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Circular Economy in Architecture: Reducing Waste and Promoting Reuse in Construction

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Abstract:- This paper explores the concept of circular economy within the Architecture, Engineering, and Construction (AEC) industries. It examines the evolution of the circular economy framework from the traditional 4R model to more expansive 9R and 10R iterations. The study investigates the challenges and opportunities in implementing circular economy principles in Nigeria's AEC sector, considering its significant contribution to the country's GDP and potential for sustainable economic development. By analysing the relationship between construction activities and economic growth, this research aims to provide insights into the transformative potential of circular economy practices in AEC industry and its broader implications for national development.

Keywords:- *Circular Economy, Waste, Roadmap, Architecture, Engineering, Construction, Nigeria.*

I. INTRODUCTION

The concept of circular economy has gained significant traction across various sectors, including the Architecture, Engineering, and Construction (AEC) industries. This paradigm shift represents a departure from the traditional linear economic model of "take-make-dispose" towards a more sustainable and regenerative approach. At its core, the circular economy seeks to maximise resource efficiency, minimise waste, and create value through the continuous circulation of materials and products within economic systems.

The circular economy framework has evolved over time, with the most recognized model being the 4R framework: reduce, reuse, recycle, and recover. However, recent scholarly discourse has expanded this concept to include more comprehensive 9R and 10R frameworks [1][2][3]. These extended models incorporate additional principles such as refuse, rethink, repair, refurbish, remanufacture, and rot (composting), providing a more nuanced approach to circular economy implementation.

Despite the growing recognition of circular economy principles, research suggests that the 'recovery' aspect often receives the least emphasis within the 4R framework. This imbalance could potentially hinder the full realisation of circular economy benefits, as effective resource recovery is crucial for closing material loops and maximising value retention.

As the global economy transitions from a linear to a circular model, there is an urgent need for the AEC industry to adapt and embrace these changes. The adoption of circular economy principles in the AEC sector is not only essential for achieving sustainability goals but also for driving economic growth and development [4]. This transition presents both challenges and opportunities, particularly in developing countries like Nigeria, where the construction sector plays a pivotal role in economic development.

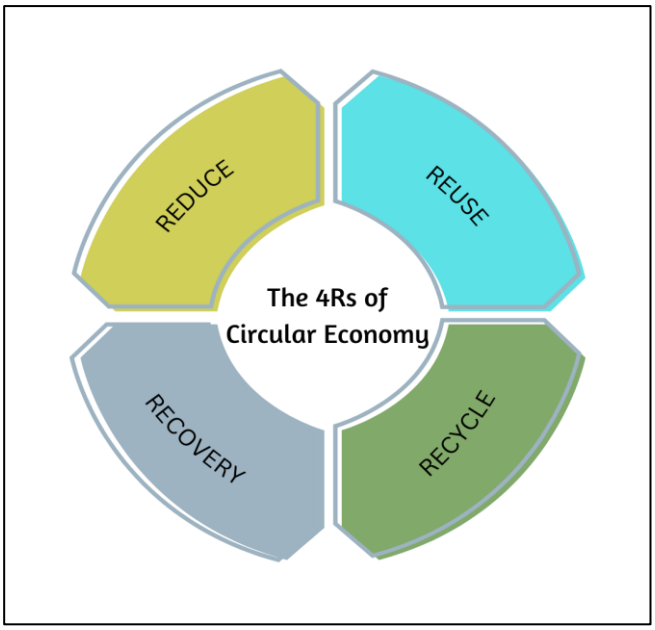

Fig 1 The 4R Framework of Circular Economy [1]

- *The Nigerian Roadmap; Construction and Economic Development*

In Nigeria, the adaptation of the circular economy in the AEC industry is not without its challenges and pitfalls, some of which include but are not limited to late design changes [5], poor regulatory frameworks, insufficient knowledge among professionals, restricted access to good infrastructure and materials needed to function in the sector, unstable forex in the economy, among others [6][7].

Nigeria has experienced an upward shift in the rate of urbanisation [8] and this has been accompanied by growth in the construction sector. According to [9], the construction sector is one of the top 10 contributing activities to real GDP and in the fourth quarter of 2023, it grew by 2.87% in nominal terms (year-on-year) thus contributing 9.00% to nominal

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GDP. The construction industry boosts a nation's economy by providing numerous job and investment opportunities and is influenced by the nation's GDP, which in effect would suggest that the relationship is not unidirectional [10]. A nation with an increased GDP is more likely to improve its construction sector, while the construction sector in turn boosts the economy [5].

Findings from data analysis from 15 developing countries in Sub-Saharan Africa spanning 22 years have shown a positive correlation between the construction industry and sustainable economic development in a country [11]. This could imply that developing countries successfully transitioned into developed countries invested in this thriving sector.

Globally, the same trend can be seen, as more people choose to immigrate to urban regions with better amenities, the rate of construction increases, thus driving the economy forward [4]. That is not to say that the effect on the economic development of nations caused by the construction sector is a stand-alone feat. Unfortunately, these have also led to some adverse conditions tipping the scale of nature in an unfavourable direction. There has been a high generation of waste in the country, which has eaten into the nation's GDP, thus affecting economic growth and development adversely [6]. Furthermore, the lack of effective systems in recycling, reducing and/ or reusing waste has contributed ultimately to impeding economic growth and development. While there are countries that are smoothly navigating the transition into the circular economy, some developing countries are yet to meet up. Countries such as Algeria, Botswana and Nigeria have fallen behind in efficiently managing waste [6] and implementing principles that aid the preservation of natural resources is crucial. In Nigeria, there is a need for actionable plans to replenish forest resources, which are often depleted due to the constant felling of trees. Historically, buildings, furniture, and other structures were made from original wood, but today, we often use materials like HDF and MDF. While the production of HDF and MDF helps prevent waste by recycling wood shavings and other by-products, these materials are typically not reusable after their lifecycle. Although this recycling process enhances sustainability, the finished products themselves cannot be reused once they reach the end of their life.

This raises an important question: With the use of such materials in modern construction, how can we effectively practise the principle of reuse? There have been instances of compromised structures, some of which become uninhabitable or present health risks. The concept of reuse in architecture relies heavily on the quality of materials used. Inferior materials are unlikely to maintain their integrity long enough to be reused in other structures. In contemporary Nigerian construction, we see numerous low-quality structures being built. Although they may be aesthetically pleasing, the primary concern is not aesthetics but the preservation of our environment and the safety of human lives. It is essential to consider where to draw the line to ensure both sustainability and structural integrity.

II. THE CONCEPTS, REUSE AND REDUCE

According to the European Commission, 're-use' means any operation by which products or components that are not classified as disposable waste are used again for the same purpose for which they were conceived. While 'reduce' takes place before the materials are classified into waste and this is achieved via prevention. In 1997, the Council of the European Commission confirmed that so long as they are the best options ecologically, re-use and recycling of waste materials should be preferred over other uses for waste such as the generation of energy [12]. The reuse of materials serves to extend the lives of building materials and cause an overall reduction in the emission of gases which usually occurs during the production of most construction materials. The concept of reuse stems from the assumption that the target materials are in such a reusable state that they cannot be ruled as waste meant to be disposed of [6]. Evidence suggests that there are certain barriers to the reduction and reuse of construction and demolition waste, and [13] have classified these barriers into three, governance, operational and market barriers. In greater detail, some of the barriers highlighted in their research comprise a paucity of enforced laws on construction and demolition waste, the absence of infrastructure, the lack of waste-treatment facilities and little demand for second-hand building materials. The authors' literature review, drawing on works by [14][15], highlighted several additional factors. Two significant concerns emerged from this review: first, the risk of raw materials being contaminated with hazardous substances such as heavy metals, other pollutants, and asbestos originating from building products; and second, the absence of a culture that promotes resource conservation and optimal use. Circular economy is achieved using various strategies, but this paper will be putting more spotlight on reuse.

The concept of reuse focuses on re-establishing structures or buildings in the environment without making drastic transformations which contribute to the consumption of primary resources. According to [16], strategies such as 'reduce primary resource inputs', 'design for reversibility', 'smart use of space' and 'urban mining' are partially built on reuse.

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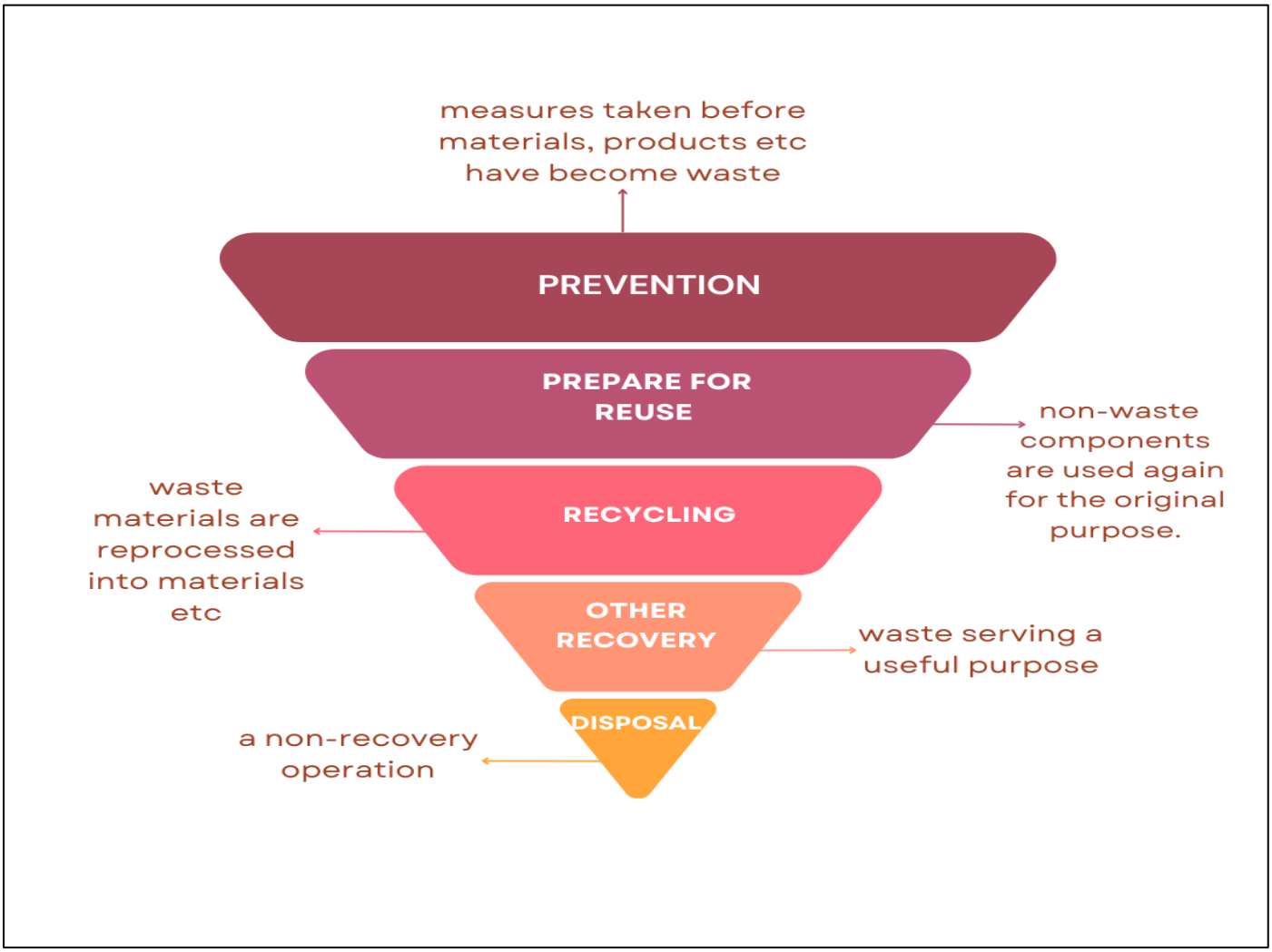

Fig 2 Adapted from the Directive 2008/98/EC of the European Parliament and of the Council on Waste and Repealing Certain Directives.

The construction industry increasingly contributes to the depletion of natural resources over the centuries as it evolves in its processes and material use [17]. For example, the importance of sand in producing most materials such as glass, cement, and bricks, and even in building construction cannot be underestimated. In Nigeria, the ocean bed is being dredged [18] more than ever before, whereas materials such as glass made from sand can be recycled and reused [6][12][13]. There has been a growing concern that the depletion of natural resources is happening at a faster rate than they can be replenished, leading to an imbalance in nature [12]. At the RIO+20 conference in June 2012, the United Nations committed to advancing sustainability, leading to the creation of the SDGs. Among the key outcomes were initiatives to sustainably manage natural resources, minimise environmental harm, enhance resource efficiency, and decrease waste [19]. Members acknowledged the crucial need for immediate action to address unsustainable production and consumption patterns, emphasising environmental sustainability, conservation, and sustainable utilisation of biodiversity and ecosystems. They also emphasised the importance of regenerating natural resources and fostering global growth that is inclusive and equitable over the long term [19]. The circular economy is a cornerstone of sustainability efforts, with research indicating its strongest correlations with the objectives of SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land). Sustainability, as a broad concept, encompasses endeavours aimed at enhancing the overall quality of life for everyone, within which the principles of the circular economy are encapsulated.

Two case studies of construction in which the principle of re-use was successfully implemented are discussed below.

- *Case One - Villa Welpeloo*

Villa Welpeloo, a residence and art studio conceptualised and built by Superuse Studios in 2005, stands as a testament to innovative design and sustainability. Beyond its striking architectural presence lies a profound story of resourcefulness and environmental consciousness.

Villa Welpeloo stands out for its visual appeal and unique construction approach, utilising 60% salvaged materials sourced locally through innovative methods. Architect Jan Jongert explains how they engaged individuals

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with access to waste material streams, using tools like Google Earth to locate industrial zones abundant in discarded resources. This proactive strategy resulted in materials with a rich history, such as steel from textile machinery and wood from damaged cable reels. This commitment to salvaging materials not only adds character to the building but also aligns with sustainability principles. The design and materialisation of Villa Welpeloo evolved simultaneously, showcasing a holistic approach where creativity and sustainability intersect. Additionally, using a treatment method called Plato, harnessing waste heat from a local power plant, preserved the wood without chemical treatments, further demonstrating the project's innovative and eco-friendly ethos [20].

- *Case Two - Temporary Courthouse, Amsterdam*

In the case of the temporary courthouse, the structure was erected with the plan to reuse the parts that make up the building.

The building was designed with a well-adaptable configuration, thus facilitating changing uses by changing users in changing locations in the future; the removal and the reuse were embedded in the contract. To render the structure as customizable and circular as possible, it was designed as a kit of parts that can as easily be assembled as disassembled and reassembled. Hence, once the life cycle was terminated, the structure was disassembled with precision. This was successfully done using a 3D model and scan to ensure that each component was correctly located and retrieved. Thereafter, the construction materials were reused in erecting another building which houses a research facility and an office [21].

III. CONCLUSION

The field of architecture wields significant influence in curbing and overseeing waste in construction, as their impact extends beyond mere design and client preferences. The decisions of these professionals can either bolster or harm the environment [22]. Altercations and last-minute decisions in design changes are major contributors to waste generation [22], and architecture has a better chance of controlling wastage if clients can be persuaded to make these changes before construction. Design for flexibility, adaptability and reusability are a few of the principles that can be engaged to promote a circular economy even before the construction commences. The impact of architecture can be better experienced if they take more control of decisions and provide guidance to clients in making choices regarding materials, designs and other components. Considering that the world is currently transitioning from a linear to a circular economy, architecture has an essential role to play in accomplishing this. Therefore, positive collaborations between clients and professionals and among professionals, creating markets for used construction materials, favourable government policy and the use of quality materials in building would go a long way in driving the adoption of a circular economy in architecture [4].

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