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(IJLGC)**www.gaexcellence.com/ijlgc**FROM E-WASTE REGULATION TO CLIMATE ACTION:
A CONCEPTUAL FRAMEWORK OF LEGAL
EFFECTIVENESS, REGULATORY COMPLIANCE, AND
CLIMATE GOVERNANCE**

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Abstract:

Electronic waste (e-waste) continues to grow in volume, raising concerns for environmental protection and climate change mitigation. Legal and regulatory measures govern its collection, recycling, treatment, disposal, transboundary movement and producer responsibility. Yet their existence does not necessarily ensure effective implementation, regulatory compliance or alignment with climate objectives. While the literature addresses these issues, it pays far less attention to how environmental legal framework effectiveness, regulatory compliance, and climate governance might work together. This paper examines that relationship and considers regulatory compliance as a potential mediating mechanism between environmental legal framework effectiveness and climate governance. To develop the framework, relevant multidisciplinary studies were identified through Scopus and reviewed using a narrative approach, followed by integrative thematic analysis. Four broad dimensions emerged from the literature: legal effectiveness, implementation and compliance, governance capacity, and the integration of e-waste regulation with climate and circular economy objectives. Drawing on Responsive

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Regulation Theory, the framework proposes that effective legal and institutional arrangements may encourage compliance, reflected in responsible e-waste practices that may, in turn, contribute to climate-responsive governance. It also recognises a potential direct relationship between environmental legal framework effectiveness and climate governance. Theoretically, the framework brings the three constructs into a single explanatory model and extends Responsive Regulation Theory to the broader climate-governance implications of compliant e-waste practices. Practically, it highlights the importance of effective implementation, monitoring, institutional coordination, stakeholder accountability, and climate-responsive regulatory design. As these relationships remain theoretical, the framework provides a basis for future empirical research into whether, and under what conditions, effective e-waste regulation and sustained compliance contribute to broader climate governance objectives.

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Keyword:

Climate Governance; E-Waste; Environmental Legal Framework Effectiveness; Regulatory Compliance; Responsive Regulation Theory



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Introduction

The growing amount of electronic waste (e-waste) is an important issue for environmental preservation, resource governance, and climate action. The rapid pace of technological change, shorter product life cycles, increasing use of electrical and electronic equipment, and premature obsolescence have resulted in an increase in the amount and complexity of discarded electronic items globally. E-waste is especially problematic, as it comprises both toxic elements and recoverable materials of value. Poor handling of e-waste can consequently create environmental pollution, whereas optimal recovery and recycling can help save resources and promote more circular patterns of production and consumption (Kiddee et al., 2013; Widmer et al., 2005). Further complicating e-waste management are differences among countries in recycling infrastructure, technological capabilities, waste-management systems, and legislative structures (Widmer et al., 2005). In response, international, regional, and national regulatory arrangements have been developed to govern e-waste collection, transboundary movement, recycling, recovery, and disposal, including the Basel Convention, national legislation, and Extended Producer Responsibility (EPR) schemes (Castellón et al., 2025; Patil & Ramakrishna, 2020; Sasso, 2023). E-waste has also become increasingly relevant to the climate agenda. Improper practices such as open burning, landfilling, and informal recycling may generate greenhouse gas emissions and other environmental harms, whereas reuse, recycling, material

recovery, and circular resource use can reduce dependence on primary resources and support broader sustainability and climate objectives (Mdoe et al., 2026; Shaker et al., 2026).

Despite the expansion of e-waste legislation, a gap remains between regulatory expectations and implementation in practice. Existing regulations address areas such as transboundary waste movements, recycling and recovery, producer responsibility, and environmentally sound management (Castellón et al., 2025; Patil & Ramakrishna, 2020). The European Union provides a useful example. Although it has developed a comprehensive regulatory framework based on the WEEE and RoHS Directives and EPR principles, e-waste management still faces challenges related to inconsistent implementation, informal waste flows, collection difficulties, inadequate incentives, and variations across member states (Boateng et al., 2026). This experience shows that a regulatory framework does not necessarily achieve its objectives in practice. It also points to an important distinction between environmental legal framework effectiveness and regulatory compliance. Legal rules may establish responsibilities, standards, and penalties, but their effectiveness depends, in part, on how regulated actors respond to these requirements. The issue therefore extends beyond whether e-waste laws exist to how effectively they are implemented and whether they encourage compliance.

Integrating e-waste regulation into climate governance introduces an additional conceptual challenge. Much of the existing legal and policy literature approaches e-waste through pollution prevention, hazardous-waste control, recycling, resource recovery, EPR, and circular economy perspectives, while its relationship with climate governance remains comparatively underdeveloped. Shaker et al. (2026) identify limited integration of carbon accounting, eco-design criteria, and emission-based incentives within climate-responsive EPR systems, suggesting that e-waste regulation may support environmentally sound waste management even where climate objectives are not explicitly embedded. Similarly, Mdoe et al. (2026) observe growing interest in climate-responsive resource management and circular economy approaches but conclude that scholarship connecting e-waste management with climate change remains fragmented. Although existing research therefore provides substantial knowledge on e-waste legislation, regulatory implementation, stakeholder behaviour, circular economy practices, and barriers to effective e-waste management, these strands of scholarship have largely developed separately. Consequently, limited conceptual explanation exists of how environmental legal framework effectiveness, regulatory compliance, and climate governance are interconnected within a unified explanatory framework. In particular, insufficient attention has been given to whether regulatory compliance may provide a mechanism through which effective legal and institutional arrangements contribute to climate-responsive e-waste governance. This study addresses this gap by integrating the three constructs and proposing regulatory compliance as a potential mediating mechanism between environmental legal framework effectiveness and climate governance.

Accordingly, this study aims to develop a conceptual framework explaining how environmental legal framework effectiveness may contribute to climate governance, both directly and through a proposed indirect pathway involving regulatory compliance. In the proposed framework, environmental legal framework effectiveness is the independent construct, regulatory compliance is proposed as the potential mediating construct, and climate governance is the dependent construct. Regulatory compliance is conceptualised as a potential pathway through which environmental legal requirements may be reflected in responsible e-waste practices, including formal collection and recycling, environmentally sound treatment, responsible producer behaviour, material recovery, and reduced reliance on informal processing. These practices may, in turn, contribute to greater alignment between e-waste

governance and broader climate objectives. The framework is primarily based on Responsive Regulation Theory (Ayres & Braithwaite, 1992; Braithwaite, 2011), which explains how monitoring, accountability, enforcement, cooperation, and appropriate regulatory responses may shape the behaviour of regulated actors. This theoretical perspective shifts attention from the mere existence of e-waste regulation towards how effective regulatory arrangements may encourage compliance and how compliant practices may, in turn, contribute to climate-responsive governance. The proposed relationships remain theoretical and require future empirical testing.

This paper contributes in three major ways. First, it advances e-waste scholarship beyond largely descriptive accounts of legislation and policy by bringing environmental legal framework effectiveness, regulatory compliance, and climate governance together within a single conceptual framework. Second, it extends the explanatory application of Responsive Regulation Theory beyond its conventional focus on regulatory responses and compliance behaviour by considering, in the e-waste context, how compliant practices may have wider implications for climate governance. In particular, the framework considers how compliance with requirements concerning formal collection, environmentally sound recycling, EPR, and resource recovery may support greater alignment between e-waste governance and climate-related objectives. In this context, regulatory compliance is conceptualised as a potential mediating mechanism linking environmental legal framework effectiveness with climate governance. This proposed relationship provides the basis for theoretically informed propositions that can be tested in future empirical research. Third, the framework offers policy-relevant insights by suggesting that strengthening the contribution of e-waste regulation to climate action requires more than legislative reform. Effective implementation, enforcement, monitoring, institutional coordination, stakeholder accountability, and closer alignment among e-waste regulation, circular economy initiatives, and climate objectives are equally important.

Literature Review

Environmental Legal Framework Effectiveness

Environmental legal framework effectiveness refers to the extent to which environmental laws, regulatory instruments, institutions, and enforcement mechanisms translate formal legal obligations into intended environmental outcomes. In the context of e-waste, legal frameworks operate at international, regional, and national levels and govern activities across the waste-management chain, including generation, collection, transportation, transboundary movement, recycling, recovery, treatment, and disposal. The Basel Convention is the main international legal instrument for managing transboundary movements of hazardous waste. At the same time, national and regional regimes are progressively introducing Extended Producer Responsibility (EPR), take-back schemes, recycling mandates, restrictions on hazardous substances and obligations for environmentally sound management (Goodall, 2019; Patil & Ramakrishna, 2020). These regulatory approaches reflect the increasing complexity of e-waste management, which requires attention not only to end-of-life disposal but also to collection, recycling, resource recovery, and the institutions that regulate such activities (Kiddee et al., 2013; Kumar et al., 2017). Nevertheless, considerable variation remains among jurisdictions in the scope, design, maturity and implementation of e-waste regulatory regimes (Arya & Kumar, 2020; Kumar et al., 2017). The ongoing development of e-waste regulation therefore reflects increasing recognition of the need for regulatory action to prevent environmental damage,

promote resource recovery and foster more sustainable and circular patterns of production and consumption (Castellón et al., 2025).

However, the existence of laws does not, by itself, mean a legal framework is effective. More important is whether regulatory requirements can be implemented and enforced in ways that affect the behaviour of regulated actors and achieve their intended outcomes. This depends on several interlinked factors, including the clarity and enforceability of legal duties, institutional capacity, monitoring and enforcement, and the infrastructure required to implement regulatory obligations. Legal accountability is also relevant to this assessment, particularly where liability mechanisms assign responsibility for harm associated with improper e-waste management (Ahmed, 2026). Previous research on e-waste management highlights several challenges involving collection systems, recycling capacity, institutional frameworks, enforcement and implementation capacity (Arya & Kumar, 2020; Kiddee et al., 2013; Kumar et al., 2017). Similarly, Li et al. (2015) show that e-waste recycling performance depends not only on national legislation but also on technical capacity, consumer participation and procedural requirements. These issues persist even in relatively well-established regulatory frameworks. For instance, the EU continues to face inconsistent implementation, informal waste streams, inadequate incentives, collection difficulties, and differences across Member States within the broader legislative framework of the WEEE and RoHS Directives (Boateng et al., 2026). Together, these findings show an important distinction between law as formally established and law as applied in practice. While comprehensive regulation is important, it does not guarantee legal effectiveness.

In this context, the present study conceptualises environmental legal framework effectiveness not only as the existence or comprehensiveness of e-waste legislation but also as the regulatory system's capacity to create the legal and institutional conditions through which environmental and governance outcomes may be pursued. This involves clear, enforceable legal obligations; clearly defined institutional roles; effective implementation and monitoring; credible enforcement; coordination among responsible authorities; and the ability to influence the behaviour of regulated stakeholders. This view shifts attention from the formal architecture of e-waste law to its practical operation. In particular, it considers whether the regulatory system creates the institutional and behavioural conditions needed to collect, treat, recycle, recover and dispose of e-waste responsibly. Environmental legal framework effectiveness therefore provides a regulatory foundation through which e-waste governance may move beyond formal legal commitments towards substantive environmental and climate-related outcomes (Boateng et al., 2026; Li et al., 2015; Patil & Ramakrishna, 2020). However, regulatory design and institutional capacity alone cannot achieve these outcomes. They also depend on how regulated actors respond to legal requirements in practice, which brings regulatory compliance to the centre of the discussion.

Regulatory Compliance

Regulatory compliance refers to the extent to which actors subject to e-waste laws and regulations conform to prescribed legal obligations, standards, procedures, and responsibilities. In environmental governance, compliance is critical because legal rules can produce meaningful outcomes only when those subject to them respond to regulatory requirements through their actions and practices. This is particularly important in e-waste governance, which involves a diverse network of actors, including producers, manufacturers, importers, distributors, retailers, consumers, collectors, recyclers, waste-management operators, informal-

sector participants, and public authorities. Stakeholders' behaviours and interactions can ultimately determine whether regulatory objectives are realised. This complex stakeholder environment has long been identified as a challenge for e-waste management, especially where effective implementation requires coordinated engagement, proper management mechanisms and ongoing regulatory supervision (Godbole, 2011). Therefore, even well-designed legislation may have a limited impact when inadequate monitoring, weak enforcement, insufficient institutional capacity, limited stakeholder awareness, poor access to formal collection systems, or incentives that favour informal disposal and recycling constrain compliance.

However, regulatory compliance is not just an enforcement issue. It also has important institutional and behavioural dimensions. Li et al. (2015) point out that national legislation alone cannot ensure successful e-waste management and that outcomes also depend on technical competence and consumer participation, showing how regulatory effectiveness depends on stakeholders' capacity and motivation to comply with legal obligations. Parajuly et al. (2020) also emphasise the significance of behavioural change in achieving circular economy objectives for e-waste management. Their analysis focuses on stakeholder actions in responsible consumption, collection, reuse, and recycling. They suggest that formal legislative measures are unlikely to accomplish their intended aims without corresponding behavioural responses. Similarly, Patil and Ramakrishna (2020) identify significant disparities among national e-waste regulatory regimes and stress the importance of implementation and stakeholder participation in shaping regulatory outcomes. These problems persist even in relatively well-established regulatory regimes. In the European Union, for instance, uneven enforcement, informal waste flows, high collection costs, insufficient repair and reuse incentives, and limited public participation continue to hamper consistent e-waste-management outcomes across Member States (Boateng et al., 2026). Overall, the literature suggests that compliance results from the interaction between regulatory expectations and the institutional capacity, incentives, opportunities and behavioural responses that enable stakeholders to meet those expectations.

In this context, the current study conceptualises regulatory compliance as extending beyond formal obedience to legal norms. It describes how regulatory expectations are transformed into observable practices that align with responsible e-waste management. These practices may include formal collection, environmentally sound treatment and recycling, responsible producer behaviour, resource recovery, reduced informal processing, and compliance with EPR obligations. In the proposed framework, regulatory compliance is conceptualised as a potential mediating mechanism between environmental legal framework effectiveness and climate governance. Effective legal frameworks are expected to promote compliance through clear requirements, credible monitoring and enforcement, institutional accountability and appropriate regulatory responses. In turn, compliance may be reflected in responsible e-waste management practices that may contribute to broader environmental and governance outcomes. Regulatory compliance may therefore serve as the conceptual bridge between law as formally established and law as implemented in practice and may help to explain why similar regulatory frameworks can lead to different outcomes depending on how regulated actors respond to their requirements (Boateng et al., 2026; Li et al., 2015; Parajuly et al., 2020). This proposed mediating role is especially relevant when compliant e-waste practices are assessed not only in terms of waste-management outcomes but also in their potential to contribute to the wider aims of climate governance.

Climate Governance

Climate governance is a broad concept that encompasses the laws, policies, institutions, regulatory processes, actors and decision-making arrangements through which societies organise and coordinate their responses to climate change. Historically, waste governance and climate governance have developed as partly separate fields of environmental policy, but their interaction has become increasingly important. Material systems, comprising waste generation, resource extraction, production, consumption, recycling and disposal, are interrelated components of the global economy that influence energy use, resource demand, emissions and environmental sustainability. As O'Neill (2019) demonstrates, waste-related concerns have increasingly entered global climate governance, with waste management seen not only as a means of controlling pollution but also as a potential strategy for climate mitigation. This link is especially pertinent to e-waste, as managing discarded electrical and electronic products may have implications beyond conventional waste management. Improper activities, including open burning, landfilling and informal recycling, can result in greenhouse gas emissions and other environmental problems. Conversely, reuse, repair, material recovery, formal recycling and circular resource management may alleviate the pressures associated with virgin-material extraction and energy-intensive production. From this perspective, responsible e-waste management can be integrated into a broader approach to managing material flows in support of climate and sustainability goals.

However, this link has not resulted in sufficient integration of climate considerations into e-waste governance. Recent literature has therefore recommended regulatory approaches that respond more directly to the climate impacts of e-waste management. For example, Shaker et al. (2026) highlight shortcomings in EPR frameworks that do not fully incorporate carbon accounting, eco-design criteria, and emission-based incentives. This demonstrates how e-waste regulation might meet traditional waste-management goals without necessarily furthering climate-mitigation goals. Similarly, Mdoe et al. (2026) indicate that research on the nexus between e-waste governance and climate action is still fragmented and unevenly developed, despite the increased emphasis on circular economy strategies and climate-responsive resource management. Research on e-waste management in Asia also reflects a broader shift toward sustainability-oriented approaches, including smart recycling and more sustainable management practices, reinforcing the need to consider e-waste within wider sustainability and circular-resource agendas (Usha Amulya et al., 2026).

Taken together, this literature suggests that climate governance in the e-waste context should extend beyond end-of-life regulation to consider how climate objectives can be incorporated into regulatory design and implementation, producer responsibility, resource recovery, circularity, technological innovation and institutional decision-making. The challenge, therefore, is not simply to regulate e-waste more effectively but to align regulatory and management practices more closely with broader climate objectives. Against this background, the present study conceptualises climate governance as the dependent construct, representing the broader governance arrangements through which e-waste regulation and its implementation become aligned with climate-related objectives. This conceptualisation completes the explanatory pathway developed across the three constructs. Environmental legal framework effectiveness represents the legal and institutional conditions within which e-waste is governed. At the same time, regulatory compliance reflects the extent to which regulated actors respond to those requirements through their behaviour and practices. Where regulatory compliance is reflected in formal collection, environmentally sound treatment, responsible recycling, resource recovery, reduced informal processing and circular use of materials, these responsible

e-waste practices may provide a pathway through which e-waste regulation may contribute to climate-responsive governance (Mdoe et al., 2026; O'Neill, 2019; Shaker et al., 2026). Climate governance, in this sense, is not treated merely as an environmental outcome of e-waste management. Rather, it captures the broader alignment of legal, institutional and behavioural responses to e-waste with climate-related priorities. This completes the conceptual relationship among the three constructs and provides the basis for proposing that environmental legal framework effectiveness may contribute to climate governance directly and through a proposed indirect pathway involving regulatory compliance.

Methodology

Research Design

This study adopts a narrative review methodology to develop a conceptual framework examining the relationships among environmental legal framework effectiveness, regulatory compliance, and climate governance in the context of e-waste regulation. Narrative reviews suit conceptual research because they allow critical interpretation and integration of literature from different but related fields, providing a basis for developing broader theoretical explanations from existing knowledge (Baumeister & Leary, 1997; Green et al., 2006; Snyder, 2019). Compared with review approaches primarily oriented towards synthesising evidence on a narrowly defined empirical question, a narrative review offers greater flexibility to explore scholarship across disciplinary boundaries. This makes it especially useful for identifying conceptual patterns, contrasting perspectives, clarifying relationships among constructs, and developing theoretically informed propositions. This approach suits the present study because research on the nexus of e-waste regulation and climate action is dispersed across several disciplines, including environmental law, regulatory governance, regulatory compliance, waste management, Extended Producer Responsibility (EPR), circular economy, and climate governance. Bringing together these different strands of scholarship therefore enables the study to examine relationships that remain fragmented or insufficiently explained within any single field.

The review is concept-driven and integrative. It reviews and synthesises literature on the study's three main constructs: environmental legal framework effectiveness, regulatory compliance, and climate governance. Rather than simply summarising existing research, the review identifies common themes, explanatory mechanisms, points of consensus and contention, and underdeveloped relationships in the literature. It pays special attention to evidence on the effectiveness and implementation of e-waste regulation, stakeholder compliance and behaviour, and the emerging integration of e-waste management with climate-related governance objectives. This process integrates insights from otherwise fragmented bodies of scholarship to develop a coherent conceptual account of how environmental regulation, regulatory compliance, and climate governance may be linked. The resulting synthesis provides the analytical and theoretical foundation for the proposed conceptual framework and the propositions developed in the subsequent sections.

Key Steps in Conducting the Narrative Review

The narrative review followed a structured sequence of interrelated steps to enhance transparency, coherence, and conceptual rigour. The first step involved problem formulation, which defined the central issue as the limited conceptual understanding of the relationship

between e-waste regulation and climate governance, particularly the potential role that regulatory compliance may play in connecting effective environmental regulation with climate-related governance objectives. The second step involved developing the search strategy, during which the principal concepts and related terminology concerning e-waste, environmental law and regulation, legal effectiveness, regulatory compliance, climate change, and climate governance were identified. The third step consisted of literature identification and data collection using the Scopus database. Scopus was selected for its multidisciplinary coverage, which allowed the review to draw on relevant scholarship across environmental law, regulatory governance, e-waste and waste management, sustainability, circular economy, and climate governance. The authors then developed search terms and Boolean combinations to identify literature relevant to these areas within the broader context of e-waste regulation and climate action.

The fourth step involved relevance assessment. Titles, abstracts, keywords, and available bibliographic information were examined to determine whether the identified publications contributed meaningfully to the conceptual focus of the study. Particular attention was given to literature addressing e-waste regulation, environmental legal effectiveness, regulatory implementation and enforcement, stakeholder compliance, EPR, circular resource management, and the relationship between waste governance and climate action. Consistent with the purpose of a narrative review, publications were considered primarily for their conceptual relevance and explanatory contribution rather than according to a single methodological design. The fifth step involved literature organisation and thematic synthesis. Relevant studies were organised around three principal analytical domains: environmental legal framework effectiveness, regulatory compliance, and climate governance. Recurring themes were then identified across the literature, including legislative design, implementation and enforcement capacity, institutional coordination, stakeholder behaviour, monitoring and accountability, EPR, the circular economy, resource recovery, and climate-responsive e-waste management.

The final step involved conceptual integration and framework development. At this stage, the themes and explanatory insights identified through the review were compared and brought together to examine how the three principal constructs may be conceptually related. The synthesis highlighted the importance of distinguishing between the formal existence of e-waste regulation, its effectiveness in implementation, the compliance responses of regulated actors, and the wider integration of e-waste management with climate-related governance objectives. These insights informed the development of a framework in which environmental legal framework effectiveness is conceptualised as the independent construct, regulatory compliance is proposed as a potential mediating construct, and climate governance is conceptualised as the dependent construct. The review therefore moved from identifying separate themes within the literature to developing an integrated explanation of how the three constructs may operate in relation to one another. The proposed relationships remain theoretical and provide the conceptual foundation for the key findings, theoretical framework, conceptual model, and propositions presented in the subsequent parts of the paper, as well as for future empirical testing.

Data Collection and Review Strategy

Literature for this conceptual study was retrieved from the Scopus database, selected for its broad multidisciplinary coverage of peer-reviewed scholarship across environmental law,

environmental regulation, e-waste management, regulatory compliance, circular economy, sustainability, and climate governance. Consistent with the narrative review design, the search strategy was developed to capture the regulatory, environmental, and governance dimensions of e-waste while accommodating differences in terminology across disciplinary fields. The following Boolean search string, incorporating synonymous and conceptually related terms, was employed: ("e-waste" OR "electronic waste" OR "ewaste" OR "electronic refuse") AND ("regulation" OR "policy" OR "legislation" OR "governance") AND ("climate" OR "environment" OR "sustainability" OR "ecological") AND ("management" OR "disposal" OR "recycling" OR "treatment") AND ("impact" OR "effect" OR "assessment" OR "analysis"). The search was designed to identify scholarship at the intersection of e-waste regulation, environmental and climate considerations, management practices, and regulatory or governance outcomes.

As the study adopted a narrative rather than a systematic review design, the literature-selection process was guided by conceptual relevance to the research problem rather than by a predetermined systematic-review protocol. Retrieved publications were examined based on their titles, abstracts, keywords, and, where relevant, full texts to determine their contribution to the conceptual development of the study. Studies were considered relevant where they addressed e-waste regulation, legal and regulatory effectiveness, implementation and enforcement, regulatory compliance, stakeholder behaviour, EPR, circular economy, resource recovery, or the relationship between e-waste management and climate governance. The thematic synthesis included only publications that substantively addressed these conceptual areas and contributed to explaining the relationships among the three constructs.

Given the interdisciplinary nature of the research problem, the review was not restricted to a particular methodological tradition or jurisdiction. This approach allowed legal, policy, governance, environmental, and interdisciplinary scholarship to inform the development of the three constructs and the relationships among them. Scopus AI was used as a supplementary literature-discovery and synthesis aid to assist in identifying potentially relevant studies, recurring themes, and connections within the Scopus-indexed literature. However, decisions concerning source relevance, interpretation of the literature, thematic organisation, and the development of the conceptual framework remained author directed.

The selected literature was subsequently examined using an integrative thematic analysis, which enabled findings and theoretical insights from diverse disciplinary sources to be compared, organised, and synthesised into a coherent conceptual account (Braun & Clarke, 2006; Snyder, 2019; Torraco, 2005). The analysis involved iterative reading and comparison of the literature to identify recurring concepts, regulatory mechanisms, implementation challenges, theoretical perspectives, and emerging relationships relevant to e-waste regulation and climate action. Concepts identified across the literature, including legislative comprehensiveness, regulatory clarity, enforcement capacity, institutional coordination, monitoring, stakeholder participation, producer responsibility, compliance behaviour, informal recycling, circularity, resource recovery, and climate-responsive e-waste management, were progressively grouped into broader analytical categories. These categories were then organised around the study's three principal conceptual domains. Environmental legal framework effectiveness encompassed literature concerning regulatory design, implementation, enforceability, monitoring, and institutional capacity. Regulatory compliance captured the behavioural and institutional processes through which regulated actors respond to legal requirements. Climate governance encompassed literature concerning the integration of e-

waste management with climate-related, circular economy, resource efficiency, and sustainability objectives. The analysis then moved beyond descriptive categorisation by comparing areas of convergence, divergence, and interdependence across these domains. Through this process, the synthesis provided a conceptual basis for proposing regulatory compliance as a potential mediating mechanism between environmental legal framework effectiveness and climate governance. This proposed mediating relationship remains theoretical and requires future empirical testing. The resulting synthesis informed the development of the theoretical framework, conceptual relationships, and propositions presented in the subsequent parts of the paper.

Key Findings from the Narrative Review

The integrative thematic analysis identified six interrelated themes that help explain how e-waste regulation may progress from formal legal requirements towards broader climate governance objectives: (1) comprehensive legal and regulatory frameworks; (2) implementation and enforcement capacity; (3) stakeholder compliance and participation; (4) monitoring, transparency, and traceability; (5) integration of e-waste regulation with climate governance; and (6) circular economy as a pathway to climate action. Collectively, these themes indicate that the existence of e-waste legislation alone is insufficient to achieve intended environmental and climate-related objectives. Rather, the literature points to a progression in which the practical effectiveness of environmental legal frameworks depends on their capacity to be implemented and enforced, while their influence is also shaped by the extent to which regulated stakeholders respond to and comply with legal requirements. At the same time, environmentally responsible e-waste practices need to be considered within broader climate governance objectives if e-waste regulations are to contribute meaningfully to climate action. Table 1 synthesises the principal findings of the narrative review and shows how each theme informs the constructs and relationships incorporated into the proposed conceptual framework.

Table 1: Key Findings from the Narrative Review on E-Waste Regulation and Climate Governance

Key Finding / Theme	Description	Conceptual Relevance	Sources
Comprehensive Legal and Regulatory Frameworks	International, regional, and national legal frameworks establish requirements governing e-waste collection, recycling, treatment, disposal, transboundary movement, and producer responsibility. Comprehensive, coherent, and enforceable regulation provides the legal foundation for environmentally sound e-waste management.	Environmental Legal Framework Effectiveness: Establishes the regulatory foundation through comprehensiveness, clarity, coherence, allocation of responsibilities, and enforceability.	Goodall (2019); Patil and Ramakrishna (2020); Sasso (2023); Castellón et al. (2025)

Key Finding / Theme	Description	Conceptual Relevance	Sources
Implementation and Enforcement Capacity	The existence of comprehensive legislation does not automatically ensure effectiveness. Institutional capacity, enforcement, monitoring, technical capability, coordination, infrastructure, and accountability influence whether formal legal requirements are translated into practice.	Environmental Legal Framework Effectiveness → Regulatory Compliance: Effective implementation and enforcement create conditions that can encourage regulated actors to comply with e-waste requirements.	Li et al. (2015); Patil and Ramakrishna (2020); Boateng et al. (2026)
Stakeholder Compliance and Participation	Effective e-waste governance depends on the participation and compliance of producers, importers, consumers, collectors, recyclers, waste-management operators, regulators, and other relevant stakeholders. Weak participation and continued informal practices may undermine regulatory objectives even where formal legal frameworks exist.	Regulatory Compliance: Stakeholder responses translate environmental legal obligations into e-waste-management practices through their behavioural and operational mechanisms.	Godbole (2011); Li et al. (2015); Parajuly et al. (2020); Boateng et al. (2026)
Monitoring, Transparency, and Traceability	Effective monitoring and transparent waste-tracking mechanisms can strengthen accountability and facilitate the identification of non-compliance. Digital technologies may further improve traceability across e-waste collection, transportation, recycling, and disposal systems.	Regulatory Compliance: Monitoring, transparency, and traceability enhance regulatory visibility and accountability and can facilitate adherence to legal requirements.	Karthikeyan et al. (2026)
Integration of E-Waste Regulation with Climate Governance	E-waste management has implications extending beyond conventional waste control. The environmental consequences of inappropriate treatment and the resource benefits associated with responsible	Environmental Legal Framework Effectiveness → Climate Governance: Climate-responsive regulatory design provides a conceptual pathway through which e-waste regulation may become more closely	O'Neill (2019); Mdoe et al. (2026); Shaker et al. (2026)

Key Finding / Theme	Description	Conceptual Relevance	Sources
	management provide a basis for closer integration between e-waste regulation and climate-related policy and governance.	aligned with broader climate objectives.	
Circular Economy as a Pathway to Climate Action	Reuse, repair, recycling, material recovery, eco-design, resource efficiency, and EPR support circular material flows and can reduce dependence on virgin resources. Climate-responsive e-waste regulation can therefore connect responsible waste-management practices with wider climate objectives.	Regulatory Compliance → Climate Governance: Compliant circular economy and environmentally sound e-waste practices provide an operational pathway through which regulatory implementation may contribute to climate-responsive governance.	Sasso (2023); Mdoe et al. (2026); Shaker et al. (2026); Usha Amulya et al. (2026)

The findings presented in Table 1 first underscore the importance of environmental legal framework effectiveness as the regulatory foundation of e-waste governance. Comprehensive legal frameworks establish responsibilities relating to collection, recycling, treatment, transboundary movement, producer responsibility, and environmentally sound management (Castellón et al., 2025; Goodall, 2019; Patil & Ramakrishna, 2020). Yet regulatory comprehensiveness alone does not establish effectiveness. The practical operation of e-waste law also depends on implementation and enforcement capacity, institutional coordination, monitoring, technical capability, infrastructure, and accountability. Persistent implementation disparities and informal waste flows, including within comparatively mature regulatory systems, illustrate the continuing distinction between the formal existence of legal rules and their effectiveness in practice (Boateng et al., 2026; Li et al., 2015). These findings reinforce the conceptualisation adopted in this study. Environmental legal framework effectiveness concerns not simply whether e-waste laws exist but whether the regulatory system has the capacity to create the legal and institutional conditions through which meaningful governance responses may be pursued.

Second, the synthesis emphasises that regulatory compliance could serve as a crucial mechanism for reflecting legal requirements in responsible e-waste management practices. Compliance depends on the behaviour and participation of multiple stakeholders, including producers, importers, consumers, collectors, recyclers, waste-management operators, and regulatory authorities. The literature suggests that monitoring, credible enforcement, transparency, stakeholder participation, institutional accountability, and appropriate incentives can facilitate adherence to regulatory requirements, whereas weak enforcement and continued reliance on informal collection, recycling, or disposal channels may undermine regulatory objectives (Boateng et al., 2026; Li et al., 2015). Behavioural responses are particularly significant because regulatory objectives ultimately depend on stakeholders adopting practices consistent with responsible collection, reuse, recycling, and resource recovery (Parajuly et al., 2020). These findings provide a conceptual basis for proposing regulatory compliance as a

potential mediating mechanism in the conceptual framework. Environmental legal framework effectiveness represents the legal and institutional conditions within which compliance may occur, while regulatory compliance reflects the behavioural and operational responses of regulated actors to those requirements.

Third, the review reveals an emerging but still insufficiently developed relationship between e-waste regulation and climate governance. E-waste regulation has traditionally concentrated on hazardous-waste control, pollution prevention, recycling, resource recovery, and environmentally sound disposal. More recent scholarship, however, increasingly situates e-waste within broader sustainability and climate debates, particularly through circular economy strategies, resource efficiency, material recovery, climate-responsive EPR, and sustainable recycling (Mdoe et al., 2026; Shaker et al., 2026; Usha Amulya et al., 2026). Practices such as reuse, repair, recycling, eco-design, and material recovery provide potential pathways through which responsible e-waste management may reduce resource pressures and become more closely aligned with climate-related objectives. At the same time, the literature indicates that the integration of e-waste regulation and climate governance remains fragmented (Mdoe et al., 2026). This finding is particularly relevant to the present study because it suggests that the contribution of e-waste regulation to climate governance should be considered not only in relation to regulatory design itself but also through the practices that emerge when regulated stakeholders comply with environmental requirements.

Taken together, the six themes provide the analytical foundation for the theoretical and conceptual framework developed in this study. The synthesis suggests a proposed explanatory pathway in which environmental legal framework effectiveness may establish the legal and institutional conditions for regulatory compliance; compliance may be reflected in responsible e-waste-management practices, such as formal collection, environmentally sound treatment and recycling, fulfilment of EPR obligations, material recovery, and reduced informal processing; and these practices may, in turn, contribute to greater alignment between e-waste management and climate-governance objectives. Within this pathway, responsible e-waste management is not treated as a separate construct but as a practical manifestation of regulatory compliance. The synthesis also provides a conceptual basis for examining a potential direct relationship between environmental legal framework effectiveness and climate governance and a proposed indirect relationship through regulatory compliance. These relationships are conceptual rather than empirically established and therefore require future empirical testing. Accordingly, the narrative review informs four theoretically relevant relationships: environmental legal framework effectiveness and climate governance; environmental legal framework effectiveness and regulatory compliance; regulatory compliance and climate governance; and the proposed mediating role of regulatory compliance in the relationship between environmental legal framework effectiveness and climate governance. These relationships provide the foundation for the theoretical framework and proposition development presented in the subsequent parts of the paper.

Development of the Theoretical Framework

The results of the narrative review indicate a significant regulatory challenge: extensive e-waste legislation does not necessarily result in effective implementation, and formal legal obligations are unlikely to achieve their intended objectives unless they influence the behaviour of regulated actors. The main theoretical basis for explaining this relationship is Responsive Regulation Theory developed by Ayres and Braithwaite (1992). The theory contends that

regulators ought to respond strategically to the conduct, motivations and compliance behaviour of regulated actors through a graduated combination of persuasion, cooperation, monitoring, incentives and increasingly stringent enforcement where necessary, rather than equating regulatory effectiveness with prescriptive rules and punitive enforcement alone (Ayres & Braithwaite, 1992; Braithwaite, 2011). This perspective is especially pertinent to environmental regulation because the effectiveness of law depends not only on the existence and strength of regulatory requirements but also on the ability of regulatory institutions to foster compliance and attain substantive regulatory goals. E-waste governance exemplifies this challenge in particular. It attracts a wide variety of stakeholders ranging from producers, importers, distributors, consumers, collectors and recyclers to waste-management operators and public authorities whose roles, capabilities and incentives to comply may vary significantly. Thus, Responsive Regulation Theory offers a useful lens through which to explain why seemingly comprehensive e-waste regulations can result in different outcomes depending on regulatory clarity, monitoring, enforcement credibility, institutional capacity, stakeholder engagement and the responses of regulated actors. This reasoning is in line with e-waste scholarship that finds that differences in legislation, implementation capacity, stakeholder participation and enforcement continue to shape regulatory outcomes even where formal legal structures are comparatively well developed (Boateng et al., 2026; Li et al., 2015; Patil & Ramakrishna, 2020).

In the current research, Responsive Regulation Theory offers a theoretical foundation for explaining the proposed relationship between environmental legal framework effectiveness and regulatory compliance. Environmental legal framework effectiveness is the capacity of the regulatory and institutional system to establish clear and coherent obligations, assign responsibilities, support monitoring and enforcement, coordinate responsible institutions, and provide credible regulatory responses. Regulatory compliance, in turn, is how regulated actors respond in their behaviour and operational practices to those legal and institutional arrangements. From a responsive-regulation perspective, compliance is more likely to be sustained if regulatory systems combine clear obligations and credible enforcement with strategies that encourage cooperation, accountability, participation and behavioural adaptation rather than relying exclusively on punitive sanctions (Ayres & Braithwaite, 1992; Braithwaite, 2011). Such responses could be reflected in e-waste governance through meeting collection and recycling needs, EPR obligations, environmentally appropriate treatment, formal waste-management routes, responsible producer conduct and resource recovery requirements. The present study applies this rationale of regulation to climate governance by joining Responsive Regulation Theory with the nascent literature on the e-waste and climate nexus. With waste and climate governance increasingly intertwined, the framework proposes an explanatory pathway in which effective legal and institutional arrangements may encourage regulatory compliance, while compliance may be reflected in responsible e-waste-management practices such as formal collection and recycling, environmentally sound treatment, fulfilment of EPR obligations, material recovery, resource efficiency, and reduced informal processing. These practices may, in turn, contribute to greater alignment between e-waste governance and broader climate objectives (Mdoe et al., 2026; O'Neill, 2019; Shaker et al., 2026). Responsible e-waste management is therefore understood within the framework as a practical manifestation of regulatory compliance rather than as a separate construct. On this basis, the framework proposes a theoretically plausible indirect pathway through which environmental legal framework effectiveness may contribute to climate governance via regulatory compliance, while also recognising a potential direct relationship between environmental legal framework effectiveness and climate governance. Regulatory compliance is consequently conceptualised

as a potential mediating mechanism. These proposed relationships are theoretical and remain subject to future empirical testing.

Integrating responsive regulation theory with e-waste, circular economy, and climate governance scholarship extends the explanatory application of the theory beyond its conventional focus on regulator-regulated interactions and compliance behaviour. The theoretical novelty of the proposed framework lies in extending responsive-regulation reasoning beyond explaining how regulatory strategies may shape compliance to considering how compliant e-waste practices may, in turn, contribute to broader climate-governance objectives. The e-waste context makes this extension particularly relevant because compliance with requirements relating to formal collection, environmentally sound recycling, EPR, material recovery, and reduced informal processing may have implications beyond immediate regulatory adherence. Such practices may also support resource efficiency, circular material use, and greater alignment between waste-management practices and climate-related objectives. The e-waste–climate nexus therefore provides a context in which responsive-regulation processes can be considered not only in terms of whether they encourage compliance, but also in terms of how the resulting compliant practices may contribute to broader climate governance. In this way, the study extends the application of Responsive Regulation Theory from explaining regulatory responses and compliance behaviour to considering the wider governance implications that may arise from compliant environmental practices. It proposes that the contribution of environmental law to climate governance cannot be understood solely by examining whether e-waste legislation exists or how stringent it appears on paper. It is equally important to consider whether regulatory arrangements can elicit compliance and whether the practices associated with such compliance become aligned with climate-responsive forms of resource governance. In this respect, the framework responds to the fragmentation identified across e-waste regulation, regulatory implementation, circular economy strategies, and climate policy (Mdoe et al., 2026; O'Neill, 2019; Shaker et al., 2026). From a practical perspective, this reasoning suggests that strengthening the contribution of e-waste regulation to climate action requires more than legislative reform. Policymakers and regulators should also consider enforcement capacity, monitoring and traceability, institutional coordination, stakeholder participation, producer accountability, and incentives that encourage compliant and circular practices. Responsive and graduated regulatory strategies may further enable the adaptation of interventions to variations in stakeholder behaviour, capacity, and willingness to comply.

Responsive Regulation Theory thus provides the theoretical basis for explaining how effective regulatory arrangements may shape regulatory compliance, while the proposed framework extends this regulatory logic by considering how compliance may provide a pathway towards broader climate-governance objectives. This theoretical extension provides the foundation for the proposed conceptual framework and the propositions developed in the following part of the paper.

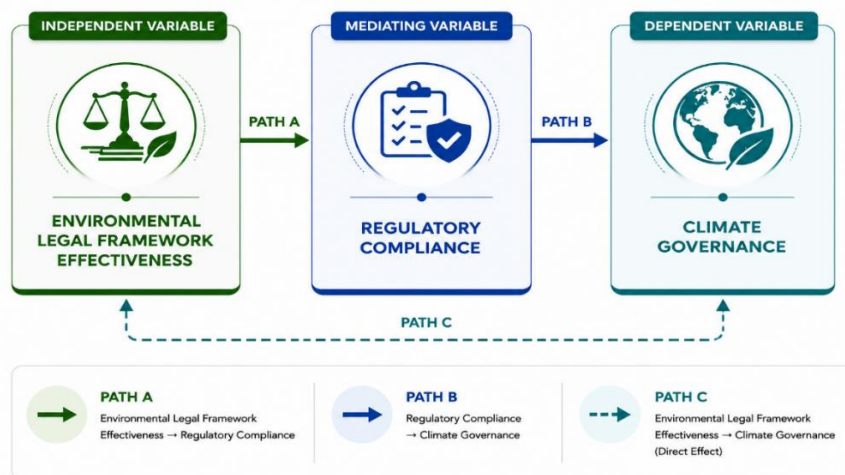


Figure 1. Proposed Theoretical and Conceptual Framework

Figure Note. The proposed framework conceptualises environmental legal framework effectiveness as the independent variable, regulatory compliance as the mediating variable, and climate governance as the dependent variable. Grounded in Responsive Regulation Theory (Ayres & Braithwaite, 1992), Path A represents the proposed relationship between environmental legal framework effectiveness and regulatory compliance, while Path B represents the proposed relationship between regulatory compliance and climate governance. Path C represents the proposed direct relationship between environmental legal framework effectiveness and climate governance. Together, Paths A and B constitute the proposed indirect pathway through which environmental legal framework effectiveness may influence climate governance via regulatory compliance. Accordingly, regulatory compliance is proposed to mediate the relationship between environmental legal framework effectiveness and climate governance. The proposed mediating relationship is theoretical and remains subject to future empirical testing.

Proposition Development

Drawing on responsive regulation theory and the findings of the narrative review, the proposed framework develops four propositions concerning the relationships among environmental legal framework effectiveness, regulatory compliance, and climate governance. Collectively, these propositions reflect a proposed explanatory pathway in which effective legal and institutional arrangements may encourage regulatory compliance, while compliance may be reflected in responsible e-waste management practices that may, in turn, contribute to stronger climate governance. Within this pathway, responsible e-waste management represents the practical manifestation of regulatory compliance rather than a separate construct. The framework considers both a potential direct relationship between environmental legal framework effectiveness and climate governance and a proposed indirect pathway through regulatory compliance. These conceptual relationships, depicted in Figure 1, are theoretically derived and remain subject to future empirical testing.

Environmental Legal Framework Effectiveness and Climate Governance

Environmental Legal Framework Effectiveness is expected to contribute directly to climate governance by establishing the legal and institutional conditions through which e-waste

management can become more closely aligned with environmental and climate objectives. Legal effectiveness extends beyond the formal existence or comprehensiveness of legislation. It also concerns the capacity of regulatory arrangements to establish clear obligations, allocate responsibilities, coordinate institutions, monitor regulated activities, and provide credible enforcement. Comparative research indicates that differences in regulatory design, institutional capacity, implementation, and enforcement can shape e-waste-management outcomes across jurisdictions (Boateng et al., 2026; Li et al., 2015; Patil & Ramakrishna, 2020). Responsive regulation theory reinforces this reasoning by emphasising that regulatory effectiveness depends on how regulatory institutions respond to the conduct of regulated actors, rather than on formal legal rules or punitive sanctions alone (Ayres & Braithwaite, 1992; Braithwaite, 2011).

The relevance of legal effectiveness to climate governance becomes more apparent as e-waste regulation increasingly intersects with climate-related concerns. Effective regulatory frameworks can establish conditions that support environmentally sound treatment, resource recovery, producer responsibility, circular material flows, and reduced reliance on environmentally harmful disposal practices. These regulatory arrangements can also provide a basis for incorporating resource efficiency, circularity, and other climate-related considerations into e-waste governance (Mdoe et al., 2026; O'Neill, 2019; Shaker et al., 2026). Although the literature indicates that the integration of e-waste and climate policy remains fragmented, stronger legal and institutional arrangements may facilitate the incorporation of climate considerations into regulatory design and governance. Environmental Legal Framework Effectiveness is therefore expected to have a direct relationship with climate governance, alongside any additional influence transmitted through regulatory compliance. Accordingly, the following proposition is advanced:

P1: Environmental Legal Framework Effectiveness positively influences Climate Governance.

Environmental Legal Framework Effectiveness and Regulatory Compliance

Environmental Legal Framework Effectiveness is also expected to influence the extent to which regulated stakeholders comply with e-waste obligations. Formal legislation alone cannot secure compliance where regulatory requirements are unclear, monitoring is inadequate, enforcement is inconsistent, institutional responsibilities are fragmented, or non-compliance carries limited consequences. This issue is particularly important in e-waste governance because implementation depends on the behaviour of multiple actors, including producers, importers, consumers, collectors, recyclers, waste-management operators, and regulatory authorities. Existing research indicates that regulatory implementation is shaped by enforcement capacity, technical capability, stakeholder participation, collection infrastructure, and institutional coordination (Boateng et al., 2026; Li et al., 2015; Patil & Ramakrishna, 2020). Legal effectiveness should therefore be understood not simply in terms of legislative comprehensiveness but also in terms of the capacity of the regulatory system to encourage and secure adherence to environmental obligations.

Responsive regulation theory provides the clearest theoretical basis for this relationship. Rather than assuming that compliance results solely from deterrence or punitive sanctions, the theory proposes that regulators respond to the conduct and motivations of regulated actors through a graduated combination of persuasion, cooperation, monitoring, incentives, accountability, and

progressively stronger enforcement where necessary (Ayes & Braithwaite, 1992; Braithwaite, 2011). Applied to e-waste governance, an effective legal framework should create conditions conducive to compliance by clarifying responsibilities, strengthening regulatory oversight, improving accountability, and providing credible and proportionate responses to non-compliance. Such arrangements may encourage stakeholders to participate in formal collection systems, comply with recycling and treatment requirements, fulfil producer-responsibility obligations, and avoid informal or environmentally harmful practices. Environmental Legal Framework Effectiveness is therefore expected to strengthen regulatory compliance by creating a regulatory environment in which legal obligations are both clearly communicated and credibly implemented. Accordingly, the following proposition is advanced:

P2: Environmental Legal Framework Effectiveness positively influences Regulatory Compliance.

Regulatory Compliance and Climate Governance

Regulatory compliance reflects the behavioural and operational responses of regulated stakeholders to environmental legal duties and requirements. Legislation establishes what is expected or required from regulated stakeholders, while compliance concerns the extent to which these requirements are reflected in their conduct and operational practices. In the e-waste context, compliant practices may include participation in formal collection and recycling systems, adherence to environmentally sound treatment requirements, fulfilment of EPR obligations, responsible handling and disposal, increased material recovery, and reduced reliance on informal processing. Stakeholder behaviour is therefore important to the achievement of regulatory objectives, particularly because e-waste governance requires coordinated engagement across multiple stages of the product and waste-management chain (Boateng et al., 2026; Li et al., 2015; Parajuly et al., 2020).

Where compliant practices contribute to resource efficiency, circularity, and climate-responsive environmental management, the significance of compliance extends beyond traditional waste management objectives. Adherence to requirements relating to reuse, recycling, recovery, eco-design, producer responsibility, and environmentally sound treatment may support more circular patterns of resource use and reduce environmentally harmful e-waste-management practices. These practices are increasingly recognised in emerging literature as important areas of convergence between e-waste governance and climate action, although their integration into climate policy remains underdeveloped (Mdoe et al., 2026; Shaker et al., 2026). Regulatory compliance may therefore be conceptualised not merely as an immediate legal outcome but as an operational pathway through which responsible e-waste-management practices may become more closely aligned with broader climate objectives. Accordingly, the following proposition is advanced:

P3: Regulatory compliance positively influences climate governance.

The Mediating Role of Regulatory Compliance

The relationships proposed above provide the conceptual basis for considering regulatory compliance as a potential mediating mechanism between environmental legal framework effectiveness and climate governance. This proposed mediating relationship addresses a central conceptual question in the study: how might effective legal and institutional arrangements

contribute to broader climate-responsive governance through the compliance responses of regulated actors? Environmental laws establish obligations, institutional responsibilities, monitoring arrangements, and enforcement mechanisms, but their wider contribution depends in part on whether regulated actors respond with compliant behaviour. Responsive Regulation Theory provides the theoretical foundation for the first stage of this proposed mechanism by explaining how appropriately designed and implemented regulatory strategies may shape stakeholder behaviour through cooperation, monitoring, accountability, incentives, and proportionate enforcement (Ayres & Braithwaite, 1992; Braithwaite, 2011). Regulatory compliance consequently provides a theoretically plausible mechanism through which the legal and institutional capacity represented by environmental legal framework effectiveness may be reflected in operational e-waste-management practices.

Within the proposed framework, environmental legal framework effectiveness is expected to create regulatory conditions conducive to compliance, while compliance may be reflected in responsible e-waste-management practices that may support climate-responsive governance. Effective legal arrangements may, for example, strengthen adherence to formal collection, recycling, treatment, EPR, resource recovery, and monitoring requirements. When reflected in stakeholder behaviour, these practices may encourage circular resource use, reduce informal and environmentally harmful e-waste management, strengthen accountability, and improve the alignment of e-waste governance with climate-related objectives (Mdoe et al., 2026; Shaker et al., 2026). The framework therefore proposes that part of the relationship between environmental legal framework effectiveness and climate governance may operate through regulatory compliance. This proposed indirect pathway complements the direct relationship suggested in P1 rather than replacing it, thereby conceptualising regulatory compliance as a potential mediating mechanism through which legal effectiveness may be associated with broader climate governance outcomes. This mediating relationship is theoretically proposed and remains subject to future empirical testing. Accordingly, the following proposition is advanced:

P4: Regulatory compliance is proposed to mediate the relationship between environmental legal framework effectiveness and climate governance.

Conclusion

This conceptual paper examined how environmental legal framework effectiveness may contribute to climate governance in the context of e-waste regulation, with regulatory compliance proposed as a potential mediating mechanism. Drawing on an integrative synthesis of literature on environmental regulation, e-waste governance, regulatory compliance, circular economy practices, and climate-responsive waste management, the study argues that the existence of environmental legislation alone is insufficient to achieve meaningful governance outcomes. Rather, the synthesis suggests that legal frameworks may be better positioned to contribute to climate governance where regulatory obligations are clear and enforceable, institutional responsibilities are adequately coordinated, and implementation is supported by credible monitoring and enforcement mechanisms. Within the proposed explanatory pathway, effective legal and institutional arrangements may encourage regulatory compliance, which may be reflected in responsible e-waste-management practices, including formal collection and recycling, resource recovery, traceability, fulfilment of EPR obligations, and environmentally sound treatment. These practices may, in turn, contribute to greater alignment between e-waste governance and broader climate objectives.

The principal theoretical contribution of this study lies in integrating environmental legal framework effectiveness, regulatory compliance, and climate governance within a single conceptual framework. Drawing primarily on responsive regulation theory, the framework explains how regulatory effectiveness may shape stakeholder behaviour through a combination of regulatory clarity, institutional capacity, monitoring, cooperation, accountability, and graduated enforcement. The theoretical novelty lies in extending the explanatory application of Responsive Regulation Theory beyond its conventional focus on regulatory responses and compliance behaviour to consider the broader climate governance implications of compliant e-waste practices. Regulatory compliance is therefore conceptualised not merely as a potential outcome of effective regulation but as a potential mediating mechanism through which effective environmental legal frameworks may contribute to broader climate governance objectives. At the same time, the framework recognises a potential direct relationship between legal effectiveness and climate governance where regulatory systems incorporate climate-related considerations through mechanisms such as extended producer responsibility, reporting and traceability requirements, circular-economy measures, resource-efficiency standards, and inter-agency coordination. The framework consequently extends regulatory analysis beyond the question of whether environmental laws exist to an examination of how effective regulatory arrangements may encourage compliant practices and how such practices may become aligned with climate-responsive governance.

From a policy perspective, the proposed framework suggests that strengthening the contribution of e-waste regulation to climate action requires greater attention to the implementation conditions that may encourage and sustain regulatory compliance. Policymakers should therefore complement legislative development with adequate institutional capacity, consistent enforcement, effective monitoring and reporting systems, transparent material-flow tracking, stakeholder engagement, and stronger coordination among regulatory authorities, producers, recyclers, consumers, and other actors within the e-waste value chain. Integrating e-waste regulation with extended producer responsibility, circular-economy strategies, resource recovery, and climate-policy objectives should also receive particular attention. Closer integration across these areas may enable e-waste governance to move beyond a predominantly pollution-control and waste-management function towards a more climate-responsive governance approach, in which compliant practices may support resource conservation, reduced dependence on primary material extraction, improved recycling practices, and progress towards low-carbon and circular development.

Nevertheless, the proposed relationships remain theoretical and require future empirical testing. The narrative review approach and reliance primarily on Scopus also mean that the synthesis may not capture all relevant legal, policy, and interdisciplinary scholarship across jurisdictions. Subsequent research should empirically investigate the suggested direct and mediated relationships, as well as formulate suitable metrics for the multidimensional constructs of environmental legal framework effectiveness, regulatory compliance, and climate governance. Comparative studies across jurisdictions with different regulatory capacities, enforcement systems, extended producer responsibility arrangements, and levels of e-waste formalisation would be particularly valuable in determining the contextual conditions under which the proposed relationships may be strengthened or weakened. Future studies could also examine additional mediating or moderating factors, including institutional capacity, technological traceability, stakeholder participation, enforcement credibility, and informal-sector integration. Such research would enable the proposed framework to be empirically assessed and further clarify the conditions under which effective e-waste regulation, regulatory

compliance, and responsible e-waste practices may contribute to broader climate-governance objectives.

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