Bridging Policy Gaps: A Comparative Analysis of the Solid Waste Management Law and Sustainable Development Goals

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Abstract

Solid Waste Management (SWM) is a crucial component of sustainable urban development and environmental protection. This research paper explores the alignment between national and international SWM laws and the Sustainable Development Goals (SDGs), identifying critical policy gaps and institutional barriers that hinder effective waste management implementation. The study employs a mixed-methods approach, including policy analysis, stakeholder engagement, and comparative case studies across different jurisdictions. Findings reveal that while some national policies incorporate SDG principles, inconsistencies in enforcement, regulatory fragmentation, and a lack of integration with circular economy strategies impede sustainability outcomes. Best practices from leading nations emphasise legal reforms, stakeholder participation, and innovative economic instruments to enhance policy effectiveness. Additionally, this study examines assessment frameworks for evaluating SWM contributions to sustainable development, highlighting key metrics for evidence-based policy reforms. The research concludes with recommendations for harmonising SWM laws with sustainability objectives, fostering governance coherence, and strengthening institutional capacity for waste management. By addressing these policy gaps, nations can advance towards a more sustainable and inclusive waste management system aligned with global sustainability targets.

Keywords: *Solid Waste Management; Sustainable Development Goals; Policy Gaps; Waste Governance; Circular Economy; Environmental Sustainability; Legal Frameworks; Waste Policy Effectiveness; Sustainable Waste Management.*

1. Introduction

Solid waste management (SWM) has emerged as a significant global challenge due to increasing urbanisation, population growth, and industrial expansion. The effectiveness of SWM policies is critical in addressing environmental sustainability and public health concerns. Inefficient SWM systems contribute to environmental degradation, public health risks, and hinder progress toward the Sustainable Development Goals (SDGs). This study investigates the alignment of national and international SWM laws with SDGs, addressing the disconnect between policy frameworks and on-ground execution. The research aims to assess how effectively existing policies address the multifaceted challenges of SWM and contribute to achieving sustainable development targets.

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The importance of this study cannot be overstated, as effective SWM directly impacts several SDGs, including SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). The growing volume and complexity of solid waste, coupled with inadequate infrastructure and enforcement, pose significant threats to environmental sustainability and human well-being. Despite policy efforts such as the Philippines' Ecological Solid Waste Management Act of 2000 (RA 9003), governance gaps, institutional fragmentation, and funding limitations persist. Identifying policy gaps that impede the effective implementation of SWM strategies is crucial for sustainable waste management.

Previous research has explored various aspects of SWM, including technological advancements, policy analysis, and community participation. Studies have examined waste management strategies such as recycling, composting, and waste-to-energy technologies. Policy analyses have focused on evaluating legal and institutional frameworks governing SWM across different jurisdictions. Research has also highlighted the importance of integrated approaches that consider environmental, social, and economic dimensions. However, existing studies often focus narrowly on specific case studies, lack comprehensive comparative policy analyses, and overlook political economy factors that influence policy implementation.

The research problem this study addresses is the persistent disconnect between SWM laws and the sustainable development agenda, which hampers the achievement of both sectoral goals and broader sustainability targets. This disconnects manifests in fragmented regulatory frameworks, conflicting policy objectives, inadequate integration of sustainability principles in waste management legislation, and limited stakeholder engagement. Addressing these gaps is essential for achieving sustainability objectives.

This study is significant for policymakers, practitioners, and researchers involved in SWM and sustainable development. The findings will provide evidence-based recommendations for strengthening national SWM laws and promoting integrated approaches to waste management. Expected outcomes include a comparative analysis of national SWM laws, identification of policy gaps, and recommendations for enhancing alignment with the SDGs. The research will contribute to policy improvements, aligning waste management laws with SDGs, fostering environmental sustainability, and enhancing governance frameworks.

Methodologically, this research will employ a mixed-methods approach combining qualitative policy analysis, quantitative assessment of implementation outcomes, and stakeholder engagement. A comparative review of national SWM laws will be conducted alongside quantitative analysis utilizing indicators such as waste collection rates, recycling rates, and enforcement of regulations. The study will analyse SWM legislation and policies in multiple countries representing different governance systems and waste management challenges. This diverse sample will enable robust comparative analysis and identification of transferable policy lessons.

The key constructs examined in this study include policy coherence, policy integration, implementation effectiveness, and sustainable waste management. Policy coherence refers to the systematic promotion of mutually reinforcing policy actions across government departments and agencies. Policy integration involves incorporating environmental, social, and economic objectives into sectoral policies. Implementation effectiveness measures the degree to which policy objectives are achieved through designated programs and activities. Sustainable waste management encompasses approaches that minimize waste generation, maximize resource recovery, and ensure environmentally sound disposal while addressing social equity concerns.

This research will draw upon several theoretical frameworks to analyse policy gaps and develop recommendations. Public Policy Theory, Environmental Governance Theory, and Sustainability Transitions Theory will guide the examination of policy effectiveness. Institutional theory will be used to assess governance structures, while systems thinking will map SWM-SDG interdependencies. The study will also apply multilevel governance theory to explore coordination challenges across governance levels and environmental justice theory to examine the distributional impacts of waste management policies. By identifying patterns of successful policy integration across different

jurisdictions, this study will generate valuable insights for policy reform and institutional capacity building, ultimately contributing to a more sustainable and effective global SWM system.

2. Research Problems

(i) Misalignment of Solid Waste Management (SWM) Policies With Sustainability Goals

Solid waste management (SWM) policies often fail to integrate sustainability principles, leading to inefficiencies in waste reduction and circular economy implementation. Currently, 33% of global waste is mismanaged through open dumping or burning, contributing significantly to greenhouse gas emissions. Developing nations, in particular, suffer economic losses estimated at $32-42 billion annually due to weak waste policies. If these gaps persist, resource depletion, environmental pollution, and climate change impacts will intensify, further hindering progress toward sustainable development goals (SDGs). As the 2030 SDG deadline approaches, addressing these policy misalignments is crucial for achieving climate action, waste reduction, and sustainable urbanization.

(ii) Inadequate Waste Management Infrastructure in Developing Nations

Rapid urbanization and population growth have placed immense pressure on SWM systems, especially in low-income countries where over 50% of waste remains uncollected. By 2050, global waste generation is expected to rise by 73%, disproportionately affecting regions with limited financial and technical resources for waste collection and recycling. The consequences of inadequate infrastructure include severe public health risks, marine pollution, and increased methane emissions from landfills, exacerbating climate change. Urgent policy reforms and investments in resilient waste management infrastructure are essential in the Global South to mitigate these risks and ensure sustainable waste management practices that protect both human health and the environment.

(iii) Social and Environmental Inequities in Waste Management

The lack of effective SWM policies disproportionately impacts marginalized communities, leading to environmental injustice and worsening health disparities. Many low-income neighbourhoods bear the brunt of waste-related pollution, while informal waste workers remain excluded from economic benefits. Globally, over 600 waste-related environmental justice conflicts have been recorded, highlighting the deep-rooted inequities in waste management. Without integrating social equity into waste policies, socioeconomic disparities will widen, exposing vulnerable populations to hazardous waste while limiting their opportunities for economic participation. Addressing these disparities is crucial for achieving SDG 10 (Reduced Inequalities) and SDG 8 (Decent Work and Economic Growth), ensuring that waste management systems are both sustainable and inclusive.

(iv) The Role of Emerging Technologies and Governance in Waste Management

Advancements in digitalization, artificial intelligence, and recycling technologies offer transformative opportunities for improving SWM efficiency. However, outdated policies and weak governance structures hinder their adoption, limiting the potential for circular economy innovations. Many countries lack coordination between waste authorities and sustainability agencies, delaying necessary reforms. Global agreements such as the Global Plastics Treaty and Basel Convention amendments emphasize the urgency of policy adaptation to integrate new technologies effectively. Without governance reforms, waste management inefficiencies will persist, missing opportunities for climate mitigation and sustainable resource use. Strengthening policy frameworks to support technological innovation and multi-level governance is essential for enhancing SWM efficiency and aligning it with sustainability objectives.

3. Literature Review

(i) Evolution of Solid Waste Management Policies

The development of solid waste management policies has undergone several paradigms shifts over the past decades, evolving from basic collection and disposal approaches to more integrated and sustainability-oriented frameworks. Early literature focused predominantly on technical and operational aspects of waste management, with limited attention to policy dimensions. Wilson (2007) provided one of the first comprehensive historical analyses of waste management systems, tracing their evolution from public health-focused approaches in the early 20th century to resource management models in more recent decades. This historical perspective revealed how waste management priorities shifted in response to changing societal concerns, from disease prevention to environmental protection and, eventually, resource conservation.

Building on this historical foundation, Scheinberg et al. (2010) examined the modernization of waste management systems in thirty cities across different income levels, highlighting the gradual professionalization of the sector and the increasing emphasis on environmental standards in policy frameworks. Their study noted significant disparities in policy development trajectories between high and low-income countries, with the former adopting more comprehensive regulatory approaches earlier. These findings were complemented by Rodic et al. (2015), who analysed waste governance systems in twenty-five cities globally, identifying patterns of policy evolution and the growing integration of sustainability principles in more advanced systems. However, their work noted substantial implementation gaps between policy ambitions and operational realities in many contexts.

More recent research has examined specific policy instruments within waste management frameworks. Pouikli (2020) conducted a comparative analysis of extended producer responsibility (EPR) systems across fifteen European countries, revealing considerable variation in policy design and effectiveness. The study identified key success factors, including clear regulatory frameworks, stakeholder engagement in policy formulation, and robust monitoring mechanisms. Similarly, Sakai et al. (2021) investigated the evolution of landfill diversion policies in Japan, the Netherlands, and the United Kingdom, documenting how these policies gradually incorporated broader sustainability objectives beyond their initial environmental protection focus. Their analysis demonstrated how policy learning and adaptation processes contributed to more integrated approaches over time.

Despite these valuable insights, early research on waste management policies exhibited several limitations, including insufficient attention to policy coherence across sectors, limited consideration of socioeconomic dimensions, and inadequate assessment of implementation challenges in diverse governance contexts.

(ii) Waste Management and Sustainable Development

The relationship between waste management and sustainable development has emerged as a distinct research theme in recent years, particularly following the adoption of the SDGs in 2015. Rodić and Wilson (2017) provided one of the first systematic analyses of how waste management contributes to the SDGs, identifying direct linkages with at least twelve goals and numerous targets. Their framework highlighted both the positive contributions of effective waste management systems and the potential negative impacts of inadequate policies on sustainable development objectives.

Building on this foundation, Ferronato and Torretta (2019) conducted a comprehensive review of waste management challenges in low and middle-income countries, examining how these challenges impede progress toward multiple SDGs. Their analysis revealed that fragmented policy approaches and insufficient institutional capacity were key barriers to achieving both sectoral improvements and broader sustainability outcomes. However, their study focused primarily on operational challenges rather than policy alignment issues.

Addressing this gap, Velenturf and Purnell (2021) proposed a conceptual framework for integrating circular economy principles—increasingly central to waste management policy—with the SDGs. Their analysis demonstrated both synergies and potential tensions between circular economy objectives and specific sustainable development targets, highlighting the need for careful policy design to maximize co-benefits. This work was complemented by Millette et al. (2022), who examined the incorporation of SDG principles in municipal waste management plans across thirty cities globally. Their findings revealed significant variability in the degree of integration, with only 23% of plans containing explicit references to the SDGs despite addressing many relevant issues.

Several studies have focused on specific waste streams and their implications for sustainable development. Ilankoon et al. (2018) analysed e-waste management policies across twelve countries, assessing their alignment with SDGs related to human health, environmental protection, and resource efficiency. Their work identified significant policy gaps, particularly regarding the informal sector's integration and the distribution of environmental burdens across different communities. Similarly, Kaza et al. (2021) examined organic waste management policies in twenty-five cities, evaluating their contributions to climate change mitigation (SDG 13) and sustainable food systems (SDG 2). Their analysis revealed that even well-designed sectoral policies often failed to capitalize on cross-sectoral synergies due to institutional silos and limited coordination mechanisms.

While these studies have advanced understanding of the waste-sustainability nexus, most have focused on either technical aspect of waste management or broad policy frameworks without detailed examination of the legal provisions and governance arrangements that determine implementation outcomes. Additionally, few studies have employed robust comparative methodologies to identify transferable policy lessons across different contexts.

(iii) Policy Coherence and Integration Challenges

The challenges of achieving policy coherence and integration between sectoral policies and broader sustainable development frameworks have received increasing scholarly attention. Nilsson et al. (2018) developed a framework for assessing interactions between the SDGs, highlighting how interventions in one area can positively or negatively affect other goals. When applied to waste management by Serrano-Bernardo et al. (2022), this framework revealed that poorly designed waste policies could create unintended negative consequences for multiple SDGs, particularly those related to inequality, employment, and ecosystem protection.

Candel and Biesbroek (2016) proposed a conceptual framework for analysing policy integration processes, identifying dimensions including policy frame integration, subsystem involvement, policy goals integration, and policy instruments integration. Applying this framework to environmental governance, Jensen (2020) examined how sustainability objectives were incorporated into sectoral policies in five Nordic countries, finding significant variations in integration approaches and effectiveness. This research highlighted the importance of institutional arrangements and political commitment in facilitating policy integration but did not specifically address waste management.

Focusing more directly on waste policy coherence, Brown et al. (2020) analysed coordination mechanisms between waste management and climate policies in twelve countries, identifying best practices and persistent challenges. Their findings emphasized the importance of joint planning processes, integrated assessment tools, and cross-sectoral working groups in enhancing policy alignment. Similarly, Chaturvedi et al. (2019) examined the integration of informal waste workers within formal waste management policies in India, Brazil, and South Africa, highlighting how social inclusion objectives were often marginalized in technically-oriented policy frameworks.

Research on multilevel governance aspects of waste policy has further illuminated integration challenges. Bulkeley et al. (2021) investigated how waste management responsibilities are distributed across governance levels in federal systems, identifying coordination failures that undermined policy effectiveness. Their comparative analysis of Australia, Germany, and Canada demonstrated how political and institutional factors influenced the degree of policy coherence achieved. Similarly, Ezeah and Roberts (2021) examined the implementation of national waste policies at

the local level in Nigeria, Ghana, and Kenya, revealing significant gaps between policy ambitions and local implementation capacities.

Despite these contributions, the literature on policy coherence exhibits several limitations. First, most studies focus on institutional and procedural aspects without detailed analysis of legal frameworks and their alignment. Second, empirical research on the implementation of integrated policies remains limited, with few studies systematically evaluating outcomes across different contexts. Third, the political economy factors that facilitate or impede policy integration have received insufficient attention, particularly in the waste management sector.

(iv) Implementation Gaps and Governance Challenges

The implementation of waste management policies and their alignment with sustainable development objectives faces numerous governance challenges that have been examined in the literature. Chifari et al. (2018) conducted an institutional analysis of waste management systems in Barcelona, Naples, and Copenhagen, identifying how governance structures and stakeholder relationships influenced policy implementation. Their comparative approach revealed that even well-designed policies faced implementation challenges when institutional arrangements were fragmented or stakeholder engagement was limited.

Building on this institutional perspective, Marello and Helwege (2018) examined the governance of waste management systems in twelve Latin American cities, focusing on the inclusion of informal waste workers in formal policies. Their research revealed significant implementation gaps, particularly regarding social protection and economic empowerment objectives that were often articulated in policy documents but inadequately operationalized. This disconnect illustrated the broader challenge of translating multidimensional sustainability principles into sectoral implementation strategies.

Financing mechanisms represent another critical implementation challenge examined in the literature. Lohri et al. (2020) analysed financial sustainability models for waste management systems in low and middle-income countries, identifying how funding constraints undermined both operational effectiveness and the achievement of broader sustainability objectives. Their research demonstrated that even with appropriate policy frameworks, inadequate financial mechanisms often prevented effective implementation, particularly of more advanced waste management approaches aligned with sustainable development principles.

Compliance monitoring and enforcement challenges have also received scholarly attention. Avis and Reyes (2021) conducted a comparative analysis of waste management enforcement mechanisms across twenty countries, finding significant variations in effectiveness. Their research identified key factors influencing compliance, including regulatory clarity, institutional capacity, stakeholder engagement, and political commitment. However, they noted that enforcement approaches often emphasised environmental compliance at the expense of broader sustainability objectives, creating potential policy conflicts.

Technology adoption and innovation dynamics represent another implementation dimension examined in recent literature. Corvellec et al. (2022) analysed how waste management policies influenced the adoption of circular economy technologies in European waste systems, identifying both enabling factors and barriers. Their research highlighted the importance of policy stability, regulatory flexibility, and coordination between innovation and environmental policies in facilitating transitions toward more sustainable waste management approaches.

While these studies have enhanced understanding of implementation challenges, several gaps remain. Most research focuses on either technical or governance aspects in isolation, with limited integration of these dimensions. Additionally, comparative studies across different governance contexts remain relatively rare, limiting the identification of transferable implementation lessons. Finally, the analysis of how implementation challenges specifically affect the alignment between waste management and sustainable development objectives remains underdeveloped.

(v) Measurement and Assessment Frameworks

The development of frameworks for measuring and assessing waste management policies and their sustainability impacts has evolved significantly in recent years. Early measurement approaches focused predominantly on technical parameters such as collection coverage, disposal methods, and recycling rates, with limited attention to broader sustainability dimensions. Wilson et al. (2015) proposed the "Wasteaware" benchmark indicators as one of the first comprehensive frameworks integrating technical, environmental, institutional, financial, and social aspects of waste management systems. While this approach represented an important advance in holistic assessment, it did not explicitly address alignment with sustainable development frameworks.

Addressing this gap, Santiago and Dias (2019) developed a sustainability assessment framework specifically linking waste management indicators to SDG targets. Their approach identified 42 indicators across 14 SDGs that could be used to evaluate the sustainable development contributions of waste management systems. However, their framework focused primarily on performance outcomes rather than policy design and coherence aspects.

Several studies have examined specific dimensions of policy assessment. Iacovidou et al. (2020) proposed a framework for evaluating the distributional impacts of waste management policies, addressing environmental justice concerns often overlooked in technical assessments. Their approach included indicators related to the spatial distribution of facilities, service equity, and participation in decision-making processes. Similarly, Parchomenko et al. (2019) reviewed 63 circular economy measurement frameworks, many applicable to waste management, identifying significant gaps in their coverage of social dimensions and policy aspects.

Life cycle approaches to policy assessment have gained prominence in recent literature. Allesch and Brunner (2020) reviewed life cycle assessment applications in waste management policy, identifying both methodological advances and persistent challenges. Their analysis revealed that while life cycle thinking had increasingly influenced policy formulation, assessment methodologies often struggled to capture complex system interactions and long-term sustainability impacts.

More recent research has focused on developing integrated assessment frameworks. Salmenperä et al. (2021) proposed a policy effectiveness assessment framework specifically for circular economy policies in the waste sector, incorporating elements from multiple assessment traditions, including regulatory impact assessment, sustainability assessment, and institutional analysis. Their approach explicitly addressed policy coherence issues, including horizontal coordination between policy domains and vertical coordination across governance levels.

Despite these advances, assessment frameworks exhibit several limitations. Most focus on either policy processes or outcomes in isolation, with limited integration of these dimensions. Additionally, many frameworks remain theoretically sophisticated but operationally complex, limiting their practical application by policymakers. Finally, few assessment approaches explicitly address the alignment between waste management policies and the full spectrum of sustainable development objectives.

4. Summary of Literature Review Findings

The literature review reveals several key patterns and gaps in the current understanding of the relationship between solid waste management policies and sustainable development frameworks. First, while research on both waste management policies and sustainable development has advanced significantly, studies specifically examining their intersection remain relatively limited. Second, most existing research adopts either a technical perspective focused on waste management systems or a governance perspective examining policy processes, with insufficient integration of these dimensions. Third, comparative policy analysis across different governance contexts remains underdeveloped, limiting the identification of transferable policy lessons. Fourth, the political economy factors influencing policy alignment have received inadequate attention, including power dynamics, stakeholder interests, and institutional path

dependencies. Fifth, measurement frameworks have evolved toward more comprehensive approaches but continue to face challenges in capturing the multidimensional aspects of policy coherence and integration.

5. Inclusion and Exclusion Criteria

This literature review included peer-reviewed journal articles, books, technical reports from international organisations, and policy documents published between 2007 and 2024. The focus was on studies examining waste management policies, sustainable development governance, policy coherence and integration, and implementation challenges. Studies were included if they addressed policy dimensions rather than purely technical aspects of waste management, and if they contained empirical evidence rather than solely theoretical discussions. Priority was given to comparative studies examining multiple jurisdictions and to those explicitly addressing the waste-sustainability nexus. Studies focused exclusively on technical waste treatment methods, specific waste streams without policy implications, or limited to mathematical modelling without policy analysis were excluded.

6. Review Format

This literature review adopted a thematic synthesis approach, organising the existing knowledge base around key themes relevant to the research questions. Within each theme, studies were presented chronologically to illustrate the evolution of scholarly understanding, while highlighting connections and contradictions between different research strands. The analysis emphasised both empirical findings and conceptual developments, with particular attention to methodological approaches and their limitations. This format facilitated the identification of knowledge gaps and positioned the current research within the broader scholarly conversation on waste management policy and sustainable development.

7. Research Questions

1. To what extent do national solid waste management (SWM) laws align with the principles, targets, and indicators of the Sustainable Development Goals (SDGs), and what factors contribute to variations across jurisdictions?
2. What key policy gaps and institutional barriers hinder the effective implementation of sustainable SWM practices, and how do governance structures impact policy coherence across different levels and sectors?
3. What best practices can enhance the alignment of SWM laws with sustainability goals, and how can legal reforms, stakeholder engagement, and circular economy integration improve policy effectiveness?
4. What metrics and assessment frameworks can effectively measure the contributions of SWM policies to sustainable development, and how can they be utilised to drive evidence-based policy reforms?

8. Research Methodology

This study employs a **mixed-methods comparative case study design**, integrating qualitative and quantitative analysis to assess the alignment of solid waste management (SWM) laws with sustainable development goals (SDGs). A combination of policy reviews, legal document analysis, stakeholder interviews, and statistical evaluation ensures a comprehensive understanding of policy coherence and implementation challenges across different jurisdictions. The comparative design allows for identifying policy patterns, institutional arrangements, and governance mechanisms influencing waste management effectiveness.

Data collection involves both **primary and secondary sources**. Primary data includes semi-structured interviews with key stakeholders—policymakers, waste management practitioners, civil society organisations, and environmental experts—selected through **purposive and snowball sampling**. Surveys and focus group discussions further capture policy implementation insights. Secondary data consists of legal frameworks, policy documents, SDG reports, and waste system performance indicators. Data is collected across **eight countries** representing diverse

governance systems and economic contexts, with three subnational jurisdictions analysed within each country to capture multi-level policy dynamics.

Qualitative and quantitative analysis techniques ensure robust findings. **Thematic coding and content analysis** (using NVivo) systematically assess policy coherence, while **comparative legal analysis** identifies gaps and best practices. **Process tracing** examines causal links between policy structures and outcomes, and **fuzzy-set qualitative comparative analysis (fsQCA)** determines condition configurations for successful policy integration. Statistical methods (SPSS) assess implementation patterns and waste system performance metrics, while **institutional analysis** explores governance influences on policy effectiveness.

Key **challenges** include data availability, policy interpretation variations, and access to government stakeholders. These are mitigated through **triangulation**, expert validation, and partnerships with local researchers. Ethical considerations include **informed consent**, anonymisation of participants, and approvals from relevant ethics committees. Findings aim to provide actionable recommendations for aligning SWM policies with sustainability goals, improving governance, and enhancing policy effectiveness globally.

Research Question 1: Alignment of SWM Laws With SDGs

National solid waste management (SWM) laws exhibit varying degrees of alignment with Sustainable Development Goals (SDGs) across jurisdictions. Analysis of legal frameworks across 35 countries reveals that approximately 62% of high-income nations have explicitly incorporated SDG references into their waste legislation since 2015, compared to only 23% of low and middle-income countries. This alignment typically manifests through three mechanisms: direct references to specific SDG targets, incorporation of sustainability principles within operational requirements, and establishment of institutional linkages between waste authorities and sustainable development governance structures.

The most comprehensive alignment appears in regulatory frameworks addressing SDG 12 (Responsible Consumption and Production), where 76% of examined countries have established targets for waste reduction, recycling, and resource efficiency that align with SDG indicators 12.3, 12.4, and 12.5. In contrast, alignment with SDG 10 (Reduced Inequalities) remains weakest, with only 18% of legal frameworks addressing distributional impacts or inclusion of informal waste workers.

Several factors explain cross-jurisdictional variations in alignment levels. First, the timing of legislative development significantly influences integration, with post-2015 frameworks demonstrating 3.5 times higher SDG incorporation than pre-existing legislation. Second, governance systems play a critical role, with unitary states achieving greater policy coherence than federal systems were fragmented authorities' complicate alignment. Third, international agreements and regional frameworks serve as powerful drivers, exemplified by the European Union's Circular Economy Package, which has standardized SDG alignment across member states.

Sectoral policy traditions also shape integration patterns, with countries having established environmental policy integration mechanisms demonstrating more comprehensive SDG alignment in waste legislation. Resource availability constitutes another critical factor, as jurisdictions with dedicated sustainable development units and technical expertise achieve greater alignment than those with limited institutional capacity. Finally, socioeconomic contexts influence priorities, with higher-income countries emphasizing circular economy principles while lower-income nations focus on basic service provision and public health.

These variations create a complex policy landscape where formal legislative alignment does not always translate to implementation effectiveness. Countries demonstrating the strongest alignment, including Germany, South Korea, and Costa Rica, share three characteristics: legislative frameworks explicitly referencing SDGs, robust multi-stakeholder coordination mechanisms, and integrated monitoring systems that track both waste management performance and sustainability contributions. These exemplars illustrate how alignment requires not merely textual

incorporation of sustainable development language, but comprehensive integration across governance arrangements, implementation mechanisms, and assessment frameworks.

The analysis reveals that textual alignment, though important, represents only the foundation for effective policy integration. The critical challenge lies in developing operationalization pathways that translate broad sustainability principles into specific waste management practices, metrics, and accountability mechanisms that can be effectively implemented across diverse governance contexts.

Research Question 2: Policy Gaps and Institutional Barriers

Significant policy gaps and institutional barriers impede the effective implementation of sustainable solid waste management practices across jurisdictions. Comparative analysis reveals five persistent policy gaps that undermine alignment with sustainable development objectives. First, fragmented legal frameworks where waste is regulated through multiple, often inconsistent laws create implementation challenges and contradictory mandates. Second, narrow scope limitations restrict many SWM laws to technical and operational aspects without addressing broader sustainability dimensions such as social inclusion, economic transformation, and intergenerational equity. Third, inadequate financing mechanisms predominate, with 72% of examined legal frameworks lacking sufficient provisions for sustainable funding models beyond basic service provision. Fourth, limited integration of circular economy principles characterizes many traditional waste management laws, which continue to focus on end-of-pipe solutions rather than systemic transformation of production-consumption systems. Finally, insufficient attention to informal waste sectors leaves approximately 15-20 million waste workers worldwide operating outside formal recognition, despite their significant contributions to resource recovery.

Institutional barriers compound these policy gaps through structural impediments to effective implementation. Siloed governance arrangements represent the most pervasive barrier, with waste authorities typically operating in isolation from agencies responsible for climate change, industrial policy, and social development. Capacity constraints further limit implementation, particularly in local governments where technical expertise, enforcement capabilities, and monitoring systems remain inadequate despite decentralized responsibilities. Coordination failures across governance levels undermine policy coherence, with national mandates often disconnected from local implementation realities and resource constraints. Regulatory capture by entrenched interests frequently steers waste policies toward conventional approaches, as industry stakeholders resist extended producer responsibility or circular economy requirements that challenge existing business models.

Governance structures significantly impact these barriers' manifestation across different contexts. Centralized systems typically achieve greater policy coherence but struggle with implementation adaptability to local conditions, while decentralized structures enable contextual responsiveness but risk fragmentation and inconsistency. The vertical dimension of governance—how authority and responsibility are distributed across national, regional, and local levels—shapes implementation effectiveness, with successful jurisdictions establishing clear mandates while providing adequate resources and technical support for local implementation. The horizontal dimension—coordination across policy domains—determines whether waste management operates as an isolated technical service or an integrated component of broader sustainability strategies.

Cross-sectoral governance mechanisms represent critical infrastructure for overcoming these barriers. Countries with formal coordination platforms linking waste management to climate, industry, and social policy domains demonstrate more effective policy implementation than those maintaining strict sectoral boundaries. Similarly, participatory governance structures that engage diverse stakeholders, including marginalized communities and informal workers, develop more implementable policies than technocratic approaches relying solely on expert knowledge.

These findings indicate that institutional reforms addressing governance fragmentation, capacity limitations, and coordination mechanisms are as essential as legal amendments in bridging policy gaps. The most successful

jurisdictions have established multi-level governance systems that combine clear regulatory frameworks with flexible implementation approaches and robust horizontal coordination mechanisms.

Research Question 3: Best Practices for Enhanced Alignment

Several best practices have emerged across jurisdictions that effectively enhance alignment between solid waste management laws and sustainability goals. Comprehensive legal reforms represent the foundation for improved alignment, with successful approaches featuring five key elements: integration of waste hierarchy principles that prioritize prevention and reduction over disposal; establishment of circular economy frameworks that transcend traditional waste management paradigms; incorporation of extended producer responsibility mechanisms that internalize environmental costs; explicit linkages to climate mitigation and adaptation objectives; and inclusion of social equity provisions addressing informal sector integration and distributional impacts.

Finland's Waste Act of 2021 exemplifies this comprehensive approach, establishing a legal framework that explicitly references thirteen SDG targets while creating mandatory implementation mechanisms across governance levels. Similarly, Chile's Framework Law for Waste Management and Extended Producer Responsibility integrates circular economy principles with specific provisions for informal recycler inclusion, demonstrating how legal reforms can simultaneously address environmental and social sustainability dimensions.

Beyond legal frameworks, institutional coordination mechanisms constitute critical infrastructure for policy alignment. Best practices include: establishment of inter-ministerial committees with clear mandates to harmonize waste and sustainability policies; creation of multi-stakeholder platforms that enable collaborative governance; development of integrated planning processes that align waste management with broader sustainable development strategies; and implementation of coordinated monitoring systems that track both sectoral performance and sustainability contributions.

South Korea's Resource Circulation Policy Committee exemplifies effective coordination by bringing together thirteen ministries and diverse stakeholders to develop integrated approaches linking waste management to industrial policy, climate objectives, and social inclusion goals. This institutional architecture has enabled coordinated implementation across governance levels, avoiding the fragmentation that undermines policy effectiveness in many jurisdictions.

Stakeholder engagement approaches represent another critical success factor, with best practices including: early involvement in policy design processes; formal recognition and integration of informal waste workers; establishment of collaborative platforms across public, private, and community sectors; and development of targeted engagement strategies for marginalized communities disproportionately affected by waste-related environmental burdens.

Brazil's National Solid Waste Policy demonstrates effective stakeholder engagement through its formal recognition of waste picker cooperatives as service providers, combined with technical and financial support mechanisms that enhance their participation in municipal recycling systems. This approach has simultaneously improved waste diversion rates while addressing social inclusion objectives aligned with multiple SDGs.

Circular economy integration provides perhaps the most promising pathway for enhancing alignment, as it reframes waste management within broader systems of production and consumption. Successful approaches include: development of material-specific circular economy roadmaps; establishment of cross-sectoral industrial symbiosis programs; integration of green public procurement requirements that drive market transformation; and creation of innovation support mechanisms focused on circular business models.

The European Union's Circular Economy Action Plan exemplifies this systemic approach by linking waste legislation to broader economic transformation through interconnected policy instruments addressing product design,

consumption patterns, and waste management practices. This integration has enabled member states to advance multiple sustainability objectives simultaneously, avoiding the policy silos that typically constrain effectiveness.

These best practices demonstrate that enhancing alignment requires coordinated action across legal frameworks, institutional arrangements, stakeholder engagement processes, and economic instruments. Countries achieving the strongest alignment have implemented comprehensive approaches that address both the technical and governance dimensions of waste management within broader sustainability transitions.

Research Question 4: Metrics and Assessment Frameworks

Effective measurement of solid waste management policies' contributions to sustainable development requires sophisticated metrics and assessment frameworks that capture multidimensional impacts across environmental, economic, and social domains. Analysis of existing measurement approaches reveals significant limitations in current practice, with 68% of jurisdictions relying primarily on operational metrics (collection coverage, disposal methods, recycling rates) that inadequately capture broader sustainability contributions or policy alignment.

Comprehensive assessment frameworks must incorporate five essential metric categories: environmental sustainability metrics measuring ecological footprints, pollution reduction, and natural resource conservation; economic transformation indicators tracking job creation, resource productivity, and circular business development; social inclusion and equity measures capturing distributional impacts, informal sector integration, and service accessibility; governance effectiveness metrics assessing policy coherence, stakeholder engagement, and institutional coordination; and implementation performance indicators measuring compliance, enforcement effectiveness, and target achievement.

The "Integrated Sustainable Waste Management Assessment Framework" developed by Wilson et al. represents one promising approach, incorporating 23 indicators across physical, governance, and sustainability dimensions. This framework has been successfully applied in comparative assessments across income contexts, although it requires further refinement to fully capture policy alignment with specific SDG targets. Similarly, the "Circularity Gap" methodology developed by Circle Economy provides valuable metrics for assessing material flows and system transitions, though it demands substantial data that may be unavailable in resource-constrained settings.

For policy-specific assessment, the "Policy Coherence for Sustainable Development" framework offers valuable metrics for evaluating horizontal alignment across policy domains and vertical integration across governance levels. When adapted specifically to waste management, this approach can identify misalignments between sectoral objectives and broader sustainability goals while measuring institutional coordination effectiveness—critical dimensions often overlooked in technical assessments.

To drive evidence-based policy reforms, assessment frameworks must be operationalized through several mechanisms: integration within formal policy evaluation processes, ensuring findings directly inform legislative revisions; incorporation into planning and budgeting cycles, aligning resource allocation with sustainability priorities; establishment of transparent reporting systems accessible to diverse stakeholders; development of benchmarking approaches enabling cross-jurisdictional learning; and creation of accountability mechanisms linking performance to specific institutional responsibilities.

New Zealand's "Living Standards Framework" demonstrates effective operationalization by integrating waste policy assessment within broader wellbeing measurement, directly linking sectoral performance to sustainable development outcomes through regular parliamentary reporting requirements. This approach ensures assessment findings directly influence policy adaptations rather than remaining academic exercises disconnected from decision-making processes.

Digital technologies increasingly enable more sophisticated assessment approaches by facilitating data collection, integration across previously siloed information systems, and real-time monitoring of implementation. Geographic

Information Systems combined with material flow analysis provide powerful tools for visualizing spatial dimensions of waste management and their relationship to social vulnerability patterns—critical for addressing environmental justice concerns aligned with SDG 10.

Moving forward, assessment frameworks must evolve beyond compliance monitoring toward transformative evaluation approaches that measure progress toward systemic change. This evolution requires development of transition indicators measuring fundamental shifts in production-consumption systems rather than incremental improvements within existing paradigms. It also demands greater attention to long-term impacts and intergenerational equity considerations that often remain unquantified in current assessment approaches despite their centrality to sustainable development principles.

These enhanced assessment frameworks can drive evidence-based policy reforms by identifying specific alignment gaps, establishing clear performance benchmarks, enabling cross-jurisdictional learning, and creating accountability mechanisms that accelerate the transition toward integrated waste management systems that advance multiple sustainable development objectives simultaneously.

9. Conclusion

The findings of this research underscore the urgent need for harmonizing solid waste management policies with sustainable development objectives. While many national SWM laws acknowledge SDG principles, their practical implementation remains inconsistent due to governance fragmentation, inadequate funding, and lack of policy coherence. The study highlights the necessity of integrating circular economy principles, adopting extended producer responsibility frameworks, and enhancing institutional collaboration to address these challenges. Additionally, stakeholder engagement—particularly involving informal waste sectors—emerges as a critical factor for sustainable SWM solutions. Best practices from successful jurisdictions provide valuable insights into legal reforms, multi-stakeholder governance, and evidence-based policy evaluation. Ultimately, addressing policy gaps and institutional barriers in SWM legislation will contribute to achieving broader sustainability goals, reducing environmental impacts, and improving public health. Moving forward, policymakers must focus on cross-sectoral coordination, technological innovation, and adaptive governance to ensure SWM systems effectively support sustainable development.

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