International Journal of Economics, Commerce and Management
United Kingdom ISSN 2348 0386 Vol. 11, Issue 3, March 2023

https://ijecm.co.uk/

EVALUATING THE LEVEL OF KNOWLEDGE AND AWARENESS REGARDING E-WASTE AMONG UNIVERSITY STUDENTS IN BANGLADESH

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Abstract

Electronic waste shortly e-waste entails significant worries in Bangladesh due to its large amount of production and lack of proper recycling facility. This study used non-probability sampling to gauge information about university students' knowledge, awareness, perceptions, and disposal behaviors regarding electrical and electronic waste or e-waste. The purpose of this study is to evaluate the awareness, understanding, and involvement of university students in sustainable e-waste management methods. The report also examines Bangladesh's e-waste recycling processes as well as the country's present legal framework. The study's findings revealed that while consumers are aware of what electronic e-waste is, they have very little awareness about its recycling and management. To increase environmental awareness and sustainable e-waste management practices among university students in Bangladesh, practitioners may benefit greatly from the findings.

Keywords: E-waste, E-waste recycling, e-waste management, level of knowledge, level of awareness

INTRODUCTION

Background of The Study

The information and communication revolution of the 20th century brought about significant changes in how we structure our institutions, economies, and societies. At the same time, these have caused a variety of issues like huge volume of hazardous trash and other pollutants produced by electric devices. The environment and human health are seriously endangered by these toxic and other wastes. Therefore, the issue of efficient waste management is essential to the preservation of the environment, human health, and livelihood. It poses a significant issue to contemporary society and needs to be addressed in a coordinated manner in order to achieve sustainable development (Islam, 2016).

E-waste is made up of outdated technology such as home appliances (televisions, radios, lamps, fans, air conditioners, refrigerators, washing machines, and heat pumps), IT equipment (desktops, laptops, tabs, notebooks, and printers), and telecommunications equipment (cell Phone, cyber networking accessories). Used electronics that are destined for reuse, resale, salvage, recycling, or destruction are referred to as e-waste (Subhaprada & Kalyani, 2017). The term "e-waste" can be used to describe WEEE (waste electrical and electronic equipment) that has been made or repaired but needs to be disposed of. E-waste has a dual nature as a potentially harmful menace and a beneficial resource. Those attempting to reduce e-waste in an environmentally responsible way face significant obstacles. The informal processing of e-waste in developing countries can harm people's health and harm the environment (Subhaprada & Kalyani, 2017).

With the constant introduction of new designs, "smart" features, and technology over the past two decades, the worldwide market for electrical and electronic equipment (EEE) has continued to grow tremendously even as the lifespan of such goods has shrunk (Azodo, et al., 2017). In the past, damages were the primary cause of electronic device disposal. However, with the current technology boom, technical wear and tear, improved cost of ownership, new product features, a better aesthetic appearance, and emotional value are all having a significant impact on the disposal of these devices. A rapidly expanding excess of electronic trash is present all over the world as a result of planned obsolescence, lowering pricing, and rapid technological advancement (Chen & Yee, 2011).

Valued metals and a variety of hazardous materials are included in e-waste. The ample use of toxic metals in e-waste (Cd, Hg, Pb, and Cr) will increase the ecosystem's toxicity levels (Qu, et al., 2019). Hazardous materials could be exposed at higher risk due to e-long-term waste's persistence in the environment. These dangerous substances may seriously pollute groundwater and negatively impact human health. The pathway between soil, crops, and food is

one of the keyways that toxic chemicals from e-waste may transmit to human bodies. A metal recovery from e-waste is required due to toxicity, adverse environmental effects, and financial compensations from e-waste.

In recent years the massive generation of e-west is a great concern. Majority of electronic waste is unofficially dumped in landfills. Annual production of e-waste is approximately 40 million metric tons globally, including 5% of all solid wastes (Hazra et al., 2019). European Union, itself, are producing and disposing 9 million tons trash from phones, televisions, and computers (Pahari & Dubey, 2019). According to the United Nation's Global E-waste Monitor 2020, a record amount of electronic waste (53.6 million metric tons) was generated in 2019 worldwide which has increased more than 21% over a span of five years and only 17.4% of this huge amount of e-waste had been recycled (Forti, et al., 2020). Worldwide total e-waste generation will reach to almost 74 million metric tons by 2030 (Forti, et al., 2020). According to the report, in 2019 Asia generated the highest amount of e-waste in 2019 followed by America & Europe (Forti, et al., 2020). Currently Bangladesh produces 2.8 million tons e-waste each year the lion's share of which comes from ship breaking industry alone (2.5 million tons) and the amount of e-waste being generated in Bangladesh is increasing at an alarming rate of 20% each year (Prothom Alo, 2021).

From consumers side it is not easy to repair or update their existing e-waste devices and sometime impossible as well, which results in a high turnover rate of electronic goods and the design of electronic products as well as changing technology. In addition, expanding markets in emerging nations, innovative gadgets, and an increase in the incorporation of electronics into already existing items (such refrigerator LCD screens) all contribute to the rising annual consumption of electronic products.

If not correctly managed, the toxic chemical components of e-waste could have adverse effects on ecosystems and human health (Rahman, 2016). This poses a pressing obstacle to accomplishing sustainable development objectives (Rahman, 2016). Since e-waste is considered hazardous waste, recycling it in an ecologically friendly treatment facility is expensive. E-waste recycling in less economically developed nations, where labor is less expensive, is one potential solution. E-waste has turned into a sought-after "commodity" since recycling it offers many people in these nation job chances and lucrative business opportunities (Rahman, 2016).

When electronic waste is improperly disposed of, it can release harmful substances like lead, cadmium, flame retardants, and others into the environment and harm people's health (Widmer, et al., 2005; Robinson, 2009; Luo, et al., 2011). Improperly recycled electronics may wind up in landfills, where they might lose otherwise recoverable elements and leak hazardous

substances into the groundwater (Zeng, et al., 2018). As an alternative, abandoned e-waste may be exported to low or middle-income nations where the materials are recycled using risky processes that endanger the workers and pollute the local environment (Wong, et al., 2007; Grant, et al., 2013; Arain & Neitzel, 2019). Recycling e-waste, however, may recover valuable metals that would otherwise need to be mined to create new devices and limit the amount of hazardous trash that ends up in landfills when done properly (Wang, et al., 2012).Therefore, aim of this paper is to evaluate knowledge and awareness regarding e-waste.

It is crucial in the modern world to address the e-waste problem. On the one hand, e-waste is not only a source of hazardous substances, but also a source of valuable metals like copper, aluminum, gold, silver, and other metals (Borthakur & Govind, 2017).

Rationale of The Study

In industrialized nations, the significance of efficient e-waste management is understood and is quite successful. Unfortunately, most developing countries were unable to do so because of a variety of reasons, including a lack of legislation, unfair transnational trade, sociocultural factors, a lack of consumer and producer responsibility, a lack of self-control, etc. In particular, the continents of Asia and Africa became e-waste dumps as a result of these rising nations' shortcomings. However, there has been a significant shift in recent years from the developing nations, who have a strong desire to adhere to the specialized e-waste management methods through partnerships or through independent businesses (Gollakota, et al., 2020).

Bangladesh is evolving with increasing technology usage. An economically successful nation can benefit from environmentally friendly and secure technology, but the waste produced by these electronic products can be quite harmful. EEEs are consumed and then thrown out in Bangladesh without taking environmental costs or sustainability into account (ESDO, 2012).

The current administration is devoted to creating an ICT-based society to stimulate economic growth. As a result, many ICT-related legislation have recently been adopted, which are essential to standardizing this industry (Rahman, 2016). Digital Bangladesh is a designation that involves the use of IT for management, administration, and governance to promote openness, accountability, and accountability at all levels of citizens and the state. E-waste production from the general use of primary commodities like computers, televisions, and mobile phones surged in Bangladesh along with economic expansion. The administration has acknowledged the need to increase the nation's capacity in the field of information technology (Rahman, 2016).

From the standpoint of effective waste management, collection programs are required to collect consumer e-waste before transporting used appliances to specialized facilities for

treatment. E-waste is heterogeneous and complicated, so it should ideally not be collected and handled with other common solid wastes like municipal rubbish, metal scraps, or plastic scraps. The treatment criteria necessary to recover all e-waste elements and reduce environmental impacts cannot be reached by conventional trash processing techniques including landfills, municipal incinerators, and metal recyclers (Wang, 2014). It is crucial to comprehend the current definition of e-waste, how it has changed over time, as well as the factors that influence and obstruct its evaluation and safe disposal, particularly in the context of the youth population.

For some reasons, the study's target audience is university students. University students are heavy users of technology devices. For a technologically evolved society and educational purposes, they must use electronic devices for an extended period of time. It is critical that university students grasp the need of sustainable e-waste management techniques in order to hold them accountable and bring about social and behavioral change in the near future. As a result, an exploratory survey on sustainable e-waste management practices awareness, knowledge, and engagement is being undertaken in this study. Along with this, the study discussed the existing state of e-waste recycling in Bangladesh, as well as the associated regulatory framework and practices. The study offers some useful recommendations for practitioners to encourage sustainable e-waste management practices among university students based on analysis.

Scope of The Study

Though electronic devices & appliances come in disparate varieties, this study tries to identify how the widely used household appliances (light, fan, AC, microwave oven, blender) and communication devices (cell phone, laptop, computer, and desktop) contribute to the development of e-waste. Hence, the focus of this study aligns with the high probability of e-waste generation and also with the target group of the study. We've tried to add different dimensions like types of education institutes of respondents'' to perceive their understating & the inherent difference in their perception regarding e-waste. A thorough comparison among different variables have also been presented in the study to better capture this difference. To identify the level of knowledge & awareness regarding e-waste among the university students, this study delineates the outcome of the survey responses with the help of statistical analysis by incorporating Linear Probability Model (LPM) which is the uniqueness of this study. A significant number of studies confine their analysis only to graphical description but in this study, we've tried to establish a model to identify the relationship between respondents'' Willingness to Pay (WTP) & level of knowledge & level of awareness regarding e-waste. Though the result is not convincing enough, it still provides us with an opportunity of future investigation. Limited

numbers of data could have been collected due to time constrains which is one of the biggest shortcomings of this study. But even with this limited information we're sanguine that there is scope of future study in this arena if a large number of data can be collected with enough time & resources.

LITERATURE REVIEW

Modern equipment quickly becomes obsolete due to the speedy development of new technology. When electrical appliances and electronic devices are used and eventually become e-waste after an average life cycle, toxic substances are left behind that have a detrimental effect on the environment (Chi, et al., 2003; Nnorom & Osibanjo, 2008; Onwughara, et al., 2010). Large-scale production of e-waste that includes both dangerous and beneficial components (Zhan & Xu, 2014). These e-wastes can provide health and environmental dangers to people, animals, and the environment, if necessary, safeguards aren't taken (Hossain, et al., 2010). E-waste management, put simply, is the process of gathering, storing, treating, and properly discarding e-waste in order to safeguard both humans and the environment (Attah, 2013). Lack of knowledge and warnings about appropriate and effective e-waste management procedures, particularly when handling or reusing outdated gadgets, may put people at risk for health problems (Hossain, et al., 2010). E-waste treatment is risky, difficult, and expensive from an environmental perspective (Inoka, 2018).

Modern electronics can contain up to 60 distinct elements such as metals, polymers, and other substances; many of these components are useful, while others are harmful or both (United Nations Environment Programme, 2009; United Nations University (UNU), 2009). Iron, aluminum, polymers, and glass make for more than 80% of the weight of most modern appliances (EMPA, 2009). Iron, aluminum, copper, zinc, and lead are the five most common metals. The most complex mixture of substances is commonly found in printed wiring boards (PWBs) or circuit boards, which include both precious and dangerous metals (Centre for Environmental and Resource Management (CERM), 2018). Even though they make up a smaller portion of an electrical equipment, expensive and hazardous materials are nonetheless quite important. The material makeup of various electronic equipment may be similar, yet the percentages may vary. People are drawn to recycling e-waste because it contains valuable materials like gold, silver, copper, and platinum, but doing so also releases hazardous materials like lead, arsenic, lithium, mercury, and nickel, which are dangerous to human health and the environment if improperly handled (Rahman, 2016).

One of the waste sources that is growing the fastest globally is e-waste (Lundgren, 2012), 22% of the world's e-waste is produced in the United States (Baldé, et al., 2017). Among

the Midwestern states without e-waste legislation are North Dakota, South Dakota, Nebraska, Kansas, Iowa, and Ohio. The remaining Midwestern states with producer responsibility legislation include Minnesota, Wisconsin, Illinois, Missouri, Indiana, and Michigan. Studies from many communities throughout the world have repeatedly shown that consumer's under-recycle their gadgets, despite the significance of each component varying (Nnorom, et al., 2009; Wang, et al., 2016; Echegaray & Hansstein, 2017; Favot & Grassetti, 2017). Additionally, it has been discovered that socioeconomic factors like wealth and education have a significant role in influencing recycling behavior (Saphores, et al., 2006; Song & Wang, 2012). Cost and incentives are significant variables of recycling behavior when employing traditional recycling materials (Hornik & Madansky, 1995).

The quantity of e-waste flowing into full recovery facilities, unofficial recyclers, public awareness, and government legislation regarding e-waste all have an impact on the pollutant flows that end up in landfills explained by Soo, et al., (2013) in their article titled "E-waste Assessment in Malaysia". According to the study, the following driving variables helped reduce waste production. Public awareness, incentives, and law enforcement had varying effects on Malaysia's long-term e-waste generation. An important factor in lowering the environmental damage caused by chemicals from mobile phones and the recycling of those devices was raised public awareness (Rahman, 2016).

Except for the US, all industrialized nations have ratified the UN Basel Convention, which prohibits the transfer of hazardous waste to developing countries (United Nations (UN), 1989). Due to the high cost of recycling and processing due to environmental and health concerns, India has also grown to be a popular site for wealthier nations to dump their electronic waste (Subhaprada & Kalyani, 2017).

To solve the E-Waste Problem (StEP) programs E-Waste World Map shows that Tanzania produced 26,000 tons of e-waste in 2014, or 0.5 kg per person (STEP, n.d.). Similar to this, according to estimates from UNIDO, 18,000 to 33,000 tons of e-waste are created annually (Magashi & Schluep, 2011). Numerous studies have demonstrated that the prevalence of e-waste is higher in developing countries like Tanzania due to the lack of institutional recycling systems, rules, and legislation pertaining to e-waste (Sthiannopkao & Wong, 2013; Heeks, et al., 2015).

According to Zaccaï (2008), consumer behavior is vital in environmental actions like buying environmentally friendly electronics, retaining and using electronics to lessen their harmful effects on the environment, and criticizing disposal procedures. Environmental ethics serves as a bridge between the other two disciplines, according to Solomon(2010) analysis of the three critical disciplines that are necessary to the improvement and protection of the

environment: environmental education, environmental laws, and ethics. Nnorom, et al. (2009) explained a model illustrating consumers' awareness of and attitude toward environmental preservation was developed as part of the initiative of consumers' willingness to pay (WTP) for greener product purchases (Kumar & Dixit, 2018).

Public awareness of e-waste management is low explained by Supian, et al. (2015) in their published article “Current waste generation of e-waste and challenges in developing countries: an overview”. According to the study, most consumers were unaware of the proper way to dispose of e-waste, and government and institutional promises were not kept because there was insufficiently strict and consistent enforcement. In addition, low-cost equipment and manual segregation were prevalent, and the informal sector plays a significant role. To achieve best practices in e-waste management, the research suggested that methodical e-waste management policies and guidelines in developing countries need to be improved. Additionally, because proper treatment comes with high capital and maintenance costs, the problems in these developing nations are made even more difficult by a lack of financial support (Rahman, 2016).

EEEs are consumed and subsequently dumped in Bangladesh without taking environmental costs or sustainability into account (ESDO, 2012). The Bangladesh Environment Conservation Act-2010 was proposed by the department of the environment to address e-waste management, however the ministry of law recommended that it be included in a separate act (Karim, et al., 2014). The issue is currently causing the government of Bangladesh great anxiety. The annual production of e-waste in Bangladesh is close to 2.7 million metric tons (Sadik, et al., 2017). And as the use of electronic products grows, the amount of e-waste produced is growing dramatically (Sadik, et al., 2017). In underdeveloped nations like Bangladesh where formal recycling equipment is unavailable and informal operators are collecting precious metals through illegal means for quick cash, the dumping of e-waste combined with solid urban waste poses a greater hazard to environmental deterioration (Sadik, et al., 2017).

According to the study “Environmental and health challenges of the global growth of electronic waste” defined by Liu, et al (2012), communities exposed to e-waste should pay close attention to the hereditary effect, specifically cytogenetic damage. Within the context of the scenario of health concerns in e-waste recycling locations, long-term genetic impacts are a crucial issue. Most of these recycling facilities have been in operation for more than ten years, with prolonged exposure to harmful elements in e-waste. Both the immediate surroundings and people may experience the expanding effect. Additionally, the researcher advises nations to construct centers of excellence for e-waste evaluation and management, drawing on already-

existing businesses engaged in trash management and recycling to lessen biological consequences. The management of e-waste, including the recycling process, exports, and imports, should be developed through the establishment of reasonable regulations in both emerging and developed nations (Rahman, 2016).

E-waste management in Bangladesh by Rahman, et al (2011) stated that regulatory agencies must be established in each district, comprehensive laws governing the management and disposal of hazardous wastes must be written, strict laws prohibiting the dumping of e-waste must be enforced, the polluter-pays principle and expanded producer responsibility must be adopted, and NGOs and the private sector must be encouraged and supported in their efforts to address the issue (Rahman, 2016).

OBJECTIVES

Overall Objective

Main goal of this study is to investigate the degree of knowledge and awareness apropos to e-waste among university students in Bangladesh along with the analysis of current policy gap and environmental management concerns regarding e-waste.

Specific Objectives

- Evaluating the current situation of e-waste in Bangladesh.
- Evaluating the knowledge level and awareness of university students regarding e-waste.
- Evaluating the effectiveness of existing legislation regarding e-waste in Bangladesh.
- Discovering Bangladesh's challenges in managing e-waste.

RESEARCH METHODOLOGY

Survey Procedures and Sampling Framework

The aim of this survey was to identify the level of knowledge and awareness related to e-waste among university students in Bangladesh. To ensure statistical credibility & unbiased response, simple non-random sampling like judgmental or purposive sampling had been used which is concomitant to previous literatures as well (Azodo, et al., 2017; Chen & Yee, 2011; Subhaprada & Kalyani, 2017). As the population for the study was quite large, researcher's own judgement, expertise and knowledge were used to select the representing sample. Since the total population is unknown, $n = \frac{z^2(p \times q)}{d^2}$ is the formula to find out the sample size. Here z is score for confidence level 95%, p is the sample size and q is (1-p). d is the margin of error which is estimated 5%. The total number of responses were 161 but only 150 responses were

accepted as rest of the 11 responses were incomplete. Due to time constrain it was not possible to increase the sample size. The survey questionnaire was e-mailed & shared in various platform to ensure unbiased response. A handful of responses were collected face to face.

Data Collection Method

The survey questionnaire contained mainly close ended questions with few open-ended questions. It was divided into multiple subsections to collect information regarding different aspects of the topic selected. The content of the sub-sections is summarized as follows:

- Demographic Information: Information regarding respondents' gender, age, university name, department name, education level & home division were collected in this section.
- Type of E-Waste Generated: Information regarding number of communications devices being used, number of households appliances being used and how many of these became have become obsoleted in last five years were collected.
- Level of Knowledge Regarding e-waste: Respondents' familiarity with the concept of e-waste, familiarity with concept of 3R, knowledge regarding e-waste recycling, source of learning about e-waste & e-waste recycling were collected in this section.
- Level of Awareness Regarding e-waste: Respondents' awareness regarding harmful effect of e-waste to our health & environment, awareness regarding e-waste collection schemes, recycling programs or campaigns and policies, rules, or regulations were collected.
- Level of Environmental Awareness: Respondents' awareness regarding how e-waste can damage the environment was collected.
- Attitude towards e-waste Generation & Recycling: What do respondents generally do with those obsolete electrical and electronics communicating devices & household appliances were collected along with the information if respondents' have ever participated in any e-waste recycling campaign.
- Willingness to Pay Behavior: Adequacy of the current policies, rules & regulations regarding e-waste, willing to pay money to establish e-waste collection and recycling center in their area & how much money respondents are willing to pay for a hypothetical establishment of e-waste collection center in their area were collected (Rahman, 2016).

No responses were collected without the consent of the respondent & a disclosure has also been mentioned at the beginning of the survey questionnaire in case of online response. This was done to justify the study from an ethical point of view and to ensure that the respondents are aware of the information that they are providing. No sensitive private

information of respondents was collected to ensure that respondents feel safe while they are providing information apropos to the topic.

Data Analysis

For statistical analysis, we used Linear Probability Model (LPM) which looks like a typical linear regression model but the regressand in a LPM model is dichotomous or binary (Aldrich & Nelson, 1984; J.M.Woolridge, 2015; Amemiya, 1985; W.C.Horrace & R.L.Oaxaca, 2006). This is because the conditional expectation of regressand Y_i given regressor X_i, $E(Y_i|X_i)$, can be interpreted as the conditional probability that the event will occur given X_i, that is, $\Pr(Y_i = 1|X_i)$.
Consider the following regression model,

$$Y_i = \beta_1 + \beta_2 X_i + u_i \qquad (1)$$

Where X = Willingness to pay (WTP) for each individual respondent and Y = 1 if the respondent has knowledge/awareness regarding various dimensions of e-waste. Thus, in our model, $E(Y_i|X_i)$ gives the probability of an individual having knowledge/awareness regarding e-waste whose WTP is the given amount X.
Assuming $E(u_i) = 0$, we obtain,

$$E(Y_i|X_i) = \beta_1 + \beta_2 X_i \qquad (2)$$

Now if P_i = probability that $Y_i = 1$ that is, individual has knowledge/awareness regarding e-waste and $(1 - P_i) =$ probabilioty that $Y_i = 0$ that is induvial has no/partial knowledge/awareness regarding e-waste, then the variable Y_i has the following probability distribution:

Y_i	Probability
0	$1 - P_i$
1	P_i
Total	1

That is, here Y_i follows Bernoulli probability distribution. Now, considering the definition of mathematical expectation, we can obtain the following:

$$E(Y_i) = 0\ (1 - P_I) + 1\ (P_i) = P_i \qquad (3)$$

Now comparing equation (2) with equation (3), we can obtain the following equation:

$$E(Y_i|X_i) = \beta_1 + \beta_2 X_i = P_i \qquad (4)$$

Since the probability P_i must lie between 0 and 1, we have the following restriction:

$$0 \leq E(Y_i|X_i) \leq 1 \qquad (5)$$

That is the conditional probability must lie between 0 and 1.
The hypothesis assumed in case of our model is following:
H_0 = Probability of individual's knowledge/awareness doesn't increase with the increase in WTP
$H_1 =$ Probability of individual's knowledge/awareness increases with the increase in WTP

To measure the level of knowledge we considered 3 dimensions: 1) knowledge of individual respondents regarding e-waste 2) knowledge of individual respondent regarding triple R 3) knowledge of individual respondent regarding e-waste recycle. We took a product of these 3 different dimensions under knowledge to get an overall idea of individual's knowledge regarding e-waste. To measure the level of awareness, we considered 2 different dimensions: 1) awareness of individual respondent regarding harmful effect of e-waste on our health 2) awareness of individual respondent regarding harmful impact of e-waste on environment. Here, we also took a product of these 2 dimensions to get an overview of the individual's awareness.

RESULTS

Demographic Information

Total respondents of the survey were 150. Among them 105(70%) male and 45(30%) female respectively (Edumadze, et al., 2013; Azodo, et al., 2017; Subhaprada & Kalyani, 2017). Age range among the participants was below 18 years (3%), between 18-21 years (24%), between 22-25 years (57%) and above 25 years (16%). Maximum students were from undergraduate level about 77% (116), graduate was 15% and postgraduate were 8% (Azodo, et al., 2017). Students from both public and private university were taken part in survey. 61% of students were from public universities and 39% students are from private universities. According to our survey data most of the respondents' home district were mostly in Dhaka division (54%) and the rest were from other district.

Types of e-waste Generated

We asked about mostly used communication devices such as desktop, computer, laptop, and cellphone. Majority of the respondents use cell phone (91%), other use laptop (65%) and the rest use computer (33%) and desktop (11%) (Arain & Neitzel, 2019; Ramzan, et al., 2019). 41% respondents identified that last five years they had 1 obsolete device, 35% had 2 obsolete devices. About 9% and 15% respondents responded that they have 3 and more than 3 obsolete devices respectively. Mostly used household appliances were air conditioner, microwave oven, fan, light, blender and television. Among 150 respondents 95% (143) uses light and fan, 81% (121) uses television, 73% (110) uses blender, 55% uses microwave oven, 46% uses AC and 44% respondents mentioned that they use other electronic appliances. In the case of number of obsoleted household appliances 34% respondents identified that last five years they had 1 obsoleted household appliance, 29% had 2 obsolete devices, 27% had 3 obsoleted devices and 10% had more than 3 obsoleted devices.

Level of Knowledge Regarding e-waste

In our study more than half of the respondents were familiar with the concept of e-waste. This is actually good that the students' awareness about e-waste is not much low. 32% respondents had partial knowledge regarding e-waste and 13% of students didn't have any idea about e-waste. A previous survey by Sadik, et al. (2017) also found that more than half of the respondents are familiar with the concept of e-waste. Another survey by Chen & Yee (2011) found that least percentage students are familiar with the concept of e-waste.

In the question about the concept of triple R less than half of the respondents know about e-waste recycling. This shows that the student's knowledge regarding e-waste recycling is much low. 44% respondents have partial knowledge regarding e-waste recycling. 18% of students didn't have any idea about e-waste recycling. Respondent (56%) heard of e-waste from online sources. It is worth noting that 11% of the respondents heard of e-waste from textbook indicating the complementary role of education system. This prove that not much of e-waste is heard or taught through our educational system. 6% respondents learnt from friends and family and 2% learnt from government campaign. Which shows that they are not exposed through government or educational effort at all unlike the other pollution like air, water or sound pollution. There is huge lack of initiative to educate the youngsters about the e-waste. Two previous survey Edumadze, et al. (2013) and Sadik, et al. (2017) found same results.

Level of Awareness

Those who know about e-waste (60%) are aware of the hazardous effect on health. 22% respondents know partially and 18% have no idea. But at least maximum respondents know about the hazardous effects on health and it is somehow good. 71% of respondents are aware of the hazardous effect of e-waste on environment. 17% respondents know partially and 12% have no idea. 65% of the total respondents are aware that hazardous elements require special treatment for environmentally sound disposal. 19% are partially aware and 7% responded that they are not aware these hazardous elements require special treatment for environmentally sound disposal. Few respondents are aware of policies, rules, or regulations regarding e-waste, 27% knows partially. But 39% are not aware of any policies, rules, or regulations. 33% respondents are aware of collection schemes, recycling programs or campaigns regarding e-waste, 25% are partially aware and 42% are not aware about it at all.

Level of Environmental Awareness

46% respondents strongly agreed that if e-waste is not treated in environmentally friendly way, it can damage the environment. Regarding the same question 30% are agree, 15% are neutral, 1% disagree and 7% are strongly disagree. 53% respondents strongly agree that everyone should contribute to prevent environmental damage. 26% are agree, 11% are neutral, 2% disagree and 8% are strongly disagree.

Attitude towards e-waste Generation & Recycling

Very few respondents attended in any type of e-waste recycling campaign, 54% of the respondents were not aware of any recycling program. 9% of the respondents were concern about their safety and another 9% found recycling process inefficient. 3% respondents did not think those programs are important. And rests 25% did not attend for other reason. Many of respondents (42%) indicated that they keep them away for no reason, 17% use for exchange, 15% recycle obsolete devices, 10% donate to others and a similar percentage of the respondents (9%) throw as waste. And rest 8% give those devices to kids as toy.

Some other survey also found same result where they found maximum respondents keep obsolete electrical and electronics communicating devices for no reason (Chen & Yee, 2011; Sadik, et al., 2017; Kaijage & Mtebe, 2017). Another survey found that large number of respondents fix and re-use their obsolete communication devices (Azodo, et al., 2017). 25% of the respondents keep obsolete household appliances for no reason, 25% use for exchange, 21% throw as waste and 17% recycle those obsoleted devices. 8% donate to others and 4% give those devices to kids as toy. 46% respondents think current policies, rules & regulations regarding e-waste are inadequate while 37 % think partially inadequate. 17% think current policies, rules & regulations are adequate.

Willingness to Pay & Behavior to Get Involved

56% respondents wished to participate e-waste recycling process/campaign in future, 37% may participate and 7% respondents do not want to participate any recycling campaign in future. In the question of establishing e-waste collection and recycling centre 31% responded “yes”, 43% responded “maybe” and 2% responded “no” that they are willing to pay to establish e-waste collection & recycling center in their area.

Level of Awareness vs Gender, Age & Types of Educational Institutions of The Respondents

Among 150 respondents, 105 are male and 45 are female (Table 1). Between male and female respondents about similar percentage of respondents are aware of harmful effect of e-waste to our health and environment. But female respondents are more aware of policies, rules, or regulations are aware of collection schemes, recycling programs or campaigns regarding e-waste than respondents. Female respondents represent 40% while male respondents represent around 30%.

Table 1: Relationship between Level of Awareness & Gender

Variables	Male (105)		Female (45)	
Are you aware of harmful effect of e-waste to our health?	Yes (63) (60%)	No/Partially (42) (40%)	Yes (27) (60%)	No/Partially (18) (40%)
Are you aware of harmful effect of e-waste to environment?	Yes (74) (71%)	No/Partially (31) (29%)	Yes (32) (71.1%)	No/Partially (13) (28.9%)
If yes, are you aware that these toxic/hazardous elements require special treatment for environmentally sound disposal?	Yes (66) (63%)	No/Partially/N/A (39) (37%)	Yes (31) (69%)	No/Partially/N/A (14) (31%)
Are you aware of any policies, rules, or regulations regarding e-waste?	Yes (32) (31%)	No/Partially (73) (69%)	Yes (18) (40%)	No/Partially (27) (60%)
Are you aware of collection schemes, recycling programs or campaigns regarding e-waste?	Yes (31) (30%)	No/Partially (74) (70%)	Yes (18) (40%)	No/Partially (27) (60%)

Table 2 shows, 36 respondents are from age group 18-21, 85 respondents are from age group 22-25, and 24 respondents are from age above 25 years. Age group of 18-21 are more aware of harmful effect of e-waste to our health and environment than other two age group. While both age group of respondents 18-21 and 22-25 years are more aware of environmentally sound disposal of e-waste and collection schemes, recycling programs or campaigns than

above 25 years age group. But regarding policies, rules, or regulations above 25 age group are more aware than other two age group.

Table 2: Relationship between Level of Awareness & Ages Distribution

Variables	Below 18 years (5)		18-21 years (36)		22-25 years (85)		Above 25 years (24)	
Are you aware of harmful effect of e-waste to our health?	Yes (1) (20%)	No/Partially (4) (80%)	Yes (26) (73%)	No/Partially (10) (27%)	Yes (51) (60%)	No/Partially (34) (40%)	Yes (12) (50%)	No/Partially (12) (50%)
Are you aware of harmful effect of e-waste to environment?	Yes (2) (40%)	No/Partially (3) (60%)	Yes (29) (81%)	No/Partially (7) (19%)	Yes (64) (75%)	No/Partially (21) (25%)	Yes (11) (46.1%)	No/Partially (13) (54%)
If yes, are you aware that these toxic/ hazardous elements require special treatment for environmentally sound disposal?	Yes (1) (20%)	No/Partially/N/A (4) (80%)	Yes (24) (67%)	No/Partially/N/A (12) (33%)	Yes (57) (67%)	No/Partially/N/A (28) (33%)	Yes (15) (63%)	No/Partially/N/A (9) (37%)
Are you aware of any policies, rules, or regulations regarding e-waste?	Yes (2) (40%)	No/Partially (3) (60%)	Yes (10) (28%)	No/Partially (26) (72%)	Yes (28) (33%)	No /Partially (57) (67%)	Yes (10) (42%)	No/Partially (14) (58%)
Are you aware of collection schemes, recycling programs or campaigns regarding e-waste?	Yes (1) (20%)	No/Partially (4) (80%)	Yes (12) (34%)	No/Partially (24) (66%)	Yes (29) (35%)	No /Partially (56) (65%)	Yes (7) (30%)	No /Partially (17) (70%)

Table 3: Relationship between Level of Awareness & Types of Educational Institutions

Variables	Public University (91)		Private University (59)	
Are you aware of harmful effect of e-waste to our health?	Yes (60) (66%)	No/Partially (31) (34%)	Yes (30) (51%)	No/Partially (29) (49%)
Are you aware of harmful effect of e-waste to environment?	Yes (65) (71%)	No/Partially (26) (29%)	Yes (41) (70%)	No/Partially (18) (30%)
If yes, are you aware that these toxic/hazardous elements require special treatment for environmentally sound disposal?	Yes (59) (65%)	No/Partially/N/A (32) (35%)	Yes (38) (64%)	No/Partially/N/A (21) (36%)
Are you aware of any policies, rules, or regulations regarding e-waste?	Yes (34) (37%)	No/Partially (57) (63%)	Yes (16) (27%)	No/Partially (43) (73%)
Are you aware of collection schemes, recycling programs or campaigns regarding e-waste?	Yes (34) (37%)	No/Partially (57) (63%)	Yes (15) (25%)	No/Partially (44) (75%)

Table 3 shows comparison between respondents from different public and private universities. Similar percentage of students from both public and private universities aware of harmful effect of e-waste to environment and hazardous elements require special treatment for environmentally sound disposal. Where awareness of harmful effect of e-waste to environment is higher than awareness of toxic/hazardous elements require special treatment for environmentally sound disposal. But awareness regarding harmful effect of e-waste to our health, policies, rules, or regulations and collection schemes, recycling programs or campaigns regarding e-waste are higher among public university students than private universities. Still percentage is lower. 37% (34) respondents are aware of policies, rules, or regulations and collection schemes, recycling programs or campaigns regarding e-waste. For private universities this percentage is about 26%.

Level of Knowledge vs Gender, Age & Types of Educational Institutions of The Respondents

Table 4: Relationship between Level of Knowledge & Types of Educational Institutions

Variables	Public University (91)		Private University (59)	
Are you familiar with the concept of e-waste?	Yes (54) (59%)	No/Partially (37) (41%)	Yes (28) (47%)	No/Partially (31) (53%)
Are you aware of the Triple R (Reduce, Reuse and Recycle) for waste management?	Yes (55) (60%)	No/Partially (36) (40%)	Yes (35) (59%)	No/Partially (24) (41%)
Do you have any knowledge regarding e-waste recycling?	Yes (36) (39%)	No/Partially (55) (61%)	Yes (21) (35%)	No/Partially (38) (65%)

Table 4 shows another comparison between public and private university students. Respondents from public universities are more aware of concept of e-waste, Triple R and waste recycling than students at private universities. But respondents from both types of universities have much lower knowledge regarding e-waste recycling.

Table 5: Relationship between Level of Knowledge & Gender

Variables	Male (105)		Female (45)	
Are you familiar with the concept of e-waste?	Yes (55) (52%)	No/Partially (50) (48%)	Yes (27) (60%)	No/Partially (18) (40%)
Are you aware of the Triple R (Reduce, Reuse and Recycle) for waste management?	Yes (62) (59%)	No/Partially (43) (41%)	Yes (28) (62%)	No/Partially (17) (38%)
Do you have any knowledge regarding e-waste recycling?	Yes (41) (39%)	No/Partially (64) (61%)	Yes (16) (36%)	No/Partially (29) (64%)

Female respondents are more aware regarding e-waste and Triple R than male respondents. But both male and female respondents are not or partially aware of e-waste recycling, representing 64% female and 61% male (Table 5).

Table 6: Relationship between Level of Knowledge & Age Distribution

Variables	Below 18 years (5)		18-21 years (36)		22-25 years (85)		Above 25 years (24)	
Are you familiar with the concept of e-waste?	Yes (1) (20%)	No/ Partially (4) (80%)	Yes (21) (59%)	No/ Partially (15) (41%)	Yes (49) (58%)	No/ Partially (36) (42%)	Yes (11) (46 %)	No/ Partially (13) (54%)
Are you aware of the Triple R (Reduce, Reuse and Recycle) for waste management?	Yes (3) (60%)	No/ Partially (2) (40%)	Yes (23) (64%)	No/ Partially (13) (36%)	Yes (54) (64%)	No/ Partially (31) (36%)	Yes (10) (42. 1%)	No/ Partially (14) (58%)
Do you have any knowledge regarding e-waste recycling?	Yes (2) (40%)	No/ Partially (3) (60%)	Yes (13) (36%)	No/ Partially (23) (64%)	Yes (35) (41%)	No/ Partially (50) (59%)	Yes (7) (29 %)	No/ Partially (17) (71%)

About similar percentage of respondents from age group 18-21 years and 22-25 years are aware of the concept of e-waste and 3R, representing 59% for e-waste and 64% for 3R respectively. Above 25 age group has lower knowledge. Every age group has lower knowledge regarding e-waste recycling.

Inferential Statistical Analysis

Table 7: Linear Probability Model Showing Relationship between Level of Knowledge & WTP

Knowledge	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Lnwtp	.002	.016	0.10	.924	-.03	.033	
Constant	.144	.099	1.46	.146	-.051	.34	
Mean dependent var		0.153	SD dependent var			0.362	
R-squared		0.000	Number of obs			150	
F-test		0.009	Prob > F			0.924	
Akaike crit. (AIC)		123.434	Bayesian crit. (BIC)			129.455	

**** p<.01, ** p<.05, * p<.1*

In table 7, we measured the probability of increase in the level of knowledge of each induvial respondent regarding e-waste, with the increase in the willingness to pay (WTP). From

table 1, it is apparent that with increase in WTP by 1 unit, the probability increase of individual's knowledge is .002. Thus, it can be inferred that, individuals who are willing to pay more to establish recycling center has knowledge regarding e-waste. Everyone's increase in probability is also between 0 to 1 which is in line with the conditions of probability. But the high p-value doesn't readily allow us to accept the co-efficient and the r-squared value is very low. Though the result matches with our expectation but it is not statistically significant because of the quirkiness of individual's responses. A thorough analysis of the responses shows us the even when respondents do not have knowledge of e-waste, they are still willing to pay a significant sum of money toward the cause which is not rational. Since, a lot of human action can't be rationally justified, we also fail to justify our result because of this limited data. Since the result meets our expectation but insignificant, it can be inferred that a large set of data may provide a statistically significant output. Hence, this study opens the way to new investigation which is a unique characteristic of this study.

Similarly in table 8, we face with same dilemma of insignificant output where we measure the increase in the probability of individual's awareness regarding harmful impact of e-waste with the increase in willingness to pay. The resulting co-efficient is in line with our expectation but the high p-value doesn't allow us to accept the result. Though here we have comparatively high r-squared value, still we can't accept the result. We have faced the problem of a small dataset & irrational behavior in this case as well.

Therefore, in case of both the level of knowledge & awareness measurement we cannot reject our null hypothesis, but this doesn't mean that the result is invalid. As for both cases we were able to get expected sign of the coefficient, it allows us to conclude that there is scope of additional investigation in the topic which can unravel new insights regarding the level of knowledge & awareness of university students regarding e-waste in Bangladesh.

Table 8: Linear Probability Model Showing Relationship between Level of Awareness & WTP

Awareness	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Lnwtp	.016	.022	-0.73	.466	-.059	.027	
Constant	.681	.135	5.05	0	.414	.947	***
Mean dependent var		0.587	SD dependent var			0.494	
R-squared		0.004	Number of obs			150	
F-test		0.534	Prob > F			0.466	
Akaike crit. (AIC)		216.621	Bayesian crit. (BIC)			222.643	

*** p<.01, ** p<.05, * p<.1

SUMMARY OF THE FINDINGS

E-waste is a significant problem in Bangladesh & our study shows that more than half of our respondents who are students at university level are familiar with the concept of e-waste (55%). They don't care about recycling e-waste, though and despite being aware of the risks that e-waste poses to human health and the environment, students nevertheless treat it like regular trash. They either keep electronic trash without a purpose or discard it with regular trash which indicates that they are reluctant regarding e-waste management. Regarding the source of knowledge, we have found that internet is the primary source of information for students about e-waste (56%) and only a small portion of students are aware of the laws and regulations governing e-waste (33%) along with the majority being unaware of the waste recycling program. As a result, current laws, rules-regulations, and policies are not very effective. Students won't be able to inform others of this if they are unaware of it. Bangladesh may have significant challenges in handling e-waste due to a lack of information, awareness, and e-waste recycling practices.

RECOMMENDATIONS

E-waste management is not just crucial for the University but also a national initiative. University plays a crucial function in training the industry's workforce to acquire a sound improvement in e-waste management (Chen & Yee, 2011).

The university must do everything possible to raise student awareness of e-waste. An interdisciplinary course on e-waste management should be introduced as a liberal arts subject that must improve students' attitudes about nature and the environment (Edumadze, et al., 2013). Green products, or items made entirely of recycled materials, should be promoted through various incentives, such as financial ones (Sadik, et al., 2017). The carbon and plastic footprint should be as little as possible. Government should take action to raise public awareness of the impending environmental crisis that might result from improper e-waste treatment. Newspapers, electronic media, and social media must step up to continue playing a role in increasing public awareness (Sadik, et al., 2017). It is necessary to create an inventory of the e-waste present in Bangladesh's major cities. Establish an effective collecting system, at the very least for some types of electronic waste [E-waste Management of Bangladesh, 2016]. The nation should implement an effective e-waste collecting and tracking system (Sadik, et al., 2017).

There is greater scope for further research on this topic as in the upcoming days production and use of electronic goods will increase more and more. One major weakness of the study is fewer data set. If it is possible to increase the sample size and the scope of the

study, more exact result will come. Another important point is this study only included the university students who haven't enough earning in their hand to spend for e-waste management. If it is possible to include the young people who have earning, the result will statistically significant with less probability of error.

CONCLUSION

The survey showed that the knowledge of e-waste among respondents was not significantly reduced. They also have a greater understanding of how destructive e-waste is to the environment and our health. However, they are significantly less knowledgeable when it comes to recycling e-waste. Students are less likely to be aware of any government policy. Internet sources make up the majority of the respondent's sources for information on e-waste.

However, respondents who are also college students and are knowledgeable about e-waste do not know about recycling. They maintain their obsolete communication equipment at home for no apparent reason. For broken household appliances, people either keep them for no reason, toss them away, or replace them. No ecologically friendly treatment exists. Students handle e-waste in their own way, just like they would any other type of waste. And it must be altered right away to address the issues in the future days. It is important to educate the next generation about the correct handling of e-waste to raise awareness among them (Sadik, et al., 2017). When addressing e-waste, students frequently employ the following techniques: repair, storage, selling, recycling, and disposal like regular household waste. Universities, apart from the department of Information and Communication Technology, do not offer any courses in green IT or e-waste management. This is one of the factors contributing to the students' lack of knowledge about e-waste management. Consequently, it will be harder for the government to educate the public about e-waste management (Chen & Yee, 2011).

This study also showed that just having a good education is not enough to get students to properly dispose of their electronic waste. In Bangladesh, Dhaka and other large cities create thousands of tons of electronic waste. Additionally, the Covid epidemic increased the usage of information technology. As of right present, the unregulated, low-wage informal sector recycles up to 97% of the garbage. Cleaning, melting, and incineration are also included in the processing phases. There are no safety precautions known to these employees. Through these processes, hazardous metals including lead, cadmium, mercury, chromium, and other pollutants are released into the air along with the precious metals being extracted. This results in environmental contamination. After ten years of effort, on June 10, 2021, the Government of the People's Republic of Bangladesh's Department of Environment (DoE) released its "Hazardous Waste (e-waste) Management Rules 2021" in accordance with the Bangladesh Environmental

Protection Act, 1995. The country's registered electronic waste producers and recyclers are required to submit their WEEE management plans, according to the law. The Department of Environment held a consultation session on Bangladesh's e-waste management on January 9, 2022. It's critical to keep an eye on their job (Haque & Rahman, 2022).

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