A Sustainable E-Waste Management System for Bangladesh

Md. Shahadat Anik Sheikh, Rashik Buksh Rafsan, Hasib Ar Rafiul Fahim, Md. Tabib Khan, and Ahmed Wasif Reza(✉)

Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh
wasif@ewubd.edu

Abstract. The use of electronic devices is increasing rapidly as it is an essential part of our life in today's world. Shown in numbers, it has grown from zero to 7.2 billion in only three decades. There is a 5–10% annual rise in the quantity of used electronic equipment, which, if not correctly disposed of, can result in environmental dangers that harm human health, marine life, and soil fertility. For developing countries like Bangladesh, managing this massive stream of electrical and electronic garbage is challenging due to the lack of solid organizational and governmental e-waste management infrastructure. Lack of public knowledge, policies, and funding in waste management are only a few of the significant causes driving this situation. In this study, a majority of the adopted E-waste management systems and their limitations, along with the proposal of a new and sustainable E-waste management system, have been discussed. The implementation gap of government rules and policies has been highlighted here. The successful application of these recommended strategies could improve Bangladesh's E-waste management capability.

Keywords: E-waste Bangladesh · E-waste collection · Effective E-waste Management

1 Introduction

E-waste is used to describe all sorts of electrical and electronic equipment (EEE) and its parts that have been dumped as wastes by the owner with no intention of re-use [1, 2]. And those expired products are then thrown away or dumped into the environment as people are unaware of their harmful effects [3]. Hazardous substances like lead, mercury, cadmium, barium, and lithium, among others, can be found in e-waste. As a result, the worldwide E-waste management system is a crucial topic to consider, particularly in poor and emerging countries such as ours. Recently, Bangladesh has been approaching rapidly to digitalization with the developing world. Therefore, the use of electronic equipment is increasing rapidly, and these products are also expiring. But those e-wastes are not appropriately managed and hamper our environment, health, etc. Also, in Bangladesh, there is no active policy from the government for e-waste management, but some third-party organizations of Bangladesh are trying to manage these e-wastes sustainably. This

© ICST Institute for Computer Sciences, Social Informatics and Telecommunications Engineering 2023
Published by Springer Nature Switzerland AG 2023. All Rights Reserved
Md. S. Satu et al. (Eds.): MIET 2022, LNICST 491, pp. 739–753, 2023.
https://doi.org/10.1007/978-3-031-34622-4_58

is a significant issue affecting nature's ecosystem and human health and should be addressed accordingly.

During this time of globalization, Bangladesh has been working on industrial transformation to become a middle-income country. However, in the name of E-waste, it has its drawbacks. E-waste is increasing proportionally as more IT platforms are formed in Bangladesh, and the use of electronic gadgets in households rises daily. It could have long-term harmful implications if it is not dealt with quickly. As the world advances toward a greener future, E-waste policies are being implemented to aid in this goal. Proper management systems are being discovered to ensure a better and healthier world.

1.1 Background

Electronic waste has the potential to seriously harm the environment and its sustainability. As a result, it must be appropriately controlled and disposed of. In recent years, the amount of e-waste has gone over the roof due to excess use and easily broken products. E-waste represents 5% of municipal solid trash generated globally, as emerging countries invest more in electronics [4]. Bangladesh produces around 2.81 million metric tons of E-waste each year. In the north-eastern area of this country, 36.3% of women who live near recycling sites have lost a child. Because of E-waste mishandling, around 15% of child workers die, and 83% of child laborers are seriously exposed to E-waste pollutants and struggle with long-term health issues [5].

Every electronic equipment is made up of different materials and compositions, with different use and functions, characteristics, structure, and prices. As a result, conventional waste disposal procedures should not be utilized to dispose of e-waste. Being made from various hazardous and reactive materials such as lead, sulfur, and plastic, among others, combining those components with other wastes may cause significant harm to the environment and ecosystem, as well as be highly hazardous to human life [6]. For better e-waste management, collection schemes need to be aggregated from the product users before throwing away or sending those waste products to treatment in facilities. Landfilling, dumping, and other traditional waste disposal methods cannot be utilized to appropriately diagnose and manage e-waste and prevent adverse environmental consequences [5].

Several wealthy countries have built infrastructures and technology to effectively handle and re-use E-waste while minimizing environmental and health hazards. Bangladesh, on the other hand, as a developing country, lacks access to such E-waste processing processes as well as the legislative framework to ensure efficient E-waste management [7]. Digitalization of Bangladesh is mostly done thanks to the use of technology and science. These technologies are developing our country in a lot of ways, but the lack of proper waste management of these electronic devices is a serious setback that can be very dangerous and damaging. As electronic devices can't be burned or dismantled due to toxicity, so they are often subjected to unsafe re-use, recycling, or dangerous waste disposal. As a result, e-waste has raised serious concerns on a national and even global level. In this study, a good idea about E-waste and its efficient management method has been thoroughly discussed.

1.2 Problem Statement

We live in an age of science and technology. Computers and mobile phones have become widely available and inexpensive to purchase for individuals of all ages. A few people only think of recycling them or re-using them after repairing them. Apart from them, everyone buys new products and discards the old ones, resulting in a massive amount of e-waste in our environment. As a result, the necessity of E-waste management is becoming challenging. However, the world's developed countries are taking steps to dispose of the garbage created by electronic gadgets. Developing and underprivileged countries, according to the author, are falling far behind. Bangladesh, being a developing country, has a knowledge gap in terms of regulations and processes for dealing with E-waste. However, we were unable to locate any systematic review or case study in this field to our knowledge [8].

1.3 Aim

In Bangladesh, there is a lack of managing e-waste appropriately, which causes a significant impact on our environment. This research aims to propose a sustainable way to manage e-waste. The authors are going to collect data, compare existing models, and propose an effective model by visiting different organizations.

1.4 Objective

The objectives of this study are:

- To find out the government's e-waste management policies' effectiveness.
- To compare the policies and practices of e-waste management organizations in Bangladesh with government policies.
- To develop an efficient method of managing e-waste.

1.5 Scope of the Study

This research looks at the management of e-waste in Bangladesh. It is a discussion on how various organizations handle wastage caused by worn out/used/expired electronic equipment such as computers, machinery, and electronic devices. We are not in charge of any other waste management. Furthermore, the research is focused on Dhaka, Bangladesh. The study will be based on observations of the Bangladesh E-waste management scenario.

2 Related Works

The authors of the paper [9] explained the current situation of e-waste management and showed how e-waste management works in Bangladesh. From Fig. 1, we can see that "Repairing," "Recycling," and "Dumping parts which cannot be recycled or repaired" are the methods of informal sectors of Bangladesh. The authors also mentioned that at that time, there were no governmental initiatives on e-waste management. That's why

people were not aware of the harmfulness of e-waste. Also, the author mentioned that A 5–10% annual rise in the quantity of used electrical and electronic equipment that is properly disposed of could lead to environmental dangers that harm human health, destroys marine life, pollutes groundwater, and reduces soil fertility. Insufficient public knowledge, policies, and a lack of funding in the field of waste management are only a few of the significant causes driving this situation. As a result, the authors identified the issue and recommended an e-waste management system. According to the authors, integrating with current e-waste systems will address e-waste management difficulties.

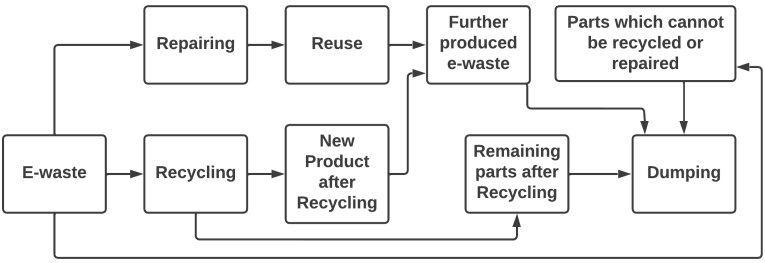

Fig. 1. Informal Scenario of Bangladesh's E-waste Management System [9].

The authors of the paper [10] have mentioned various laws, regulations, and standards for managing e-waste in Bangladesh [11]. The paper, electronic items, and electrical wastes are defined in the law, as well as the responsibilities of manufacturers, consumers, buyers, stores, repairers, collection centers, recyclers, and the ministry. Not only that, but the authors also analyzed the consumer WTP (Willingness to pay) for recycling costs in their research. For analysis, the author gathered information by doing a questionnaire-based survey. By doing that, the author found out that consumers 5–10% WTP will cover the recycling cost of e-waste in Bangladesh. But participants of the survey also mentioned the government's initiatives in e-waste management. For that reason, the author suggested increasing environmental awareness and educating the public about the harmfulness of e-waste to make recycling more convenient. Also, the author mentioned that environmental education is essential for promoting environmental awareness and increasing the WTP of consumers [10].

In the paper [11], The goal was to examine the current state, concerns, and challenges facing Asia Pacific countries, as well as to recommend a path forward for environmentally sound management (ESM) of e-waste [11]. Besides, the author thoroughly explained the regulations and current practices of e-waste in almost every country in the Asia Pacific Region.

The authors of the article [12] evaluated India's e-waste management system to that of other industrialized countries throughout the world. As per a United Nations Environment Program estimate, the volume of e-waste in India might rise by 500% every ten years. In this research, practical recommendations relating to the Indian context, such as financial system sustainability, implementation, legislation and regulation, and monitoring, will play a vital role in the e-waste management system [12].

The author of the paper [13] is developing a new method for estimating the cost and life-cycle effect of e-waste management. Some process models might be investigated to improve recycling and categorize e-waste while minimizing system costs and carbon emissions (such as consumer drop-off, Interfacility Transportation, and System Net Cost, where the cost, energy use, and emissions are associated). A Washington study case based on a process-level life-cycle model is also offered for modeling e-waste collection, transportation, processing, and disposal [13].

The author of the paper [14] analyzed e-waste management in Switzerland and Australia. The government of Switzerland has made e-waste recycling a high contribution. In 2017, 122,800 tons of e-waste were collected in Switzerland for recycling. This adds up to a significant volume of e-waste gathered. By recycling the gathered e-waste, the country achieved tremendous success in e-waste management. This program aims to recycle e-waste rather than landfilling it. As a result of the corresponding section, Australia has had a lot of success with e-waste management.

2.1 Research Questions

- What are the policies of e-waste management of the government of Bangladesh?
- What are the differences in the policies and practices of the e-waste management process in Bangladesh by different organizations?
- What are the hindrances of managing e-waste effectively?

3 Methodology

3.1 Data Collection Method

There are two types of research from a broad perspective. The first is qualitative, whereas the second is quantitative. Qualitative research is descriptive and non-numerical, whereas quantitative study is more concerned with numbers, algorithms, and statistics [15]. Words are used to acquire qualitative information. The nature of the data generated by the research defines the sort of research, not the techniques employed to acquire it. Qualitative data may be obtained using a variety of research methods [16].

There are five different approaches to doing research. Surveys, case studies, simulations, subjective/argumentative research, and action research are the types of research. Surveys, a popular research technique, is helpful for gathering current information and learning about people's latest activities, and by this, we access a large amount of data. A case study can be used to try to describe links between various topics and theoretical ones. Those who wish to investigate a unique circumstance of a present situation or research, where solving issues analytically is difficult, approach the simulation technique. Subjective/argumentative research is used to develop new hypotheses and concepts that may later be evaluated. Action research is the most productive technique because it allows authors to uncover practical answers to real-world issues while still adding theoretical value [17].

Case studies, grounded theory, ethnography, and phenomenology are the most often utilized qualitative research methods. These strategies include a variety of research methodologies. Sampling is one of the approaches. There are several types of sampling,

including simple random sampling, systematic sampling, stratified sampling, cluster sampling, multi-stage sampling, Quota Sampling, Haphazard sampling, and so on [16]. Interviews, which are extensively utilized in qualitative research, are another approach included in these methodologies. Taking interviews is more appropriate for qualitative research. Interviews can be conducted in a structured, semi-structured, or unstructured manner. Structured interviews have well-defined questions and responses. In a semi-structured interview, the questionnaire might expand from its root as the interviewer progresses. An unstructured interview is a free-form conversation [16].

There are two kinds of data gathering: Primary and secondary. Primary data collection refers to information gathered from sources by the investigators themselves. Secondary data collection refers to data obtained from secondary sources such as a database or data pre-collected by other people [17].

Authors have collected data in both ways, primarily and secondarily because authors have interviewed a few e-waste management companies and also collected data from research papers, journals, and so on.

3.2 Interview

It may appear simple at first glance because the conversation is already a strength that the interviewers possess, but it is essential to remember that an interview is not a conversation. The investigator is responsible for passively controlling the conversion flow and ensuring that all relevant data is obtained. When the participant is asked about any vital information, the situation might get a bit odd. A similar situation occurred when one of the authors questioned a participant from "Azizu Recycling & E-Waste Company" about the company's annual income. The participant replied that this information was confidential [16]. But other than that, they have shared all the information related to the research which had been asked. Authors have asked about their strategy to collect, process, and manage e-waste by their company. The participant willingly shared their strategy and showed their types of machinery and how they work and process to dismantle e-waste components.

The interview was semi-structured. The authors have a clear list of topics and questions to discuss and answer during semi-structured interviews. In semi-structured interviews, however, authors have more freedom with the replies and question sequence. The participants are free to answer in their style and can add more information to the initial ones, and the interview can grow from there [16]. So, the authors of this study asked the participants the pre-prepared questions but then allowed them to explain so that more information could be gained from the session.

To be concerned about e-waste management, a country's organizations and industries that employ electrical equipment must first be concerned since they are responsible for a significant portion of overall e-waste. This is a qualitative study since the primary goal is to find out a sustainable way to manage e-waste [17]. The information was gathered in the form of words. The authors collected data for this study using interviews, which is a scientific approach for collecting data for qualitative research [16]. They also gathered information by interviewing persons who collect and handle E-waste from large organizations and businesses. By conducting the interviews, themselves, the investigators were able to acquire primary data [17].

3.3 Data Analysis

The authors conducted interviews with IT officials from notable Bangladeshi firms since interviewing is a scientific approach to conducting qualitative research. The information gathered from the conducted interviews will be presented scientifically and systematically in this study. The whole e-waste management practices of organizations where the investigators conducted interviews are described. Flow charts are used to depict the entire process since they may represent a complicated process simple.

3.4 Research Ethics

The consent form was provided for collecting data from individual interviews that outlined the purpose of this research project. The participants' anonymity was protected. Participants in the offline survey had to read the informed consent form, and only if they accepted the conditions, their interviews were taken. They had the option to deny giving an opinion. The phone conversations in which the author contacted participants described the context of the study and acquired permission to record the call.

4 Materials and Method

4.1 Data Collection and Analysis

In this study, the authors gathered information by interviewing experts on this subject. The authors were divided into two groups. One group was interviewed at "Azizu Recycling & E-Waste Firm Ltd." in Narayanganj, and the other at "Yousuf Enterprise – Electronic waste recycling company" in Badda. The authors created an informed consent form and questionnaire before beginning the interviews. The interviewees' consent was obtained verbally or in writing. The information was gathered through handwriting and recording. The information gathered is qualitative. After gathering the data, the authors analyzed it and utilized the online tool Lucid Chart to build flowcharts of the procedures reported by the interviewees.

4.2 Policies of E-waste Management of the Government

The relevant goods manufacturers, traders, dealers, transporters, repairers, collection centers, recyclers, dismantlers, and others must register with the DOE using a prescribed form. They must provide a WEEE management strategy with their registration application. According to the Bangladesh Environmental Protection Rules, 1997, registered producers, recyclers and others must acquire environmental clearance. Manufacturers must set up individual or collaborative collection facilities and budget for WEEE management. WEEE traders, dealers, and collectors are required to collect WEEE from customers at authorized locations and transfer it to collection facilities [18].

4.3 Policies of E-waste Management of Different Organizations

The authors went to some e-waste management organizations to collect data and learn how the e-wastes are managed at their organizations. The company's name was "Azizu Recycling & E-Waste Company Ltd" (Fig. 2), where the authors went to interview the participants of the company. Azizu Recycling & E-Waste Company Ltd. Was formed in 2006 as an importer of computer parts and accessories. In 2008, the company started working with "Tes-Amm," a Singapore recycler company. But in 2013, the company started e-waste management instead of importing electronic parts.

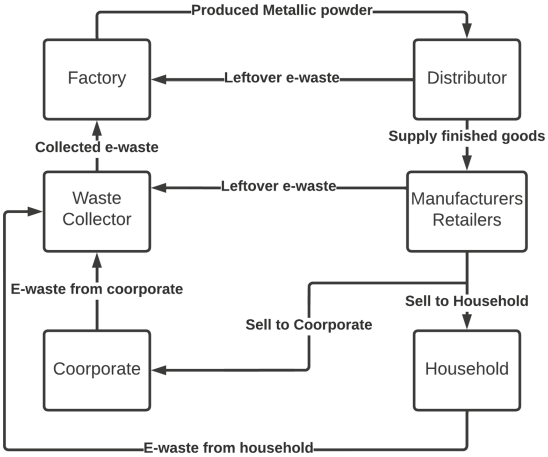

Fig. 2. Azizu Recycling & E-Waste Company Ltd Recycling Process.

The authors asked the participant what e-waste means in their company. The participant replied that any kind of electronic component is considered e-waste, and they recycle all kinds of electrical components. As for collecting e-wastes, the participants mentioned that telecom company, office, garments, and street vendors are their sources of e-wastes. About their recycling techniques, the participant mentioned that they have recycling techniques that are different based on the components. First, they dismantle the component and then sort the dismantled component according to recycling techniques. They have five recycling processes by which they separate metals, plastics, glasses, etc., which were later shown and explained by the participant. The researcher asked about is the company's techniques were adapted from an overseas company. The participant talked about the Tes-Amm company, from where they adapted their techniques. However, the company is not getting enough e-wastes to recycle from the mentioned sources. For that reason, their profit from recycling is relatively lower. As for following governmental regulations, the government published a direction for managing e-waste on June 22, 2021, and they are following those regulations. The researcher asked about the cost of e-waste management and recycling. The participant replied that the cost varies on the components they are recycling. They not only recycle the components in Bangladesh but also receive products from overseas to recycle those components. As per their participant, by recycling, they get 90% copper and 5% or less gold, and others are mixed

metals which are later separated by a sorting machine. The researcher also asked what the company would do with those recycled metals. The participant said they often sell it to manufacturing companies or export it overseas.

Another company, the authors, visited was "Yousuf Enterprise" which is also an e-waste management company. The mobile, laptop and sim companies give tenders to them to collect their e-waste. Yousuf Enterprise mainly targets those tenders and collects e-wastes from those companies. After collecting that e-waste, they dismantle the products, send the components like PCBs (Printed Circuit Board), and export them to overseas companies, mainly in Japan or Malaysia. As for other e-wastes, they collect metals from those and sell them to mills based on the metal they get. Before dismantling e-wastes, they take permission from BTRC (Bangladesh Telecommunication Regulatory Commission), BEDS (Bangladesh Environment and Development Society), and other organizations.

From an interview with a local vendor, the authors found that the local vendors don't get enough e-waste from people to send to a recycling company. The main reason is that people do not get enough money selling their unused e-products as the vendor buys them based on their weight. Another reason for the local vendors not getting enough e-waste is that they cannot sell them to recycling companies at the expected price. As a result, most of the e-waste remains un-recycled.

4.4 Design and Framework for Bangladesh and Other Countries

The author of the paper [9] mentioned a framework of e-waste management in Bangladesh, including repairing, recycling, and parts that cannot be repaired or recycled (Fig. 1). These initiatives were encircled in one framework, later divided into two frameworks by the author (Figs. 3 and 4).

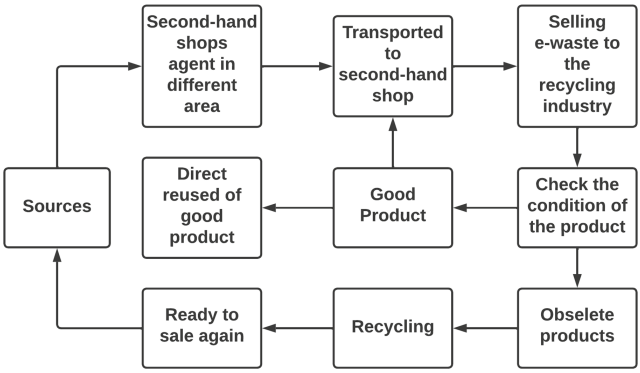

Fig. 3. Re-using of E-wastes components [9].

In Fig. 3, the author mentioned how the re-using would occur depending on the condition of the received product. So, if the product quality is good enough, it will be sent to a secondhand shop, which they will sell, and eventually, the products will be re-used. If the quality is not good, then it will be sent for recycling. After recycling,

the product will be re-manufactured by the manufacturing company and be ready to sell again in the market.

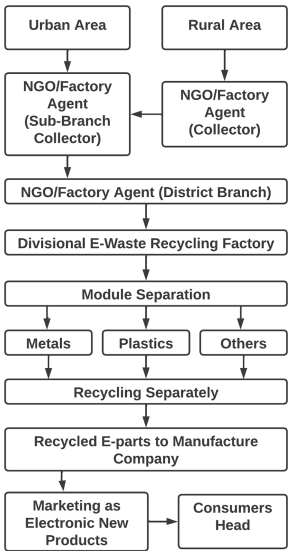

Fig. 4. Recycling of E-wastes components [9].

In Fig. 4, the author mentioned how recycling works. The author also designed the after products of module separation should be recycled separately because the metals are mixed products, and those cannot be dumped. Still, these products can be used for making other electrical components. That's why metals should be recycled separately. As for plastics, things are the same. After recycling the elements, these metals and plastics are sent to the manufacturer.

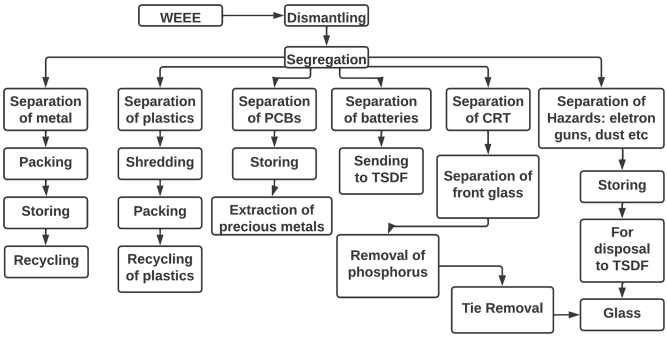

Fig. 5. Recycling operation of a company in India [9].

Bangladesh's neighboring country India also has some initiatives for managing e-waste. Figure 5 is showing a company's recycling operation. It represents the company's

recycling techniques are different based on the components. Also, it gives the company a complete framework for what they will do after separating the elements. Like after the metal separation, they will pack the metal, store it and recycle the component for re-manufacturing other electrical products or sell it to a manufacturing company.

Other nations worldwide have already introduced a law and begun implementing electronic recycling and take-back schemes. Switzerland was the first country to develop and implement a comprehensive framework for e-waste recycling and disposal [19]. The WEEE guideline governs European nations, requiring IT equipment providers to back up their outmoded equipment and provide protocols for safely disposing of it. The legislative framework of the country is founded on the concept of Extended Producer Responsibility (EPR) [20, 21].

The US e-waste management framework consisted of re-use programs, recycling, domestic landfill discharge, and many more characteristics within the Circular Economy concept. Furthermore, while Brazil and Canada have signed the Basel Convention, which intends to stress hazardous chemical management, uniform regulation, and limited control of the illicit e-waste trade, their regulatory scopes differ [22]. Furthermore, several countries manufacturing IT equipment, such as China, Vietnam, and Japan, have adopted ISWM's (Integrated Sustainable Waste Management) global best practice guideline for e-waste management [23].

4.5 Proposed Model

To solve the issues of e-waste collection and management, the authors proposed a model (Fig. 6) that is expected to change toward effective e-waste management significantly.

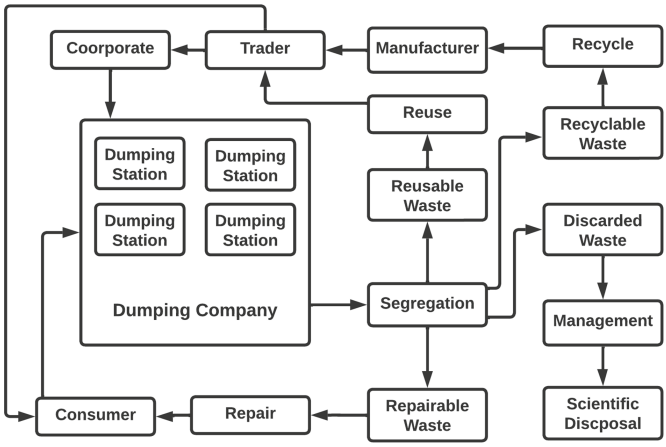

Fig. 6. Proposed model of Dumping Station for E-Products.

The authors propose a model that includes a Dumping Company for managing e-waste. There will be several dumping stations throughout the country which will trade unusable e-products from people with reasonable prices based on products condition.

Then the dumping company collects all products from dumping stations and sorts them. Also, the dumping company collects e-waste from Corporates through tenders or contracts. The Dumping company will segregate the collected e-waste. After that, reusable products will be sent to the traders, repairable products to the consumers after repairing, recyclable products to the recyclers, and the rest of the products will be sent for scientific disposal. The recycling company recycles the products into raw materials and sells them to the manufacturer. Manufacturers produce a finished product and individual components. Manufacturers sell the individual components to repair companies or shop and finished products in the market, from where the corporate and general public buys the product. Repair companies refurbish the repairable e-waste and sell the refurbished product in the market.

5 Result and Discussion

In this research, the authors discussed the policies and processes of different organizations and countries' e-waste management systems. The summary is given in this table (Table 1):

In terms of the segregation of e-waste, there is a similarity in plastic, metal, PCB, and CRT recycling techniques of "Azizu Recycling & E-waste Company" with an Indian recycling company. In paper [5], the authors proposed a model which includes an e-waste collection factory, but the government or any other NGOs took no initiative. As a result, recycling companies must collect e-waste on their own or look for local vendors. Two European Union policies are the waste electrical and electronic equipment (WEEE) directive and the Restrictions of hazardous substances (RoHS) directive. Another strategy is extended producer responsibility, in which the producer bears partial liability for product return [11]. Along with WEEE, RoHS, and EPR, China has enacted the 3R (Recycle, re-use, reduce) rule, which significantly reduces the environmental effect of e-waste and increases resource efficiency [24]. Under the WEEE law, users in Japan must drop off their old products and pay a collection charge to cover the expenses of collecting, shipping, and recycling. Used household appliances are meant to be collected by retailers, and manufacturers are required to recycle them with government funding. Previously owned electrical products must be returned to retailers or municipalities [25].

The authors found out that collecting e-waste is a significant concern in these policies. For that reason, the authors proposed a model which is effective for managing e-waste. To recycle e-waste, recycling companies must first collect e-waste from the general people who have electronic devices. To do that, the authors proposed making some "Dumping Stations" across the country where people can sell their useless electronic devices reasonably. Now people can only sell their e-products according to their weight, giving them very little money. But as Dumping Stations will provide them with a price based on product condition, people will get a reasonable price for their e-products and will be encouraged to recycle them at Dumping stations. Then the Dumping Station can send those e-products to the Dumping Company, where repairable products will be sent to repair shops, non-repairable products will be sent to the recycling company, and reusable products will be sent to traders. Big organizations can also tender out their e-products to Dumping companies to recycle or re-use them.

Table 1. Different organizations and countries' e-waste management policies and practices.

Serial	Country or organization	E-Waste Management Policies and Practices
1	Azizu Recycling & E-Waste Company Ltd	Collects e-waste from Street vendors, Telecommunication Companies then process the e-waste to form metal plates then sell it to Manufacturing companies or factories
2	Yusuf Enterprise	Collects e-waste from Mobile, Laptop, Sim then dismantles those e-wastes and exports them to Japan or Malaysia
3	An Indian Company	After collecting e-waste, they dismantle and segregate the e-waste using different techniques and sell those recycled products to a manufacturing company
4	Japan	Drop their old product, and pay the collection charge for recycling under WEEE law. Also, household appliances are collected by retailers and manufacturers to recycle with government funding
5	China	Adapted 3R rules, which reduced the environmental effect of e-waste
6	Other Nations	Introduced law and implemented electronic recycling techniques and take-back schemes

A survey conducted by the researchers found that 65% of people use scrap shops to dump their e-waste. According to 77% of people, scrap shop buys e-product according to weight and 66% of people keep storing their e-product to them without recycling them as the money scrap shop offers is not sufficient. Therefore, the researchers asked if their proposed model will be able to solve this problem and the rate of positive response was 87%. From the research, the authors found different ways to manage e-waste in Bangladesh by different organizations. The authors also found the government's approach to managing e-waste. This indicates lacking e-waste collections, so the authors introduced a model to fill the knowledge gap. This model is expected to make a significant change in e-waste collections and management. Local vendors don't get enough e-waste nowadays. This also makes local vendors jobless. As people of all stages can trade any unnecessary electronic devices at a reasonable price, they will be encouraged to recycle, which will solve the issue of e-waste collections. Then the recycling company can get enough e-waste to recycle. Local vendors can work in Dumping stations and Dumping companies, which will solve their employment problem.

6 Conclusion

The sole purpose of this research was to find a sustainable way to manage e-waste in Bangladesh and to compare the proposed model with the existing ones. The existing models have many drawbacks. Some models were designed for other countries and were not entirely compatible with Bangladesh. Also, the current e-waste collecting and managing system were not appropriate, thus, causing recycling companies not to get enough e-wastes. Through the model, the authors can solve the issues regarding the existing models by proposing a proper e-waste collecting and managing system.

Acknowledgment. We want to express our gratitude to "Azizu Recycling & E-waste Company" and "Yousuf Enterprise" for cooperating with us. We want to thank Rashedul Amin Tuhin, Senior Lecturer, East West University, and Abdulla Al Mamun Asif from "Azizu Recycling & E-waste Company" for guiding and helping through our research.

References

1. Chaudhary, K., Vrat, P.: Optimal location of precious metal extraction facility (PMEF) for E-waste recycling units in National Capital Region (NCR) of India. Opsearch **54**(3), 441–459 (2016). https://doi.org/10.1007/s12597-016-0287-0
2. Solving the E-Waste Problem (Step) White Paper One Global Definition of E-waste 1 Solving the E-Waste Problem (Step) Initiative White Paper One Global Definition of E-waste (2014)
3. Karim, R.T., Bari, N., Amin, M.A.: E-waste management in Bangladesh. In: 2014 2nd International Conference on Green Energy and Technology, ICGET 2014, pp. 104–109 (2014). https://doi.org/10.1109/ICGET.2014.6966673
4. Encyclopedia Britannica: Electronic waste. https://www.britannica.com/technology/electronic-waste. Accessed 3 Aug 2022
5. Meem, R.A., et al.: A review on the environmental and health impacts due to electronic waste disposal in Bangladesh. GSC Adv. Res. Rev. **8**, 116–125 (2021). https://gsconlinepress.com/journals/gscarr/sites/default/files/GSCARR-2021-0174.pdf. https://doi.org/10.30574/GSCARR.2021.8.2.0174
6. Irthiza, A.: Environmental Policy Instruments Use-design for Improving E-waste Management in Bangladesh (2021)
7. Rahman, M.A.: E-waste Management: A Study on Legal Framework and Institutional Preparedness in Bangladesh (2016)
8. Herat, S.: E-waste management in Asia Pacific Region: review of issues, challenges and solutions. https://doi.org/10.46488/NEPT.2021.v20i01.005
9. Masud, M.H., et al.: Towards the effective E-waste management in Bangladesh: a review. Environ. Sci. Pollut. Res. **26**(2), 1250–1276 (2018). https://doi.org/10.1007/s11356-018-3626-2
10. Ananno, A.A., Masud, M.H., Dabnichki, P., Mahjabeen, M., Chowdhury, S.A.: Survey and analysis of consumers' behaviour for electronic waste management in Bangladesh. J. Environ. Manage. **282**, 111943 (2021). https://doi.org/10.1016/J.JENVMAN.2021.111943
11. Herat, S., Agamuthu, P.: E-waste: a problem or an opportunity? Review of issues, challenges and solutions in Asian countries. Waste Manage. Res. **30**, 1113–1129 (2012). https://doi.org/10.1177/0734242X12453378

12. Wath, S.B., Vaidya, A.N., Dutt, P.S., Chakrabarti, T.: A roadmap for development of sustainable E-waste management system in India. Sci. Total Environ. **409**, 19–32 (2010). https://doi.org/10.1016/J.SCITOTENV.2010.09.030
13. Jaunich, M.K., DeCarolis, J., Handfield, R., Kemahlioglu-Ziya, E., Ranjithan, S.R., Moheb-Alizadeh, H.: Life-cycle modeling framework for electronic waste recovery and recycling processes. Resour. Conserv. Recycl. **161**, 104841 (2020). https://doi.org/10.1016/J.RESCONREC.2020.104841
14. Islam, M.T, Dias, P., Huda, N.: Comparison of e-waste management in Switzerland and in Australia: a qualitative content analysis. World Acad. Sci. Eng. Technol. **12**(10), 610–616 (2018). http://scholar.waset.org/1307-6892/10009626
15. Jackson, R.L., Drummond, D.K., Camara, S.: What is qualitative research? **8**, 21–28 (2007). https://doi.org/10.1080/17459430701617879
16. Denscombe, M.: The Good Research Guide: For Small-Scale Social Research Projects (2010)
17. Igwenagu, C.: Fundamentals of Research Methodology and Data Collection, pp. 4–5. LAP Lambert Academic Publishing (2016)
18. Bangladesh Government: E-waste Management Rule of Bangladesh. https://www.dpp.gov.bd/upload_file/gazettes/40075_81487.pdf. Accessed 3 Aug 2022
19. Premalatha, M., Tabassum-Abbasi, Abbasi, T., Abbasi, S.A.: The generation, impact, and management of E-waste: state of the art. Crit. Rev. Environ. Sci. Technol. **44**, 1577–1678 (2014). https://doi.org/10.1080/10643389.2013.782171
20. Shumon, M.R.H., Ahmed, S.: Sustainable WEE management in Malaysia: present scenarios and future perspectives. IOP Conf. Ser. Mater. Sci. Eng. **50** (2013). https://doi.org/10.1088/1757-899X/50/1/012066
21. de Oliveira, C.R., Bernardes, A.M., Gerbase, A.E.: Collection and recycling of electronic scrap: a worldwide overview and comparison with the Brazilian situation. Waste Manage. **32**, 1592–1610 (2012). https://doi.org/10.1016/J.WASMAN.2012.04.003
22. Xavier, L.H., Ottoni, M., Lepawsky, J.: Circular economy and e-waste management in the Americas: Brazilian and Canadian frameworks. J. Clean. Prod. **297**, 126570 (2021). https://doi.org/10.1016/J.JCLEPRO.2021.126570
23. Ignatuschtschenko, E.: Electronic waste in China, Japan, and Vietnam: a comparative analysis of waste management strategies. Vienna J. East Asian Stud. **9**, 29–58 (2018). https://doi.org/10.2478/VJEAS-2017-0002
24. Liu, L., Liang, Y., Song, Q., Li, J.: A review of waste prevention through 3R under the concept of circular economy in China. J. Mater. Cycles Waste Manage. **19**(4), 1314–1323 (2017). https://doi.org/10.1007/s10163-017-0606-4
25. Chung, S.-W., Murakami-Suzuki, R.: A comparative study of e-waste recycling systems in Japan, South Korea and Taiwan from the EPR perspective: implications for developing countries (2008)