



Advancing Circular Economy in Construction: Recycling and Reusing Construction Waste and Demolition Waste for Sustainable Building Development

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ABSTRACT

Original Research Article

The construction industry is one of the largest consumers of natural resources and generators of solid waste globally. Construction and demolition waste (CDW) constitutes a significant proportion of landfill volumes, contributing substantially to resource depletion, environmental degradation, and greenhouse gas emissions. As urbanization accelerates and building lifecycles shorten, the need to minimise waste generation, enhance recycling rates, and transform CDW into valuable secondary resources has become imperative. The circular economy (CE) paradigm presents a transformative approach to addressing these challenges by promoting closed-loop systems and sustainable lifecycle management of construction materials.

This study systematically evaluates contemporary methodologies for the sorting, processing, and repurposing of CDW into high-quality recycled aggregates and alternative building components. Drawing on a comprehensive review of comparative international case studies, material performance testing, and lifecycle assessment data, the research examines the structural integrity, economic viability, and environmental benefits of incorporating recycled CDW materials into new construction projects. Findings demonstrate that well-structured circular practices can divert up to 70% of CDW from landfills while significantly lowering the carbon footprint associated with building material production.

The study highlights critical enablers and barriers to scaling CE adoption and emphasises the urgent need for supportive policy frameworks, regulatory incentives, and industry-wide collaboration. By bridging theoretical principles with practical implementation, this research contributes to the advancement of circular construction practices and supports the transition from the traditional linear “take-make-dispose” model toward a regenerative, closed-loop built environment. Implications for policymakers, practitioners, and future research are discussed.

Keywords: Circular Economy, Construction and Demolition Waste, Waste Management, Material Recovery.

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Introduction

The construction industry is among the most resource-intensive sectors globally, accounting for a substantial share of raw material consumption and generating enormous volumes of construction and demolition waste (CDW). CDW, which includes demolished concrete, broken bricks, used

wood, reinforcement, and other materials from building, renovation, and demolition activities, often constitutes 30–40% of total solid waste in many countries contributes significantly to landfill overuse, resource depletion, and greenhouse gas emissions (Papamichael et al., 2023; Purchase et al., 2022). Traditional linear “take-make-dispose” practices

exacerbate these issues by failing to recover valuable materials and perpetuating environmental degradation amid rapid urbanisation and infrastructure expansion.

Advancing the circular economy (CE) in construction through the recycling and reuse of CDW represents a strategic shift toward regenerative systems. CE principles emphasize keeping materials and components in use at their highest value for as long as possible via strategies such as reduce, reuse, recycle, recover, and regenerate, thereby closing material loops and minimising waste (López Ruiz et al., 2020; Oluleye et al., 2022). This approach not only mitigates environmental impacts but also offers economic benefits through cost savings, new business models, and job creation in the green economy, while supporting the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) (Ogunmakinde et al., 2022).

Research Objective

The primary objectives are:

1. To systematically review, integrate, and critically appraise existing academic research, industry reports, and policy documents on material recycling and reuse in construction and demolition waste management.
2. To explore practical strategies and case-based approaches for recycling and reuse, including innovative techniques, design-for-disassembly methods, material recovery technologies, and supply chain models.
3. To systematically investigate the multifaceted barriers that hinder the widespread adoption of recycling and reuse practices, as well as the key enablers that facilitate successful implementation.
4. To propose a pathway to sustainable building practice by developing a comprehensive, evidence-based strategic framework that outlines phased interventions, policy recommendations, and practical guidelines for transitioning toward sustainable and circular building practice.

Research Questions

Specific research questions include: What are the prevailing frameworks and trends in CE for CDW? What barriers impede adoption across different economic contexts? What assessment tools and future directions can guide effective implementation?

Literature Review

This review critically examines the state of CE adoption in CDW management, with a focus on recycling and reuse practices for sustainable building development. The review is organised thematically: it begins with conceptual foundations

and frameworks, followed by barriers and challenges, strategies and case studies, environmental and economic implications, and finally, assessment methods and future directions. This structure facilitates a logical progression from theoretical understanding to practical implementation and research gaps.

Conceptual Foundations and Frameworks

A foundational theme in the literature is the conceptual shift from linear to circular models in CDW management. Early integrative frameworks highlight the need to embed CE principles across the entire building lifecycle. López Ruiz et al. (2020) conducted a systematic review and proposed a comprehensive model identifying 14 CE strategies distributed across five lifecycle phases.

1. Pre-construction Phase (Design & Planning): This focus on avoidance of waste and entails four (4) Foundational Strategies with the highest Impact.
 - Design for disassembly and adaptability (DfD): Enable easy future deconstruction and component reuse.
 - Selection of durable, recyclable, and low-impact materials: Incorporation of CE principles in tendering, material passports, and lifecycle planning to facilitate future recovery.
 - Modular and prefabricated design: Standardise components for reusability and reduced on-site waste.
 - Lifecycle planning and CE integration in early design: Using tools like BIM to simulate end-of-life scenarios.
2. Construction and Building Renovation Phase: This phase involve three(3) strategies,
 - Waste prevention through efficient material management: Optimise ordering, prefabrication, and just-in-time delivery.
 - On-site sorting and segregation protocols: Maintain material purity for higher-value recovery.
 - Use of reusable temporary elements (e.g., formwork, scaffolding): Reduce single-use resources during execution.
3. Collection and Distribution Phase
 - Optimised separate collection systems by improving logistics for different CDW fractions.
 - Development of secondary material markets and reverse supply chains by Facilitating trading and distribution of recovered materials.
 - Quality assurance and certification of recovered materials: This is to build trust and market acceptability.
4. End-of-Life Phase (Demolition/Deconstruction)
 - Selective demolition and deconstruction techniques — Prioritise careful disassembly over destructive methods.
 - Component salvage and direct reuse planning — Maximise recovery of intact elements (e.g., beams, panels).

5. Material Recovery and Production Phase

- Advanced processing and upcycling technologies by Converting CDW into high-quality secondary aggregates and products.
- Integration of recovered materials into new production cycles: this actually closing the loop by feeding recycled content back into manufacturing.

This framework move beyond the isolated 3 r approach (reduce reuse recycle) to provide holistic systemic model to maximise material value and minimize waste throughout the entire value chain. Therefore has been widely cited as a foundational reference for subsequent CE research in construction (e.g., Oluleye et al., 2022; Papamichael et al., 2023). Building on these foundations. Oluleye et al. (2022) employed a mixed-method approach to analyse research trends, identifying key clusters around **waste minimization** (i.e. reduction, reuse recycling strategies in BCDW), **policy interventions** (i.e. regulatory frameworks, incentives and governance for CE adoption), and **digital technologies** (i.e. BIM, advanced tools for tracking, sorting, and decision support in circular practices)

To complement the above, Ginga et al. (2020) also reviewed material recovery and production processes, demonstrating how recycled aggregates and components can be effectively reintegrated into new construction.

The authors considered CDW as a Resource which accounts for a significant portion of global solid waste (e.g., ~30% or more) and also discuss shifting from a linear "take-make-dispose" model to CE principles of reducing, reusing, recycling, and recovering.

They review the Material Recovery Processes through reuse and recycling techniques for CDW, which include sorting, processing (e.g., crushing to produce recycled aggregates), and reintegration.

Reintegration into New Construction is also a major focus, they demonstrates the feasibility of reprocessing recycled materials (particularly aggregates) into new products like concrete, paving blocks, and other building elements. This evaluates technical viability, performance, and environmental benefits of CE.

The paper presents CE frameworks for material recovery and production, with figures illustrating building lifecycle comparisons (conventional vs. design for deconstruction) and offsite recycling processes. It discusses real-world studies showing effective reintegration and overall effectiveness in reducing CDW. Ginga et al. excels at exploring practical strategies for material recovery and reintegration.

Similarly, Hasibuan et al. (2025) and Ossio et al. (2023) refined the notion of "circular construction," emphasising holistic integration of CE into the built environment. These works collectively establish CE as a multifaceted paradigm

that extends beyond mere recycling to encompass systemic transformation.

Hasibuan et al. (2025) refine circular construction by emphasizing **comprehensive lifecycle integration** and the need for **systemic transformation** at multiple scales (project, organizational, and urban). This was achieved by:

1. **Holistic Lifecycle Coverage:** They expand CE application from end-of-life (demolition/recovery) to the full building lifecycle including early design for disassembly/adaptability, material selection with circular criteria, construction-phase waste minimization, operational efficiency, and end-of-life recovery. This creates closed loops rather than linear processes.
2. **Multi-Level Systemic Approach:** The authors highlight integration across:
 - **Technical systems** — Digital tools (BIM, material passports, traceability tech) for tracking and optimizing material flows.
 - **Organizational/Actor Networks** — Stakeholder collaboration (clients, designers, contractors, recyclers, policymakers) to overcome silos.
 - **Urban/Regional Scale** — Linking individual buildings to city-level material banks and industrial symbiosis.
1. **Beyond Recycling:** They stress higher-order CE strategies (reduce, reuse, remanufacture) alongside recycling. Emphasis is placed on **regenerative design** i.e. buildings that not only minimize harm but actively contribute to environmental restoration (e.g., through adaptive reuse and bio-based materials).
2. **Barriers-to-Enablers Framework:** The paper identifies implementation challenges (regulatory gaps, economic incentives, knowledge deficits) and proposes enablers like performance metrics, certification schemes, and business model innovation (e.g., product-service systems for buildings).

There work establishes circular construction as a **transformative paradigm** requiring fundamental shifts in industry practices and governance.

Ossio et al. (2023) complement this by focusing on contextual and multidimensional integration of CE in the built environment, particularly in diverse socio-economic settings. They achieve refinement through:

- 1 **Multidimensional Definition of Circular Construction:** They define it as an integrated system encompassing environmental, social, economic, and cultural dimensions. It goes beyond material loops but also include social equity (e.g., job creation in reuse sectors) and long-term resilience.
- 2 **Design and Process Integration:** Strong focus on design-stage interventions (e.g., Design for Circularity, modular construction, material passports) that enable downstream

recovery. They advocate embedding CE metrics into building codes, procurement, and project delivery methods.

3 Systemic Transformation Pathways: The authors outline pathways for scaling:

- **Technological Integration** — Combining digitalization with traditional practices.
- **Policy and Governance** — Harmonized regulations that incentivize circular outcomes.
- **Value Chain Reconfiguration** — Shifting from fragmented supply chains to collaborative ecosystems (e.g., reverse logistics for reclaimed materials).

4 Case-Based and Empirical Grounding: Through analysis of real-world examples, they demonstrate how holistic CE reduces environmental impacts while delivering economic value (e.g., cost savings from reuse) and social benefits.

Collective Contribution: From Recycling to Systemic Paradigm

Together, Hasibuan et al. (2025) and Ossio et al. (2023) establish circular construction as:

- **Multifaceted** — Encompassing technical, organizational, policy, and socio-cultural elements.
- **Holistic** — Covering the entire value chain and lifecycle, not isolated phases.
- **Transformative** — Requiring fundamental changes in mindsets, business models, and industry structures rather than incremental recycling improvements.

Barriers and Challenges to Circular Economy Implementation

The shift towards a circular economy (CE) in the construction industry, particularly for recycling and reusing construction and demolition waste (CDW), remains slow despite growing policy support and academic interest. While CE offers substantial environmental, economic, and social benefits, numerous interconnected barriers hinder widespread adoption and acceptability. Mahpour (2018) prioritised barriers using multi-criteria decision analysis, categorising them into regulatory (inadequate policies), economic (high initial costs), technical (quality variability of recycled materials), and organisational domains.

Categories of Barrier

1. Regulatory/institutional,
2. Economic/financial, technical,
3. Organisational/behavioural,
4. Social/cultural dimensions for clarity.

Regulatory and Institutional Barriers

One of the most frequently cited obstacles is the inadequacy of existing policies and regulatory frameworks. Many countries have the policy in place but lack the enforcement standards to achieve CDW recovery targets, material quality certification, or incentives for secondary material use.

Mahpour (2018) prioritised regulatory gaps as a top barrier through multi-criteria analysis, observing ambiguous and insufficient legislation that fails to mandate selective demolition or recycled content quotas. Ferriz-Papi et al. (2024) reinforced this in their systematic review, highlighting non-existent or inadequate regulations in many jurisdictions as a primary challenge to CE implementation.

In emerging economies, enforcement weaknesses exacerbate the issue. Bhavsar et al. (2023) and Awodele et al. (2025) documented how weak governance, corruption risks, and limited institutional capacity in countries like Nigeria impede progress. Even in more advanced contexts, policy fragmentation between design, construction, and waste management authorities creates implementation silos (Khalfan et al., 2026). These institutional shortcomings link directly to downstream challenges, as the absence of clear rules discourages investment in circular infrastructure.

Economic and Financial Barriers

Economic viability remains a critical hurdle. High upfront costs for selective demolition, lack of reliable sorting technologies, and quality testing of recycled materials often outweigh short-term benefits compared to cheap virgin resources and traditional landfilling. The substantial initial capital investment required for modular prefabrication also present a major financial barrier to its adoption. Martin et al. (2024) and Purchase et al. (2022) emphasised that uncertain market demand for secondary materials, price volatility, and long payback periods deter contractors, developers and other stakeholders from engaging in CE. Mahpour (2018) ranked economic barriers highly, including additional transportation and processing costs that make recycled aggregates less competitive.

In developing contexts, limited access to finance for CE technologies and the absence of green incentives or tax breaks further constrain adoption (Awodele et al., 2025). Ferriz-Papi et al. (2024) noted that making a viable business case for waste recovery is particularly difficult for small and medium-sized enterprises (SMEs), which dominate many construction markets. These financial barriers are compounded by perceived risks around material performance and liability, creating a cycle of low investment and slow market development.

Technical and Operational Barriers

Technical challenges centre on material quality, processing capabilities, technical-know-how and supply chain logistics. Recycled CDW aggregates often exhibit variability in strength, contamination, and consistency, limiting their use in high-performance applications (Bayram et al., 2025; Ginga et al., 2020). Papamichael et al. (2023) highlighted difficulties in achieving high-purity sorting on-site and the lack of advanced processing facilities in many regions.

Logistical issues, such as inadequate on-site storage, inefficient collection systems, and long transport distances to

recycling plants, add complexity (She et al., 2024). Integration with existing construction workflows is another constraint; traditional practices generally encourage speed over circularity, making selective deconstruction time-consuming (Eberhardt et al., 2022). Digital tools like BIM can help, but their adoption for CE traceability remains limited (Rong et al., 2025).

Organisational, Behavioural, and Knowledge Barriers

Organisational resistance and lack of awareness represent significant soft barriers. Many stakeholders view CE as an added cost rather than a value-creating opportunity due to insufficient training and knowledge (Oluleye et al., 2022; Hasibuan et al., 2025). Bhavsar et al. (2023) identified behavioural inertia among contractors accustomed to linear practices, while Martin et al. (2024) pointed to low client demand for circular buildings as another major key disincentive.

Supply chain fragmentation further complicates collaboration. Designers, contractors, demolishers, and recyclers often operate in silos with misaligned incentives (Colorado et al., 2022). This lack of integrated project delivery models hinders the implementation of CE strategies across the lifecycle.

Social and Cultural Barriers

Broader social factors include public perception and acceptability of recycled materials most time often viewed as inferior. Limited community engagement in circular initiatives. In some contexts, cultural preferences for new materials and resistance to change slow market acceptance (Nunes & Mahler, 2024).

Interconnections and Systemic Nature

These barriers are highly interdependent. Regulatory gaps fuel economic uncertainty, which in turn discourages technical innovation and organisational change. These barriers are interlinked, creating a complex ecosystem that impedes widespread adoption even where technological solutions exist. Subsequent studies in emerging economies reinforce these findings while adding context-specific layers. Bhavsar et al. (2023) and Awodele et al. (2025) highlight infrastructure deficits, low stakeholder awareness, and weak enforcement mechanisms in regions such as Nigeria and other developing markets. Ferriz-Papi et al. (2024) and Martin et al. (2024), further examine challenges including supply chain fragmentation, market acceptance of recycled products, and behavioural resistance.

As Ferriz-Papi et al. (2024) and Oluleye et al. (2022) note, a systemic approach is required, addressing one barrier in isolation will be insufficient and unproductive. Advancing Circular Economy in CDW management is technically feasible and environmentally beneficial, multifaceted barriers slow its mainstreaming. Overcoming them requires

coordinated policy reform, economic incentives, technological advancement, capacity building, and collaborative business models.

Strategies, Practices, and Empirical Evidence

Transitioning from challenges, the literature explores practical strategies and case-based evidence for advancing CE. Eberhardt et al. (2022) focused on building design and construction strategies, such as design for deconstruction (DfD) and modular approaches that facilitate future reuse. The strategy was to emphasize on reversible connections, standardized components, and material passports to enable easy disassembly without damage and also Prefabricated modules that support adaptability, relocation, and high-value reuse. During their study, the Quantitative LCA shows significant reductions in waste and embodied carbon when DfD/modular designs are used. Case examples demonstrate higher recovery rates (e.g., >90% material reuse potential) compared to traditional demolition.

- She et al. (2024) analysed CE-related strategies in Australian projects to minimise waste generation at source. With the Mixed-methods Methodology, analysis of real Australian construction projects (likely case studies + quantitative waste audits) combined with stakeholder interviews or surveys was done. Their strategy was to Source reduction through better planning, material optimization, and on-site sorting. Also, Integration of CE principles in procurement and project delivery (e.g., targets for recycled content). They quantify reductions in landfill waste and improvements in resource efficiency with the Project-level data showing measurable waste diversion rates and cost savings. They also highlights how local regulations and industry maturity influence outcomes. Their study provides **case-based evidence** from a developed market, demonstrating that front-end strategies (prevention) are more effective than end-of-pipe recycling.

Purchase et al. (2022) and Bayram et al. (2025) evaluated the performance of recycled aggregates and selective demolition techniques.

Purchase et al. (2022) worked on laboratory testing + performance evaluation of recycled aggregate concrete (RAC). They compare mechanical properties (strength, durability), environmental impacts, and economic viability against virgin materials.

Bayram et al. (2025) Focus on selective demolition techniques (vs. conventional). Uses empirical data from demolition projects, including material recovery rates, quality of salvaged components, and integration into new builds.

Both provide quantitative results, recycled aggregates achieving 70-90% of virgin material performance with proper processing; selective demolition increasing recovery rates by

2-3x while reducing contamination. They both offers technical validation and practical techniques, addressing quality barriers to reuse/recycling.

Some case studies illustrate contextual variations. Khalfan et al. (2026) compared policy approaches between the UK and UAE. These examples link barriers to actionable solutions, showing that supportive regulations and technological integration (e.g., BIM for traceability) can enhance recycling and reuse rates (Rong et al., 2025). This theme demonstrates that while challenges are widespread, targeted strategies can yield measurable progress.

Environmental, Economic Implications, and Assessment Methods

CE adoption in CDW management delivers tangible benefits, as evidenced by lifecycle and impact studies. Bayram et al. (2025) quantified reductions in carbon emissions and virgin resource use through selective demolition and recycling. The authors combine empirical project data from selective demolition sites with life cycle assessment (LCA). They compare conventional demolition versus selective approaches, measuring metrics such as CO₂ emissions, energy consumption, landfill diversion rates, and natural aggregate savings. They discovered that Selective demolition and recycling can reduce embodied carbon by 20–40% (depending on material streams) and cut virgin resource extraction significantly, while generating economic returns through avoided disposal costs and revenue from secondary materials. This demonstrates clear environmental-economic synergies, addressing the barrier of perceived high costs by showing net benefits.

Ogunmakinde et al. (2022) explicitly connected CE practices to broader SDG contributions via improved resource efficiency and reduced environmental burdens. Assessment tools play a crucial role in validating these outcomes. Through a **systematic mapping** of CE interventions (reuse, recycling, waste minimisation) against UN Sustainable Development Goals. They use case examples and secondary data to link practices to specific SDGs (e.g., SDG 12: Responsible Consumption and Production; SDG 13: Climate Action; SDG 11: Sustainable Cities). They discover that CE in CDW management advances multiple SDGs simultaneously by lowering pollution, conserving resources, and creating green jobs. This consequentially elevates CE from a technical solution to a **strategic contributor** to global sustainability agendas, useful for policy justification

Assessment Methods and Tools for Validation

Assessment tools are essential for moving from hearsay benefits to evidence-based implementation.

Lovrenčić Butković et al. (2023) reviewed available methodologies for evaluating CE projects. A comprehensive systematic literature review of CE assessment frameworks.

They categorize tools into environmental (LCA), economic (Life Cycle Costing — LCC), social (Social LCA — SLCA), and integrated approaches. They evaluate strengths, limitations, and applicability in construction contexts. They discovered that many tools exist, but fragmentation and lack of standardization hinder widespread use. They recommend hybrid methodologies for holistic evaluation and also provides a critical overview of enablers (standardized tools) and barriers (inconsistent metrics).

Balasbaneh et al. (2025) emphasised Life Cycle Sustainability Analysis (LCSA) to inform decision-making. They apply LCSA; an integrated framework combining LCA (environment), LCC (economy), and SLCA (social) on CDW/CE case studies. This includes scenario modelling for different recycling/reuse levels. LCSA reveals trade-offs (e.g., higher upfront costs but long-term savings) and supports optimized choices (e.g., selective demolition over bulk methods). This offers a practical decision-support tool for stakeholders, which in turn paved way for actionable pathways.

These studies collectively affirm the triple-bottom-line advantages of CE but also stress the need for standardised metrics to enable comparability across projects and regions.

Pathway to Sustainable Building Practice.

Prefabrication and Reusable Formwork Systems in Circular Construction

A key strategy for advancing circular economy principles in construction involves the integration of prefabricated concrete elements and reusable formwork systems during the early design stage. Traditional timber formwork contributes significantly to construction waste, as wooden elements are often single-use or limited in reusability cycles. In contrast, metal and plastic formwork systems, along with modular prefabricated concrete components, enable multiple reuses — sometimes dozens of cycles, thereby drastically reducing reliance on virgin wood resources and minimising overall CDW generation (Cheng et al., 2022; Vandezande et al., 2024).

The designing for prefabrication (DfP) and design for manufacturing and assembly (DfMA) allows for the incorporation of reusable metal or plastic formwork from the conceptual phase. These systems support complex geometries while maintaining structural integrity and facilitating disassembly for future projects. For instance, studies on modular construction highlight how structurally optimised, reusable precast concrete components, combined with automated design and production, can reduce CO₂ emissions by up to 14.6% and promote high-value material loops (Teuffel et al., 2025; Dervishaj et al., 2023).

Reusable plastic formwork, such as PETG-based systems produced through 3D printing or digital fabrication, further exemplifies circular practices by enabling near-zero waste through material recovery and regrinding for subsequent uses. **PETG** (Polyethylene Terephthalate Glycol-modified) is a durable, transparent, and recyclable thermoplastic which has been increasingly explored in **circular economy (CE)** applications for the built environment. It offers a balance of mechanical strength, weather resistance, and processability, making it suitable for modular, reusable, and 3D-printed components. These approaches not only lower wood consumption but also improve site efficiency, reduce labour costs, and enhance quality control compared to conventional on-site casting methods (Material Metabolism studies, 2024). By embedding these methods in the design stage, projects can achieve substantial waste diversion and align with broader CE goals of resource efficiency and closed-loop systems.

Recovery and reprocessing of on-site wood waste for secondary construction applications

Complementing prefabrication strategies, this study underscores the importance of on-site recovery and reprocessing of used wood and bamboo as critical components of circular CDW management. Softwood, hardwood offcuts, and discarded bamboo scaffolding or formwork which often treated as waste. it can be systematically collected, sorted, and upcycled into higher-value products such as MDF board, particleboard, wallpaper, engineered panels, or wood-plastic composites, thereby extending material lifecycles and reducing demand for virgin timber (Balasbaneh et al., 2025; Jahan et al., 2024).

Research on wood cascade utilisation demonstrates that recovered construction wood can be reprocessed into structural or non-structural applications. For example, clean softwood and bamboo residues are suitable for manufacturing plywood, laminated veneer lumber, or decorative wallpaper products after cleaning, resizing, and bonding processes. This approach supports the circular economy hierarchy by prioritising reuse and recycling over energy recovery or landfilling (Vis et al., 2016; Tighnavard Balasbaneh et al., 2026). Studies show that recycling demolition wood into cross-laminated timber (CLT) or particleboard yields significant environmental benefits, including reduced global warming potential and embodied energy compared to virgin material production.

On-site recovery practices, when integrated with selective demolition and digital tracking tools, enhance material traceability and quality assurance for secondary uses. However, challenges such as contamination, inconsistent supply, and the need for standardised reprocessing protocols remain areas of ongoing research. These strategies collectively contribute to minimising wood-related CDW, conserving forest resources, and fostering bio-based circular flows in sustainable building development (Höglmeier et al., 2017; Faraca et al., 2019).

Conclusion and Research Gaps

In summary, the reviewed literature reveals a maturing field with strong conceptual foundations (López Ruiz et al., 2020; Oluleye et al., 2022), well-documented barriers (Mahpour, 2018; Ferriz-Papi et al., 2024), promising strategies and case evidence (She et al., 2024; Purchase et al., 2022), and demonstrated environmental-economic benefits (Bayram et al., 2025; Ogunmakinde et al., 2022). Systematic reviews and bibliometric analyses indicate growing research interest, yet adoption remains fragmented and context-dependent.

Nevertheless, significant gaps persist. There is limited empirical research on long-term performance and scalability of recycled materials in diverse climatic and economic settings, particularly in emerging economies. Integration of advanced digital technologies (e.g., BIM, digital twins) with CE frameworks requires deeper exploration (Rong et al., 2025). Holistic, context-sensitive policy-technology-business model frameworks are underdeveloped, and standardised, actionable key performance indicator KPIs for monitoring circularity across the full CDW lifecycle remain inconsistent (Papamichael et al., 2023; Lovrenčić Butković et al., 2023).

Furthermore, interdisciplinary studies linking CE practices to social equity, acceptability, technical know how, behavioural change, and post-implementation evaluation are scarce.

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