

# INTERVENTIONS FOR CHANGING BEHAVIOUR OF STAKEHOLDERS FOR CIRCULAR ECONOMY ADOPTION IN CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

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**Abstract.** Stakeholder resistance to change remains one of the primary challenges in adopting Circular Economy (CE) principles for construction and demolition waste management (CDWM). While behaviour of stakeholders is dynamic and can be influenced by various interventions, there has been limited research on which interventions are commonly used to derive behavioural change. At the same time, CE is emerging as a promising approach to addressing inefficiencies in current CDWM practices by promoting resource efficiency, waste minimisation, and material reuse. However, for CE to be effectively implemented, it is crucial to understand what interventions can facilitate behaviour change and overcome resistance. This study aims to bridge this gap by identifying commonly used interventions to change the behaviour of stakeholders in adopting CE for CDWM. This paper employs a literature review to identify behavioural barriers and interventions. Pareto analysis is used to identify the most used interventions to adopt CE in CDWM. The results indicate that policy and regulations are the most widely used interventions, followed by stakeholder engagement and education, economic incentives and market development, technological advancements and innovation, and design and construction practices. However, the effectiveness of these interventions has not been extensively tested in real-world applications. The findings offer valuable insights for policymakers, industry professionals, and researchers to revisit their policies, design new practices, and design and implement interventions for changing the behaviour of stakeholders to adopt CE in CDWM.

**Keywords.** Circular Economy, Construction and Demolition Waste, Interventions, Behaviour of Stakeholders

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## 1. Introduction

The construction sector is a major global resource consumer, utilizing approximately 30% of raw materials, 40% of energy, 25% of water sources, and 12% of land (Bilal et al., 2020). Consequently, C&D waste accounts for a significant portion of global waste, contributing over 30% to total waste generation (Wu et al., 2019). The continuous extraction of natural resources to support construction activities accelerates environmental degradation, resource depletion, and greenhouse gas emissions, while also exerting pressure on landfill capacities and ecosystems (Ma et al., 2020; Zhang et al., 2021). Alarming, C&D waste generation is expected to increase by 70% by 2050 if immediate measures are not taken (Kaza et al., 2018).

In response to these challenges, the CE has emerged as a viable solution to mitigate the environmental and economic impacts of C&D waste. CE principles focus on resource efficiency by minimizing waste, promoting recycling, and extending material lifespans (Benachio et al., 2020). The construction sector was the largest contributor, accounting for 38.4% of total waste, followed by mining and quarrying (22.7%), waste and water services (10.5%), manufacturing (10.4%), and households (8.9%) (Eurostat, 2024). Similarly, countries like China and Brazil produced 2.3 billion tons and 100 MT of C&D waste, respectively (Zhao, 2021). In Australia, approximately 75.8 MT of waste was generated in 2020/21,

with construction and demolition materials constituting 25.1 MT (Pickin et al., 2022).

Despite the growing global recognition of CE, its implementation remains hindered by multiple barriers, including stringent regulatory requirements, high costs of recycled materials, lack of market incentives, and stakeholder resistance to change (Urbinati et al., 2021). Stakeholder behaviour is a key determinant of CE adoption, influencing compliance, investment in sustainable practices, and overall industry transformation (Shooshtarian et al., 2022). Factors such as perceived behavioural control, awareness of environmental benefits, and financial constraints play significant roles in shaping stakeholder decisions (Ajzen, 1991; Adabre et al., 2022). While government regulations and policy frameworks aim to facilitate the transition to CE, stakeholders often show reluctance due to economic and operational uncertainties (Bilal et al., 2020).

To overcome these barriers, targeted interventions are required to influence stakeholder behaviour and drive the adoption of CE principles in CDWM. Interventions such as policy incentives, economic instruments, technological innovations, and education programs can play a crucial role in modifying stakeholder perceptions and enabling structural changes within the industry (Shooshtarian et al., 2021). However, there is a lack of comprehensive analysis on which interventions are most effective in changing stakeholder behaviour and overcoming the barriers to CE adoption.

This study aims to fill this gap by identifying the commonly used interventions that change the behaviour of stakeholders in CDWM. Hence, the research provides insights into strategic measures that can accelerate CE adoption, reduce C&D waste, and promote long-term sustainability. The findings will support policymakers, industry practitioners, and researchers in designing tailored interventions to change the behaviour of stakeholders to adopt CE.

## **2. Literature Review**

### **2.1. BEHAVIOURAL CHANGE**

Individual behaviour change is a complex process influenced by a variety of factors that can significantly impact environmental and societal outcomes (Schultz et al., 2018). Behaviour change refers to the modification of human actions and habits, often in response to internal motivations or external stimuli (Michie et al., 2011; Kolb, 1987). Understanding what drives behaviour change is essential for developing effective interventions. In addition, to effectively influence stakeholder behaviour, it is essential to understand the theoretical foundations that explain how and why individuals change their behaviours (Michie et al., 2011). There are approximately 60 behaviour change models, with many of them sharing similar frameworks (Darnton, 2008). Behaviour change models can be categorised into two categories. One category aims on how individual behaviour is shaped by attitudes and beliefs. The second type of model emphasizes how individual behaviour evolves. The first type, which focuses on beliefs and attitudes, is known as knowledge-attitude-behaviour (KAB) models or cognitive decision models. The

latter are referred to as stages of change models or diffusion models. These models are suitable for situations where individuals' beliefs and attitudes evolve, or where individuals progress through various stages and can be categorized within a target population. Numerous models and theories are employed to alter individual behaviour, and the most adopted ones are discussed in Table 1.

*Table 1: Behavioural change theories*

| <b>Theories</b>  | <b>Key concepts</b>   | <b>Connections to CE interventions</b>   | <b>Authors</b> |
|--|---|--|----------------|
| Health Belief Model (HBM)  | Decisions are influenced by perceived threats, benefits, and self-efficacy.                             | Public awareness campaigns and stakeholder engagement programs to enhance knowledge and perceive benefits of CE adoption.      | [1]            |
| Transtheoretical Model (TTM)   | Behavior change occurs in stages, from awareness to active adoption.                                    | Training programs, certification schemes, and structured incentives to guide stakeholders through progressive CE adoption.     | [2]            |
| Diffusion of Innovation Theory   | Describes how new ideas, behaviors, or technologies spread within a population.                         | Economic incentives, technological innovations, and regulatory frameworks encouraging early adopters and industry-wide uptake. | [3]            |
| Evolutionary Game Theory (EGT)   | Decision-making is influenced by strategic interactions within a competitive environment.               | Financial subsidies, landfill levies, and digital material tracking to create incentives for cooperative waste management.     | [4], [5], [6]  |
| Kotter's 8-Step Change Model   | Organizational change follows eight structured steps, from creating urgency to embedding new behaviors. | Phased implementation of CE strategies, policy enforcement, and industry-wide incentives to sustain long-term adoption.        | [7]            |
| Lewin's Change Management Model  | Change occurs in three phases: Unfreeze (prepare), Change (implement), and Refreeze (stabilize).        | Stepwise transition towards CE adoption through regulatory frameworks, training programs, and incentive-based interventions.   | [8]            |
| Elaboration Likelihood Model (ELM)   | Persuasive communication influences behavior through central and peripheral processing routes.          | Tailored communication strategies to address different stakeholder groups and drive CE adoption in CDWM.                       | [9]            |
| [1] (Glanz & Rimer, 2005); [2] (Prochaska & DiClemente, 1970); [3] (Rogers & Smith, 1962); [4] (Osborne & Rubinstein, 1994); [5] (Kahan, 2014); [6] (Camerer, 2003); [7] (Kotter, 1996); [8] (Lewin, 1947); [9] (Petty & Cacioppo, 1986) |   |  |                |

Each of these theories provides a fundamental understanding of how behaviour change occurs and can be influenced. HBM suggests that individuals are more likely to act when they perceive a risk and recognize the benefits of a new behaviour. Applied to CE and CDWM, this means that increasing awareness of the

environmental and economic consequences of construction waste can drive stakeholders toward more sustainable practices. Public awareness campaigns, stakeholder engagement initiatives, and transparent communication of CE benefits align with this model by ensuring that stakeholders understand the importance of waste reduction and resource efficiency. The TTM describes behaviour change as a gradual process, moving through stages from pre-contemplation to maintenance. In the context of CE, stakeholders may initially resist circular practices due to unfamiliarity or perceived complexity. Interventions such as structured training programs, phased certification schemes, and policy incentives ensure a progressive transition, supporting stakeholders at different levels of readiness. By acknowledging that change does not happen instantly, this model supports the need for long-term engagement and reinforcement mechanisms in CE adoption. The Diffusion of Innovation Theory explains how new ideas and practices spread within a community or industry. Early adopters play a critical role in influencing broader adoption, and this is particularly relevant for CE in CDWM. Regulatory interventions, financial incentives, and the promotion of successful case studies help drive the diffusion of circular construction practices. Technologies such as BIM for waste tracking and digital platforms for secondary materials enable industry-wide knowledge sharing and standardization, accelerating the adoption curve. The EGT emphasizes that stakeholder decisions are influenced by competitive interactions and strategic incentives. In CE and CDWM, companies are more likely to adopt sustainable practices if they see economic advantages or reputational benefits. Government-led incentives, such as tax benefits for circular construction, competitive grants, and procurement policies favouring sustainable projects, ensure that adopting CE principles becomes the most beneficial strategy in the long run. Market-driven interventions, such as waste exchange platforms and financial rewards for recyclers, further create a system where circular behaviours are advantageous and self-sustaining. Kotter's 8-Step Change Model provides a structured approach to organizational transformation, making it highly relevant for implementing CE interventions in industries resistant to change. The staged approach of creating urgency, gaining stakeholder buy-in, and embedding CE practices into company policies ensures long-term success. Lewin's Change Management Model simplifies behaviour change into three phases: unfreezing existing practices, implementing change, and reinforcing new behaviours. This model is useful for phased CE implementation, where regulatory frameworks, education, and incentives are introduced progressively to support stakeholder transition. The ELM emphasizes the role of persuasive communication in shaping stakeholder behaviour. Targeted awareness campaigns using both logical (central route) and emotional (peripheral route) appeals can effectively influence different stakeholder groups, increasing CE adoption in CDWM.

Theories highlight that a multi-dimensional intervention approach is necessary to change stakeholder behaviour effectively. Studies emphasize that interventions are crucial in modifying individuals' behaviour (Zhang et al., 2023; Shoostarian et al., 2021). These interventions are categorized into five key areas: (1) Policy and Regulatory Measures, influencing stakeholder behaviour through legal mandates and waste management regulations; (2) Stakeholder Engagement and Education, fostering awareness and participation through training programs and communication strategies; (3) Economic Incentives and Market Development, utilizing financial support, tax benefits, and funding to encourage sustainable

practices; (4) Technological Advancements and Innovation, integrating digital tools and material tracking technologies to improve efficiency; and (5) Design and Construction Practices, promoting circular design principles to minimize waste. Table 2 highlights the diverse range of interventions implemented globally for CE adoption in CDWM.

*Table 2: Interventions to change behaviour of stakeholders to adopt CE in CDWM*

| <b>Common Category</b>  | <b>Interventions</b>  | <b>Countries</b>         | <b>Authors</b>   |
|---|---|--------------------------|------------------|
| Policies and Regulatory Measures  | Mandatory waste segregation laws, landfill taxes, recycling targets                       | EU, Australia, China     | [1], [2], [3]    |
| Stakeholder Engagement and Education  | Stakeholder training programs, public awareness campaigns                                 | UK, Germany, Australia   | [4], [5], [6]    |
| Economic Incentives and Market Development  | Tax credits for recycled material use, grants for CE projects, reduced landfill fees      | USA, Australia, EU       | [3], [7], [8]    |
| Technological Advancements and Innovation   | BIM for waste tracking, digital waste exchange platforms, advanced recycling technologies | Japan, EU, China         | [9], [10], [11]  |
| Design and Construction Practices   | Designing for deconstruction, modular construction, use of recyclable materials           | Netherlands, Germany, UK | [12], [13], [14] |
| 1] (Alhawamdeh et al., 2024); [2] (Ma & Hao, 2024); [3] (Shooshtarian et al., 2022); [4] (Almeida et al., 2022); [5] (Ferriz-Papi et al., 2024); [6] (Ramos & Martinho, 2023); [7] (Tanthanawiwat et al., 2024); [8] (Ghafoor et al., 2022); [9] Karanafti et al., 2024); [10] (Swarnakar & Khalfan, 2024); [11] (Cocco & Ruggiero, 2023); [12] (Antunes et al., 2024); [13] (Santos et al., 2021); [14] (Lederer et al., 2020) |   |                          |                  |

### 3. Methodology

A literature review was conducted using Web of Science and Scopus, two widely recognized academic databases. The literature search was carried out using keywords such as Circular Economy, Construction and Demolition Waste Management, Stakeholder Behaviour, and Interventions. The keyword search was conducted across the article title, abstracts, and keywords. Following the initial retrieval, full-text screening was carried out to confirm the inclusion of studies that met the review criteria. A total of 33 papers were initially identified through comprehensive searches in Scopus (29 papers) and Web of Science (4 papers) using the keywords: "Circular economy" OR "CE" AND "Construction and demolition waste management" OR "CDWM" AND "Interventions". This process initially identified 210 records. After removing 35 duplicates, 175 unique papers remained. Titles and abstracts were screened for relevance, followed by full-text screening of 67 papers. Only peer-reviewed journal articles and conference papers published within the last 10 years (2014–2024) were included, thus, 34 papers were excluded due to being outside the date range or not directly addressing behavioural interventions in CE for CDWM. As a result, 33 studies were included in the final analysis. The last 10 years have seen significant advancements and policy developments in CE and CDWM, making recent studies more pertinent to the current research context (Geissdoerfer et al., 2017). In addition to peer-reviewed

literature, several government reports and policy documents from different countries were analysed to identify interventions implemented at various levels. These reports provided insights into policy frameworks, regulatory measures, and financial incentives to promote CE adoption in CDWM.

The selected literature and policy documents were analysed using a Pareto analysis to determine the commonly used interventions to adopt CE in CDWM. This approach helped identify the most used interventions that facilitate stakeholder behaviour change. Pareto analysis was employed as a statistical technique based on the 80/20 principle (Powell and Sammut-Bonnici, 2015). This principle suggests that 80% of the effects come from 20% of the causes, meaning that a small number of key interventions contribute to most of the stakeholder behaviour change in CE adoption. The literature review provided the basis for classifying interventions into five key categories: Policy and Regulatory Measures, Stakeholder Engagement and Education, Economic Incentives and Market Development, Technological Advancements and Innovation, and Design and Construction Practices. The frequency of each intervention was manually recorded across the 33 selected studies. The frequency refers to the number of studies (out of the 33 reviewed) in which each intervention explicitly appeared as a recommended or implemented strategy to CE adoption in CDWM. A relative frequency analysis was conducted using the formula:

A cumulative percentage was then calculated to determine the proportion of interventions contributing to the overall impact:

The results were visualized using a Pareto chart as shown in Figure 1, where interventions were sorted in descending order of frequency on the X-axis, while the Primary Y-axis represented the number of occurrences, and the Secondary Y-axis depicted the cumulative percentage. The threshold for identifying the most significant interventions was set using the 80/20 rule, where interventions contributing to approximately 80% of the cumulative frequency were considered the most impactful.

#### **4. Findings and Discussion**

Pareto analysis was employed in this study, as shown in Figure 1, to prioritize the most used interventions for CE adoption in CDWM. Given the wide range of interventions identified in the literature, it was essential to determine which interventions are commonly used to change the behaviour of stakeholders to adopt CE in CDWM. By applying Pareto analysis, the study was able to highlight the most frequently appeared interventions from the selected 33 papers and assess their cumulative influence. This is evident from the chart, where the first few categories, such as Policy and Regulations, Stakeholder Engagement, and Economic Incentives, account for a significant portion of the cumulative percentage. The orange cumulative line helps identify the threshold where approximately 80% of the total impact is achieved, highlighting the most critical interventions.

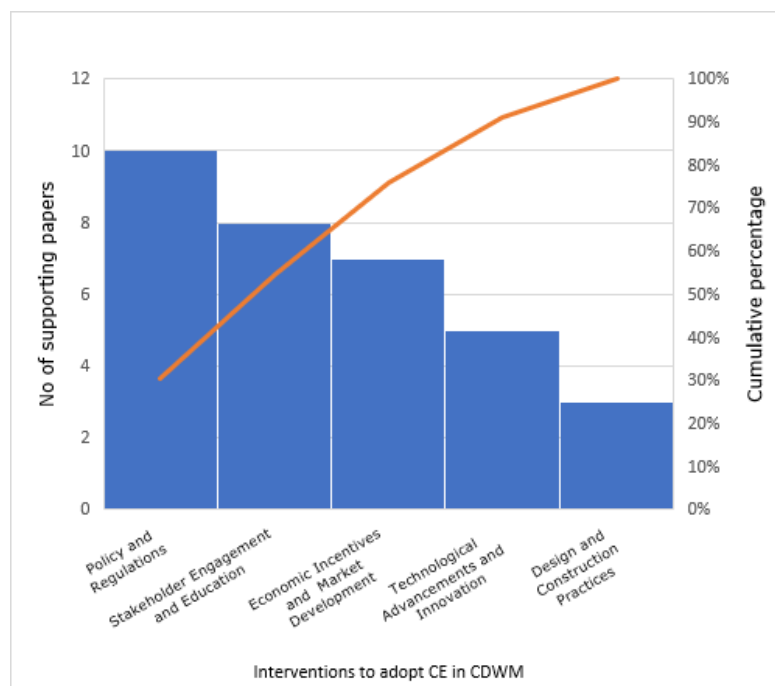


Figure 1: Interventions for CE adoption

#### 4.1 POLICY AND REGULATIONS

This category, supported by 10 papers, was identified as the most significant intervention. This alone accounts for a significant proportion of the total impact, contributing to the highest cumulative percentage on the Pareto chart. Policies and regulatory frameworks are critical in driving CE adoption as they establish the necessary legal and institutional infrastructure to support circular practices. Several countries have implemented regulatory measures to promote CE adoption in CDWM. In the European Union, the Waste Framework Directive enforces waste hierarchy principles, encouraging recycling and reuse (Ferriz-Papi et al., 2024). China has introduced mandatory construction waste sorting policies, which require developers to separate and recycle materials on-site (Ma & Hao, 2024). Australia has adopted landfill levies and extended producer responsibility (EPR) schemes, making it more expensive to dispose of materials in landfills while encouraging product stewardship (Shooshtarian et al., 2022). These interventions primarily address regulatory barriers, such as the lack of policies and standards concerning recovered and recycled materials (Ramos et al., 2023). By enforcing mandatory recycling policies and waste diversion targets, governments create a structured regulatory environment that compels industry compliance. Additionally, these policies mitigate economic barriers, particularly the high cost of recycling, by providing financial incentives for businesses to invest in sustainable practices (Alhawamdeh et al., 2024).

#### 4.2 STAKEHOLDER ENGAGEMENT AND EDUCATION

With support from 8 papers, this category emerged as the second most critical intervention. Countries like the Netherlands and Sweden have implemented public awareness campaigns and professional training programs to encourage circular

construction practices (Gherman et al., 2023). Singapore has introduced mandatory training for construction professionals, ensuring they are equipped with knowledge of sustainable building materials and deconstruction methods (Martin et al., 2024). The UK has integrated CE education into university curricula, ensuring future professionals adopt circular principles early in their careers (Karanafti et al., 2024). Educational programs, workshops, and stakeholder forums help disseminate knowledge about the benefits and practicalities of CE adoption. Almeida et al. (2022) demonstrated that stakeholder training initiatives in Europe led to higher acceptance and implementation of CE practices in the construction sector. These interventions address the lack of technical knowledge, misconceptions about CE benefits, and limited collaboration among stakeholders. Effective stakeholder engagement ensures that all parties, from project planners to waste managers, are informed and motivated to participate in circular practices, thereby promoting a culture of sustainability. These interventions directly address behavioural barriers, including a lack of awareness about CE benefits and negative perceptions about recycled materials (Soto-Paz et al., 2023). By increasing education and engagement, stakeholders are more likely to adopt CE principles and support sustainable waste management practices.

#### 4.3 ECONOMIC INCENTIVES AND MARKET DEVELOPMENT

This category, highlighted in 7 papers, plays a vital role in mitigating financial barriers. Economic incentives play a pivotal role in overcoming the financial barriers associated with CE adoption, particularly the high initial costs and perceived lack of financial returns. Germany has successfully implemented tax reductions on recycled materials, making them more competitive with virgin materials (Tanthanawiwat et al., 2024). In Japan, the government provides subsidies for construction companies that integrate recycled aggregates and low-carbon materials into projects (Almeida et al., 2022). Australia's waste levy schemes make it economically unviable to send construction waste to landfills, pushing companies to adopt circular strategies (Wu et al., 2022). Interventions such as tax incentives for using recycled materials, grants for CE projects, and reduced landfill fees lower the financial burden on construction firms, encouraging them to invest in sustainable practices. Shooshtarian et al. (2022) found that economic incentives in Australia stimulated market demand for recycled construction materials, making circular practices financially attractive. These incentives address behavioural barriers like reluctance to invest in new practices due to financial uncertainty and perceived economic disadvantages of CE materials compared to virgin resources. Moreover, economic instruments promote a competitive market for recycled products, encouraging innovation and fostering a circular supply chain. However, the study by Ramos and Martinho (2021) emphasizes that for economic interventions to be effective, they must be easily accessible and substantial enough to offset the initial costs of CE adoption.

#### 4.4 TECHNOLOGICAL ADVANCEMENTS AND INNOVATION

Supported by 5 papers, technological advancements such as Building Information Modelling (BIM), material recovery facilities, and digital platforms for waste exchange enhance operational efficiency and material reuse. Karanafti et al. (2024) emphasized that BIM facilitates accurate material tracking and management,

reducing waste and enabling efficient recycling. South Korea has adopted Building Information Modelling (BIM) tools, enabling real-time tracking of materials and their potential for reuse (Cocco & Ruggiero, 2023). In Finland, automated waste sorting technology helps separate and recover valuable construction materials, reducing waste sent to landfills (Karanafti et al., 2024). China has developed digital marketplaces for surplus construction materials, allowing contractors to buy and sell reclaimed materials efficiently (Ramos et al., 2023). These technological interventions address operational and site constraints, including lack of time for waste management and limited space for material sorting and storage (Cocco & Ruggiero, 2023). By automating sorting and improving material traceability, technology makes CE adoption more feasible and scalable in construction projects. However, the adoption of these technologies requires significant investment and technical expertise, highlighting the need for supportive policies and training programs.

#### 4.5 DESIGN AND CONSTRUCTION PRACTICES

Although supported by only 3 papers, this category remains critical. The Pareto analysis demonstrated that while fewer studies highlighted this intervention, its impact on design-related barriers is significant. Denmark has led the way with modular construction techniques, where buildings are designed for easy disassembly and reuse (Santos et al., 2021). In Canada, sustainable design guidelines promote the use of low-impact and recycled materials in building projects (Lederer et al., 2020). Austria has mandated pre-demolition audits, requiring developers to assess materials for potential reuse before demolition (Bao & Lu, 2020). These interventions address design-related barriers like lack of circularity in construction designs and limited use of recyclable materials. By integrating circular principles from the project inception, construction firms can ensure that materials are reused and recycled efficiently at the end of a building's lifecycle. However, widespread adoption of circular design practices requires changes in design standards, professional training, and industry-wide collaboration.

### 5. Conclusion

This study provides a comprehensive analysis of interventions aimed at promoting CE adoption in CDWM. By employing systematic literature review and conducting a Pareto analysis, the study identifies key intervention categories, including policies and regulatory measures, stakeholder engagement and education, economic incentives and market development, technological advancements and innovation, and design and construction practices. The top three intervention categories, policies and regulations (supported by 10 papers), stakeholder engagement and education (8 papers), and economic incentives and market development (7 papers) are cumulatively represented around 80% of the intervention frequency across the 33 selected studies. These are the most used interventions, addressing major behavioural barriers such as resistance to change, lack of awareness, and financial constraints. Technological innovations and sustainable design practices further support CE adoption by enhancing operational efficiency and promoting material reuse. The findings emphasize the need for an integrated approach that combines

regulatory frameworks, economic support, technological solutions, and stakeholder collaboration to achieve sustainable CDWM practices. This study contributes to the existing body of knowledge by outlining the most used interventions and providing insights into overcoming behavioural barriers, thereby facilitating the transition to a circular economy in the construction sector. A key limitation of this study is that it is based solely on a systematic literature review and does not involve testing the identified interventions using real-life data. As such, while the frequency analysis highlights which interventions are most proposed in literature, it does not confirm their effectiveness or impact in practice. Future research can focus on empirical validation of the identified interventions through stakeholder surveys or simulation-based methods. This would allow researchers to assess not only the theoretical relevance of each intervention but also its practical influence on stakeholder behaviour to adopt CE in CDWM.

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