
Developing a Sustainable Business Model Framework for E-Waste Management in Emerging Economies: Evidence from Malaysia

Abdul Nafai Naeem¹, Zulhasni Abdul Rahim²

¹ Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Kuala, Email: nafai.naeem@graduate.utm.my

¹ ORCID ID: <https://orcid.org/0009-0003-2605-6096>

² ORCID ID: <https://orcid.org/0000-0002-4391-8589>

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Abstract

Electronic waste (e-waste) is one of the fastest-growing waste streams globally, driven by rapid technological change, shorter product life cycles, and increasing demand for electrical and electronic equipment. In emerging economies, the problem is intensified by fragmented collection systems, incomplete reverse logistics, uneven regulatory enforcement, and the continued dominance of informal recovery practices. Although previous studies have examined e-waste from technological, environmental, and policy perspectives, limited attention has been given to the business-model conditions required for formal e-waste enterprises to become economically viable and environmentally effective. This paper addresses that gap by developing a sustainable business model framework for e-waste management in emerging economies, using qualitative evidence from Malaysia. The study adopts an exploratory qualitative design informed by stakeholder interviews, industry observations, documentary review, and strategic synthesis through thematic analysis and SWOT interpretation. The findings show that sustainable e-waste enterprises are shaped by five interdependent dimensions: regulatory alignment, collection and reverse logistics design, circular value recovery, partnership architecture, and diversified revenue logic. Based on these findings, the paper proposes a framework that connects circular economy principles with the operational realities of e-waste enterprise development in resource-constrained settings. The paper contributes to the literature by shifting attention from policy and recycling technologies alone to business model innovation as a central mechanism for sustainability transition. The framework also offers practical guidance for entrepreneurs, policymakers, and investors seeking to strengthen formal e-waste systems in emerging economies.

Keywords: E-Waste Management; Circular Economy; Business Model Innovation; Emerging Economies; Reverse Logistics; Resource Recovery; Sustainability

Introduction

Electronic waste (e-waste) has become one of the most rapidly growing waste streams in the world because of accelerated product obsolescence, digital expansion, and rising household and organizational demand for electronic devices. Discarded electrical and electronic equipment contains hazardous materials such as lead, mercury, cadmium, and brominated flame retardants, which create serious environmental and health risks when handled improperly. At the same time, e-waste also contains valuable materials such as copper, aluminium, gold, silver, and rare earth elements. This combination makes e-waste both a waste-management challenge and a resource-recovery opportunity within the broader logic of the circular economy (Forti et al., 2020; Pan et

al., 2022). Existing scholarship has extensively examined e-waste through environmental, technical, and governance lenses. Prior studies have addressed recycling technologies, policy instruments, extended producer responsibility, life-cycle impacts, and material flow challenges (Widmer et al., 2005; Ismail & Hanafiah, 2021). Circular economy research has further argued that waste electrical and electronic equipment should be managed through tighter loops such as reuse, repair, refurbishment, remanufacturing, and recycling rather than linear disposal systems (Bresanelli et al., 2020; Rosa et al., 2019). However, while the literature increasingly recognizes the importance of circularity, relatively less attention has been paid to the business-model conditions that enable formal e-waste ventures to operate sustainably in emerging-market settings.

In many emerging economies, regulatory frameworks coexist with fragmented infrastructure, weak household collection mechanisms, low public awareness, uncertain feedstock supply, and strong informal-sector participation. Under such conditions, the challenge is not merely one of policy design but of operationalization. Formal enterprises must acquire waste streams, comply with legal requirements, organize reverse logistics, recover value from heterogeneous product conditions, and remain financially viable despite thin margins and market volatility. Recent work on circular business model innovation in the electrical and electronic equipment sector highlights the need to connect circularity with firm strategy and implementation processes (Pollard et al., 2021). Yet a context-sensitive framework for e-waste enterprise development in emerging economies remains underdeveloped. This paper addresses that gap by developing a sustainable business model framework for e-waste management in emerging economies, informed by qualitative evidence from Malaysia. Malaysia is a relevant empirical setting because it combines a growing electronics market with an evolving but incomplete e-waste governance system. Previous work has shown that the country's e-waste system still faces structural constraints in collection, formal recovery, and environmental performance planning (Ismail & Hanafiah, 2021). Rather than presenting a single-company case narrative, the paper synthesizes industry-grounded insights into a generalized framework for formal e-waste enterprise development.

Three research questions guide the paper. First, what barriers and opportunities shape the development of sustainable e-waste enterprises in emerging economies? Second, how can circular economy principles be translated into a viable business model for e-waste management? Third, what framework can guide sustainable e-waste venture development in resource-constrained regulatory environments? The paper contributes to the literature in three ways. It recenters business model innovation within e-waste scholarship, translates circular economy principles into enterprise-level design logic, and offers a practically useful framework for entrepreneurs, regulators, and ecosystem actors.

Literature Review

E-Waste, Circularity, and Resource Recovery

E-waste occupies a distinctive position in sustainability research because it combines toxicity risks with high residual resource value. Unlike conventional municipal waste, e-waste requires specialized collection, sorting, dismantling, and downstream treatment. Improper disposal generates pollution and occupational health hazards, while ineffective recovery leads to the loss of valuable secondary materials (Forti et al., 2020; Quinto et al., 2025). For this reason, e-waste management is closely linked to industrial ecology, sustainable production and consumption, and resource productivity. Circular economy thinking reframes e-waste from an end-of-pipe disposal problem into a failure of material-loop design. Recent reviews of circularity in the WEEE sector argue that value retention depends on strategies extending beyond recycling alone, including reuse, refurbishment, remanufacturing, redesign, and recovery (Pan et al., 2022). These strategies are significant because recycling often captures lower value than product-life extension pathways. Therefore, the effective management of e-waste depends not only on environmental

safeguards but on systems capable of routing products to their highest feasible value-retention pathway.

Circular Business Models and the Electronics Sector

The circular economy has increasingly been operationalized through the concept of circular business models. These models differ from linear models by creating, delivering, and capturing value from repeated use cycles, performance extension, and material recirculation. In the electronics sector, circular business model innovation has been identified as essential to improving collection, recovery, and resource efficiency (Pollard et al., 2021). Similarly, scholarship on circular business models in the WEEE sector argues that environmental benefit does not arise automatically from labeling a venture as circular; rather, benefits depend on how value creation and recovery activities are actually configured (Rosa et al., 2019). Recent literature also suggests that circular business model development must be aligned with product condition, service capability, stakeholder collaboration, and downstream market demand (van Loon et al., 2021; Fatimah et al., 2023). In other words, circularity is not only a technical ambition but an organizational and commercial design challenge. This is particularly relevant in e-waste systems, where businesses may need to combine collection services, refurbishment, parts harvesting, recycling, data destruction, asset disposition, and compliance support within a single operating model.

Emerging-Economy Constraints

Emerging economies face a specific set of constraints in e-waste management. These include underdeveloped reverse logistics, low consumer participation in formal disposal channels, uneven enforcement of environmental regulations, and the widespread presence of informal collectors and recyclers. While these actors often increase collection reach, they may also reduce traceability and environmentally safe handling. Studies of circular economy implementation in electronics and WEEE repeatedly identify policy, awareness, budgets, and ecosystem coordination as key determinants of performance (Yazdi et al., 2024; Zoka et al., 2025). In this context, formal e-waste enterprises need more than technical recovery capability. They need viable access to waste streams, revenue models that can absorb compliance costs, and partnership structures that stabilize both inflows and outflows. Yet the literature still offers limited empirically grounded frameworks for how such enterprises should be designed in emerging-market conditions. This gap is important because policy effectiveness ultimately depends on the existence of organizations capable of translating regulatory objectives into functioning circular systems.

Research Gap

Three gaps emerge from the literature. First, much of the e-waste literature focuses on environmental impacts, regulation, and recycling technologies rather than business-model design. Second, circular economy discussions often remain conceptual and insufficiently sensitive to the operational constraints of emerging economies. Third, there is limited framework-building work that integrates regulation, reverse logistics, value recovery, partnership design, and revenue diversification into a coherent model for formal e-waste enterprise development. This paper addresses those gaps by proposing an integrated sustainable business model framework based on qualitative evidence from Malaysia.

Methodology

This study employed a qualitative exploratory design to investigate how sustainable e-waste enterprises can be structured in emerging economies. A qualitative approach was appropriate because the study sought to understand interactions among regulation, stakeholder behavior, logistical constraints, value recovery opportunities, and enterprise strategy. These issues are complex,

context-dependent, and not easily reducible to purely quantitative indicators. The empirical setting was Malaysia. The country is relevant because it is a significant consumer and user of electronics within Southeast Asia and has an established yet still evolving regulatory environment for e-waste and scheduled waste management. The purpose of the study was not to test a hypothesis statistically or evaluate a single firm as an isolated case. Instead, the study aimed to derive broader design insights from industry-grounded evidence. The study drew on three primary evidence sources: stakeholder interviews, industry observations, and documentary review. Semi-structured interviews were used to collect perspectives from individuals familiar with the e-waste ecosystem, including industry practitioners and stakeholders with knowledge of operational, market, and regulatory conditions. Interviews focused on waste collection, compliance challenges, market opportunities, reverse logistics, refurbishment and recycling practices, and partnership needs. Industry observations were used to understand the practical flow of materials, operational constraints, and the realities of value recovery in the local context. Documentary materials, including policy-related sources, reports, and prior academic studies, were used to support contextual interpretation and triangulation.

Data were analyzed through thematic interpretation. Interview notes and documentary insights were reviewed repeatedly to identify recurring patterns related to barriers, opportunities, capabilities, and strategic requirements for e-waste ventures. These patterns were then organized into higher-order themes. A SWOT lens was used as an interpretive bridge to structure insights around strengths, weaknesses, opportunities, and threats relevant to formal e-waste enterprise development. However, SWOT was not treated as a standalone managerial output. Rather, it was used to support the synthesis of a framework that could connect empirical findings with circular business model design. The study sought to enhance trustworthiness through triangulation across data sources and through iterative comparison between stakeholder accounts, observed practices, and the wider literature. Nevertheless, the study remains exploratory. Its goal is analytical generalization and framework development rather than statistical generalization. Future studies can strengthen the evidence base by testing the proposed framework across multiple settings and with mixed-method approaches.

Findings

Regulatory Alignment as a Foundational Condition

A first major finding is that regulatory alignment functions as a foundational condition for formal e-waste enterprise viability. Compliance is not merely a legal obligation at the edge of the business; it shapes legitimacy, access to waste streams, transport arrangements, storage practices, downstream collaboration, and customer trust. At the same time, compliance can increase operating costs and complexity, particularly for newer firms operating with limited resources. This creates a structural paradox. Stronger regulation is necessary for environmentally sound management, but regulatory complexity may discourage entry into the formal sector or weaken competitiveness relative to informal actors. The finding suggests that sustainable e-waste business models must treat regulation as a design variable from the beginning. Compliance functions need to be embedded into operating logic, partnership arrangements, and service offerings rather than added later as an administrative afterthought.

Collection and Reverse Logistics as the Weakest Link

A second finding is that collection and reverse logistics remain the weakest link in the formal e-waste chain. Household e-waste is dispersed, often stored rather than released, or diverted to informal buyers offering convenience and immediate cash. Institutional and small-business waste generators may also lack clarity about compliant disposal options. As a result, formal enterprises struggle to secure stable and traceable inflows of e-waste. This has direct implications for

business-model design. Without reliable inflows, downstream activities such as sorting, refurbishment, component harvesting, and recycling become unstable. Reverse logistics should therefore be treated as a strategic core rather than a support activity. Viable business models require deliberate collection-channel design, awareness building, institutional linkages, and logistics partnerships that reduce friction for waste generators.

Circular Value Recovery Requires Multiple Pathways

The third finding is that value recovery in e-waste is inherently multi-pathway. Economic viability depends on recognizing that obsolete electronics can generate value through several routes: direct resale, refurbishment, parts harvesting, material recovery, and specialized service offerings. A model focused only on scrap-material recovery is more exposed to commodity-price volatility and often captures lower value than models that also include product-life extension or component reuse. This suggests that circularity in e-waste should be understood as a hierarchy of value-preserving options rather than a single recycling function. Enterprises need capabilities to assess product condition and route items into the most value-retaining channel available. The business model must therefore accommodate heterogeneous product states and multiple output markets.

Partnership Architecture Shapes System Performance

A fourth finding is that formal e-waste enterprises are fundamentally networked organizations. No single actor typically controls waste generation, collection, logistics, treatment, refurbishment, recycling, and downstream sales. Sustainable enterprise performance depends on how well these actors are coordinated. Partnerships reduce transaction costs, enable specialization, improve access to waste streams, and support legitimacy and compliance. In practical terms, partnership architecture may include institutional generators, logistics providers, treatment partners, refurbishers, recyclers, regulators, and secondary-market actors. The strength of the model therefore depends not only on internal capabilities but also on ecosystem positioning. This finding reinforces the view that e-waste business models in emerging economies must be designed as collaborative systems rather than self-contained firms.

Revenue Diversification Is Essential

The final finding is that financial sustainability requires diversified revenue logic. Heavy dependence on one revenue source, such as raw material recovery, creates vulnerability to feedstock uncertainty, fluctuating prices, and regulatory costs. More resilient models combine multiple income streams, including collection services, refurbishment and resale, component recovery, data destruction, IT asset disposition, recycling margins, and contract-based services. Revenue diversification is particularly important in volatile operating environments. It allows firms to absorb shocks, use recovered assets more flexibly, and align service offerings with different customer segments. In this sense, revenue diversification is not a supplementary growth strategy but a core design principle for formal e-waste enterprises.

Discussion

Proposed Sustainable Business Model Framework

The findings support the development of a sustainable business model framework for e-waste management in emerging economies. The framework consists of five interconnected pillars. First, regulatory alignment requires the enterprise to embed compliance into operational design, including waste classification, transport, storage, reporting, and downstream treatment. Second, reverse logistics and collection design require the enterprise to build or coordinate channels that can secure reliable inflows from households, institutions, and corporate generators. Third,

circular value recovery requires the enterprise to evaluate each incoming item for its highest feasible value pathway, prioritizing reuse, refurbishment, and component recovery before lower-value recycling routes. Fourth, partnership architecture requires the enterprise to operate through a collaborative ecosystem involving suppliers, collectors, transporters, treatment partners, market intermediaries, and regulators. Fifth, diversified revenue logic requires the enterprise to spread risk across multiple value streams rather than depending on one recovery channel. Taken together, these five pillars link circular economy principles with the real operating constraints of emerging-market e-waste systems. The framework is especially useful because it avoids treating circularity as a purely normative objective. Instead, it shows how circularity becomes implementable when translated into decisions about inflows, activities, partnerships, compliance, and value capture.

Theoretical Contribution

The paper contributes to the literature by moving business model design to the center of e-waste management analysis. Much existing research treats firms as downstream implementers of policy or as sites of technical recovery. By contrast, this paper conceptualizes e-waste enterprises as active intermediaries that connect regulation, waste generation, value recovery, and market creation. This perspective enriches both e-waste governance scholarship and circular business model research. The paper also extends circular economy debates by showing that circularity in the e-waste sector is not reducible to recycling performance. Rather, it depends on enterprise-level capabilities to capture value through multiple loops while remaining compliant and financially viable. In this way, the study responds to calls for more context-sensitive and implementation-oriented research in circular economy scholarship.

Practical Implications

For entrepreneurs, the framework offers a strategic blueprint for building e-waste ventures that are both commercially realistic and environmentally credible. It highlights the need to prioritize collection design, partnership building, compliance planning, and multiple revenue streams at the outset. For policymakers, the findings suggest that stronger regulation alone will not formalize the sector unless formal enterprises can access waste streams and compete with the convenience of informal channels. Policy interventions may therefore need to include take-back schemes, awareness programs, procurement-linked disposal standards, and institutional collection partnerships. For investors and development agencies, the framework indicates that e-waste opportunities should be assessed not only in terms of recycling capacity but also in terms of ecosystem access, reverse-logistics capability, and value-recovery diversity.

Alignment with Target Journals

The paper is well aligned with journals focusing on cleaner production, circular economy, resource recovery, and sustainability transitions. *Journal of Cleaner Production* states that it serves as a platform for theoretical and practical work on cleaner production, environmental, and sustainability issues across corporations, governments, institutions, regions, and societies. *Resources, Conservation and Recycling* focuses on transformation toward sustainable production and consumption patterns, resource productivity, and innovation processes. *Resources, Conservation & Recycling Advances* publishes work on sustainable resource management, circular economy, and resource sustainability, with a rapid review orientation. These scopes make the manuscript particularly suitable for a circular-economy business-model paper grounded in e-waste management (Elsevier, 2026a, 2026b, 2026c).

Conclusion

This paper developed a sustainable business model framework for e-waste management in emerging economies using qualitative evidence from Malaysia. The analysis shows that the viability of formal e-waste enterprises depends on five interrelated dimensions: regulatory alignment, reverse logistics and collection design, circular value recovery, partnership architecture, and diversified revenue logic. Together, these dimensions explain how environmentally responsible and commercially viable e-waste systems can be organized under resource-constrained and institutionally uneven conditions. The paper responds to an important research gap by shifting the focus from policy and recycling technology alone toward enterprise design. In doing so, it argues that formal e-waste systems will remain weak unless viable business models exist to translate circular economy objectives into working operational arrangements. The framework presented here offers both a conceptual contribution and a practical guide for entrepreneurs, regulators, and investors.

The study remains exploratory and contextually grounded. Future research should test and refine the framework across multiple countries, enterprise types, and policy settings. Comparative case studies, survey-based validation, and mixed-method research would help determine which framework components are most decisive under different market and regulatory conditions. Even with these limitations, the study provides a strong basis for repositioning e-waste management as a problem not only of waste governance, but of sustainable enterprise design.

Table 1. Sustainable business model framework for formal e-waste enterprises

Framework pillar	Core question	Operational implication
Regulatory alignment	How will the enterprise remain compliant and legitimate?	Embed licensing, transport, storage, traceability, reporting, and downstream treatment requirements into the operating model.
Collection and reverse logistics	How will the enterprise secure reliable and traceable inflows?	Build accessible collection channels, institutional take-back links, awareness mechanisms, and logistics partnerships.
Circular value recovery	How will the enterprise maximize value from heterogeneous items?	Route items to reuse, refurbishment, component recovery, or recycling based on condition and market demand.
Partnership architecture	Which actors are required to make the system function?	Coordinate generators, collectors, transporters, refurbishers, recyclers, regulators, and secondary-market actors.
Diversified revenue logic	How will the enterprise remain financially resilient?	Combine service fees, refurbishment and resale, parts harvesting, recycling margins, and specialized contract services.

References

- Balde, C. P., Wang, F., Kuehr, R., & Huisman, J. (2017). The global e-waste monitor 2017: Quantities, flows and resources. United Nations University.
- Bressanelli, G., Sacconi, N., Perona, M., & Baccanelli, I. (2020). Circular economy in the WEEE industry: A systematic literature review and a research agenda. *Sustainable Production and Consumption*, 23, 174-188. <https://doi.org/10.1016/j.spc.2020.05.007>
- Elsevier. (2026a). *Journal of Cleaner Production: Aims and scope*. ScienceDirect.
- Elsevier. (2026b). *Resources, Conservation and Recycling: Aims and scope*. ScienceDirect.

- Elsevier. (2026c). Resources, Conservation & Recycling Advances: Aims and scope. ScienceDirect.
- Fatimah, Y. A., Govindan, K., Murniningsih, R., & Setiawan, A. (2023). Circular economy e-business model portfolio development for e-waste management: A conceptual and strategic perspective. *Journal of Cleaner Production*, 420, 138428. <https://doi.org/10.1016/j.jclepro.2023.138428>
- Forti, V., Balde, C. P., Kuehr, R., & Bel, G. (2020). The global e-waste monitor 2020: Quantities, flows and the circular economy potential. United Nations University.
- Ismail, H., & Hanafiah, M. M. (2021). Evaluation of e-waste management systems in Malaysia using life cycle assessment and material flow analysis. *Journal of Cleaner Production*, 308, 127358. <https://doi.org/10.1016/j.jclepro.2021.127358>
- Pan, X., Wong, C. W. Y., & Li, C. (2022). Circular economy practices in the waste electrical and electronic equipment industry: A systematic review and future research agendas. *Journal of Cleaner Production*, 365, 132671. <https://doi.org/10.1016/j.jclepro.2022.132671>
- Pollard, J., Osmani, M., Cole, C., Grubnic, S., & Colwill, J. (2021). A circular economy business model innovation process for the electrical and electronic equipment sector. *Journal of Cleaner Production*, 305, 127211. <https://doi.org/10.1016/j.jclepro.2021.127211>
- Quinto, S. M., Quitadamo, A., & colleagues. (2025). Exploring the e-waste crisis: Strategies for sustainable management and circular economy transition. *Recycling*, 10(2), 72.
- Rosa, P., Sassanelli, C., & Terzi, S. (2019). Circular business models versus circular benefits: An assessment in the waste from electrical and electronic equipment sector. *Journal of Cleaner Production*, 231, 940-952. <https://doi.org/10.1016/j.jclepro.2019.05.310>
- van Loon, P., Van Wassenhove, L. N., & Vanheusden, B. (2021). Circular products and business models and environmental impact reductions: Current knowledge and knowledge gaps. *Journal of Cleaner Production*, 288, 125627. <https://doi.org/10.1016/j.jclepro.2020.125627>
- Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M., & Boni, H. (2005). Global perspectives on e-waste. *Environmental Impact Assessment Review*, 25(5), 436-458. <https://doi.org/10.1016/j.eiar.2005.04.001>
- Yazdi, M., et al. (2024). E-waste circular economy decision-making: A comprehensive approach for sustainable operation management. *Neural Computing and Applications*. <https://doi.org/10.1007/s00521-024-09754-3>
- Zoka, M., et al. (2025). Circular economy implementation in the electric and electronic equipment industry: Benefits, barriers, and incentives. *Sustainability*, 17(17), 7700.