Journal of The Nigerian Institute of Architects (NIAJ)
ISSN: 2315-8913 (print)
ISSN: 1595-4110 (digital)

Architecture and Circular Economy: Challenges and Prospects

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Abstract: ***The architecture industry has a significant impact on the environment, and the circular economy (CE) offers a promising approach to reduce waste and promote sustainability. CE is in its infant stage with limited knowledge and application in architecture. Thus, this article uses a narrative review as its methodology to broaden the knowledge of CE. The article presents an overview on the concept of circular economy within the Architecture industry, and explores the challenges and prospects of implementing CE principles in architecture. It examines the current state of CE adoption in the industry, identifies key challenges, and discusses potential solutions and future directions. Challenges include; Knowledge and Awareness Gaps, Economic, cost and Financial Barriers, Regulatory and Policy Deficiencies, Technical and Logistical Issues, and Supply chain limitations. Whilst the prospects are; promoting sustainability, environmental benefits, economic opportunities, innovation and technology, policy and collaboration and long-term value and resilience and, enhanced brand reputation. Hence, the prospects offer opportunities for diversification. Recommendations include; adopting/integrating CE principles into architectural practices for sustainable development, architectural digitalization, collaboration and knowledge sharing to uncover the diversification that abound in the architecture industry.***

Keywords; architecture, circular economy, sustainability, waste

Introduction

Global construction and urbanization activities have accelerated the negative environmental impact of the built environment due to increasingly unsustainable practices. The architecture industry is a significant contributor to environmental degradation, with buildings accounting for 40% portion of global greenhouse gas emissions leading to climate change (Allu, 2014; Allu, & Ebohon 2014; Huang et al., 2023; Warren-Myers et al., 2024), and unsustainable resource consumption (Allu-Kangkum, 2024; Hasibuan et al.; 2025). Architecture must shift and evolve from being a traditionally functional or aesthetic provider to becoming intentional in providing sustainable regenerative and resource-efficient pursuits (Geissdoerfer et al., 2017; Pierzchlewicz et al., 2025). Circular economy architecture, a design approach that eliminates waste, keeps materials in use, and regenerates natural systems also provide a pathway for sustainable solution to environmental problems like climate resilience.

The 2030 Agenda for Sustainable Development established in 2015 with seventeen goals, has seven of these goals directly related to the implementation of CE. Yet, not much is known about CE, its implementation and application within the built environment (Circularity Gap Report, 2023; Stoiljković et al., 2023).

Circular economy has emerged as a potential solution to reduce waste and promote sustainability (Cruz Rios et al., 2021). CE is an economic model that aims to reduce waste and pollution by promoting the reuse and recycling of materials (Röck et al. (2020). This is achieved through the use the CE principles or concepts. The integration of circular economy (CE) principles into architecture offers significant opportunities for sustainability, product redesign and resource efficiency (Röck et al. (2020), but faces traction, challenges across limited knowledge, policy, economics, and technology (Ellen MacArthur Foundation, 2017; 2020; Suleman et al., 2023). Thus, the motivation to contribute to this knowledge gap and perhaps spur future research contributions in this regard with other methodologies.

Literature Review

Literature review methodologies are becoming increasingly more relevant because it creates a solid foundation for advancing knowledge and promoting theory development (Snyder, 2019). The narrative review is often employed because when seeking an initial understanding of a body of literature it is most suitable (Snyder, 2019). Furthermore, the narrative review offers helpful summary of relevant and current knowledge on a specific topic, while simultaneously highlighting new perspectives and unveiling new questions yet to be explored by the literature (Rother 2007; Ferrari 2015;

Greenhalgh et al. 2011). This article employs a narrative review which provides a broad overview on the subject of discourse because of knowledge limitation on circularity amongst the architectural profession as was posited by the study of Stoiljković et al. (2023).

As global and Nigerian population continue to soar, the demand on materials, land, and infrastructure continue to grow. As such, Architects are looked upon for solutions that will meet these demands, shape and provide sustainable built environments without compromising ecological integrity (Mba et al., 2024). Hence embracing sustainability remains an urgent imperative as construction activities expand to meet Nigeria's developmental needs through CE adaptation.

The adaptation of circular economy in architecture industry is important and is of concern for many reasons; firstly, the industry accounts for 39% of global energy-related carbon emissions (Stoiljkovic et al., 2023). Secondly, over 50% - 60% of extracted building materials are used in buildings and infrastructure projects (The European Commission, 2011; Schlegl et al., 2019). Thirdly, less than 40% of all construction and demolition wastes are reused or recycled in most global regions (Stoiljkovic et al., 2023; Hans et al., 2024). In Nigeria, the concern is that, construction waste accounts for about 35 million tons, with less than 30% being recycled (Okere et al., 2019). These concerns have spur researchers and other built environment operators to look for sustainable solution enshrined in CE (Selman and Gade, 2020; Suleman et al., 2023; Farokhi & Miri, 2025).

Circular Economy

According to Patil et al., (2025) study, CE is defined as a regenerative economic model that separates economic growth from resource depletion by maintaining products value, materials, and resources for as long as possible while minimizing waste. Their study further suggests that, within architectural design, CE manifests as concepts such as design for disassembly (DfD), modularity, material passports, and adaptive reuse, which aim at reducing negative environmental impact.

Circular Economy Architecture

Babbitt et al. (2021) opined that architecture is the key to the success of CE in the entire construction industry being the initial phase for all construction development. CE architecture is considered to be regenerative design philosophy which applies the principles of the CE in the design of buildings and developments in the urban built environments (Farokhi, & Miri, 2025). Moving away from traditional design for linear lifecycles, where materials are unsustainably extracted, used, and then discarded, this action is known as "plan, design, build, and finally demolish" (Giorgi, et al., 2019, p.1; Pierzchlewicz et al., 2025). CE in the field of architecture is a combination of technical, systemic, a link between material flows with social, cultural, and governance dimensions.

Circular economy architecture aims to:

i. Ensure buildings and materials are kept in use to the greatest extend feasible.

ii. Designs are futuristic - adaptability, deconstruction, and reuse.

iii. Specifications/Use of non-toxic, recyclable, and renewable materials

iv. Minimize energy use and embodied carbon throughout the lifecycle

Circular economy transforms the role of architecture from passive infrastructure to active, sustainable and enabler of sustainable circular systems, where buildings are designed to serve as resource banks as oppose to waste generators (Farokhi, & Miri, 2025).

Examples of Circular Economy Architecture

Examples of circular economy architecture include buildings designed for disassembly and reuse, structures using recycled and renewable materials, and projects that incorporate features like rainwater harvesting and solar panels. Figures 1 – 4 are a few examples presented across the globe. These examples applied circular principles to minimize waste, reduce resource consumption, and extend the life of building components and materials through reuse, repair, refurbishment, and recycling.

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Figure 1. Waste bottle house in Paipe, Abuja, Nigeria. Source: Onyenokporo et al. (2024).

Nigeria has demonstrated its waste plastic bottles as shown in Figure 1 and showcases the different experimental affordable eco-friendly houses (Onyenokporo et al., 2024).

Figure 2. Waste Bottles house in Kaduna- Nigeria.

Figure 2 shows a two-bedroom house uses 14,800 bottles was carried out at Kaduna, Nigeria. However, none of the demonstrated waste bottles houses in Nigeria seems to go beyond a demonstration status. The demonstration projects do not seem to have acceptance despite the claims of being affordable, ecofriendly and climate resilient during launch of such project in Abuja and Kaduna. It is obvious there is room for improvement especially in the manual construction processes and the pale appearance of the two buildings.

Figure 3. Italian Pavilion at Expo Dubai 2020
Source: Ratti (2021).

Figure 3 shows the Italian Pavilion building at Expo Dubai 2020, designed by CRA-Carlo Ratti Associati and Italo Rota Building Office, with Matteo Gatto and F & M Ingegneria. It was officially unveiled on October 1st, 2021 and opened for use March 31st, 2022. The pavilion features a multimedia facade made with two million recycled plastic bottles and other waste materials sourced from algae and coffee grounds to orange peels and sand – showcasing an advanced system for climate mitigation that constitutes an alternative to air conditioning. Reusing is also fundamental to how the structure was conceived and extends over a surface of 3.500 square meters (38.000 square feet). This boat-like curtained pavilion has an aesthetic appeal and would attract future adaptations.

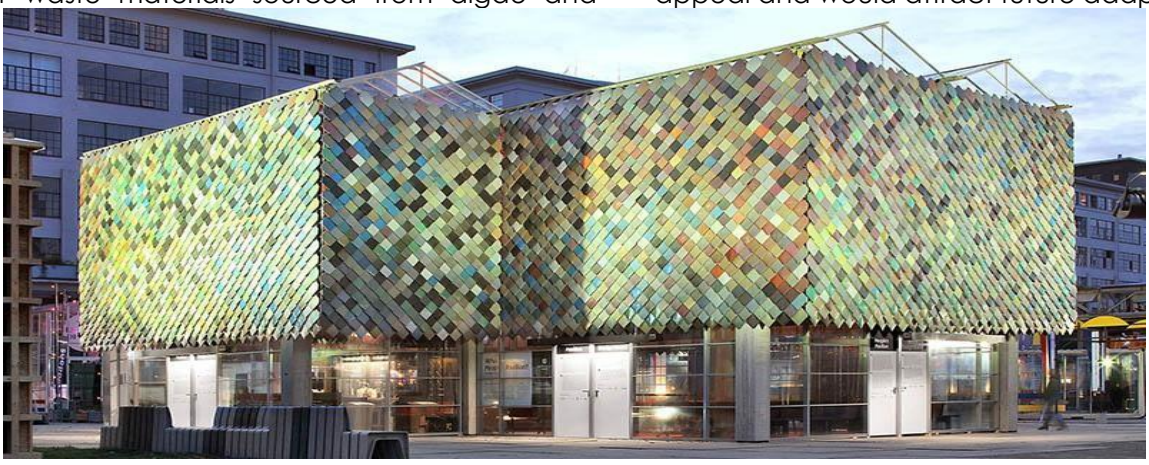

Figure 3. People 's Pavilion, Eindhoven, Netherlands.
Source: Archivibe, https://www.archivibe.com/circular-economy-inthe-built-environment/ (20/08/2025).

A pioneer CE building was designed by ARUP in Netherlands in 2017, named the People 's Pavilion. This building was completely built from borrowed material and devised a construction technique that didn't use glue, nails, or screws. After it was showcased, the building was successfully disassembled. Great potential abounds for increased recycled materials in products, future reuse (product, component and building) and future for recyclability and transformation, reuse potential and reversible building design score were achieved. This bold sustainability and material reuse project has the potential to make the design professionals to re-imagine a circular economy-inspired future creativity.

Challenges of Circular Economy in Architecture

i. **Lack of Awareness, Knowledge and Understanding Gaps**: Studies have shown that

many architects and other stakeholders lack awareness and understanding of CE principles (Suderson et al., 2023) and their application in architecture (Kirchherr et al., 2017; Circularity Gap Report, 2023; Stoiljković et al., 2023). This gap can be bridged through formal and informal training and continuous development programmes.

ii. **Design and Material Constraints:** CE principles often require significant technicalities and changes to design and material selection, which can be challenging for architects (Babbitt et al., 2021). The building industry is a complex system, and changes to one part of the system can have unintended consequences on other parts. Initiative technological advancement and sustainable building materials specification training and advocacy are required to manage these challenges.

iii. **Supply Chain Limitations:** Some have noted that, the sourcing and accessibility of circular materials and products can be limited (Adams et al., 2019; Farokhi & Miri, 2025). Projects are dependable on the availability of circular building materials for completion, as such, architects may not be confident to adopt, specify or patronage the materials despite the potentials therein. Supply chain expos need to be explored to showcase advances in sustainable supply chain innivations.

iv. **Cost, Financial Barriers and Economic Viability**: High initial investment costs for CE technologies and materials, combined with a focus on short-term return on investment (ROI) and the current low cost of new, virgin materials, make circular approaches seem less economical (Dong and Ng, 2016; Hart et al., 2019; Dong et al., 2021; Suleman et al., 2023). In Nigeria, the market for secondary materials is also underdeveloped and fragmented, leading to uncertainty in supply and pricing. The long long-run value of CE must be made public and beneficial live projects demonstration must be showcased alongside the perceptions of users from research results.

v. **Regulatory and Policy Deficiencies**: Inadequate or outdated regulations and a lack of specific CE policies and fiscal incentives (e.g., tax rebates for using recycled content) hinder widespread adoption (Suleman et al., 2023). Existing building codes may not accommodate innovative circular designs and materials, and a lack of enforcement of existing waste management regulations persists. Contextual regulatory and policy formulation are to be developed and all stakeholder must be involved.

vi. **Technical and Logistical Issues**: Challenges include the complexity of designing for disassembly (DfD) and adaptability, the absence of standardized material passports for tracking resources, and a lack of adequate infrastructure for sorting, storing, and processing recovered materials (Pierzchlewicz et al., 2025). Logistics on construction sites can be difficult due to limited space for waste segregation and storage. Hence, collaborative research with related industries would provide the necessary easement required.

vii. **Cultural and Social Resistance**: The construction industry is often conservative and risk- averse, with resistance to new methods and technologies (Soane, 2025). There are also quality concerns and cultural misconceptions surrounding the use of non-traditional, "old" or reused materials (Pierzchlewicz et al., 2025). This is most likely the case for Nigeria where the reason sand-filled waste bottles houses are yet to be accepted for use by the citizens. CE principles can be tailored to accommodate cultural preferences.

viii. **Lack of Impact Measurement and Emission Control**: the study conducted by Kayaçetin et al. (2023) notes that there is a lack of deliberate effort to measure the impact of construction-related activities on both users and society. This study also opined that omission or gap is mostly within the context of social impacts related to circular and bio-based construction. Again, standardized regulatory metrics for circularity are lacking and therefore, complicating emissions assessments have been observed (Dsilva et al., 2023). These two concerns pose a great challenge that require the formulation of frameworks to guide and guard against these concerns.

Potentials of Circular Economy in Architecture

The role of architecture is considered important in circular economy because design phase of buildings provides the most effective setting for

influencing major decisions about the sustainability of construction materials choices (Arrigoni et al., 2018; Llatas et al., 2020). The World Green Building Council, also advised that the greatest reduction in sustainability impacts can be achieved at the start of projects by optimizing material usage, savings and designing with low-carbon materials options (Adams et al., 2020). These potentials and or benefits of circular economy architecture are enumerated as follows;

i. **Environmental Benefits:** Architecture in a CE can significantly reduce the industry's environmental impact by minimizing waste (up to 84% through prefabrication) and cutting carbon emissions (Dsilva et al., 2023; Moustafa et al., 2025). This also helps conserve natural resources and supports a healthier ecosystem. This is an area that promotes biophilic architecture and produce specialist architects in the field of health architecture.

ii. **Economic Opportunities**: Circular practices offer potential for long-term operational savings, job creation in new sectors like urban mining and material recovery, and the development of innovative business models (Lundgren et al., 2023). Many architects in practice tend to be more drawn to the business aspects of architecture in this regard.

iii. **Innovation and Technology**: The adoption of digital technologies like Building Information Modeling (BIM) (Ahuja et al., 2020; Sundarsan et al., 2023), and blockchain can enhance material traceability, optimize resource planning, and facilitate design for disassembly (Khadim et al., 2023). Innovation and technology are becoming more popular amongst the tech-savvy who must be supported for diverse specialty and more efficient and transparent circular processes.

iv. **Policy and Collaboration**: Government leadership, through the enactment of supportive policies, incentives, and certifications, can drive industry-wide adoption (Combier et al., 2021). Public-private partnerships and increased collaboration among stakeholders (architects, engineers, contractors, clients) are crucial for developing necessary frameworks, and professional skills diversification in governance, practice and research.

v. **Long-term Value and Resilience**: Designing for longevity, adaptability, and multi-use purposes ensures that buildings and materials maintain their value over a longer lifespan, contributing to a more resilient and sustainable built environment (Ghobadi, & Sepasgozar, 2023; Moustafa et al., 2025), that can adapt to changing needs and diverse professional expectations.

vi. **Emissions and Waste Reduction**: The adoption of principles CE in architecture can bring benefits, including reduced waste and by about 85% of emissions, (Ghisellini et al., 2017; Basic et al., 2020; Lacy et al. 2020; Ghobadi, & Sepasgozar, 2023). Furthermore, this ensures clean air (Paulu et al., 2022). Standards can be developed to ensure compliance and reward systems.

vii. **New business opportunities and enhanced brand reputation**: Adopting CE promotes modular construction and studies have shown that, consumers are more likely to purchase from companies that prioritize sustainability (Sundarsan et al., 2023). Thus, creating an avenue for specialization and business pursuits in branding and customised construction materials.

viii. **Promotes Social Justice and inclusiveness**: According to Eberhardt et al. (2021) CE promotes social justice by creating opportunities for individuals and communities to access all resources and products. Architects could take advantage and become advocates and form professional pressure groups that would drive this agenda.

5. The Way Forward

The enumerated potentials as well as benefits of adopting circular economy architecture are worth pursuing. Despite the challenges outlined, they are surmountable from the prospects established and diversified benefits contained therein. Therefore, architects through the regulators of architectural practice – Architects Registration Council of Nigeria (ARCON) and the Nigerian Institute of Architects (NIA) must find ways to adapt and boost the adaptation/integration of circular economy architecture into the architectural practices.

6. Conclusion and Recommendation

This narrative review presents a theoretical discourse with an overview of CE. The discourse is able to uncover the challenging of adopting CE

and the potentials therein within the architectural domain.

The adoption of circular economy principles in architecture has the potential to reduce waste, promote sustainability and create avenues for diversification for economic growth. However, there are challenges to be addressed in the implementation of effective circular economy applications and strategies. These strategies must be tailored for the Nigerian built environment and to include; formulation of guiding policy, framework development with cultural infusions, standards, and promote the advancement of architectural digitalization. Additionally, modalities for collaboration and knowledge sharing between educators, researchers, communities, public and private practitioners are encouraged for inclusive lasting solutions and architectural diversification noted in the prospects presented. Thus, circular economy in architecture presents a unique platform that reconcile urban development and sustainable environmental solutions.

Summarily, the potentials and benefits of CE are multidimensional in nature. For the reasons that both occupants and the communities as a whole are beneficiaries, in terms of health, energy performance, inclusiveness, quality of life and environmental sustainability, respect for nature and the practice cum business benefits. Adopting CE Architecture means building diversified fields in architecture, balanced practice, resilient, viable and responsible future for the profession.

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