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ENVIRONMENTAL AND ECONOMIC IMPLICATIONS OF ELECTRONIC WASTE (E-WASTE) IN MALAYSIA

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ABSTRACT

As one of the fastest-growing waste streams globally, e-waste presents significant challenges and opportunities for developing economies. The research highlights how Malaysia's rapid technological advancement and urbanization have contributed to increased e-waste generation, while regulatory frameworks remain inadequately implemented. The environmental implications include soil and water contamination, air pollution, increased carbon footprint, and threats to biodiversity due to hazardous substances like heavy metals. From an economic perspective, e-waste contains valuable recoverable materials that could contribute to resource security and economic resilience. The study also discusses how proper e-waste management creates employment opportunities and stimulates entrepreneurship. However, low recycling rates persist due to inadequate infrastructure and limited public awareness. The paper concludes that improving regulatory enforcement, enhancing public education, and investing in sustainable recycling infrastructure are essential steps toward creating an e-waste management system that effectively balances environmental protection with economic development.

Keywords: Electronic waste, Environmental contamination, Hazardous materials, Sustainable recycling, Economic opportunities

Introduction

Electronic waste (e-waste) has emerged as a significant global environmental and economic issue due to the increasing consumption and disposal of electronic products. The rapid pace of technological advancement, urbanization, and population growth has led to an unprecedented surge in e-waste generation worldwide. The World Health Organization (WHO) has reported that e-waste is one of the fastest-growing waste streams worldwide, with an estimated 53.6 million metric tons generated in 2019 alone, a figure projected to rise to 74 million metric tons by 2030 (Razali et al., 2019). According to the Global E-Waste Monitor, an estimated 53.6 million metric tons of e-waste were generated globally in 2019, with only 17.4% being properly collected and recycled (Forti et al., 2020). This rapid growth in e-waste generation is driven by several intersecting factors: accelerating technological innovation, decreasing product lifespans, expanding digital access in developing economies, and changing consumer preferences that favor frequent device upgrades. The resulting waste stream creates complex management challenges, as e-waste contains both valuable materials worth recovering (precious metals, rare earth elements, and base metals) and hazardous substances requiring careful handling to prevent

environmental contamination. The improper disposal of e-waste results in severe environmental hazards due to toxic materials such as heavy metals, lead, mercury, and cadmium.

In Malaysia, the situation is similarly alarming, with e-waste generation increasing significantly due to rapid urbanization and technological advancement (Sujá et al., 2014). The Malaysian government has classified e-waste as scheduled waste under the Environmental Quality Regulations, emphasizing the need for regulated management to mitigate its hazardous impacts (Noor et al., 2023; El-Gawhari et al., 2024). These regulations mandate that e-waste must be handled, transported, and treated by licensed facilities. Additionally, the government introduced the Environmental Quality (Prescribed Premises) (Treatment and Disposal Facilities) Order 1989, which establishes requirements for waste treatment and disposal facilities. Despite these regulatory efforts, implementation and enforcement challenges persist, resulting in a significant portion of e-waste being managed through informal channels or improperly disposed of with general waste (Yuan et al., 2019). The difference between formal and informal e-waste management systems creates a dual set of challenges. The informal sector, while providing economic livelihoods, often employs primitive recycling techniques that pose environmental and health risks. Meanwhile, the formal sector struggles to capture sufficient e-waste volumes to achieve economic viability, despite offering superior environmental performance. This dynamic creates a complex policy landscape requiring interventions that address both environmental protection and economic development objectives.

This paper investigates the environmental and economic implications of e-waste in Malaysia, highlighting the associated risks and potential opportunities.

Environmental Implications of e-waste

E-waste poses substantial environmental risks due to the presence of hazardous substances. The primary environmental concerns associated with e-waste include soil and water contamination, air pollution, and adverse effects on biodiversity. These impacts are particularly reflected in areas with informal recycling operations, where inadequate technological capacity and limited regulatory oversight result in ineffective waste management practices. Improper disposal of e-waste leads to the leaching of toxic substances into the soil and water bodies. The toxic effects of e-waste pollutants on wildlife, particularly in aquatic environments, have been well documented. E-waste contains hazardous materials such as heavy metals (lead, mercury, cadmium) and toxic substances posing significant risks to human health and the environment (Sujá et al., 2014). Uncontrolled disposal methods, particularly in informal recycling sectors, exacerbate these risks, leading to soil and water contamination (Sujá et al., 2014; Ohajinwa et al., 2019).

The improper disposal and management of e-waste contribute to Malaysia's carbon footprint. Burning e-waste to extract valuable metals is a common practice, especially in informal recycling

sectors. This process releases harmful dioxins and furans, contributing to air pollution and respiratory issues among local populations. When electronic devices are disposed of in landfills instead of being recycled, valuable resources are wasted, necessitating the extraction and processing of virgin materials, which is energy-intensive and generates significant greenhouse gas emissions. Furthermore, certain electronic components, particularly refrigerants in cooling devices, contain potent greenhouse gases that can be released into the atmosphere when improperly handled, exacerbating climate change impacts (Tukimin et al., 2019). Research highlights that unregulated e-waste processing in Malaysia exacerbates air pollution, leading to increased health risks in affected communities. The improper handling of e-waste not only threatens local ecosystems but also affects public health, with studies indicating that workers in informal recycling operations are often unaware of the health risks associated with exposure to these hazardous materials (Aja et al., 2016). Exposure to e-waste-derived pollutants has been associated with various health issues, including neurological damage, respiratory problems, skin disorders, and increased risk of certain cancers (Sujá et al., 2014; Ohajinwa et al., 2019). Particularly vulnerable are informal recyclers and communities living near unregulated e-waste processing sites, who face heightened exposure to hazardous substances through direct contact, inhalation of toxic fumes, or consumption of contaminated water and food.

Furthermore, Malaysia's rapid urbanization has resulted in increased e-waste generation, which, if not managed properly, could lead to severe environmental degradation (Tiep et al., 2015). The Malaysian government has recognized these challenges and has implemented regulations to manage e-waste. However, despite the legal framework, the actual recycling rates remain dismally low, with a significant portion of e-waste ending up in landfills (Yuan et al., 2019; El-Gawhari et al., 2024). E-waste disposal has been linked to declining biodiversity in water bodies near urban landfills. This situation highlights the urgent need for improved waste management practices and public awareness campaigns to promote responsible disposal and recycling of e-waste (Noor et al., 2023).

Economic Implications of e-Waste

The economic implications of e-waste management in Malaysia are equally significant. If managed properly, e-waste can serve as a valuable resource for recovering precious metals and fostering economic growth. Valuable materials such as gold, silver, and palladium are embedded in electronic devices, and proper recycling can recover these resources (Sujá et al., 2014). For instance, a ton of mobile phones contains approximately 300 times more gold than a ton of gold ore, highlighting the economic potential of urban mining (Sofian et al., 2023). Effective e-waste recycling could reduce Malaysia's dependence on imported raw materials, contributing to resource security and economic resilience. The development of a robust e-waste recycling industry in Malaysia presents significant opportunities for job creation and economic growth.

Studies suggest that formal e-waste recycling creates more employment opportunities than landfilling, with jobs spanning collection, transportation, dismantling, processing, and material recovery (Afroz et al., 2020). Additionally, the sector can stimulate entrepreneurship through the establishment of collection centers, recycling facilities, and refurbishment businesses. Research indicates that effective e-waste management could create thousands of jobs in Malaysia while generating substantial revenue from recovered materials (Sofian et al., 2023; Afroz et al., 2020).For instance, effective e-waste management can lead to the creation of green jobs in recycling facilities and related sectors, thereby enhancing local economies (Sofian et al., 2023).

However, the current e-waste recycling rate in Malaysia remains low due to inadequate infrastructure and limited public awareness. (Azlan et al., 2021; Hussin et al., 2023). Public attitudes and behaviors significantly influence e-waste management outcomes in Malaysia. Research indicates that while awareness of e-waste hazards is increasing, this knowledge does not consistently translate into appropriate disposal practices (Akhtar et al., 2014; Azlan et al., 2021). Many consumers continue to store obsolete devices at home, sell them to informal collectors, or dispose of them with general waste due to convenience, lack of accessible recycling options, or insufficient incentives for proper disposal. Understanding these behavioral patterns is crucial for developing effective interventions to enhance participation in formal e-waste recycling programs (Hussin et al., 2023). Educational initiatives play a critical role in fostering responsible e-waste management behaviors. Studies suggest that increased awareness and knowledge about e-waste can lead to more proactive recycling behaviors among residents (Akhtar et al., 2014; Azlan et al., 2021). However, many individuals still lack a comprehensive understanding of the e-waste management systems in place, which can lead to improper disposal practices (Yuan et al., 2019; Tukimin et al., 2019). Targeted awareness campaigns, educational programs in schools, and community engagement initiatives are essential for cultivating a culture of responsible e-waste management in Malaysia. By fostering a culture of recycling, Malaysia can not only mitigate the environmental impacts of e-waste but also harness its economic potential.

Conclusion

The environmental and economic implications of e-waste in Malaysia underscore the urgent need for improved management strategies. While e-waste poses significant environmental risks, it also presents opportunities for resource recovery and economic growth. Strengthening regulatory frameworks, increasing public awareness, and investing in sustainable recycling infrastructure are crucial steps toward mitigating the negative impacts of e-waste. By addressing these challenges, Malaysia can transition towards a more sustainable e-waste management system that balances economic benefits with environmental protection.

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