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# Towards integrative multi-stakeholder responsibility for net zero in e-waste: A systematic literature review

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## Abstract

Despite extensive research on e-waste management, the integrative responsibilities of multi-stakeholders and the dependency on technology remain underexplored. This study aims to develop an integrative multi-stakeholder responsibility model to advance the net-zero goal in e-waste management. Following the PRISMA protocol, we conducted a systematic review of 99 articles. The review revealed three themes of stakeholder responsibility, four performance measure categories, three e-waste solutions, and four roles of smart technologies. These insights informed the development of a conceptual model to enhance environmental performance in e-waste. The proposed model emphasises critical attributes of multi-stakeholder relationships, including partnership, shared responsibility, inclusiveness, and transparency; it offers practical guidance for multi-stakeholders in prioritising efficient and mature technologies to be adopted and diffused, enabling effective e-waste management. Our study extends stakeholder theory from an organisation-centric to a problem-based perspective, highlighting its practical implications for effective e-waste management and suggesting future research directions for sustainability.

**KEYWORDS**
circularity, environmental performance, e-waste, extended stakeholder theory, multi-stakeholder responsibility, net zero

## 1 | INTRODUCTION

The waste of electrical and electronic equipment (WEEE, or e-waste) is recognised as the fastest-growing solid waste stream globally World Health Organization (WHO, 2023). From mobile phones to solar panels and electric vehicle batteries, the resulting waste at the end of the lifecycle remains inadequately addressed to a considerable extent.

The 2021 United Nations Climate Change Conference established a crucial global commitment to achieve net-zero emissions (ukcop26.org, 2021). While it is widely acknowledged that reaching net zero is essential for sustainable WEEE management, the current approach seems at odds with the growing amount of e-waste that must be managed to meet this goal. Central to achieving net-zero emissions is the maximising of resource utilisation and minimising of global e-waste.

**Abbreviations:** AI, Artificial intelligence; CE, Circular economy; CSR, Corporate social responsibility; EEE, Electrical and electronic equipment; EOL, End of life; EPR, Extended producer responsibility; ESG, Environmental, social and governance; EU, European Union; EV, Electric vehicle; ICT, Information and communication technology; IoT, Internet of things; LED, Light emitting diode; O2O, Online to offline; PCBs, Printed circuit boards; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SLR, Systematic literature review; UNWCED, United Nations World Commission on Environment and Development; WEEE, Waste of electrical and electronic equipment; WHO, World Health Organization.

This study is motivated to explore how we can enhance environmental performance in WEEE management, thereby mitigating the escalating e-waste issue.

While scholars have proposed substantial ideas and research solutions associated with WEEE management, such as extracting valuable metals and reducing rare earth elements (Işıldar et al., 2018) and implementing circular business models (Ranjbari et al., 2021), significant gaps remain in the literature. One prominent solution, enhancing producer accountability through extended producer responsibility (EPR), was identified nearly two decades ago as a key solution (Widmer et al., 2005). Despite these insights, EPR's narrow focus on collection and recycling targets (Favot et al., 2016) reveals its limitations. Addressing the global e-waste issue to achieve enhanced environmental performance requires considering a broader spectrum of multi-stakeholders. It necessitates partnership and integration among the multi-stakeholders, including designers, producers, distributors, recyclers, waste collectors (Sharma et al., 2020), and those involved in e-waste exporting and greenwashing (Abalansa et al., 2021). Additionally, the informal e-waste sector, characterised by workers often unaware of harmful substances(Scruggs et al., 2016), indicates systemic failures that require thorough investigation. The integration of multi-stakeholders into a cohesive WEEE ecosystem and the extent of influence and interdependence among these WEEE stakeholders remains incompletely understood.

This study critically reviews the state of the art in the literature regarding WEEE stakeholders and their responsibilities in WEEE management and explores the role of multiple stakeholders in enhancing WEEE management performance. Stakeholders, defined as individuals or groups with legitimate interests in corporate activities (Donaldson & Preston, 1995), seek to prioritise their own interests, whilst environmental interests require upholding multiple shared interests. In conventional stakeholder theory, stakeholders are centred around a corporation with insufficient promotion of sustainable environmental outcomes that require an emphasis on shared responsibility. Despite recent calls for multi-stakeholder approaches (e.g. Hina et al., 2022), a shift towards purpose-driven, multi-objective organisations (Mitchell et al., 2016) and a preference for cooperation over competition (Bridoux & Stoelhorst, 2022), conventional stakeholder theory falls short of fostering sustainable environmental outcomes without a central dimension of shared responsibility. This study positions stakeholders as having shared interests and values aligned with broader societal and environmental issues such as WEEE management. Moving away from the organisation-centric approach of traditional stakeholder theory, this study highlights the interdependence of multiple stakeholders (Eikelenboom & Long, 2022) whose interests are aligned with, if not obliged to, serving the broader societal interest (Valentinov, 2023).

Building on the identified literature gap in stakeholder theory, this study aims to develop an integrative multi-stakeholder responsibility model toward enhanced environmental sustainability in e-waste management. We address pertinent research questions through a Systematic Literature Review (SLR), laying the foundation for our proposed conceptual model.

- RQ1: What are WEEE stakeholders' responsibilities in WEEE management?
- RQ2: What are WEEE management performance measures and indicators?
- RQ3: How to improve WEEE management performance?
- RQ4: What is the role of smart technology in WEEE management?

This study makes three distinct contributions to the literature. First, it consolidates fragmented WEEE management literature, categorising and clarifying multi-stakeholder responsibilities, performance indicators and the role of smart technologies. Second, it extends stakeholder theory, offering a practical solution for societal and environmental issues. Third, the study introduces an integrative multi-stakeholder responsibility model for achieving net zero, offering a roadmap for sustainable environmental performance in WEEE management and similar contexts.

The following section provides the narrative context and reviews the study's theoretical foundation. Subsequently, we detail the research method, utilising SLR following the PRISMA protocol. Building upon the SLR findings and analysis, we introduce the integrative multi-stakeholder model to enhance environmental sustainability in WEEE management. The study concludes by summarising its contributions and acknowledging limitations.

## 2 | NARRATIVE CONTEXT AND THEORETICAL GROUND

### 2.1 | Net zero and environmental sustainability

The concept of net zero is rooted in the Brundtland Report, which defines sustainability as meeting present needs without compromising future generations (UNWCED, 1987). Since its inception, many frameworks have sought to encapsulate the essence of sustainability. Elkington's triple bottom line model (Elkington,1997), considering economic, social and environmental dimensions, though well-intentioned, garnered widespread criticism due to conceptual vagueness (Kuhlman & Farrington, 2010) and challenges in quantification (Tullberg, 2012).

In contrast, 'net zero' offers a more precise concept, aiming for a neutral environmental impact and providing a practical measure for assessing the repercussions of human activities on climate change (Rogelj et al., 2015). Achieving net-zero emissions sustains economic productivity without environmental harm throughout the supply chain. However, due to its relative novelty, there is a lack of standardisation of terms, particularly around human innovation's potential, to garner a more comprehensive understanding of the involved factors (Desrochers, 2020).

### 2.2 | Circularity and multi-stakeholder approach in WEEE management

Circularity in WEEE management is rooted in the principle of a circular economy (CE), which aims to minimise waste through reuse, repair and remanufacturing (Korhonen et al., 2018), reinforcing this life cycle with closed-loop supply chains (Ranjbari et al., 2021). The CE relies on robust stakeholder networks and has gained traction as a viable business model (Korhonen et al., 2018). However, CE business models may not inherently be synonymous with environmental sustainability (Ferasso et al., 2020). Influenced by the best available alternatives, economic agents may constrain their engagement in environmental performance-driven WEEE management (Pérez-Martínez et al., 2021) and are more likely to prioritise organisational interests over addressing broader environmental issues (Hina et al., 2022). Moreover, successful CE implementation hinges on the existing system, facing hurdles like stakeholder mobilisation, infrastructure development, and product traceability (Korhonen et al., 2018; Sundar et al., 2023).

While CE prioritises a commitment to net zero, responsibility in WEEE management is under-represented. EPR legislation focuses on producer accountability but is less clear about importers of goods from producers outside legislative powers or collectors' logistics solutions, which may be polluting. Thus, understanding stakeholders and their roles and responsibilities in the WEEE circularity process is vital for achieving net-zero objectives effectively.

## 2.3 | Extended stakeholder theory

Stakeholder theory, corporate social responsibility (CSR), and environmental, social and governance (ESG) are pivotal theories informing the development of a WEEE-based multi-stakeholder responsibility model to achieve net-zero outcomes. Stakeholder theory underscores the necessity of considering the interests of all stakeholders in decision-making processes (Clarkson, 1995). It contends that organisations bear a social responsibility to balance stakeholder interests rather than solely pursuing shareholder value maximisation (Freeman, 2010; Jones, 1995). However, criticism has been levelled at stakeholder theory for its limitations in effectively guiding corporate responsibility towards societal and environmental performance (Orts & Strudler, 2002).

CSR extends stakeholder theory by emphasising an organisational responsibility for broader societal and environmental sustainability performance (Freeman, 2010). Carroll's (1991) CSR model is a widely recognised and frequently referenced framework, providing a comprehensive understanding of an organisation's responsibilities across four interrelated components: economic, legal, ethical, and philanthropic responsibilities. Nevertheless, CSR theory does not fully address governance and accountability (Elkington, 2004). A more precise delineation of problems among stakeholders' responsibilities is vital for ensuring accountability and avoiding the shifting of problems among stakeholders, particularly within specific contexts like WEEE.

ESG, a recent concept gaining traction among investors, extends beyond CSR to quantify organisational accountability for environmental and social performance (Cornell & Shapiro, 2021). It posits that companies prioritising ESG factors are more likely to outperform their peers in the long run (Serafeim, 2020). ESG addresses governance issues not fully covered by CSR, which is a significant factor in market failures related to environmental sustainability (Stern, 2008).

This study introduces an extended stakeholder theory, drawing from CSR and ESG. In this context, stakeholders refer to organisations directly responsible for social and environmental issues, such as WEEE, diverging from the organisation-centric focus of traditional stakeholder theory. By integrating elements of CSR and ESG and incorporating these distinct stakeholders, the WEEE management model developed in this study is well-equipped to navigate the complexities of e-waste management. Moreover, the extended stakeholder theory is more appropriate for effective multi-stakeholder governance and integration to tackle societal and environmental challenges. It is important to note that, for focus, this study does not include individual stakeholders, such as consumers and their behaviours.

# 3 | RESEARCH METHODS

We conduct an SLR following the PRISMA 2020 statement (Page et al., 2021) (Figure 1). PRISMA is a widely used approach for studies in medicine, nursing and neuroscience. Due to its robustness, reliability and transparency of research (Parmentola et al., 2022), PRISMA has been seen in an increasing number of publications in high-impact journals in the business, management and social science domains (e.g. Behl et al., 2022; Buonomo et al., 2020). To search for research articles related to the maximisation of resources and the minimisation of e-waste, we applied a search string to the SCOPUS database that consists of three broad yet related themes: e-waste, sustainability, and CE. The search query in TITLE-ABS-KEY includes (e-waste OR WEEE OR 'waste electrical and electronic equipment*') AND (environment OR environmental OR sustainable OR sustainability OR 'carbon emission*') AND ('circular economy' OR circularity OR 'circular business model*' OR reuse OR recycle OR 'closed loop'). This resulted in 996 records spanning publication years from 2002 to 2022, and 536 records were automatically filtered out using limits to Language (English), Document type (Article), Source type (Journal), and Subject areas ('ENVI', 'ECON', 'BUSI', and 'SOCI'). The screening process for the remaining 460 records is displayed in Figure 1.

In screening, we first selected all journals listed in the ABS Journal Guide 2021 to ensure that only peer-reviewed journals are considered. If a journal was not found in the list, we considered its impact factor a supplementary reference point because it has practical relevance and enhances academic rigour (Tranfield et al., 2003). The journal screening resulted in 145 records being sought for retrieval (Figure 1). An additional five were eliminated due to the unavailability of full papers. Subsequently, out of the 140 remaining full-text articles assessed, 41 were further excluded either because they were unrelated to e-waste management, such as engineering articles that do not contribute to the knowledge base of achieving net zero or consumer studies. As noted earlier, this study focuses on stakeholders directly involved in the e-waste process, whereas the complexity of consumer

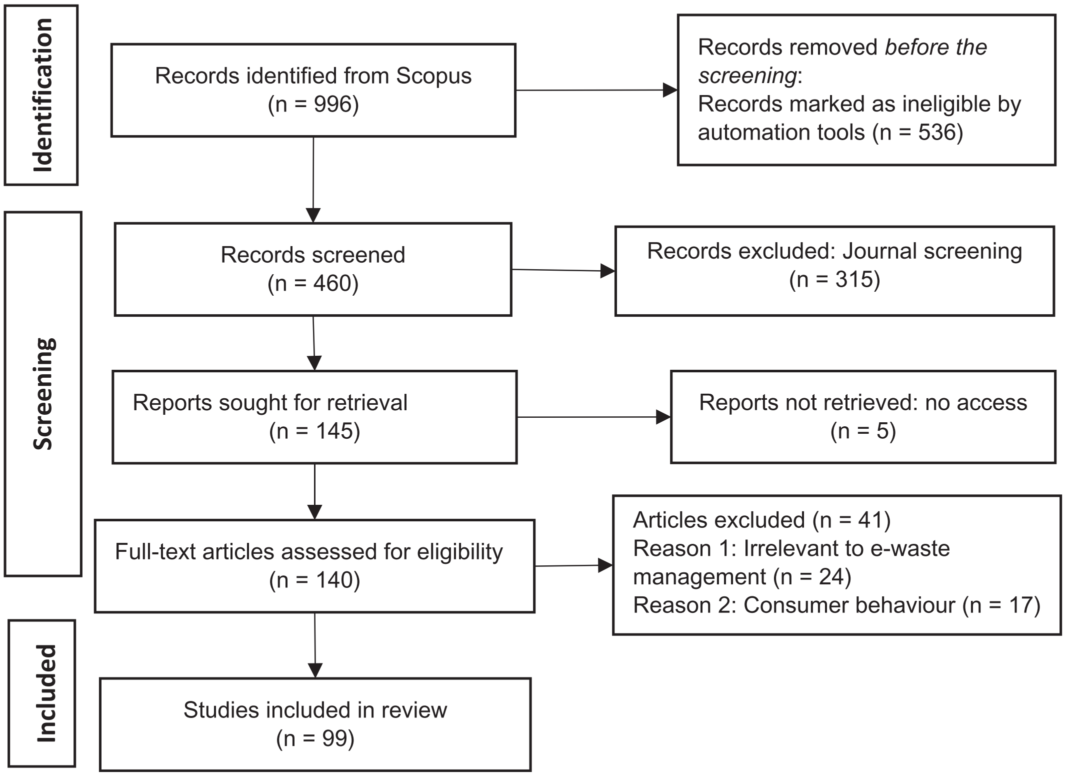


**FIGURE 1** The review process following the PRISMA updated guideline (Page et al., 2021).

behaviour is beyond our scope. Ultimately, a sample of 99 studies constituted the dataset for this study.

As authors interpret information differently (Gioia et al., 2013), the screening was performed by two authors working independently who reviewed all titles and abstracts, followed by joined reviews and discussions. Within this process, all relevant sample information was entered into an MS Excel spreadsheet, including author name, title, journal name, year of publication, abstract and author keywords. A binary coding system was employed: '0' denoted non-selection and '1' indicated selection. Any disparities between the two assessors were reviewed and resolved through joint deliberation and consensus building. This transparent and collaborative approach was crucial in maintaining the integrity and robustness of our selection process.

Thematical analysis is used to explore themes across the extracted dataset. We follow the commonly used six-step approach for the analysis: familiarisation, coding, generating themes, reviewing themes, defining themes, and writing up (Kiger & Varpio, 2020). In the familiarisation step, each author skimmed all articles to develop an understanding of the data material, common and recurring themes, and challenges associated with e-waste management. This includes predominant types of e-waste, treatment methods, measurements, business models, and policy-relevant issues. The second step, coding, involved the extraction of content related to the pre-defined research questions. Each author was allocated to a specific research question and proposed codes that informed Step 3, that is, the generation of themes. The fourth step was the review of codes and themes by all authors. As this is an iterative process (Gioia et al., 2013), multiple attempts were required to achieve meaningful constructs that are free from overlaps (Braun & Clarke, 2006). Once a shared understanding was established, we proceeded to the fifth step, which is the definition of themes by justifying their relevance and importance. In the final step, writing up, we extended the analysis by integrating the findings into a multi-stakeholder responsibility model.

# 4 | RESULTS AND ANALYSIS

## 4.1 | Descriptive analysis

Table 1 presents descriptive data, including paper types, study methods, regions/countries studied and types of e-waste studied.

Figure 2 shows publications by journal and year. E-waste management has seen a significant increase in publications in recent years. Among the identified 22 publication outlets, a significant concentration (71%) of the articles is observed in four journals: *Resources, Conservation & Recycling* (22 articles), *Journal of Cleaner Production* (21 articles), *Sustainability* (14 articles) and *Waste Management* (13 articles).

Unlike article titles designed for reader attention, author keywords aim to enhance searchability, encapsulate content, and accurately reflect an article's essence (Uddin & Khan, 2016). We identified 290 unique author keywords, averaging 6 per article. Key terms like 'CE' appeared 54 times, 'e-waste' 34 times, and 'recycling' 17 times. In the sample split by periods (2009–2017 and 2018–2022), 'CE' gained significance. Notably, 'sustainability', 'closed-loop supply chain', 'waste management', 'reuse' and 'reverse logistics' emerged as pivotal keywords (Table 2).

**TABLE 1** Descriptive summary.

| Type of articles | Number of articles | Regional context | Number of articles |
|---|---|---|---|
| Empirical | 78 | Europe | 28 |
| Conceptual | 15 | Global | 23 |
| Review | 6 | China | 15 |
| Total | 99 | US | 7 |
| **Research method** | | India | 6 |
| Quantitative | 62 | Brazil | 4 |
| Qualitative | 22 | Australia | 3 |
| Mixed | 15 | Canada | 3 |
| Total | 99 | Iran | 2 |
| **Type of WEEE** | | Caribbean Islands | 2 |
| All types | 63 | New Zealand | 1 |
| ICT products incl. TVs | 17 | Taiwan | 1 |
| Batteries | 12 | Japan | 1 |
| PCBs | 3 | Other | 3 |
| Solar panels | 1 | Total | 99 |
| LED luminaires | 3 | | |
| Total | 99 | | |

Abbreviations: ICT, Information and Communication Technology; LED, Light-emitting Diode; PCBs, Printed Circuit Boards; WEEE, Waste of Electrical and Electronic Equipment.

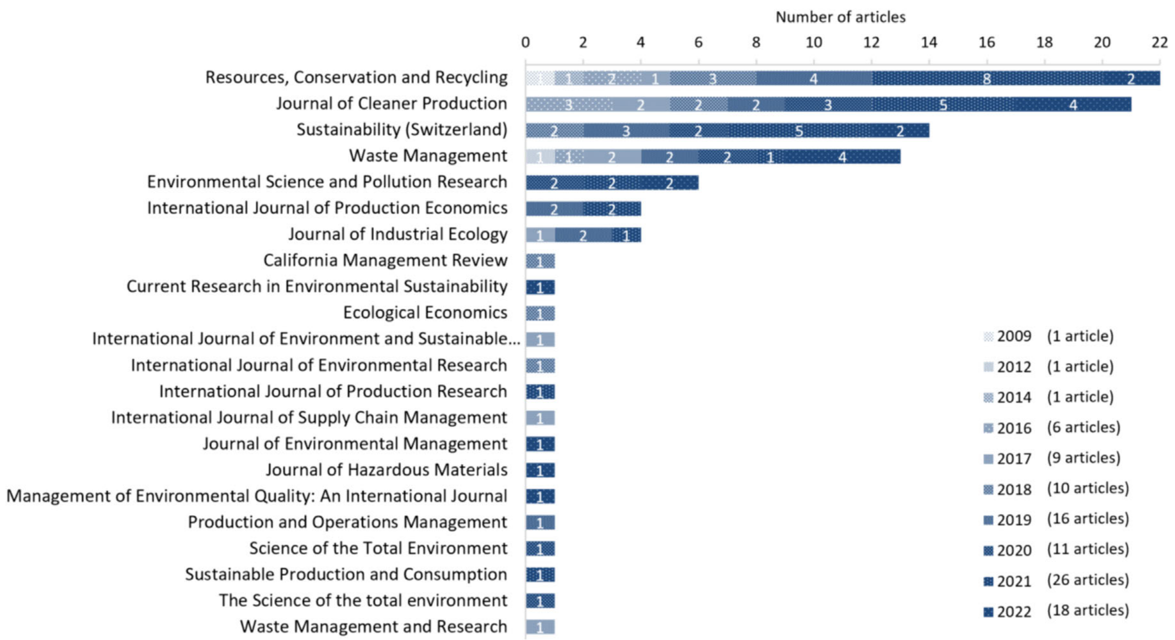


**FIGURE 2** Articles by journal and year.

## 4.2 | WEEE stakeholder responsibilities (RQ1)

This study concerns the business stakeholder, one of the four stakeholder groups: business, government, non-governmental organisation (NGO) and education (Preuss et al., 2023). The WEEE stakeholders encompass business organisations directly involved in the life cycle of electrical and electronic equipment (EEE) products and their end-of-life (EOL) components and materials (Albertsen et al., 2021; Xue et al., 2018a). This includes stakeholders like WEEE producers, product designers, distributors, collectors, and recyclers, who are vital in WEEE management (Appendix A). This study does not consider non-business stakeholders such as policymakers, regulators, compliance bodies and individual consumers.

Figure 3 illustrates 10 distinct responsibilities across stakeholders, categorised into three themes: product life cycle, environmental, and communication and collaboration responsibilities.

TABLE 2 Trends in author keywords.

| Articles from 2009 to 2017 | Frequency | Articles from 2018 to 2022 | Frequency |
|---|---|---|---|
| E-waste | 9 | Circular economy | 50 |
| WEEE | 5 | E-waste | 25 |
| Circular economy | 4 | Recycling | 17 |
| Closed-loop supply chain | 3 | WEEE | 12 |
| System dynamics | 3 | Sustainability | 9 |
| Waste electrical and electronic equipment | 3 | Closed-loop supply chain | 7 |
| Electronic waste | 2 | Waste management | 6 |
| End-of-life | 2 | Reuse | 5 |
| Recycle | 2 | Waste electrical and electronic equipment | 5 |
| Advanced recycling fee | 1 | Reverse logistics | 4 |

Abbreviation: WEEE, waste of electrical and electronic equipment.

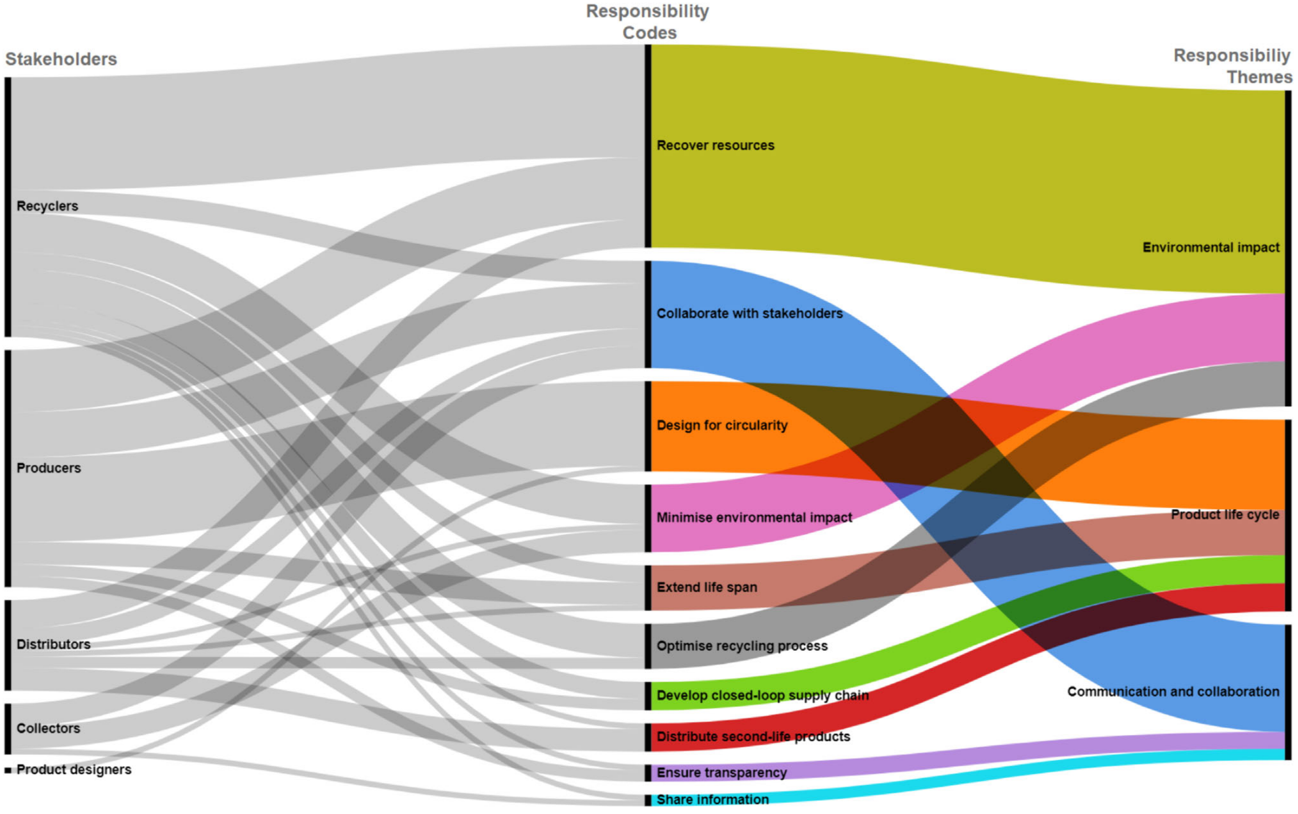


FIGURE 3 Stakeholders and their responsibilities (sorted by frequency in descending order).

Table 3 provides a detailed mapping of WEEE stakeholders' responsibilities with references.

*Product life cycle responsibility* involves designing products for circularity, extending operational life and establishing transparent, closed-loop supply chains. Producers advocate for responsible battery use, promote repair and refurbishment, and ensure transparent information flow (Albertsen et al., 2021; Gu et al., 2018; Parajuly & Wenzel, 2017).

Distributors play a crucial role in enhancing battery use and distributing second-life products (Ahmadi & Amin, 2019; Bonsu, 2020; Luo et al., 2019). Conversely, recyclers are responsible for secure data wiping and effective repurposing (Albertsen et al., 2021; Walzberg et al., 2022). Collaborative efforts among producers, recyclers and distributors are crucial, particularly for orphan products with extended lifespans and no surviving producer (Singh et al., 2022). These present accountability challenges due to the time lag between production and recycling, particularly in dynamic industries like photovoltaics (Duran et al., 2022).

*Environmental responsibility* includes recovering resources, minimising impact, and optimising recycling processes. Producers conduct

**TABLE 3** WEEE stakeholders' responsibilities in the literature.

| Responsibility theme | Responsibility code | References |
|---|---|---|
| Product life cycle responsibility | • Design for circularity<br>• Extend life span<br>• Develop a closed-loop supply chain<br>• Distribute second-life products | Ahmadi and Amin (2019); Albertsen et al. (2021); Althaf et al. (2021); Andersen (2022); Bhuyan et al. (2022); Bonsu (2020); Bridgens et al. (2019); Bruno et al. (2021); Cole et al. (2019); Gu et al. (2018); Guzzo et al. (2022); Levänen et al. (2018); Luo et al. (2019); Mahmoudi et al. (2019); Miao et al. (2017); Miao et al. (2022); Ozgur Polat and Gungor (2021); Parajuly and Wenzel (2017); Richa et al. (2017); Rizos and Bryhn (2022); Ryen et al. (2018); Sharma et al. (2020); Silvestri et al. (2021); Tong et al. (2018); Xavier et al. (2021); Xue et al. (2018b); Zeng and Li (2016) |
| Environmental responsibility | • Recover resources<br>• Minimise environmental impact<br>• Optimise the recycling process | Ahmadi & Amin (2019); Albertsen et al. (2021); Althaf et al. (2021); Bhuyan et al. (2022); Blake et al. (2019); Bridgens et al. (2019); Cole et al. (2019); Duran et al. (2022); Işıldar et al. (2018); Kunz et al. (2018); Levänen et al. (2018); Li et al. (2020); Liu et al. (2021); Luo et al. (2019); Miao et al. (2017); Miao et al. (2022); McMahon et al. (2021); Moraga et al. (2022); Nowakowski et al. (2017); Nowakowski et al. (2020); Nowakowski & Mrówczyńska (2018); Ozgur Polat & Gungor (2021); Pan et al. (2019); Parajuly & Wenzel (2017); Shimada & Van Wassenhove (2019); Singh et al. (2020); Singh et al. (2022); Slattery et al. (2021); Singh et al. (2022); Tong et al. (2018); Xue et al. (2018a); Zeng & Li (2016); Zhao & Nie (2017); Zuo et al. (2020) |
| Communication and collaboration responsibility | • Share information<br>• Ensure transparency<br>• Collaborate with stakeholders | Albertsen et al. (2021); Bonsu (2020); Bruno et al. (2021); Castro et al. (2022); Duran et al. (2022); Favot et al. (2016); Ghisolfi et al. (2017); Gu et al. (2018); Kumar et al. (2022); Mazahir et al. (2019); Nowakowski & Mrówczyńska (2018); Rezayat et al. (2020); Scruggs et al. (2016); Singh et al. (2022); Zuo et al. (2020) |

Abbreviation: WEEE, waste of electrical and electronic equipment.

life-cycle assessments (Hermoso-Orzáez et al., 2019; Pérez-Martínez et al., 2021), while recyclers assess environmental impact during WEEE handling (Li et al., 2020; Miao et al., 2022). Recyclers and distributors adhere to regulations, especially when handling hazardous materials (Magrini et al., 2021; Ozgur Polat & Gungor, 2021). Producers monitor and track hazardous materials, extending to fraud detection (Salmon et al., 2021; Scruggs et al., 2016). Sommerville et al. (2021) advocate for a strategic materials weighting and value evaluation (SWAVE) method, prioritising materials based on economic value and toxicity. Sharing such information facilitates resource recovery, a pivotal environmental responsibility. Producers offer take-back schemes and recover components for reassembly and reuse (Bridgens et al., 2019; Shimada & Van Wassenhove, 2019), relying on distributors to route WEEE back for remanufacturing (Xue et al., 2018a). Recyclers focus on recovering valuable materials, relying on information from producers (Miao et al., 2022).

*Communication and collaboration responsibility* across the life cycle flow is vital for effective WEEE management. Stakeholders share crucial information, promoting transparency, inclusivity and value creation (Mohammadi et al., 2021a). This involves transparent data exchange, insights and strategies among relevant parties. Collaboration involves concerted efforts and joint initiatives, such as the social inclusion of waste pickers in closed-loop supply chains (Ghisolfi et al., 2017). This inclusive approach supports livelihoods and enhances recycling process efficiency and sustainability.

Moreover, collaboration extends to business models, creating synergistic solutions by leveraging strengths and resources (Albertsen et al., 2021). Collaborative business models foster innovation, efficiency, and overall WEEE management effectiveness.

## 4.3 | WEEE performance measures and indicators (RQ2)

Based on the dataset, WEEE management performance is categorised into four measures with 12 indicators (Table 4). Economic, environmental and social performance measures are commonly applied in the literature (e.g. Ottoni et al., 2020; Sagnak et al., 2021; Schroeder et al., 2019). Additionally, the fourth measure, technical sustainability performance, is unique to the WEEE literature and evaluates the efficiency of the WEEE management system (Ghisolfi et al., 2017).

*Technical sustainability performance* refers to the extent of the proper management of WEEE in terms of supply risk reduction, retention or recovery of natural resources (Althaf et al., 2021; Magrini et al., 2021; Silvestri et al., 2021). It assesses the efficiency of direct and reverse supply chains, involving optimisation of stock, flow and auxiliary measures (Ghisolfi et al., 2017). The efficiency of the WEEE collection and recycling system is another critical measure, encompassing recycling, reuse, recovery rates and collection accessibility (Grdic et al., 2020; Pérez-Martínez et al., 2021). The life cycle performance of resources and materials, including inventory management and environmental friendliness awareness, contributes to overall technical performance (Chen et al., 2019; Moraga et al., 2022; Ryen et al., 2018; Shimada & Van Wassenhove, 2019; Zhao & Nie, 2017).

*Economic performance* evaluates the cost of implementing the EPR principle, approximating costs through fees paid by producers (Favot et al., 2016). This measure involves assessing costs related to collection, transportation, manufacturing, sales and inspection (Chen et al., 2019; Ozgur Polat & Gungor, 2021; Salmon et al., 2021). Economic performance also considers the value, revenue and profit

TABLE 4 WEEE management performance measures and indicators.

| Performance measure | Performance indicator | Reference |
|---|---|---|
| Technical measures | • Efficiency of direct and reverse supply chains<br>• Efficiency of collection/recycling system<br>• Efficiency of resource and materials' life cycle | Chen et al. (2019); Dura et al. (2022); Favot et al. (2016); Ghisolfi et al. (2017); Grdic et al. (2020); Isernia et al. (2019); Miao et al. (2017); Moraga et al. (2022); Mohammadi et al. (2021a); Nowakowski et al. (2017); Oliveira et al. (2022); Pérez-Martínez et al. (2021); Ryen et al. (2018); Sinha et al. (2016); Shimada and Van Wassenhove (2019); Zhao and Nie (2017) |
| Economic measure | • Cost effectiveness<br>• Value/revenue/profit<br>• Net present value (NPV) | Ahmadi & Amin (2019); Albertsen et al. (2021); Ali et al. (2021); Chen et al. (2019); D'Adamo et al. (2019); Dura et al. (2022); Duran et al. (2022); Favot et al. (2022); Ghodrat et al. (2016); Levänen et al. (2018); Mahmoudi et al. (2019); Mohammadi et al. (2021a); Nowakowski and Mrówczyńska (2018); Ozgur Polat and Gungor (2021); Parajuly & Wenzel (2017); Salmon et al. (2021); Slattery et al. (2021); Walzberg et al. (2022); Xue et al. (2018a); Zhu & Li (2020); Zuo et al. (2020) |
| Environmental measure | • Environmental impact<br>• Emergy efficiency<br>• Emissions of logistics/benefits (economic versus environmental benefits | Ali et al. (2021); André et al. (2019); Bridgens et al. (2019); Chen et al. (2019); Dura et al. (2022); Hischier & Böni (2021); Jain et al. (2022); Leclerc & Badami (2022); Li et al. (2020); Luo et al. (2019); Miao et al. (2022); Nowakowski & Mrówczyńska (2018); Pan et al. (2019); Pérez-Martínez et al. (2021); Rena et al. (2022); Scruggs et al. (2016); Tian et al. (2022); Walzberg et al. (2022); Yeom et al. (2018) |
| Social measure | • Trust in data security<br>• Social impact of product service system<br>• Jobs and skills development opportunities | Abalansa et al. (2021); Bonsu (2020); Bridgens et al. (2019); Dura et al. (2022); McMahon et al. (2021); Singh et al. (2020); Singh et al. (2022) |

Abbreviation: WEEE, waste of electrical and electronic equipment.

generated from WEEE reverse logistics (Albertsen et al., 2021; Parajuly & Wenzel, 2017; Xue et al., 2018a).

*Environmental impact* is critical to covering climate change, human toxicity and environmental impact from raw material extraction to finished components (Ali et al., 2021; Li et al., 2020; Miao et al., 2022; Scruggs et al., 2016). Additional measures include emergy efficiency of resources—a measure to assess the efficiency of natural resources in economic terms (Geng et al., 2013), environmental outcomes for product take-back systems and the environmental impact of WEEE repurposing (Chen et al., 2019; Pan et al., 2019).

*The social measure* of social benefit is equally critical in improving WEEE management performance. This involves the trust in data security between the e-waste unit and waste holders (Singh et al., 2020), as well as the social impact of the product-service system (Bridgens et al., 2019), and job and skills development opportunities (Abalansa et al., 2021; Bonsu, 2020). *The social measure* addresses trust in data security, the social impact of product-service systems, and job and skills development opportunities (Abalansa et al., 2021; Bonsu, 2020; Bridgens et al., 2019; Dura et al., 2022; Singh et al., 2020, 2022).

While these measures provide a comprehensive view of WEEE management, it is essential to note potential tensions among them, necessitating a balance. For instance, economic cost-effectiveness may conflict with environmental impact, requiring careful prioritisation. Balancing efficiency in the WEEE system with social benefits is another consideration. Striking a balance is crucial to manage WEEE effectively, emphasising the need to prioritise environmental performance in the trade-off.

## 4.4 | WEEE management models (RQ3)

Improving WEEE management performance is crucial for reducing environmental harm and promoting sustainable development. The literature shows three distinctive bases for improving WEEE management performance: product or material-based solutions, business models or stakeholder-based solutions, and government agency-based systems (Table 5). By adopting a comprehensive approach, it is possible to reduce the environmental impact of e-waste and promote sustainable development.

*Product or material-based solutions* focus on EOL electronics and their environmental impact (Sommerville et al., 2021). A life cycle assessment of EEE can help identify the environmental impact of a product from raw materials to EOL (Villares et al., 2016). Furthermore, analysing material and waste flows can help improve recycling, reuse, resale and material recovery processes, leading to increased recyclability (Althaf et al., 2019; Ryen et al., 2018).

Business models or stakeholder-based solutions emphasise the accountability of key players, such as designers, manufacturers, recyclers, retailers and industry representatives (Bhuyan et al., 2022; Kumar et al., 2022). Implementing EPR transfers the responsibility of product disposal onto manufacturers (Favot et al., 2016). Business models led by recyclers or retailers similarly underscore the roles of diverse stakeholders in WEEE management (Miao et al., 2017; Xue et al., 2018a). These diverse business strategies share the common goal of establishing a closed-loop supply chain system through circular business models (André et al., 2019), ultimately fostering material recycling and recovery to enhance resource efficiency and minimise

**TABLE 5** WEEE management solutions in the literature.

| Theme of solutions | Code | Reference |
|---|---|---|
| Product or material-based solution | • Life cycle assessment of EEE<br>• Material/waste flow<br>• Recycling/reuse/resale/material recovery/recyclability | Ali et al. (2021); Althaf et al. (2019); Ghodrat et al. (2016); Jain et al. (2022); Leclerc and Badami (2022); Mahmoudi et al. (2019); Mohammadi et al. (2021b); Moraga et al. (2022); Parajuly & Wenzel (2017); Rena et al. (2022); Ruiz-Mercado et al. (2017); Ryen et al. (2018); Sinha et al. (2016); Sommerville et al. (2021); Villares et al. (2016); Zeng and Li (2016) |
| Business model or stakeholder-based solution | • Modular design<br>• Manufacture-led recycling business model and EPR<br>• Social entrepreneur business model<br>• Material recycling and recovering business model<br>• Retailer-led recycling business model<br>• Recycler-based business model<br>• O2O collection business model<br>• Closed-loop supply chain<br>• Reverse logistics | Ahmadi & Amin (2019); Albertsen et al. (2021); André et al. (2019); Bhuyan et al. (2022); Bonsu (2020); Bridgens et al. (2019); Castro et al. (2022); Cole et al. (2019); Dura et al. (2022); Favot et al. (2016); Ghisolfi et al. (2017); Ghodrat et al. (2016); Gu et al. (2018); Isernia et al. (2019); Kumar et al. (2022); Magrini et al. (2021); Miao et al. (2017); Nowakowski et al. (2017); Oliveira et al. (2022); Ottoni et al. (2020); Rezayat et al. (2020); Richa et al. (2017); Rizos & Bryhn (2022); Silvestri et al. (2021); Tian et al. (2022); Tong et al. (2018); Walzberg et al. (2022); Xue et al. (2018a, 2018b); Zuo et al. (2020) |
| Government agency-based system | • Hierarchical recycling system<br>• Funding model<br>• Agency-lead recovery system<br>• Collection centres | Blake et al. (2019); Chen et al. (2019); Gu et al. (2018); Luo et al. (2019); Silvestri et al. (2021); Sagnak et al. (2021); Xavier et al. (2021) |

Abbreviations: EEE, electrical and electronic equipment; EPR, extended producer responsibility; WEEE, waste of electrical and electronic equipment.

**TABLE 6** The role of smart technology in WEEE management.

| Themes of the role | Code of the role | References |
|---|---|---|
| Reducing environmental impact | • Keep materials in use with a lower footprint<br>• Develop *green logistics*<br>• Assist in WEEE management<br>• Securely wipe data | Kumar et al. (2022); Moraga et al. (2022); Rizos & Bryhn (2022); Singh et al. (2022); Walzberg et al. (2022) |
| Optimising | • Plan routes of collection vehicles<br>• Enable new processes and better use of resources<br>• Improve waste management via smart reverse system<br>• Eliminate information asymmetry | Dura et al. (2022); Nowakowski et al. (2017); Nowakowski et al. (2020); Nowakowski & Mrówczyńska (2018); Ranjbari et al. (2021); Rizos & Bryhn (2022); Zuo et al. (2020) |
| Forecasting | • Forecast material flow<br>• Anticipate supply chain disruptions and manage material flow<br>• Predict recyclability at the design stage | Althaf et al. (2019); Kumar et al. (2022); Rizos & Bryhn (2022); Zeng & Li (2016) |
| Tracking and tracing | • Improve tracking of materials during product life<br>• Record keeping to identify dishonest practices<br>• Link producers of EEE to WEEE | Andersen (2022); Magrini et al. (2021); Rizos & Bryhn (2022); Salmon et al. (2021); Scruggs et al. (2016) |
| Enabling collaboration | • Support reverse logistics through new business models<br>• Facilitate trading<br>• Network for technology and information sharing<br>• Form a complete recovery network | Kumar et al. (2022); Luo et al. (2019); Rena et al. (2022); Rizos & Bryhn (2022); Tong et al. (2018); Zuo et al. (2020); Zhu & Li (2020) |

Abbreviations: EEE, electrical and electronic equipment; WEEE, waste of electrical and electronic equipment.

waste (Mohammadi et al., 2021b). A CE for WEEE management also incorporates collection business models based on online platforms with offline collection, known as online-to-offline (O2O) (Zuo et al., 2020), and a closed-loop supply chain network as integral components (Gu et al., 2018; Nowakowski et al., 2017).

Government agency-based systems focus on streamlining the funding mode and implementing e-waste management, recycling and agency-based recovery systems (Silvestri et al., 2021). The EU hierarchical waste recycling system—waste prevention, preparing for reuse, recycling, recovery and disposal (European Commission, 2008)—is an example of a government-led initiative to improve WEEE management (Sagnak et al., 2021). The location of collection centres and efficient e-waste management are also crucial components of a government agency-based system (Gu et al., 2018).

However, these solutions face various challenges, such as a lack of standardisation, unclear roles and responsibilities of each stakeholder, economic and legal hurdles for adopting circular business models, and difficulties in securing funding and collaboration among different agencies and stakeholders. These challenges limit the effectiveness of WEEE management efforts and need to be addressed to achieve sustainable environmental performance.

### 4.5 | Role of smart technology in WEEE management (RQ4)

Technology serves as a catalyst for innovation, enabling the development of integrated solutions that streamline waste collection, recycling and disposal processes. By leveraging digital platforms and data-driven approaches, technology facilitates enhanced traceability and transparency across the e-waste lifecycle, improving accountability and compliance with environmental regulations (Kannan et al., 2024). Furthermore, technology fosters collaboration among stakeholders, including manufacturers, governments, recyclers and consumers, to implement effective e-waste management strategies. This collaborative approach encourages the adoption of CE principles, where materials are recovered, recycled and reintegrated into production cycles, reducing the reliance on raw resources and minimising environmental impacts.

Smart technology (Smart tech) refers to integrating and utilising advanced technologies and systems such as Internet of Things (IoT), artificial intelligence (AI) and data analytics to enhance efficiency, connectivity and information management (Chiarini, 2021; Ogbeibu et al., 2023). In the context of WEEE, smart tech, including AI, IoT, blockchain, and Internet+, plays a crucial role in reducing environmental impact, optimising processes, forecasting, tracking and tracing, and enabling collaboration (Table 6). Smart tech minimises waste by reducing operational expenses; fostering partnerships; enabling waste reduction strategies; cultivating a regenerative economy; and aligning environmental, economic and social benefits within the CE (Tseng et al., 2022; Kurniawan & Fernando, 2023). AI holds the potential to recognise patterns, segment waste and devise appropriate ways of handling it, streamlining the e-waste management process (Selvakanmani et al., 2024). IoT devices and sensors optimise waste management by refining collection routes and schedules, thereby minimising unnecessary transportation and energy consumption (Sung et al., 2020). Moreover, blockchain technology enhances transparency and traceability across the e-waste life cycle, ensuring adherence to responsible disposal and recycling practices (Sahoo et al., 2022). Collectively, these smart technologies not only enhance data-driven operational efficiency but also significantly contribute to sustainable electronic product life cycles by mitigating environmental impact and advancing principles of the CE.

Reducing environmental impact: Digital technologies contribute to managing and utilising recovered materials (Rizos & Bryhn, 2022), explicitly focussing on technologies facilitating secure data wiping from electronic devices like hard disc drives to enable refurbishment and reuse, addressing current privacy concerns (Walzberg et al., 2022).

Optimising processes and resources: Smart technologies, such as AI algorithms and IoT, enable environmentally friendly and cost-effective WEEE collection networks. These include algorithms that plan routes and calculate vehicle combinations, enhancing the cost efficiency of collection (Nowakowski et al., 2017, 2020). IoT is linked with innovations supporting circularity (Rizos & Bryhn, 2022) and the development of intelligent reverse systems with interactive maps for recyclers (Ranjbari et al., 2021).

Forecasting: Efficient e-waste treatment requires forecasting resource and waste flows (Althaf et al., 2019). Leveraging IoT and digital technologies enables streamlined information flow, efficient e-waste flow forecasting, and coordinated supplier efforts (Kumar et al., 2022). Zeng and Li (2016) introduce a model predicting practical recyclability at the design stage to enhance recovery strategies, and Rizos and Bryhn (2022) emphasise anticipating supply chain disruptions for circularity.

*Tracking and tracing*: Material and substance identification through tracking and tracing, facilitated by IoT and blockchain, is crucial for handling toxic materials effectively (Miao et al., 2022). The combination of IoT and blockchain is proposed to record recycling processes and identify illegal practices (Magrini et al., 2021; Salmon et al., 2021).

Enabling collaboration: Technology plays a significant role in facilitating collaboration, especially with the emergence of WEEE platform technologies (Zhu & Li, 2020). Internet+ in China has led to new business models connecting local recycling sectors with suppliers through online-to-offline solutions (Zuo et al., 2020) and reverse logistics vending machines (Tong et al., 2018). Proposed measures include establishing networks for technology and information sharing (Kumar et al., 2022) and forming comprehensive recovery networks (Luo et al., 2019).

While technology integration is vital for higher resource efficiency and sustainability, challenges exist, such as the complexity of a dynamic system with multi-stakeholders, producers' reluctance to share information, unclear stakeholder responsibilities and hurdles in adopting sophisticated technologies (Albertsen et al., 2021; Mohammadi et al., 2021a; Singh et al., 2020). Addressing these challenges and conceptualising environmental sustainability in a multi-stakeholder setting is a crucial addition to conventional stakeholder theory.

## 5 | PROPOSED MODEL

### 5.1 | Stakeholder responsibility practice

The role of stakeholders in realising and implementing CE principles and, in particular, minimising the WEEE cannot be undermined. Literature has identified their importance in terms of their internal and external collaborations, technology initiatives, collective efforts and innovative governance (Schöggl et al., 2024; Schultz et al., 2024; Thukral & Singh, 2023). In the context of WEEE, each stakeholder holds a distinct importance and contributes uniquely to minimising electronic waste.

General responsibility practices for WEEE stakeholders include having written policies, implementing environmentally responsible processes, conducting comprehensive employee training, regularly evaluating and reporting practices, and collaborating with industry initiatives. Product designers should take responsibility for designing products that minimise waste (Cole et al., 2019) and are easily recyclable (Althaf et al., 2021). Producers, including manufacturers, brand owners and component assemblers, provide guidance for EOL treatment (Albertsen et al., 2021) and collaboratively with other stakeholders to facilitate product takeback for closed-loop supply (Rezayat et al., 2020) and take products back (Blake et al., 2019). Distributors, including importers, exporters, retailers, stores, distribution and logistics centres, are responsible for minimising environmental impact by optimising processes of recycling and distributing second-life products and reverse supply (Bonsu, 2020; Ozgur Polat & Gungor, 2021). Collectors and recyclers should communicate and collaborate with other stakeholders to collect and recycle WEEE with minimal environmental impact (Chen et al., 2019; Miao et al., 2022).

Stakeholder responsibilities are pivotal in organisational performance and sustainability (e.g. Bello-Pintado et al., 2023; El Akremi et al., 2018; Raja Mamat et al., 2016). Raja Mamat et al. (2016) identify stakeholder responsibility as one of Malaysia's eight success factors in establishing EOL vehicle management systems. El Akremi et al. (2018) introduce a CSR scale that aligns with economic, social and environmental goals, and this scale positively correlates with organisational pride, support, identification, job satisfaction and commitment. Bhattacharjee et al. (2023) emphasise the need to identify the right stakeholders in the WEEE and CE context, as it is the only means to actualise the reduction of WEEE. For effective e-waste management for environmental sustainability performance, all stakeholders, including product designers, producers, distributors, collectors and recyclers, bear inherent responsibility. Hence, we propose the following:

> **Proposition 1.** Stakeholder responsibility practices positively influence environmental sustainability performance.

## 5.2 | Smart-tech usage

Efficient WEEE management demands stakeholders to function as a cohesive system (Grewatsch et al., 2023). Smart tech integrates advanced technologies and systems to connect all WEEE stakeholders (Zuo et al., 2020) and monitor data throughout the product life cycle, which enhances a collaborative information management system and allows forecasting, tracking, tracing, and optimising collecting and recycling processes along the product life cycle (Magrini et al., 2021).

Smart-tech usage involves technology implementation (reflected by adoption rate and diffusion) and technology characteristics (reflected by efficiency and maturity). Technology adoption rate refers to the extent to which individuals or organisations adopt a new technology. The adoption rate of a technology is determined by several factors, including system purchasing fixed cost, variable cost, perceived usefulness, incentives and disincentives, education and awareness, government support, and customer preferences (Cheng & Yeh, 2011; Hanes et al., 2019; Osei et al., 2022; Taheri et al., 2022). As technology adoption rate increases, stakeholders are more likely to invest in new technologies that improve environmental performance (Block et al., 2023). This leads to a positive moderation effect, where high technology adoption rates amplify the relationship between stakeholder responsibility and environmental performance.

Technology diffusion refers to the process by which new technologies are adopted and spread across various stakeholders, ensuring that all stakeholders contribute collectively to improved environmental sustainability in e-waste life cycle management. Technology diffusion can play a role in mediating the relationship between WEEE multi-stakeholder responsibility and environmental performance. As technology diffusion increases and more stakeholders adopt and invest in it, firms that adopt smart tech are more likely to perform well (Majumdar & Chang, 2010). However, Dahlke et al. (2024) suggest that the benefit of technology diffusion on firm performance may depend on other factors such as network position and social capital.

Technology efficiency refers to the ability of technology to perform its intended functions effectively while minimising resource use and waste (Li et al., 2021). Enhanced efficiency, achieved through research and development collaboration, mediates the relationship between stakeholder responsibility and environmental performance (Beldi et al., 2010; Block et al., 2023; Chang & Shih, 2004; Zhang & Bhuiyan, 2015). Increased technology efficiency encourages greater stakeholder investment in sustainability-oriented technologies and enhances environmental outcomes (Block et al., 2023; Zuo et al., 2020). Technology maturity represents the level of development, stability and reliability of technology. In the study by Keramati et al. (2016), information technology maturity was found to impact firm performance significantly. Matured technology fosters efficiency and wider adoption, intensifying the relationship between stakeholder responsibility and environmental performance. When highly efficient, mature technologies become mainstream and effectively address e-waste challenges (Taylor & Taylor, 2012). Thus, this study posits that technology maturity mediates the impact of stakeholder responsibility practice on environmental sustainability performance.

Owing to the transformative capabilities of these technologies across various facets of the product life cycle, smart tech mediates the relationship between stakeholder responsibility and environmental performance. Smart technologies such as IoT, AI and blockchain enable enhanced collaboration and information management among e-waste stakeholders, fostering connectivity and data sharing, which is essential for effective waste management. By leveraging these technologies, processes in waste collection, recycling and disposal can be optimised, leading to reduced operational expenses, resource consumption and environmental impact (Kannan et al., 2024). Additionally, blockchain technology ensures transparency and traceability, promoting responsible disposal practices and stakeholder accountability. These advancements align with CE principles, facilitating waste minimisation; fostering partnerships; and aligning environmental, economic and social benefits (Kurniawan & Fernando, 2023). Smart tech also enables data-driven decision-making to anticipate supply chain disruptions, forecast material flows and optimise resource allocation. Moreover, the use of smart tech for waste management is also realised by digital innovation that is enabled by data-driven processes and insights (Kurniawan & Fernando, 2023). Overall, by incorporating smart tech and leveraging the full potential of these technologies in different stages of e-waste management practices, stakeholders can secure data, improve logistics, plan collection routes efficiently and establish a robust recovery network, ultimately contributing to a more sustainable and efficient electronic product life cycle.

Propositions 2a-2d: Technology efficiency (P2a), technology maturity (P2b), technology adoption rate (P2c), and technology diffusion (P2d) positively mediate the relationship between stakeholder responsibility practice and environmental sustainability performance.

## 5.3 | Multi-stakeholder relationship

Each stakeholder is responsible for minimising their environmental impact, and therefore, individual responsible practices contribute to WEEE management. However, achieving net-zero goals requires a collective and systems approach among multi-stakeholders. Interactions among multi-stakeholders are crucial for an efficient closed-loop supply chain and the circularity of WEEE (Rezayat et al., 2020; Stefano et al., 2023). The inter-organisational collaboration (Schoggl et al., 2024), collective innovation (Schultz et al., 2024), regional consortiums (Yuan et al., 2022) and shared responsibility for rewards and penalties for a CE are imperative in achieving sustainability. These aspects indicate the dire need for integrative stakeholder responsibility that facilitates actualising WEEE and the net-zero agenda.

Four dimensions of multi-stakeholder relationships are extracted from the existing literature: partnership, shared responsibility, inclusiveness and transparency. Partnerships are vital in addressing complex challenges. They facilitate collaborative innovation for sustainable development (Mariani et al., 2022) and the global environment (Stefano et al., 2023). Studying decision-making processes, MacDonald et al. (2019) emphasise organisational design's impact on the effectiveness of multi-stakeholder partnerships. Collaboration, resource mobilisation and shared responsibility, demonstrated in various contexts (Maher, 2022; Molina, 2018; Seeliger, 2021), showcase the beauty of partnerships. For example, effective EV battery management hinges on a robust collection and transportation system, requiring collaboration among EV manufacturers, battery producers, recycling facilities, transportation companies, regulators and environmental organisations. Like those between EV manufacturers and recyclers, partnerships foster closed-loop recycling systems. EOL batteries are collected, dismantled and recycled for valuable materials, promoting reuse in new battery production. Such collaborations may employ reverse logistics to optimise EOL battery collection from various sources. Regulatory frameworks, like EPR policies, incentivise and regulate collaborative efforts, ensuring compliance with environmental standards while driving industry-wide innovation (Slattery et al., 2021).

In the WEEE industry, shared responsibility among stakeholders is crucial for positive environmental outcomes (Ghisolfi et al., 2017; Rezayat et al., 2020). A balanced distribution of responsibility ensures economic viability (Gu et al., 2018) and prevents any stakeholder from shouldering an excessive burden. Shared responsibility through, for example, contractual sector-specific agreements, as Ghisolfi et al. (2017) suggested, fosters a culture of accountability, transparency and collective effort, which is essential for optimal environmental performance.

Achieving positive social outcomes (Fiandrino et al., 2022) and breaking the cycle of marginalisation in WEEE management requires an inclusive decision-making process (Eikelenboom & Long, 2022). Involving all stakeholders, including the informal recycling sector (Kumar et al., 2022; Singh et al., 2020), brings diverse perspectives and ideas, leading to better environmental solutions and equitable performance. These collaborative efforts are essential for effectively addressing WEEE management's complex challenges, particularly in contexts where formal systems alone may be insufficient. It ensures that the expertise and knowledge of informal recyclers are valued and leveraged within the broader framework of sustainable WEEE management. However, informal sector recyclers often face challenges and need access to resources and support to operate more efficiently, safely and sustainably.

Transparency is critical for multi-stakeholder communication (Høvring et al., 2018) and essential in governance involving multi-stakeholder responsibility (Abouddaka et al., 2021). Transparent decision-making and implementation are crucial to monitoring environmental impact, ensuring accountability, building stakeholder trust, and promoting effective and sustainable environmental performance (Walzberg et al., 2022). Figure 4 summarises all propositions in our proposed model.

Propositions 3a-3d: Partnership (P3a), shared responsibility (P3b), inclusiveness (P3c) and transparency (P3d) of multi-stakeholder responsibility positively moderates the relationship between stakeholder responsibility practice and environmental sustainability performance.

The proposed model outlines four key attributes underpinning multi-stakeholder responsibility: partnership, shared responsibility, inclusiveness and transparency. These attributes serve as foundational pillars for fostering collaboration and effective management of e-waste. Smart-tech usage in the WEEE context is evaluated in four dimensions: technology efficiency, technology maturity, technology adoption rate and technology diffusion. Building upon the existing studies, this model contributes to a focused understanding of the evolving integrative responsibility and system dependency of multi-stakeholders and technology's influential role in e-waste management. The framework is not just a theoretical model but a practical tool representing the interconnectedness of stakeholders, their responsibilities and the mechanisms for collaboration through smart-tech usage within the e-waste management ecosystem.

Various methods can evaluate the model's effectiveness, including surveys, interviews and tracking key performance indicators such

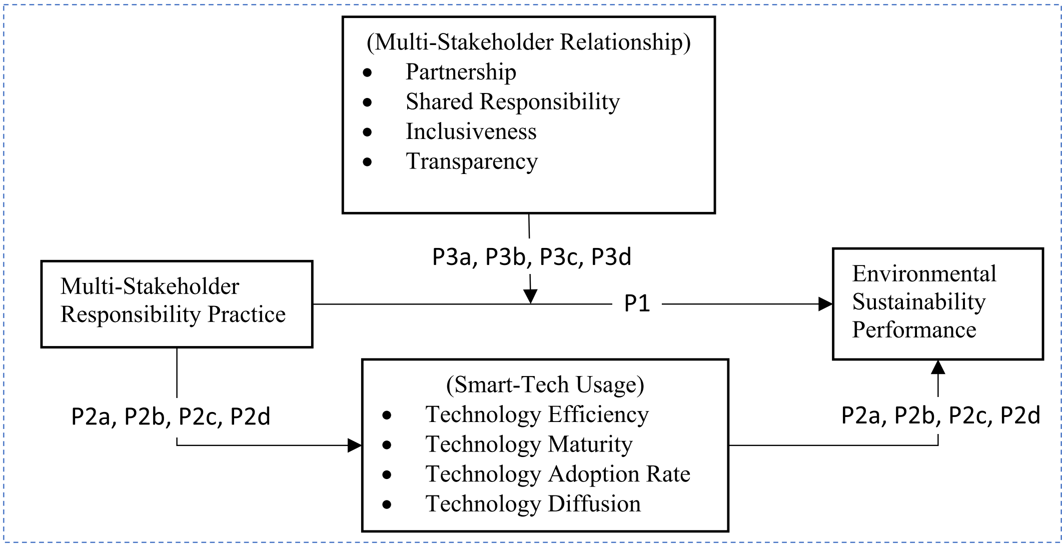


**FIGURE 4** Integrative multi-stakeholder responsibility model for environmental sustainability performance.

as waste reduction and recycling rates. Case studies of successful collaborations offer insights. Implementing and assessing the proposed model may encounter several challenges and limitations. Challenges include diverse stakeholder priorities, necessitating strong leadership for consensus and equitable participation. Resource constraints and methodological challenges in measuring impact are also significant hurdles.

## 6 | DISCUSSION AND CONCLUSIONS

Through SLR, we found key e-waste stakeholders: producers, product designers, distributors, collectors and recyclers; ten distinct responsibilities categorised into three themes: *product life cycle responsibility* (design for circularity, extend life span, develop closed-loop supply chain and recycle second-life products), *environmental responsibility* (recover resources, minimise environmental impact and optimise recycling process), and *communication and collaboration responsibility* (share information, ensure transparency and collaborate with stakeholders). WEEE management performance can be categorised into four measures: *social*, *economic*, *environmental and technical performance. The technical component is unique* yet underexplored in the environmental performance literature. Hence, this promises a more focused study in the future. We categorise three unique e-waste solutions in the literature: *product or material-based solutions*, *business models or stakeholder-based solutions* and *government agency-based systems*. In the context of WEEE, smart tech plays a crucial role in *reducing environmental impact*, *optimising processes*, *forecasting*, *tracking and tracing*, and *enabling collaboration*.

Furthermore, this study introduces the extended stakeholder theory and presents an integrated multi-stakeholder responsibility model for enhancing environmental sustainability performance in WEEE management. Subsequent sections delve into the specific contributions and implications of this research.

### 6.1 | Theoretical contributions

The extended stakeholder theory is an original contribution in this study. The theory transcends the traditional organisation-centric (Elkington, 2004; Freeman, 2010; Stern, 2008) to a problem-centred lens. This means that instead of solely concentrating on organisational interests, the theory considers broader societal or systemic issues and addresses problems within that context. This approach recognises that organisations are embedded in larger social, economic, and environmental systems and that their actions can have significant impacts beyond their immediate stakeholders. This shift in perspective aligns with the growing recognition of the interconnectedness and ecosystem of business and society, directing attention to multi-stakeholders jointly addressing societal or environmental concerns and advocating sustainable business practices for the greater good.

Our proposed integrative multi-stakeholder model underscores the pivotal role of stakeholder responsibility practices in shaping environmental sustainability performance (Eikelenboom & Long, 2022; MacDonald et al., 2019). The model contributes to achieving net zero and advancing the collective commitment to a sustainable future. It stresses the importance of leveraging technological advancements to mediate integrative and collaborative multi-stakeholder practices, ultimately enhancing environmental sustainability (Block et al., 2023; Chiarini, 2021; Grewatsch et al., 2023). The model also highlights multi-stakeholder relationships as a crucial moderator in achieving net-zero commitments, emphasising the need for collaborative and joint efforts and partnerships for environmental sustainability (Bello-Pintado et al., 2023; Preuss et al., 2023).

### 6.2 | Policy and practical implications

The theoretical framework and integrative multi-stakeholder model proposed in this study carry substantial policy and practical implications for effectively managing WEEE and realising net-zero commitments. Adopting a societal and environmental problem-centred stakeholder theory prompts a strategic shift in the approach to WEEE management, acknowledging and addressing the collaborative nature of ecological challenges. WEEE practitioners can navigate the intricacies of stakeholder engagement beyond organisational boundaries, fostering a collaborative environment essential for addressing the complexities associated with WEEE.

Policymakers may explore mechanisms for incentivising collaboration and knowledge sharing among stakeholders, such as creating platforms for dialogue and partnership building. Also, policymakers could consider implementing initiatives to facilitate informal sector recyclers' access to resources and training, enabling them to operate more efficiently, safely and sustainably. Promoting the formalisation and integration of informal recyclers into the formal waste management system could enhance overall system effectiveness and sustainability. By integrating the expertise and knowledge of informal recyclers within the broader framework of sustainable WEEE management, policymakers can unlock innovative solutions and promote inclusive growth in the sector.

Furthermore, the integrative multi-stakeholder model provides actionable insights for stakeholders involved in WEEE management, elucidating the crucial role of stakeholder-responsibility practices in determining environmental sustainability performance. Emphasising the need for proactive engagement and responsible practices across the entire spectrum of stakeholders, including product designers, producers, distributors, collectors and recyclers, the model recognises the mediating influence of smart-tech usage in this relationship. This directs attention to the importance of leveraging technological advancements to enhance sustainability outcomes. WEEE practitioners can strategically deploy and integrate smart technologies to predict waste flows, optimise processes, and prioritise the recovery of materials with high economic value or known to be hazardous to the environment or human health.

The mediating effect of smart tech provides policy and practical implications for leveraging data and advanced analytics to monitor and predict e-waste generation patterns. Policies should deploy advanced tech, such as IoT-based real-time tracking systems for WEEE, which can improve transparency and traceability among stakeholders throughout the waste management process. These systems can provide detailed insights into the life cycle of electronic products, from manufacturing to EOL disposal, thereby optimising resource utilisation and minimising environmental impact.

Moreover, policies for investing in state-of-the-art recycling facilities equipped with the latest technologies can significantly improve the efficiency and effectiveness of the WEEE management system. Policymaking in this direction can encourage upgrading existing facilities and establishing new ones in underserved areas, ensuring equitable access to recycling services. Likewise, regulations for enhancing the logistics infrastructure for WEEE collection and transportation can reduce operational costs and environmental impacts, optimising collection routes and utilising eco-friendly transportation options.

Considering the moderating effect of multi-stakeholder relationships, the model emphasises the significance of collaborative efforts in achieving net-zero targets. This insight is pivotal for developing policies and strategies that foster partnerships among diverse stakeholders, ensuring a collective and coordinated approach towards sustainable WEEE management and the broader commitment to a net-zero future.

### 6.3 | Limitations and future research

This study has limitations that need consideration in future research. Excluding end consumers overlook their pivotal role in EEE and WEEE circularity, impacting the stakeholder perspective. Future studies should incorporate end-consumer insights to enrich the understanding of WEEE management dynamics. Additionally, this study provides a limited exploration of the governmental dimension in WEEE policymaking. Future research should delve deeper into the role of government stakeholders to understand regulatory landscapes and policy dynamics influencing WEEE management strategies.

Given the crucial role of smart tech in enhancing WEEE management, future research should explore the adoption and diffusion of new technologies within the sector. This includes studying the barriers to technology adoption and identifying best practices for integrating intelligent solutions into WEEE management processes. Moreover, the potential of emerging technologies, such as blockchain and digital twins, in improving transparency, traceability and efficiency in e-waste management can be explored.

Customers' roles, attitudes, and education are important avenues for reducing WEEE, although this aspect is out of the scope of the current study. Future research can delve into the psychological and social barriers that prevent consumers from disposing of e-waste properly. Understanding these barriers can inform the design of more effective awareness campaigns and educational programmes.

Methodologically, relying solely on the Scopus database may introduce bias. Future studies should adopt a more inclusive approach by incorporating diverse sources like the Web of Science and Google Scholar for a more comprehensive literature review. Theoretical contributions need more empirical validation. Future research should emphasise empirical studies to validate and refine the proposed multi-stakeholder model, enhancing its practical applicability in real-world WEEE management scenarios.


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## REFERENCES


Abalansa, S., El Mahrad, B., Icely, J., & Newton, A. (2021). Electronic waste, an environmental problem exported to developing countries: The good, the bad and the ugly. *Sustainability*, *13*(9), 5302. https://doi.org/10.3390/su13095302

Abouddaka, I., Bassiri, M., Atibi, A., Tridane, M., & Belaaouad, S. (2021). The engineering of e-governance and technology in the management

of secondary schools: Case of the Nouaceur delegation. *Journal of Information Technology Management*, *13*, 229–237.
Ahmadi, S., & Amin, S. H. (2019). An integrated chance-constrained stochastic model for a mobile phone closed-loop supply chain network with supplier selection. *Journal of Cleaner Production*, *226*, 988–1003. https://doi.org/10.1016/j.jclepro.2019.04.132
Albertsen, L., Richter, J. L., Peck, P., Dalhammar, C., & Plepys, A. (2021). Circular business models for electric vehicle lithium-ion batteries: An analysis of current practices of vehicle manufacturers and policies in the EU. *Resources, Conservation and Recycling*, *172*, 105658. https://doi.org/10.1016/j.resconrec.2021.105658
Ali, A. K., Layton, A., Kio, P., & Williams, J. (2021). Matrix trays: From waste to opportunities. *Journal of Cleaner Production*, *300*, 126813. https://doi.org/10.1016/j.jclepro.2021.126813
Althaf, S., Babbitt, C. W., & Chen, R. (2019). Forecasting electronic waste flows for effective circular economy planning. *Resources, Conservation and Recycling*, *151*, 104362. https://doi.org/10.1016/j.resconrec.2019.05.038
Althaf, S., Babbitt, C. W., & Chen, R. (2021). The evolution of consumer electronic waste in the United States. *Journal of Industrial Ecology*, *25*(3), 693–706. https://doi.org/10.1111/jiec.13074
Andersen, T. (2022). A comparative study of national variations of the European WEEE directive: Manufacturer's view. *Environmental Science and Pollution Research*, *29*(14), 19920–19939. https://doi.org/10.1007/s11356-021-13206-z
André, H., Söderman, M. L., & Nordelöf, A. (2019). Resource and environmental impacts of using second-hand laptop computers: A case study of commercial reuse. *Waste Management*, *88*, 268–279. https://doi.org/10.1016/j.wasman.2019.03.050
Behl, A., Jayawardena, N., Pereira, V., Islam, N., Giudice, M. D., & Choudrie, J. (2022). Gamification and e-learning for young learners: A systematic literature review, bibliometric analysis, and future research agenda. *Technological Forecasting and Social Change*, *176*, 121445. https://doi.org/10.1016/j.techfore.2021.121445
Beldi, A., Cheffi, W., & Dey, P. K. (2010). Managing customer relationship management projects: The case of a large French telecommunications company. *International Journal of Project Management*, *28*(4), 339–351. https://doi.org/10.1016/j.ijproman.2009.12.004
Bello-Pintado, A., Machuca, J. A. D., & Danese, P. (2023). Stakeholder pressures and sustainability practices in manufacturing: Consideration of the economic development context. *Business Strategy and the Environment*, *32*(7), 4084–4102. https://doi.org/10.1002/bse.3355
Bhattacharjee, P., Howlader, I., Rahman, M. A., Taqi, H. M. M., Hasan, M. T., Ali, S. M., & Alghababsheh, M. (2023). Critical success factors for circular economy in the waste electrical and electronic equipment sector in an emerging economy: Implications for stakeholders. *Journal of Cleaner Production*, *401*, 136767. https://doi.org/10.1016/j.jclepro.2023.136767
Bhuyan, A., Tripathy, A., Padhy, R. K., & Gautam, A. (2022). Evaluating the lithium-ion battery recycling industry in an emerging economy: A multi-stakeholder and multi-criteria decision-making approach. *Journal of Cleaner Production*, *331*, 130007. https://doi.org/10.1016/j.jclepro.2021.130007
Blake, V., Farrelly, T., & Hannon, J. (2019). Is voluntary product stewardship for e-waste working in New Zealand? A Whangarei case study. *Sustainability*, *11*(11), 3063. https://doi.org/10.3390/su11113063
Block, C., Rennings, M., & Bröring, S. (2023). Selecting technologies to engage in sustainability transitions—A multi-stakeholder perspective. *Business Strategy and the Environment*, *32*(6), 3569–3595. https://doi.org/10.1002/bse.3316
Bonsu, N. O. (2020). Towards a circular and low-carbon economy: Insights from the transitioning to electric vehicles and net zero economy. *Journal of Cleaner Production*, *256*, 120659. https://doi.org/10.1016/j.jclepro.2020.120659
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
Bridgens, B., Hobson, K., Lilley, D., Lee, J., Scott, J. L., & Wilson, G. T. (2019). Closing the loop on E-waste: A multidisciplinary perspective. *Journal of Industrial Ecology*, *23*(1), 169–181. https://doi.org/10.1111/jiec.12645
Bridoux, F., & Stoelhorst, J. W. (2022). Stakeholder theory, strategy, and organization: Past, present, and future. *Strategic Organization*, *20*(4), 797–809. https://doi.org/10.1177/14761270221127628
Bruno, G., Diglio, A., Passaro, R., Piccolo, C., & Quinto, I. (2021). Measuring spatial access to the recovery networks for WEEE: An in-depth analysis of the Italian case. *International Journal of Production Economics*, *240*, 108210. https://doi.org/10.1016/j.ijpe.2021.108210
Buonomo, I., Benevene, P., Barbieri, B., & Cortini, M. (2020). Intangible assets and performance in nonprofit organisations: A systematic literature review. *Frontiers in Psychology*, *11*, 1–9. https://doi.org/10.3389/fpsyg.2020.00729
Carroll, A. B. (1991). The pyramid of corporate social responsibility: Toward the Morai management of organizational stakeholders. *Business Horizons*, July/August, 39–48.
Castro, F. D., Xavier, B. G., do Carmo Cardeal, J. A., Perpétuo, B. M. P., Lopes, L. G., da Silva, J. L., da Costa, R. F. F., Cutaia, L., & Vaccari, M. (2022). The (un) shared responsibility in the reverse logistics of portable batteries: A Brazilian case. *Waste Management*, *154*, 49–63. https://doi.org/10.1016/j.wasman.2022.09.021
Chang, P., & Shih, H. (2004). The innovation systems of Taiwan and China: A comparative analysis. *Technovation*, *24*(7), 529–539. https://doi.org/10.1016/S0166-4972(02)00117-7
Chen, W., Kucukyazici, B., & Saenz, M. J. (2019). On the joint dynamics of the economic and environmental performances for collective take-back systems. *International Journal of Production Economics*, *218*, 228–244. https://doi.org/10.1016/j.ijpe.2019.04.028
Cheng, Y., & Yeh, Y. (2011). Exploring radio frequency identification technology's application in international distribution centers and adoption rate forecasting. *Technological Forecasting and Social Change*, *78*(4), 661–673. https://doi.org/10.1016/j.techfore.2010.10.003
Chiarini, A. (2021). Industry 4.0 technologies in the manufacturing sector: Are we sure they are all relevant for environmental performance? *Business Strategy and the Environment*, *30*(7), 3194–3207. https://doi.org/10.1002/bse.2797
Clarkson, M. B. E. (1995). A stakeholder framework for analyzing and evaluating corporate social performance. *The Academy of Management Review*, *20*(1), 92–117. https://doi.org/10.2307/258888
Cole, C., Gnanapragasam, A., Cooper, T., & Singh, J. (2019). An assessment of achievements of the WEEE directive in promoting movement up the waste hierarchy: Experiences in the UK. *Waste Management*, *87*, 417–427. https://doi.org/10.1016/j.wasman.2019.01.046
Cornell, B., & Shapiro, A. C. (2021). Corporate stakeholders, corporate valuation and ESG. *European Financial Management: the Journal of the European Financial Management Association*, *27*(2), 196–207. https://doi.org/10.1111/eufm.12299
D'Adamo, I., Ferella, F., Gastaldi, M., Maggiore, F., Rosa, P., & Terzi, S. (2019). Towards sustainable recycling processes: Wasted printed circuit boards as a source of economic opportunities. *Resources, Conservation and Recycling*, *149*, 455–467. https://doi.org/10.1016/j.resconrec.2019.06.012
Dahlke, J., Beck, M., Kinne, J., Lenz, D., Dehghan, R., Wörter, M., & Ebersberger, B. (2024). Epidemic effects in the diffusion of emerging digital technologies: Evidence from artificial intelligence adoption. *Research Policy*, *53*(2), 104917. https://doi.org/10.1016/j.respol.2023.104917
Desrochers, P. (2020). The paradoxical Malthusian. A promethean perspective on Vaclav smiles growth: From microorganisms to megacities

(MIT press, 2019) and energy and civilization: A history (MIT press, 2017). *Energies*, *13*(20), 1–22.
Donaldson, T., & Preston, L. E. (1995). The stakeholder theory of the corporation: Concepts, evidence, and implications. *Academy of Management Review*, *20*(1), 65–91. https://doi.org/10.2307/258887
Dura, C. C., Iordache, A. M. M., Ionescu, A., Isac, C., & Breaz, T. O. (2022). Analyzing performance in wholesale trade Romanian SMEs: Framing circular economy business scenarios. *Sustainability*, *14*(9), 5567. https://doi.org/10.3390/su14095567
Duran, A. S., Atasu, A., & Van Wassenhove, L. N. (2022). Cleaning after solar panels: Applying a circular outlook to clean energy research. *International Journal of Production Research*, *60*(1), 211–230. https://doi.org/10.1080/00207543.2021.1990434
Eikelenboom, M., & Long, T. B. (2022). Breaking the cycle of marginalization: How to involve local communities in multi-stakeholder initiatives? *Journal of Business Ethics*, *186*, 31–62. https://doi.org/10.1007/s10551-022-05252-5
El Akremi, A., Gond, J., Swaen, V., De Roeck, K., & Igalens, J. (2018). How do employees perceive corporate responsibility? Development and validation of a multidimensional corporate stakeholder responsibility scale. *Journal of Management*, *44*(2), 619–657. https://doi.org/10.1177/0149206315569311f
Elkington, J. (1997). *Cannibals with forks: The triple bottom line of the 21st century*. Capstone.
Elkington, J. (2004). Enter the triple bottom line. In A. Henriques & J. Richardson (Eds.), *The triple bottom line: Does it all add up?* (pp. 1–16). Taylor and Francis.
European Commission. (2008). *Directive 2008/98/EC of the European Parliament and of the council*. Official Journal of the European Union of 19 November 2008. https://eur-lex.europa.eu/eli/dir/2008/98/oj
Fallah, N., Fitzpatrick, C., Killian, S., & Johnson, M. (2021). End-of-Life Electric Vehicle Battery Stock Estimation in Ireland through Integrated Energy and Circular Economy Modelling. *Resources, Conservation and Recycling*, *174*, 105753. https://doi.org/10.1016/j.resconrec.2021.105753
Favot, M., Grassetti, L., Massarutto, A., & Veit, R. (2022). Regulation and competition in the extended producer responsibility models: Results in the WEEE sector in Europe. *Waste Management*, *145*, 60–71. https://doi.org/10.1016/j.wasman.2022.04.027
Favot, M., Veit, R., & Massarutto, A. (2016). The evolution of the Italian EPR system for the management of household waste electrical and electronic equipment (WEEE). Technical and economic performance in the spotlight. *Waste Management*, *56*, 431–437. https://doi.org/10.1016/j.wasman.2016.06.005
Ferasso, M., Beliaeva, T., Kraus, S., Clauss, T., & Ribeiro-Soriano, D. (2020). Circular economy business models: The state of research and avenues ahead. *Business Strategy and the Environment*, *29*(8), 3006–3024. https://doi.org/10.1002/bse.2554
Fiandrino, S., Scarpa, F., & Torelli, R. (2022). Fostering social impact through corporate implementation of the SDGs: Transformative mechanisms towards interconnectedness and inclusiveness. *Journal of Business Ethics*, *180*(4), 959–973. https://doi.org/10.1007/s10551-022-05189-9
Freeman, R. E. (2010). *Strategic management: A stakeholder approach*. Cambridge University Press. https://doi.org/10.1017/CBO9781139192675
Geng, Y., Sarkis, J., Ulgiati, S., & Zhang, P. (2013). Measuring China's circular economy. *Science*, *339*(6127), 1526–1527. https://doi.org/10.1126/science.1227059
Ghisolfi, V., Chaves, G. D. L. D., Siman, R. R., & Xavier, L. H. (2017). System dynamics applied to closed loop supply chains of desktops and laptops in Brazil: A perspective for social inclusion of waste pickers. *Waste Management*, *60*, 14–31. https://doi.org/10.1016/j.wasman.2016.12.018
Ghodrat, M., Rhamdhani, M. A., Brooks, G., Masood, S., & Corder, G. (2016). Techno economic analysis of electronic waste processing through black copper smelting route. *Journal of Cleaner Production*, *126*, 178–190. https://doi.org/10.1016/j.jclepro.2016.03.033
Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods*, *16*(1), 15-31. https://doi.org/10.1177/1094428112452151
Grdic, Z. S., Krstinic Nizic, M., & Rudan, E. (2020). Circular economy concept in the context of economic development in EU countries. *Sustainability*, *12*(7), 3060. https://doi.org/10.3390/su12073060
Grewatsch, S., Kennedy, S., & Bansal, P. (2023). Tackling wicked problems in strategic management with systems thinking. *Strategic Organization*, *21*(3), 721–732. https://doi.org/10.1177/14761270211038635
Gu, X., Ieromonachou, P., Zhou, L., & Tseng, M. L. (2018). Developing pricing strategy to optimise total profits in an electric vehicle battery closed loop supply chain. *Journal of Cleaner Production*, *203*, 376–385. https://doi.org/10.1016/j.jclepro.2018.08.209
Guzzo, D., Rodrigues, V. P., Pigosso, D. C., & Mascarenhas, J. (2022). Analysis of national policies for circular economy transitions: Modelling and simulating the Brazilian industrial agreement for electrical and electronic equipment. *Waste Management*, *138*, 59–74. https://doi.org/10.1016/j.wasman.2021.11.017
Hanes, R., Carpenter, A., Riddle, M., Graziano, D. J., & Cresko, J. (2019). Quantifying adoption rates and energy savings over time for advanced energy-efficient manufacturing technologies. *Journal of Cleaner Production*, *232*, 925–939. https://doi.org/10.1016/j.jclepro.2019.04.366
Hermoso-Orzáez, M. J., Lozano-Miralles, J. A., Lopez-Garcia, R., & Brito, P. (2019). Environmental criteria for assessing the competitiveness of public tenders with the replacement of large-scale LEDs in the outdoor lighting of cities as a key element for sustainable development: Case study applied with PROMETHEE methodology. *Sustainability*, *11*(21), 5982. https://doi.org/10.3390/su11215982
Hina, M., Chauhan, C., Kaur, P., Kraus, S., & Dhir, A. (2022). Drivers and barriers of circular economy business models: Where we are now, and where we are heading. *Journal of Cleaner Production*, *333*, 130049. https://doi.org/10.1016/j.jclepro.2021.130049
Hischier, R., & Böni, H. W. (2021). Combining environmental and economic factors to evaluate the reuse of electrical and electronic equipment—A Swiss case study. *Resources, Conservation and Recycling*, *166*, 105307. https://doi.org/10.1016/j.resconrec.2020.105307
Hong, I.-H., Lee, Y.-T., & Chang, P.-Y. (2014). Socially optimal and fund-balanced advanced recycling fees and subsidies in a competitive forward and reverse supply chain. *Resources, Conservation and Recycling*, *82*,75–85. https://doi.org/10.1016/j.resconrec.2013.10.018
Høvring, C. M., Andersen, S. E., & Nielsen, A. E. (2018). Discursive tensions in CSR multi-stakeholder dialogue: A Foucauldian perspective. *Journal of Business Ethics*, *152*(3), 627–645. https://doi.org/10.1007/s10551-016-3330-4
Isernia, R., Passaro, R., Quinto, I., & Thomas, A. (2019). The reverse supply chain of the e-waste management processes in a circular economy framework: Evidence from Italy. *Sustainability*, *11*(8), 2430. https://doi.org/10.3390/su11082430
Işıldar, A., Rene, E. R., van Hullebusch, E. D., & Lens, P. N. L. (2018). Electronic waste as a secondary source of critical metals: Management and recovery technologies. *Resources, Conservation and Recycling*, *135*, 296–312. https://doi.org/10.1016/j.resconrec.2017.07.031
Jain, V., Kumar, S., Mostofi, A., & Momeni, M. A. (2022). Sustainability performance evaluation of the E-waste closed-loop supply chain with the SCOR model. *Waste Management*, *147*, 36–47. https://doi.org/10.1016/j.wasman.2022.05.010
Jones, T. M. (1995). Instrumental stakeholder theory: A synthesis of ethics and economics. *Academy of Management Review*, *20*(2), 404–437. https://doi.org/10.2307/258852
Kannan, D., Khademolqorani, S., Janatyan, N., & Alavi, S. (2024). Smart waste management 4.0: The transition from a systematic review to an

integrated framework. *Waste Management*, *174*, 1–14. https://doi.org/10.1016/j.wasman.2023.08.041

Keramati, A., Afshari-Mofrad, M., Behmanesh, I., & Gholami, R. (2016). The impact of information technology maturity on firm performance considering the moderating role of relational maturity: An empirical research. *International Journal of Business Information Systems*, *23*(1), 23–43. https://doi.org/10.1504/IJBIS.2016.078021

Kiger, M. E., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE guide no. 131. *Medical Teacher*, *42*(8), 846–854. https://doi.org/10.1080/0142159X.2020.1755030

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular economy: The concept and its limitations. *Ecological Economics*, *143*, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

Kuhlman, T., & Farrington, J. (2010). What is sustainability? *Sustainability*, *2*(11), 3436–3448. https://doi.org/10.3390/su2113436

Kumar, A., Gaur, D., Liu, Y., & Sharma, D. (2022). Sustainable waste electrical and electronic equipment management guide in emerging economies context: A structural model approach. *Journal of Cleaner Production*, *336*, 130391. https://doi.org/10.1016/j.jclepro.2022.130391

Kunz, N., Mayers, K., & Van Wassenhove, L. N. (2018). Stakeholder views on extended producer responsibility and the circular economy. *California Management Review*, *60*(3), 45–70. https://doi.org/10.1177/0008125617752694

Kurniawan, I., & Fernando, Y. (2023). Circular economy supply chain for sustainable development goals (SDGS): A review and future opportunities. *International Journal of Industrial Management*, *17*(1), 32–39. https://doi.org/10.15282/ijim.17.1.2023.9211

Leclerc, S. H., & Badami, M. G. (2022). Material circularity in large organizations: Action-research to shift information technology (IT) material flows. *Journal of Cleaner Production*, *348*, 131333. https://doi.org/10.1016/j.jclepro.2022.131333

Levänen, J., Lyytinen, T., & Gatica, S. (2018). Modelling the interplay between institutions and circular economy business models: A case study of battery recycling in Finland and Chile. *Ecological Economics*, *154*, 373–382. https://doi.org/10.1016/j.ecolecon.2018.08.018

Li, J., Song, H., Sun, W., Sun, P., & Hao, J. (2021). Measuring performance and its influence factors of national sustainable development pilot zones in Shandong, China. *Journal of Cleaner Production*, *289*, 125620. https://doi.org/10.1016/j.jclepro.2020.125620

Li, Z., Guo, C., Li, X., Wang, Z., Wu, J., Qian, Y., & Wei, Y. (2020). Associations between metal exposure and global DNA methylation in potentially affected people in E-waste recycling sites in Taizhou City, China. *Science of the Total Environment*, *711*, 135100. https://doi.org/10.1016/j.scitotenv.2019.135100

Liu, Z., Li, K. W., Tang, J., Gong, B., & Huang, J. (2021). Optimal operations of a closed-loop supply chain under a dual regulation. *International Journal of Production Economics*, *233*, 107991. https://doi.org/10.1016/j.ijpe.2020.107991

Luo, M., Song, X., Hu, S., & Chen, D. (2019). Towards the sustainable development of waste household appliance recovery systems in China: An agent-based modeling approach. *Journal of Cleaner Production*, *220*, 431–444.

MacDonald, A., Clarke, A., & Huang, L. (2019). Multi-stakeholder partnerships for sustainability: Designing decision-making processes for partnership capacity. *Journal of Business Ethics*, *160*(2), 409–426. https://doi.org/10.1007/s10551-018-3885-3

Magrini, C., Nicolas, J., Berg, H., Bellini, A., Paolini, E., Vincenti, N., Campadello, L., & Bonoli, A. (2021). Using internet of things and distributed ledger technology for digital circular economy enablement: The case of electronic equipment. *Sustainability*, *13*(9), 4982. https://doi.org/10.3390/su13094982

Maher, R. (2022). Deliberating or stalling for justice? Dynamics of corporate remediation and victim resistance through the lens of parentalism: The Fundão dam collapse and the Renova foundation in Brazil. *Journal of Business Ethics*, *178*(1), 15–36. https://doi.org/10.1007/s10551-021-04803-6

Mahmoudi, S., Huda, N., & Behnia, M. (2019). Photovoltaic waste assessment: Forecasting and screening of emerging waste in Australia. *Resources, Conservation and Recycling*, *146*, 192–205. https://doi.org/10.1016/j.resconrec.2019.03.039

Majumdar, S. K., & Chang, H. (2010). Technology diffusion and firm performance: It pays to join the digital bandwagon! *Technology in Society*, *32*(2), 100–109. https://doi.org/10.1016/j.techsoc.2010.03.006

Mariani, L., Trivellato, B., Martini, M., & Marafioti, E. (2022). Achieving sustainable development goals through collaborative innovation: Evidence from four European initiatives. *Journal of Business Ethics*, *180*(4), 1075–1095. https://doi.org/10.1007/s10551-022-05193-z

Mazahir, S., Verter, V., Boyaci, T., & Van Wassenhove, L. N. (2019). Did Europe move in the right direction on E-waste legislation? *Production and Operations Management*, *28*(1), 121–139. https://doi.org/10.1111/poms.12894

McMahon, K., Ryan-Fogarty, Y., & Fitzpatrick, C. (2021). Estimating job creation potential of compliant WEEE pre-treatment in Ireland. *Resources, Conservation and Recycling*, *166*, 105230. https://doi.org/10.1016/j.resconrec.2020.105230

Miao, S., Wang, T., & Chen, D. (2017). System dynamics research of remanufacturing closed-loop supply chain dominated by the third party. *Waste Management & Research*, *35*(4), 379–386. https://doi.org/10.1177/0734242X16684384

Miao, Y., Liu, L., Zhang, Y., Tan, Q., & Li, J. (2022). An overview of global power lithium-ion batteries and associated critical metal recycling. *Journal of Hazardous Materials*, *425*, 127900. https://doi.org/10.1016/j.jhazmat.2021.127900

Mitchell, R. K., Weaver, G. R., Agle, B. R., Bailey, A. D., & Carlson, J. (2016). Stakeholder agency and social welfare: Pluralism and decision making in the multi-objective corporation. *Academy of Management Review*, *41*(2), 252–275. https://doi.org/10.5465/amr.2013.0486

Mo, H., Wen, Z., & Chen, J. (2009). China's recyclable resources recycling system and policy: A case study in Suzhou. *Resources, Conservation and Recycling*, *53*(7), 409–419. https://doi.org/10.1016/j.resconrec.2009.03.002

Mohammadi, E., Singh, S. J., & Habib, K. (2021a). Electronic waste in the Caribbean: An impending environmental disaster or an opportunity for a circular economy? *Resources, Conservation and Recycling*, *164*, 105106. https://doi.org/10.1016/j.resconrec.2020.105106

Mohammadi, E., Singh, S. J., & Habib, K. (2021b). How big is circular economy potential on Caribbean islands considering e-waste? *Journal of Cleaner Production*, *317*, 128457. https://doi.org/10.1016/j.jclepro.2021.128457

Molina, J. G. (2018). Advancing small island resilience and inclusive development through a convergence strategy in Carles, Philippines. *Disaster Prevention and Management: an International Journal*, *28*(1), 33–41. https://doi.org/10.1108/DPM-06-2018-0190

Moraga, G., Huysveld, S., De Meester, S., & Dewulf, J. (2022). Resource efficiency indicators to assess circular economy strategies: A case study on four materials in laptops. *Resources, Conservation and Recycling*, *178*, 106099. https://doi.org/10.1016/j.resconrec.2021.106099

Mueller, J. R., Boehm, M. W., & Drummond, C. (2012). Direction of CRT waste glass processing: Electronics recycling industry communication. *Waste Management*, *32*(8), 1560–1565. https://doi.org/10.1016/j.wasman.2012.03.004

Murthy, V., & Ramakrishna, S. (2022). A review on global E-waste management: Urban mining towards a sustainable future and circular economy. *Sustainability*, *14*(2), 647. https://doi.org/10.3390/su14020647

Nowakowski, P., Król, A., & Mrówczyńska, B. (2017). Supporting mobile WEEE collection on demand: A method for multi-criteria vehicle routing, loading and cost optimisation. *Waste Management*, *69*, 377–392. https://doi.org/10.1016/j.wasman.2017.07.045

Nowakowski, P., & Mrówczyńska, B. (2018). Towards sustainable WEEE collection and transportation methods in circular economy-comparative study for rural and urban settlements. *Resources, Conservation and Recycling*, *135*, 93–107. https://doi.org/10.1016/j.resconrec.2017.12.016

Nowakowski, P., Szwarc, K., & Boryczka, U. (2020). Combining an artificial intelligence algorithm and a novel vehicle for sustainable e-waste collection. *Science of the Total Environment*, *730*, 138726. https://doi.org/10.1016/j.scitotenv.2020.138726

Ogbeibu, S., Emelifeonwu, J., Pereira, V., Oseghale, R., Gaskin, J., Sivarajah, U., & Gunasekaran, A. (2023). Demystifying the roles of organisational smart technology, artificial intelligence, robotics and algorithms capability: A strategy for green human resource management and environmental sustainability. *Business Strategy and the Environment*, *33*, 369–388. https://doi.org/10.1002/bse.3495

Oliveira, J. C., Lopes, J. M., Farinha, L., Silva, S., & Luízio, M. (2022). Orchestrating entrepreneurial ecosystems in circular economy: The new paradigm of sustainable competitiveness. *Management of Environmental Quality*, *33*(1), 103–123. https://doi.org/10.1108/MEQ-11-2020-0271

Orts, E. W., & Strudler, A. (2002). The ethical and environmental limits of stakeholder theory. *Business Ethics Quarterly*, *12*(2), 215–233. https://doi.org/10.2307/3857811

Osei, B. A., Ragavan, N. A., Kandappan, B., & Frempong, F. (2022). Exploring measures to enhance the low adoption rate of IR 4.0 technologies: A qualitative inquiry with hotels during COVID-19. *European Journal of Innovation Management*, *27*, 1547–1574. https://doi.org/10.1108/EJIM-09-2022-0484

Ottoni, M., Dias, P., & Xavier, L. H. (2020). A circular approach to the e-waste valorization through urban mining in Rio de Janeiro, Brazil. *Journal of Cleaner Production*, *261*, 120990. https://doi.org/10.1016/j.jclepro.2020.120990

Ozgur Polat, L., & Gungor, A. (2021). WEEE closed-loop supply chain network management considering the damage levels of returned products. *Environmental Science and Pollution Research*, *28*, 7786–7804. https://doi.org/10.1007/s11356-020-10249-6

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/BMJ.n71

Pan, H., Geng, Y., Dong, H., Ali, M., & Xiao, S. (2019). Sustainability evaluation of secondary lead production from spent lead acid batteries recycling. *Resources, Conservation and Recycling*, *140*, 13–22. https://doi.org/10.1016/j.resconrec.2018.09.012

Parajuly, K., & Wenzel, H. (2017). Potential for circular economy in household WEEE management. *Journal of Cleaner Production*, *151*, 272–285. https://doi.org/10.1016/j.jclepro.2017.03.045

Parmentola, A., Petrillo, A., Tutore, I., & De Felice, F. (2022). Is blockchain able to enhance environmental sustainability? A systematic review and research agenda from the perspective of sustainable development goals (SDGs). *Business Strategy and the Environment*, *31*(1), 194–217. https://doi.org/10.1002/bse.2882

Pérez-Martínez, M. M., Carrillo, C., Rodeiro-Iglesias, J., & Soto, B. (2021). Life cycle assessment of repurposed waste electric and electronic equipment in comparison with original equipment. *Sustainable Production and Consumption*, *27*, 1637–1649. https://doi.org/10.1016/j.spc.2021.03.017

Preuss, L., Fischer, I., & Arora, B. (2023). How do stakeholder groups make sense of sustainability: Analysing differences in the complexity of their cognitive frames. *Business Strategy and the Environment*, *33*, 2367–2383. https://doi.org/10.1002/bse.3611

Raja Mamat, T. N. A., Mat Saman, M. Z., Sharif, S., & Simic, V. (2016). Key success factors in establishing end-of-life vehicle management system: A primer for Malaysia. *Journal of Cleaner Production*, *135*, 1289–1297. https://doi.org/10.1016/j.jclepro.2016.06.183

Ranjbari, M., Saidani, M., Shams Esfandabadi, Z., Peng, W., Lam, S. S., Aghbashlo, M., Quatraro, F., & Tabatabaei, M. (2021). Two decades of research on waste management in the circular economy: Insights from bibliometric, text mining, and content analyses. *Journal of Cleaner Production*, *314*, 128009. https://doi.org/10.1016/j.jclepro.2021.128009

Rena, Yadav, S., Patel, S., Killedar, D. J., Kumar, S., & Kumar, R. (2022). Eco-innovations and sustainability in solid waste management: An Indian upfront in technological, organizational, start-ups and financial framework. *Journal of Environmental Management*, *302*, 113953. https://doi.org/10.1016/j.jenvman.2021.113953

Rezayat, M. R., Yaghoubi, S., & Fander, A. (2020). A hierarchical revenue-sharing contract in electronic waste closed-loop supply chain. *Waste Management*, *115*, 121–135. https://doi.org/10.1016/j.wasman.2020.07.019

Richa, K., Babbitt, C. W., & Gaustad, G. (2017). Eco-efficiency analysis of a lithium-ion battery waste hierarchy inspired by circular economy. *Journal of Industrial Ecology*, *21*(3), 715–730. https://doi.org/10.1111/jiec.12607

Rizos, V., & Bryhn, J. (2022). Implementation of circular economy approaches in the electrical and electronic equipment (EEE) sector: Barriers, enablers and policy insights. *Journal of Cleaner Production*, *338*, 130617. https://doi.org/10.1016/j.jclepro.2022.130617

Rogelj, J., Schaeffer, M., Meinshausen, M., Knutti, R., Alcamo, J., Riahi, K., & Hare, W. (2015). Zero emission targets as long-term global goals for climate protection. *Environmental Research Letters*, *10*(10), 105007. https://doi.org/10.1088/1748-9326/10/10/105007

Ruiz-Mercado, G. J., Gonzalez, M. A., Smith, R. L., & Meyer, D. E. (2017). A conceptual chemical process for the recycling of Ce, Eu, and Y from LED flat panel displays. *Resources, Conservation and Recycling*, *126*, 42–49. https://doi.org/10.1016/j.resconrec.2017.07.009

Ryen, E. G., Gaustad, G., Babbitt, C. W., & Babbitt, G. (2018). Ecological foraging models as inspiration for optimized recycling systems in the circular economy. *Resources, Conservation and Recycling*, *135*, 48–57. https://doi.org/10.1016/j.resconrec.2017.08.006

Sagnak, M., Berberoglu, Y., Memis, İ., & Yazgan, O. (2021). Sustainable collection center location selection in emerging economy for electronic waste with fuzzy best-worst and fuzzy TOPSIS. *Waste Management*, *127*, 37–47. https://doi.org/10.1016/j.wasman.2021.03.054

Sahoo, S., Kumar, S., Sivarajah, U., Lim, W. M., Westland, J. C., & Kumar, A. (2022). Blockchain for sustainable supply chain management: Trends and ways forward. *Electronic Commerce Research*, 1–56. https://doi.org/10.1007/s10660-022-09569-1

Sahoo, S., Mukherjee, A., & Halder, R. (2021). A unified blockchain-based platform for global e-waste management. *International Journal of Web Information Systems*, *17*(5), 449–479. https://doi.org/10.1108/ijwis-03-2021-0024

Salmon, D., Babbitt, C. W., Babbitt, G. A., & Wilmer, C. E. (2021). A framework for modeling fraud in E-waste management. *Resources, Conservation and Recycling*, *171*, August 2021, 105613. https://doi.org/10.1016/j.resconrec.2021.105613

Schöggl, J. P., Stumpf, L., & Baumgartner, R. J. (2024). The role of interorganizational collaboration and digital technologies in the implementation of circular economy practices—Empirical evidence from manufacturing firms. *Business Strategy and the Environment*, *33*(3), 2225–2249. https://doi.org/10.1002/bse.3593

Schroeder, P., Anggraeni, K., & Weber, U. (2019). The relevance of circular economy practices to the sustainable development goals. *Journal of Industrial Ecology*, *23*(1), 77–95. https://doi.org/10.1111/jiec.12732

Schultz, F. C., Valentinov, V., Kirchherr, J., Reinhardt, R. J., & Pies, I. (2024). Stakeholder governance to facilitate collaboration for a systemic circular economy transition: A qualitative study in the European chemicals and plastics industry. *Business Strategy and the Environment*, *33*(3), 2173–2192. https://doi.org/10.1002/bse.3592

Scruggs, C. E., Nimpuno, N., & Moore, R. B. B. (2016). Improving information flow on chemicals in electronic products and E-waste to minimize negative consequences for health and the environment. *Resources, Conservation and Recycling*, *113*, 149–164. https://doi.org/10.1016/j.resconrec.2016.06.009

Seeliger, L. (2021). The ethics of groundwater governance: Evaluating a methodology in Philippi in Cape town. In *Advances in science, technology and innovation* (pp. 437–439). Springer, Cham. https://doi.org/10.1007/978-3-030-59320-9_92

Selvakanmani, S., Rajeswari, P., Krishna, B. V., & Manikandan, J. (2024). Optimizing E-waste management: Deep learning classifiers for effective planning. *Journal of Cleaner Production*, *443*, 141021. https://doi.org/10.1016/j.jclepro.2024.141021

Serafeim, G. (2020). The board's role in sustainability a new framework for getting directors behind ESG efforts. *Harvard Business Review*, 98(5), 12–16.

Sharma, M., Joshi, S., & Kumar, A. (2020). Assessing enablers of e-waste management in circular economy using DEMATEL method: An Indian perspective. *Environmental Science and Pollution Research*, *27*(12), 13325–13338. https://doi.org/10.1007/s11356-020-07765-w

Shimada, T., & Van Wassenhove, L. N. (2019). Closed-loop supply chain activities in Japanese home appliance/personal computer manufacturers: A case study. *International Journal of Production Economics*, *212*, 259–265. https://doi.org/10.1016/j.ijpe.2016.11.010

Silvestri, L., Forcina, A., Silvestri, C., & Traverso, M. (2021). Circularity potential of rare earths for sustainable mobility: Recent developments, challenges and future prospects. *Journal of Cleaner Production*, *292*, 126089. https://doi.org/10.1016/j.jclepro.2021.126089

Singh, A., Panchal, R., & Naik, M. (2020). Circular economy potential of e-waste collectors, dismantlers, and recyclers of Maharashtra: A case study. *Environmental Science and Pollution Research*, *27*, 22081–22099. https://doi.org/10.1007/s11356-020-08320-3

Singh, S., Dasgupta, M. S., & Routroy, S. (2022). Analysis of critical success factors to design e-waste collection policy in India: A fuzzy DEMATEL approach. *Environmental Science and Pollution Research*, *29*(7), 10585–10604. https://doi.org/10.1007/s11356-021-16129-x

Sinha, R., Laurenti, R., Singh, J., Malmström, M. E., & Frostell, B. (2016). Identifying ways of closing the metal flow loop in the global mobile phone product system: A system dynamics modeling approach. *Resources, Conservation and Recycling*, *113*, 65–76. https://doi.org/10.1016/j.resconrec.2016.05.010

Slattery, M., Dunn, J., & Kendall, A. (2021). Transportation of electric vehicle lithium-ion batteries at end-of-life: A literature review. *Resources, Conservation and Recycling*, *174*, 105755. https://doi.org/10.1016/j.resconrec.2021.105755

Sommerville, R., Zhu, P., Rajaeifar, M. A., Heidrich, O., Goodship, V., & Kendrick, E. (2021). A qualitative assessment of lithium ion battery recycling processes. *Resources, Conservation and Recycling*, *165*, 105219. https://doi.org/10.1016/j.resconrec.2020.105219

Stefano, R., Clodia, V., & Stefano, P. (2023). Joining multi-stakeholder initiatives to fight climate change: The environmental impact of corporate participation in the science based targets initiative. *Business Strategy and the Environment*, *33*(4), 2817-2831. https://doi.org/10.1002/bse.3639

Stern, N. (2008). The economics of climate change. *American Economic Review*, *98*(2), 1–37. https://doi.org/10.1257/aer.98.2.1

Sundar, D., Mathiyazhagan, K., Agarwal, V., Janardhanan, M., & Appolloni, A. (2023). From linear to a circular economy in the e-waste management sector: Experience from the transition barriers in the United Kingdom. *Business Strategy and the Environment*, *32*(7), 4282–4298. https://doi.org/10.1002/bse.3365

Sung, S.-I., Kim, Y.-S., & Kim, H.-S. (2020). Study on Reverse Logistics Focused on Developing the Collection Signal Algorithm Based on the Sensor Data and the Concept of Industry 4.0. *Applied Sciences*, *10*(14), 5016. https://doi.org/10.3390/app10145016

Taheri, F., D'Haese, M., Fiems, D., & Azadi, H. (2022). The intentions of agricultural professionals towards diffusing wireless sensor networks: Application of technology acceptance model in Southwest Iran. *Technological Forecasting and Social Change*, *185*, 122075. https://doi.org/10.1016/j.techfore.2022.122075

Taylor, M., & Taylor, A. (2012). The technology life cycle: Conceptualization and managerial implications. *International Journal of Production Economics*, *140*(1), 541–553. https://doi.org/10.1016/j.ijpe.2012.07.006

Thukral, S., & Singh, M. (2023). An exploratory study on producer's perspective towards E-waste management: A case of emerging markets. *Cleaner Waste Systems*, *5*, 100090. https://doi.org/10.1016/j.clwas.2023.100090

Tian, T., Liu, G., Yasemi, H., & Liu, Y. (2022). Managing e-waste from a closed-loop lifecycle perspective: China's challenges and fund policy redesign. *Environmental Science and Pollution Research*, *29*(31), 47713–47724. https://doi.org/10.1007/s11356-022-19227-6

Tong, X., Tao, D., & Lifset, R. (2018). Varieties of business models for post-consumer recycling in China. *Journal of Cleaner Production*, *170*, 665–673. https://doi.org/10.1016/j.jclepro.2017.09.032

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, *14*(3), 207–222. https://doi.org/10.1111/1467-8551.00375

Tseng, M. L., Ha, H. M., Tran, T. P. T., Bui, T. D., Chen, C. C., & Lin, C. W. (2022). Building a data-driven circular supply chain hierarchical structure: Resource recovery implementation drives circular business strategy. *Business Strategy and the Environment*, *31*(5), 2082–2106. https://doi.org/10.1002/bse.3009

Tullberg, J. (2012). Triple bottom line—A vaulting ambition? *Business Ethics*, *21*(3), 310–324. https://doi.org/10.1111/j.1467-8608.2012.01656.x

Uddin, S., & Khan, A. (2016). The impact of author-selected keywords on citation counts. *Journal of Informetrics*, *10*(4), 1166–1177. https://doi.org/10.1016/j.joi.2016.10.004

UKcop26.org. 2021. *The UK hosted the 26th UN climate change conference of the parties (COP26) in Glasgow on 31 October – 13 November 2021*. UK Government Web Archive. https://ukcop26.org/

UNWCED. 1987. *Report of the world commission on environment and development: Our common future*. United Nations Digital Library. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Valentinov, V. (2023). Stakeholder theory: Toward a classical institutional economics perspective. *Journal of Business Ethics*, *188*(1), 75–88. https://doi.org/10.1007/s10551-022-05304-w

Villares, M., Işıldar, A., Beltran, A. M., & Guinee, J. (2016). Applying an ex-ante life cycle perspective to metal recovery from e-waste using bioleaching. *Journal of Cleaner Production*, *129*, 315–328. https://doi.org/10.1016/j.jclepro.2016.04.066

Walzberg, J., Burton, R., Zhao, F., Frost, K., Muller, S., Carpenter, A., & Heath, G. (2022). An investigation of hard-disk drive circularity accounting for socio-technical dynamics and data uncertainty. *Resources, Conservation and Recycling*, *178*, 106102. https://doi.org/10.1016/j.resconrec.2021.106102

WHO (World Health Organization) Newsroom. (2023). *Electronic waste (e-waste)*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/electronic-waste-(e-waste).

Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M., & Böni, 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

Xavier, L. H., Ottoni, M., & Lepawsky, J. (2021). Circular economy and e-waste management in the Americas: Brazilian and Canadian frameworks. *Journal of Cleaner Production*, *297*, 126570. https://doi.org/10.1016/j.jclepro.2021.126570

Xue, R., Zhang, F., & Tian, F. (2018a). A system dynamics model to evaluate effects of retailer-led recycling based on dual chains competition: A case of e-waste in China. *Sustainability*, *10*(10), 3391. https://doi.org/10.3390/su10103391

Xue, R., Zhang, F., Tian, F., Oloruntoba, R., & Miao, S. (2018b). Dual chains competition under two recycling modes based on system dynamics method. *Sustainability*, *10*(7), 2382. https://doi.org/10.3390/su10072382

Yeom, J. M., Jung, H. J., Choi, S. Y., Lee, D. S., & Lim, S. R. (2018). Environmental effects of the technology transition from liquid–crystal display (LCD) to organic light-emitting diode (OLED) display from an E-waste management perspective. *International Journal of Environmental Research*, *12*, 479–488. https://doi.org/10.1007/s41742-018-0106-y

Yuan, Q., Gu, Y., Yang, M., Wu, Y., Hu, G., & Zhou, G. (2022). Synergistic utilization mechanism of e-waste in regions with different levels of development: A case study of Guangdong Province. *Journal of Cleaner Production*, *380*, 134855. https://doi.org/10.1016/j.jclepro.2022.134855

Zeng, X., & Li, J. (2016). Measuring the recyclability of e-waste: An innovative method and its implications. *Journal of Cleaner Production*, *131*, 156–162. https://doi.org/10.1016/j.jclepro.2016.05.055

Zhang, D., & Bhuiyan, N. (2015). A study of the evolution of uncertainty in product development as a basis for overlapping. *IEEE Transactions on Engineering Management*, *62*(1), 39–50. https://doi.org/10.1109/TEM.2014.2377217

Zhao, W., & Nie, J. (2017). The establishment and decision-making about recycling model of waste electronic products under government's incentive. *International Journal of Supply Chain Management*, *6*(3), 102.

Zhu, X., & Li, W. (2020). Research on the pricing strategy of "internet+" recycling platforms in a two-sided network environment. *Sustainability*, *12*(3), 1001. https://doi.org/10.3390/su12031001

Zuo, L., Wang, C., & Sun, Q. (2020). Sustaining WEEE collection business in China: The case of online to offline (O2O) development strategies. *Waste Management*, *101*, 222–230. https://doi.org/10.1016/j.wasman.2019.10.008

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## APPENDIX A

### Example of stakeholder groups, stakeholders and close match

| Stakeholder | References and close match |
|---|---|
| **Producers** | **Producer** (Bruno et al., 2021; Chen et al., 2019; Favot et al., 2016, 2022; Kumar et al., 2022; Kunz et al., 2018; Levänen et al., 2018; Murthy & Ramakrishna, 2022; Ozgur Polat & Gungor, 2021; Parajuly & Wenzel, 2017; Pérez-Martínez et al., 2021; Richa et al., 2017; Rizos & Bryhn, 2022; Sharma et al., 2020; Slattery et al., 2021; Tong et al., 2018; Xavier et al., 2021); **manufacturer** (Ahmadi & Amin, 2019; Althaf et al., 2019; Althaf et al., 2021; Andersen, 2022; Bonsu, 2020; Ghisolfi et al., 2017; Gu et al., 2018; Hong et al., 2014; Miao et al., 2017; Mueller et al., 2012; Rezayat et al., 2020; Scruggs et al., 2016; Shimada & Van Wassenhove, 2019; Silvestri et al., 2021; Singh et al., 2022; Walzberg et al., 2022; Xue et al., 2018b; Zeng & Li, 2016; Zhao & Nie, 2017); **OEM** (Albertsen et al., 2021; Bhuyan et al., 2022; Liu et al., 2021; Mazahir et al., 2019); **component manufacturer** (Bridgens et al., 2019); **EEE provider** (Magrini et al., 2021); **EV manufacturer** (Fallah et al., 2021); **importer** (Gu et al., 2018); **industry** (Salmon et al., 2021); **component assembler** (Bridgens et al., 2019); **assembler** (Singh et al., 2022); **brand owners** (Liu et al., 2021; Scruggs et al., 2016); **providers of raw material** (Bonsu, 2020; Bridgens et al., 2019; Singh et al., 2022); **primary sector** (Sommerville et al., 2021); **chemical producers** (Scruggs et al., 2016); **contract suppliers** (Ahmadi & Amin, 2019); **LIB manufacturer** (Bhuyan et al., 2022); **manufacturing subsidiaries** (Andersen, 2022) |
| **Product designers** | **Product designer** (Bhuyan et al., 2022; Blake et al., 2019; Cole et al., 2019) |
| **Distributors** | **Distributor** (Gu et al., 2018; Işıldar et al., 2018; Magrini et al., 2021); **distributor and seller** (Bonsu, 2020); **distribution centres** (Ozgur & Gungor, 2021); **distribution providers** (Bridgens et al., 2019); **importers & seller firms** (Hong et al., 2014); **retailer** (Ahmadi & Amin, 2019; Bruno et al., 2021; Castro et al., 2022; Favot et al., 2016; Ghisolfi et al., 2017; Miao et al., 2017; Rezayat et al., 2020; Shimada & Van Wassenhove, 2019; Singh et al., 2022; Tong et al., 2018; Xue et al., 2018b; Zhao & Nie, 2017); **service provider** (Blake et al., 2019); **stores** (Ozgur Polat & Gungor, 2021) |
| **Collectors** | **Waste collector** (Isernia et al., 2019; Nowakowski et al., 2017; Rezayat et al., 2020; Singh et al., 2020); **waste picker** (Castro et al., 2022; Ghisolfi et al., 2017); **logistics operators** (Favot et al., 2016); **logistics** (Slattery et al., 2021); **collection scheme providers** (Richa et al., 2017); **formal or informal unless provided by municipal services** (Tong et al., 2018); **waste collection companies** (Gu et al., 2018; Nowakowski et al., 2020; Nowakowski & Mrówczyńska, 2018; Zuo et al., 2020); **collection centres** (Bruno et al., 2021; Ozgur Polat & Gungor, ); **drop-off centres** (Ahmadi & Amin, 2019); **location** (Sagnak et al., 2021); **transport companies** (Ozgur & Gungor, 2021; Richa et al., 2017); **storage providers** (Duran et al., 2022) |
| **Recyclers** | **Recycler** (Albertsen et al., 2021; Althaf et al., 2021; Bhuyan et al., 2022; Duran et al., 2022; Gu et al., 2018; Hong et al., 2014; Işıldar et al., 2018; Luo et al., 2019; Miao et al., 2022; Mueller et al., 2012; Salmon et al., 2021; Shimada & Van Wassenhove, 2019; Singh et al., 2020; Singh et al., 2022; Xavier et al., 2021; Xue et al., 2018b; Zhao & Nie, 2017), **recycling companies/firms/plants/facilities** (D'Adamo et al., 2019; Levänen et al., 2018; Li et al., 2020; Mo et al., 2009; Tong et al., 2018; Walzberg et al., 2022; Zeng & Li, 2016); **e-waste management companies** (Mohammadi et al., 2021b); **e-waste sites/processing facility** (Ottoni et al., 2020; Ryen et al., 2018); **treatment plants/facilities** (Favot et al., 2016; Ghodrat et al., 2016); **e-waste disposal companies** (Parajuly & Wenzel, 2017); **third party** (Miao et al., 2017); **recycling plants** (Gu et al., 2018); **scrappers** (McMahon et al., 2021); **recycling systems** (Althaf et al., 2019); **international recyclers** (Schroeder et al., 2019); **recycling sector** (Kumar et al., 2022; Schroeder et al., 2019); **refurbisher** (Moraga et al., 2022); **remanufacturer** (Gu et al., 2018; Miao et al., 2022); **assistance workshops/repairer** (Guzzo et al., 2022; Hischier & Böni, 2021); **partner for repurpose** (Albertsen et al., 2021); **waste handler** (Zuo et al., 2020); **formal/informal** (Scruggs et al., 2016); **waste operator** (Kunz et al., 2018); **mobile collection** (Nowakowski & Mrówczyńska, 2018); **workers** (McMahon et al., 2021); **scrap dealer** (Singh et al., 2022); **recovery centres** (Mo et al., 2009); **recovery plant** (D'Adamo et al., 2019); **providers of component and material recovery** (Bridgens et al., 2019); **smelters** (Singh et al., 2022); **dismantling companies** (Gu et al., 2018; Singh et al., 2020); **product consolidation** (Ahmadi & Amin, 2019; Bridgens et al., 2019); **disposal sites** (Ahmadi & Amin, 2019; Gu et al., 2018; Ozgur Polat & Gungor, 2021); **entrepreneur** (Murthy & Ramakrishna, 2022) |