in Fast Moving Consumer Goods with high trade volumes [25], and its highly characterized waste management problems [26]. Consequently, the level of economic development is a vital factor in the amount and composition of e-waste generated in that place [27]. Therefore, to accomplish the objective of this paper, the authors focused on assessing the strategic aspects revolving the political structure, social context, individual economy and technical inputs.

2.5 Market potential of innovative e-waste recycling at firm level

The industrialization of Africa could be achieved through sustainable innovation and awareness creation of its innovation potentials. According to a report published by Schluep et al. in 2009 [28], sustainable innovation refers to the shift of sustainable technologies, products and services to the marketplace, requiring a market creation concept and a shared global agenda. Whereas, environmental management and sustainability focuses on finding solutions to global pressing environmental

problems. It is said that the best available environmentally sound management (ESM) systems are programs and techniques that produces sustainable environment through its protection, paving way for safer health and working conditions, generating employment as well as other socioeconomic benefits [10]. In pursuit of these, there arises the deployment of frontier strategies (including the 5Rs) in e-waste management. However, the activities of metal recyclers in Nigeria are secondarily connected with the e-waste recycling sector, because the business outputs are a measure of functional items and valuable components rather than just raw materials [7]. Though, the 2011 Basel Report found the sector producing significant amount of e-waste. This is because the e-waste recycling sector in Nigeria is dominated by firms (or individuals) with "informal" arrangements which collect WEEE at random, manually dismantling (or sorting), preprocessing, selling valuable components and, disposal of the leftovers [10]. On the other hand, prized metals present in printed wiring boards (PWBs) are hardly collected for export to recycling facilities, and when that happens, the selling price is often below world market prices and discouraging to WEEE traders [7]. Also, some devices extracted from WEEE are used as spare parts in the repairs of faulty EEE.

Obviously, the ease to getting vital production materials used in the manufacture of new EEE is progressively attracting concern as global reserves of raw materials is fast declining and becoming more expensive [1]. The overall aim for "formal" e-waste recycling is to avert hazardous materials from WEEE in an ESM manner; recover prized items as much as possible; build an eco-friendly and sustainable SMEs and; consider the socio-economic implications [24]. Consequently, the recycling of e-waste is a key strategy for reducing "stockpiled" waste streams, minimizing the consumption of natural resources as well as improving energy usage. In this light, the paper briefly discuss the sustainability benchmarks for evaluating and adopting technologies for e-waste recycling; some innovative WEEE recycling technologies that could be adopted by recycling firms; as well as the market potential for e-waste recycling in many developing nations.

For a better consideration of the procedure for selecting innovative e-waste recycling technologies in developing countries, Schluep et al. [28] suggested, among others, the importance of sustainability benchmarks. **Table 1** shows the sustainability benchmarks for evaluating and adopting technologies for WEEE recycling in developing nations, including Nigeria. The benchmarks to compare the innovation of technologies were then grouped with elements of sustainability. Whereas, **Table 2** shows some innovative e-waste recycling technologies that could be adopted by e-waste recycling firms in Nigeria.

To sum up, the market potential for e-waste recycling are enormous as the annual growth rate of WEEE in Nigeria is put at 10% in the volume of waste generated [13]. It has been identified that a mid-term medium potential for integrated e-waste smelting already exist in some countries of Asia, Africa, South and North America [24]. Hence, from job creation, entrepreneurship and sustainability viewpoints, the "informal" practices of collection and manually dismantling of e-waste may not really require a transformation to a "formal" arrangement using high-tech equipment for the processing of WEEE [29]. The innovative technologies been continuously adapted by the larger informal sector in Nigeria is gaining ground [7]. Opportunities in recycling of e-waste arise in the improvement of the processing of cable-coated from poly-vinyl-chloride and insulators, and poly-brominated biphenyls coated plastics. Also is the collection of large quantities of PWBs for export and fair pricing. By using the voluntary carbon standard (VCS) or carbon action reserve (CAR) schemes, there is now the potential of recovering chlorofluorocarbon from cooling units and insulation foam which in turn brings both environmental and economic gains [7]. It was also suggested that the improved

Attributes	Indicators involved
Economic attributes	
Low net costs	Costs for transport, processing and labour vs. revenues
Low capital costs	Investment costs for additional plants and technologies used in a scenario
Increased potential for local economic growth	Additional industries and services involved by implementing a scenario
Environmental attributes	
Low use of electricity	Savings of electricity but also energy in general by implementing a scenario
Low fuel use for transport	Fuel used by shipping and road transport
Low use of freshwater	Freshwater consumption of a recycling scenario
Little (toxic) emissions	Caused vs. prevented emissions according to the savings of raw materials calculated with eco-indicator '99 (or other appropriate tools)
High metal recovery rates	Range and yields of metals contained in the waste, which can be recovered and used as secondary raw material. In case of technical conflicts prioritization by economic and environmental value ("footprint") of the recovered substances.
Social attributes	
Creation of jobs for the previously unemployed	Working hours for low-skilled and semi-skilled workers generated
Creation of highly skilled jobs	Working hours for highly skilled workers generated
Creation of jobs outside the target country	Working hours generated outside the target country
Low health and safety impacts	Impacts of a scenario on health and safety of the employees engaged in a scenario

Table 1.
Sustainability benchmarks for evaluating and adopting technologies for e-waste recycling in developing countries (Adapted from Schluep et al. [28]).

	Waste streams	Economic attributes	Environmental attributes	Social attributes
Manual dismantling/ sorting of fractions	All	Low capital cost, sorting of valuable fractions/ components	Efficient sorting of fractions	Labour intensive, Job creation
De-gassing CFC, HCFC	C&F	Mandatory requirement having low cost	Fundamental step to ensure control over hazardous substances having huge GWP potential	
Semi-automatic CRT cut and cleaning	CRT	Low capital and net cost	Low energy consumption	Labour intensive
Integrated smelter for non-ferrous (pyrometallurgical methods)	Non-ferrous (including printed wiring boards) like Cu, Pb, Zn, Sn or mix	Capital cost high Low net (unit) costs due to economies of scale Local growth potential high	No toxic emissions Low water use Transport: internationally Little waste products Recovery rates >> 90%	Automated process control so less jobs created Highly skilled workforce EHS*
Aluminium remelter/refiner	Aluminium	Captial cost medium – high Net cost low Economies of scale	No toxic emissions Salt slag has to be treated or disposed Env. sound Transport within region or country Water use: low - medium	Job creation: yes Mix of low skilled and high skilled jobs EHS low risks

Table 2.
Innovative e-waste recycling technologies for recycling firms (Adapted from Schluep et al. [28]).

utilization of polystyrene from e-waste recycling would guarantee a higher monetary value from the pricing of carbon (IV) oxide.

3. Materials and methods

The methodical conception for this article is based on both reviews from available literature on sustainability, innovations and management strategies for

e-waste, and results from e-waste survey carried out in Southeastern Nigeria. The survey was carried out in mutually exclusive strata of States (Enugu, Anambra, Ebonyi, Imo and Abia) with 95 local government areas (LGAs). A local government area (LGA) was purposefully chosen from every senatorial district in each State, and the fourth LGA was taken as the State's capital. This selection was predicated on the high volume of e-waste generated and handled in these LGAs. Altogether, 20 LGAs were picked for the survey, with 4 LGAs selected from each State. Questionnaires were administered in each of these LGAs to end-users, traders/recyclers, and policy makers/monitors assessing the "socioeconomic of WEEE" of the study area. A population of 280 respondents was surveyed. From the table for determining sample size [30], a population of 280 respondents gives 162 sample size representatives of the respondents. Using qualitative and quantitative methods, the study measured e-waste needs and demands; generation, collection and final disposal; recycling measures; associated jobs; incomes to traders and technicians; as well as technology frontiers. Both **Table 3** and **Figure 2** shows methodological approach employed. The analysis that followed established the extent of reliability and a 95% confidence level placed on the information elicited.

Sketchy findings suggest that a sustainable WEEE management scheme requires sufficient and continuous financing, frontier technologies, an equipped working environment and the right institutional motivations for key players [10]. The end-users of WEEE are mainly responsible for the patronage/usage of these UEEE. WEEE traders (or recycling firms) serve to collect and distribute these items, while the monitoring agencies ensure execution of policies, taking feedbacks and acting as check on other stakeholders. Hence, we administered three distinct questionnaires to these three players. **Table 4** shows an outline of the main areas of interest captured in the respective questionnaire.

Three distinct questionnaires were administered to stakeholders. These are (1) the policy regulators and managers vis-a-vis "NESREA, SON, State Environment Protection Agencies, Environmental Health offices & Nigeria Customs Service"; (2) e-waste traders/recyclers—"Dealers, Marketer, Retailers, Technicians and Refurbishers/Recyclers of WEEE"; and (3) e-waste consumers/end-users—"Households, Government Institutions, Industries, Private Offices, Communication/Entertainment Businesses, Educational and Health-Care Centers".

The responses are presented in tables and figures in the sections that follow. The tables depict a collection of these stakeholders, managerial framework and end-users' participation. It then measured waste disposal pattern by the consumers, as

Stakeholders	Number administered	Number retrieved	% of Number retrieved	Number of valid retrieved questionnaire	% of valid retrieved questionnaire
Monitoring/ control agencies	40	40	100	35	12.50%
Distributors/ recyclers	40	29	72.5	29	22.86%
Consumers/ end-users	200	137	68.5	137	48.93%
Total	280	206	73.6%	201	71.79%

Source: Field Survey, 2015.

Table 3.
Schedule of questionnaire administered.

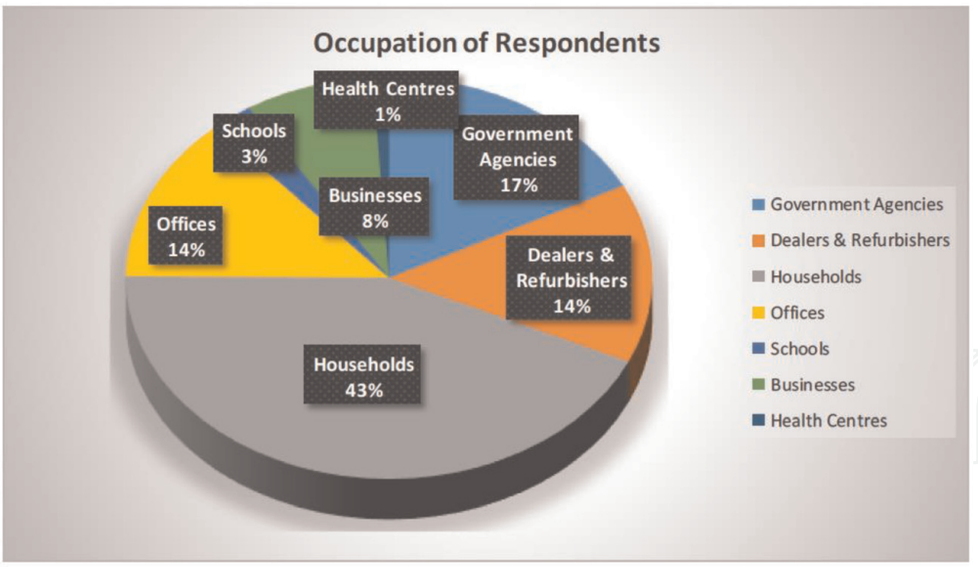

Figure 2.
Representation of the retrieved administered questionnaire.

S/No	Outline of key areas of interest of the questionnaire for "Socio-economic assessment of e-waste"	Stakeholder(s)	Questionnaire type administered	No. of respondents
1	Administrative framework for WEEE	Monitoring/control agencies	A	35
2	End-user participation in WEEE management activities	Monitoring/control agencies	A	35
3	e-Waste disposal practices and patterns by the consumers/end-users	End-users/consumers	B	137
4	Factors considered in adopting strategies for final disposal of WEEE by recyclers and dealers	Distributors/recyclers	C	29
5	WEEE collection, handling and disposal methods by entrepreneurs and recyclers in South Eastern Nigeria	Distributors/recyclers	C	29
6	Socio-economic drivers on trends in generation, collection and disposal of WEEE	Monitoring/control agencies; end-users/consumers; distributors/recyclers	A, B and C	201
7	Factors influencing technical planning and design for WEEE management systems	Monitoring/control agencies	A	35

Table 4.
Key sections of the questionnaire.

well as factors leading to choice of strategies adopted for the final disposal of e-waste recyclers and traders. It showed some of the strategies used by these entrepreneurs in the gathering, management and final disposal of WEEE. Lastly, it reflected on the socioeconomic drivers of e-waste, and the issues militating on sustainable framework for e-waste management systems.

4. Results and discussions

4.1 Managerial framework for e-waste by policy administrators

Government's Regulation S.I.28 of 2009 stresses that part of the plans for e-waste management should comprise endorsing current guidelines and strategies for "solid waste (including e-waste) management" through the conduct of baseline surveys, instituting public health and environmental standards, and making sure there is a monitoring program that include early warning system [6, 10]. Therefore, the promotion of a supportive management strategies and plan of action for WEEE was confirmed by 25(71.43%) policy administrators to be an all-encompassing aspect of policy planning. Also, **Table 5** revealed that 19(54.29%) administrators affirmed government's endorsement of regulations which enforces protection to the environs against indiscriminate disposal of e-waste. Furthermore, results showed that this strategy is supported with the development and implementation of strategic work plans for this special waste in assisting stakeholders—23(62.71%) of these respondents. Nonetheless, 8(22.86%) administrators affirmed that policy regulators (tiers of government) put in place dedicated and competent bodies to implement strategies for e-waste management, while nearly half of these officials—15(42.86%) argued that such a specialized section or unit for an exclusive management of e-waste do not exist in their establishments. Field observations showed that in few places where such relative departments exited, it was rooted under units such as "special waste unit" or "harmful waste division", and it barely gets adequate appropriations to combat these special wastes. Lastly, results revealed that the management strategies for operation were considered unsuitable by a total of 25 (71.43%) policy regulators (from combining 8(22.86%), 13(37.14%) and 4(11.45%) respondents).

4.2 Regulators opinion of end-users' participation in e-waste management activities

Public education and participation are necessary to support the plan of action for e-waste management. This is in order to achieve an efficient implementation process of management strategies. As depicted in **Table 6**, together 18(51.43%) policy regulators affirmed government engagement in the sensitization of interested parties. While more than half of them—19(54.29%) agreed that the populace is amply involved with the implementation process of control strategies. However, 24(68.57%) respondents admitted that end-users simply comply with the implemented strategies. Furthermore, these administrators also suggested that the common means for e-waste sensitization were executed with Radio jingles/programs—17(48.57%), Television announcement/documentaries 5(14.29%), Posters 5(14.29%), Handbills/flyers 5(14.29%), as well as (mobile advertisements, campaigns, road-shows, etc.) 3(08.57%) respondents.

4.3 Disposal practices and patterns of e-waste by the end-users

Together **Table 7** and **Figure 3** underlined management strategies adopted and practiced for e-waste by the customers. This assessment discovered that the most common strategy adopted in the final disposal of WEEE by many homes and businesses is the direct disposal of e-waste along with other regular solid wastes—96 (70.07%) respondents. Additional measures embraced by the households included the reselling of disused EEE—32(23.36%), and stockpiling—21(15.33%). In few

	Q/N	Policy instrument: Does your agency:	To very great extent		To great extent		To small extent		To very small extent		Not at all	
			N	%	N	%	N	%	N	%	N	%
Political framework for WEEE	1	Provide e-waste management tenets in written codes	4	11.45	4	11.45	5	14.29	5	14.29	17	45.57
	2	Prepare and develop working and management plans to stakeholders	6	17.14	17	45.57	10	28.57	1	02.86	1	02.86
	3	Have adequate periodic documentation on e-waste quantity and budgeting to support management process	1	02.86	3	08.57	3	08.57	10	28.57	18	51.43
	4	Establish a competent body to implement e-waste management strategies	4	11.45	4	11.45	8	22.86	4	11.45	15	42.86
	5	Monitor the sources of e-waste into South Eastern Nigeria	2	05.71	8	22.86	5	14.29	6	17.14	14	40.00
	6	Monitor and protect the environment against illegal e-waste dumping	9	25.71	11	31.43	3	08.57	4	11.45	8	22.86
	7	Promote strategies/ policies/legislations/ acts/regulations for WEEE management	6	17.14	19	54.29	8	22.86	0	00.00	2	05.71
	8	Promulgate edicts to enforce protection policies against illegal disposal of WEEE	7	20.00	12	34.29	2	05.71	7	20.00	7	20.00
	9	Enact appropriate legislation on grading rules, waste minimization and so on to back e-waste management strategies	6	17.14	13	37.14	8	22.86	2	05.71	6	17.14
	10	Are the strategies for implementation appropriate?	2	05.71	8	22.86	8	22.86	13	37.14	4	11.45

Total number of respondents = 35.
Source: Field Survey, 2015.

Table 5.
Administrative framework for WEEE.

cases, end-users were found to abandon their defective e-devices with technicians/ recyclers who at times refurbish or recovers valuable components—21(15.33%) end-users. In similarly manner, some consumers take apart components of simple devices and reclaim functional parts—25(18.25%). Also, end-users admitted donating certain disused devices to individuals, friends, religion centers, schools, non-governmental organizations (NGOs), etc.—19(13.89%). Besides, it was shown that

	Q/N	Policy instrument: Does your agency:	To very great extent		To great extent		To small extent		To very small extent		Not at all	
			N	%	N	%	N	%	N	%	N	%
Public education and participation	1	Educate the public on e-waste management scheme	7	20.00	11	31.43	2	05.71	2	05.71	13	37.14
	2	Are all sectors of the populace adequately carried along during implementation of strategies?	2	05.71	9	25.71	14	40.00	5	14.29	5	14.29
	3	Does all sectors always comply with the strategies employed?	0	00.00	2	05.71	9	25.71	15	42.86	9	25.71

Total number (N) of respondents = 35.
Source: Field Survey, 2015.

Table 6.
End-user participation in WEEE management activities.

whatsoever strategy choice(s) chosen by the consumer, the state of the E.o.L EEE or e-waste was definitely taken into account before disposal. 100(72.99%) end-users said that their e-devices which were damaged beyond repairs would certainly be thrown away. However, 4(02.92%) consumers agreed that they would rather throw away any disused EEE which could likely be repaired. An additional 33(24.09%) respondents proposed that E.o.L EEE or disused (obsolete) EEE would also be thrown into the waste stream (**Figure 3**). In addition to the aforementioned decisions, 91(66.42%) consumers established that they hardly apply any particular stratification measure for generated e-waste before the final disposal into waste streams. Specifically, 85(62.04%) end-users confirmed that their disused batteries are disposed along with other household waste.

4.4 Factors influencing the adoption of strategies for the disposal of e-waste by recycling firms

Starting with **Table 8**, several factors were admitted by the stakeholders as reasons for the choice of final disposal of generated e-waste. The survey considered some of these drives to include: obsolescence devices; damaged beyond parts; high cost of maintenance/replacement of components; unavailable spare-parts; as well as unwarranted e-devices. Additional reasons considered by the respondents included business growth, innovation within the firm, slow processing speed of e-devices, inadequate storage capacity of EEE, faults from power-surge, and fault resulting from lightning. Field survey results [10] showed that many recyclers/technicians throw away disused e-devices owing to outdated functionality—12(41.38%), and when these items are broken beyond repair—15(51.72%). One more noteworthy cause for this latter practice is the absence of replacement spare-parts—9(31.04%) respondents. On the other hand, e-waste traders were unlikely to dispose of faulty e-devices because of non-warranty (divestment)—9(31.04%); business expansion—9(31.04%); power-surge faults—10(34.48%); as well as damages occasioned by lightning—12(41.38%). These second factors are the obvious reasons for e-waste stockpiling in my places and locations surveyed.

Q/N	(Section D—Consumers/end-users questionnaire) Policy instrument		N	%
	Question	**Option**		
20	How do you discard your waste electronics devices?	Keep in store room	21	15.33
		Resell the devices	32	23.36
		Disposed with general waste	96	70.07
		Give them to a recycler	21	15.33
		Donate to family, friends, school, NGO, etc.	19	13.89
		Return to the store where it was bought for a reduction on the price of a new device	11	08.03
		Return to the seller on a buy-back arrangement	2	01.46
		Disassemble to reuse some parts	25	18.25
		Put it on the street	2	01.46
		Give it to hawkers	1	00.73
21	At what state do you do this?	Broken—Not repairable	100	72.99
		Broken—repairable	4	02.92
		Old or out dated (Obsolete)	33	24.09
27	Do you apply any specific classification/ stratification for e-waste before disposal?	Yes	15	10.93
		No	91	66.42
		Not Sure	31	22.63
28	How do you dispose used batteries?	Disposed along with other waste	85	62.04
		Stratified and disposed alone	18	13.14
		Disposed along with other classified hazardous waste	21	15.33

Total number (N) of respondents = 137.
Source: Field Survey, 2015.

Table 7.
e-Waste disposal practices and patterns by the consumers/end-users.

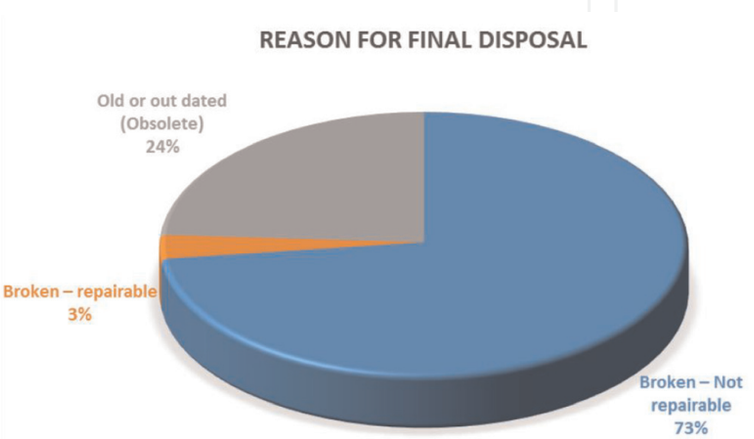

Figure 3.
Disposal measures adopted by the end-users for WEEE generated.

S/N	Factors	Ranking									
		Insignificant ↔ Most_Significant									
		1		2		3		4		5	
		N	%	N	%	N	%	N	%	N	%
1	Functional obsolescence	4	13.79	2	06.70	5	17.24	6	20.67	12	41.38
2	Damage beyond repair	2	06.70	2	06.70	4	13.79	6	20.67	15	51.72
3	Cost of maintenance	4	13.79	8	27.59	7	24.14	7	24.14	2	06.70
4	Repair components not available	3	10.35	0	00.00	6	20.67	4	13.79	9	31.04
5	Divestment	9	31.04	9	31.04	4	13.79	3	10.35	4	13.79
6	Expansion of business	9	31.04	9	31.04	3	10.35	5	17.24	3	10.35
7	Business innovation	6	20.67	8	27.59	7	24.14	5	17.24	3	10.35
8	Processing speed inadequate	8	27.59	3	10.35	11	37.93	5	17.24	2	06.70
9	Storage capacity inadequate	7	24.14	8	27.59	6	20.67	6	20.67	2	06.70
10	Power surge	8	27.59	10	34.48	6	20.67	3	10.35	2	06.70
11	Lightning	12	41.38	4	13.79	6	20.67	2	06.70	5	17.24

Total number (N) of respondents = 29.
Source: Field Survey, 2015.

Table 8.
Factors considered in adopting strategies for final disposal of WEEE by recyclers and dealers.

4.5 e-Waste management measures adopted by recycling firms

Table 9 suggests that the stakeholders involved in WEEE refurbishing and recycling applies one or more of the seven standard strategies in the management of generated e-waste. Many entrepreneurs and recyclers of WEEE in Southeastern Nigeria manage their E.o.L EEE and e-waste by adopting strategies like Reuse of e-waste—18(45%); Repair of disused devices—16(40%); and Incineration (burning)—16(40%). In other occasions, technicians searched for and recycle peculiar components from disused e-device that are valuable and could serves as repair spare-parts for other faulty appliances. In such cases, e-waste is dismantled to retrieve these valuable components and reuse directly during repairs or indirectly in developing of new items. A computer technician confirmed the use of Light Emitting Diode

Q/N	(Section D) Policy instrument	N	%
1	Recycling of e-waste	13	32.50
	Reuse of e-waste	18	45.00
	Recovery of e-devices	10	25.00
	Source reduction of generated e-waste	5	12.50
	Repair of E.o.L electrical/electronic equipment	16	40.00
	Landfill of waste	11	27.50
	Incineration of waste	16	40.00

Total number (N) of respondents = 29.
Source: Field Survey, 2015.

Table 9.
WEEE collection, handling and disposal methods by entrepreneurs and recyclers in South Eastern Nigeria.

salvaged from disused laptops in the development of electricity detector used in homes. Likewise, some mobile phone businesses in major commercial towns in Southeastern Nigeria were engaged to recalling E.o.L mobile phones on behalf of the parent manufacturers. For instance, two sales outlets of a particular firm in Enugu metropolis accepted from their customers E.o.L mobile phones as trade-in for a new ones with an average of 70% price (of the new product) being committed by the customer. This is apparent under agreed conditions dictated by the fronting firm to the end-users. In contrast, it is important to mention that the assertion of using incinerators as a strategy in managing e-waste is far from reality in the study area. Observations from the study area revealed that stakeholders rather practiced surface burning of WEEE and this takes place in a number of locations (mostly in low-lying lands). This is clearly misjudged as incineration of e-waste. Despite the fact that both processes lead to combustion of the waste materials, surface burning occurs in lower temperatures of between 20°C and 300°C, and incineration involved higher temperatures ranges of up to 1000°C in an environmentally confined engineered plant that traps ashes and non-combustibles remnants [22]. Not a single stakeholders surveyed possesses or operates a confined incinerator for the aim of e-waste management. Also, 11(27.50%) respondents admitted that generated e-waste was management by landfilling. Yet again, observations on the field suggested otherwise. Similarly, landfills are well-engineered facilities designed, operated, carefully monitored, and located off town. They are closely cared for even after years of closure. It could be cleaned up when need be and pay for to insure adequate compliance with standard environmental laws. From global perspective, several landfills maintenances are intermittently managed by government's prescribed environmental authorities. Most of the surveyed policy regulators could not affirmed to have a well-engineered system of landfill and incinerator in place in Southeastern Nigeria. Also, where claims of landfilling practices took place in the surveyed area, it was another misrepresented for a long term low-land repossession by using collected wastes as a feedstock.

4.6 The socioeconomic drivers on trends in the management of e-waste

Four factors were recognized and reflected as likely economic drivers which determined the disposal pattern of obsolete EEE (or e-waste) in Southeastern Nigeria. These included cheaper e-devices, access to EEE, crave over inferior devices, and the quest for superior EEE. **Table 10** showed officials of the regulatory agencies in the surveyed area strongly affirming some of these key economic drives as access to e-waste—25(71.43%), as well as low-priced WEEE—16(45.71%). From this, a line can be drawn from several literatures which have shown clear suggestions buttressing the claims that Nigeria was undergoing rapid ICT revolution in recent years [13]. As a result to connect with the "digital divide", attempts were made by individuals and e-waste traders to import cheap and (sometimes) durable E.o.L e-devices (or e-waste) from developed countries into Nigeria. Also, **Table 10** showed that the upsurge in the demand by end-users and e-waste traders for UEEE (or e-waste) could be linked to its cheap pricing—141(79.66%); device durability—96 (54.24%); economic class of consumers—77(43.50%); EEE accessibility—82 (46.33%); as well as the quality of WEEE and its superiority to (some brand) new products. While the noting the factors influence the final disposal of e-waste, these respondents associated these to high cost of disposal—43(24.29%); inadequate storage space—38(21.47%); associated disposal fees—46(25.99%); quick obsolesce of UEEE—42(23.73%); and the inaccessibility to formal recycling plants/facilities, as well as enormous cost in setting up a formal recycling facility for e-waste disposal. Owing to such associated cost, there exists only one eco-friendly electronic waste recycling company—E-Terra in Nigeria.

S/N	Question	Responses				
	(*Monitoring Agencies = 35*)	Cheap EEE	Availability of EEE	Inferior EEE	Superior EEE	Others
1	What are the economic drives that help to determine the disposal of used electrical/ electronic device?	16 (45.71%)	25(71.43%)	13(37.14%)	5(14.39%)	
	(*End-users + Dealers = 177*)	Cost	Durability	Income	Accessibility	Others
2	What give rises to the attractiveness of used (Tokunbo) electrical electronic equipment in South Eastern Nigeria?	141 (79.66%)	96(54.24%)	77(43.50%)	82(46.33%)	Quality(2), superiority, cheap
	(*End-users + Dealers = 177*)	Cost of disposal	Lack of storage space	Money exchanged for WEEE	Obsolesce	Others
3	What are the possible economic drivers for final disposal of WEEE	43 (24.29%)	38(21.47%)	46(25.99%)	42(23.73%)	Availability of recycling facilities, cost of recycling (2)

Total number (N) of respondents = 201.
Source: Field Survey, 2015.

Table 10.
Socio-economic drivers on trends in generation, collection and disposal of WEEE.

4.7 Factors swaying the planning and design for sustainable e-waste management systems

The laws and guidelines that support e-waste management schemes in South-eastern Nigeria were identified to be anchored on four strategic aspects and therefore considered for this study. These included establishment of state-of-the-art technologies and essential working equipment, capable and sufficient manpower, funding of WEEE schemes, as well as impediment in implementation of e-waste regulations. From **Table 11**, 18(51.43%) of the monitory and regulatory agencies

S/N	Question:	Are there any particular difficulties in the implementation process of e-waste management strategies?			
		Strongly Agreed	Agreed	Disagreed	Strongly Disagreed
1	Lack of technologies /necessary equipment	18(51.43%)	6(17.14%)	4(11.43%)	1(02.86%)
2	Lack of adequate manpower (Personnel)	7(20.00%)	12(34.29%)	9(25.71%)	1(02.86%)
3	Inadequate finances	14(40.00%)	8(22.86%)	6(17.14%)	1(02.86%)
4	Nature of guideline options formulated by the political system	10(28.57%)	11(31.43%)	5(14.29%)	3(08.57%)

Total number (N) of respondents = 35.
Source: Field Survey, 2015.

Table 11.
Factors influencing technical planning and design for WEEE management systems.

were able to show that the absence of frontier technologies, essential and new equipment has hindered the operations and enthusiasm of e-waste managers. Furthermore, inadequate funding of e-waste schemes—14(40.00%) was acknowledged as a major factor influencing the ineffectiveness in the process of e-waste collection and disposal, as well as the choice adopted for final disposal measures. Collectively, 21(60.00%) policy regulators agreed that the type of guideline framed and approved by the political system sometimes militates against the effective execution of management plans for e-waste.

5. Conclusion and policy recommendations

To recapitulate, this paper discussed the transboundary movements of e-waste, the sustainability benchmarks for evaluating and adopting technologies, innovative recycling technologies, and market potential for e-waste recycling in Nigeria. With the aim of assessing the socioeconomic factors swaying e-waste generation and disposal, data collected were analyzed and discussed. The survey revealed that the structure for developing sustainable strategies frameworks and establishing resilient infrastructure for the effective management of e-waste are clearly lacking. End-users of e-waste are in the habit of stockpiling and indiscriminately disposal of e-waste. Also, it was revealed that e-waste was not segregated from household waste before final disposing. Formal recycling of e-waste is yet to be domesticated in Southeastern Nigeria. The socioeconomic reasons for the rising volume of WEEE in the study area include its cheap pricing, quality and durability, economic status of the consumer, and easy access to disused e-waste. Some of the acknowledged factors hindering the sustainable disposal of e-waste includes unavailability of innovative technologies, high cost of setting up of recycling facilities, inadequate space for stockpiling, and total obsolesce of disused EEE.

A sustainable e-waste recycling scheme would not be economically worthwhile without suitable policies in place, adoption of frontier technologies and financial measures attached. First, the management strategies for WEEE should be focused on evolving tenets of operations, and frontiers in e-waste recycling that deploys innovative and sustainable technologies. This could be achieved by adopting sustainability benchmarks for evaluating and adopting new strategies and technologies for e-waste recycling; awareness creation in the value-chain for stakeholders; as well as exploring the market potentials for e-waste recycling. These would in turn improve social and economic benefits, including decent job creations. Lastly, this can be realized through promoting appropriate policies and deliberate producer-led (and government support) initiative for recycling of e-waste.

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