



Review paper

Governance in built environment: Development and monitoring of circular policies in the sector

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ABSTRACT

The transition toward a Circular Economy (CE) in the construction sector is essential for addressing escalating pressures related to resource scarcity, climate change, and environmental degradation. This study investigates the development and monitoring of circular policies within the built environment by examining international initiatives and evaluating policy instruments through a multi-level governance perspective. A systematic literature review was conducted to identify regulatory frameworks, strategies, and evaluation tools implemented across different regions. The findings reveal that CE policies remain predominantly focused on end-of-life waste management, while upstream strategies—such as design for disassembly, modularity, material traceability, and digital integration—are still underutilized. Most initiatives lack comprehensive monitoring indicators and rarely integrate micro (local), meso (regional), and macro (national) levels in a cohesive feedback loop. The analysis demonstrates that effective CE implementation requires synergistic policy packages supported by robust data, digital technologies, and multi-stakeholder collaboration. The study concludes that advancing circularity in the built environment depends on the development of adaptive, evidence-based policies capable of aligning national agendas with local realities and ensuring continuous evaluation across the construction life cycle.

1 Introduction

Globally, resource consumption continues to rise as both population and income levels increase. According to the McKinsey Global Institute [1], the rapid economic expansion of countries such as China and India could bring nearly three billion people into the global middle class over the next two decades, significantly accelerating the demand for urban infrastructure. The institute estimates that China alone could add each year the equivalent of 2.5 times the total existing floor area of the city of Chicago.

The persistent growth in the demand for and use of natural resources has made these materials increasingly scarce and costly, compromising their long-term availability. Until the twentieth century, governments and companies primarily focused on capital and labor; however, in the coming decades, natural resources will need to be placed at the center of public policies and corporate strategies [2].

According to the One Planet Network [3], countries with large territorial areas and abundant natural resources face fewer pressures to transition toward a Circular Economy (CE) compared with European and Asian nations, which operate under stronger spatial and resource constraints. In

Belgium and the Netherlands, for example, the scarcity of raw materials makes recycling particularly attractive [4]. Figure 1 illustrates the difference between linear, recycling, and circular economies.

Unlike the linear economy—based on extraction, production, and disposal—the CE seeks to reduce and preserve material use, decrease carbon footprints, and establish a balanced relationship among economic, environmental, and social pillars [5]. One of the main barriers to implementing circular strategies in the built environment is the lack of regulatory frameworks and guidance. Guerra [6] identifies the absence of local regulations as a critical gap, noting that such instruments are essential for enabling effective territorial action.

Nonetheless, recent years have seen the development of guidelines aimed at enhancing resource efficiency and promoting the adoption of CE-aligned practices, particularly in Europe and Asia [7]. China, for instance, has introduced CE-based regulations since 2013, including the CE Promotion Law, the CE Development Strategy, and a short-term action plan. In Europe, the European Commission launched its CE Action Plan in 2015 [8].

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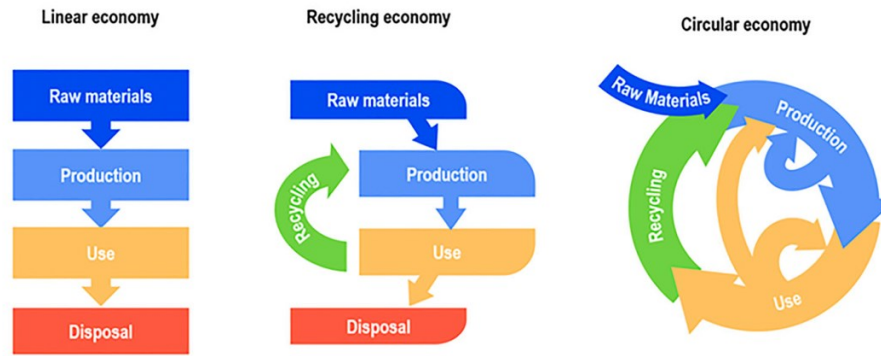


Figure 1. Linear, recycling and circular economies (Downes, 2018).

In the context of construction and demolition (C&D) activities, a significant number of old buildings are being demolished due to inadequacy to contemporary requirements [10]. The substantial volume of waste generated makes increasing recycling and reuse rates an urgent priority.

In the construction sector, regulatory frameworks are widely recognized as essential for guiding market behavior and shaping industry practices [11]. Political leadership is therefore critical for advancing circularity; however, the success of any regulatory instrument depends on the cooperation and commitment of all stakeholders involved [12].

Regulatory instruments can either remove or create barriers. Soininen et al. [13] observe that legal instruments are often oversimplified, offering limited support for the effective adoption of sustainable practices. Policymakers must carefully consider the guidance and acceleration roles of regulations, as well as potential obstacles at each intervention point [14].

The CE offers a promising pathway to address environmental challenges in the construction industry, yet achieving a circular built environment requires strong policy support and governance. Significant gaps remain in the formulation of CE policies in the construction sector [15], and knowledge about instruments capable of enabling an effective transition is still limited [16].

2 Circular policy instruments in the built environment

Across the world, CE policies for the construction sector are emerging, although practical evidence of their implementation remains limited. A critical issue within this global CE landscape is that many policies continue to rely predominantly on conventional regulations associated with the recycling of construction and demolition waste (C&DW) [17].

As highlighted by Hao et al. [18], certain regulations have failed to achieve the desired increases in resource efficiency, let alone generate added value or reach broader socioeconomic objectives. Bolger et al. [19] illustrate this gap by pointing to ambitious national recovery targets for C&DW that do not specify how such levels should be achieved by local actors in practice.

In Italy, for example, although recycling rates are relatively high, the practice of reuse remains limited due to the lack of regulations concerning the quality and performance of secondary materials [21]. Policy integration and harmonization remain underexplored in the built

environment. This challenge is directly linked to the disconnection frequently observed between policy formulation and implementation.

Yu et al. [22] note that policy implementation is generally perceived as a top-down approach, with limited consideration for evaluation and feedback from local actors. Effective policy design and evaluation must incorporate local knowledge and implementation experiences, contributing to refinement and redefinition of subsequent policy agendas. Evaluation is fundamental for establishing a virtuous cycle, ensuring continuous alignment between policy design and the sector's adherence to established parameters [23].

The authors contend that newly proposed policies are never perfect, as information and knowledge remain incomplete during formulation. To improve policy effectiveness, governments must learn from successes, failures, and unexpected outcomes. Moreover, a considerable time gap may exist between policy design and implementation. During this interval, the implementation environment may change—particularly in a sector characterized by long building lifespans and the involvement of multiple actors. Therefore, adaptive policy adjustments are essential to ensure relevance over time [24].

There remains a lack of robust evaluation indicators to assess CE policy performance at different organizational levels [26]. To address this, transparent and collaborative environments are needed in which diverse actors can communicate and assess regulatory measures effectively.

A comprehensive understanding of the entire supply chain is necessary to address the sector's complexity, while the various actors involved must recognize the economic, social, and environmental benefits associated with CE adoption. Policies should shift away from the traditional waste-centered perspective and move toward "designing from waste" regulatory approaches [27].

CE-oriented policies must therefore incorporate this shift: information from actors directly involved should be integrated at the micro level; supply chain evaluations should be conducted at the meso level, with a regional focus; and policy refinement should occur at the macro level, aligned with national agendas [28]. Such a configuration can foster more effective and robust public policy frameworks.

Given the importance of ongoing assessments, as emphasized by numerous authors, this study aims to examine the extent to which CE-related policies and regulatory instruments include mechanisms for evaluation and monitoring.

The effective implementation of circularity requires rigorous consideration of local specificities, the engagement of all actors, and continuous monitoring and evaluation. In a

global scenario marked by resource scarcity, climate change, and escalating environmental degradation, integrating CE practices into urban planning emerges as a promising strategy for building more sustainable and resilient cities [30].

3 Methodology

This study initially conducted a systematic literature review to identify works related to development of circular policies in the construction sector. Identified studies were subsequently screened to determine whether they referenced evaluation or monitoring tools for the policies under analysis.

Diagram 1 illustrates the research steps followed by the study. The procedure followed a structured workflow comprising successive stages of selection and analysis:

Research objective: evaluate the development and monitoring of circular policies within the construction sector.

Literature review: exploratory literature review was performed, complemented by case-study analyses to

capture practical instances of policy development and monitoring.

Study selection: articles were filtered based on their relevance to policy development and the presence of explicit references to monitoring or evaluation mechanisms. Inclusion criteria prioritized studies that discussed both policy formulation and instruments for assessing policy performance.

Descriptive analysis: selected studies were subjected to a descriptive analysis that involved the identification and definition of key variables, followed by the selection of appropriate methods for data analysis. This stage aimed to summarize the scope, objectives, and evaluation approaches of the reviewed policies.

Tool analysis: identified evaluation and monitoring instruments were analyzed through the lens of Yu et al. [31] bidirectional policy-making framework (Figure 2). This analytical step examined how each instrument aligned with micro (local), meso (regional), and macro (national) levels of policy operation and feedback.

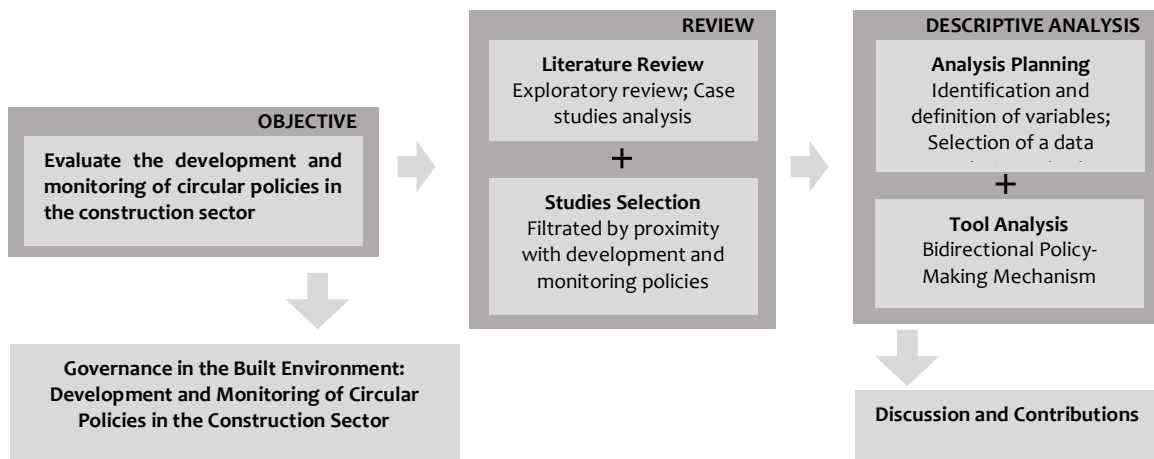


Diagram 1. Research process steps

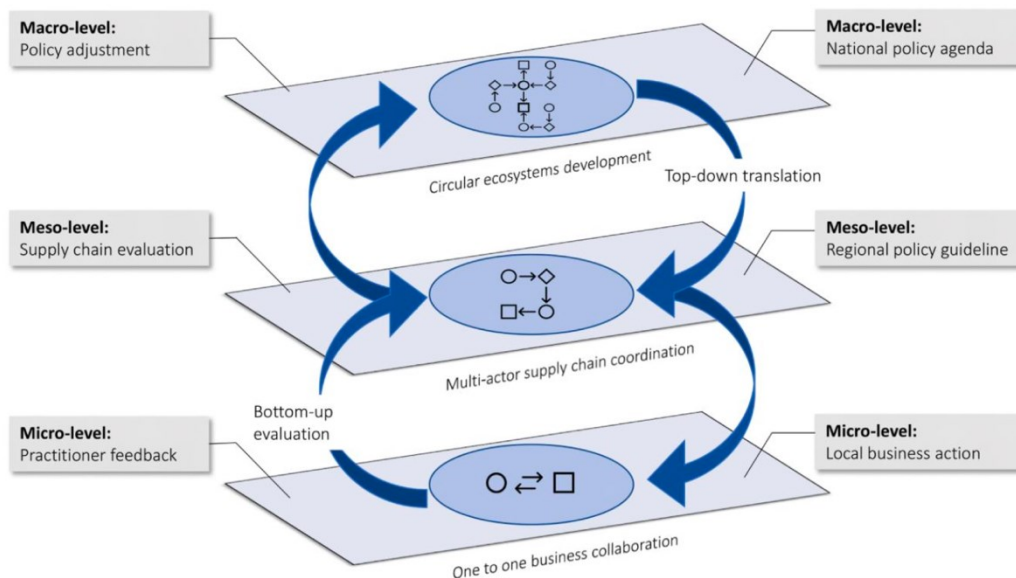


Figure 2. Bidirectional policy-making mechanism (Yu et al., 2022)

Discussion and contributions: Findings were synthesized to inform the governance discourse on circularity in the built environment, highlighting strengths, gaps and opportunities for improving the development and monitoring of circular policies.

4 Analysis of policy instruments and international initiatives

The scientific studies analyzed, which presented examples of policy evaluation and monitoring within the Circular City (CC) context, are briefly introduced below to provide an overarching understanding of how the selected works are grouped. Table 1 synthesizes the articles, emphasizing existing initiatives and their respective strategies, policies, and monitoring mechanisms.

Table 1. Evaluation and monitoring strategies

	INITIATIVE	STRATEGIES	POLICY	EVALUATION / MONITORING
EUROPEAN UNION	CE action plan (2020)	Regulation for construction products: durable, repairable, recyclable, reusable.	Digital passport for products; technological infrastructure; industrial symbiosis; secondary-material markets.	Implementation of CE across different sectors, alignment with the ReSOLVE framework.
NETHERLANDS	CE by 2050	Four levels of transition management: Transition Arenas, Transition Agendas, Transition Experiments, Monitoring and Evaluation	Regional leadership integrating with cross-border strategies; facilitating cross-sectoral partnerships.	Assessment limited by availability and accessibility data; Material flow analysis of construction and demolition.
CHINA	Sustainable use of resources	BIM modeling to reduce waste; Flexible design, prefabrication	Life-cycle monitoring; Regulations for waste prevention; Policies for C&D recycling.	Standardizing practices; Life-cycle monitoring system.
SAUDI ARABIA	Waste management regulation	Regulations for recycling, sustainable practices and quality materials; Reduce impacts of cement and concrete industries; Efficiency in design and construction.	Recycling programs; Collaborative policy development; Energy-performance for new cement factories; Carbon taxes to energy efficiency and technology.	Research institutions to monitor and provide data to actors; Tracking system to monitor C&D waste management; GHG reductions in cement and concrete industries.
FINLAND	Circular Economy in the Built Environment	Expand on CE: develop indicators and measures, stakeholder collaboration.	CE goals for the construction sector; Land Use incorporate CE;	CE implementation monitored; Target for space efficiency; CE activities rewarded.
GERMANY		Integration C&D material stocks; Reduce material demand and increase secondary-material supply by 2030; Policy for CE implementation.	Taxes on primary resources and waste disposal; Environmental awareness in educational curriculum.	Integrating material-flow modeling with stakeholder perspectives; Analysis impacts of CE policies.
HONG KONG		Modular design and deconstruction strategies; Maintenance, dismantling and end-of-life treatments.	Increase reuse of modular components; Recognize steel's recycling potential.	Sobol indices to identify parameters for LCA results.
INDIA		Circular supply chain framework; Integrate smart technologies to CE decision-making.	CE principles when renovating buildings; CE design on urban local governments; CE responsibilities to all levels of governance.	Material flows through IoT; responsible supply chain systems.
UNITED KINGDOM		CE in design, construction, and renovation; Building passports; CE into urban planning processes.	CE s at design stage; Regulatory frameworks for CE adoption; Supportive planning for CE implementation.	CE requirements to the sub-regional level; CE principles into national and local planning policies.

SOMALIA		Integrate CE into national development strategies.	Regulation for construction waste management.	Evaluate results aligned with the 11 pillars of the IG-ADAPT framework.
QATAR		Reduce construction waste via prevention, reuse, and recycling; Adoption of private-sector CE strategies.	Partnerships between research institutions and municipalities; Use of recycled aggregates; C&D waste recycling hubs.	Alignment circular city initiatives with national strategic objectives; Monitoring public-private partnerships in the waste sector.
GHANA		Increase recycling and material recovery rates; Enhance waste management; Market development for secondary materials.	Economic incentives for recycling enterprises; Regulations for responsible landfilling; Guidelines for sustainable C&D waste.	Quantitative analysis and qualitative feedback from stakeholders; Scenario-based modeling for evaluating policy.
DENMARK		Reduce material consumption in construction; Energy efficiency and waste minimization; CE practices across the life cycle.	Landfill taxation; Building renovation to extend lifespan; Guidelines for CE-based building design.	Bottom-up stakeholder input with top-down supply chain evaluation; Monitoring micro, meso, and macro levels, feeding results into policymaking.
SINGAPORE & INDONESIA		Cooperation for CE adoption; Reduce C&D waste and increase recycling; Private-sector participation in circular practices.	Industrial symbiosis; Standards for recycled construction materials; Waste-to-resource industrial networks.	Assessment of cross-border CE collaborations; Performance through life-cycle-based indicators.
CENTRAL AND EASTERN EUROPE		Building renovation and aging stock; CE principles into construction practices; Reuse and recycling of key materials.	C&D waste directives for member states; Harmonization of C&D classification systems; Pre-demolition audits and material passports.	C&D management relation to EU circular transition; Monitoring platforms to assess EU waste directives; Gaps and opportunities for C&D circularity.

The initiatives reviewed highlight a wide range of circular strategies implemented across different regions, including the European Union, Asia, and Africa. Among the regulatory evaluation and monitoring mechanisms examined, tools were identified across the three organizational levels proposed by Yu et al. [32]: micro, meso, and macro. However, one noticeable issue is that many analytical tools only encompass two levels—typically micro and meso—while few incorporate the macro level, which represents national agendas.

Two strong examples that integrate micro and meso levels include: (i) Pilot projects designed to test and advance CE-oriented approaches; (ii) The involvement of local research institutions responsible for monitoring waste management practices and generating data for stakeholders.

Integrating coordination with national-level agendas would support adaptive policy adjustments, offering meaningful feedback to high-level policymakers and reinforcing the policy cycle as a dynamic, iterative mechanism.

A full integration of CE principles is essential for effective policymaking, given that different circular mechanisms are more effective at distinct phases of the construction life cycle. The absence of a universal solution reflects the need to articulate prevention, recycling, and waste management strategies according to project stages. The market competitiveness of secondary materials depends on

reducing recovery costs and ensuring consistent material quality—conditions that necessitate economic policy interventions such as subsidies, tax reductions, and incentives for technological innovation.

A synergistic combination of policy instruments is therefore fundamental to generating value across the life cycle. Additionally, advances in Information and Communication Technologies (ICT) strengthen digital governance by enhancing transparency, collaboration, and traceability, all of which support continuous policy evaluation [33].

5 Discussion

The analysis of international initiatives reveals that the transition toward a CE in the built environment remains uneven and highly dependent on contextual factors such as governance structures, technological capacity, regulatory maturity, and market readiness. While many countries have advanced significantly in establishing CE frameworks—particularly within the European Union—implementation gaps persist, especially in regions where institutional capacity is limited or where regulatory mechanisms remain fragmented.

A notable finding across the reviewed studies is the predominance of waste-centric approaches, despite the well-established understanding that the most effective circular strategies occur upstream, particularly during the design and

planning phases. This persistent focus on end-of-life (EoL) waste management reinforces linear practices, while opportunities for waste prevention, modularization, design for disassembly, and material traceability remain underexploited.

The structure proposed by Yu et al. [34], which organizes policy formulation and evaluation according to micro, meso, and macro levels, proves to be an insightful analytical lens for understanding governance dynamics. However, only a

limited number of countries integrate mechanisms across all three levels:

- Micro level: municipal regulations as pilot projects, local data, life-cycle tracking.
- Meso level: inter-municipal coordination as regional supply chain, interoperability measures.
- Macro level: national policy agendas, legislative frameworks, and long-term CE.

Table 2. Evaluation and monitoring levels

	EVALUATION / MONITORING		
	MICRO LEVEL individual corporate collaboration	MESO LEVEL multi-actor supply chain	MACRO LEVEL development of circular ecosystems
EUROPEAN UNION	Alignment of CE with ReSOLVE framework		
NETHERLANDS	Evaluation limited by availability of material flows and resource use		
CHINA	Department for standardizing practices; monitoring system for life cycle and demolition waste		
SAUDI ARABIA	Local research institutions to monitor C&D and provide data to stakeholders	Achieve significant GHG reductions in the cement and concrete industries	Tracking system to monitor and regulate CDW management
FINLAND	CE implementation will be monitored; definition of target levels; CE activities will be rewarded		
GERMANY	Combining material-flow modeling with stakeholder perspectives to identify effective policy measures, improving efficiency and resource economy		
HONG KONG	Sobol indices identify parameters influencing LCA		
INDIA	Blockchain to life-cycle monitoring, traceability, process automation, closed-loop, recycling and remanufacturing		
UNITED KINGDOM	Multi-level transformative urban model to reshape technology, construction, and waste sectors		
SOMALIA	Real-time monitoring and data-driven decision through circular principles		

QATAR	Monitoring statistics, blockchain applications, and data blocks to support CE in built environment and urban spaces
GHANA	Integrated management of waste influences CE activities
DENMARK	Pilot projects to test and advance CE approaches
SINGAPORE & INDONESIA	Assessment potential for urban mining, recovery, and reuse of building components
CENTRAL & EASTERN EUROPE	Convergence of legislative changes, technological advances and sustainability in design competitions signals a profound evolution in the architecture and construction sector.

The absence of mechanisms connecting these three levels jeopardizes policy coherence. Without structured feedback loops, policies tend to remain generic and disconnected from ground-level realities. This reinforces one of the primary challenges identified in the literature: the lack of iterative cycles that enable continuous improvement, recalibration of goals, and adaptation to emerging conditions.

Moreover, the lack of robust indicators for evaluating CE policies in the construction sector is a recurring limitation. Existing tools often focus on recycling rates or landfill metrics that capture only a fraction of circularity's potential benefits. Broader indicators are needed to assess: resource efficiency gains across the life cycle, material circulation and quality assurance, design-stage circularity criteria, market competitiveness of secondary materials, carbon reduction impacts, and technological innovation related to CE.

Another important trend is the increasing reliance on ICT-based tools, including digital twins, BIM-integrated material databases, IoT tracking devices, and blockchain-enabled material passports, which allow for greater transparency, traceability, and informed decision-making. These tools can strengthen data quality and significantly enhance monitoring systems. However, their adoption remains uneven, often limited by financial constraints, lack of interoperability, or insufficient technical capacity.

Across the global cases examined, economic instruments alone, such as subsidies, tax reductions, and incentives for secondary material use, are not sufficient to drive systemic change. Their effectiveness depends on complementary regulatory, institutional, and informational instruments. Policymakers therefore need to adopt synergistic policy packages, tailored to the life-cycle characteristics of the construction sector, while fostering collaboration between public and private stakeholders.

Although the development and implementation of CE policies in the construction sector have intensified, the

analysis conducted shows that the effectiveness of these approaches, as well as their monitoring mechanisms, could be further improved. The sector still relies heavily on linear models, with a predominant focus on waste management rather than preventive strategies throughout the life cycle.

A key weakness observed is the insufficient integration among local, regional, and national governance levels. The literature demonstrates that the absence of structured feedback mechanisms undermines the adaptation and improvement of public policies.

Significant limitations are also evident in monitoring systems. Recent studies advocate for the incorporation of life-cycle assessments, material traceability, and carbon metrics as more robust control criteria.

Despite the identified gaps, the literature highlights criteria that exemplify good practices, such as multi-level governance integration with coordination across institutional scales; circular design strategies, such as design for disassembly; digital monitoring through BIM, traceability, and data-driven models; policies that combine regulatory and economic instruments; and active stakeholder engagement in policy implementation and evaluation.

The effective transition toward a CE in the built environment depends on life-cycle-oriented approaches, evidence-based adaptive governance, multidimensional performance indicators, and the integration of regulatory, economic, and technological instruments.

Finally, the literature shows that successful CE implementation depends on aligning national strategies with local realities. This means acknowledging the heterogeneity of construction markets, regional material flows, and diverse governance capacities. Only through multi-level coordination, continuous evaluation, and evidence-based adjustments can CE policies achieve lasting and meaningful transformations in the built environment.

6 Conclusions

The CE policy in the construction sector is neither uniform nor particularly advanced, despite a decade of institutional interest. The initiatives reviewed reveal a field caught between aspirational frameworks and operational constraints. Countries that have developed sophisticated regulatory language frequently lack the monitoring infrastructure to assess whether that language translates into material change. Countries with monitoring capacity, conversely, often operate without the upstream design mandates that would make data collection meaningful. This asymmetry points to a structural misalignment in how CE policy for the built environment has been conceptualized.

The predominance of waste-centric approaches across virtually every region examined is the most persistent and arguably the most consequential finding of this review. Recycling rate targets, favored by the EU, Saudi Arabia, Ghana, and Qatar, quantify one narrow slice of circularity. Downstream management of materials have already completed their linear journey through extraction, production, use, and disposal. What such metrics systematically ignore is the regulatory architecture governing material choices at the earliest project stages, where the greatest resource-efficiency gains are available.

Yu et al. [15] established that CE implementation in the construction sector has remained focused on end-of-life waste, while design-stage interventions (design for disassembly, modular construction, pre-demolition audits, material passports), remain marginal in most national frameworks. The cases reviewed here confirms that even among countries with explicit commitments to upstream circularity, regulatory enforcement mechanisms for design-stage compliance are conspicuously absent or voluntary. The United Kingdom's multi-level transformative model represents a partial exception, but its sub-national planning inconsistency limits its scalability. The Netherlands' CE by 2050 strategy is architecturally sophisticated yet constrained, in its own monitoring assessments, by data availability at the material-flow level.

The framework proposed by Yu et al. [34], which organizes CE policy evaluation across micro (local), meso (regional), and macro (national) levels, provides the most analytically productive lens available in the literature for examining the cases reviewed. Its application, however, reveals a pattern more troubling than a simple absence of integration: what exists in many jurisdictions is the formal appearance of multi-level coordination without the operational mechanisms that would make feedback loops functional.

China's case is instructive precisely because it inverts the typical pattern. The national government has deployed a comprehensive standardization and life-cycle monitoring system, while local feedback mechanisms remain structurally subordinated. The result is a top-down policy architecture with significant data-collection capacity but limited adaptive responsiveness to ground-level implementation realities. Denmark demonstrates the opposite configuration. Its pilot-project approach explicitly tests CE interventions at the micro level before generating data for meso-level supply chain evaluation and, ultimately, macro-level legislative adjustment.

Germany's model occupies a middle position that is perhaps the most replicable for industrialized economies outside Northern Europe. Material-flow modeling at the meso level is integrated with stakeholder perspectives to identify effective policy measures, while economic instruments (taxes on primary resources, waste disposal fees) operate at the macro level. The critical weakness, also present in Finland's approach, is the absence of binding design-stage requirements capable of shifting construction market behavior rather than merely adjusting waste management incentives. Germany monitors material flows efficiently but does not yet mandate the design decisions that would make those flows circular rather than linear.

The increasing adoption of ICT-based tools (digital twins, BIM-integrated material databases, IoT tracking, blockchain-enabled material passports) represents one of the more technically coherent trends in the evidence reviewed. India's deployment of blockchain for life-cycle traceability and closed-loop manufacturing, Qatar's use of blockchain and data analytics for CE monitoring in built environments, and Saudi Arabia's real-time C&D waste tracking system all demonstrate that technological capability to monitor circular performance exists and is diffusing beyond high-income contexts. Somalia's case introduces a real-time data-driven governance infrastructure that is documented in a context where the broader regulatory and institutional framework for CE remains absent.

The observation challenges a common assumption in the governance literature, namely that monitoring tools are downstream outputs of mature regulatory systems. The evidence suggests the relationship can be reversed, with implications for policy sequencing. In contexts of limited institutional capacity, investments in digital monitoring infrastructure may generate the evidence base needed to justify and design the regulatory frameworks that should logically precede them. Whether this inversion constitutes an adaptive strategy or a structural limitation depends on whether the data generated is institutionally actionable.

Despite the heterogeneity of the cases reviewed, the evidence converges on a set of criteria that differentiate more advanced CE policy systems from those that remain largely symbolic. These criteria are not merely descriptive of what exists in high-performing jurisdictions. They are operationalizable as benchmarks for evaluating and improving CE governance frameworks in any construction sector. Table 3 synthesizes these criteria, with specific country exemplars and policy implications derived from the evidence reviewed.

Some patterns found could be highlighted:

- Governance integration without instrument synergy produces coordination without policy traction; instrument synergy without governance integration produces locally coherent packages that fail to scale;
- the secondary material market development criterion exposes what may be the most underaddressed structural barrier in the entire policy landscape;
- governance design failure reflects the absence of political commitment to adaptive policy cycles;
- input-oriented evaluation permits governments to claim policy success without demonstrating behavioral change in construction markets.

Table 3. Summary of criteria found in the analyzed cases

CRITERION	DEFINITION	CASES	POLICY IMPLICATIONS
MULTI-LEVEL GOVERNANCE INTEGRATION	Coordinated regulatory mechanisms operating simultaneously at micro, meso, and macro levels	Denmark: pilot projects feeding supply chain evaluation and legislative adjustment; Netherlands: Transition Arenas and formal monitoring	Establish inter-institutional coordination protocols and structured feedback loops between governments levels
UPSTREAM CIRCULAR DESIGN MANDATE	Regulatory requirements for design for disassembly, modularity, and material traceability prior to construction permit issuance	United Kingdom: multi-level integrating technology, construction, and waste sectors; EU: digital product passports and design requirements	Embed circularity criteria in planning permission frameworks; modular prefabrication through procurement standards
DIGITAL MONITORING INFRASTRUCTURE	ICT-enabled traceability systems (BIM, IoT, blockchain) linked to policy evaluation mechanisms across governance levels	India: blockchain for life-cycle and closed-loop manufacturing; Qatar: blockchain and data analytics for CE monitoring; Saudi Arabia: real-time C&D waste tracking	Mandate interoperable digital standards for material passports; invest in shared data infrastructure accessible to all governance levels
SYNERGISTIC POLICY PACKAGES	Combination of regulatory, economic, and informational instruments designed as a coherent system rather than isol	Finland: CE implementation with reward mechanisms and land-use criteria; Germany: material-flow integrated with tax instruments and policy	Replace single-instrument approaches with adaptive packages; establish regular review cycles tied to quantified performance thresholds
SECONDARY MATERIAL MARKET DEVELOPMENT	Policy instruments designed to reduce recovery costs, assure quality of secondary materials, and enable competitive market formation	Singapore & Indonesia: urban assessment for building component recovery; Central & Eastern Europe: legislative reform with deconstruction incentives; Italy: high recycling rates but reuse constrained	Establish quality certification frameworks for recycled aggregates and components; combine landfill taxation with subsidies for secondary material procurement in public projects
ADAPTIVE EVALUATION CAPACITY	Institutionalized mechanisms for continuous policy assessment, including life-cycle metrics, carbon performance, and stakeholder feedback	Denmark: feedback loop integrating local data into national legislative; China: national life-cycle monitoring system for demolition waste; Somalia: real-time data-driven governance through circular digital infrastructure	Develop multidimensional indicator sets beyond recycling rates; institutionalize periodic policy review cycles with mandatory stakeholder input

Advancing CE governance in the built environment therefore depends less on the invention of new policy instruments than on resolving the institutional conditions under which existing instruments are evaluated, revised, and politically sustained. That resolution is, ultimately, a governance challenge rather than a technical one. And it is, by the evidence reviewed here, the challenge most consistently evaded.

The study concludes that the successful implementation of CE in the built environment depends on the continuous alignment of political agendas with local realities, the active participation of stakeholders across all levels, and the establishment of adaptive regulatory systems capable of

evolving alongside technological, environmental, and socio-economic transformations. Only through holistic, coordinated, and evidence-based approaches can CE policies contribute effectively to creating more sustainable, resilient, and resource-efficient cities.

Future research should advance on multidimensional evaluation frameworks, assessing CE performance on construction life cycle, to incorporate design-stage strategies, material traceability, carbon reduction performance, and digital integration. Empirical studies should examine how multi-level governance structures operate in practice, analyzing feedback mechanisms linked to micro, meso and macro-level policy.

CRediT authorship contribution statement

Simone Cassilha: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, review & editing. Sergio Tavares: Conceptualization, Supervision, Validation.

Declaration of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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