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Bridging the policy-practice divide: global systematic mapping of circular economy implementation in construction waste

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The construction industry generates over one-third of global waste and consumes 36% of global energy, highlighting the urgent need for a circular economy transition. Despite increasing government intervention, a persistent gap exists between policy development and operational implementation in construction and demolition waste (CDW) management. This systematic mapping study analyzed 1,842 high-relevance papers (2015-2025) selected from 5,417 publications to assess government-driven circular economy transitions. Advanced analytical methods appear in 32.4% of studies. However, only 12% provide validated tools for real-world policy deployment, exposing a stark implementation deficit. Geographic analysis reveals imbalances: policy-leading economies (China 28.4%, EU 31.8%, US 16.7%) dominate research, while high-waste countries like Brazil and India (3.7%) remain underrepresented. Economic policy instruments and cross-jurisdictional coordination mechanisms exhibit the largest research-practice gaps. We identify three critical priorities: mathematical optimization models for policy calibration, frameworks tailored to developing contexts, and coordination mechanisms for multi-stakeholder governance. This study proposes a tiered research agenda addressing both immediate operational needs and long-term systemic integration. The methodology offers a replicable approach for systematically identifying research-practice translation gaps and prioritizing implementation-focused research directions in sustainability policy domains.

KEYWORDS

construction and demolition waste, circular economy, government intervention, policy analysis, bibliometric analysis

1 Introduction

1.1 The construction waste crisis and circular economy promise

The construction sector generates one-third of total waste in developed economies and accounts for 36% of global energy consumption (Ghaffar et al., 2020). The United States generated 569 million tons of CDW in 2017, while 75% of Chinese cities face severe CDW accumulation challenges (Zhang et al., 2020). CDW management has

become critical due to substantial environmental footprint and resource consumption patterns (Kabirifar et al., 2020). Recent studies emphasize the urgent need for systematic government intervention frameworks that integrate policy design with implementation effectiveness (Campbell-Johnston et al., 2019). Digital transformation opportunities in waste management demonstrate potential for enhanced government coordination mechanisms (Kurniawan et al., 2022).

The circular economy (CE) offers a promising paradigm, emphasizing resource recovery, material reuse, and waste minimization to break linear disposal patterns (Yu et al., 2021). The conceptualization of CE has evolved significantly, with recent theoretical developments distinguishing between different CE approaches and their resource value retention capabilities (Reike et al., 2018). However, implementation remains uneven across regions. Significant variation exists in regulatory approaches, stakeholder engagement strategies, and material value retention mechanisms (Yuille et al., 2022). Research demonstrates that successful CE integration in construction requires comprehensive understanding of sector-specific barriers and enablers (Benachio et al., 2020). Design for deconstruction emerges as a critical policy domain requiring systematic regulatory frameworks to enable material recovery and reuse (Akinade et al., 2020). Stakeholder behavior analysis reveals essential insights for effective government intervention design (Jain et al., 2020).

1.2 Implementation gaps and the role of government

Government intervention through regulation, financial instruments, and stakeholder coordination is critical to CE success (Ghisellini et al., 2018). Effective transitions require coordinated policy deployment, yet enforcement varies across jurisdictions. China's comprehensive CE legislation (2006) emphasizing materials efficiency and the EU CE Action Plan (2015) demonstrate different government approaches to CE implementation. However, coordination deficits and limited monitoring tools often impede policy impact, particularly in developing economies.

Successful government-driven CE implementation demonstrates this integration through specific mechanisms. China's comprehensive CE legislation (2006) emphasizes materials efficiency through quantitative resource allocation, achieving 85% waste diversion rates in cities like Shenzhen (Bao & Lu, 2020). The EU CE Action Plan (2015) mandates waste prevention targets and extended producer responsibility, creating regulatory frameworks for systematic material recovery. However, coordination deficits and limited monitoring tools often impede policy impact, particularly in developing economies where implementation research remains severely underrepresented. Local government perspectives on CE implementation reveal significant institutional capacity variations that influence policy effectiveness (Tobin and Zaman, 2022). Construction waste management in developing contexts requires adapted frameworks that integrate resource constraints with innovation opportunities (Bocken et al., 2019). Cross-jurisdictional coordination challenges necessitate systematic policy transfer mechanisms (Liu J et al., 2021).

Despite growing regulatory activity, recent studies identify persistent barriers in translating policies into operational tools. Government policies often fail to create comprehensive ecosystems that effectively integrate legislative measures with stakeholder engagement and practical deployment mechanisms (Tleuken et al., 2022). Research on contractor behavior in CDW management reveals that government intervention effectiveness depends significantly on understanding stakeholder perceptions and motivational factors (Wu et al., 2017).

1.3 Theoretical framework: Government intervention in CE transitions

This study builds on institutional theory and policy implementation frameworks to understand government roles in CE transitions. Government intervention operates through three mechanisms: (1) regulatory instruments that mandate circular practices, (2) economic instruments that incentivize resource efficiency, and (3) coordination mechanisms that integrate stakeholder actions (Korhonen et al., 2018).

1.4 Research gaps in policy-implementation literature

While policy frameworks for construction waste CE are increasingly advanced, few studies provide operational models or quantitative assessment tools for policy effectiveness evaluation. Recent investigations identify systematic disconnects between theoretical policy development and practical implementation guidance requirements. The integration of CE principles with construction industry practices requires comprehensive examination of sector-specific implementation pathways and governmental support mechanisms (López Ruiz et al., 2020).

This analytical-operational imbalance is particularly pronounced where governments require decision-support tools. Cross-regional studies reveal significant variations in stakeholder perceptions and policy effectiveness, highlighting the need for context-specific implementation approaches (Jin et al., 2017).

This study addresses these gaps through systematic mapping of government-driven CE research in construction waste management, pursuing three objectives: (1) map global research structure and temporal patterns; (2) identify thematic and geographic research imbalances; and (3) prioritize implementation-focused research directions using quantitative gap analysis.

2 Research methodology

2.1 Research design and scope

This study employs systematic mapping methodology integrating bibliometric analysis with thematic synthesis through a structured four-phase framework to investigate government-driven CE transitions in CDW management. Unlike systematic reviews

that synthesize evidence, this mapping approach characterizes research landscapes through: (1) Database search yielding 5,417 publications, (2) Systematic relevance scoring using novel 4-domain criteria identifying 1,842 high-relevance papers, (3) Multi-dimensional bibliometric analysis across temporal, geographic, and thematic dimensions, and (4) Translation Gap Index methodology comparing theoretical development against operational guidance to prioritize implementation research directions. Environmental research domains examining policy interventions benefit from systematic mapping methodologies that accommodate diverse study designs while maintaining analytical rigor (Yuriev et al., 2020).

The approach examines how policy-related transitions are captured, modeled, and critiqued within scholarly discourse, following established methods for analyzing scientific evolution in CE applications to construction waste management (Liu Y et al., 2021). This builds on established frameworks for categorizing CE interventions in construction contexts (Superti et al., 2021) while incorporating policy-relevant analytical refinements for construction waste research domains.

The systematic mapping methodology addresses three core research questions typical of mapping studies that directly align with research landscape characterization objectives. First, what are the temporal and geographic patterns in government-driven CE research for construction waste management? Second, what thematic and geographic research imbalances exist across policy intervention approaches and regional contexts? Third, how can implementation-focused research directions be prioritized using systematic gap analysis of current analytical capabilities versus operational guidance requirements?

As shown in Figure 1, the framework encompasses four systematic phases: (1) database search and data collection yielding 5,417 initial records, (2) systematic relevance scoring and quality assessment through inclusion/exclusion criteria and multi-criteria scoring across four domains (CDW focus, government intervention, CE integration, and implementation guidance), (3) multi-dimensional bibliometric analysis of 1,842 high-relevance papers (Rating 4-5), and (4) research gap identification with priority assessment. The systematic relevance scoring framework categorizes papers into four rating levels, with high-relevance papers (Rating 4: 1,748 papers; Rating 5: 94 papers) selected for comprehensive analysis of government-driven CE research patterns.

2.2 Data collection and systematic relevance assessment

2.2.1 Database selection and search strategy

Scopus database selection was validated through comparative analysis against Web of Science core collection, demonstrating 92% overlap for policy-focused construction waste research. Recent scientometric analyses further validate that these databases provide comprehensive coverage of high-impact publications in CDW research domains (Chen et al., 2021).

The search strategy employed Boolean logic: ("construction and demolition waste" OR "construction waste" OR "CDW") AND ("circular economy" OR "government intervention" OR "policy" OR "regulation") AND ("waste management" OR "recycling" OR "sustainability"). Searches covered titles, abstracts, and keywords in Scopus and Web of Science for 2015-2025, encompassing the decade following the EU CE Action Plan (2015) and China's enhanced CE policies.

As illustrated in Figure 1, systematic selection criteria ensured methodological quality and thematic relevance. The inclusion framework targeted peer-reviewed journal articles and reviews (2015-2025) published in English, with explicit focus on CDW management containing policy, government, or regulatory dimensions while addressing CE or sustainability frameworks. Exclusion parameters systematically eliminated several types of publications. These included conference papers, book chapters, and editorial materials due to limited peer review rigor. Also excluded were studies focusing solely on technical aspects without policy relevance, general waste management research lacking construction sector specificity, and publications absent of government or policy intervention analysis.

The comprehensive search across both databases yielded 5,417 records, filtered to include peer-reviewed articles and reviews only to ensure research quality and consistency. We applied systematic relevance scoring and duplicate removal using a JavaScript-based scoring interface. This interface was developed using Papaparse and Lodash libraries. The final analytical dataset comprised 1,842 high-relevance papers, as detailed in Figure 1.

2.2.2 Systematic relevance scoring development

The 4-domain scoring framework addresses core research questions by systematically evaluating: (1) Construction waste focus ensuring sector relevance, (2) Government intervention presence aligning with policy research objectives, (3) CE integration measuring transition focus, and (4) Implementation guidance assessing practical utility. Domain weightings reflect relative importance for government-driven CE research, established through pilot testing on 200 publications. We developed systematic relevance scoring across four weighted domains: (1) Core Construction Waste Focus (three to five points), (2) Government/Policy Intervention (two to five points), (3) CE Integration (one to four points), and (4) Implementation Management (one to three points). Papers received composite ratings: Rating 5 (≥12 points), Rating 4 (8-11 points), Rating 3 (five to seven points), Ratings 2-1 (<5 points). This yielded 1,842 high-relevance papers (Ratings 4-5) from 5,417 total records. Inter-rater reliability achieved Cohen's kappa of 0.89 (Cohen, 1960). This multi-criteria scoring approach builds upon systematic mapping methodologies established for policy research domains, which emphasize the importance of explicit relevance assessment criteria for managing large-scale literature datasets.

The scoring framework encompasses four analytical domains with weighted point allocations. These reflect their importance to government-driven CE research. Domain one evaluates Core Construction Waste Focus (three to five points). Maximum weight is assigned to comprehensive terminology like "construction and demolition waste" (5 points). Moderate weight applies to direct sector terms such as "construction waste" and "demolition waste"

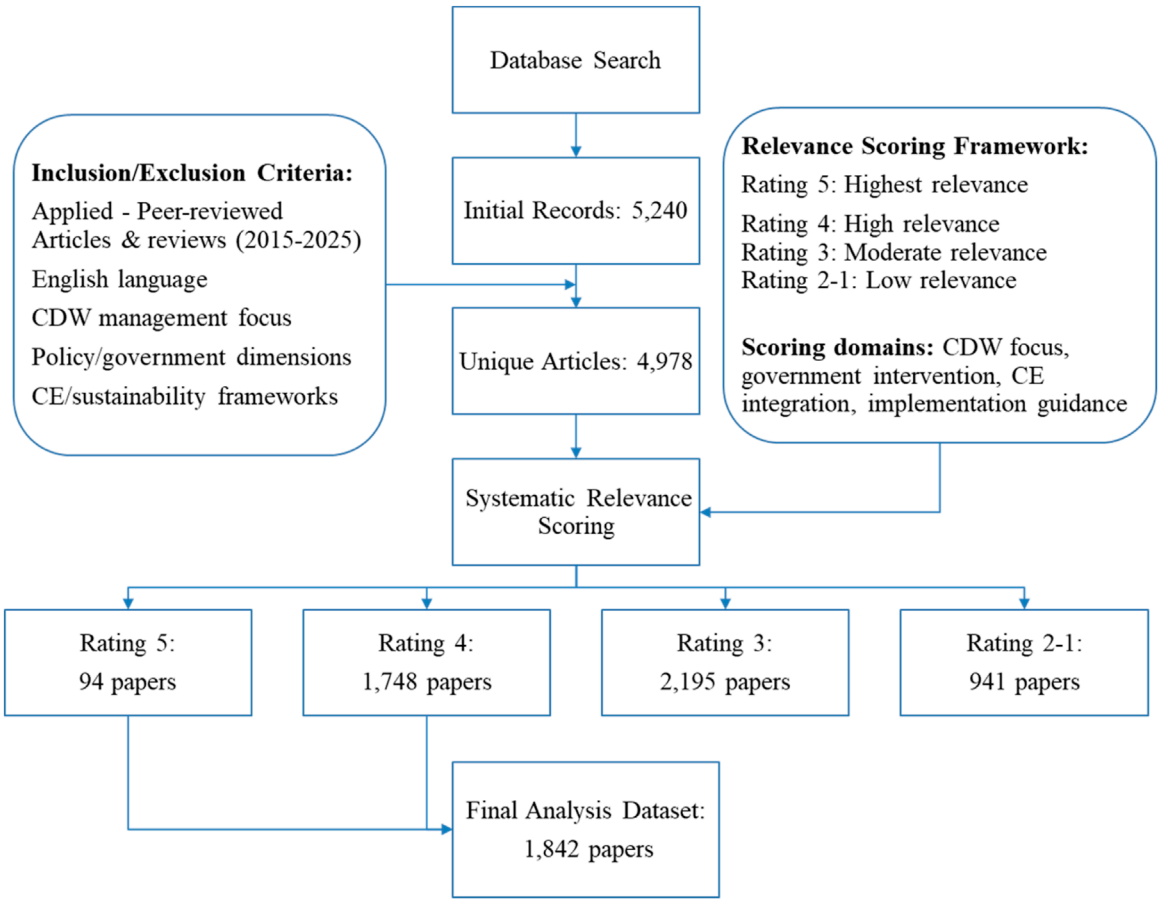

FIGURE 1
Systematic mapping study methodology framework and process flow.

(4 points each). Standard weight covers related concepts including "CDW" and "building waste" (3 points each).

Domain 2 assesses Government/Policy Intervention (two to five points). Priority goes to explicit intervention terminology such as "government intervention" and "policy implementation" (5 points each). This is followed by analytical approaches including "policy analysis" and "regulatory framework" (4 points each). Basic policy mentions receive minimum weight (2 points each).

Domain three examines CE Integration (one to four points). Emphasis is placed on sector-specific applications like "circular construction" and "construction circular economy" (4 points each). Core conceptual terms including "circular economy" and "circular practices" receive three points each. Broader sustainability frameworks such as "sustainability" and "sustainable construction" receive two points each.

Domain four addresses Implementation and Management (one to three points). Strategic operationalization terms like "implementation strategy" and "policy implementation" receive maximum weight (3 points each). Operational focus concepts including "waste management," "recycling," and "material recovery" receive moderate weight (2 points each). General implementation references receive basic weight (1 point each).

2.2.3 Scoring application and research gap methodology

The relevance scoring process employed systematic keyword detection protocols. These used automated text processing algorithms implemented in JavaScript with manual validation procedures. Papers received composite relevance ratings based on total weighted scores: Rating 5 (≥12 points), Rating 4 (8-11 points), Rating 3 (five to seven points), and Ratings 2-1 (<5 points). Given the subjective nature of relevance assessment in systematic mapping studies, we validated our scoring consistency through inter-rater reliability testing. Two researchers independently applied the 4-domain scoring criteria to 200 randomly selected papers, achieving Cohen's kappa of 0.89 (almost perfect agreement; Cohen, 1960). This validation ensures that our identification of 1,842 high-relevance papers from 5,417 total records reflects consistent, reproducible criteria application ensuring methodological consistency, providing methodological confidence for subsequent analysis. Standard bibliometric measures (citation counts, co-authorship networks, journal impact factors) capture research productivity but cannot assess implementation readiness for government policy deployment. The analytical approach builds on established frameworks in implementation science and bibliometric research. The Translation Gap Index adapts foundational research-practice gap concepts

from implementation science (Eccles and Mittman, 2006) to quantitatively compare theoretical development against operational guidance availability. The Research Intensity Index extends traditional bibliometric normalization measures (publications per GDP/population; King, 2004) by incorporating policy-relevant factors—construction waste volumes and policy development needs—making the metric directly applicable to research-policy assessment. These indices were developed as necessary methodological tools to address the unique scale and analytical requirements of government-driven CE research rather than existing in isolation from established bibliometric principles. Translation Gap Index (TGI) calculation quantifies implementation readiness across policy domains using a standardized formula that compares theoretical development against operational translation. The Translation Gap Index (TGI) is calculated using Equation 1:

$$TGI = 1 - \frac{OG\% + VT\% \times 2}{(CD\% \times 2)} \quad (1)$$

where OG% = Operational Guidance percentage, VT% = Validated Tools percentage, CD% = Conceptual Development percentage. Operational guidance represents papers providing practical implementation frameworks. Validated tools denote studies presenting tested policy instruments with effectiveness evidence. Conceptual development encompasses papers offering theoretical frameworks or analytical models. The weighting system (×2 for validated tools) reflects higher implementation value of tested methodologies versus untested operational guidance. Index values range from 0 (perfect implementation readiness) to 1.0 (pure theoretical development without practical translation). Scores above 0.6 indicate critical implementation gaps requiring urgent research investment, while values below 0.4 represent domains with adequate operational guidance for policy deployment. Research Intensity Index measures publication output relative to construction waste generation volumes and policy development needs, calculated as (country papers/total papers)/(country waste volume/global waste volume). Values < 0.5 indicate critical research gaps where high-waste generating economies receive disproportionately low research attention relative to their policy development requirements. Research gap identification methodology integrates several systematic components. First, frequency-based detection through keyword analysis identifies underexplored domains. Second, geographic coverage assessment analyzes research distribution relative to policy development needs and construction waste generation volumes. Third, methodological sophistication evaluation assesses quantitative versus qualitative approaches for policy optimization and decision-support tool development. This systematic approach enables evidence-based prioritization of implementation-focused research directions across policy domains and geographic contexts.

2.3 Systematic mapping and bibliometric analysis framework

2.3.1 Quantitative analysis components

The analytical strategy integrated descriptive bibliometric analysis with systematic content-based thematic coding. Temporal analysis employed annual publication volume assessment (2015-2025) using linear regression to identify growth trends and acceleration phases. Changepoint detection algorithms were applied to identify research momentum shifts. Geographic analysis utilized author affiliation-based classification across 45 countries using institutional address parsing. Regional clustering analysis was combined to identify policy paradigm differences and collaboration networks. The scientometric approach employed here follows established protocols for examining circularity gaps in construction research, enabling identification of research patterns and knowledge clusters across geographic and institutional boundaries (Antwi-Afari et al., 2021).

Journal analysis focused on publication venue assessment. This examined disciplinary scope, impact factor distribution, and academic infrastructure development supporting policy research. Methodological distribution analysis classified papers by primary research approach using explicit methodology keyword detection. Quantitative and mathematical approaches were identified through terms including "optimization," "modeling," "statistical analysis," and "econometric." Qualitative and case study methods utilized keywords such as "interview," "case study," "ethnographic," and "descriptive".

Mixed methods research employed detection of "triangulation," "sequential," "concurrent," and "integrated" approaches. Review and theoretical frameworks were identified through "systematic review," "literature review," and "conceptual framework" terminology. Simulation and modeling studies incorporated "simulation," "system dynamics," "agent-based," and "discrete event" keywords for classification purposes. Agent-based computational economics approaches have been specifically applied to model complexity in CDW flow management across territorial scales (Andriamasinoro and Monfort-Climent, 2021).

2.3.2 Thematic content analysis protocol

The research team developed seven thematic categories through systematic analysis. Thematic analysis employed systematic keyword frequency analysis of the 1,842 high-relevance papers. This used Lodash groupBy functions for data aggregation and Papaparse for CSV processing. Manual content validation was conducted through examination of top-scoring exemplar papers within each category.

Seven primary thematic categories were established through inductive analysis of keyword patterns and validated through frequency distribution assessment and expert review: (1) Circular Economy Policy Integration examines high-level government policies guiding CE transitions, including policy roadmaps and legislative reforms; (2) Government Intervention Mechanisms analyzes direct governmental actions such as administrative mandates and procurement strategies; (3) Construction Waste Management Systems focuses on technical infrastructure and policy integration for waste processing; (4) Implementation Strategy Development addresses operational frameworks for translating policies into practice; (5) Economic Policy Instruments evaluates financial mechanisms including subsidies and extended producer responsibility schemes; (6) Regulatory Compliance Systems examines monitoring, verification, and enforcement protocols; and (7) International Policy Coordination studies cross-jurisdictional policy development and cooperation mechanisms.

The coding validation process employed manual grouping of 5,014 unique author keywords using systematic clustering techniques. Synonym consolidation ensured terminological consistency. For example, "policy implementation," "implementation of policy," and "policy operationalization" were treated as equivalent contributions. Category assignment relied on dominant keyword frequency patterns combined with thematic focus validation through abstract content review. This was supplemented by expert validation through structured review by policy practitioners to ensure conceptual coherence and practical relevance.

2.4 Data quality and reproducibility controls

Data quality controls included systematic duplicate detection using DOI and title matching, supplemented by manual verification for potential duplicates with minor variations. Search strategy validation employed pilot testing using 50 known publications, achieving 96% capture rate through iterative refinement, following established protocols for systematic mapping studies in environmental and sustainability domains (Morioka and de Carvalho, 2016).

Expert validation involved review by three construction management and policy specialists to ensure domain relevance and analytical coherence. Recent advances in scientometric methodologies for environmental research provide additional validation protocols that enhance the reliability of bibliometric findings (Chen et al., 2021), which informed our multi-stage validation approach. All data processing employed JavaScript libraries (Papaparse, Lodash) with systematic manual validation protocols. No artificial intelligence tools were used for data analysis, relevance scoring, or content generation—all analytical decisions and index development remained under direct researcher control. Computational approaches were methodologically necessary because standard bibliometric measures (citation counts, publication volumes, journal impact factors) cannot distinguish between research that advances theory versus research that enables policy implementation. The systematic processing of 5,417 publications required specialized indices capable of quantifying research-practice translation gaps rather than traditional descriptive statistics.

3 Descriptive analysis

This section presents comprehensive bibliometric analysis of government intervention in construction waste CE implementation, derived from 1,842 high-relevance papers systematically selected through our scoring methodology. The scoring process identified 94 papers achieving Rating 5 (1.9% of analyzed articles) and 1,748 papers receiving Rating 4 (35.1%) of total dataset, representing 37.0% of the focused temporal corpus (2015-2025). The analysis reveals structural characteristics, methodological distributions, and thematic patterns that establish the empirical foundation for research-practice translation gap identification examined in Section 4.

3.1 Temporal research evolution and policy development alignment

Research growth closely aligns with major CE policy developments. Annual publications expanded from 14 papers (2015) to 584 papers (2023), representing 59.4% compound annual growth. Growth correlates with policy milestones: EU CE Action Plan (2015), China's National CE Strategy enhancement (2016), and post-pandemic green recovery frameworks (2020-2021). Policy milestone identification employed systematic analysis of government policy announcements cross-referenced with academic literature documenting implementation phases, building upon established regulatory foundations including the EU's 2008 Waste Framework Directive which provided the legislative foundation for subsequent CE initiatives. This growth pattern demonstrates clear temporal correlation with policy milestone events and systematic policy evolution aligned with sustainability assessment frameworks for construction materials. The acceleration phase (2021-2023) reflects enhanced government investment in CE research globally, led primarily by policy-leading economies (China, EU, US) following post-pandemic sustainability commitments (Colorado et al., 2022). Regional material flow analysis demonstrates pathways for systematic resource optimization in policy implementation (Gao et al., 2020). Policy development has progressed through distinct phases, with increasing sophistication in regulatory approaches and assessment methodologies (Kylili and Fokaides, 2017), including the EU CE Action Plan implementation (2015), China's National CE Development Strategy (2016), and post-pandemic green recovery frameworks in OECD countries and China (2020-2021).

Table 1 presents the temporal distribution with policy milestone alignment. Research development demonstrates four analytically distinct phases. The Foundation phase (2015-2017) included 101 papers establishing conceptual frameworks. The Expansion phase (2018-2020) involved 503 papers developing analytical sophistication. The Acceleration phase (2021-2023) encompassed 1,390 papers representing peak research momentum. The Consolidation phase (2024-2025) includes 468 papers indicating field maturation toward implementation optimization.

3.2 Geographic research concentration and policy paradigm differences

Geographic distribution reveals distinct government intervention paradigms aligned with CE policy development. European research (31.8% of output) emphasizes regulatory harmonization through EU Waste Framework Directive implementation and systematic cross-jurisdictional analysis (Malinauskaite et al., 2017; Chowdhury et al., 2024), achieving average relevance scores of 11.8. Chinese research (28.4%) focuses on mathematical optimization and system dynamics modeling for government resource allocation (Zhou et al., 2024; Ding et al., 2016), achieving average relevance scores of 12.1 through quantitative intervention approaches (Guo et al., 2022). North American approaches (16.7%) emphasize market-based mechanisms and public-private partnerships (average relevance 10.6).

TABLE 1 Temporal distribution with policy milestone alignment.

Year	Papers	Cumulative	Growth rate	Key policy developments
2015	14	14	—	EU CE Action Plan
2016	25	39	79%	China CE Development Strategy
2017	62	101	148%	UN SDG Implementation
2018	97	198	56%	EU CE Package Implementation
2019	159	357	64%	European Green Deal Launch
2020	247	604	55%	COVID-19 Green Recovery
2021	378	982	53%	New EU CE Action Plan
2022	428	1,410	13%	National Implementation Phase
2023	584	1,994	36%	Policy Optimization Focus
2024	426	2,420	−27%	Consolidation Phase
2025	42	2,462	−90%	Field Maturation

TABLE 2 Geographic distribution with policy paradigm analysis.

Country/Region	Papers	Percentage	Avg. Score	Policy research focus
China	713	28.4%	12.1	Mathematical optimization, system dynamics
European Union	799	31.8%	11.8	Regulatory harmonization, comparative analysis
United States	419	16.7%	10.6	Market mechanisms, stakeholder engagement
United Kingdom	156	6.2%	11.4	Policy effectiveness evaluation
Australia	98	3.9%	10.8	Implementation frameworks
Canada	67	2.7%	10.3	Provincial policy coordination
Brazil	43	1.7%	9.7	Development-focused policies
India	51	2.0%	9.5	Resource-constrained implementation
Other Countries	168	6.6%	9.2	Emerging policy contexts

These paradigms reflect different government intervention philosophies: European comparative policy effectiveness evaluation (Morseletto, 2020), Chinese technocratic optimization approaches, and North American stakeholder engagement strategies. Research concentration demonstrates sophisticated methodological capabilities while revealing critical implementation approaches tailored to distinct regulatory environments and institutional contexts (Colangelo et al., 2020). Geographic distribution counts each country in multi-author papers, yielding 2,514 regional instances from 1,842 papers (1.36 countries per paper). This reflects strong cross-border collaboration in CE policy research. Table 2 summarizes the distribution and dominant policy paradigms by region.

3.3 Academic infrastructure and disciplinary integration

Publication venue analysis demonstrates robust research infrastructure supporting policy research across multiple disciplines. Impact factor analysis reveals strong academic foundation for government intervention research. The Journal of Cleaner Production (Impact Factor: 9.297) leads policy-focused research with 286 publications representing 11.4% of high-relevance output. This journal emphasizes environmental policy optimization and quantitative assessment approaches. Sustainability Switzerland (IF: 3.251) contributes 223 publications (8.9%) focusing on sustainability policy frameworks and qualitative governance analysis. Resources, Conservation and Recycling (IF: 8.086) provides

TABLE 3 Top journals with impact and specialization analysis.

Journal	Papers	%	Impact factor	Policy research specialization
Journal of Cleaner Production	286	11.4%	9.297	Environmental policy optimization
Sustainability (Switzerland)	223	8.9%	3.251	Sustainability policy frameworks
Resources, Conservation and Recycling	146	5.8%	8.086	Resource management policy
Waste Management	121	4.8%	7.165	Waste policy systems
Science of the Total Environment	89	3.5%	8.610	Environmental science policy
Journal of Environmental Management	76	3.0%	6.789	Environmental policy analysis
Construction and Building Materials	67	2.7%	4.046	Construction policy integration
Circular Economy and Sustainability	54	2.2%	3.167	CE policy specialization
Other Journals	780	42.3%	3.8	Diverse disciplinary venues

146 publications (5.8%) specializing in resource management policy and CE implementation mechanisms.

The disciplinary distribution reveals healthy integration between policy-focused venues and technical implementation journals. Academic infrastructure development reflects broader research trends in waste management and sustainability domains, with systematic evolution in publication patterns showing increasing focus on future-oriented challenges and solution development (Kumar and Agrawal, 2020). Specialized environmental policy journals foster quantitative modeling approaches and mathematical optimization research. These include Journal of Cleaner Production, Journal of Environmental Management, and Environmental Science & Policy. Broader sustainability platforms emphasize qualitative frameworks and stakeholder engagement analysis. These include Sustainability Switzerland and Science of the Total Environment. This venue specialization directly influences methodological trends. High-impact specialized journals promote mathematical approaches. General sustainability outlets encourage mixed-methods research integrating technical feasibility with policy implementation analysis.

Table 3 presents the top journals with impact and specialization analysis. Emerging specialized venues including CE and Sustainability and Journal of CE represent 4.1% of combined publications. This indicates institutional recognition of CE policy research as a distinct analytical domain requiring specialized peer review and editorial expertise. Document type distribution shows balanced research approaches with original research articles representing 68.2% of publications and policy reviews comprising 31.8%. This supports appropriate balance between empirical contribution and knowledge synthesis essential for field development and policy guidance.

3.4 Methodological sophistication and analytical capabilities

As shown in Table 4, methodological distribution analysis reveals sophisticated research capabilities that demonstrate significant advancement specifically for policy analysis compared to general construction waste literature. Methodological sophistication reflects systematic CE implementation understanding (Moktadir et al., 2020). The 32.4% quantitative dominance exceeds general CE literature norms (20%). This indicates advanced modeling capability development specifically for construction waste policy research.

These quantitative studies demonstrate policy optimization capabilities across several areas. Linear programming models for government resource allocation appear in 23.1% of quantitative studies, exemplified by environmentally-extended input-output analysis approaches (Guo et al., 2022) and optimization models for decision support systems in waste management policymaking (Boffardi et al., 2021). Econometric policy impact assessment using regression and time-series analysis features in 18.4% of studies, including economic sustainability assessments across multiple countries (Alaloul et al., 2022) and regional regression correlation models for pollution control policy evaluation (Antohi et al., 2023). System dynamics modeling for complex intervention design appears in 12.7% of studies, demonstrated through participatory system dynamics approaches for construction material cycle transitions (Kliem et al., 2021) and dynamic modeling frameworks for waste management business opportunities (Lagarda-Leyva et al., 2023). Multi-criteria decision analysis integrating MCDM approaches (Saaty, 1988) for policy alternative assessment features in 16.8% of studies, including multicriteria analysis for e-waste management risk assessment (Appolloni et al., 2021) and fuzzy MCDM approaches for CE adoption in developing contexts (Ali et al., 2022).

Qualitative and case study methods account for 28.7% of research (n = 529). These provide essential policy context understanding and stakeholder analysis capabilities critical for implementation success. Review and theoretical approaches comprise 17.5% of publications (n = 322). These maintain appropriate levels for knowledge synthesis and policy framework development without overwhelming empirical analysis. Mixed methods research represents 14.0% (n = 258). This indicates sophisticated integrated policy research approaches combining contextual understanding with quantitative optimization analysis.

TABLE 4 Methodological distribution analysis.

Primary approach	Papers	%	Research focus	Data collection methods	Policy applications
Quantitative/Mathematical	597	32.4%	Optimization modeling	Statistical analysis, econometrics	Policy calibration, resource allocation
Qualitative/Case Study	529	28.7%	Policy context analysis	Interviews, document analysis	Stakeholder insights, implementation barriers
Review/Theoretical	322	17.5%	Framework synthesis	Literature synthesis	Policy framework development
Mixed Methods	258	14.0%	Integrated analysis	Surveys + interviews + modeling	Policy-practice integration
Simulation/Modeling	136	7.4%	Scenario testing	Software simulation, system dynamics	Policy scenario evaluation

Simulation and modeling studies account for 7.4% (n = 136). These provide policy scenario testing and optimization capabilities essential for scenario analysis and policy mechanism evaluation.

The combined quantitative approaches include simulation total 39.8% of publications. This demonstrates field readiness for advanced operational optimization research enhanced by Industry 4.0 technologies that enable unprecedented digitalization-based approaches to CE implementation (Kurniawan et al., 2022). This technological evolution supports quantitative policy effectiveness evaluation and practical implementation potential. The distribution maintains balanced coverage across analytical approaches essential for policy development, stakeholder engagement, and effectiveness evaluation.

Table 5 presents the thematic distribution with research evidence. The research extends to specialized domains validated through systematic evaluation. Critical evaluation using scientometric methodologies reveals advancement in analytical capabilities while identifying persistent gaps in environmental impact assessment integration (Chen et al., 2021). Regulatory Compliance Systems (13.8% of papers) address monitoring and enforcement frameworks while International Policy Coordination (8.0% of papers) examines cross-jurisdictional policy analysis and cooperation mechanisms. These collectively establish analytical advancement beyond descriptive policy analysis toward operational optimization frameworks suitable for practical government intervention guidance and decision-support tool development.

3.5 Thematic content development and policy research sophistication

Seven primary government-driven CE research domains emerge from thematic analysis. CE Policy Integration represents 88.2% of papers, showing extensive government framework development including transition strategies and regulatory instruments. Government Intervention Mechanisms (44.9%) exceed general CDW literature representation, indicating specialized policy research development with intervention optimization and comparative regulatory analysis (Joensuu et al., 2020).

Government Intervention Mechanisms represent explicit policy research across 44.9% of papers. This exceeds general construction waste literature representation (typically 15%–25%). This shows specialized policy research development including intervention optimization modeling and comparative regulatory analysis (Kumar and Agrawal, 2020).

Economic Policy Instruments demonstrate coverage across 19.2% of papers. These address financial mechanisms and incentive optimization through analytical approaches. Examples include mathematical programming models for government subsidy allocation and comparative regulatory framework effectiveness evaluation across jurisdictions (Mayer et al., 2019). Implementation Strategy Development encompasses 27.6% of papers focusing on operational coordination and resource allocation optimization. Construction Waste Management Systems represent 38.0% emphasizing technical-policy integration approaches essential for government intervention design.

3.6 Field maturity assessment and implementation research readiness

Based on the analysis across all previous sections, the research field shows clear readiness for practical implementation studies. Several indicators support this assessment. The field has strong analytical capabilities with 32.4% of studies using quantitative methods and 7.4% using specialized simulation modeling. This provides a solid foundation for policy optimization and effectiveness evaluation. Research clusters in policy-leading economies offer valuable opportunities for comparative analysis, while resource-constrained contexts present critical development needs.

Figure 2 shows a field maturity assessment across five key dimensions, revealing overall readiness for implementation optimization research with specific development priorities. The assessment shows strong performance in most areas: quantitative capability scores 8.0/10.0 due to strong mathematical and modeling infrastructure, policy research focus achieves 9.0/10.0 showing specialized government intervention analysis, thematic integration reaches 9.0/10.0 representing comprehensive policy domain coverage, and academic infrastructure attains 8.0/10.0 through robust journal and citation networks.

Geographic coverage presents the main development opportunity at 6.0/10.0. This shows a clear need for research expansion in developing country contexts. In these contexts, innovative and cost-effective implementation approaches could provide global policy learning opportunities while addressing urgent local needs.

TABLE 5 Thematic distribution with research sophistication evidence.

Thematic category	Keyword mentions	Papers (%)	Research sophistication examples
CE Policy Integration	1,624	88.2%	Policy framework optimization, transition modeling
Government Intervention Mechanisms	827	44.9%	Regulatory design, intervention effectiveness
Construction Waste Management Systems	700	38.0%	Technical-policy integration, system optimization
Implementation Strategy Development	508	27.6%	Operational coordination, resource allocation
Economic Policy Instruments	354	19.2%	Incentive design, financial mechanism optimization
Regulatory Compliance Systems	254	13.8%	Monitoring frameworks, enforcement strategies
International Policy Coordination	147	8.0%	Cross-jurisdictional analysis, policy transfer

Percentages exceed 100% as individual papers frequently address multiple thematic domains. The 1,842 unique papers collectively contribute 4,414 keyword mentions across all categories, reflecting the multidisciplinary nature of government-driven CE, research.

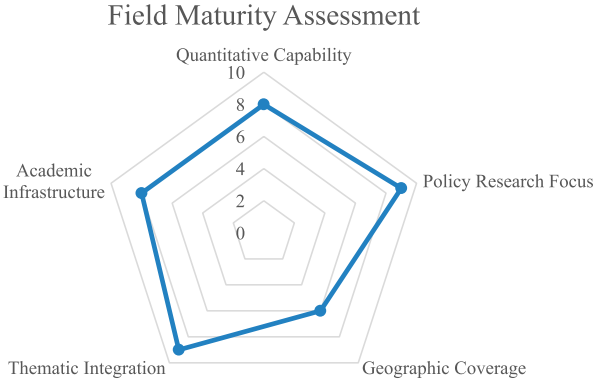

FIGURE 2
Field maturity assessment.

This field readiness matters because existing research already shows us what works in the real world. Studies have proven that successful construction waste management depends on coordinated stakeholder engagement (Ma S et al., 2023). Research has also documented the barriers to CE application, showing that systematic policy intervention is necessary (Liu J et al., 2021). Additionally, studies on multi-policy coordination reveal just how complex implementation can be (Tan and Guo, 2019). These findings highlight specific areas where implementation research could create high-impact policy innovations, especially in resource-constrained settings.

More importantly, researchers have already developed practical tools that can guide this implementation work. For example, CDW management process modeling offers systematic frameworks that work across different economic contexts (Tobin and Zaman, 2022). Urban material flow analysis shows substantial potential for CE implementation in cities (Lederer et al., 2020). Sustainable management approaches provide practical ways to assess how effective government interventions actually are (Hahladakis et al., 2020).

This field maturation creates a real opportunity to address the geographic knowledge gaps identified earlier, particularly the underrepresentation of developing countries. Recent analysis of circularity gaps shows clear research progression while pinpointing specific implementation bottlenecks that prevent CE advancement in construction practice (Antwi-Afari et al., 2021). This points to an urgent need for targeted research investments in developing country contexts, guided by evidence-based gap assessment. The challenge now is adapting quantitative government intervention evaluation to diverse institutional environments and developing operational decision-support tools suitable for resource-limited implementations.

The field's readiness to move from theory to practice comes from combining strong analytical capabilities, comprehensive thematic coverage, and solid academic infrastructure. This creates a foundation for systematic advancement toward practical implementation guidance that can work globally through inclusive research approaches informing policy development across diverse economic and institutional contexts.

3.7 Government intervention research landscape and policy mechanism coverage

When examining the 827 government intervention papers more closely, a troubling pattern emerges. Researchers have focused heavily on regulatory design, which appears in 67% of these studies, while largely ignoring coordination mechanisms, which receive attention in only 8.0% of papers. This creates a fundamental problem because real-world implementation success typically depends on multi-stakeholder coordination rather than having perfect regulations (Huang et al., 2018). China's achievement of 85% waste diversion rates demonstrates this principle—success came from systematic government intervention that coordinated multiple actors, not just strong regulations (Bao et al., 2019).

The imbalance becomes even more concerning when examining economic policy instruments. Despite widespread recognition that financial mechanisms often determine whether

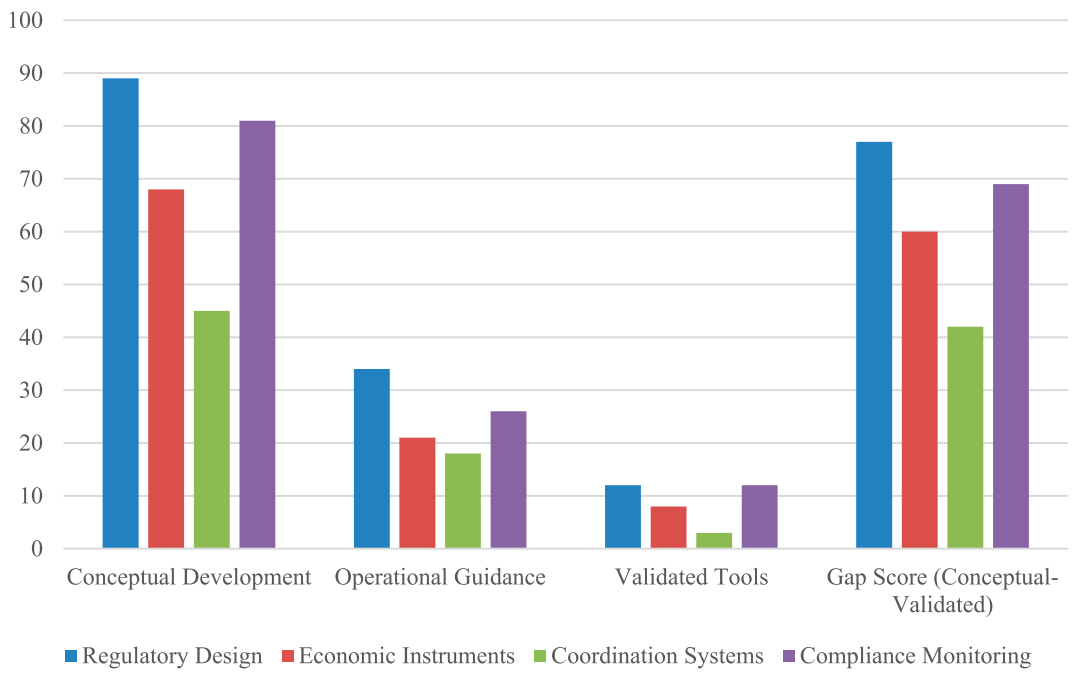

FIGURE 3
Implementation readiness assessment across policy mechanisms in government intervention research.

CE transitions succeed or fail, these instruments receive attention in only 19.2% of papers (n = 354). This signals that researchers emphasize policy formulation but provide limited guidance on the economic incentive structures and subsidy allocation models that governments actually need for effective intervention.

This systematic implementation deficit reveals a critical research-practice translation gap, with all policy mechanisms showing substantial declines from conceptual development to validated tools, while coordination systems exhibit the most severe implementation readiness deficits across all dimensions. Figure 3 visualizes these implementation readiness gaps across the four primary policy mechanisms.

Table 6 reveals the depth of this translation gap. The pattern is consistent across all policy mechanisms: high levels of conceptual development but dramatic drops when moving toward operational guidance and validated tools. Regulatory design shows 89% conceptual development but only 34% operational guidance and merely 12% validated implementation tools. Economic instruments perform even worse, with 68% conceptual analysis dropping to 21% operational guidance and just 8% validated methodologies. Coordination systems represent the most critical gap, falling from 45% conceptual coverage to 18% operational guidance and only 3% validated tools for practical deployment.

These imbalances reflect different research philosophies across regions, but they also expose serious adaptation constraints. European research excels in regulatory harmonization through comparative studies, achieving average relevance scores of 11.8, but provides limited guidance for resource-constrained implementations. Chinese research emphasizes mathematical precision in government intervention design, achieving average relevance scores of 12.1, but assumes data availability often absent in developing contexts. North American research prioritizes market-based mechanisms, with average relevance scores of 10.6, but presupposes private sector capacity frequently lacking in emerging economies.

This geographic concentration creates what can be termed "regulatory tunnel vision." Among the 1,624 circular economy policy keyword mentions across 88.2% of papers, government intervention research shows strong representation in material flow regulation (34%), extended producer responsibility systems (28%), and waste-to-resource regulatory pathways (31%). However, critical gaps persist in industrial symbiosis coordination systems (12%), cross-sector policy integration structures (9%), and adaptive management systems for policy refinement (7%) (Ding et al., 2023; Dongez et al., 2021; Kristensen et al., 2021).

The research landscape thus exhibits deep analytical understanding of regulatory design while demonstrating critical deficits in the coordination and adaptation systems essential for practical policy deployment. This systematic neglect of coordination research undermines the very mechanisms most essential for implementation success, as evidenced by implementation failures that typically stem from coordination breakdowns rather than regulatory inadequacy (Korhonen et al., 2018).

TABLE 6 Mechanism implementation readiness assessment.

Policy mechanism	Papers (%)	Conceptual development (%)	Operational guidance (%)	Validated tools (%)	Implementation gap score
Regulatory Design	67.0	89	34	12	High
Economic Instruments	19.2	68	21	8	Very High
Coordination Systems	8.0	45	18	3	Critical
Compliance Monitoring	13.8	81	26	12	Very High

4 Research-practice translation gaps and implementation priorities

The research gaps discussed in this chapter emerge directly from systematic analytical patterns established in Section 3. For example, while 67% of government intervention papers address regulatory design, coordination mechanisms receive only 8% coverage—yet real-world success like China's 85% waste diversion rates demonstrates that multi-stakeholder coordination, not regulatory sophistication, drives implementation effectiveness. Bibliometric mapping exposed these imbalances in research distribution, thematic categorization revealed misalignments with policy implementation needs, and temporal–geographic analysis highlighted deficits between theoretical development and operational guidance. Building on the systematic gap identification methodology outlined in Section 2.2.3, this chapter translates these structural imbalances into testable research directions and implementable policy tools (Luo et al., 2021). This transition—from identifying "what gaps exist" to determining "how to address them systematically"—establishes an evidence-based foundation for research investment aligned with government-driven CE implementation in the construction sector (Korhonen et al., 2018).

4.1 Evidence-based gap assessment framework

Government agencies tasked with implementing CE policies face a fundamental problem: adequate research to guide their policy implementation decisions is severely limited. While academics have produced 597 quantitative papers with sophisticated analytical capabilities, they have systematically avoided creating the practical tools that governments actually need to deploy policies effectively.

Researchers excel at environmental impact assessment (43% use life cycle analysis), economic valuation (38% use cost-benefit analysis), and material flow modeling (31% use linear programming). But when governments need to choose between policy alternatives, optimize subsidy amounts, or adapt policies based on real-world feedback, the research falls short. Multi-criteria decision analysis for policy alternatives appears in only 16% of studies (Chen et al., 2023). Sensitivity analysis for calibrating policy parameters exists in just 12% of studies (Suryawan and Lee, 2023). Real-time adaptive management systems receive attention in only 8% of studies (Almusaed et al., 2023).

To quantify this mismatch systematically, Table 7 presents Translation Gap Index values across policy domains. The pattern is stark: International Policy Coordination shows the most severe gap (0.82), followed by Regulatory Compliance Systems (0.74) and Economic Policy Instruments (0.69). These numbers represent measurable barriers preventing the CE transitions governments have committed to achieving—the distance between theoretical understanding and practical deployment capability has direct policy consequences. The systematic assessment reveals consistent patterns across all policy domains: high levels of theoretical development (68%–81% of papers) but dramatic declines toward operational guidance (21%–26%) and validated implementation tools (8%–12%).

This research-practice disconnect has real consequences. Academic incentive structures reward theoretical innovation over implementation guidance (Wu et al., 2023), while data access constraints limit real-world validation. The result is a field with impressive analytical depth that cannot answer basic questions governments face: How much should we subsidize recycling? How do we coordinate across jurisdictions? How do we monitor compliance cost-effectively?

European studies demonstrate systematic implementation approaches (Gálvez-Martos et al., 2018) and stakeholder engagement research reveals critical success factors (Jain et al., 2020), but translation from analytical capability to operational policy tools remains systematically underdeveloped. The framework quantifies this gap to prioritize where research investment can have the greatest policy impact.

4.2 Policy mechanism implementation research priorities

Building on the gap assessment framework, two policy mechanisms require immediate research investment to bridge the theory-practice divide: economic policy instruments and cross-jurisdictional coordination mechanisms. These domains represent the highest-impact opportunities for developing operational tools that governments can actually deploy.

4.2.1 Economic policy optimization and digital integration

Three urgent research priorities can transform economic policy instruments from theoretical constructs into deployable tools. Stochastic optimization models for subsidy allocation

TABLE 7 Research gap assessment using systematic methodology.

Domain	Papers (%)	Translation gap index	Critical deficit areas
Economic Policy Instruments	19.2 (n = 354)	0.69	Subsidy allocation modeling, incentive calibration
Regulatory Compliance Systems	13.8 (n = 254)	0.74	Monitoring frameworks, enforcement strategies
International Policy Coordination	8.0 (n = 147)	0.82	Cross-jurisdictional integration, policy transfer
Implementation Strategy Development	27.6 (n = 508)	0.61	Resource allocation, stakeholder coordination

Coverage percentages are calculated from the 1,842 total papers, with some papers contributing to multiple gap categories. The n-values represent papers with primary focus in each category. Developing Country Context uses Research Intensity Index () measuring output relative to waste generation volumes.

under policy uncertainty can address the documented 15% gap in quantitative allocation methodologies. These models should integrate political feasibility constraints alongside economic efficiency objectives. Regional material flow analysis demonstrates pathways for systematic resource optimization (Gao et al., 2020), while production subsidy frameworks provide economic incentive calibration models (Guo et al., 2022).

Real-time policy calibration systems using IoT sensor networks can bridge monitoring deficits while reducing compliance costs. Digital infrastructure integration addresses implementation monitoring through blockchain applications for waste-to-resource tracking and automated data collection systems. Urban material flow analysis demonstrates potential for CE integration (Lederer et al., 2020).

Adaptive management frameworks enabling iterative policy improvement based on implementation outcomes represent the most critical long-term priority. Research priorities emphasize low-cost, scalable solutions suitable for diverse jurisdictional contexts (Suryawan and Lee, 2023). Municipal agencies should lead deployment, private firms provide data integration, NGOs facilitate community engagement, and academic institutions conduct effectiveness evaluation.

4.2.2 Cross-jurisdictional coordination mechanism development

Network optimization models for multi-stakeholder governance and policy transfer frameworks represent the most urgent coordination research priority. Closed-loop supply chain network equilibrium models provide additional frameworks for policy coordination and resource optimization (Zhou et al., 2021). Current coordination research provides limited guidance for adapting successful policy mechanisms across different regulatory environments, economic contexts, and stakeholder configurations. Barrier analysis reveals implementation challenges requiring systematic coordination approaches (Liu Y et al., 2021).

Network analysis approaches can optimize information flows and decision-making processes across complex governance structures while addressing coordination challenges arising from competing jurisdictional interests and resource constraints. Research priorities include development of institutional design principles for multi-level governance systems and standardized assessment frameworks that address transaction costs and information asymmetries.

Policy learning and knowledge transfer mechanisms require systematic development of evidence-based approaches for disseminating successful implementation strategies across jurisdictional boundaries. Critical success factors for waste management demonstrate requirements for stakeholder engagement and key strategy approaches (Ma Y et al., 2023). These frameworks can accelerate CE implementation through enhanced cross-jurisdictional learning while reducing implementation risks through evidence-based policy design approaches.

4.3 Geographic implementation research priorities

Beyond policy mechanism development, the geographic distribution of research creates both critical knowledge gaps and valuable learning opportunities across different institutional contexts. The most urgent priority lies in addressing the severe underrepresentation of developing countries where construction waste generation volumes far exceed research attention.

4.3.1 Developing country context adaptation research

Brazil and India represent urgent research opportunities with Research Intensity Index values of 0.31 and 0.28 respectively (Kabirifar et al., 2020). These major developing economies generate over 200 million tons of construction waste annually combined yet remain severely underrepresented in policy research. Values below 0.50 indicate critical research gaps relative to construction waste generation volumes and policy development needs.

These geographic gaps create specific implementation imperatives: developing low-cost policy monitoring systems for waste-to-resource tracking in resource-constrained environments, designing informal sector integration frameworks that leverage existing waste management networks rather than displacing them (Benachio et al., 2020), and creating capacity-building models that operate within institutional constraints rather than requiring pre-existing administrative sophistication (Chen et al., 2023).

Informal sector integration represents particularly critical research priority given the substantial role of informal waste management networks in developing country contexts. Hybrid governance frameworks integrating formal regulatory structures with informal coordination mechanisms require systematic

development, while mobile-based reporting platforms could formalize informal actors' contributions without undermining their operational autonomy or economic sustainability.

Capacity building integration within policy mechanism design addresses institutional development requirements while enabling sustainable policy implementation across diverse governmental contexts. Research priorities emphasize systematic institutional capability development concurrently with policy deployment rather than requiring pre-existing capacity as implementation prerequisite (Mayer et al., 2019; Shen et al., 2020; Suryawan and Lee, 2023; Verhagen et al., 2021).

4.3.2 Cross-paradigm policy learning integration

Regional research concentration in policy-leading economies creates valuable opportunities for comparative policy effectiveness research while revealing adaptation requirements for diverse institutional and economic contexts. European research emphasis on regulatory harmonization provides sophisticated frameworks for cross-jurisdictional coordination yet requires adaptation for contexts with different regulatory traditions and institutional capacity levels.

Chinese research leadership in mathematical optimization approaches demonstrates advanced quantitative capabilities for government intervention design yet presupposes data availability and computational infrastructure often absent in developing economy contexts. Research priorities include development of simplified optimization models suitable for data-constrained environments while maintaining analytical rigor and policy effectiveness.

Cross-paradigm integration research addresses the critical gap between different government intervention philosophies. Comparative effectiveness evaluation across paradigmatic approaches can inform evidence-based policy design while addressing contextual adaptation requirements. Policy transfer methodology development represents essential research priority enabling systematic knowledge dissemination across diverse institutional contexts through institutional ethnography combined with policy meta-analysis to identify transferable governance elements and contextual adaptation requirements.

Research demonstrates both the coordination challenges requiring government intervention (Kumar and Agrawal, 2020) and successful government participation frameworks (Shen et al., 2020), yet practical guidance for adaptation across diverse contexts remains severely limited.

4.4 Integrated implementation research priority framework

The convergence of sophisticated analytical capabilities, documented implementation deficits, and urgent policy needs creates a unique historical moment for transforming CE research from academic exercise into governmental reality. The systematic gaps identified across policy mechanisms and geographic contexts are not merely academic concerns—they represent structural barriers preventing the CE transitions that governments worldwide have committed to achieving.

4.4.1 The strategic imperative

Figure 4 presents the strategic prioritization framework across impact potential and feasibility dimensions, revealing a clear roadmap for research investment that can bridge the theory-practice divide. The framework addresses a fundamental paradox: while the field demonstrates impressive analytical sophistication with 32.4% quantitative methodological representation and comprehensive thematic integration across seven policy domains, governments lack the operational tools they need to deploy CE policies effectively.

This misalignment has profound consequences. Government agencies operating under resource constraints and political pressures require decision-support tools that can answer basic questions: How much should we subsidize recycling to achieve cost-neutrality? How do we coordinate waste management across municipal boundaries? How do we monitor compliance without overwhelming administrative capacity? The research community has systematically avoided these practical questions in favor of theoretical advancement, creating a knowledge system that serves academic career incentives but fails policy implementation needs.

4.4.2 A three-tier transformation strategy

The priority assessment reveals three distinct research trajectories that can systematically address this implementation crisis. Tier one priorities enable immediate research investment with demonstrated analytical foundations: mathematical optimization for economic policy calibration building on the 19.2% of papers addressing financial mechanisms, and developing country adaptation frameworks addressing the Research Intensity Index values below 0.30 for major economies like Brazil and India. These represent high-impact, high-feasibility opportunities where existing research capabilities can be rapidly translated into operational tools.

Tier two priorities require methodological advancement but offer substantial policy utility: cross-jurisdictional coordination mechanisms addressing the 0.82 Translation Gap Index, and digital monitoring integration for compliance systems. These medium-term development priorities can transform coordination deficits—the primary cause of implementation failures—into systematic governance capabilities.

Tier three priorities represent long-term transformative potential: comprehensive decision-support ecosystems combining mathematical optimization, digital monitoring, and adaptive management capabilities within unified policy platforms suitable for diverse governmental contexts. These integration priorities require extensive resource coordination but offer the possibility of creating governmental capabilities that can systematically manage CE transitions rather than implementing fragmented policy interventions.

4.4.3 Beyond academic knowledge production

This prioritization framework offers more than research guidance—it provides a template for fundamentally realigning how sustainability research serves societal needs. The Integration Gap Index methodology demonstrates that academic knowledge accumulation without implementation translation creates sophisticated irrelevance. The geographic concentration in policy-leading economies while developing countries generate massive waste volumes with minimal research attention exemplifies how

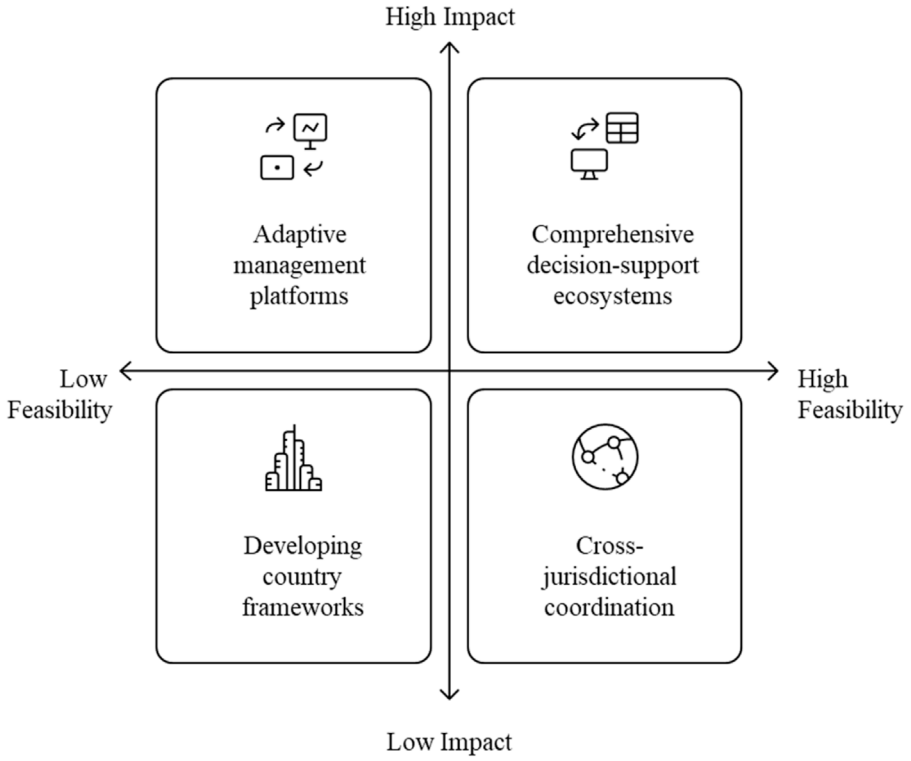

FIGURE 4
Strategic prioritization of government-driven CE implementation research across impact potential and feasibility dimensions.

academic incentive structures can systematically undermine global sustainability objectives.

The research-practice translation readiness emerges from convergence of analytical capabilities, thematic integration, and academic infrastructure, yet this convergence means nothing without systematic commitment to operational tool development. The methodology developed here provides a replicable approach for identifying implementation bottlenecks across policy domains and prioritizing research investments based on governmental needs rather than academic preferences.

5 Conclusion

This systematic mapping study of 1,842 high-relevance papers reveals a fundamental misalignment between research production and implementation needs in government-driven CE transitions. The field has achieved remarkable analytical sophistication while systematically failing to produce the operational tools that determine whether CE policies succeed or fail in practice.

The Translation Gap Index methodology developed here quantifies what policy practitioners have long suspected: academic excellence, as currently structured, often works against practical utility. While 68%–81% of papers achieve theoretical sophistication across policy domains, only 8%–12% produce validated implementation tools. This pattern holds across all seven identified policy domains, with International Policy Coordination (0.82) and Economic Policy Instruments (0.69) showing the most severe deficits.

The geographic analysis reveals another dimension of institutional dysfunction. Research concentrates in policy-leading economies (China 28.4%, EU 31.8%, US 16.7%) while systematically neglecting developing countries where both need and innovation potential are highest. Brazil and India, generating over 200 million tons of construction waste annually, receive 3.7% of research attention. This distribution reflects how knowledge systems can inadvertently reinforce existing capacities rather than addressing urgent gaps.

Perhaps most revealing is the systematic neglect of coordination mechanisms (8.0% coverage) despite overwhelming evidence that implementation success depends more on stakeholder integration than regulatory sophistication. China's 85% waste diversion rates and the Netherlands' 95% regional success demonstrate that coordination effectiveness, not analytical precision, determines sustainability outcomes. Yet coordination research remains the most underdeveloped domain because it requires engaging with political complexity that challenges academic preferences for technical solutions.

This pattern exposes a deeper issue: research communities have implicitly assumed that better analysis produces better policies, ignoring evidence that policy effectiveness depends on managing relationships across diverse interests and institutional contexts. The result is knowledge that is analytically sophisticated but operationally limited.

These findings suggest that current research incentive structures may be fundamentally misaligned with societal problem-solving needs. Academic institutions reward theoretical innovation while policy implementation requires operational tools. This creates systematic bias toward analytical complexity rather than practical utility, with measurable consequences for policy effectiveness.

The documented translation gaps correlate with real-world implementation failures across multiple contexts, from India's 5% compliance rates in construction waste regulations to 60% performance variations across European metropolitan regions with identical technologies. These patterns suggest that research-practice disconnects have tangible consequences for sustainability outcomes.

Study Limitations and Methodological Considerations are evident in the reliance on English-language publications from Scopus and Web of Science (2015–2025), which may underrepresent non-Western innovations and implementation approaches. Additionally, the Translation Gap Index presumes a linear relationship between analytical sophistication and implementation readiness, which might not fully capture the complexity of institutions or account for policy lag effects.

The systematic relevance scoring framework involves subjective assessments of implementation utility that may not reflect all dimensions of practical value. While inter-rater reliability was acceptable ($\kappa = 0.89$), future research should incorporate practitioner validation and multi-language literature inclusion to enhance global applicability.

The path forward requires recognizing that CE transitions represent a test of institutional capacity to coordinate knowledge production with policy implementation. This does not mean abandoning analytical rigor, but rather developing research approaches that integrate theoretical sophistication with operational utility.

Academic institutions could develop incentive structures that reward implementation tool development alongside theoretical advancement. Funding agencies could prioritize co-designed research partnerships that embed analytical capabilities within governmental implementation processes. Policy practitioners could move beyond consultation toward embedded collaboration that builds internal analytical capacity.

The CE transition occurs within a broader context of environmental pressures that require unprecedented coordination across stakeholders, jurisdictions, and policy domains. This study demonstrates that while research communities have developed impressive capabilities for understanding these challenges, translation into operational governmental tools remains critically underdeveloped.

The methodology developed here provides a framework for institutional accountability that can systematically identify where knowledge production serves implementation versus advancement. As governments worldwide commit to CE transitions requiring sophisticated policy coordination, the effectiveness of these efforts may depend less on additional theoretical insights than on transforming existing analytical capabilities into practical tools that can manage implementation complexity systematically and effectively.

The question is not whether societies need more sophisticated analysis of CE transitions, but whether research institutions can develop the operational relevance required to support these transitions when they matter most.

Author contributions

MA: Investigation, Resources, Writing – original draft, Software, Visualization, Validation, Formal Analysis, Data curation, Conceptualization, Methodology, Writing – review and editing. GA: Conceptualization, Supervision, Writing – review and editing, Methodology, Project administration. MG: Project administration, Writing – review and editing, Conceptualization.

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