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A REVIEW ON IMPLEMENTING CIRCULAR BUILT ENVIRONMENT IN NIGERIA THROUGH MULTIDISCIPLINARY APPROACH

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ABSTRACT

This paper reviewed the implementation of Circular Built Environment (CBE) principles in Nigeria, focusing on its transformative potential through a multidisciplinary lens. Employing a comprehensive literature review, the study reviewed academic journal articles, conference proceedings, and industry reports to assess the current state of CBE integration across nine professional disciplines: Urban and Regional Planning, Quantity Surveying, Fine Arts, Industrial Design, Environmental Management, Surveying and Geoinformatics, Architecture, Estate Management, Building. The review uncovers several critical barriers to CBE implementation, including limited awareness, financial limitations, industry fragmentation, insufficient policy frameworks, and resistance to change within the sector. Despite these challenges, the study highlights CBE adoption's significant environmental, economic, and social benefits, such as waste reduction, enhanced resource efficiency, and job creation. The paper underscores the necessity of collaborative efforts among policymakers, industry professionals, and academic institutions to facilitate the successful implementation of CBE strategies. Key enabling factors include robust policy support, stakeholder collaboration, capacity building, and circular innovation. Furthermore, the study emphasizes the importance of developing supportive policies, increasing investment in research and development, and promoting education and awareness initiatives to drive CBE implementation. By addressing existing obstacles and capitalizing on emerging opportunities, the Nigerian built environment can substantially contribute to sustainable development and align with global sustainability objectives. This review offers critical insights into the possibilities of CBE to reshape Nigeria's built environment and lays the groundwork for future research and policy advancements.

Keywords: Circular Built Environment; Circular Economy; Nigeria; Multidisciplinary

INTRODUCTION

Circular Economy (CE) is now central to global sustainability trends. It is acknowledged for its capacity to optimize resource utilization by reducing extraction impacts and promoting efficiency (Ezema, Suleman, & Okorigba, 2023). Escalating global challenges, including pollution, industrialization, urbanization, environmental degradation, resource depletion, deforestation, overpopulation, and climate change drive this shift. CE is an industrial model that creates waste-free systems by applying repair and renewal practices with careful intention and precise design (Ellen MacArthur Foundation [EMF], 2021). However, despite international efforts, the world has not achieved full circularity. The Circularity Gap Report underscored this concern presented at the 26th United Nations Climate Change Conference (COP26) in November 2021, revealing that the global economy was only 8.6% circular in 2021, a decline from 9.1% in 2018. Alarmingly, this figure fell further to 7.2% in 2023. CE is often considered an extension of sustainable practices, emphasizing optimal resource use. Initially, the CE model was based on the 3Rs: Recycle, Reduce, and Reuse. Over time, additional principles have been incorporated, leading to the development of the R-imperative framework, which includes Recovery, Reusing, Recycling, Repurposing, Remanufacturing, Refurbishing, Repairing, Reducing, Refusing, Rethinking at the macro (city), meso (building), and micro (product) levels (EMF, 2021). According to the EMF, CE is built on three fundamental principles: maintaining materials at their highest utility (slowing the resource loop), eliminating waste (narrowing the resource loop), and regenerating natural systems (closing the resource loop) within both engineered and natural cycles.

Despite the growing recognition of CE's potential, the built environment, including its planning, construction, operations, maintenance, and decommissioning, largely adheres to the Linear Economy (LE), characterized by an extract-transform-dispose approach. Given current consumption patterns, this extractive model, in which resources are typically discarded after a single use, is unsustainable. The situation is coupled with global production expected to double by 2030 and triple by 2050 to meet the demands of the rising population (Suleman, Ezema, & Aderonmu, 2023). The population growth will exacerbate waste generation and infrastructure development, intensifying global environmental challenges such as resource depletion (Figure 1), biodiversity loss, and climate change.

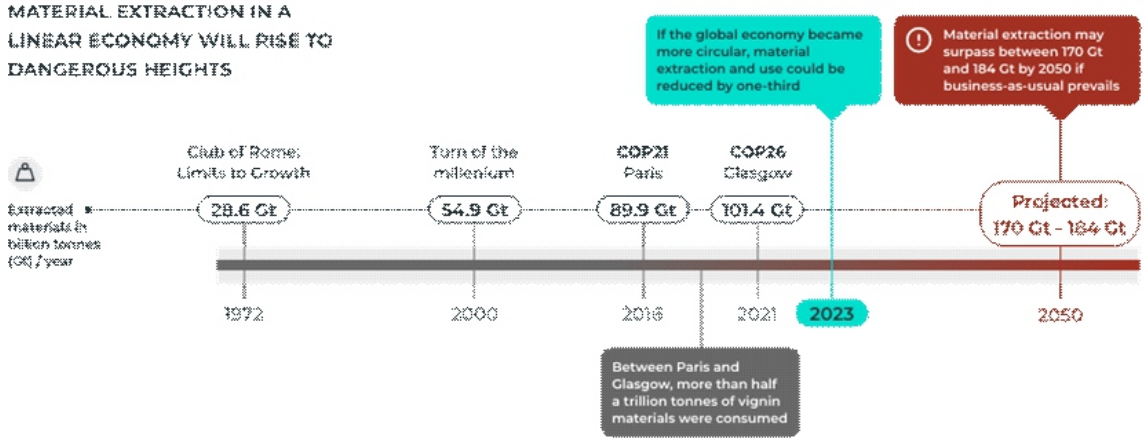

Figure 1. Material extraction in a linear economy
Source: Circularity Gap Report (2023)

The European Commission has set two critical goals for waste reduction: optimizing resource use and minimizing extraction impacts. The EMF advocates for an urgent transition from LE to CE, as encapsulated in the CE Butterfly framework (Figure 2). CE's foundational theories, such as the Law of Ecology, Industrial Ecology, Performance and Looped Economy, Blue Economy, Biomimicry, Cradle-to-Cradle, and Regenerative Design, underscore the need for a systemic shift in the built environment. Several studies have projected significant economic benefits from adopting CE in the built environment. For instance, CE adoption in the European Union's construction sector is anticipated to generate €600 billion in resource benefits by 2030 (Berg et al., 2018). Similarly, in India, CE in the building sector could create ₴218 billion by 2030 and ₴624 billion by 2050, corresponding to 23% and 44% reduction in greenhouse gas emissions (Gupta, 2019). Globally, the EMF estimated a potential economic benefit of £1.8 trillion from CE adoption in the built environment. Developed economies, including England, Finland, and Austria, actively pursue Circular Built Environment (CBE) models supported by policy frameworks, action plans, and cross-sectoral collaborations.

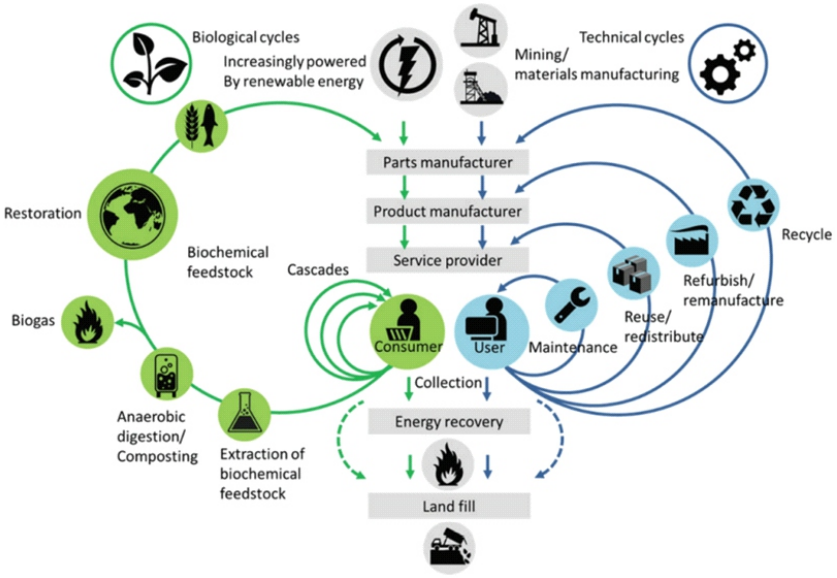

Figure 2. Ellen MacArthur Foundation CE Butterfly Framework
Source: (EMF, 2021)

In the Global South, CBE adoption is gaining momentum, albeit slowly. Existing studies indicate that emerging economies face challenges in implementing CBE (Amudjie, Agyekum, Adinyira, Amos-Abanyie, & Kumah, 2023). CE principles have been successfully applied in food production, waste management, and telecommunications sectors in Nigeria. However, the built environment, which constitutes 5.8% of Nigeria's GDP and represents one of Africa's largest construction markets, remains entrenched in the LE model (Afolabi, Tunji-Olayeni, Ojelabi, & Omuh, 2018). Research on comprehensive CBE adoption in Nigeria is limited, with most existing studies focusing on construction waste, energy, and sustainable development (Afolabi et al., 2018; Akhimien & Latif, 2019; Mokuolu & Timothy, 2021; Ogunmakinde, 2019). Increasing attention is being paid to the potential of CE to transform the built environment in recent times. For instance, Akhimien and Latif (2019) explored the theoretical application of CE to passive design strategies in tropical climates. Similarly, Suleman et al. (2023) examined the hindrances to adopting CE by design firms in sustainable buildings. Ezema et al. (2023) analyzed CE in the context of affordable housing in Lagos, Nigeria. Notwithstanding, there is a pressing need for a comprehensive and multidisciplinary approach to CBE adoption, as highlighted by Dokter et al. (2021) and Hart et al. (2019).

Transitioning to a CBE offers significant environmental, economic, and social benefits. For example, Zvirgzdins et al. (2019) emphasize the importance of cross-industry interactions and collaborations, while Joensuu et al. (2020) underscore the need for strategies across multiple geographic scales. The review contributes to the global discourse by examining the integration of CE principles across Nigeria's built environment, adopting a multidisciplinary approach that spans nine professional disciplines: Urban and Regional Planning, Quantity Surveying, Fine Arts, Industrial Design, Environmental Management, Surveying and Geoinformatics, Architecture, Estate Management, Building. This research is one of the first to explore the holistic adoption of CE in Nigeria's built environment, adding valuable insights from Sub-Saharan Africa to the broader global conversation on circularity.

MATERIALS AND METHODS

Using the traditional literature review approach, this study critically examined the current state of the CBE in Nigeria, with a focus on various disciplines, including Urban and Regional Planning, Quantity Surveying, Fine Arts, Industrial Design, Environmental Management, Surveying and Geoinformatics, Architecture, Estate Management, Building. The literature review approach was selected to consolidate existing research, identify knowledge gaps, and explore potential avenues for advancing the implementation of CBE principles in Nigeria. A comprehensive literature search was carried out using multiple scholarly platforms, such as Google Scholar, ScienceDirect, and Scopus, to ensure a thorough representation of relevant academic and industry sources. Inclusion and exclusion criteria were specified to maintain the significance and quality of the selected literature. Inclusion criteria were as follows: (1) papers published in scholarly journals or respected industry publications; (2) studies that focused on or provided insights applicable to the Nigerian context; and (3) publications from the past decade, ensuring the capture of recent developments and trends. Exclusion criteria included: (1) articles not available in English; (2) studies concentrating solely on technical aspects without addressing CE principles; and (3) publications older than 15 years.

The selected studies were systematically reviewed using narrative analysis to extract pertinent information regarding implementing CBE principles across various disciplines. Key themes from the review included the current state of CBE adoption, barriers and challenges, potential benefits, and strategies for successful implementation. The data collected were categorized and analyzed to provide a detailed and cohesive overview. The synthesized findings offer a comprehensive perspective on the opportunities and challenges of transitioning to a CBE in Nigeria.

RESULTS AND DISCUSSION

3.1 Circular Built Environment (CBE) in Nigeria

The built environment is widely recognized as resource-intensive throughout its lifecycle, from planning and construction to operation and demolition, with limited consideration given to circularity. Achieving comprehensive adoption of a CBE in Nigeria requires the integration of circularity across multiple scales: micro (product level), meso (building level), and macro (city level). Several studies have highlighted opportunities for embracing CBE within Nigeria. The innovative implementation of CBE principles in the Nigerian built environment could result in a 30% saving in water consumption, reducing greenhouse gas (GHG) emissions by 35% (Afolabi et al., 2018), a 42% drop in energy usage, and a 50% decrease in the consumption of new materials (Ogunmakinde, 2019). According to the McKinsey Global Institute, CBE could contribute approximately 13% to global GDP, projected at 19.2% by 2035 (Figure 3). Furthermore, another study found that adopting CBE in Nigeria could result in a €4.4 billion reduction in imports and create 1.6 million jobs between 2020 and 2030 (Rajput et al., 2020). For instance, the Lagos State government's 90-day demolition order following the collapse of a 21-story building in Ikoyi on November 1, 2021, led to a significant loss of resources sent to landfills (Oyero, 2022). A CE approach could have enabled resource recovery, reuse of salvaged materials, reduced deconstruction time and costs, and promoted more

environmentally friendly dismantling processes (Suleman, 2024). Despite these potential benefits, the Nigerian built environment has yet to capitalize on the opportunities CBE adoption provides.

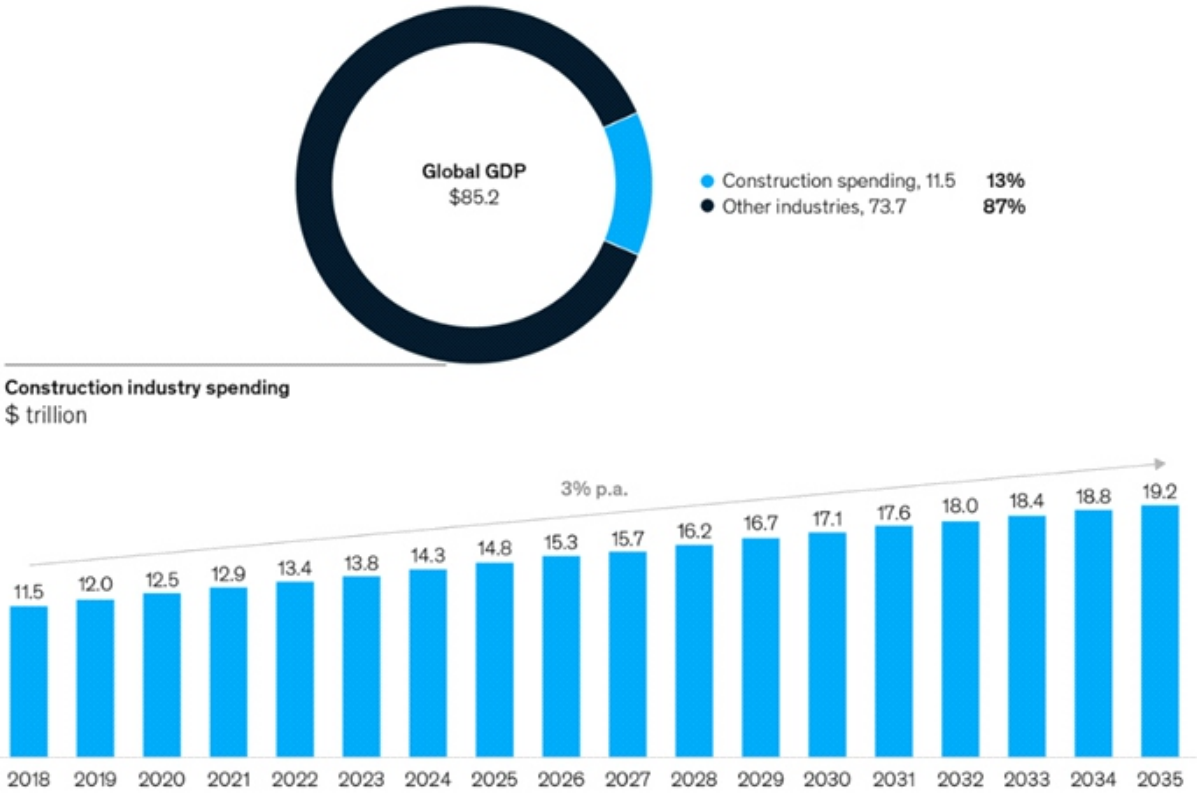

Figure 3. Construction sector contribution to global GDP
Source: Mckinsey Global Institute (2020)

The successful implementation of CBE in Nigeria requires several enabling conditions, including adequate infrastructure, favorable techno-economic factors, socio-cultural acceptance, and supportive institutional and regulatory frameworks (Dunmade et al., 2019). Key drivers for integrating CBE into Nigerian policies and legislation include community participation, policy coherence, institutional stability, government support, and active private-sector involvement (Ogunmakinde, 2019). Additionally, fostering locally relevant engineering education and training, particularly by incorporating contemporary engineering practices into higher education curricula, is essential to facilitate CBE adoption (Suleman, 2024). Sustainability in public procurement, design for circularity, and recycling as waste reduction strategies are crucial to achieving CBE in Nigeria. Numerous studies, including those by Adewuyi (2020), Akhimien and Latif (2019), and Osobajo et al. (2020), have attributed the low adoption of CBE in Nigeria to several factors, such as the absence of empirical data, limited awareness of implementation processes, the lack of CBE-specific policies and regulatory frameworks, insufficient stakeholder support, and a lack of transdisciplinary collaboration. For Nigeria to meet its SDGs and the African Union's Agenda 2063 targets, transitioning to a CE is imperative. Aliamin (2021) demonstrated that CBE has the potential to foster cross-sector partnerships (SDG 17), reduce energy consumption (SDG 13), improve resource efficiency (SDG 12), strengthen communities (SDG 11), reduce unemployment (SDG 8), lower air pollution (SDG 3), and indirectly contribute to SDGs 6, 7, and 9. However, to fully realize these benefits, there is a need for multidisciplinary collaboration to facilitate the exchange of knowledge, information, and expertise.

3.2 Architecture in CBE

The emergence of CE in the architectural design industry has significantly influenced various stages of procurement for buildings (Suleman et al., 2023). The design stage is particularly important, where CE principles are most effectively integrated. Circular design strategies are essential in promoting resource efficiency, ensuring that materials are utilized or repurposed to maintain their maximum value, thereby extending the lifespan of resources (Suleman, 2024). These strategies also prioritize waste reduction by tightening the resource cycle and integrating regenerative practices within technological and biological systems. The ultimate goal is to close the resource loop fully, minimizing the need for new inputs and reducing waste output (Ezema et al., 2023). The CBE model strongly advocates for design approaches

that eliminate waste or adopt zero-waste principles, positioning these strategies as essential to sustainable development. The circular design strategies employed during the design phase of building development are design for long life and maintainability (DfLL/Ma), design for adaptability and flexibility (DfA/F), design for lifetime extension (DfLe), design for regeneration (DfReg), design for deconstruction and disassembly (DfD), design for end-of-life (DfEoL), design for modularity (DfM), and design for prefabrication (DfP). Others include design for reuse (DfReu), design for high performance (DfHP), design for standardization and dimensional coordination (DfS/DC), designing out waste (DoW), design for energy efficiency (DfEe), designing in layers (DL), design for excellence (DfX), design for modern methods (DfMm), whole systems design (WSD), design for resilience (DfRes), design for sustainability (DfS), innovative use of space, product-service systems, and the specification of circular materials (SCM).

Although these circular design strategies can be applied individually, they are often interrelated and mutually reinforcing, as Ezema et al. (2023) have emphasized. Figure 4 illustrates the interconnectedness of these strategies, identifying three levels of connection: coordinating strategies (whole systems design), primary strategies (design for disassembly, design for sustainability, design for excellence, and design for reuse), and supporting strategies (Suleman, 2024). The design phase is thus critical for optimizing resource use and achieving environmentally sustainable building solutions within the context of a CBE. Major institutions, including the Ellen MacArthur Foundation (EMF), IDEO Design Consultancy, and multiple studies, have identified design as essential for reducing and preventing waste, enhancing resource capital, and maximizing renewable resources. To support the transition to a CBE, the EMF has proposed the ReSOLVE Framework (Table 1).

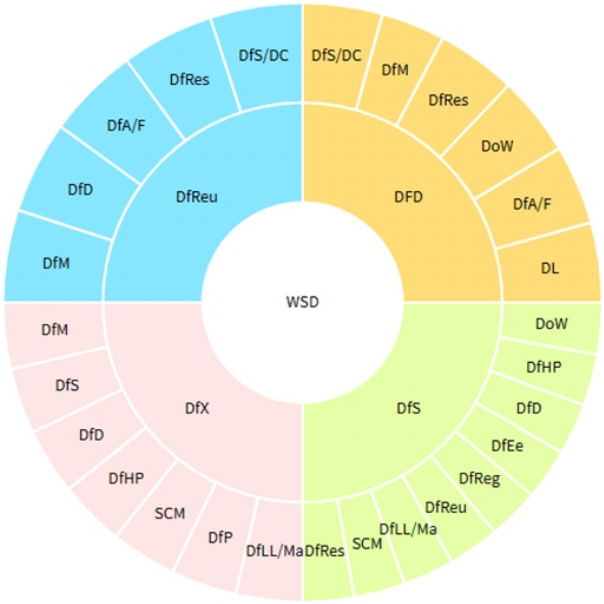

Figure 4. Interconnectedness between circular design strategies
Source: Suleman, 2024

To capitalize on the potential of CBE in the Nigerian context, it is essential to adopt the following strategies:

1. ***Recycling and Remanufacturing Materials:*** This practice is essential for closing the loop in building processes and fostering material sustainability, addressing the waste challenges prevalent in the Nigerian construction industry.
2. ***Creating Modular Buildings:*** Modular construction promotes flexibility and adaptability in urban development, accommodating Nigeria's rapidly urbanizing population and diverse housing needs.
3. ***Promoting Urban Development that incorporates Circularity:*** Urban growth must align with sustainable practices to ensure Nigeria's urbanization does not compromise environmental integrity.
4. ***Designing Energy-Positive Buildings:*** Structures that generate more energy than they consume are crucial in achieving national sustainability targets, especially in energy-deficient regions.
5. ***Constructing Sustainable Circular Buildings:*** These buildings should embody sustainability principles and circularity throughout their life cycle, reflecting local materials and climatic conditions while minimizing environmental impact.

By embracing these strategies, stakeholders within the Nigerian construction industry can catalyze significant advancements in sustainable building practices, ultimately fostering a robust CBE. These strategies successfully address pressing environmental concerns and enhance economic resilience and social equity within the Nigerian context.

Table 1. Ellen MacArthur Foundation's ReSOLVE Framework

Elements	Description
Regeneration	This involves restoring and renewing biological and technological resources to upgrade or increase their value.
Sharing	This involves the repeated reuse of underutilized resources through collaboration to promote resource efficiency.
Optimization	This involves ensuring resources reach their maximum value and useful life without redundancy and obsolescence.
Looping	This involves maintaining a closed-use cycle of resources to avoid waste, which is the core concept of CE.
Virtualization	Digital technologies are deployed to enhance resource-efficient practices through collaboration and communication and tracking resources across the lifecycle.
Exchange	This involves the transfer of resources between different stakeholders with the intent to elongate their service life and aid reuse.

3.3 Building Construction in CBE

The building and construction sector has increasingly embraced various strategies associated with the CE, prioritizing waste minimization, material reuse, recycling, adaptability, and improved resource efficiency. This transition is paramount, particularly given the significant waste generated throughout the building lifecycle. Minunno et al. (2018) proposed a comprehensive taxonomy that delineates 16 primary CE strategies pertinent to building design and construction, addressing the entire lifecycle of buildings. Their research underscores the pivotal role of prefabrication in facilitating the integration of CE principles, especially when achieved through value-chain collaboration (Chen, Feng, & García De Soto, 2022). Furthermore, Timm et al. (2023) identified 23 critical CE strategies to enhance the construction industry's environmental performance. Despite these advancements, the widespread adoption of these strategies is often obstructed by fragmented supply chains and a pervasive lack of awareness throughout the sector, as identified by Minunno et al. (2018). The limited adoption of CE approaches is primarily due to inadequate knowledge and engagement within the industry.

Chen et al. (2022) advocate for fostering social engagement, enhancing market maturity, balancing material flows, and introducing financial incentives and legislative measures concerning material certification to promote broader industry acceptance. Moreover, incorporating Building Information Modelling (BIM) has emerged as an essential mechanism for implementing CE principles within building construction, potentially reducing lifecycle costs (Aljaber et al., 2023). The integration of circular business model in construction necessitates the adoption of digital technologies that augment both efficiency and effectiveness. Recent advancements in digital construction methods, including robotic/3D printing, have garnered attention for their potential to improve precision, increase efficiency, minimize waste, and standardize construction processes, yielding significant time and cost savings.

In Nigeria, the momentum toward CBE within the construction sector is gradually building. Realizing a CBE in Nigeria's construction industry involves the sustainable conservation of resources and effective waste management through adopting renewable materials, designs that facilitate disassembly, and the establishment of comprehensive recycling facilities (Ogunmakinde, 2019). Additionally, promoting educational initiatives, providing recycling incentives, disseminating pertinent information to stakeholders, and enforcing government regulations are crucial for effective construction and demolition waste management. Using sustainable local building materials is vital for enhancing resource efficiency and reducing costs. Furthermore, the emergence of Construction 4.0, propelled by digital technologies, offers a promising avenue for advancing a CBE in Nigeria; however, its integration into standard practices remains limited (Suleman, 2024). The slow adoption of these innovations can be attributed to several challenges, including interoperability issues, organizational resistance, insufficient governmental support, skill shortages, infrastructural deficiencies, vulnerabilities in data management, and financial constraints (Sofolahan et al., 2024). To address these barriers, it is crucial for the government to proactively implement necessary incentives, enforce pertinent policies, and invest in local industrial production and exemplary practices.

3.4 Environmental Management in CBE

Babalola et al. (2019) posit that adopting lean practices can be pivotal in promoting environmental sustainability by effectively reducing waste that poses risks to ecosystems. In alignment with this perspective, Oyebode (2018) underscores the critical need to cultivate a green environment to diminish dependence on fossil fuels, which are significant contributors to greenhouse gas emissions. This transition is vital for

mitigating environmental degradation and curbing biodiversity loss, particularly stemming from rampant deforestation. Embracing CE principles in environmental management practices presents an opportunity for transformative advancements across diverse sectors, including supply chain dynamics, waste management, and improvements in environmental quality. Additionally, it has implications for health outcomes and enhancing the durability and quality of manufactured products. This paradigm shift fosters eco-innovative endeavors that are essential for achieving sustainable development. Kazancoglu et al. (2021) further assert that robust environmental management systems can significantly bolster CBE initiatives by enhancing economic viability and ecological integrity by adopting comprehensive environmental policies. However, effective cross-sectoral collaboration and information sharing among key actors are imperative in realizing these beneficial outcomes. Marrucci, Daddi, and Iraldo (2022) emphasize the necessity of environmental certifications, such as environmental product declarations, in establishing standardized circular and ecological practices to ensure compliance and best practices.

Successfully transitioning towards a CBE in Nigeria has become imperative. To achieve this, Kazancoglu et al. (2021) advocate for implementing strategies to achieve a climate-neutral economy. These strategies should prioritize clean production methods, comprehensive product life cycle management, reverse logistics, and establishing closed-loop systems. The study also identifies challenges that could impede this transition, encompassing market, policy, social, technological, organizational, and financial barriers. Nevertheless, these challenges can be mitigated through strategic planning, the formulation of targeted policies and legislation, the provision of incentives and rewards, the establishment of circular public procurement systems, and efforts to raise awareness, foster partnerships, and enhance communication among stakeholders. In the Nigerian context, averting these barriers is essential to contributing towards the SDGs and a resilient economy that supports environmental sustainability. This necessitates a concerted effort from the government, professionals, and private organizations to implement these strategies effectively.

3.5 Estate Management in CBE

The discipline of estate management must adapt to the transformative shifts of the 21st century, particularly concerning the property lifecycle. This adaptation necessitates the acquisition of expertise and an in-depth understanding of prevailing megatrends, notably sustainability and CBE principles (Wrase, Haase, & Wang-Speiser, 2023). Within the real estate and facility management sectors, there has been a notable increase in the adoption of CE principles, especially concerning asset lifecycles, thereby enhancing contributions to CBE. These principles involve a range of design approaches, such as designing for disassembly, ensuring ease of maintenance, creating products with the potential for reuse, developing designs that allow for remanufacturing and incorporating features that facilitate recycling (Zvirgzdins et al., 2019). Collectively, these design methodologies are pivotal in augmenting the value of real estate assets throughout their lifecycle and optimizing recovery methods at the decommissioning of facilities.

Adopting CE practices in Nigeria's real estate industry holds enormous opportunities. Both Wrase et al. (2023) and Zvirgzdins et al. (2019) emphasize the pivotal role of education in facilitating this transition towards sustainable CBE. While some European universities have begun incorporating these megatrends into their curricula, the focus often diverges from CBE principles. To foster a more robust integration of circularity in the Nigerian real estate sector, some studies advocate for further research on circularity, implementing innovative teaching methods rooted in experiential learning, and establishing comprehensive policies to promote top-down adoption of CBE within the industry. Moreover, Nigeria's current real estate valuation practices must evolve to include sustainable innovations, such as building and component reusability, adaptability, and other circular interventions (Utmani, 2023). Zvirgzdins et al. (2019) further advocate for integrating a circular construction supply chain and advancing circular real estate practices to enhance property value and profitability. Such initiatives underscore the importance of circular thinking, effective collaboration, and coordination among stakeholders in the real estate sector.

Aligning estate management practices with CE principles and CBE frameworks is essential for fostering sustainable growth in Nigeria’s real estate industry. By prioritizing education, policy development, and innovative valuation methods, Nigeria can effectively navigate the complexities of the property lifecycle while maximizing the potential for economic and environmental sustainability.

3.4 Fine Arts and Industrial Design in CBE

The interconnectedness of art and sustainability has been aptly described by Mayne (2021) as a relationship akin to "Siamese twins." This symbiosis has historically manifested in utilizing natural resources and materials across various artistic and industrial design endeavors (Núñez-Cacho et al., 2024). In the fashion industry context, Jain (2023) highlights the detrimental effects of pollution and waste generation, revealing that the LE model has precipitated environmental degradation and excessive resource consumption. While efforts to mitigate ecological impacts within the art and craft sectors have emerged, significant challenges remain. Núñez-Cacho et al. (2024) elucidate the environmental ramifications associated with artistic practices, including negative externalities stemming from creative

processes, energy usage, greenhouse gas emissions, as well as in the exploitation of natural capital. Their study promotes environmental conservation through strategies to minimize waste generation and resource extraction. In addressing these challenges, the CE principles have begun to gain traction in the arts, influenced by the interplay of sustainability and technological advancements such as artificial intelligence/. These principles encompass reducing chemical usage, sustainable design practices, cleaner production methods, and the optimal utilization of renewable energy and resources throughout the lifecycle of artistic works.

Achieving these goals necessitates the integration of eco-design and lean design methodologies (Núñez-Cacho et al., 2024), alongside the adoption of rental and sharing models, take-back and recycling initiatives (Jain, 2023), and optimal strategies for reuse, refurbishment, and remanufacturing (van Dam et al., 2020). These approaches are critical components of sustainable design interventions (Alahira et al., 2024) and can be implemented through regenerative and restorative practices. Notably, Mayne (2021) underscores that artists have historically engaged in recycling, repurposing, and reusing materials out of economic necessity and creative intention long before the formal introduction of the CE model. This is evident in using waste materials such as plastics, electronics, and metals in painting and sculpture.

Fine arts and industrial design convergence emerge from a shared commitment to promoting sustainability and harnessing their collaborative potential to address environmental challenges (Alahira et al., 2024). In Nigeria, the adoption of CE principles within the visual arts is progressively becoming mainstream, as exemplified by the works of notable artists like Dotun Popoola. Núñez-Cacho et al. (2024) noted that integrating CE principles into art can stimulate creativity and innovation while fostering environmental stewardship and sustainable living. Rinaudo (2019) further asserts that integrating computer and creative arts can promote CE principles within society, particularly in waste reuse and establishing closed-loop systems through the communicative power of artworks. To cultivate a more sustainable environment, art and design practitioners must adopt eco-conscious visual communication strategies, biomimicry, and upcycling through a cross-disciplinary approach (Alahira et al., 2024). Additionally, van Dam et al. (2020) emphasize the importance of education focused on the CE alongside supportive design policies and practices that encourage circular consumption and production processes, thereby serving as critical enablers of a circular business ecosystem in Nigeria. The alignment of art with sustainable practices is imperative for environmental conservation and offers a unique opportunity for innovation and creativity within the Nigerian context. By embracing these principles, artists and designers can contribute significantly to sustainable development, reflecting a broader societal shift towards ecological responsibility.

3.7 Quantity Surveying in CBE

Recent advancements in quantity surveying have catalyzed a transformation within the construction industry, with professionals increasingly venturing into new domains such as cost and project management (Jayawardhana & Withanage, 2023). This evolution is particularly relevant within the Nigerian context, where the construction sector is poised for significant growth and modernization. Integrating CE principles into quantity surveying practices has gained traction, especially during construction projects' pre-contract and design phases (Victar et al., 2022). Such integration is essential for enhancing sustainability within Nigeria's burgeoning construction landscape.

Jayawardhana and Withanage (2023) highlighted the deployment of BIM as a critical factor in facilitating quantity surveyors' implementation of CE principles. BIM offers innovative solutions that can streamline processes, enhance collaboration, and optimize resource use. In Nigeria, where the construction sector faces resource scarcity and environmental degradation, leveraging BIM can provide quantity surveyors with the tools to adopt sustainable practices effectively. Guided by reduce, reuse, and recycle principles, quantity surveyors are positioned to implement CBE strategies more effectively. During the design phase, they play a pivotal role in various essential functions, including value engineering, risk management, technology integration, measurement, feasibility studies, planning, resource allocation, and cost control. These functions are critical to advancing CBE within the Nigerian construction context, as Victar et al. (2022) identified.

Furthermore, the study underscores quantity surveyors' need to acquire essential skills and develop competencies aligned with contemporary sustainable construction practices. This includes proficiency in BIM management, ecology-embodied costing, and economic analysis. In Nigeria, fostering such competencies will ensure quantity surveyors remain relevant and effectively contribute to the sector's sustainability goals. As the country seeks to modernize its infrastructure and construction practices, embracing these advancements will be vital for achieving a resilient and sustainable built environment.

3.5 Surveying and Geoinformatics in CBE

Recent studies have illustrated the growing embrace of CE principles within the surveying and geoinformatics disciplines, particularly within the mining and construction sectors (Dilakshan et al., 2023). These sectors increasingly leverage advanced digital tools, including Geographic Information Systems (GIS) and remote sensing, to enhance urban mining practices and facilitate comprehensive data analysis. Specifically,

GIS has proven invaluable in identifying optimal locations for recycling centers and evaluating resource spatial distribution (Dilakshan et al., 2023). Graham (2024) underscores the potential of GIS to assess a nation's recycling capacity by employing methodologies such as time-distance measures, location-allocation, and hot spot analysis. Such analytical tools provide critical insights into the operational efficacy of recycling initiatives, allowing stakeholders to gauge the effectiveness of selective collection processes and the associated management costs (Ferronato et al., 2019). Moreover, data from these analyses is pivotal in developing urban cadasters, essential for assessing building materials' recycling and reuse potential. This, in turn, supports informed decision-making regarding end-of-life scenarios for various construction materials (Hausegger et al., 2022).

Within the built environment, land surveyors emerge as key stakeholders, actively participating throughout the procurement phases of construction projects. This unique position affords them a significant opportunity to catalyze transformations toward sustainable development, particularly in advancing Nigeria's CBE. In a comprehensive report examining the role of the surveying profession in promoting sustainable development, Murphy (2022) highlights the necessity of enhancing competencies and skills pertinent to sustainable practices. The report emphasizes that a robust understanding of sustainable development principles is essential to address challenges such as cost inflation and inadequate capacity to implement sustainable measures, including CE practices. It advocates for higher education institutions to incorporate curriculum modules that equip emerging professionals with the requisite knowledge and skills, accompanied by appropriate assessment methods. Furthermore, surveying professionals' operational and corporate strategies should reflect a commitment to transitioning toward a CBE in Nigeria. This transition is crucial for monitoring and measuring carbon emissions and facilitating decarbonization efforts. Murphy (2022) identifies several enablers to support this transition, including formulating relevant policies and regulations, rising client demand for sustainable practices, transparent sustainability credentials, targeted training and development programmes, and heightened environmental awareness. Collectively, these factors present opportunities for enhancing competitiveness within the surveying profession and fostering a sustainable built environment in Nigeria.

3.8 Urban and Regional Planning in CBE

Recent research has indicated that the rapid industrialization of metropolitan areas and urban systems has led to significant resource consumption and waste production. In light of these challenges, Lucertini (2020) advocates adopting urban metabolism and CE principles as critical frameworks for designing future urban societies. This paradigm shift necessitates adopting CE approaches in urban planning practices, a concept increasingly called intelligent circular city planning or circular urbanism. In pursuing a CBE, promoting CE adoption on a broader scale requires the active collaboration of various stakeholders (Remøy, Wandl, Ceric, & van Timmeren, 2019). The interdisciplinary nature of CE highlights the importance of incorporating CE thinking into urban planning to facilitate the realization of a CBE, as emphasized by van der Leer et al. (2018). Their study advocates for implementing CE through bottom-up and top-down approaches, emphasizing the necessity for horizontal integration of subsystems across various domains, including industrial systems, infrastructural networks, cultural frameworks, and social systems. In the Nigerian context, these insights underscore the urgent need to address the escalating challenges of urbanization, waste management, and resource depletion. Given Nigeria's rapidly growing urban population and the increasing strain on infrastructure and services, embracing CE principles within urban planning can provide a pathway toward sustainable development. Collaborative efforts involving government agencies, private sectors, community organizations, and residents are crucial for successfully implementing circular urbanism. By fostering such collaborations, Nigeria can mitigate the adverse effects of industrialization and promote resilience and sustainability within its urban environments.

3.9 Multidisciplinary Collaboration towards CBE in Nigeria

Multidisciplinary collaboration has become a key strategy for addressing complex societal challenges and advancing the SDGs. Given the interconnected nature of the built environment, particularly in the Nigerian context, an integrative approach is essential for fostering effective transformation. Mishra et al. (2019) highlight the importance of multidisciplinary partnerships in transitioning to a CBE in developing countries, emphasizing that such collaborations are critical for success. Similarly, Guerra and Leite (2021) argue that engaging diverse stakeholders from government, industry, and academia can accelerate the sector-wide adoption of CE approaches within the built environment. This perspective aligns with the potential for cross-disciplinary collaboration within Nigeria's construction industry, which could significantly enhance the adoption of CBE practices, positively affecting supply and value chains (Suleman, 2024). Senaratne et al. (2023) further support the view that collaboration among stakeholders is essential for the broader adoption of CE principles in the built environment. Critical areas for multidisciplinary collaboration include developing innovative ownership models, managing supply and value chains effectively (Leising & Leising, 2016), and establishing inclusive and adaptive management practices. Additionally, forming circular business models (Suleman et al., 2023a), adopting cleaner production techniques, and enhancing resource efficiency (Mishra et al., 2019) are

crucial. Other pivotal areas include industrial symbiosis, sustainable urban development (Joensuu et al., 2020), sustainable material design (Poblete et al., 2023), technological deployment, and fostering long-term partnerships (Senaratne et al., 2023).

Despite the potential benefits of multidisciplinary collaboration, achieving it in practice is challenging. Owojori and Okoro (2023) identify several barriers, including policy and regulatory constraints, technological limitations, institutional barriers, and economic and financial challenges. Additionally, Suleman et al. (2023b) highlight deficiencies in communication and coordination among stakeholders, a lack of transdisciplinary research, and the absence of lifecycle thinking as significant hurdles to collaboration. Butt and Dimitrijevic (2022) also underscore the need to address challenges such as inadequate transdisciplinary professional development programmes, conflicting data collection protocols, and cultural differences that hinder collaborative efforts. To overcome these obstacles, it is essential to develop a comprehensive framework that outlines clear strategies for promoting multidisciplinary collaboration to achieve a CBE in Nigeria.

Recent research offers several promising strategies for fostering multidisciplinary collaboration in the context of CBE adoption. Köhler et al. (2022) propose the deployment of ecocentric dynamic capacities and transdisciplinary knowledge-sharing routines to promote diverse perspectives in cross-sectoral interactions. In Nigeria, the construction industry often operates in silos, with limited collaboration between architects, engineers, urban planners, and environmental scientists. Ecocentric approaches, which place the environment at the center of decision-making, are underutilized. To address this, it is necessary to create platforms where professionals from various sectors can share knowledge and collaborate on projects integrating environmental sustainability with design and construction. Another key action is encouraging professional practices to adopt environmental leadership models, where ecological goals are central to business strategies. This approach can help build dynamic capacities that respond to environmental challenges. Additionally, incorporating CE principles into training programmes within environmental sciences curricula at Nigerian universities can help future professionals adopt circular practices from the outset of their careers.

Effective multidisciplinary collaboration also requires collective stakeholder decision-making, driven by constructive dialogue, teamwork, and clear communication (Butt & Dimitrijevic, 2022). In the Nigerian construction industry, decision-making processes often exclude critical stakeholders, such as local communities and environmental advocates, leading to suboptimal sustainability outcomes. To address this issue, efforts should be made to organize workshops that bring together architects, government officials, developers, and community leaders to discuss circular design goals and co-create solutions. Establishing formal channels for continuous dialogue will also ensure that local communities and marginalized groups are included in decision-making. Furthermore, deploying digital tools like BIM can foster collaboration and enhance transparency in project design, allowing multiple stakeholders to contribute in real-time. In addition to fostering collaboration, establishing ecosystems for circular innovation is essential (Wielopolski & Bulthuis, 2022). Currently, circular innovation in Nigeria's construction industry is limited, with few ecosystems supporting the development of sustainable construction materials, waste recycling, or energy-efficient designs. To address this, there is a need to develop circular innovation hubs in major cities such as Lagos and Abuja, where startups, research institutions, and construction firms can collaborate on sustainable building technologies, materials reuse, and green construction practices. Policies that encourage venture capital and government grants to support startups focusing on circular building materials, waste-to-resource initiatives, and eco-design solutions should also be implemented. Collaboration between the public and private sectors is also crucial for developing the necessary infrastructure for recycling construction waste and creating eco-friendly materials.

Applying systems thinking and co-designing ethical interventions through meaningful stakeholder engagement can further accelerate Nigeria's transition to a CBE (Cruz Rios et al., 2022). Nigeria's fragmented approach to construction and urban planning often overlooks the interconnectedness of the built environment and natural ecosystems. To address this, systems thinking tools should be promoted in architectural and urban planning projects to account for broader environmental, social, and economic impacts of design and construction decisions. Engaging local communities in the design and construction processes, particularly in affordable housing developments, can ensure that solutions meet environmental and social needs. Developing policies and incentives promoting ethical design and construction practices, such as using sustainable materials, ensuring fair labor practices, and minimizing environmental harm, is crucial for successfully transitioning to a CBE in Nigeria. Government investment in case projects can demonstrate the successful application of these strategies within Nigeria's built environment. For instance, collaborations between local universities and construction firms in developing eco-friendly housing projects have effectively employed transdisciplinary approaches to enhance resource efficiency and integrate sustainable design principles. These projects serve as models for future initiatives. Similarly, partnerships between government agencies and private sector actors in waste management practices have successfully reduced waste generation and fostered sustainable

material use in design and construction processes through industrial symbiosis.

Multidisciplinary collaboration is fundamental to Nigeria's transition to a CBE. While challenges persist, strategic initiatives that promote effective communication, encourage diverse stakeholder engagement, and integrate knowledge across disciplines can significantly enhance sustainable practices in the built environment. The enablers (Figure 5) discussed provide critical insights into the practical application of collaborative strategies, underscoring the importance of a cohesive and integrative approach to achieving sustainable development in Nigeria's built environment.

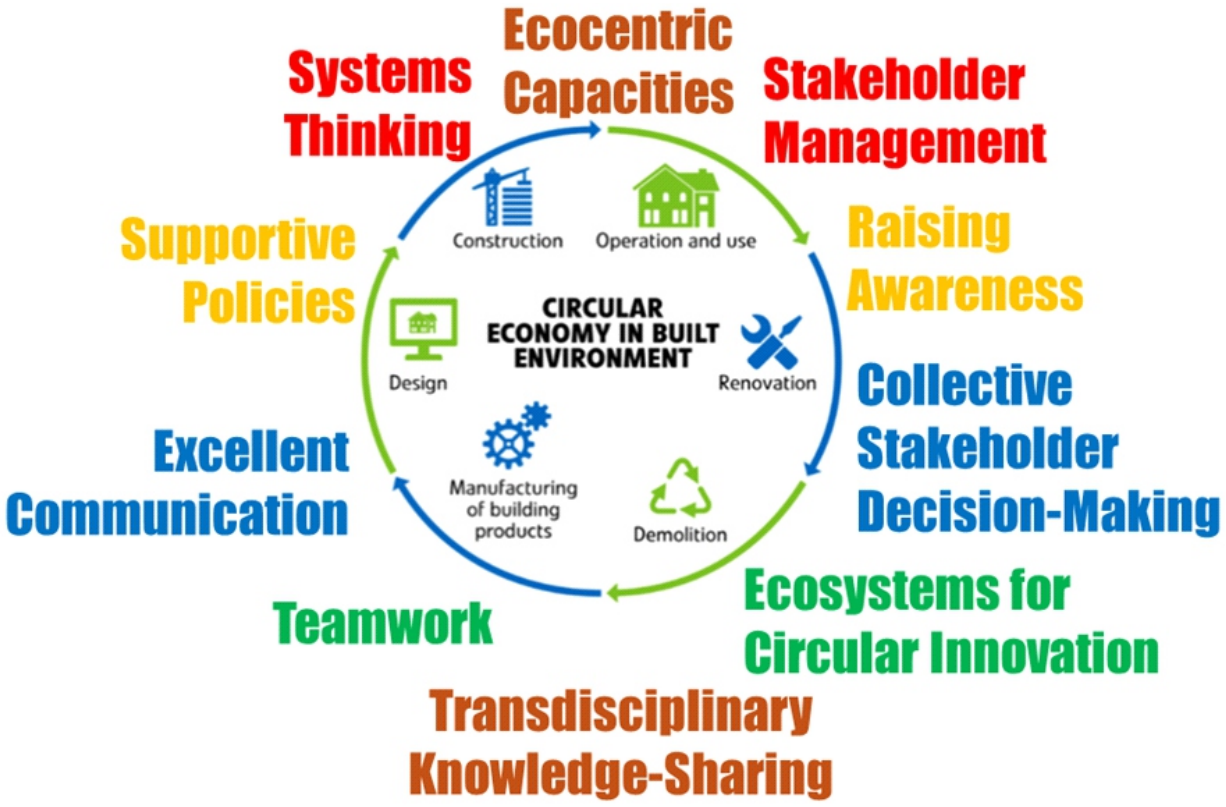

Figure 5. Enablers of CBE in Nigeria
Source: Author's Design

CONCLUSION

The transition to a CBE in Nigeria holds significant opportunities for tackling major issues such as resource scarcity, environmental degradation, and economic inefficiency. This review presented the current state of CBE adoption across various disciplines, including Urban and Regional Planning, Quantity Surveying, Fine Arts, Industrial Design, Environmental Management, Surveying and Geoinformatics, Architecture, Estate Management, and Building. Despite the benefits, the adoption of CBE in Nigeria is hindered by a lack of awareness, limited financial capacity, insufficient policy support, and resistance to change within the built environment.

Embracing CBE can lead to substantial environmental, economic, and social benefits, including reduced waste, enhanced resource efficiency, and increased job opportunities. Furthermore, implementing CBE successfully requires a multi-faceted approach that includes policy intervention, stakeholder collaboration, capacity building, and technological innovation. For Nigeria to morph into a CBE, it is imperative that stakeholders, including policymakers, industry professionals, and academia, collaborate to address the identified barriers. Strategies such as developing supportive policies, increasing investment in research and development, and promoting education and awareness campaigns are essential to drive the transition. While this study presented an overview of the current landscape, further studies are required to explore the practical application of CBE in Nigeria. Other studies can assess developed case studies and frameworks that demonstrate the feasibility and impact of CBE in Nigeria. Moreover, conducting longitudinal studies to monitor the development and results of CBE initiatives will offer important insights into their long-term viability and sustainability.

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