

E-Waste and Environmental Sustainability in Bangladesh: Building a Greener Future

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Abstract: The challenge of managing e-waste in Bangladesh intensifies due to fast technological advancements and increasing electronic device consumption coupled with insufficient disposal systems. Because e-waste receives poor management it produces major environmental harm and wellness concerns mainly in informal recycling facilities. This paper explores Bangladesh's e-waste conditions by examining all e-waste origins and patterns while analyzing all produced waste types. E-waste produces adverse environmental effects and public health problems from its toxic materials combined with heavy metals and chemicals. The paper also evaluates Bangladesh's regulatory frameworks for waste management and discovers where implementation needs improvement. This paper introduces with the sustainable approaches for public-private partnerships as part of its recommendations. The suggested solutions include policy enhancement measures along with community participation programs and financing green technologies. The research depends on secondary data content analysis to deliver its findings.

Introduction

Electrical and electronic equipment which outlive their functionality deserve the designation of E-waste regardless of their type such as mobile phones and computers and televisions and refrigerators. E-waste at present stands as among the globe's most difficult waste streams because technological progression along with expanding electronic device demands (Baldé et al., 2017). Modern technological advancements decrease the lifespan of electronics thus causing e-waste production rates to increase rapidly (Forti et al., 2020).

E-waste production has reached an overwhelming extent since millions of tons get discarded worldwide each year. E-waste has emerged as the speediest waste stream worldwide according to the United Nations 2019 report. High-income nations operate well-established e-waste recycling systems for proper waste management but developing countries such as Bangladesh along with others continue to face major problems with executing e-waste control measures. The price reductions of electronic equipment in developing economies have generated a rapid increase of e-waste which creates further difficulties in managing the situation.

The managed e-waste processing system in developed nations recovers valuable elements such as gold copper and aluminum and disposed of harmful substances correctly including lead and mercury. Low- and middle-income countries such as Bangladesh turn to disorderly and unregulated sectors when they dispose their e-waste. No suitable technology exists to protect workers from hazardous substances because informal disposal sectors handle these materials without proper safety protocols. The combination of inadequate measures leads to severe environmental pollution and dangerous toxic substance exposure.

The increasing rate of urban development and electronic device usage in Bangladesh has resulted in substantial growth of e-waste production. E-waste handling in Bangladesh occurs in unclean spaces where early processing techniques like open flames and acidic baths discharge destructive chemicals across the surroundings. The employed methods cause environmental destruction while creating substantial health hazards for both employees and residents of surrounding communities. Health complications from toxic substance exposure include neurological damage together with respiratory issues and cancer development according to Heacock et al. (2016).

The absence of formal recycling infrastructure remains the main reason behind inadequate e-waste management in developing nations. Developed countries have built extensive e-recycling systems yet Bangladesh along with other developing nations cannot afford or access the required funds and technological solutions. The absence of proper infrastructure leads to the incorrect disposal of e-waste in both standard-less landfills and casual recycling sites.

The Basel Convention serves as an international treaty that works to control hazardous waste exchanges between countries because it enables authorities to block e-waste exports to developing nations. The implementation of e-waste regulations meets obstacles because of limited resources along with poor governance and the vast informal sector that processes e-waste throughout Bangladesh as well as other countries.

Multiple methods are necessary to resolve the e-waste contamination problem in Bangladesh. A suitable solution for e-waste management requires building formal infrastructure including collection centers alongside safe recycling techniques and public information efforts targeting improper disposal risks. The government needs to work together with private sector companies and international organizations for building modern recycling plants that perform safe e-waste handling operations. The government needs to strengthen regulations to limit imports of e-waste from other nations particularly from developed countries.

Informal recyclers play a vital part in the e-waste workforce because they comprise numerous workers within this field. NGOs together with the government must offer safety training and financial rewards while providing resources to informal recycling workers in

their move to secure and formalized waste management practices. Safe e-waste shredding technology represents one solution which would help reduce environmental dangers and health threats.

E-waste management in Bangladesh represents a critical issue which impairs environmental sustainability together with public health and economic growth possibilities. The continuing technological adoption and urbanization expansion will lead to increased volumes of e-waste. The solution to this problem requires building sustainable infrastructure for e-waste management while also resolving the safety concerns present in unregulated recycling activities. Preemptive action at present will enable Bangladesh to properly handle its e-waste problems and maintain environmental sustainability. The research adopts a quantitative methodology to investigate e-waste creation patterns and consequences before proposing efficient control measures.

Literature Review

E-waste or electronic waste includes different abandoned electronic objects that feature both substantial household appliances together with compact consumer electronics. The discarded electronic products both harbor useful resources and represent substantial threats to environmental health because of harmful materials they contain. Baldé et al. (2017) divide e-waste groups into large household appliances and small devices and IT equipment. The proper classification of electronic waste enables researchers to determine how severe the problem is and which recycling processes suit individual waste types.

Under e-waste classification different substances are categorized as they contain either hazardous or non-hazardous elements. E-waste materials release toxic elements which include lead, mercury and cadmium together with flame retardants because these substances unequivocally damage environmental systems and create risks for human health (Forti et al., 2020). E-waste containment of hazardous materials plays an essential role in assessing the destructive outcomes from improper waste management procedures that occur mainly in unregulated developing world facilities.

Different theoretical guidelines influence the development of waste management strategies. Two major waste management approaches include linear economy and circular economy. A typical linear economy functions by producing materials that end up as waste following their use. Under the circular economy model sustainability practices concentrate on waste reduction together with recycling and product reusing. Murray et al. (2017) explain that the circular economy enables organizations to address resource sustainability with a unified model that tackles waste-based environmental damage particularly from e-waste. Scientists now view this framework as a preferred e-waste management system because it helps achieve reduction of environmental damage and extend product life through resource recovery efforts.

Seventy percent of e-waste should get recycled under the circular economy system to fight electronic waste while safeguarding the environment. The adoption of this model would offer better efficiency during e-waste processing while simultaneously decreasing the harmful effects electronic waste has on the environment during disposal.

Global Best Practices in E-Waste Recycling

Several nations have established advanced e-waste recycling systems which operate effectively to handle electronic waste. Japan together with Germany have implemented advanced recycling technologies which provide suitable examples for global nations to emulate. These countries supervise e-waste management by combining rigorous regulations as well as public education initiatives with Extended Producer Responsibility (EPR) policies. The systems described by Schlupep et al. (2011) have shown an outstanding capacity to minimize e-waste entering landfills and boost recycling performance ratings. Japan requires consumer recycling of electronic devices through its regulatory laws whereas Germany has implemented an Extended Producer Responsibility (EPR) system that makes manufacturers responsible for managing products at their end of life.

These countries excel in e-waste management because their established regulatory system prescribes proper e-waste collection and environmentally safe processing plus recycling procedures. These best practices particularly EPR policies demonstrate potential value to Bangladesh since the country is developing its e-waste recycling infrastructure.

Socioeconomic and Environmental Impact of E-Waste

E-waste produces extensive social and environmental problems particularly within developing countries. Improper disposal and informal recycling of e-waste pose significant risks to human health and the environment. Heacock et al. (2016) demonstrate that e-waste materials contain dangerous toxic substances like lead, mercury and cadmium that spread to air as well as soil and water. People who handle e-waste through informal recycling in developing nations experience health problems because they frequently encounter dangerous chemicals that cause neurological disorders and respiratory diseases.

E-waste produces harmful effects on human health through its role in creating contamination in soil while emitting dangerous chemicals that poison water systems (Rahman et al., 2019). Dangerous substances permeate into natural ecosystems upon improper waste disposal creating harm for both plant and animal life. Urgent action is required to properly handle e-waste in these regions because the increasing electronic waste volume produces severe environmental damage and health issues for human populations.

E-Waste in Developing Countries

The research about e-waste management practices in developing regions demonstrates major operational issues with informal recycling operations as their main concern. Baldé et al. (2017) alongside Rahman et al. (2019) both confirm that the informal e-waste recycling

field does not employ suitable protective equipment or safety measures to guard workers from dangerous elements. Ineffective management at informal recycling centers where workers lack training and equipment leads them to conduct operations by burning cables and dismantling electronic devices without safety protection. Hazardous chemicals that include heavy metals and persistent organic pollutants endanger workers during the recycling process.

Different developing countries lack organized e-waste recycling methods that produce improper electronic waste management leading to substantial environmental degradation. The current recycling practices sometimes spread e-waste to nearby dumpsites because of which environmental pollution increases (Rahman et al., 2019). E-waste management systems must address these challenges because doing so will boost effective waste control and minimize negative e-waste consequences in developing nations.

Research Objectives and Questions

The Primary Objective

1. To examine the current state of e-waste management in Bangladesh, evaluate its environmental and health impacts, and explore sustainable solutions.

The Secondary Objectives

1. To analyze the trends in e-waste generation and recycling in Bangladesh.
2. To assess the environmental and health impacts of e-waste in Bangladesh.
3. To identify and analyze the challenges in e-waste management in Bangladesh.

The research questions are:

1. What are the trends in e-waste generation and recycling in Bangladesh?
2. What are the environmental and health impacts of e-waste in Bangladesh?
3. What are the challenges in e-waste management in Bangladesh?

Methodology

Research Design

This study will use a qualitative research design to explore the socio-economic and environmental dynamics of e-waste management in Bangladesh. The aim is to gather in-depth insights from key stakeholders - including policymakers, waste workers, environmental activists, and community members - to better understand the challenges and opportunities for achieving a green, sustainable future.

Data Collection Methods

Focus Group Discussions (FGD):

- **Groups:**
 - Informal e-waste workers (scrap collectors, dismantlers)
 - Community members (households who discard electronics)
 - Small business owners (who sell or refurbish e-devices)
- **Purpose:**
 - To understand grassroots-level practices of e-waste disposal and recycling.
 - To explore community awareness about the environmental impact of e-waste.

Document Analysis:

- **Sources:**
 - National policies (e.g., E-Waste Management Rules 2021)
 - Reports from NGOs, UNDP, World Bank, and Bangladesh Bureau of Statistics (BBS)
 - Academic studies on e-waste and sustainable practices in Bangladesh
- **Purpose:**
 - To identify policy frameworks, recycling initiatives, and statistical trends in e-waste generation and management.

Data Analysis

Thematic Analysis:

- Data will be categorized into themes such as:
 - **Policy and regulatory challenges**
 - **Community awareness and practices**
 - **Innovative green technologies and recycling methods**
 - **Barriers to sustainable e-waste management**
- Emerging themes will be cross-checked with document analysis to identify patterns or contradictions.

Narrative Analysis:

- Focuses on personal stories from informal workers and community members to understand their lived experiences with e-waste handling.

Ethical Considerations

- **Informed Consent:** Participants will be fully briefed on the study's aims, and their consent will be documented.
- **Confidentiality:** All data will be anonymized to protect participant identities.

- **Voluntary Participation:** Emphasize that participants can withdraw at any time without consequences.

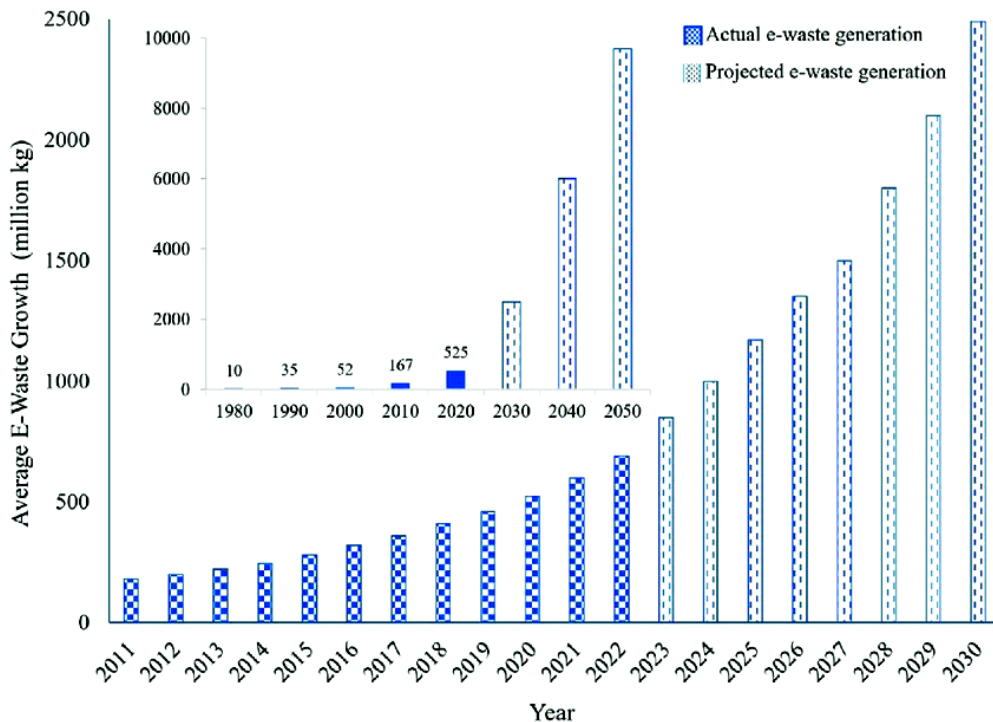
The Current State of E-Waste in Bangladesh

Trends in E-Waste Generation in Bangladesh

The increasing use of electronic technology in Bangladesh has resulted in steady growth of electronic waste production. High consumer adoption of mobile phones and computers along with televisions within urban settlements produces large amounts of e-waste according to Rahman et al. (2019). Proper collection and recycling methods have shown limited progress. Electronic waste (e-waste) generation in Bangladesh has been escalating rapidly over the past decades, posing significant environmental and health challenges.

Historical and Current Trends

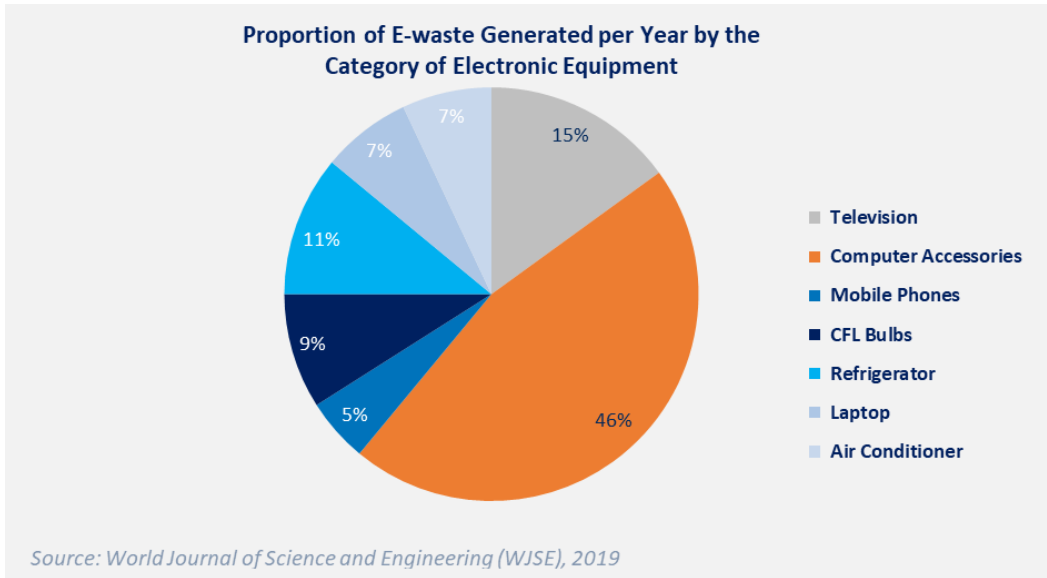
- **1980 to 2021:** E-waste generation in Bangladesh increased substantially, reaching approximately 600 million kilograms (600,000 metric tons) by 2021.



Annual Generation: Recent studies indicate that Bangladesh produces around 2.81 million metric tons of e-waste annually, with a growth rate of 20% per year.

Primary Sources of E-Waste

- **Shipbreaking Industry:** A significant portion of e-waste, approximately 2.7 million metric tons annually, originates from the shipbreaking sector.



Household Appliances: Refrigerators and televisions contribute notably to domestic e-waste, accounting for about 40% and 30% of the total, respectively.

Future Projections

- **By 2035:** E-waste generation is projected to reach 4.62 million metric tons, reflecting the ongoing increase in electronic device usage

Sources and Types of E-Waste in the Country

The main origins of e-waste in Bangladesh stem from household zones together with industrial and business areas. Mobile phones and televisions together with computers form the top discarded items whereas electronic devices get replaced by newer models at an increasing rate according to Rahman et al. (2019). The Primary Sources of E-Waste in Bangladesh are:

Households: The rapid adoption of electronic devices has led to significant e-waste generation from households. Common items include:

- **Televisions:** Constitute a substantial portion of household e-waste.

- **Refrigerators:** Another major contributor to domestic e-waste.
- **Mobile Phones and Computers:** Frequent upgrades result in the disposal of older models.

Businesses and Offices: Corporate sectors regularly update their electronic equipment, leading to the disposal of:

- **Computers and Laptops:** Obsolete or malfunctioning units.
- **Printers and Photocopiers:** Replaced due to technological advancements or wear and tear.

Educational Institutions: Schools, colleges, and universities generate e-waste through:

- **Laboratory Equipment:** Outdated scientific instruments.
- **Computers and Projectors:** Replaced to keep up with new technologies.

Healthcare Facilities: Hospitals and clinics dispose of electronic medical equipment, including:

- **Diagnostic Machines:** Such as X-ray and MRI machines.
- **Monitoring Devices:** Like heart rate and blood pressure monitors.

Informal Sector: A significant amount of e-waste is processed by informal recyclers who often lack proper safety measures, leading to environmental contamination.

Public Health Risks and Occupational Hazards

E-waste informal recyclers risk heavy exposure to dangerous materials that cause fatal lung ailments, cancer development and reproductive issues (Heacock et al., 2016). The residents who live by electronic waste disposal sites suffer potential environmental harm that results in health risks.

The government, private companies, and informal recyclers all play significant roles in e-waste management in Bangladesh. Although the government implemented regulatory standards the informal sector controls most e-waste recycling operations that perform their work using unsafe conditions (Rahman et al., 2019).

Policy and Regulatory Framework

Overview of E-Waste Regulations in Bangladesh

The government of Bangladesh created several waste management regulations yet insufficient policies exist which target e-waste specifically while also lacking proper implementation measures. Without established regulations informal recycling operations continue to operate without external supervision (Rahman et al., 2019).

The regulatory standards for e-waste management in Bangladesh exist at a lower level than international benchmarks. Japan along with Germany maintain superior regulatory approaches through EPR systems combined with fundamental collection and recycling initiatives supported by rigid environmental regulations (Schluep et al., 2011).

The Department of Environment serves as an agency under the government to control e-waste disposal regulations. Weak enforcement exists in e-waste management because the government lacks technical expertise and has insufficient resources according to Rahman et al. (2019).

Challenges in E-Waste Management

Informal Recycling and Unsafe Disposal Practices

In Bangladesh an increasing number of e-waste recycling activities take place using informal approaches that involve open burning and unprotected e-waste dismantling. The harmful substances workers encounter through these practices also result in environmental contamination (Rahman et al., 2019).

Economic and Logistical Barriers

There is an additional difficulty from economic barriers and logistical problems making formal recycling infrastructure unavailable. Formal e-waste recycling facilities remain out of reach due to high construction expenses and poor financial support systems for these initiatives (Hossain et al., 2020).

Role of Government and Environmental Agencies

The Department of Environment together with the government regulates methods for e-waste disposal across the country. Insufficient enforcement occurs because the regulatory agencies lack both resources and technical capabilities (Rahman et al., 2019).

Lack of Awareness and Public Participation

The general population stays unaware about the hazards of e-waste while ignoring the vital need for correct waste disposal. E-waste management improvements will fail to succeed unless residents actively participate in the initiative (Rahman et al., 2019).

Inadequate Funding and Technical Expertise

The limited financial support for waste management alongside insufficient e-waste recycling expertise prevents Bangladesh from establishing adequate sustainable solutions (Hossain et al., 2020).

Sustainable Solutions and Best Practices

Formalizing the Recycling Sector

The process of sustainable e-waste management in Bangladesh demands formal establishment of recycling facilities as an essential first priority. Safety and regulation need to be established through new facilities dedicated to recycling while environmental standards must be encouraged for compliance (Schluep et al., 2011).

Public-Private Partnerships in Waste Management

The combination of public and private sector collaboration through partnerships enables e-waste management activities by harnessing private sector expertise for environmental standard compliance (Schluep et al., 2011).

Innovations in Green Technology and Waste Reduction

As green technology continues to evolve it has the ability to decrease the production of electronic waste (e-waste) which creates better solutions for the rising environmental issues relating to e-waste. Using eco-friendly materials that consist of biodegradable components and recyclable materials within electronics structures can stretch the time contamination stays in landfills. Energy-efficient devices operate longer and use less electricity thus extending equipment durability which reduces the amount of e-waste produced. A crucial requirement for better e-waste processing efficiency is to advance recycling technology. More efficient approaches to recycle metals along with improved emission reduction techniques in recycling will substantially decrease the environmental impact of e-waste disposal (Murray et al., 2017). The innovative methods show potential to build sustainable electronics production and waste-handling practices which decrease e-waste's negative effects on people and nature.

Strategies for Community Engagement and Education

Public awareness campaigns and community engagement are critical to increasing participation in proper e-waste disposal and recycling programs (Hossain et al., 2020).

Investment in Infrastructure and Green Initiatives

Formal recycling infrastructure together with green technologies along with worker training must receive investment for Bangladesh to achieve better e-waste management practices. Formal e-waste processing centers would guarantee both environmental and health safety through safe waste management procedures which surpass the hazardous outcomes from informal recycling methods. The implementation of green technologies that use energy-efficient and environmentally safe material recovery approaches will enhance the sustainable management of e-waste throughout Bangladesh. Every worker who handles e-waste must receive thorough training because such programs give them essential skills to properly recycle their waste and protect themselves from dangerous materials during the process. In addition to promoting more efficient e-waste handling in Bangladesh these

financial investments would generate economic benefits and lasting environmental advantages which support sustainable waste reduction (Murray et al., 2017).

Recommendations

Strengthen Existing Laws: Enforce the E-Waste Management Rules 2021 by ensuring strict penalties for illegal disposal and informal recycling practices.

Establish E-Waste Collection Centers: Set up community-based collection points for households and businesses to safely drop off electronic waste.

Build Recycling Plants: Invest in advanced recycling facilities using eco-friendly technologies to process e-waste sustainably.

Green Tech Hubs: Encourage innovation centers where startups can develop sustainable e-waste solutions, like refurbishing old devices.

Public Awareness Campaigns: Launch national campaigns to educate people on the environmental impact of e-waste and safe disposal practices.

Corporate Collaborations: Encourage tech companies to sponsor recycling programs, offer take-back schemes, and support eco-design innovations.

Incentives for Green Businesses: Provide tax breaks and subsidies for businesses investing in sustainable e-waste solutions.

National E-Waste Database: Develop a centralized database to collect data on e-waste generation, recycling rates, and environmental impact for better policymaking.

Green Financing: Introduce "green loans" or grants for businesses and startups developing eco-friendly e-waste solutions.

Conclusion

The paper shows that Bangladesh requires immediate action to develop proper management systems for e-waste materials. The study reveals Bangladesh faces three main problems such as formal recycling has dominated over organized practices and citizens remain uninformed about these issues while enforcement levels remain inadequate. Sustainable approaches including formal recycling operations along with EPR legislation and infrastructure funding can lead Bangladesh toward a more sustainable tomorrow. The sustainable development of Bangladesh relies heavily on proper e-waste management. When properly managed resources can reduce environmental damage while boosting public health protection together with supporting the circular economy framework. A sustainable e-waste management system for Bangladesh will result from united action between the

government together with private companies and citizen participation. Through global recycling practices and technological innovation in waste management Bangladesh can develop sustainable recycling systems that other developing nations can follow.

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