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CRITICAL PERSPECTIVES ON THE ADOPTION OF CIRCULAR DESIGN STRATEGIES IN THE BUILT ENVIRONMENT FOR SUSTAINABLE DEVELOPMENT IN SUB-SAHARAN AFRICA

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ABSTRACT: *Adopting circular design strategies (CDS) in building development presents a transformative approach toward sustainability by promoting resource efficiency and reducing environmental impacts. This paper examined the current landscape of CDS adoption, focusing on barriers, enablers, benefits, and critical success factors within the built environment (BE) in Sub-Saharan Africa. Drawing on a comprehensive review of global contexts literature, the study identifies and categorizes 185 factors, subsequently pruning them to 121 pertinent to the design stage. Barriers such as low awareness, regulatory gaps, and economic constraints are explored alongside enablers like leadership commitment, technological innovation, and supportive policies. The paper underscores the pivotal role of these factors in shaping sustainable building practices, emphasizing the need for tailored strategies to overcome local socio-cultural, economic, and technological challenges in the BE of Sub-Saharan Africa. This research contributes a nuanced understanding of how CDS can be effectively integrated into the BE, offering practical implications for policymakers, industry stakeholders, and researchers striving to embrace sustainable practices.*

KEYWORDS: Sustainable Development; Circular Design Strategies; Built Environment; Sub-Saharan Africa.

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INTRODUCTION

Circular Economy (CE) is a crucial global sustainability trend, valued for optimizing resources, minimizing extraction impacts, and promoting efficient resource use. It represents an industrial business model that aims for waste-free systems through regenerative and restorative approaches characterized by intentional and meticulous design. CE is necessary to shift from the current linear economy (LE) model in the built environment (BE), which is unsustainable due to rapid resource depletion driven by global population growth (Shooshtarian et al., 2022). Parts of Asia and majorly Africa are expected to experience significant population increases, necessitating more infrastructure and buildings. This could lead to higher resource consumption and environmental degradation if resource-efficient building solutions are not implemented (Dabaieh et al., 2021; Ezema et al., 2015). Proactive measures are needed to develop resource optimization solutions in the Architecture, Engineering, and Construction (AEC) sector, especially in Sub-Saharan Africa, where there are limited scientific studies on adopting CE resource optimization strategies (Dabaieh et al., 2021; Ezema et al., 2023). CE can help achieve sustainability goals in Sub-Saharan Africa, as demonstrated in developed countries in the European Union (EU), Asia, and the Americas (Attia et al., 2021; Manninen et al., 2018; Ogunsanwo & Ayo-Balogun, 2020). Within the different phases of implementation in the AEC sector, the design stage is the most effective and efficient phase to accommodate innovations that could have maximum impact.

Central to CE is the adoption of circular design strategies (CDS), which advocate for a shift from the traditional LE to a regenerative model that minimizes waste and maximizes resource utilization across the lifecycle of buildings (Ghisellini et al., 2018; Kirchherr et al., 2018). Despite global imperatives to transition towards sustainable building practices, integrating CDS may face multifaceted challenges within developing countries' sociocultural, economic, and technological landscapes. The BE, encompassing construction, operation, and demolition phases, accounts for significant resource consumption, waste generation, and environmental degradation worldwide (Minunno et al., 2020). In response, CDS offers a systematic approach to design and construction, prioritizing reducing, reusing, and recycling, thereby contributing to sustainable development goals (SDGs) such as SDG 11 (sustainable cities and communities), SDG 12 (sustainable consumption and production), and SDG 13 (climate action) (Purchase et al., 2021). Understanding the barriers, enablers, benefits, and critical success factors (CSFs) that influence CDS adoption within distinct geographical and economic contexts is essential for developing strategies that foster sustainable building practices (Alhosni & Amoudi, 2019; Çetin et al., 2021). The context of Sub-Saharan Africa presents more pressing concerns.

Sub-Saharan Africa, experiencing rapid urbanization, faces escalating challenges related to resource scarcity, environmental degradation, and urban sprawl (Ogunmakinde & Olanrewaju, 2020). This research addresses critical gaps in current literature that predominantly explore CDS adoption in developed economies by focusing on the design phase of building development in the BE of Sub-Sahran Africa, characterized by unique socio-cultural, economic, and technological dynamics (Okafor et al., 2020; Wuni et al., 2021). By identifying barriers, enablers, benefits, and CSFs specific to this context, this study provides a comprehensive framework for developing targeted policies, regulations, and incentives that promote CDS adoption. The findings are pivotal for policymakers and industry stakeholders seeking to enhance sustainable practices within the BE. Additionally, the research provides actionable insights for design firms (DFs), equipping them with the knowledge to navigate

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challenges and leverage opportunities associated with CDS, empowering them to innovate sustainably and competitively.

MATERIALS AND METHODS

This study employed a traditional literature review methodology to synthesize and analyze scholarly literature on adopting CDS in the BE. The review focused on peer-reviewed articles, books, conference papers, and reports published between 2010 and 2023 to capture recent developments and trends, with particular attention to insights applicable to developing economies. The literature search used academic databases such as Scopus, Web of Science, and Google Scholar. Keywords included "Circular Economy," "Circular Design Strategies," "Built Environment," "Barriers," "Enablers," "Benefits," and "Critical Success Factors," among related variations. Inclusion criteria prioritized studies addressing CDS adoption in building design and construction, focusing on barriers, enablers, benefits, and CSFs relevant to the design phase. Articles were screened based on title, abstract, and full-text review. Data extraction captured critical findings on the barriers hindering CDS adoption, enablers facilitating implementation, benefits accrued, and CSFs influencing successful adoption. The data were synthesized thematically to identify recurring themes and categorize factors.

Researchers have grouped these factors into various dimensions for clarity (Bilal et al., 2020). Standard categorizations include environmental, economic, socio-cultural, educational, technical, technological, regulatory, political, and organizational dimensions (Charef & Emmitt, 2021; Cruz Rios et al., 2021; Torgautov et al., 2021). Other classifications, such as managerial, customer, structural, and operational groupings, have been proposed by Gupta (2019) and Hossain and Khatun (2021). Selman and Gade (2020) emphasized collaboration, while Çetin et al. (2021) categorized factors by sector, and Adams et al. (2017) by building lifecycle stages as presented in Table 1. This study adopted eight groupings like Cruz Rios et al. (2021) for their comprehensive approach. Detailed categorizations are provided in Tables 2, 3, 4, and 5 for barriers, enablers, benefits, and CSFs of CDS adoption, respectively. Initially, 185 factors were identified from the literature review. After deduplication, merging similar factors, and aligning them with the study context, the list was refined to 121 factors: 26 barriers, 31 enablers, 31 benefits, and 33 CSFs.

Table 1. Grouping of Factors Influencing CDS Adoption

Reference	Grouping	Number
Debacker *et al.,* 2017	Governmental, economic, environmental, behavioral, societal, and technological	6
Torgautov *et al.* 2021	Political, economic, social, and technological	4
Urbinati *et al.*, 2021	Technical/informational/technological, economic/financial, organizational, supply chain/customer management, political, and environmental	6
Alhosni & Amoudi, 2020; Hossain & Khatun, 2021	Institutional/regulatory, technological/material, social/cultural, and market/economic/financial	4
Ghisellini *et al.,* 2018	Economic, political, legislative, informative, and managerial	5

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Charef & Emmitt, 2021; Charef *et al.,* 2021; Morel *et al.,* 2021	Technical, organizational, political, sociological, economic, and environmental	6
Kirchherr *et al.,* 2018	Cultural, regulatory, market, and technological	4
Hossain *et al.,* 2020	Environmental, economic, management/behavior, technological, social, innovation, and policy	7
Selman & Gade, 2020	Economic, collaboration, policies, social, and technical	5
Masi *et al.,* 2018	Financial, institutional, infrastructural, societal, and technological	5
Çetin *et al.,* 2021	Social/cultural, organizational, financial, sectoral, technical/technological, regulatory	6
Gupta, 2019	Financial, structural, operational, attitudinal, technological, cultural, regulatory, market, and environmental	9
Hart *et al.,* 2019	Cultural, regulatory, financial, and sectoral	4
Cruz Rios et al. (2021)	Economics, educational, regulatory/legal, technical, socio-cultural, technological, organizational, and environmental	8

The analysis of synthesized findings revealed patterns, contradictions, and gaps in the literature on CDS adoption in the BE. The study focused on the influence of socio-cultural, economic, and technological factors, among others, on the uptake of circular design principles in Sub-Saharan Africa, contrasting these with global trends. Comparative analysis across geographical contexts highlighted contextual factors shaping CDS adoption dynamics.

RESULTS AND DISCUSSION

Successful long-term implementation of innovations requires thoroughly examining their opportunities, challenges, drivers, and outcomes (Rahla et al., 2021; Debacker et al., 2017). Barriers to adopting CDS in the BE include inadequate governmental support, infrastructure needs, economic incentives, and a limited understanding of recycled and reused materials (Dunmade et al., 2019; Knoth et al., 2022; Rahla et al., 2021). Literature reveals that barriers, enablers, benefits, and CSFs significantly influence CDS adoption in the BE (Dunmade et al., 2019; Knoth et al., 2022; Rahla et al., 2021).

Barriers to CDS Adoption

In the literature, barriers are recognized as factors that impede the adoption and implementation of CDS in building development (Hossain & Khatun, 2021). These barriers vary by local context and have been extensively documented (Bilal et al., 2020; Guerra & Leite, 2021; Hossain et al., 2020; Torgautov et al., 2021) as presented in Table 2.

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Table 2 Barriers to the CDS Adoption

Grouping	Variable	References
Economic	High upfront costs and unclear financial case	Guerra & Leite, 2021; Charef & Emmitt, 2021
	Limited Schedule and project timeline	Guerra & Leite, 2021
	Low price of virgin materials	Zu Castell-Rüdenhausen et al., 2021; Cruz Rios et al., 2021
	Short-termisim of clients who expect a quick return on investment	Cruz Rios et al., 2021
Educational	Lack of awareness, empirical knowledge, and clarity on what CDS entails among design practitioners	Guerra & Leite, 2021; Torgautov et al., 2021; Charef & Emmitt, 2021; Mahpour, 2018; Cruz Rios et al., 2021
	Lack of training and education on CDS	Tirado et al., 2022; Gupta, 2019; Hartwell et al., 2021
Regulatory / Legal	Lack of CE regulations, policies, fiscal incentives, and implementation guidelines	Guerra & Leite, 2021; Hossain et al., 2020; Tirado et al., 2022
	Low green building rating system points for CDS	Cruz Rios et al., 2021
Technical	Complexity of green building design	Mahpour, 2018
	Design constraints for reclaimed materials use	Charef & Emmitt, 2021; Mahpour, 2018
	Uncertainty about future spatial needs	Cruz Rios et al., 2021
	Structural over-dimensioning when using salvaged materials	Cruz Rios et al., 2021
	Lack of bio-based construction materials and components	Cruz Rios et al., 2021
Socio-Cultural	Lack of client/user's interest and awareness	Çetin et al., 2021; van Bueren et al., 2019
	Issues associated with the aesthetic quality of the architecture with reused materials	Charef & Emmitt, 2021; Rios et al., 2021; Hartwell et al., 2021
technological	Data unavailability and inaccessibility	Charef & Emmitt, 2021; Torgautov et al., 2021
	Lack of digital tools and logistics systems	Tirado et al., 2022
	Lack of circularity metrics and EOL information in existing design tools	Cruz Rios et al., 2021
	Existing design for disassembly (DfD) tools are not building information modelling (BIM)-compliant	Cruz Rios et al., 2021
	Limited visualization capacity for DfD	Cruz Rios et al., 2021
Organisational	New design approach issues	Charef & Emmitt, 2021
	Teamwork, new responsibilities, and multidisciplinary collaboration	Charef & Emmitt, 2021;Tirado et al., 2022
	Hesitant firm culture change	Bilal et al., 2020; Gupta, 2019
	Environmental benefits of reuse are not guaranteed	Cruz Rios et al., 2021

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Environmental	Not all materials can be environmentally effectively recycled	Cruz Rios et al., 2021
	Environmental case of CE is poorly understood	Cruz Rios et al., 2021

Understanding these barriers is crucial for achieving sustainable design solutions (Liu et al., 2021). Adams et al. (2017) identified ten significant barriers in the AEC sector in the United Kingdom (UK), with the lack of market mechanisms for end-of-life recovery and insufficient incentives for end-of-life design being the most critical. Bilal et al. (2020) found twelve primary barriers in developing countries, grouped into seven dimensions of CE, highlighting a modest 58% CE implementation level. In developing countries, waste management, 3Rs, and emissions are the lowest-performing indicators, while energy efficiency receives the most attention (Kirchherr et al., 2018). Cultural barriers are primary challenges for CE implementation (Guerra & Leite, 2021). In the United States of America (US), barriers include regulatory absence, lack of awareness, resistance to change, financial constraints, and project timelines (Guerra & Leite, 2021). Similar barriers, such as low awareness and resistance to change, were identified in studies in Taiwan (van Bueren et al., 2019), Sri Lanka (Wijewansha et al., 2021), and Kazakhstan (Torgautov et al., 2021).

Masi et al. (2018) revealed that resource and energy efficiency practices are more commonly adopted than green purchasing practices, with economic concerns being significant barriers. In Nigeria, barriers to waste minimization in building design include lack of training, unclear stakeholder responsibilities, and low client interest (Olanrewaju & Ogunmakinde, 2020). Mahpour (2018) categorized barriers into behavioral, technical, and legal dimensions. Regulatory and institutional barriers are significant obstacles in Bangladesh's building sector (Hossain & Khatun, 2021). These studies highlight the diverse perspectives on barriers to CE uptake, reflecting the varied challenges across different economic contexts and sectors (Çetin et al., 2021). Regulatory constraints, bureaucratic complexities, and infrastructural deficiencies are significant barriers requiring targeted investments and strategic partnerships (Gupta, 2019; Adams et al., 2017). Economic barriers, such as perceived higher upfront costs and lack of financial incentives, hinder CDS adoption (Guerra & Leite, 2021; Kirchherr et al., 2018).

To address these barriers, integrated project delivery, incorporating CDS into technologies like BIM, systems thinking, interdisciplinary collaborations, and circular procurement management are recommended (Cruz Rios et al., 2021; Suleman et al., 2023). Circularity and green certifications should be reinforced by government regulations (Guerra & Leite, 2021; Hartwell et al., 2021). Green Building Councils in Sub-Saharan Africa should develop local context-driven circularity performance assessment systems, and existing certifications should assign more weight to circularity. Government investment in prefabrication and off-site construction factories can also reduce CDS adoption costs.

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Enablers of CDS Adoption

The section discusses the factors that facilitate the adoption of CDS in building developments, as presented in Table 3. Alhosni and Amoudi (2019) highlight the importance of understanding these enablers to accelerate circularity. Kanters (2020) found that client interests, attitudes, and directives significantly drive the circular building sector by aiding decision-making processes among European architects and consultants. Çetin et al. (2021) identified 26 enablers within Dutch Social Housing Organizations, emphasizing leadership support, cost-effective circular materials, research and development (R&D) innovations, technological advancements, and CE incentives across various dimensions. Organizational enablers were deemed crucial, especially those addressing energy transitions and shifts from linear to circular systems.

Gupta (2019) emphasized public-private partnerships in India as key to achieving circularity. Hart et al. (2019) reviewed literature identifying 20 enablers across sectoral, financial, regulatory, and cultural domains, particularly emphasizing cultural and market aspects. Adams et al. (2017) underscored the importance of a clear business case and the development of tools, metrics, and design guidelines for CDS adoption in the UK. Guerra and Leite (2021) pointed to data availability, training, cultural shifts, voluntary stewardship, and CE policies as key drivers in the US-built environment. Alhosni and Amoudi (2019) also identified 20 drivers in Oman's built environment, emphasizing government regulations, public awareness, public-private partnerships, and recovery infrastructure development. Strong leadership commitment is pivotal for driving organizational change towards sustainability (Çetin et al., 2021). Firms with proactive leadership in integrating CE principles exhibit higher resilience and competitive advantage (Kanters, 2020). R&D initiatives are crucial for advancing technological innovations and sustainable materials essential for CDS (Purchase et al., 2021).

Table 3 Enablers of CDS Adoption

Group	Variable	Source
Socio-cultural	Best practice case studies and pilot projects	Çetin et al., 2021; Hart et al., 2019
	Clients interest in circular building	Kanters, 2020; Hart et al., 2019
	Exercising leadership, raising public awareness, and educating stakeholders	Cruz Rios et al., 2021
	Integrating CE in contractual requirements for design	Cruz Rios et al., 2021
	Public-private partnerships and longer-term relationships	Gupta, 2019; Alhosni & Amoudi, 2020
Technological	Enabling technologies for recovery and digital marketplaces for secondary materials	Adams et al., 2017; Çetin et al., 2021
	Development of a circular procurement system	Çetin et al., 2021; Hart et al., 2019

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	Integrating Circular design strategies to ICT (GreenBIM use)	Hentges et al., 2021
Economic	Lower cost of circular materials and urban mining	Çetin et al., 2021
	Financial incentives to use secondary materials	Olanrewaju & Ogunmakinde, 2020
	Sufficient funding for circular-designed projects	Çetin et al., 2021
	Developing Whole life costing on circular design strategies for business case	Hart et al., 2019; Adams et al., 2017; Çetin et al., 2021
	Tax benefits for circular design strategies, demolition, and carbon taxes	Hentges et al., 2021; Cruz Rios et al., 2021
	Circular business models (CBMs)	Hart et al., 2019
Educational	CE training, education, and workshops	Olanrewaju & Ogunmakinde, 2020
	Professional awareness-raising events	Alhosni & Amoudi, 2020
Organisational	Commitment and support from top management	Çetin et al., 2021
	High priority on circularity within the organisation	Çetin et al., 2021
	Collaboration of internal teams	Çetin et al., 2021
	Research and development innovation	Çetin et al., 2021; Hart et al., 2019
	Integrating LCA into Design tools and circular design strategies	Hart et al., 2019; Adams et al., 2017;
	Organisations' cultural change	Guerra & Leite, 2021
	Assigning CE consultants to assist design	Cruz Rios et al., 2021
Regulation/ Legal	CE regulations, policies, market-based incentives, and action plans	Çetin et al., 2021; Olanrewaju & Ogunmakinde, 2020;
	Development of standards and improving current methodologies for assessments	Çetin et al., 2021; Hart et al., 2019; Hentges et al., 2021;
	Zero-waste policies	Cruz Rios et al., 2021
Technical	Complex design solutions	Torgautov et al., 2021

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	Developing Design standardization for reused and recycled building components	Torgautov et al., 2021
	CDS data availability for decision-making	Guerra & Leite, 2021
	Popularization of stewardship programmes and allocating more points to CDS	Guera & Leite, 2021; Adams et al., 2017; Hentges et al., 2021;
	Interdisciplinary and multidisciplinary collaboration among sector parties	Çetin et al., 2021; Hart et al., 2019; Hart et al., 2019

Collaboration between academia, industry, and government agencies accelerates CDS adoption through knowledge sharing and technology transfer (Wuni & Shen, 2022). Regulatory support, including policies incentivizing sustainable practices and penalizing environmental degradation, is fundamental for CDS adoption (Alhosni & Amoudi, 2019). Government-led initiatives promoting green building certifications and sustainability standards are also vital (Ghisellini et al., 2018).

Practically, design firms should receive training in leadership skills for effective stakeholder management (Suleman et al., 2024). Architects play a central role in the transition by fostering collaboration. Regulatory bodies in Sub-Saharan Africa, like the Architects' Registration Council of Nigeria (ARCON) and the Council for the Regulation of Engineering in Nigeria (COREN), could incorporate CDS training into their continuing professional development programs (CPDPs). Design firms should establish internal mechanisms for CDS implementation, fostering stakeholder commitment, especially from clients. Top-down approaches, including government-funded research and reference projects, are most effective for promoting circular building projects in the BE of Sub-Saharan Africa.

Benefits of CDS Adoption

Enormous benefits reside in the adoption of CDS in building developments, most notably around resource scarcity, issues of affordability, and environmental degradation. Table 4 presents the benefits identified from the reviewed literature.

Table 4. Benefits of CDS Adoption

Group	Variable	Source
Environmental	Lesser burden on the ecosystem and resource utilisation	Guerra & Leite, 2021; Adams et al., 2017
	Reduction of greenhouse gas emissions	Guerra & Leite, 2021; Minunno et al., 2020
	Reduce CDW generation	Guerra & Leite, 2021

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	Reduction in the energy use	Ghisellini et al., 2018
	Decreased volume of waste going to the landfills	Purchase et al., 2021
	Protection of underground and surface waterways and streams	Purchase et al., 2021
	Increase the utilisation of recycled materials	Purchase et al., 2021
	Preserve and conserve biodiversity	Purchase et al., 2021
	Reduce pollution	Purchase et al., 2021
Economic	Resource productivity	Guerra & Leite, 2021
	Materials price volatility and supply risks	Guerra & Leite, 2021; Adams et al., 2017
	Controlling environmental and public health externalities	Guerra & Leite, 2021
	Employment creation	Laurea, 2020
	Improve self-sufficiency of the sector	Ghisellini et al., 2018
	Increase in GDP	Adams et al., 2017
	Component reuse	Minunno et al., 2020
	Market for reusable components	Minunno et al., 2020
	Potential operating cost savings	Minunno et al., 2020
	Increase of revenues	Laurea, 2020
	Shorter payback period ROI in recycling plants	Ghisellini et al., 2018
Organisational	Higher competitiveness	Adams et al., 2017
	Resource security	Adams et al., 2017
	Multiple business models	Adams et al., 2017
	New Horizon for Eco-innovations	Minunno et al., 2020
Educational	Development of new skill sets	Purchase et al., 2021
Socio-cultural	More quality land for development	Purchase et al., 2021
	Reduction of land converted to landfills	Minunno et al., 2020
	Improve public health	Purchase et al., 2021

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Regulatory /legal	Governmental and stakeholders meeting sustainability goals	Purchase et al., 2021
	Regulations on certification of secondary use components	focusingMinunno et al., 2020
	Corporate social responsibility practices	Laurea, 2020

The study by Ghisellini et al. (2018) indicated that CE innovates the entire value chain processes from the single end-of-life operated by the LE to a multiple cycling dimension in the use of resources to improve effectiveness and optimization. The availability of secondary use material market, shorter transportation distance, and process and method of deconstruction influence the environmental impact and economic value of salvaged materials. Refurbishing is better than demolition or new construction (Ghisellini *et al.,* 2018), and there is a shorter payback period for return on investment in recycling plants. In the review by Purchase *et al.* (2021) on the impact of CE on construction and demolition waste management, identified meeting sustainability goals, improved public health, reduction of pollutants and greenhouse gas emissions, quality land for meeting housing demand, conserving, and preserving biodiversity, and job creation as the main benefits of adopting circularity strategies in buildings. Minunno *et al.* (2020) undertook a comparative study between a circular modular building designed for disassembly and secondary-use steel structures with the conventional linear modular building to assess the environmental benefits of adopting secondary-use materials through a lifecycle assessment method. It was found that an 88% reduction in greenhouse gas emission and eutrophication and a reduction of the acidification potentials by 87% were recorded in the circular building. In addition, these advantages include reductions in landfill usage, the reuse of components, fostering innovation in the sector, and creating markets for reusable building materials.

From the sustainability perspective, the benefits associated with CDS adoption in the BE are multifaceted, encompassing environmental, economic, and social dimensions. Environmental benefits include significant reductions in resource consumption, greenhouse gas emissions, and waste generation (Purchase et al., 2021). Modular construction and material reuse contribute to enhanced resource efficiency and minimize the environmental footprint of building projects (Minunno et al., 2020). Economically, CDS adoption promises long-term cost savings and improved operational efficiencies through reduced energy consumption and lifecycle costs (Ghisellini et al., 2018). Enhanced market competitiveness and brand reputation further underscore the economic advantages of sustainable building practices (Adams et al., 2017). Socially, CDS adoption promotes healthier indoor environments, improved occupant well-being, and community engagement (Minunno et al., 2020). Strategies that prioritize social equity and inclusivity in building design contribute to sustainable urban development and enhance the quality of life for residents (Ghisellini et al., 2018).

The practical implications of these findings suggest that stakeholders need to take on an influential leadership role in promoting awareness of CDS and their benefits across the value chain. They should enhance their technical skills in CDS through knowledge sharing and invest in GreenBIM to achieve CDS environmental goals (Suleman et al., 2023a). Integrating other design optimization software into workflows can facilitate early assessment and evaluation of

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design options that best address specific environmental challenges. These findings can help develop design guidelines and tools to simplify CDS implementation. Specifying reclaimed or reused materials and components in building designs can ensure environmental resource security, utilize on-site construction waste, and reduce carbon emissions by minimizing waste transport to landfills (Purchase et al., 2021). The shift to a circular BE in Sub-Saharan Africa offers various environmental benefits through stakeholder engagement in public-private partnerships on case projects, policy amendments in building codes and regulations, and voluntary stewardship for building circularity. However, strategic government policies and regulations are crucial for driving this systemic shift. The availability of incentives for circular building design should increase interest among stakeholders. Therefore, the government should legislate policies that subsidize statutory fees for circular building design and provide incentives for design with reuse. Additionally, the government should assist in establishing a reclaimed material market to facilitate reverse logistics.

Critical Success Factors of CDS Adoption

CSFs have been defined across various disciplines as critical elements crucial for successful innovation or development (Rockart, 1979; Lu & Yuan, 2010; Wuni & Shen, 2022). Lu et al. (2008) emphasize that CSFs are particularly effective in managing complex phenomena and prioritizing significant factors amidst competition among multiple success factors. Wang et al. (2014) suggest that identifying CSFs depends on prevalent urbanization development practices in specific locales. Confusion sometimes arises between barriers and success factors because these elements can be interdependent (Knoth et al., 2022), impacting effective resource optimization strategies in building design (Wang et al., 2014). This review identifies CSFs directly influencing the design stage (see Table 5).

Table 5. Critical Success Factors of the Adoption of CDS

Group	Variable	Source
Educational	Awareness and change in culture	Knoth et al., 2022; Wang et al., 2014
	Cooperation and communication	Knoth et al., 2022
	Risk sharing	Knoth et al., 2022
	Circular practices in the curriculum of institutions	Knoth et al., 2022
	Design strategy training and knowledge	Knoth et al., 2022; Wuni & Shen, 2022
Technical	Expertise in circular building design and material reuse	Knoth et al., 2022; Lu et al., 2008
	Innovative solutions	Knoth et al., 2022
	Fewer design changes	Lu et al., 2008
	Early design completion and freezing	Wuni & Shen, 2022
	Design for manufacture, assembly, and circular economy	Wuni & Shen, 2022
	R&D in material optimisation	Lu et al., 2008
	Adequate lead time for the bespoke processes	Wuni & Shen, 2022
Socio-cultural	Early involvement of stakeholders	Knoth et al., 2022; Wuni & Shen, 2022
	Effective leadership	Wuni & Shen, 2022

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Technological	Establish infrastructure	Knoth et al., 2022
	Digitalization and standardisation	Knoth et al., 2022
	Low-waste building technologies	Lu et al., 2008
	Effective use of BIM	Wuni & Shen, 2022
Economic	Involve specialists in reuse in the design process	Knoth et al., 2022
	Innovative reuse	Knoth et al., 2022
	Creativity and innovative capacity	Knoth et al., 2022
	Circular business models	Knoth et al., 2022
	Customer demand	Knoth et al., 2022
	Financial incentives for reusing materials	Knoth et al., 2022; Wang et al., 2014
	Funding scheme for component reuse	Knoth et al., 2022
Legal/ Regulatory	Reuse-friendly regulations and stricter requirements for reuse	Knoth et al., 2022
	Responsibility for documentation: certification agencies	Knoth et al., 2022; Wuni & Shen, 2022
	Setting ambitious and achievable goals in the early planning stage	Wang et al., 2014
	Reuse-focused collaborative procurement process	Wang et al., 2014; Wuni & Shen, 2022
	Construction waste regulations	Wang et al., 2014; Lu & Yuan, 2010
	Market-stimulating systems	Wang et al., 2014; Lu et al., 2008
	Waste reduction investment	Wang et al., 2014
Environmental	Suitable site characteristics and layout	Wuni & Shen, 2022

Knoth et al. (2022) employed a qualitative approach in their study on component reuse in the Norwegian building sector (REBUS project). They identified eighteen success factors categorized under business frameworks, mindsets, knowledge, legal frameworks, and reuse infrastructure through thematic analysis of semi-structured interviews. The result revealed that business and legal frameworks are the CSFs most common in the Norwegian building sector. In another study by Wang *et al.* (2014), they investigated the CSFs associated with implementing waste minimization design in Shenzhen, China, through a quantitative survey approach. In the review, nineteen factors were highlighted. Through *t-value* statistical analysis of the quantitative data, six critical factors emerged as the most significant: investment in waste minimization, financial incentives, design freezing, modular design, large-panel metal formworks, and prefabrication of building components. In an early study from the same experimental zone, Lu and Yuan (2010) explored the CSFs that can facilitate waste management through a mixed-method approach. The study identified eighteen (18) selected success factors, and the outcome revealed seven CSFs, similar to those of the later study. However, this study emphasized awareness, low-waste building technologies, and research and development as some of the most significant CSFs. Wuni and Shen (2022) identified 21 CSFs for circular modular buildings in Hong Kong, emphasizing early design completion, client commitment, leadership support, project team knowledge, and collaboration. Malik et al. (2022) highlighted leadership and management approaches as crucial in India. Khitous et al. (2022) identified inter-firm collaboration, shared vision, technology, stakeholder participation, and CE knowledge as key in Italy.

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Global studies show that factors influencing CDS adoption in building development differ by region (Dunmade et al., 2019; Debacker et al., 2017; Ezeudu et al., 2021; Hart et al., 2019). Most studies focus on Europe, Asia, and the Americas, which may not apply to Sub-Saharan Africa. Identifying and leveraging CSFs is crucial for overcoming barriers and maximizing CDS benefits in the built environment. Strategic planning, stakeholder engagement, and integrating CDS into core business strategies are pivotal (Lu & Yuan, 2010; Wuni & Shen, 2022). Capacity building and continuous education enhance stakeholder competencies and foster a culture of sustainability (Lu et al., 2008). Collaborative partnerships facilitate knowledge exchange and collective action towards sustainability goals (Gupta, 2019). Government-industry partnerships support policy alignment and green building certifications (Guerra & Leite, 2021).

Comparative analysis highlights contextual nuances specific to Sub-Saharan Africa. Differences in regulatory frameworks, technological readiness, and cultural perceptions influence CDS adoption (Malik et al., 2022). Tailored interventions and localized strategies are essential for overcoming context-specific barriers. Training architects and engineers in CDS, focusing on material reusability and circular design, is crucial. Governments should create enabling environments through legislation and incentives to foster stakeholder adoption. Stakeholders should adopt circular procurement systems and voluntary stewardship programs like Zero-waste certification. Early design freezing, fewer modifications, and effective communication of design intents can facilitate CDS adoption. Existing building codes may hinder CDS uptake; innovative design approaches are needed to incorporate demolition techniques for material recovery in renovation projects.

CONCLUSION

A complex interplay of barriers, enablers, benefits, and CSFs influences the adoption of CDS in the BE. Regulatory constraints, infrastructural deficiencies, and economic challenges hinder widespread adoption. Overcoming these hurdles requires addressing regulatory constraints, enhancing infrastructural capabilities, and fostering collaborative partnerships among stakeholders. Critical enablers such as leadership commitment, research and development, and regulatory support provide pathways for advancing sustainable building practices. Benefits associated with CDS adoption include environmental stewardship, economic resilience, and social well-being, contributing to resource efficiency and long-term cost savings. Recommendations to promote CDS adoption include developing supportive policies, investing in capacity building, fostering partnerships, and promoting research and development in sustainable technologies and practices.

Further research should focus on quantifying environmental, economic, and social benefits, assessing sector-specific challenges, and evaluating policy effectiveness to enhance sustainability goals. Embracing a holistic approach integrating research, policy innovation, and partnerships is crucial for realizing the transformative potential of CE principles in the BE of Sub-Saharan Africa. This study provides foundational insights into CDS adoption in the BE and advocates for sustainable development practices, contributing to the global discourse on urban sustainability from Sub-Saharan Africa.

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