Volume 11, Issue 7, July – 2026 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul1808

Sustainable E-Waste Governance in Bangladesh from Hazard to Hope: Opportunities and Future Directions

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Publication Date: 2026/08/06

Abstract: The rapid growth of electronic device consumption has resulted in a significant increase in electronic waste (e-waste), creating serious environmental, public health, and economic challenges worldwide. Bangladesh is experiencing a substantial rise in e-waste generation due to rapid urbanization, technological advancement, increasing consumer demand, and the expansion of the telecommunications and electronics sectors. This study examines the current status of e-waste generation in Bangladesh, identifies the major sources and environmental risks associated with improper disposal, and evaluates existing national and international management frameworks. The study is based on a comprehensive review of published literature, government reports, and international policy documents, with a particular focus on the E-waste Management Rules 2021 of Bangladesh. The findings indicate that informal recycling practices remain the dominant method of e-waste processing, exposing workers and surrounding communities to hazardous substances such as lead, mercury, cadmium, and brominated flame retardants. The study further highlights the potential of the circular economy and the 10R hierarchy as practical approaches for improving resource efficiency, reducing environmental pollution, and extending product life cycles. It concludes that strengthening policy implementation, expanding formal recycling infrastructure, promoting Extended Producer Responsibility (EPR), and increasing public awareness are essential for achieving sustainable e-waste governance in Bangladesh.

Keywords: *Electronic Waste (E-waste), Bangladesh, Circular Economy, 10R Framework, Environmental Pollution, Sustainable Waste Management, Environmental Governance, Waste Governance.*

How to Cite: Fatema Sharmin Lucky (2026) Sustainable E-Waste Governance in Bangladesh from Hazard to Hope: Opportunities and Future Directions. *International Journal of Innovative Science and Research Technology*, 11(7), 3140-3147. https://doi.org/10.38124/ijisrt/26jul1808

I. INTRODUCTION

The rapid advancement of information and communication technology, coupled with increasing consumer demand for electronic devices, has led to a significant rise in electronic waste (e-waste) worldwide. E-waste includes discarded electrical and electronic equipment such as computers, mobile phones, televisions, refrigerators, and other household appliances. While technological progress has improved living standards and economic productivity, it has also generated complex environmental challenges due to the improper disposal and recycling of electronic products.

E-waste contains both valuable materials (such as copper, gold, and aluminium) and hazardous substances, including lead, mercury, cadmium, brominated flame retardants, and other toxic compounds. When improperly managed, particularly through informal recycling methods such as open burning, acid leaching, and manual dismantling without protective measures, these substances can contaminate soil, water, and air. This contamination poses serious risks to ecosystems and human health, including respiratory problems, neurological damage, and long-term chronic illnesses.

Bangladesh, as a rapidly developing country with increasing digitalization and urbanization, is experiencing a growing e-waste problem. The expansion of the telecommunications sector, increased importation of electronic devices, and the ship-breaking industry contribute significantly to the generation of electronic waste. However, formal e-waste management systems remain limited, and a substantial portion of recycling activities occur within the informal sector. This often involves unsafe working

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conditions and environmentally harmful processing techniques.

Despite emerging policy efforts and regulatory frameworks aimed at addressing the issue, effective implementation remains a challenge. There is a need for comprehensive assessment of the environmental risks associated with e-waste in Bangladesh and for identifying sustainable management strategies that align with national development goals.

This study aims to examine the environmental impacts of e-waste in Bangladesh, assess associated health and ecological risks, and explore future strategies for sustainable e-waste management. By analysing current practices and identifying gaps in policy and infrastructure, the research seeks to contribute to the development of safer, more efficient, and environmentally responsible solutions for managing electronic waste in Bangladesh.

II. LITERATURE REVIEW

Electronic waste (e-waste) has become one of the fastest-growing waste streams worldwide due to rapid technological development, increased consumption of electronic devices, and shorter product life cycles. According to Baldé et al. (2020), global e-waste generation continues to rise, while a massive portion remains undocumented or improperly recycled. This imbalance highlights weaknesses in formal waste collection systems and regulatory enforcement, particularly in developing countries.

E-waste contains both valuable and hazardous components. Prasad (2016) explains that electronic devices include recoverable metals such as copper and gold, along with toxic substances including lead, mercury, cadmium, and brominated flame retardants. When e-waste is processed using informal and unsafe techniques—such as open burning or acid extraction—these hazardous materials are released into the environment. Li, Lopez, and Liu (2018) note that such practices can contaminate soil, water, and air, leading to long-term environmental degradation. Johri (2008) further emphasizes that inadequate infrastructure and weak regulatory frameworks contribute significantly to environmentally unsound recycling practices in developing nations.

The health implications of e-waste exposure are also well documented. The World Health Organization (WHO, 2021) identifies children and informal sector workers as particularly vulnerable to toxic exposure at recycling sites. Exposure pathways include inhalation of toxic fumes, ingestion of contaminated dust, and direct skin contact with hazardous materials. These exposures are associated with adverse neurological, respiratory, and developmental effects. Akhtar and Prakash (2020) argue that without effective regulation and protective measures, informal recycling sectors pose significant public health risks.

At the international level, regulatory frameworks such as the Basel Convention (2011) aim to control the transboundary movement of hazardous waste and prevent illegal dumping. The European Union's WEEE Directive (2012/19/EU) introduces extended producer responsibility, requiring manufacturers to finance collection and recycling systems. These frameworks demonstrate structured governance models for e-waste management. However, their effectiveness depends heavily on institutional capacity and enforcement mechanisms.

In Bangladesh, the E-waste Management Rules 2021 introduced by the Department of Environment represent a major step toward formalizing e-waste collection, segregation, and recycling. The rules incorporate elements of extended producer responsibility and aim to regulate recycling activities. Nevertheless, the persistence of informal recycling practices and limited monitoring capacity present ongoing challenges.

Although previous studies have extensively discussed global trends, environmental risks, and regulatory frameworks, there is limited integrated assessment of environmental risk and policy effectiveness specifically within the context of Bangladesh. Therefore, further research is required to evaluate environmental impacts and explore sustainable management strategies suited to the country's socio-economic conditions.

III. MATERIALS AND METHORDS

Electronic waste is the fastest growing waste in the world. Its production has increased day by day due to the increasing use of technology, replacement of old devices, and the availability of low-cost devices. The study focused on major urban centres and regions in Bangladesh that are known for high consumption of electronic devices and active informal e-waste recycling. Cities such as Dhaka and Chittagong were selected because they host large populations with significant electronic device usage, which generates substantial amounts of e-waste annually. Additionally, these areas contain clusters of informal recycling operations, where discarded electronics are dismantled, sold, or processed using unsafe methods. Selecting these locations allows for an accurate assessment of both environmental and health risks associated with improper e-waste management. Focusing on high-consumption and high-recycling zones ensures that the study captures the most relevant patterns of e-waste generation, handling practices, and associated hazards in the context of Bangladesh.

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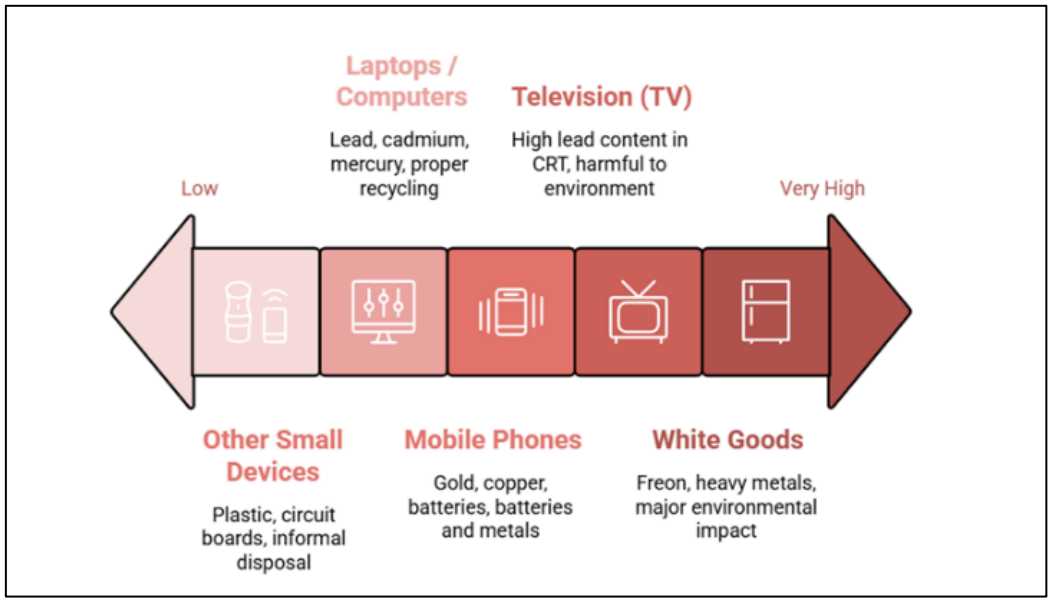

Fig 1: Electronic Waste Risk Level from LOW to VERY HIGH Environmental Impact

The most serious of the risks of e-waste is the environmental and health risks. CRT TVs, refrigerators, computer circuit boards, etc. contain toxic substances like lead, cadmium, and mercury, which increase in damage if not disposed of properly. If thrown into the ground irregularly, these metals mix with the soil and reduce the nutritional value of crops, vegetables, and soil. The soil loses fertility. Heavy metals and fluorocarbons from e-waste thrown into rivers, canals, and ponds mix with water, which accumulate in the bodies of fish and aquatic animals, which enter the human food chain.

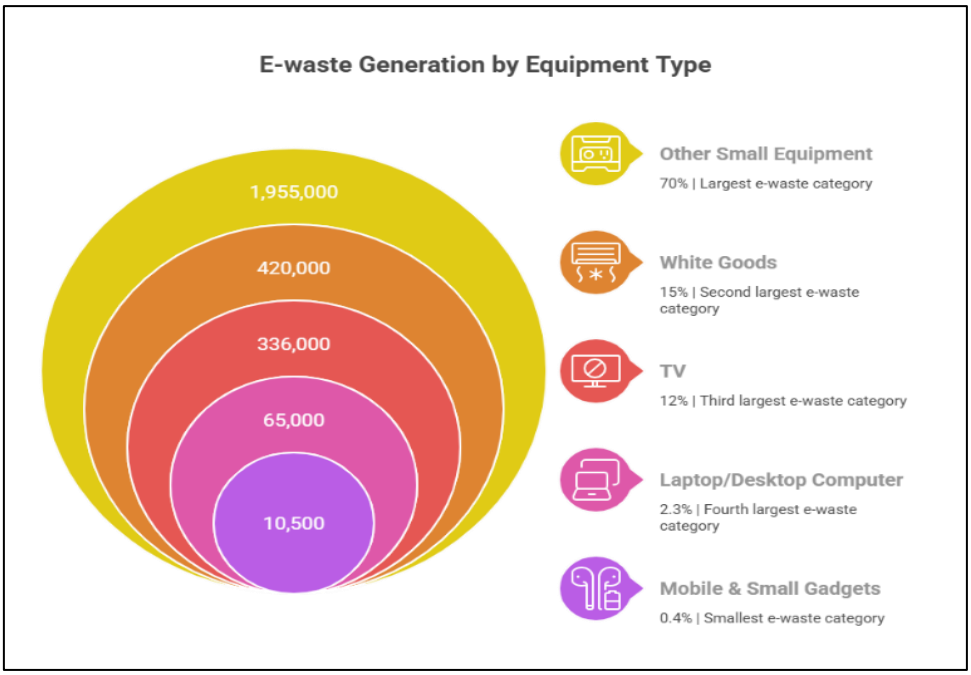

Fig 2 : Annual Electronic Waste Generation in Bangladesh by Equipment Type (Tons/Year)

When e-waste is burned, toxic fumes are released from plastics, PVC, and harmful metals. This smoke enters the human body through inhalation and damages the lungs and airways. The use of electronic products causes brain damage, hinders the mental development of children, and reduces haemoglobin. LCD/LED TVs and fluorescent lamps contain toxic substances that, when ingested, cause kidney, liver, nerve, and eye problems. They affect the respiratory tract, bones, and mental development of children.

Toxic substances in the atmosphere deplete the ozone layer and increase global warming. In pregnant women, lead and mercury affect the health and intelligence of the child. For example, workers in one area of Dhaka city separate the metals of mobile phones and laptops without masks or gloves. A health survey here found that 60% of the workers had higher than normal lead levels.

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Global production is estimated to be 55.5 million tons of electronic waste per year as of 2023. The growth rate is about 4-5% per year on average. The main sources are white goods (refrigerators, air conditioners) about 40%, small electronic devices (mobiles, laptops, printers) about 35%, computers and monitors about 25%.Old items are recycled by 20% and 80% of the items are thrown away or burned without understanding.

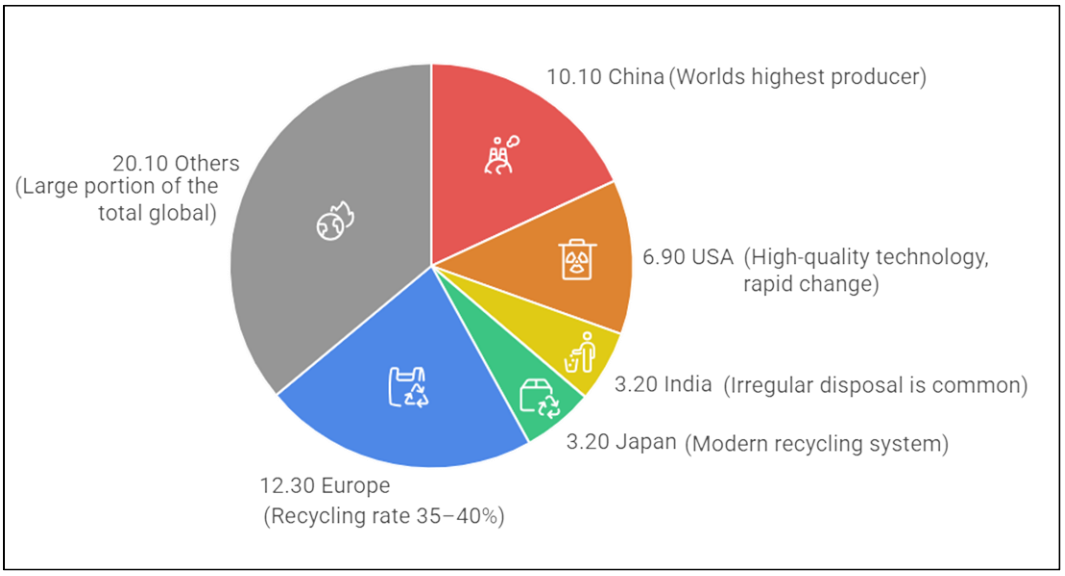

Fig 3 : Global E-Waste Generation by Region (Million Tonnes)

E-waste is growing rapidly in Asian countries. In 2023, Asia's production was about 24 million tons, which is 43% of the global total. Major sources are China, India, Japan, South Korea. In developing countries, irregular waste disposal is more common, and recycling is less common.

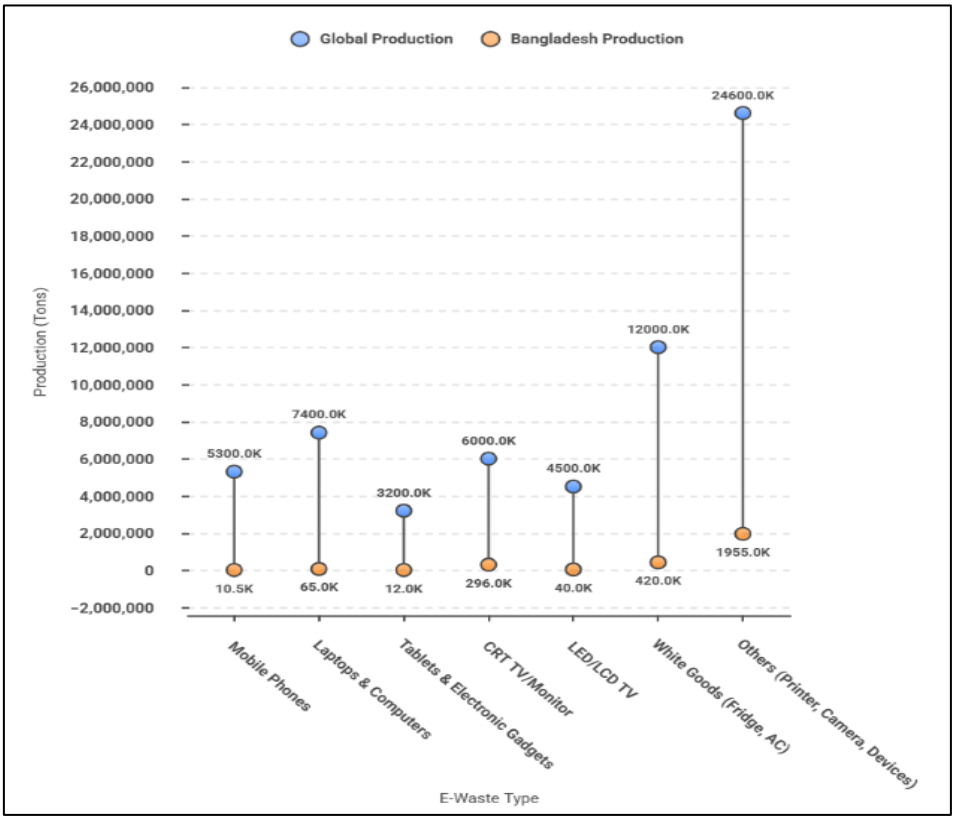

Fig 4 : E-waste Production Global vs. Bangladesh

E-waste is growing rapidly in Bangladesh, especially in major cities like Dhaka, Chittagong, Khulna, and Narayanganj. The annual production is about 2.8 million tons, with a production growth rate of about 5-6% per year.

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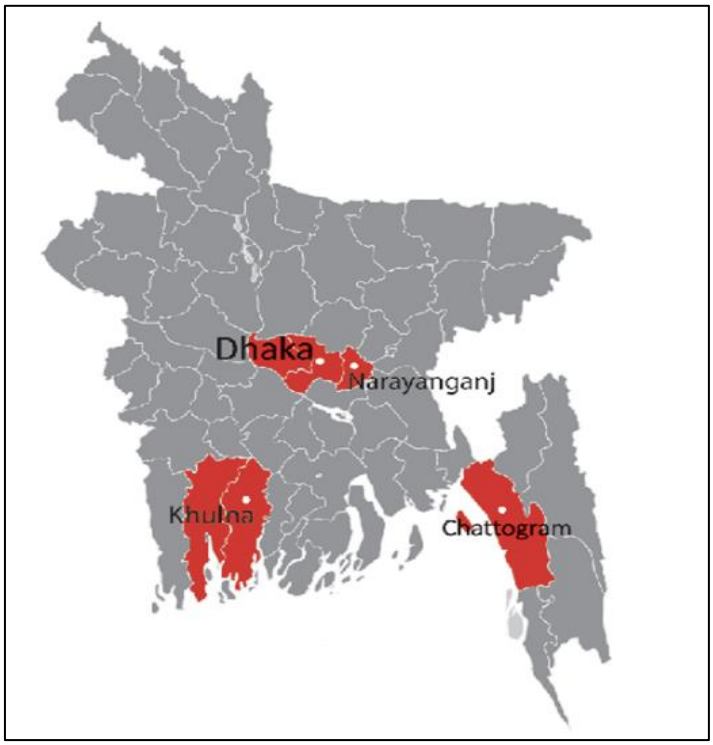

Fig 5: Rapid E-waste growing cities of Bangladesh -Dhaka, Narayanganj, Khulna and Chattogram

➢ *E-Waste Growth is due to :*

- Limited government and institutional recycling in Bangladesh.
- The impact of population growth.
- Such problems are caused by rapid changes in technology. For example, new phones, computers, TVs.
- Availability of low-cost devices.
- Easy replacement of old devices.
- Inconsistent recycling systems.
- Along with the expansion of urbanization, the spread of technology is increasing.
- Many people prefer to buy a new device instead of repairing it. Because repairs are often expensive or complicated due to design.

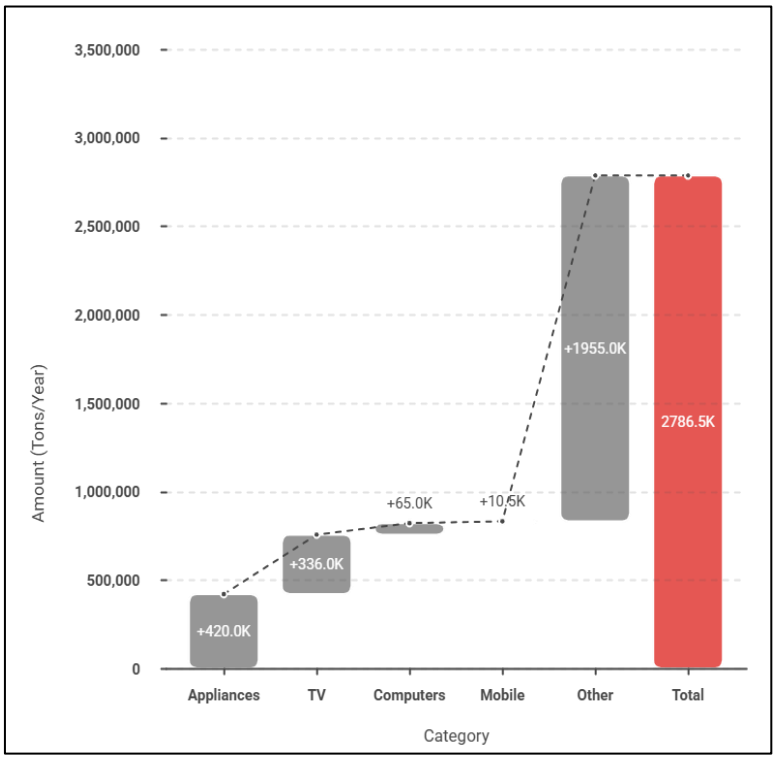

Fig 6 : E-Waste Production in Bangladesh

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IV. RESULT

The study identified five major categories of e-waste generated in Bangladesh: Mobile Phones, Laptops/Computers, Televisions (TV), White Goods, and Other Small Devices. Among these, mobile phones and laptops/computers were the most commonly discarded items in urban areas, reflecting high consumer usage and rapid technology turnover. White goods and televisions were less frequently discarded but contributed significantly to environmental risk due to their size and hazardous components.

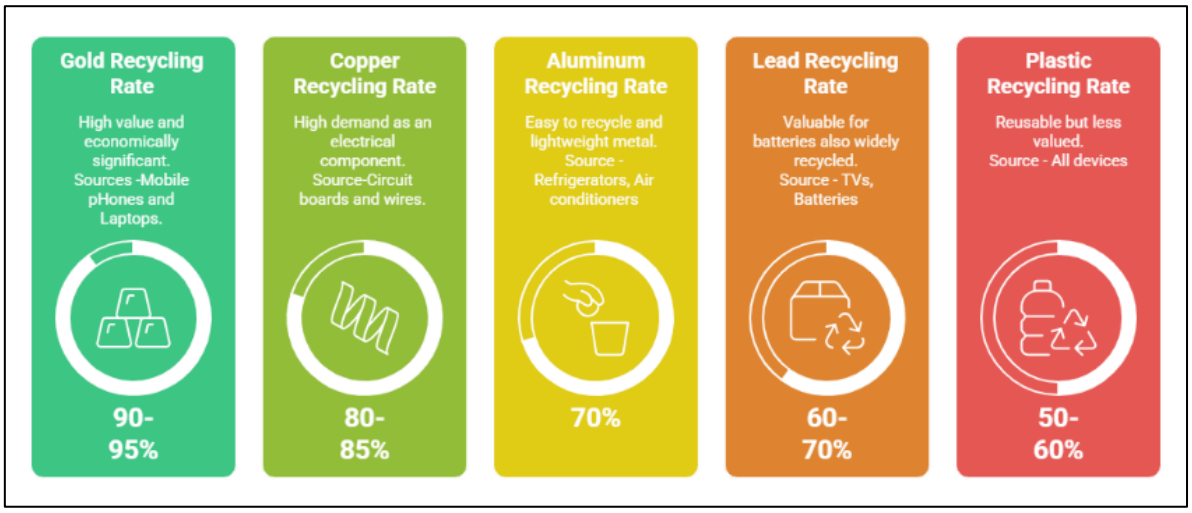

Fig 7 : Recycling Rates, Sources, and Economic Value of Common Metals

Analysis of hazardous components revealed that different device types pose varying environmental risks. Mobile phones contain valuable metals such as gold and copper, but their batteries and metals create high environmental risk if improperly overseen. Laptops and computers include lead, cadmium, and mercury, resulting in moderate risk, which can be mitigated through proper recycling. CRT televisions exhibit elevated risk due to their lead content, whereas white goods such as refrigerators and air conditioners show extremely elevated risk, primarily from freon and large metal components. Other small devices, including printers, cameras, and gaming consoles, present moderate risk, often associated with informal disposal practices.

These findings were summarized in Figure 7, which categorizes e-waste by type, examples, hazardous components, and risk level. Observational data and literature review indicate that informal recycling practices dominate in the selected study areas, focusing on extracting valuable metals while neglecting environmental and health safeguards. This pattern underscores the need for effective policy enforcement, public awareness, and structured e-waste management systems in Bangladesh.

V. DISCUSSION

E-waste is not just an environmental hazard; it is a significant economic resource. If properly collected, segregated, and recycled, Bangladesh could earn about $500 million annually. The results obtained from this study also reveal that e-waste generated in Bangladesh is primarily composed of mobile phones and laptops, which is consistent with the global scenario of a high consumption rate of electronic items, as revealed by Baldé et al. (2020). Although white goods and television sets are also present in a lower proportion, their larger size, and hazardous substances such as freon and lead also pose a prominent level of environmental risks.

The observed patterns of environmental risks also support earlier studies (Prasad, 2016; Li, Lopez, & Liu, 2018), which confirmed that informal recycling activities, which are commonly practiced in Bangladesh, may also lead to the generation of toxic substances that may affect the soil, water, and air. The informal recycling activities may also pose an important level of risks due to the improper recycling of hazardous substances, which is a matter of concern because children may also be exposed to such risks, as highlighted by WHO (2021).

The E-waste Management Rules 2021 in Bangladesh is one such regulatory framework that ensures the proper management of e-waste. However, the fact that there are still some irregular recycling activities and a lack of awareness among the people suggests that there are still some major gaps in the implementation of these rules. Some international best practices, such as the EU WEEE Directive and the Basel Convention, have shown that if there are extended producer responsibility and effective monitoring and community engagement, then there will be better compliance and less environmental risk.

The study thus highlights the need for urgent, structured, and contextually relevant e-waste management in Bangladesh. If there is no collective effort to address this issue, then the increasing consumption of electronic devices will only worsen the environmental and health risks,

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especially in the urban areas of Bangladesh where there is a high generation of e-waste.

In addition, the findings of this study can be further interpreted through the lens of the circular economy, particularly the 10R hierarchy, which prioritizes strategies such as Refuse, Rethink, Reduce, Reuse, and Repair over recycling. The results indicate that current e-waste management practices in Bangladesh are largely concentrated at the lower levels of this hierarchy, especially recycling and material recovery, while higher-value strategies such as repair, reuse, and refurbishment remain underutilized. This imbalance limits the potential for reducing environmental impact at the source. Therefore, integrating 10R principles into national e-waste management strategies could significantly improve sustainability by promoting waste prevention, extending product lifecycles, and reducing dependence on environmentally harmful recycling practices.

Fig 8 : 10R Hierarchy for Sustainable E-Waste Management

VI. FUTURE RECOMMANDATION

Several recommendations are relevant for Bangladesh for proper management. These can be analysed from policy, technical, social, and economic aspects. Companies manufacturing mobiles, laptops, TVs, refrigerators etc. should collect and recycle their products. Create special laws for the management of e-waste.

Set rules and regulations for the import, collection, storage, recycling, and disposal process. Control the informal sector and ensure health and safety. Strict surveillance against irregular dumping of E-waste. Regular inspection and fine system to prevent environmental pollution. Create modern technology-rich recycling plants centrally and regionally. Create separate units for CRT TVs, LED/LCD screens,

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batteries, refrigerators, computers etc. Use special technology to protect lithium and lead batteries from fire or explosion.

VII. CONCLUCION

Electronic waste is a rapidly growing problem in today's world, with significant environmental, health and economic impacts. Globally, about 55 million tons of e-waste are generated annually, consisting of white goods, computers, mobile phones, and other small electronic devices. Bangladesh also generates about 2.8 million tons of e-waste annually, a substantial portion of which comes from small electronic devices and white goods. With the right policies, technology, public awareness and international cooperation, this problem is solvable and economically viable. Safe recycling of recyclable metals such as gold, copper and aluminium can not only protect the environment but also ensure economic benefits for the country.

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