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TOWARDS A SUSTAINABLE E-WASTE MANAGEMENT APPROACH IN KHULNA CITY: AN ASSESSMENT OF CURRENT PRACTICES, PUBLIC AWARENESS AND POLICY RECOMMENDATIONS

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ABSTRACT

E-waste management has become a pressing global and national concern, particularly in Bangladesh. To bring structure and efficiency to the current haphazard management setup a structured, well-organized plan should be implemented across all cities and rural areas of the country. Keeping that in consideration our study draws attention to the existing circumstances of e-waste management in Khulna city, identifying their flaws, assessing public awareness, possibilities for betterment along with the required changes for improvement. Restructuring the holistic e-waste management system and developing a sustainable and structured management system for the city have become vital for comprehensive socio-economic and environmental growth. Achieving an effective and resilient management strategy requires maximizing widespread citizens participation. With this in focus, the case study aims to evaluate people's awareness, their interest and approach towards e-waste through both in-person and web-based questionnaire along with several field inspections. A case study was conducted as well with a view to exploring the entire procedure starting from collection to disposal. The finding of the paper reveals that the thorough management procedure of this city is prevalently controlled by the informal sectors. This paper also delves into the workflows and schedule of informal workers engaged in different stages of the management system within the city. To conclude, this paper outlines some recommendations along with a designed framework to establish a sustainable management chain across the city.

Keywords: *E-wastes, Waste Collection, Waste Dumping, Public Awareness, Waste Recycling, Landfills, Raw Materials, Human Health Risk, Circular Economy.*

INTRODUCTION

When electrical and electronic equipment (EEE) is discarded away without being intended for reuse, it is referred to as electronic waste (E-waste). EEE that contributes to the e-waste stream by generating waste energy and carbon dioxide emissions can also be included in the definition of e-waste. A vast array of goods from every household or business are included(Ahsan et al., 2023).

Rapid growth in technology, industries and the economy along with changing lifestyles, urbanized society has greatly increased the necessity for electronic devices in Bangladesh. Mobile phones, computers, televisions, refrigerators, and other items are now more popular than ever. The rising use of electronic items has now created a massive amount of electronic waste (e-waste). E-waste is harmful for the environment and human health, so it needs to be properly managed. They contain useful materials but it also has toxic substances like lead (Pb), nickel (Ni), cadmium (Cd), mercury (Hg), copper (Cu) and chromium (Cr), etc. E-waste contains harmful chemicals as well like chlorofluorocarbons (CFCs), polychlorinated biphenyls (PCBs), polybrominated biphenyls (PBBs) and brominated flame retardants (BFRs). These hazardous substances can harm plants, humans, and aquatic life(Poganietz & Paypay, 2025; Song et al., 2013). Mishandling of e-waste triggers the release of toxic substances into the soil, water and air, which become the reasons for the deaths of certain species of plants and animals(Auma Omondi et al., 2022).These hazardous materials can enter the human body through the consumption of plants, drinking water, by inhaling, causing damage to the kidney, brain, liver, birth capability and skeletal system(Kumar et al., 2017).

E-waste management systems vary greatly across the world. First-world countries like the USA, Japan, and those in the European Union utilize modern technologies and have strict protocols to manage e-waste. Their strategy is organized collection, efficient recycling and safe disposal methods. In general, e-waste is recycled in resources equipped with cutting-edge technologies, tools and infrastructure to recover precious materials in a secure and efficient manner. The residual waste is

disposed of according to proper guidelines(Perkins et al., 2014). Recovering metals from e-waste is a productive way to realize its financial worth and is a well-established practice in developed countries such as the USA, Japan, Taiwan, the European Union (EU) and Canada(Ilyas et al., 2021).

On the other hand, underdeveloped countries like Bangladesh face key difficulties in managing e-waste.The country has not established a proper e-waste management system yet like other developing countries. The waste accumulation, waste handling and recycling are controlled by Informal sectors(Alam & Bahauddin, 2015). These sectors use primitive and risky methods, which not only retrieve very little of the valuable materials but also put workers at severe health hazards. Studies reveal that local areas that are going through rapid urbanization play a major role in the generation of e-waste worldwide. Like other developing areas, the waste management chain of Khulna also relies on small-scale recyclers, local waste collectors, small-scale and second-hand repairing shops. To overcome these obstacles, setting up formal collection centers, combining informal recyclers with structured recycling practices are required.

The collected e-waste is either recycled or processed to extract valuable materials which are about 20% of total e-waste generation using simple technology without sufficient occupational safety precautions(Ahirwar & Tripathi, 2021).

A survey by the National Board of Revenue (NBR) Bangladesh disclosed that since 2012 approximately 63,003,818 phones have been brought in the market of Bangladesh and with the maximum lifespan of 2.5 years, most of them currently become the part of the country's solid waste stream(Masud et al., 2019). An inefficient e-waste management system in Bangladesh ultimately contributes to the collection of e-waste in the waste stream, unfavorably affecting multiple sectors of society(Debnath et al., 2018; Kaya, 2016; Reza et al., n.d.).Bangladesh, under its "Vision 2021" to become "Digital Bangladesh," has initiated multiple wide-ranging endeavors aimed at reinforcing its IT infrastructure, which is likely to lead to increased usage of electronic devices in the future (M. S. Islam & Grönlund, 2011). The government must initiate formal systems, enforce regulations, and increase public awareness to decrease the environmental and health risks linked with e-waste. This paper aims to examine the existing e-waste situation while addressing its challenges and flaws and draws attention to peoples' thinking towards the management system lastly recommends some modifications in the prevailing system.

E-WASTE COMPOSITION AND RECYCLING PROCESSES

E-waste recycling is **a fundamental step** to recover valuable materials and minimize environmental harm caused by obsolete electronic equipment. Different types of e-waste contain materials that can be utilized in a range of industrial and production processes. By recovering and utilizing these materials, we can preserve natural resources, minimize waste, and support sustainable growth. Below is a table that categorizes electronic products, the materials that can be extracted from them, and their possible applications(Alamgir et al., n.d.; Moniruzzaman & Paul, 2020a)

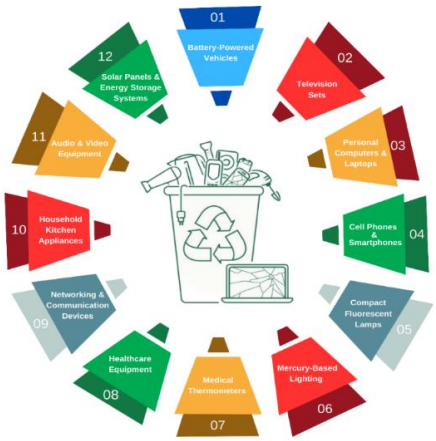

Figure 1 Sources of E-Waste

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Product Types	Recovered Materials	How It Can Be Utilized
Ceiling Fans, Bulbs, Cables	Copper (Cu), Aluminum (Al), Steel (Fe), Glass	Utilized for making electrical components,, wiring, and construction
Mobile Phones, Laptops, Televisions	Gold (Au), Silver (Ag), Lithium (Li), Palladium (Pd), Copper (Cu), Glass	Used in the production of electronics and the development of new circuit boards
Refrigerators, Washing Machines	Steel (Fe), Aluminum (Al), Copper (Cu), Rubber, CFCs	Steel and aluminum are recycled for construction use, CFCs are disposed of safely
Printers, Audio & Video Equipment	Aluminum (Al), Steel (Fe), Plastics, Glass, Toner	Materials are reused for new devices or integrated into industrial processes.
Batteries, Battery-Powered Vehicles	Lithium (Li), Nickel (Ni), Lead (Pb), Cadmium (Cd)	Applied in the development and production of advanced batteries and industrial storage systems.
Ovens, Solar Panels, Thermometers	Stainless Steel (Fe), Silicon (Si), Mercury (Hg), Glass	Used for construction projects, solar panel manufacturing and the safe handling of mercury.

Figure 2 Recovered Materials from E-Waste and Their Applications

STUDY AREA

Khulna, a major industrial and commercial city in Bangladesh, was selected for this study because of its rising e-waste generation and active informal recycling sector. It is the third largest city in Bangladesh, after Dhaka and Chittagong. The study focuses on key recycling and repairing shops of some locations across the city including Shiromoni, Fulbari, Daulatpur, Khalishpur, Sheikhpara, Dakbangla, Sonadanga, Gallamari, Rupsa and Nirala.A total 127 number of e-waste recycling shops opertate in these regions, employing 354 workers. Additionally, 290 numbers of tokais and 84 number of feriwalas are invlolved in the recycling process of the city.According to the 2022 Census of Bangladesh, Khulna District had 670,861 households and a population of 2,613,385 with an average 3.85 people per household(Moniruzzaman & Paul, 2020a).

METHODOLOGY

This paper primarily aims to review the prevailing e-waste management process in Khulna City and investigates citizen's awareness level regarding e-waste, it's generation and management system along with its effects on human health and environment. In this context a structured questionnaire survey was conducted both online and offline to understand the household e-waste disposal habits as well as management mechanism among the city dwellers, the tendency of household consumers disposing of their e-waste and their knowledge and consciousness regarding this issue. The detailed methodology of the study is depicted in fig3:

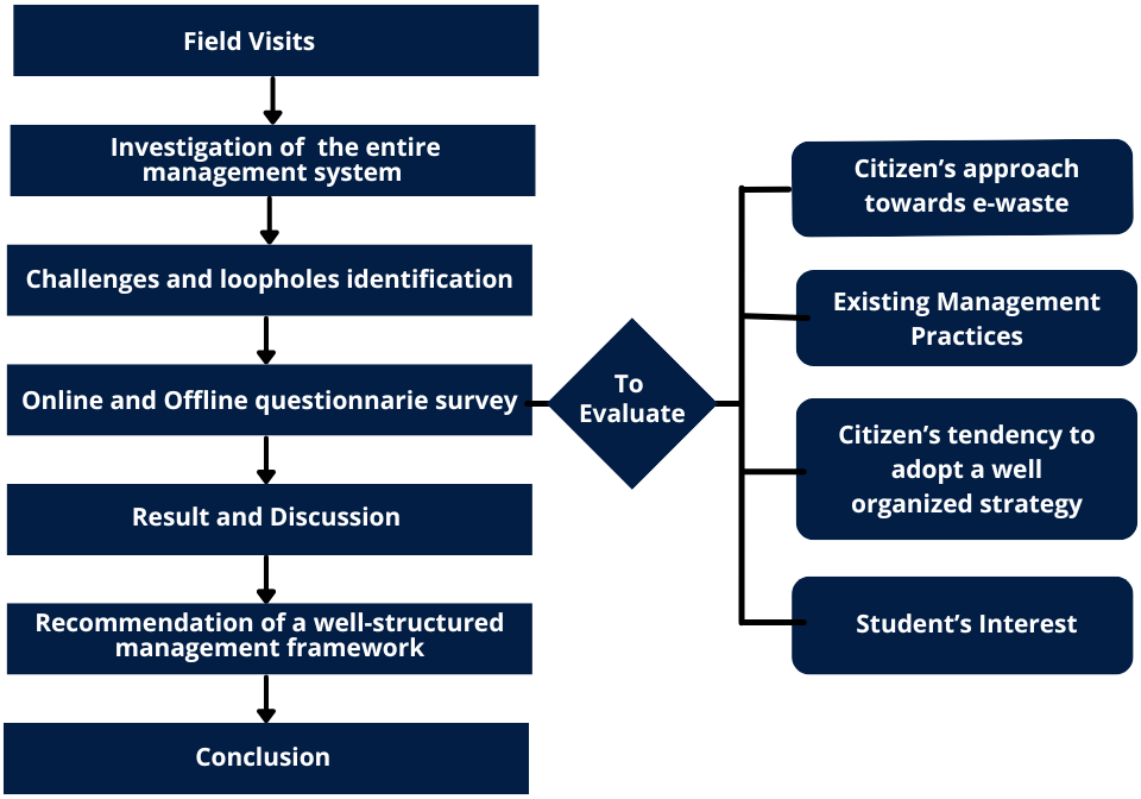

Figure 3: Methodology adopted for the study

RESULT AND DISCUSSION

Demographic Information: The study included total 320 participants, among them 57% are male, 43% are female, participated in the offline survey. In the offline survey, participants were differentiated with four different categories. Age distribution revealed that, 10% of the participants were below 25%, 32% were between 26-35% age group, 43% fell within the 36-45 age group, 11% were in 46-60 age group and the rest were above 60. In terms of educational qualifications, respondents were distinguished into 7 categories starting from no education to doctorate. Most of the participants were graduate in the offline survey as the number was 35%, 13% was with no education and 22% were higher secondary students. Regarding occupation, participants were categories into two sectors: unemployed and employed. The majority were employed which was 77% and rest was unemployed which is 23%.

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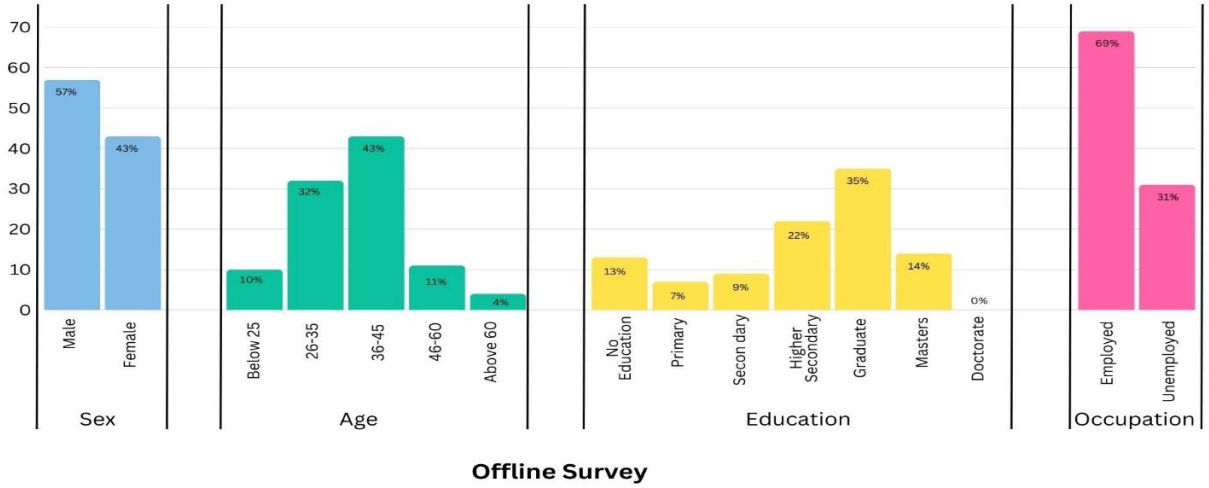

Figure 4: Demographic profile of offline survey respondents

Along with the offline survey an online questionnaire survey was also conducted focusing the students of the city. In the online survey, participants whom were mostly college and university students of the city were again differentiated with four different categories. Age distribution showed that, 10% of the participants were below 25%, 62% were between 18-22% age group, 33% fell within the 22-28 age group and the rest 5% were above 28. In terms of educational qualifications, respondents were distinguished into four categories. Most of the participants were undergraduate students in the online survey as the number was 65%, 13% were higher secondary students and 21% were masters students and the rest 4% were doctorate students. Regarding occupation, participants were categories into two sectors: unemployed and employed. The majority were employed which was 77% and rest was unemployed which is 23%.

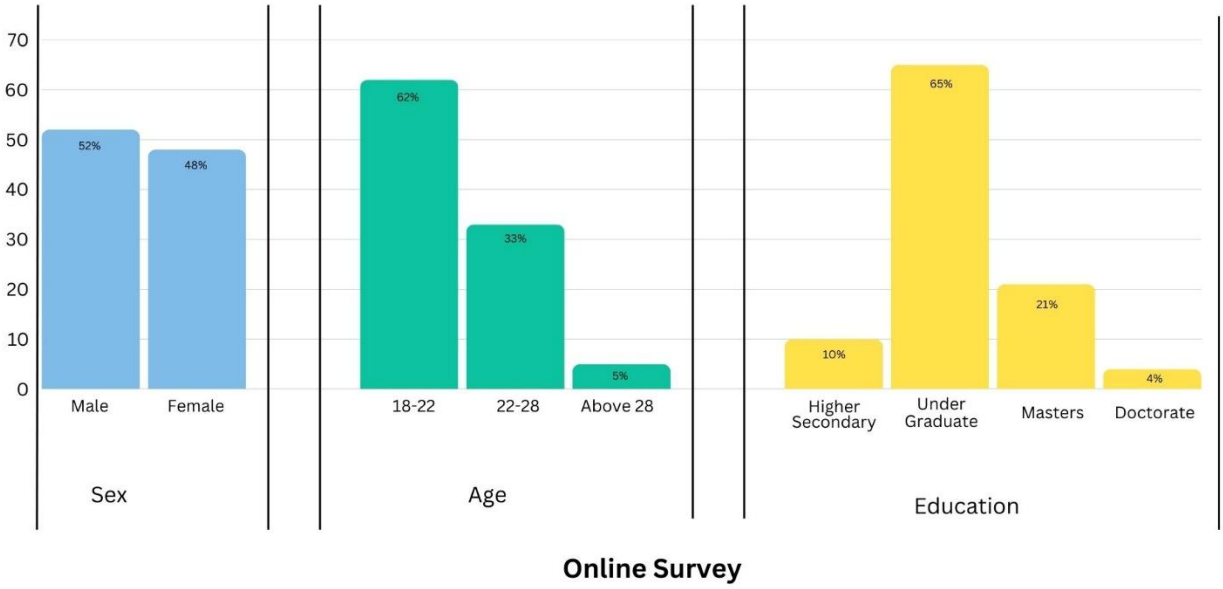

Figure 5 Demographic profile of online survey respondents

Assessing Citizen's awareness and attitude towards e-waste: One of the key aspects of the study is to evaluate citizens' approach and awareness towards e-waste and its' management system. Therefore, both online and offline surveys were conducted in order to gauge their responses ensuring all stages of people have been included. This multi-platform approach allowed us to engage a wide range of participants through reaching individuals across various age groups, professions and socio-

economic background and enabled us to assess a well-rounded understanding of public engagement and attitude towards e-waste disposal and recycling.

In response to the question whether people have heard the term e-waste, 42% of the participants have responded Yes in the online survey and 22% of them are not sure whether they have heard it or not. The response pattern in the offline survey result is completely opposite in this question as 71% of the respondents do not even know the term e-waste. It is observed that students are more aware of this term e-waste whereas general people of the city seem to have lesser knowledge about it. Most of the common people doesn't even consider old obsolete electronic products as a waste as they don't aware of the fact that these products can harm the environment and human body later.

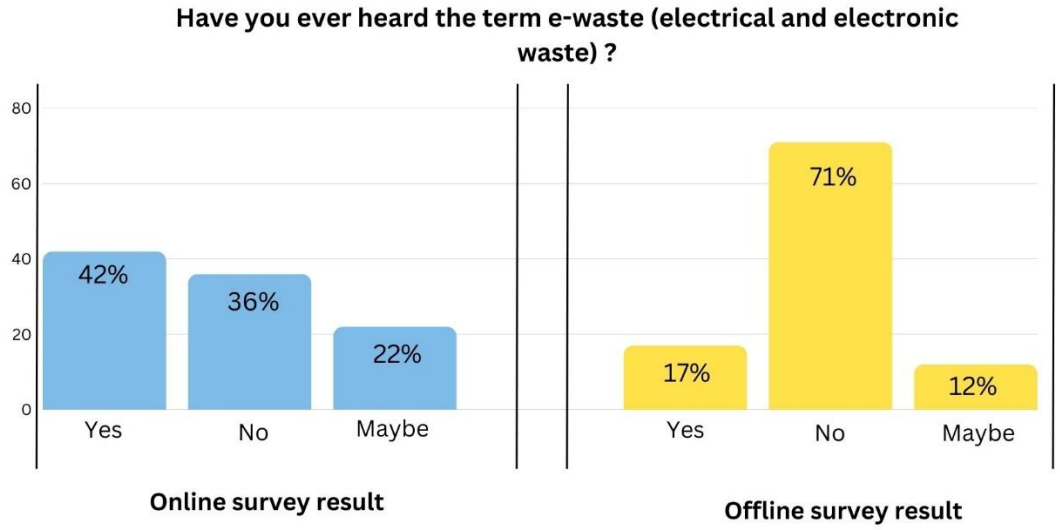

Figure 6 Response of Question 1

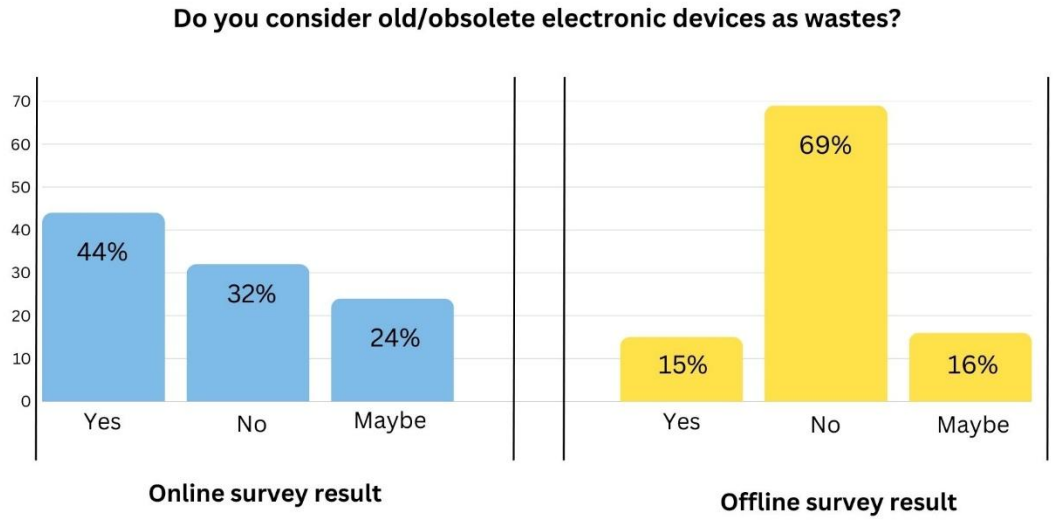

Figure 7 Response of Question 2

The third question asking what they exactly do with their obsolete electronics, there were five options. In the offline survey, the majority respondents prefer to keep old electronics as backup and % opt to sell or donate them. Recycling tendency is significantly low with only %, % tends to discard their devices rather than keeping, selling or recycling them. Maximum response (39%) was seen in the first option "keep them as a backup" Notably, a large number of citizens sell or donate their old electronics

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as 37% chose the second option. Expectedly, very few of them recycle their old electronic products as the percentage is 8% only. A percentage of 13% opt to throw them away instead of keeping, selling or recycling them.

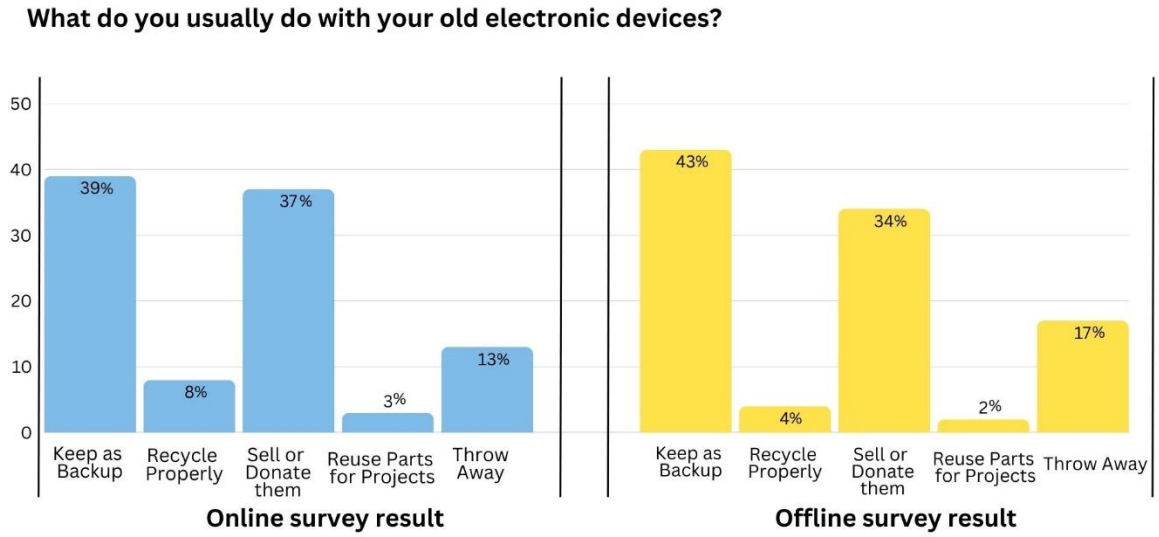

Figure 8 Response of Question 3

In order to engage them in recycling and reusing culture it is necessary to inspects whether they hold sufficient knowledge regarding this issue. In the next question inquiring if they know some parts of their used electronics can be repaired and recycled, majority of participants (55%) responded No and the 35% participants voted Yes, the rest 9% were neutral. It is clearly evident that the online respondents possess more knowledge about e-waste recycling components than the citizen surveyed offline.

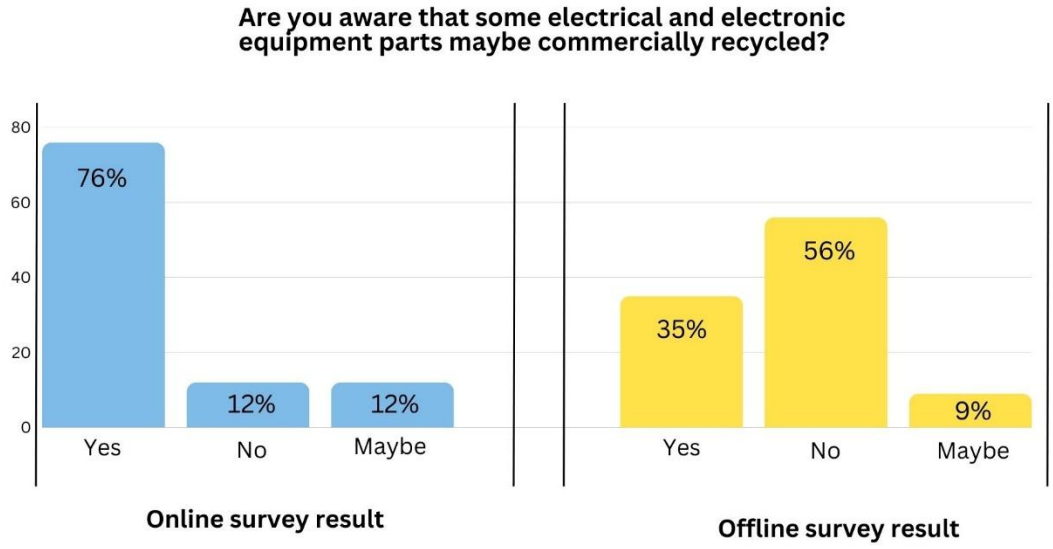

Figure 9 Response of Question 4

To ensure a sustainable management chain, citizen of the city should be conscious about the environmental hazard created by disorderly management of e-waste. In this regard, their awareness was examined by the fifth and sixth questions. 21% of the participants know that e-waste contains toxic hazardous materials that need to treated properly and 76% have no idea about the issue. On the contrary in the online survey, the result is quite satisfactory as 71% of them have knowledge about the harmful elements of e-waste and their special treatment procedures and the rest are unknown to the

fact. Further, it was asked whether they are known to the health and environmental impact of e-wastes in which 24% participants responded Yes and 64% responded No, in the offline survey. Again, a clear contradiction is seen in the online survey results. Participants in the online survey seems to have more knowledge about ecological impact as the percentage is 72%, only 23% of them stated that they are not aware about the ecological impact, rest 5% were neutral.

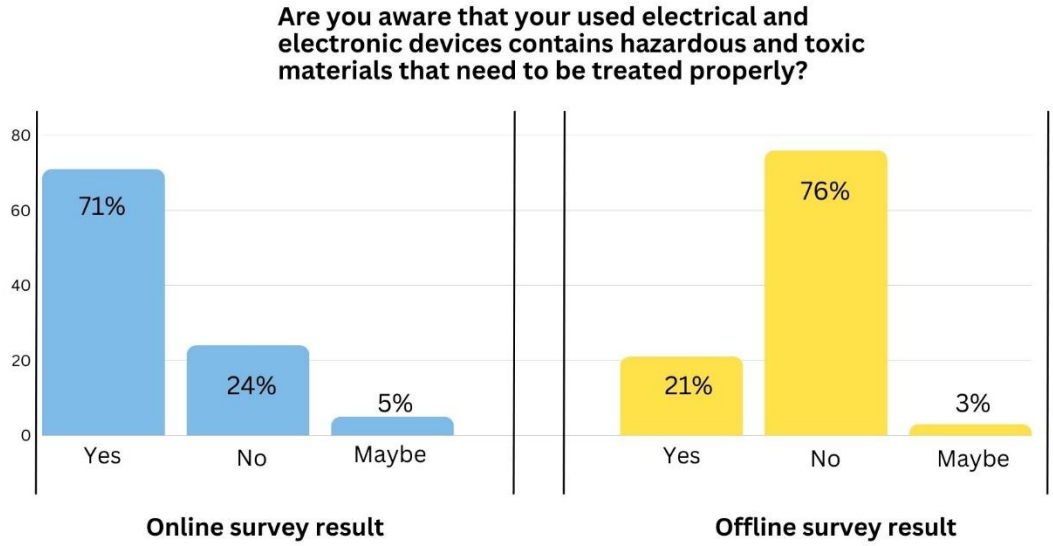

Figure 10 Response from question 5

Existing Management practices: E-waste management in the city is mostly dominated by the informal sector. There is a chain of workers dominating the whole process starting from collecting waste to disposing them. A comprehensive case study was conducted to explore their operational characteristics. The person collects the waste primarily from the households or roadside shops is locally known as feriwala. The working time of the feriwalas are not specific but generally they visit the households in the morning (around 9am-11 am) or in the afternoon (4 pm-6 pm). They buy the old obsolete e-waste products in a very cheaper price and sells them to the local thrift shops. A notable collaboration exists between the feriwalas and the thrift shops owners and workers in different localities of the city. another source of e-wastes of the thrift shops is tokai. Tokai are those who collects the wastes unsystematically from the roadside, markets, shops, parks or any other random places. Sometimes the feriwala and tokai sell their collected waste products directly to the local recycling or repairing shops. It is to be noted that they always collect the products with other solid wastes. So, the thrift shops firstly differentiate the e-waste products from the other wastes and later disintegrate them into different categories based on their condition. The products that are repairable or in a good condition are sold to the repairing shops. The second category of products that are not repairable are transformed into different materials by breaking apart and by following several conventional methods including acid bath, wire burning etc. and later they are being sold individually.

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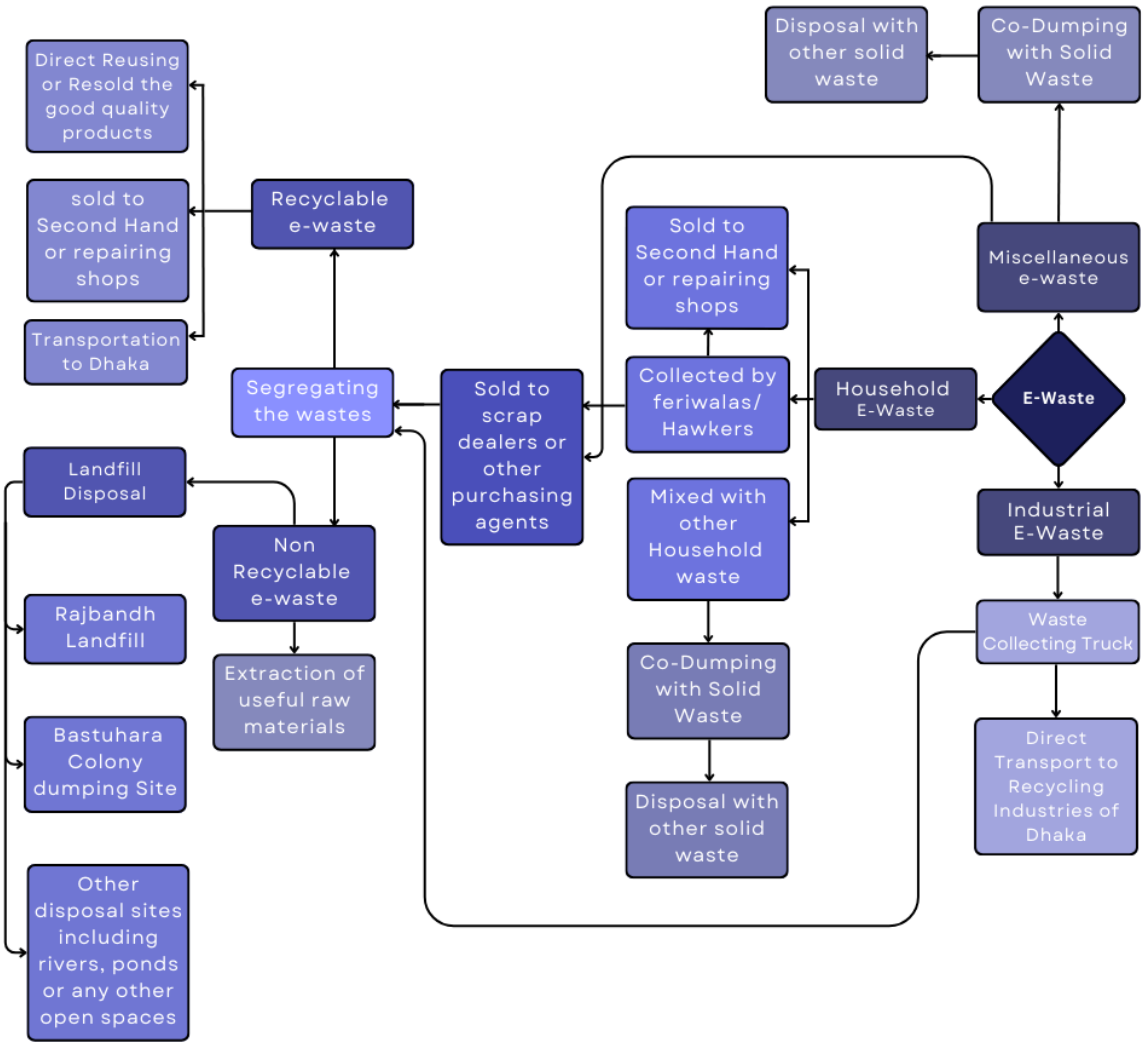

Figure 11 Flowchart of existing E-Waste management in Khulna City

Is It Safe?

The e-waste handling process in the city governed by the informal sector raises significant health and environmental hazard. Informal recycling generally involves methods that are improper, risky and not environment friendly at all. For instance, they burn wires to extract copper resulting toxic fuels emission in the environment. Acid bath is also a common process adopted by the local thrift shop workers to recover metals from the wastage electronics producing toxic chemical waste. These pollutants later seep into the soil contaminating both soil and groundwater posing serious risks to human health and the eco-system. Not only environmental hazards, the management process also includes health risks to the workers like respiratory issues, skin diseases, kidney or liver damage as they are constantly exposed to harmful substances like lead, mercury, arsenic that are mostly found in many electronic devices.

People's tendency to adopt a new structured Plan: In order to plan and execute a long-term, sustainable management framework, people's interest and tendency to cope with a new system of e-waste handling need to be examined.

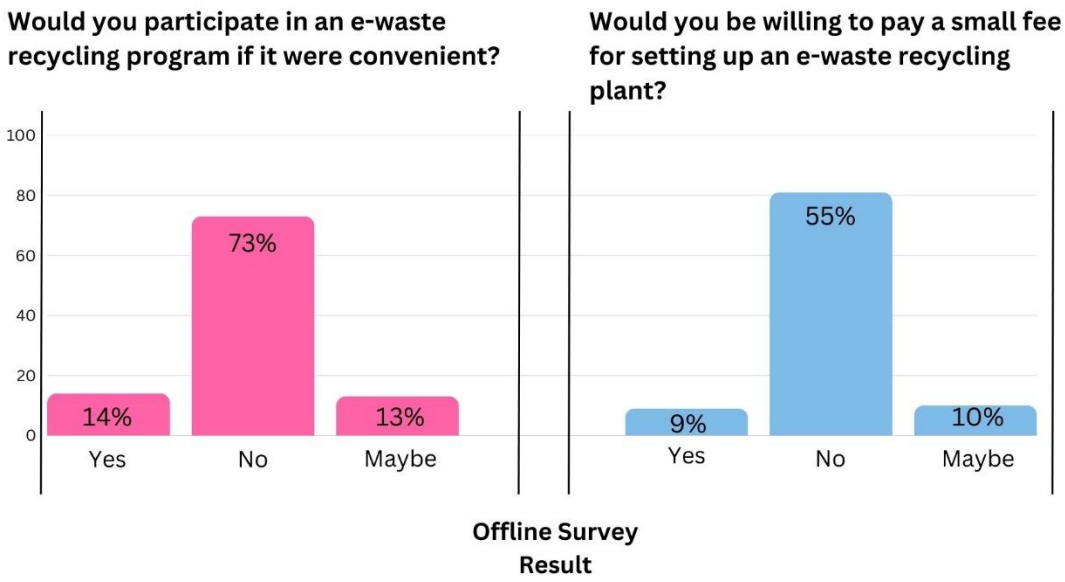

Figure 12 Response from question 6

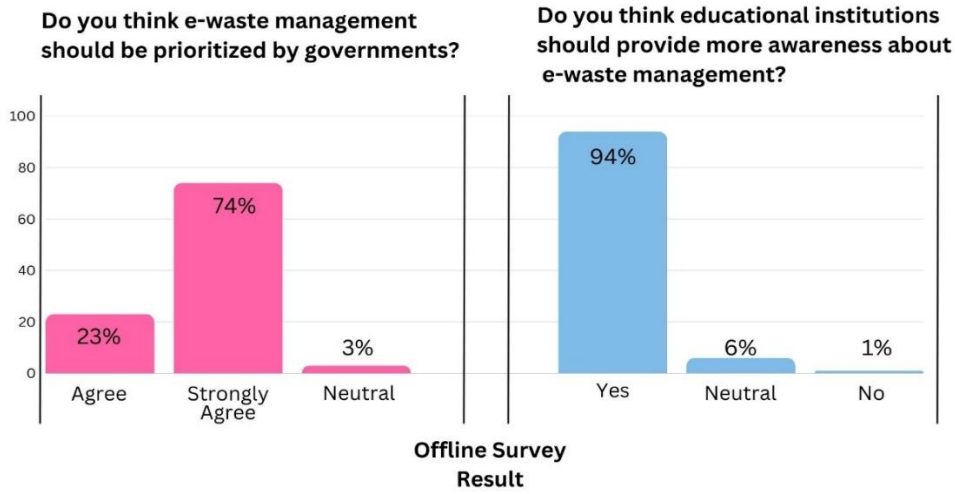

Figure 13 Response from question 7

Student's Interest: The city has several universities and colleges including with a handsome amount of students' population. To better understand their perspective, an online survey was conducted targeting the city students. In addition, we sought to assess their willingness to cope with a new restructured plan and contribute to sustainable recycling initiatives.

In the response to the first question, 65% students strongly agree to the fact that government should prioritize e-waste management and similarly 93% respondents felt that it should also be encouraged by educational institutions like universities and colleges. Further, they were asked whether they would like to participate in any e-waste recycling program if it were convenient and 30% of the participants responded Yes to that which is not quite satisfying and 41% participants responded No. Later, they were asked if they would like to pay some fees for setting up any e-waste treatment plan and like the previous question, the students didn't show that much enthusiasm regarding this issue. Only 22% respondents voted for Yes in the question and a large number of participants (55%) responded No, 23% were neutral.

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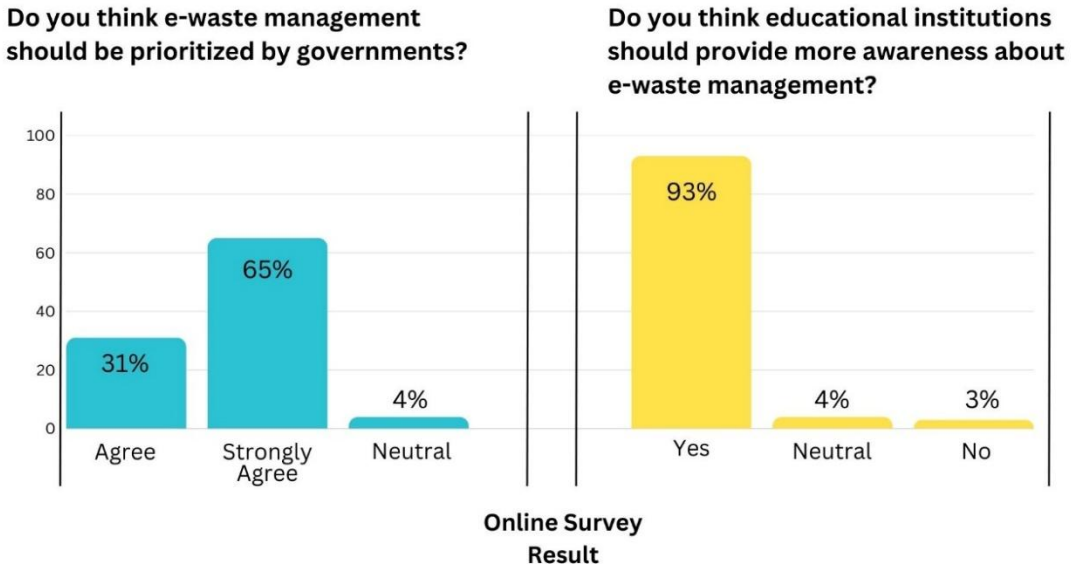

Figure 14 Response from question 8

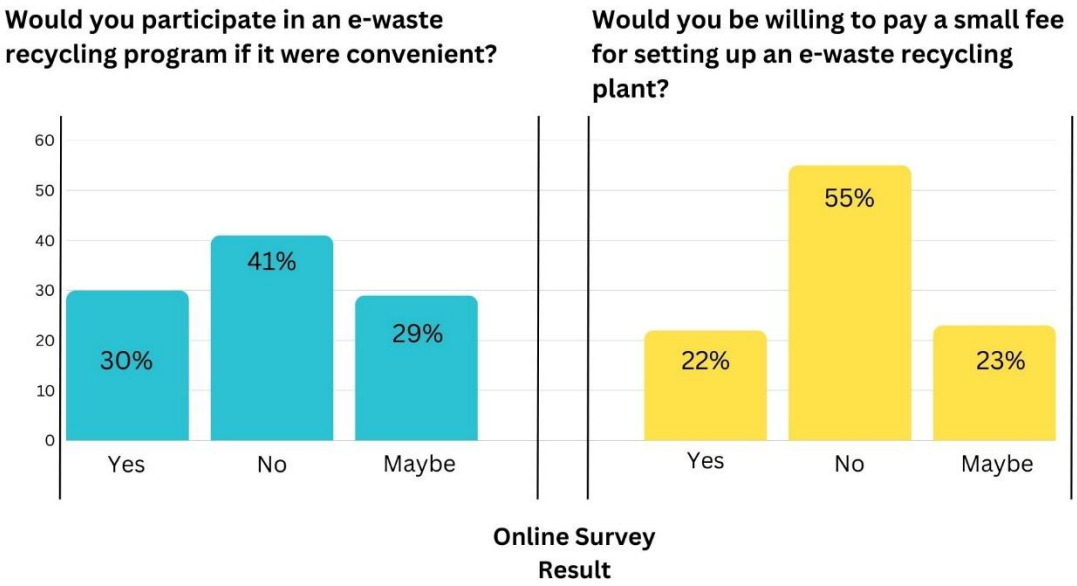

Figure 15 Response from question 9

PROPOSED FRAMEWORK FOR E-WASTE MANAGEMENT IN KHULNA CITY

This proposed framework aims to establish a comprehensive e-waste management system for Khulna City that emphasizes environmental sustainability, public health and fostering economic growth by addressing key challenges in e-waste management.

Developing a Comprehensive Regulatory System:

- Establish city-level e-waste regulations in accordance with national laws and regulations and impose penalties for violation(Hossain et al., 2022).
- Implement a licensing and permit system for all entities involved in the e-waste management chain.
- Implement Extended Producer Responsibility (EPR) schemes to incentivize manufacturers and importers to establish take-back systems for their products.

Developing an efficient pathway from collection to disposal:

- Train and formalize informal workers to engage them creating a multi-tiered collection infrastructure including-
- Door to Door pick up services for residents.
- Setting up a network of strategically located authorized drop-off and collection centers across the city.
- Provide some authorized, coloured transporting vehicles to ensure systematic and safe transportation of wastes towards the repairing or recycling shops in Khulna and the recycling factories of Dhaka as well.
- Promote the circular economy concept by maximizing repair, reuse and refurbishments of electronic goods.
- Encourage the recycling of valuable materials including both formal and informal recycling practices.
- Ensure enough and authorized disposing sites and storing sites to avoid irregular landfill storing and dumping.

Incentives and Collaborations:

- Introduce incentives to the informal workers to turn their recycling process into formal, systematic manner.
- Foster strong partnership with key stakeholders, NGO's, academic institutions and tech companies to develop innovative e-waste management solutions.

Monitoring and Enforcement:

- Establish a robust, monitoring and evaluation system to track e-waste flow and ensure compliance.
- Strictly penalize for illegal dumping, unsafe recycling and for breaking the city-level laws and regulations.

Raising Public awareness and community engagement:

- Promote awareness regarding the environmental and health hazard due to improper disposal of e-waste.
- Create job opportunities and involve local communities in e-waste collection initiatives.
- Encourage educational institutions to conduct an awareness campaign among the students of the city.

Key considerations:

01. Sustainability: Ensure the long-term sustainability of the modified management system by integrating economic viability, social equity and environmental protection into all aspects of e-waste management planning and implementation.
02. Formalizing the informal sectors: It should be noted that the management chain of the city is predominantly owned by the informal sectors. In order to implement any further recommendations in the management cycle, first and foremost the informal sector needs to be formalized and included in every aspect of the structured model.

ECONOMIC ASPECT of E-WASTE

A legitimate recycling system is estimated to generate over five billion dollars for Bangladesh by 2030(M. T. Islam & Huda, 2019).However, challenges including inadequate regulations and informal companies make it challenging to take advantage of the financial benefits. Informal recycling has a negative impact on the environment and economy(Kumar et al., 2017) .Significant financial opportunities may be discovered by formal recycling facilities, law enforcement, public education and training for employees. Innovative strategies, for example incorporating MFA-LCA models, could significantly improve recycling networks while decreasing environmental effects(Thushari et al., 2020; Xue & Xu, 2017).Household consumers, scavengers, wholesalers, material separators and recycling companies are some of those who are involved in the e-waste recycling process. Profits increase upwards throughout the chain as e-waste moves through it, suppliers and separators may generate up to ten times as much as scavengers(Rochman et al., 2017)

The e-waste recycling processes in Khulna City focus on both environmental concerns and economic opportunities. Each day, the city generates approximately 614 kg of recyclable e-waste, with televisions, computers, refrigerators, and smartphones making up the largest portion. Around 726 individuals, including Tokais, Feriwalas, and shop workers, are directly involved in recycling activities, collectively earning an estimated 22,02,808 Taka per month Despite the lack of formal e-waste treatment plants, Khulna's informal recycling industry has contributed to financial and environmental development. Establishing structured recycling systems in Khulna could further enhance the economic

and ecological benefits, reducing heavy metal contamination while improving livelihood opportunities (Moniruzzaman & Paul, 2020b)

CONCLUSION

Addressing the flaws and challenges regarding e-waste and its management has become one of the major necessities as the generation and usage of electronic products is rising massively. In this paper, we tried to convey how the management chain is working in the Khulna city and what should be done to mitigate its inefficiencies. We also brought attention to the fact that it is important to aware and encourage the citizen of the city in order to ensure a long-term sustainable management system. And finally, we aimed to propose some strategies to mitigate the obstacles and barriers of this issue. The city policymakers along with various NGOs, researchers, stakeholders, businessmen and the general people should work comprehensively towards achieving the goal of establishing a permanent, resilient e-waste regulation system.

REFERENCES

Ahirwar, R., & Tripathi, A. K. (2021). E-waste management: A review of recycling process, environmental and occupational health hazards, and potential solutions. *Environmental Nanotechnology, Monitoring & Management*, *15*, 100409. https://doi.org/10.1016/J.ENMM.2020.100409

Ahsan, M., Yousuf, M., Rahman, M. S., Proma, F. I., Reza, A. W., & Arefin, M. S. (2023). Designing a Sustainable E-Waste Management Framework for Bangladesh. *Lecture Notes in Networks and Systems*, *569 LNNS*, 1108–1122. https://doi.org/10.1007/978-3-031-19958-5_104

Alamgir, M., Islam, S. M. T., Saju, J. A., Sultana, H., Nahar, N., Nath, D., Shakib, A., & Ahmed, M. G. T. (n.d.). *DOMESTIC SOLID WASTE RECYCLING PRACTICES IN NOAKHALI REGION, BANGLADESH: A SURVEY-BASED STUDY*.

Alam, M., & Bahauddin, K. Md. (2015). E-Waste In Bangladesh: Evaluating The Situation, Legislation And Policy And Way Forward With Strategy And Approach. *Present Environment and Sustainable Development*, *9*(2), 25–46. https://doi.org/10.1515/pesd-2015-0023

Auma Omondi, E., Chepkoech Koech, G., Auma Omondi α, E., & Chepkoech Koech σ, G. (2022). *Complexity of E-waste and its Management Challenges in Developing Countries-A Review*.

Debnath, B., Chowdhury, R., & Ghosh, S. K. (2018). Sustainability of metal recovery from E-waste. *Frontiers of Environmental Science and Engineering*, *12*(6), 1–12. https://doi.org/10.1007/S11783-018-1044-9/METRICS

Hossain, I., Khan, M. H., & D'costa, A. (2022). *Review of E-waste Management Rules, 2021*. www.voicebd.org

Ilyas, S., Srivastava, R. R., Kim, H., Das, S., & Singh, V. K. (2021). Circular bioeconomy and environmental benignness through microbial recycling of e-waste: A case study on copper and gold restoration. *Waste Management*, *121*, 175–185. https://doi.org/10.1016/J.WASMAN.2020.12.013

Islam, M. S., & Grönlund, Å. (2011). Digital Bangladesh – A Change We Can Believe in? *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *6866 LNCS*, 107–121. https://doi.org/10.1007/978-3-642-22961-9_9

Islam, M. T., & Huda, N. (2019). E-waste in Australia: Generation estimation and untapped material recovery and revenue potential. *Journal of Cleaner Production*, *237*, 117787. https://doi.org/10.1016/J.JCLEPRO.2019.117787

Kaya, M. (2016). Recovery of metals and nonmetals from electronic waste by physical and chemical recycling processes. *Waste Management*, *57*, 64–90. https://doi.org/10.1016/J.WASMAN.2016.08.004

Kumar, S., Smith, S. R., Fowler, G., Velis, C., Kumar, S. J., Arya, S., Rena, Kumar, R., & Cheeseman, C. (2017). Challenges and opportunities associated with waste management in India. In *Royal Society Open Science* (Vol. 4, Issue 3). Royal Society. https://doi.org/10.1098/rsos.160764

Masud, M. H., Akram, W., Ahmed, A., Ananno, A. A., Mourshed, M., Hasan, M., & Joardder, M. U. H. (2019). Towards the effective E-waste management in Bangladesh: a review. *Environmental Science and Pollution Research*, *26*(2), 1250–1276. https://doi.org/10.1007/S11356-018-3626-2

Moniruzzaman, S. M., & Paul, S. (2020a). *RECYCLING PRACTICES OF ELECTRONIC WASTE IN KHULNA CITY, BANGLADESH*.

Moniruzzaman, S. M., & Paul, S. (2020b). *RECYCLING PRACTICES OF ELECTRONIC WASTE IN KHULNA CITY, BANGLADESH*.

Perkins, D. N., Brune Drisse, M. N., Nxele, T., & Sly, P. D. (2014). E-Waste: A Global Hazard. *Annals of Global Health*, *80*(4), 286–295. https://doi.org/10.1016/J.AOGH.2014.10.001

Poganietz, W.-R., & Paypay, V. B. (2025). *The Concept of Industrial Ecology*. 21–36. https://doi.org/10.1007/978-3-031-73576-9_2

Reza, A., Environment, T. Y.-J. of the, & 2016, undefined. (n.d.). Impacts of waste dumping on water quality in the Buriganga River, Bangladesh and possible mitigation measures. *Researchgate.Net*. Retrieved January 30, 2025, from https://www.researchgate.net/profile/Arif-Reza/publication/309310989_Impacts_of_Waste_Dumping_on_Water_Quality_in_the_Buriganga_River_Bangladesh_and_Possible_Mitigation_Measures/links/5808e0c308ae040813481b9d/Impacts-of-Waste-Dumping-on-Water-Quality-in-the-Buriganga-River-Bangladesh-and-Possible-Mitigation-Measures.pdf

Rochman, F. F., Ashton, W. S., & Wiharjo, M. G. M. (2017). E-waste, money and power: Mapping electronic waste flows in Yogyakarta, Indonesia. *Environmental Development*, *24*, 1–8. https://doi.org/10.1016/J.ENVDEV.2017.02.002

Song, Q., Wang, Z., & Li, J. (2013). Sustainability evaluation of e-waste treatment based on emergy analysis and the LCA method: A case study of a trial project in Macau. *Ecological Indicators*, *30*, 138–147. https://doi.org/10.1016/J.ECOLIND.2013.02.016

Thushari, I., Vicheanteab, J., & Janjaroen, D. (2020). Material flow analysis and life cycle assessment of solid waste management in urban green areas, Thailand. *Sustainable Environment Research*, *30*(1), 1–17. https://doi.org/10.1186/S42834-020-00057-5/FIGURES/6

Xue, M., & Xu, Z. (2017). Application of Life Cycle Assessment on Electronic Waste Management: A Review. *Environmental Management*, *59*(4), 693–707. https://doi.org/10.1007/S00267-016-0812-1/TABLES/2