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Survey on Household Awareness and Willingness to Participate in E-Waste Management in Jos, Plateau State, Nigeria

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Abstract: Nearly 290,000 tons of electronic waste was generated in Nigeria during the year 2017, which is likely to increase further due to high population growth rates, accelerated urbanization, high demand for electronic products, as well as disposal at their end-of-life. At the same time, e-waste is associated with negative human health impacts, as well as environmental pollution. Therefore, environmental awareness on this waste stream is crucial in its management and possible minimization. In this paper, we report on a survey which investigated awareness levels and knowledge amongst households in the Jos metropolis, Plateau State (Nigeria). We interviewed 228 respondents by means of close-ended questionnaires. The results indicated that cell phones (93%) and television sets (82%) were mentioned by most respondents. The main reasons for acquiring these electronic devices entailed the replacement of damaged ones (49.6%), frequent product upgrades (37.7%), as well as theft (35.55%), amongst others. The most predominant method of disposing e-waste included illegal dumping in open spaces along with other household wastes (25%), storing it at home indefinitely (27.6%), and selling it to others for possible reuse (17.5%). Although the handling and storage of this waste is currently inappropriate, most respondents (84.2%) were willing to participate in its management provided they are given appropriate knowledge (89.9%) on its safe disposal and recycling. Lastly, we found no significant correlation between existing awareness levels on e-waste and willingness to participate in its management based on the socio-demographical profile of respondents. Thus, we recommend educational interventions on sound e-waste management in the Jos metropolis, along with a systematic analysis of how policy interventions such as the extended producer responsibility schemes can be designed for effective e-waste management and recycling amongst all stakeholders.

Keywords: e-waste; awareness; willingness; correlations; disposal; households; Jos metropolis

1. Introduction

In 2016 and 2017, approximately 45 and 46 million tons of electronic waste (e-waste) was generated globally, respectively [1]. Balde et al. [1] projected that the amount of e-waste generated is likely to increase to 52.2 million tons by the year 2021. Mishra et al. [2] suggested that with an annual growth rate of 4% to 5%, e-waste is becoming one of the fastest growing waste streams in the world. European countries generate approximately 8.3 to 9.1 million tons of e-waste per annum, with Wu et al. [3]

projecting an increase of 12.3 million tons by the year 2020, while the USA alone is generating about 10 million tons annually. Moreover, the generation rates of e-waste are expected to rise further because of the shorter life spans of some of the electronic products [1,4–6].

Electronic wastes, also known as waste electrical and electronic equipment (WEEE), entail discarded electrical or electronic equipment that are no longer useful to the end-users. This waste stream is also comprised of electrical and electronic equipment such as mobile phones, laptops, computers, electric bulbs, and television sets [7,8]. Several studies have indicated that the e-waste stream is a source of about 1000 different hazardous components with potential threats to human health and environmental quality, thus making its management a challenge or problem in most communities [9–11]. The severity and significance of this problem is high in many developing countries, especially among those who lack appropriate policies, environmental management systems, and processes to regulate this waste stream, as well as suitable infrastructure to effectively and efficiently manage it.

Hence, the appropriation, utilization, disposal, and recycling of e-waste affect many stakeholders in society, including households who play an important role in the generation and management of this waste stream [8,12]. Due to some measure of ignorance in handling this waste stream, households face greater challenges in the disposal of e-waste than is the case with industrial enterprises and other institutions [8,13]. Thus, the extent to which households are informed and are aware of the problems associated with e-waste becomes an important factor that influences their 'utility maximizing decisions about the handling' of such wastes [14].

Nevertheless, in many developing countries, there is little household and public awareness about the precautions and proper management of e-waste. In a study on e-waste knowledge and attitudes in India, Sivanthanu [15] indicated that consumer awareness has a direct relationship with willingness to recycle e-waste, which is a crucial condition for efficient e-waste management. Furthermore, there are ineffective e-waste recycling efforts in developing countries such as Bangladesh and India because large proportions of their populations are relatively unaware about the precautionary measures necessary for handling and disposing e-wastes [15,16]. However, literature also points out that households in these cities are willing to pay for the effective disposal of e-wastes [15–17].

It is projected that the population of Nigeria is likely to reach 200 million people before 2025 as it exceeded 180 million inhabitants in 2017 [18], along with a growing economic base with a higher economic demand for electronic products such as mobile phones, laptops, and smart television sets [19,20]. Given the accelerated rate at which these devices are being upgraded and improved by manufacturers for enhanced functionality, the amount of discarded wastes from obsolete appliances is growing exponentially, thus leading to increased e-waste generation rates [21]. This problem is compounded by increasing e-waste imports from the USA and some of the countries in the European Union [10,22]. According to the United Nations research, over 60,000 tons of e-wastes are being shipped into Nigeria annually mainly via the ports in Lagos, apart from additional imports reaching this country from neighbouring countries [23]. These amounts are excessive for Nigeria considering that nearly 290,000 tons of a similar waste stream were generated nationally during the year 2017 [23]. This increased e-waste generation rate is leading to severe environmental management problems due to indiscriminate dumping in public open spaces, and river banks where it is illegally dumped alongside municipal or hospital wastes. Consequently, these unsafe practices are leading to undesirable environmental despoliation likely to worsen as most cities in Nigeria lack efficient management systems for dealing with e-wastes [24]. According to Nnorom and Osibanjo [24], the National Environmental Standards and Regulatory Enforcement Agency (NESREA) responsible for the administration of environmental laws, guidelines, and implementation in Nigeria, lacks appropriate resources, skills, and technology for proper e-waste management. Hence, large quantities of e-waste are smuggled into Nigeria as a result of inherent institutional weaknesses, thus creating greater e-waste management challenges.

Although research on e-waste at household level has been conducted in some of the states in Nigeria [19,25,26], there is still limited research on the knowledge and awareness of e-waste streams across many states. Therefore, in this paper, household e-waste awareness and knowledge in the

Jos metropolis of Plateau State (Nigeria) have been surveyed and the key questions are summarized as follows:

1. What types of electronic devices are used by households within this metropolis?
2. How much awareness and knowledge exists amongst households regarding e-waste?
3. Is there any willingness amongst households to participate in e-waste management?
4. What methods are used in disposing away e-waste in this metropolis?

In addition to these research questions, two different hypotheses were formulated to help validate and illuminate our results while enriching existing theory on e-waste management in the study area:

- There are no significant differences in the knowledge and awareness levels amongst households according to their socio-demographic characteristics.
- There are no significant differences in household willingness to participate in e-waste management depending on their socio-demographic characteristics.

2. Literature Background

2.1. E-Waste Classification and Sources

E-waste refers to all electrical and electronic equipment which are discarded by their owners because they are considered no longer useful unless they are reused and recycled. The environmental regulatory body of Nigeria, the National Environmental Standards and Regulatory Enforcement Agency, which was established in 2007 [27] defines e-waste as "any Waste Electrical Electronic Equipment (WEEE) that is old and near its end of life or any discarded electrical/electronic appliance that uses electricity". Furthermore, the European Union Directive (2018/849) [28] has reviewed the classification of e-waste from nearly 10 to only six categories or classes for international use (Table 1).

Table 1. Electronic (e-waste) waste categories [28].

1	Temperature exchange equipment	Refrigeration and freezing equipment such as freezers, air conditioners, and refrigerators
2	Screens, monitors	Distinctive appliances include computers, laptops, notebooks, and televisions
3	Large equipment	Typical devices include photocopiers, washing machines, dish washers, and much more
4	Lamps	Fluorescent lamps and light emitting diodes (LEDs) are examples
5	Small equipment	Typical examples include microwave ovens, radios, video cameras, and electric shavers
6	Small ICT	These include devices such as telephones, cell phones, and electronic toys

2.2. E-Waste Awareness and Management

E-waste is generated from several sources which include industries, institutions, and households [29–31]. Some of the electronic devices have very shorter life spans and are frequently changed, thus leading to increased waste generation rates [32,33]. For instance, mobile phones have a higher disposal rate due to the accelerated rates at which they are being improved.

E-waste contains both valuable and harmful components which can be toxic to human health and the environment [23,34–38]. This point is also corroborated by Machete [39] and others [40,41] that e-waste exposes people to hazardous elements such as lead, mercury, calcium, and arsenic. Moreover, some diseases such as pulmonary and cardiovascular illnesses, as well as respiratory and neurological ailments, may be exacerbated by exposure to the hazardous materials stemming from this waste

stream [13,19,23,34,42,43]. Unfortunately, large quantities of e-waste are accumulating in households and offices as they become obsolete and are no longer optimally useful [36,39,44]. With this waste accumulation comes storage and disposal problems.

According to Afroz et al. [45], most households in the urban areas of Africa have at least one piece of electronic product ranging from mobile phones and laptops to very large appliances such as television sets as well as refrigerators. However, when these electronic devices are purchased, consumers are rarely given any detailed information on how to handle and properly discard them at the end of their useful period, thus leading to ineffective e-waste management [46]. Consequently, the resulting waste is simply stored indefinitely inside offices, government storehouses, as well as households with a view to dispose of them some time in the future [47]. Given these trends, inappropriate disposal of e-wastes is becoming a serious environmental and public health problem throughout many African countries and is accentuated by lack of suitable community waste collection and recycling facilities [10,21,33,48].

To this extent, several studies have raised the importance of e-waste knowledge towards the successful management of this waste stream [15,25,48–50]. Methods for the disposal of e-waste are largely a function of attitudes and awareness levels amongst stakeholders, including households. As highlighted by Bhat and Patil [51], "consumer awareness plays a major role to route e-waste to the authorized collection centers and authorized recyclers for safe disposal". Thus, many international studies have highlighted the importance of individual recycling attitudes, behavioural dispositions, and waste disposal habits in moderating the effectiveness of waste management [12,52–54]. According to Shah [46], for effective e-waste collection and enhanced recycling rates to occur, there is a need for greater public awareness. Similarly, other studies attribute shortfalls in e-waste management to poor recycling attitudes, while existing awareness levels are not always enough for the proper management of e-wastes [50,55].

3. Study Area, Materials, and Methods

3.1. The Study Area

This survey was conducted amongst households in the Jos metropolis (Nigeria). Jos is the administrative capital of Plateau State in Nigeria and has a total land mass of about 249.7 km^2 (Figure 1). This city is located at an elevation of 1238 m (i.e., 4062 ft) above sea level [56] and is comprised of two local Government Areas (LGAs), namely, (1) Jos South and (2) Jos North as shown in Figure 1.

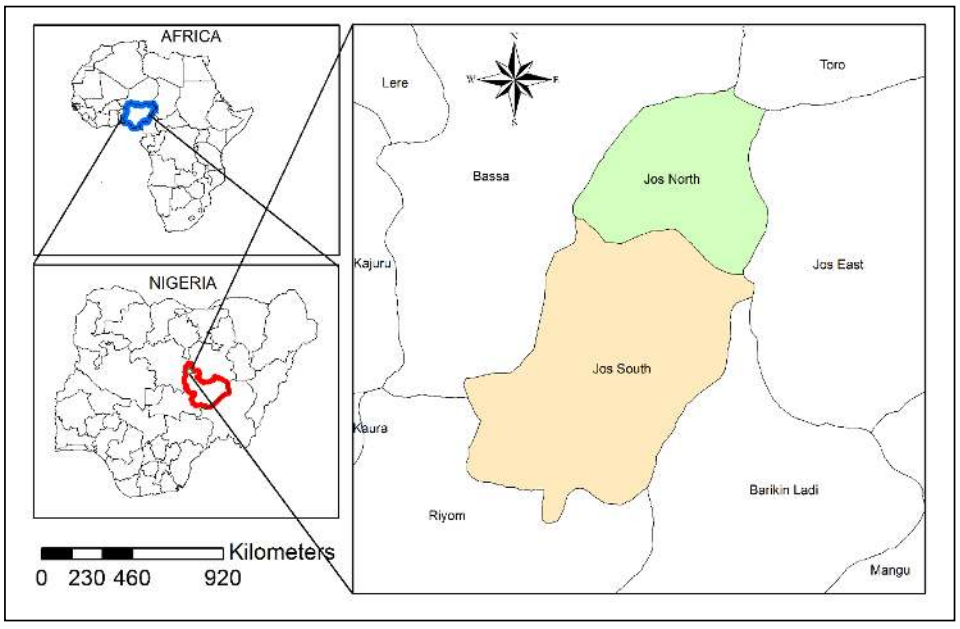

Figure 1. Map showing the location of Jos Metropolis in Plateau State.

Jos is also one of the coolest cities in Nigeria with temperatures ranging from 22 to 32 °C (minimum and maximum, respectively) and has attracted many settlers from different parts of Nigeria, as well as foreigners from other countries. The Dilimi River is an important source of water to many other states in Nigeria, both for domestic and agricultural activities, especially for irrigation farming.

Jos city was chosen for this survey mainly because of the importance of prevailing economic activities, an accelerated pace of urbanization, and a population size of about 1 million people, along with the increased burden of municipal waste management [57]. According to Peter et al. [58], the urban population in Jos is increasing at a rate of 5.5%, and similarly the proportion of e-waste is expected to rise concomitantly. Furthermore, this metropolis serves as the business hub of Plateau State, thus is home to some of the largest electrical and electronic stores which include household brands such as PZ, LG, and Samsung. Given this background, large amounts of e-wastes are generated from this city, thus necessitating the need for more empirical research to provide solutions to this environmental management problem.

3.2. Survey Procedures and Sampling Framework

The aim of this survey was to investigate knowledge and awareness levels related to e-waste and related issues amongst households in Jos. Similarly, with an e-waste survey conducted by Nduneseokwu et al. [59] in the city of Onitsha in Anambra State (Nigeria), the respondents for the present survey were selected randomly across Jos. Household heads were the main targets for face-to-face questionnaire-administered interviews. The principle of random sampling in our survey was intended to bring statistical credibility, as well as data representability, thus in line with previous research approaches adopted to investigate the willingness and behaviour of residents towards e-waste recycling in Beijing (China) [60]. Moreover, Bhat and Patil [51] followed a random sampling approach in attempting to understand the consciousness, as well as the disposal practices of residents of Pune city in India.

In total, 300 questionnaires were administered to households' respondents during our survey although only 228 were successfully populated, thus yielding a response rate of 76%. Such interviews were conducted mostly in English although there were translations into the regional indigenous language known as '*Hausa*' whenever respondents experienced difficulties in understanding interview questions.

3.3. Data Collection Methods

The survey collected mainly quantitative primary data through interviews from June 2018 until September 2018. The questionnaires were comprised of close-ended questions that were grouped into four different sections that are summarized as follows:

- Demographic and socio-economic characteristics of respondents.
- Knowledge and awareness of electronic wastes.
- Reasons for changing electronic products.
- Environmental problems associated with e-waste management.

From an ethical point of view and consonant with the research policy of the University of Johannesburg, interviews for collecting primary data occurred only when respondents offered prior informed consent for their participation in this survey. Such consent meant that the respondents understood the purpose of the surveys and gave permission for interviews while their privacy and anonymity were being protected.

3.4. Data Analyses

Primary data collected during interviews were stored in MS Excel (Version 2016) for further processing and coding. Subsequently, the data were subjected to both descriptive and inferential statistical analyses by making use of the SPSS 25 version. The hypotheses were subjected to t-tests and

analysis of variance (ANOVA). Regarding the testing of these hypotheses, a probability level of 0.05 ($p < 0.05$) was taken into consideration. The results are presented in the next section by means of tables and different types of statistical illustrations.

4. Results and Discussion

4.1. Demographic and Socio-Economic Characteristics of Respondents

Table 2 summarizes the demographic data of respondents. Out of the 228 respondents, 73.7% ($n = 168$) were men while 26.39% ($n = 60$) were women. Since we interviewed only household heads who are traditionally men, it is not surprising that women were highly under-represented. The highest percentage (51%; $n = 116$) of respondents was in the 31 to 40 age category whereas individuals aged 51 to 60 years were less represented (7%; $n = 1$). Most of the respondents had attained tertiary educational qualifications (93.27%; $n = 208$), while fewer respondents either had no education at all (0.45%; $n = 1$) or had completed only primary schooling (0.45%; $n = 1$). In terms of marital status, most respondents were married (75%; $n = 171$) whereas single individuals amounted to only 25% ($n = 57$).

Table 2. Demographic profile of respondents ($n = 228$).

Variable	Category	Frequency (F)	Percentage (%)
Gender	Male	160	70.2%
	Female	68	29.8%
Age	Less than or equal to 30 years	52	22.8%
	31–40 years	116	50.9%
	41–50 years	42	18.4%
	51–60 years	16	7%
	Above 60 years	2	0.9%
Marital status	Single	57	25%
	Married	171	75%
Educational level	No formal education	1	0.45%
	Primary education	1	0.45%
	Secondary education	13	5.82%
	Tertiary education	208	93.27%

Although most occupations occurred in nearly the same proportions (i.e., 10.53% for informal trading and 12.72% for others) amongst the respondents, most of them were employed as civil servants (46.1%; $n = 105$) (Table 3). Nearly 58% (57.9%; $n = 132$) of the respondents earned incomes between \$83.3 and \$250 while the proportions of those earning between \$252.7 and \$416.6, as well as \$419.4 to \$583.3 were 14.5% ($n = 33$) and 16.2% ($n = 37$), respectively. Given these results, those who received earnings below \$83.3, which is the national minimum wage in Nigeria, are equivalent to 29% ($n = 66$) while the rest (71%; $n = 162$) received monthly incomes that exceeded this minimum wage.

Regarding family size, 34.64% ($n = 79$) and 29.8% ($n = 68$) of respondents accounted for households occupied by three to four or five to six persons, respectively, while families with nine or more people were represented by only 5.3% ($n = 12$) of the respondents. Depending on the age and income levels of the respondents, family size may give an indication of how many electronic goods and devices they would probably buy, and how much e-waste could be expected.

Table 3. Socio-economic characteristics of respondents (n = 228).

Aspects	Components	Frequency	Percentage
Occupation	Civil servant	105	46.1%
	Trading	24	10.53%
	Farming	28	12.3%
	Mining	16	7%
	Student	26	11.4%
	Others	29	12.72%
Income	$83.3–$250	132	57.9%
	$252.7–$416.6	33	14.5%
	$419.4–$583.3	37	16.2%
	$586.1–$833.3	16	6.6 %
	$833.3	10	4.8%
Family size	1–2 persons	42	18.42%
	3–4 persons	79	34.64%
	5–6 persons	68	29.8%
	7–8 persons	27	11.84%
	9 persons and above	12	5.3%

4.2. Knowledge and Awareness of Electronic Wastes

In Figure 2, the proportions of several types of electronic devices used by members of households are depicted. Both cell phones (93%) and television sets (82%) were mentioned by most respondents. Nowadays, cell phones are some the most ubiquitous and indispensable electronic products inside households, as affirmed by a study conducted by Okoye and Odoh [61] in Onitsha (Nigeria). Furthermore, devices such as radio (59%), laptops (59%), DVDs (61%), kitchen appliances (64%), and refrigerators (66%) were reported by nearly an equal proportion of respondents. According to a study conducted in India [47], increased purchases of electronic devices can be ascribed to the rising economic growth, although some electronic devices in our study were least mentioned by the respondents. Such devices entailed food warming appliances (microwaves) (39%), media players (43%), and desktop computers (43%). As noted by Saritha et al. [62], regardless of the type of electronic goods being bought at household level, at one stage they will reach the end of their life span, thus necessitating the need for disposing them away.

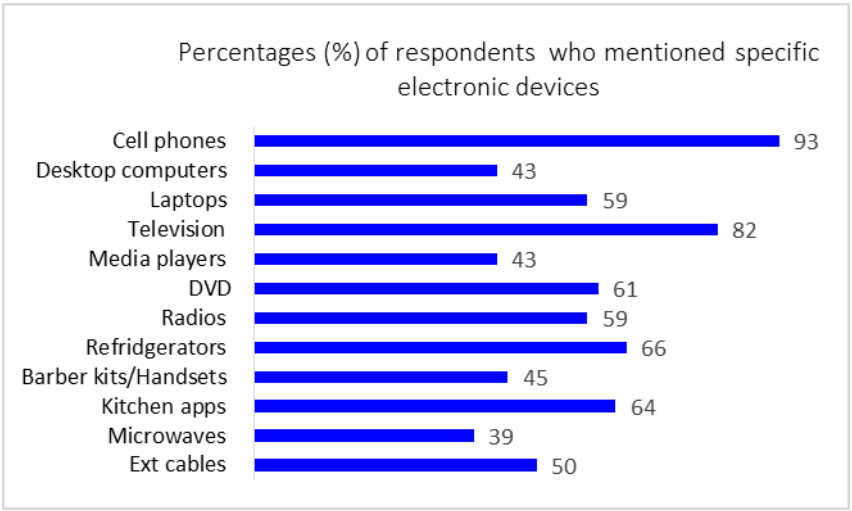

Figure 2. Electronic devices mentioned by respondents.

The results depicted in Table 4 indicate that 67.5% (n = 154) of respondents are aware of e-wastes, although 68% (n = 155) claimed that they have not received detailed education on the handling and disposal of this waste stream. Not receiving education on e-waste handling protocols is typical of many developing countries such as Nigeria and others where there is a lack of resources and institutional support for increased dissemination of applicable knowledge on e-waste [48,50,61].

Table 4. Statements estimating awareness and knowledge of e-waste amongst respondents (n = 228).

Statements Estimating E-Waste Awareness and Knowledge	No (%)	Yes (%)
Do you know what e-waste or electronic waste is?	74 (32.5%)	154 (67.5%)
Do you know that e-waste requires special treatment before disposal?	112 (49.1%)	116 (50.9%)
Do you know that improper e-waste disposal is harmful to the environment?	61 (27.5%)	157 (72.5%)
Are you aware that e-waste contains harmful substances?	73 (32.0%)	155 (68.0%)
Are you aware of the health risks associated with e-waste?	90 (39.5%)	138 (60.5%)
Have you received education on e-waste before?	155 (68.0%)	73 (32.0%)
Do you think sorting e-waste is important towards improving waste management?	21 (9.2%)	207 (90.8%)

Regardless of these limitations, many of the respondents mentioned that they are aware of the toxicity or harmfulness (68%; n = 155) of this waste stream and inherent health risks (60.5%; n = 138) associated with unsafe disposal practices, and hence the special treatment it requires for safe disposal (50.9%; n = 166). By comparison, such relatively higher awareness levels on e-waste amongst households have also been reported by another study conducted in Enugu West Senatorial District in Nigeria [63]. Consequently, in the present study 90.8% (n = 207) of respondents expressed the opinion that e-waste sorting is important (Table 4).

Figure 3 indicates the results regarding the different sources of learning about e-waste at household level in the Jos metropolis. To a greater extent, most of the knowledge sources on e-waste were mentioned by relatively fewer respondents—schooling (13.2%; n = 30), television (11.4%; n = 26), and workplaces (11%; n = 25). Moreover, other learning avenues such as information received from national or community radios (6.1%; n = 14) and local awareness programs (3.9%; n = 9) were mentioned by even fewer respondents. On the other hand, the proportion of respondents who have not been exposed to any source of e-waste learning was comparatively higher (32.5%; n = 74), thus denoting the generally low level of priority that is placed on e-waste learning in the study area.

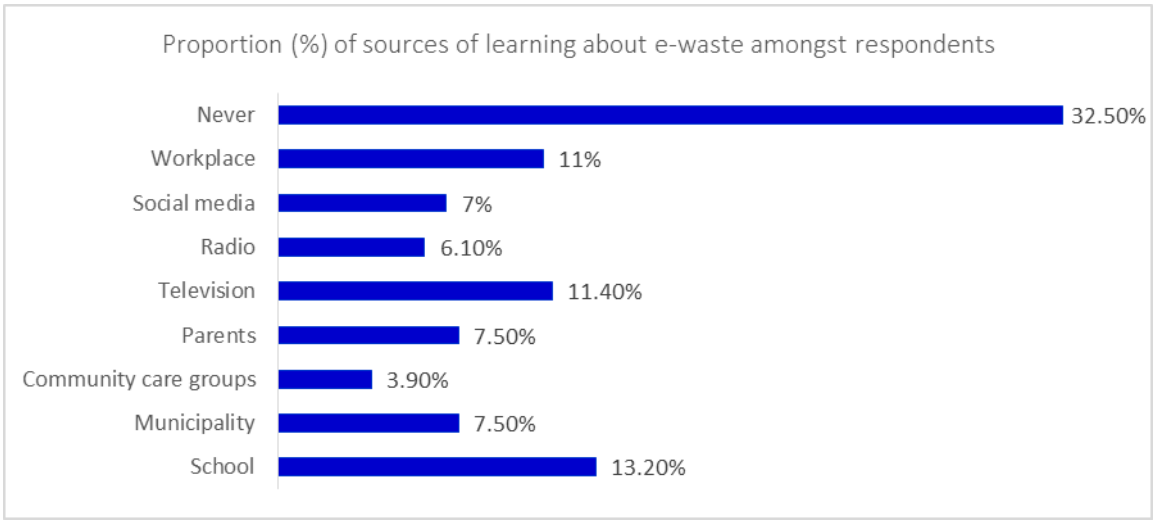

Figure 3. Sources of learning about e-waste amongst respondents.

4.3. Reasons for Changing Electronic Products

There are different reasons for changing and acquiring new electronic devices and the results on these aspects are summarized in Figure 4. Most respondents strongly agreed that they were acquiring

electronic devices mainly because of product damages (35.1%), upgrades (32.9%), theft (26.33%), and the market introduction of newer designs (25.4%). These findings concur with conclusions made by Saritha et al. [62] that the acquisition of electronic goods is accelerated by damages incurred on existing products, as well as the introduction of newer product designs. Four key reasons that influence the change of electronic devices among respondents are evident from Figure 4, namely damage, product upgrades, new designs, and theft.

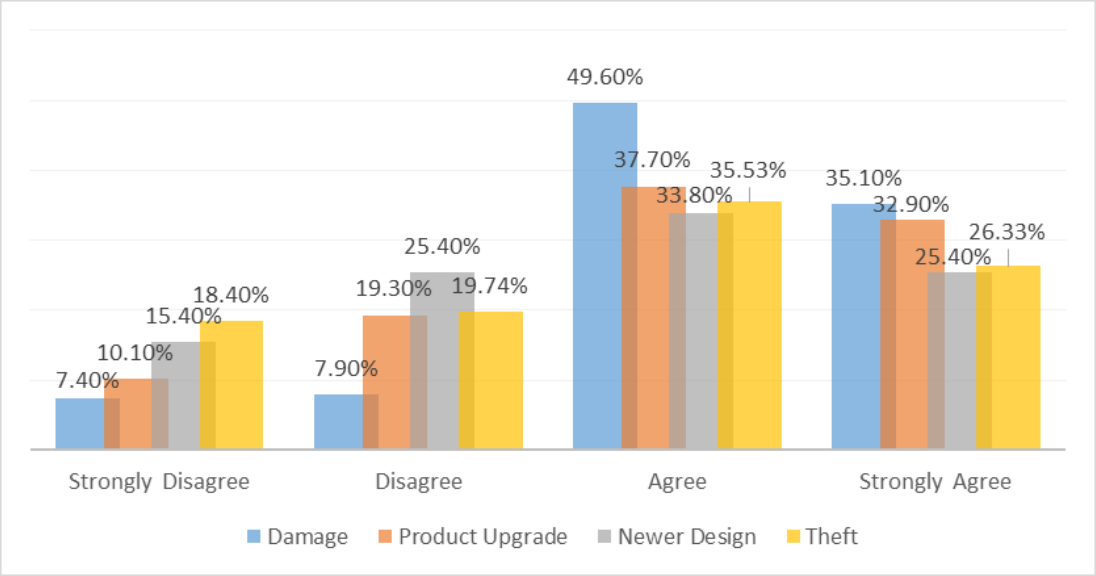

Figure 4. Reasons for changing electronic devices.

Figure 5 illustrates the various methods of handling and discarding e-wastes in the study area. Approximately the same percentages of respondents are simply storing e-waste in their homes (27.6%; $n = 63$) or dumping and mixing it with general household wastes (25%; $n = 57$). Storing e-waste at home is probably accentuated by the lack of a door-to-door collection program in the Jos metropolis. Such home storage of e-waste has also been reported in other studies due to the lack of feasible options for disposing it away effectively or reclaiming it for other uses [46,64]. With these state of affairs in the study area, residents are likely to dump their e-waste anywhere outside of their homes, thus in line with findings from other researchers in Nigeria which attest to poor e-waste management practices. However, Figure 5 also shows that some of the e-wastes are sold to individuals for possible reuse (17.50%; $n = 40$), which is a relatively more sustainable practice of dealing with this waste stream. Furthermore, to a lesser extent, e-wastes are burned at household level (7.90%; $n = 18$), thus contributing to local air pollution in the vicinity of households, or simply throwing it away at nearby dumpsites (6.70%; $n = 15$) (Figure 5). However, some of the e-waste is sold to recyclers (7.5%; $n = 17$) or is donated (7.90%; $n = 18$) to people who need it, although these proportions are relatively lower compared to the preponderance of environmentally unsustainable practices in the handling and disposal of these wastes.

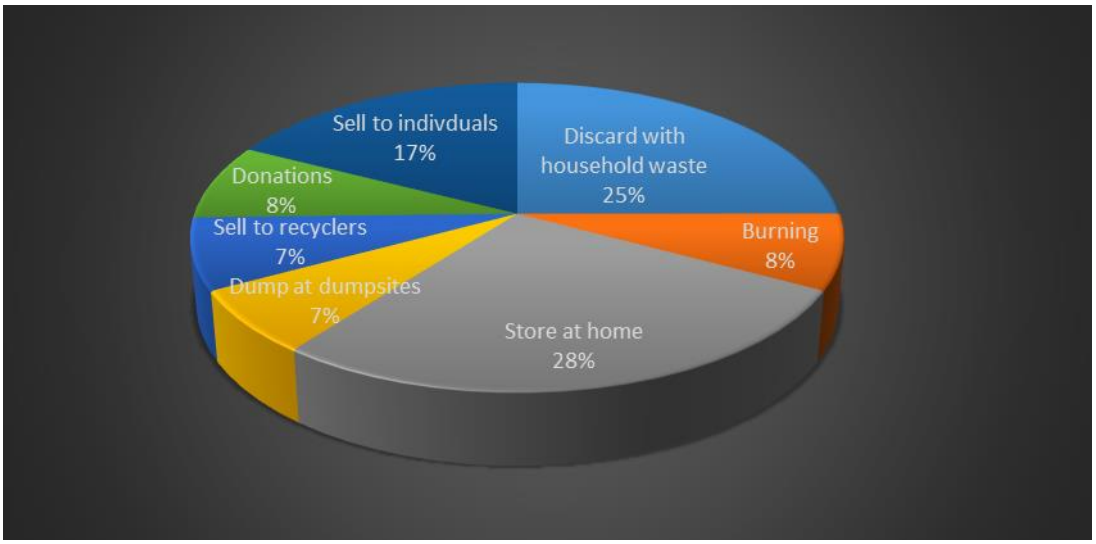

Figure 5. Methods of handling and disposing away e-waste by households.

4.4. Environmental Problems Associated with E-Waste Management

Based on Figure 6, most respondents regarded e-waste as a serious (26.30%; n = 60) to very serious (31.40%; n = 71) eyesore in the study area while nearly equal proportions regarded it as an important (28% to 30.30%) source of fugitive atmospheric emissions. Similarly, the mismanagement of e-wastes in the study area is associated with serious (28.5%) to very serious (27.60%) ineffective municipal solid waste management while it is also being blamed for being a source of diseases among people.

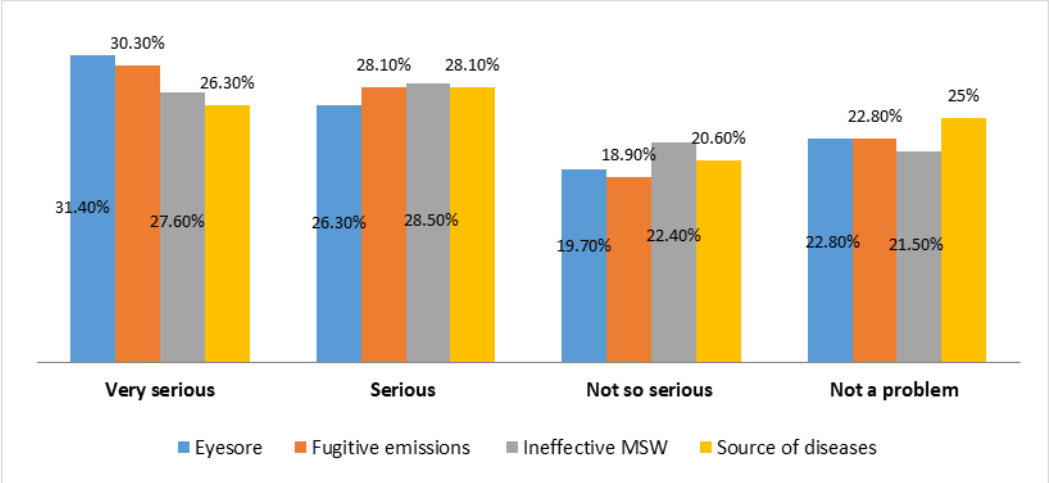

Figure 6. Environmental problems associated with e-waste management.

4.5. Households' Willingness to Participate in Waste Management

The results on households' willingness to participate in e-waste management are shown in Table 5. Determining such willingness was based on the different statements (Table 5) provided to the respondents during the survey. To a large extent, there was willingness amongst respondents to pay for proper e-waste disposal (68.9%; n = 157). Depending on their level of commitment and willingness, with such payments the local municipalities may find a source of revenue for providing drop-off facilities, thus enhancing collection rates and recycling effectiveness of e-wastes in the study area. However, such observed willingness to pay for e-waste disposal contrasts with findings associated with households in California (USA) who expressed some unwillingness to pay extra charges for effective e-waste disposal [65]. Be that as it may, we need to emphasize that the California study

was conducted nearly thirteen years ago, of which it is not clear if their public willingness to pay for e-waste disposal has not improved for the better in recent times. In addition, the need for more education to improve knowledge and awareness levels in Jos was widely recognized (89.9%; n = 205). In the same way, the role of the extended producer responsibility (EPR) policy (86.8%; n = 196) amongst the manufacturers and vendors of electronic products was seen as a viable means to manage e-waste disposal in a relatively more efficient manner. However, judging the effectiveness of such an intervention would require further engagement and collaboration with other relevant stakeholders, notably those who will finance its implementation and logistical arrangements.

Table 5. Willingness of respondents to participate in e-waste management.

Statements Estimating Willingness to Participate in E-Waste Management	No	Yes
Would you be willing to pay a token in order to have someone effectively dispose your e-waste?	71 (31.1%)	157 (68.9%)
Do you think programmes such as extended producer responsibility can help you manage your e-waste better?	30 (13.2%)	198 (86.8%)
If you agree with question 49 above, are you willing to engage in such programmes?	36 (15.1%)	192 (84.2%)
Would you want more education and awareness about e-waste?	23 (10.1%)	205 (89.9%)

4.6. T-Tests and Analysis of Variance (ANOVA)

Table 6 indicates the results from t-tests and the analysis of variance (ANOVA) for assessing the relationships or differences between variables such as the respondents' awareness of and willingness to participate meaningfully in e-waste management based on their socio-demographic characteristics. Our results showed no significant differences between the mean score of male (3.575; SD 2.135) and female (3.892; SD 2.143) respondents regarding their awareness of e-waste. Similarly, we found no significant differences in the willingness of respondents to participate in e-waste management according to their socio-economic characteristics (Table 6).

Table 6. T-tests on the awareness and willingness to participate in e-waste management.

	Gender	N	Mean	Std. Deviation	*t*	Sig.
Awareness	Male	153	3.5752	2.13582	−0.988	0.324 ns
	Female	65	3.8923	2.24390		
Willingness	Male	153	3.3125	1.12260	0.577	0.565 ns
	Female	65	3.2206	1.04875		

Note: N: Number of respondents; *t*-value: Awareness $t = -0.988$; Willingness $t = 0.577$; Significant at $p < 0.05$ level.

Furthermore, the one-way ANOVA test (Table 7) showed no significant differences between the awareness and willingness of respondents to participate in e-waste management according to their educational levels, marital status, as well as age.

Table 7. One-way analysis of variance (ANOVA) test on awareness and willingness to participate in e-waste management according to the education, marital status, and age of respondents.

Education Qualification		Sum of Squares	df	Mean Square	F	Sig.
Awareness	Between groups	55.158	4	13.790	3.030	0.019 ns
	Within groups	964.952	212	4.552		
	Total	1020.111	216			
Willingness	Between groups	3.349	4	0.837	0.686	0.602 ns
	Within groups	271.038	222	1.221		
	Total	274.388	226			
Marital status						
Awareness	Between groups	27.798	6	4.633	0.985	0.436 ns
	Within groups	992.422	211	4.703		
	Total	**1020.220**	**217**			
Willingness	Between groups	1.728	6	0.288	0.233	0.965 ns
	Within groups	272.742	221	1.234		
	Total	274.469	227			
Age						
Awareness	Between groups	15.169	5	3.034	0.640	0.669 ns
	Within groups	1005.051	212	4.741		
	Total	1020.220	217			
Willingness	Between groups	6.739	5	1.348	1.118	0.352 ns
	Within groups	267.730	222	1.206		
	Total	274.469	227			

Note: N: Number of Respondents; Sig: Level of Significance at $p < 0.05$ level; df: Degree of Freedom; F: F ratio.

5. Conclusions and Recommendations

In our survey, we investigated household awareness on e-waste and the associated willingness to participate in its management in Jos (Plateau State of Nigeria). Sound knowledge and awareness of e-waste is essential towards safe disposal, reuse, as well as its recycling, along with minimizing exposure to harmful components. Based on the findings from our survey, the following conclusions and recommendations are made.

Most (70.2%) of the respondents were men because many of them are household heads while the most (50.9%) represented age group amongst respondents were in the category of 31 to 40 years old. In terms of income levels, about 71% of respondents earned incomes above the Nigerian minimum monthly wage of $83.3, thereby raising the likelihood of increased capacity to purchase electronic goods as indicated in several studies.

Electronic devices mentioned by most households included cell phones (82%), televisions sets (82%), DVDs (61%), as well as laptops (59%). Similarly, the level of awareness on e-waste amongst the respondents was relatively high (67.5%), although many seemed to lack detailed knowledge and proper education (73%) on the proper handling and management of e-wastes. For example, 32.5% of respondents have never received any training from any source regarding e-waste management. Given this weakness, community-based interventions to improve awareness levels on e-waste management are recommended.

The most predominant reasons for acquiring more electronic devices amongst respondents entailed damage to existing products, theft, product upgrades, as well as the introduction of newer versions. Furthermore, several environmental problems from the perspective of the respondents were linked to poor practices of disposing away e-wastes in their neighbourhoods, the most important being the negative impacts it has on aesthetics, ambient air quality, as well as weak municipal management to deal effectively with this waste stream.

The majority of respondents were willing to participate in e-waste management programmes (68.9%), as well as become involved in the extended producer responsibility schemes (84.2%). However, existing literature [66–68] shows that to adequately evaluate the viability of introducing such schemes would require further engagement, interactions, and collaboration with computer manufacturers, associated vendors, and other stakeholders who are likely to be affected by the financial and logistical impacts involved.

Furthermore, the survey revealed some of the factors that may help moderate e-waste knowledge and awareness amongst respondents, as well as their willingness to participate in its management and possible recycling. Based on the hypotheses formulated for this survey, levels of awareness and knowledge amongst respondents were not affected by any of the socio-demographical characteristics of respondents. Similarly, there were no significant differences amongst respondents in terms of their willingness to participate in e-waste management.

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References

1. Baldé, C.P.; Forti, V.; Gray, V.; Kuehr, R.; Stegmann, P. *The Global E-Waste Monitor 2017: Quantities, Flows, and Resources*; United Nations University: Bonn, Germany; Geneva, Switzerland; Vienna, Austria, 2017.
2. Mishra, S.; Shamanna, B.R.; Kannan, S. Exploring the awareness regarding e-waste and its health hazards among the informal handlers in Musheerabad area of Hyderabad. *Indian. J. Occup. Environ. Med.* **2017**, *23*, 143–148.
3. Wu, Q.; Leung, J.; Geng, X.; Chen, S.; Huang, X.; Li, H.; Huang, Z.; Zhu, L.; Chen, J.; Lu, Y. Heavy metal contamination of soil and water in the vicinity of an abandoned e-waste recycling site: Implications for dissemination of heavy metals. *Sci. Total Environ.* **2015**, *506–507*, 217–225. [CrossRef] [PubMed]
4. Onwughara, N.I.; Nnorom, I.C.; Kanno, O.C.; Chukwuma, R.C. Disposal Methods and Heavy Metals Released from certain Electrical and Electronic Equipment Wastes in Nigeria. Adaptation of Environmental Sound Recycling System. *Int. J. Environ. Sci. Dev.* **2010**, *1*, 290–297. [CrossRef]
5. Fraige, F.Y.; Al-khatib, L.A.; Alnawafleh, H.M.; Dwerji, M.K.; Langston, P.A. Waste electric and electronic equipment in Jordan: Willingness and generation rates. *J. Environ. Plan. Manag.* **2012**, *55*, 161–175. [CrossRef]
6. Daliguite, R.; Zabulionis, D.; Sujetoviene, G.; Zaltauskaite, J. Waste of electrical and electronic equipment: Trends and awareness among youths in Lithuania. *Waste Manag. Res.* **2019**, *37*, 95–101.
7. Awasthi, A.K.; Li, J. Management of electrical and electronic waste: A comparative evaluation of China and India. *Renew. Sustain. Energy Rev.* **2017**, *76*, 434–447. [CrossRef]
8. Wang, W.; Tian, Y.; Zhu, Q.; Zhong, Y. Barriers for household e-waste collection in China: Perspectives from formal collecting enterprises in Liaoning Province. *J. Clean. Prod.* **2017**, *153*, 299–308. [CrossRef]
9. Widmer, R.; Oswald-Kpraf, H.; Sinha-Kheriwal, D.; Schenellmann, M.; Boni, H. Global perspectives on e-waste. *Environ. Impact Assess. Rev.* **2005**, *5*, 436–458. [CrossRef]
10. Terada, C. Recycling electronic wastes in Nigeria: Putting environmental and human rights at risk. *Northwest. J. Int. Hum. Rights* **2012**, *10*, 153–172.
11. Zhan, L.; Xu, Z. State-of-the-art of recycling e-wastes by vacuum metallurgy separation. *Environ. Sci. Technol.* **2014**, *48*, 14092–14102. [CrossRef]
12. Manomaivibool, P.; Vassanadumrongdee, S. Buying back household waste electrical and electronic equipment: Assessing Thailand's proposed policy in light of past disposal behaviour and future preferences. *Resour. Conserv. Recycl.* **2012**, *68*, 117–125. [CrossRef]

13. Liu, X.; Tanaka, M.; Matsui, Y. Electrical and electronic waste management in china: Progress and the barrier to overcome. *Waste Manag. Res.* **2006**, *24*, 92–101. [CrossRef] [PubMed]
14. Lim-Wavde, K.; Kauffmana, R.J.; Dawson, G.S. Household informedness and policy analytics for the collection and recycling of household hazardous waste in California. *Resour. Conserv. Recycl.* **2017**, *120*, 88–107. [CrossRef]
15. Sivanthanu, B. User's Perspective: Knowledge and attitude toward's E-waste. *Int. Appl. Environ. Sci.* **2016**, *11*, 413–432.
16. Ansari, N.L.; Ashraf, M.; Malik, B.T.; Grunfield, H. Green IT awareness and practices: Results from a field study on mobile phone related e-waste in Bangladesh. In Proceedings of the 2010 IEEE International Symposium on Technology and Society, Wollongong, NSW, Australia, 7–9 June 2010; pp. 375–383. Available online: https://ieeexplore.ieee.org/abstract/document/5514618 (accessed on 25 November 2019). [CrossRef]
17. Borthakur, A.; Govind, M. Emerging trends in consumers' E-waste disposal behaviour and awareness: A worldwide overview with special focus on India. *Resour. Conserv. Recycl.* **2017**, *117*, 102–113. [CrossRef]
18. Onyeajuwa, M.K. Institutions and Consumers: Assertation of ordinary consumer interest in the Nigerian digital mobile telecommunications market. *Telecommun. Policy* **2017**, *41*, 642–650. [CrossRef]
19. Omole, D.O.; Tenebe, I.T.; Emenike, C.P.; Umoh, A.S.; Badejo, A.A. Causes, impacts and management of electronic wastes: Case study of some Nigerian communities. *ARPN J. Eng. Appl. Sci.* **2015**, *10*, 7876–7884.
20. Babayemi, J.O.; Osibanjo, O.; Weber, R. Material and substance flow analysis of mobile phones in Nigeria: A step for progressing e-waste management strategy. *J. Mater. Cycles Waste Manag.* **2017**, *19*, 731–742. [CrossRef]
21. Azodo, A.P.; Ogban, P.U.; Okpor, J. Knowledge and Awareness Implication on E-Waste Management among Nigerian Collegiate. *J. Appl. Sci. Environ. Manag.* **2017**, *21*, 1035–1040.
22. Ejiogu, A.R. E-waste economics: A Nigerian Perspective, Management of Environmental Quality. *Int. J.* **2013**, *24*, 199–213.
23. United Nations Environment Programme (UNEP). Nigeria Turns the Tide on Electronic Waste. 2019. Available online: www.unenvironment.org (accessed on 7 January 2020).
24. Nnorom, I.C.; Osibanjo, O. Electronic waste (e-waste): Material flows and management practices in Nigeria. *Waste Manag.* **2008**, *28*, 1472–1479. [CrossRef] [PubMed]
25. Ben-Enukora, C.; Okorie, N.; Oresanya, T.; Ekanem, T. Awareness and perception of media campaign on e-waste effects among residents of Ado-Ota, Nigeria. *Covenant J. Commun.* **2017**, *4*, 18–32.
26. Obaje, S.O. Electronic waste scenario in Nigeria: Issues, problems and solutions. *Int. J. Eng.* **2013**, *2*, 31–36.
27. National Environmental Standards and Regulations Enforcement Agency (Establishment). 2007. Available online: http://www.placng.org (accessed on 20 November 2019).
28. EU Directives. Directive (EU) 2018/849 of the European Parliament and of the Council of 30 May 2018. *Official Journal of the European Union*. 2018. L 150/93. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.150.01.0093.01.ENG&toc=OJ:L:2018:150:FULL (accessed on 20 January 2020).
29. Kumar, V.; Bee, D.J.; Shirodkar P, S.; Tumkor, S.; Bettig, B.P.; Sutherland, J.W. Towards sustainable product and material flow cycles: Identifying barriers to achieving product multi-use and zero waste. In Proceedings of the 2005 ASME International Mechanical Engineering Congress and Exposition, Orlando, FL, USA, 5–11 November 2005.
30. Reza, A. E-Waste Management in Bangladesh: Present Trend and Future Implication. 2011. Available online: https://www.researchgate.net/publication/267762865_E-Waste_management_in_Bangladesh_Present_Trend_and_Future_Implication (accessed on 20 January 2020). [CrossRef]
31. Ercan, O.; Bilen, K.A. Research on electronic waste awareness and environmental attitudes of primary school students. *Anthropologist* **2014**, *17*, 13–23. [CrossRef]
32. Kiddee, P.; Naidu, R.; Wong, M.H. Electronic waste management approaches: An overview. *Waste Manag.* **2013**, *33*, 1237–1250. [CrossRef]
33. Alam, M.; Bahauddin, K.M. Electronic waste in Bangladesh: Evaluating the situation, legislation and policy and way forward with strategy and approach. *Present Environ. Sustain. Dev.* **2015**, *9*, 81–101. [CrossRef]
34. Adediran, Y.A.; Abdulkarim, A. Challenges of electronic waste management in Nigeria. *Int. J. Adv. Eng. Technol.* **2012**, *4*, 640–648.
35. Oliveira, C.R.; Bernades, A.M.; Gerbase, A.E. Collection and Recycling of electronic scrap: A worldwide overview and comparison with the Brazilian situation. *Waste Manag.* **2012**, *32*, 1592–1610. [CrossRef]

36. Namias, J. The Future of Electronic Waste Recycling in the United States: Obstacles and Domestic Solutions. Master's Thesis, Department of Earth and Environmental Engineering, Colombia University, New York, NY, USA, 2013.
37. Kumar, S.N.; Jain, A.K. E-waste: Health Impacts in Developing countries. *EHs J.* **2014**. Available online: http://ehsjournal.org (accessed on 27 September 2019).
38. Al-Razi, K.M.H. Resourceful recycling process of waste desktop computers. A Review study. *Resour. Conserv. Recycl.* **2016**, *110*, 30–47. [CrossRef]
39. Machete, F. Environmental health risks associated with e-waste exposure in Badplaas, Carolina and Elukwatini landfills, Republic of South Africa. *Afr. J. Sci. Technol. Innov. Dev.* **2007**. [CrossRef]
40. Guo, Y.; Huo, X.; Li, Y.; Wu, K.; Liu, J.; Huang, J.; Xu, X. Monitoring of lead, cadmium, chromium and nickel in placenta from an e-waste recycling town in China. *Sci. Total. Environ.* **2010**, *408*, 3113–3117. [CrossRef] [PubMed]
41. Nie, Z.; Tian, S.; Tian, Y.; Tang, Z.; Tao, Y.; Die, Q.; Huang, Q. The distribution and biomagnification of higher brominated DDE's in terrestrial organisms affected by a typical e-waste burning site in South China. *Chemosphere* **2015**, *118*, 301–308. [CrossRef]
42. Pinto, V.N.; Patil, D.Y. E-waste hazard: The impending challenge. *Indian J. Occup. Environ. Med.* **2008**, *12*, 65–70. [CrossRef]
43. Nowakowski, P. The influence of residents' behaviour on waste electrical and electronic equipment collection effectiveness. *Waste. Manag. Res.* **2016**, *34*, 1126–1135. [CrossRef]
44. Amachree, M. NESREA. In Proceedings of the 3rd Annual Meeting of the Global E-Waste Management Network (GEM3), San Francisco, CA, USA, 15–19 July 2013.
45. Afroz, R.; Masud, M.M.; Akhtar, R.; Duasa, J.B. Survey and analysis of public knowledge, awareness and willingness to pay in Kuala Lumpur, Malaysia–a case study on household WEEE management. *J. Clean. Prod.* **2013**, *52*, 185–193. [CrossRef]
46. Shah, A. An Assessment of Public Awareness Regarding E-Waste Hazards and Management Strategies (2014). *Independent Study Project (ISP) Collection*. 1820. Available online: https://digitalcollections.sit.edu/isp_collection/1820 (accessed on 13 November 2019).
47. Nethaji-Mariappan, V.E.; Karthik, S.; Vineeth, K.S.; Varthamanan, S. E-Waste Management & Assessment—A Review. *Int. J. ChemTech Res.* **2017**, *10*, 924–936.
48. Jafari, A.; Heydari, J.; Keramati, A. Factors affecting incentive dependency of residents to participate in e-waste recycling: A case study on adoption of e-waste reverse supply chain in Iran. *Environ. Dev. Sustain.* **2017**, *19*, 325–338. [CrossRef]
49. Saphores, J.M.; Ogunseitan, O.A.; Shapiro, A.A. Willingness to engage in pro-environmental behaviour: An analysis of e-waste recycling based on a national survey of U.S. household. *Resour. Conserv. Recycl.* **2012**, *60*, 49–63. [CrossRef]
50. Akhtar, R.; Masud, M.M.; Afroz, R. Household Perception and Recycling Behaviour On Electronic. *Malays. J. Sci.* **2013**, *33*, 32–41.
51. Bhat, V.; Patil, Y. E-waste consciousness and disposal practices among residents of Pune city. *Procedia Soc. Behav. Sci.* **2014**, *133*, 491–498. [CrossRef]
52. Robinson, B.H. E-waste: An assessment of global production and environmental impacts. *Sci. Total. Environ.* **2009**, *408*, 183–191. [CrossRef] [PubMed]
53. Townsend, T.G. Environmental issues and management strategies for waste electronic and electrical equipment. *J. Air Waste Manag. Assoc.* **2011**, *61*, 587–610. [CrossRef]
54. Ezeah, C.; Fazakerley, J.A.; Roberts, C.L. Emerging trends in informal sector recycling in developing and transition countries. *Waste Manag.* **2013**, *33*, 2509–2519. [CrossRef]
55. Thevchenko, T.; Laitala, K.; Danko, Y. Understanding consumer E-waste recycling behaviour: Introducing a new economic incentive to increase the collection rates. *Sustainability* **2019**, *11*, 2656. [CrossRef]
56. Adzandeh, E.A.; Akintunde, J.A.; Akintunde, E.A. Analysis of Urban Growth Agents in Jos metropolis, Nigeria. *Int. J. Remote Sens. GIS* **2015**, *4*, 41–50.
57. Dung-Gwom, J.Y.; Jugu, A.S. Characteristics and Planning Challenges of Hilltop Settlements in Jos Metropolis, Nigeria. *UPLanD J. Urban Plan. Landsc. Environ. Des.* **2017**, *2*, 129–149.

58. Peter, G.; Hull, A.; Jowitt, A.; Adeloye, A. Municipal solid waste management in greater Jos, Nigeria. In Proceedings of the North America Conference on Sustainability, Energy and Environment, Providence, RI, USA, 11–14 September 2014.
59. Nduneseokwu, C.K.; Qu, Y.; Appolloni, A. Factors influencing consumers' intentions to participate in a formal e-waste collection system: A case study of Onitsha, Nigeria. *Sustainability* **2017**, *9*, 881. [CrossRef]
60. Wang, Z.; Zhang, B.; Yin, J.; Zhang, X. Willingness and behaviour towards e-waste recycling for residents in Beijing city, China. *J. Clean. Prod.* **2011**, *19*, 977–984. [CrossRef]
61. Okoye, A.; Odoh, C. Assessment of the level of awareness of E-Waste management and concern for the environment amongst the Populace in Onitsha, South Eastern Nigeria. *J. Environ. Prot.* **2014**, *5*, 120–134. [CrossRef]
62. Saritha, V.; Sunil Kumar, K.A.; Srikanth, V.N. Consumer attitudes and perceptions on electronic waste: An assessment. *Pollution* **2015**, *1*, 31–43.
63. Umaebolu, E.I. Fate of e-waste in households in Enugu West Senatorial district of Enugu State, Southeast Nigeria. *Int. J. Community Med. Public Health* **2018**, *5*, 4200–4206.
64. Borthakur, A.; Sinha, K. Electronic waste management in India: A Stakeholder's Perspective. *Electron. Green J.* **2013**, *1*, 36.
65. Nixon, H.; Saphores, J.-D.M. Financing electronic waste recycling Californian households' willingness to pay advanced recycling fees. *J. Environ. Manag.* **2007**, *84*, 547–559. [CrossRef] [PubMed]
66. Gupt, Y.; Sahay, S. Review of extended producer responsibility: A case study approach. *Waste Manag. Res.* **2015**, *33*, 595–611. [CrossRef]
67. European Commission [DG ENV—Unit C2]. Use of Economic Instruments and Waste Management Performances—Final Report. Contract ENV.G.4/FRA/2008/0112. 10 April 2012. Available online: https://ec.europa.eu/environment/waste/pdf/final_report_10042012.pdf (accessed on 7 January 2020).
68. Leclerc, S.H.; Badami, M.G. Extended producer responsibility for e-waste management: Policy drivers and challenges. *J. Clean. Prod.* **2020**, *251*, 119657. [CrossRef]