Green Architecture and Circular Economy

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Abstract*— Green design helps to drive a sustainable circular economy so that the cost of living is drastically reduced and the quality of life is improved. Green architecture has been more beneficial to the built environment, adding value to the building and the lives of the inhabitants, and improving the quality of life of the people who use it. The study's objective is to develop a sustainable circular economy in Nigeria through the use of green architectural design practices. This study employed the use of SWOT analysis in analyzing case studies of buildings that employed the use of green architecture to achieve a more sustainable economy in the region where the buildings are located, the study also analyzed recently written literature on green architecture and circular economy. The study found that the use of green architecture improves health, encourages a healthy environment with cleaner air, increases the purchasing power of its residents, and enhances sustainability in the economy of a region via energy-saving mechanisms in the building which reduces the overall cost of maintenance in the building, reduces the purchasing power of materials and enhances the region's net productivity. It was recommended that green architecture be practised more in the area of study to improve the general health and lifespan of both the structure and people while promoting a more sustainable circular economy through the use of sustainable materials and construction techniques in the building industry.

Indexed Terms- Architecture, Circular Economy, Design and Construction, Green Architecture, Sustainability.

I. INTRODUCTION

- BACKGROUND OF THE STUDY

Since it has been calculated that implementing CE in the built environment of Europe by 2030 may save £300 billion via primary resource and energy savings, the potential of CE is projected to be substantial (1) The building sector, however, is distinguished by a significant institutionalized project-based practice as well as market systems that, in many ways, do not support the implementation of CE principles (2). A large number of stakeholders must contribute to the completion of construction projects as part of a complicated worldwide supply chain, where each link adds to the building's environmental effect and production cost. Therefore, to ensure CE impact, collaboration and participation of all supply chain stakeholders through system thinking are required. System thinking is the capacity of the stakeholder to grasp how components influence one another within a whole (1). To obtain the highest profit margin for their separate building projects, the stakeholders' disparate objectives and areas of concentration force them to compete with one another, which fosters distrust and insufficient cooperation. Some industrial players even base their operations on taking advantage of the present fragmented state of the sector, which makes it difficult to support change. Additionally, because stakeholders cannot see the potential returns, sustainability projects are seen as extra labour(1).

It is crucial to comprehend the value of green architecture in a country like Nigeria and how it can contribute to the development of a more sustainable economy (3). Nigeria has engaged in some circular activities, but these have largely been connected to the unorganized sectors, and the idea as a whole has been motivated by the country's rising poverty rate (4). The integration of green design in the country's overall operations would assist in improving the wealth of the nation and strengthen its economy. Nigeria, the country, can see occasional growth if it moves in the path of transitioning into a circular economy by thinking and behaving green. The two primary focuses of the research are circular economy and green architecture, which both employ green design

principles and aspects to create buildings and ensure more sustainably produced goods moving forward (5). A building's location should take into account how it will affect the environment, ranging from traffic congestion to possible pollution and environmental degradation Green architecture promotes sustainable energy sources, energy conservation, the reuse of construction materials, and the safety of their usage (6).

Building shelter (in all of its forms) used more than half of the world's resources in the early 21st century, which equates to 16 per cent of freshwater resources on Earth, 30 to 40 per cent of all energy resources, and 50 per cent by weight of all the raw materials taken from the planet's surface. Additionally, architecture was responsible for 20–30% of greenhouse gas emissions and 40–50% of garbage deposited in landfills (7).

Many architects after the post-World War II building boom were content to erect emblematic civic and corporate icons that celebrated profligate consumption and omnivorous globalization. At the turn of the 21st century, however, a building's environmental integrity—as seen in the way it was designed and how it operated—became an important factor in how it was evaluated (8).

- STATEMENT OF PROBLEM

The increasing decline in the economy of the country has caused more difficult living experiences for the citizens of the country and this challenge affects every major of human existence ranging from health to feeding to housing conditions and other facets of people's lives that can be affected by the decaying economy. The problems that emerge from disposing of materials which can be reused, regenerated and reduced can be avoided if the right thing is done and this in turn revitalizes the economy of the country as fewer resources will be required for material importation, this will lead to a sustainable environment and economy

- STATEMENT OF ARCHITECTURAL PROBLEM

The impact of the use of non-sustainable materials in the building construction industry in a nation affects the country negatively. There will be no need to dump materials in landfills if the materials can be regenerated and reused (9). More sensitization on material sustainability and recycled material use will help drive an even better economy and support a greener approach to Architecture (10).

- SIGNIFICANCE OF THE STUDY

The study's relevance cannot be overstated, it exposes various possibilities for both the economy and the built environment, exploring the advantages of green architectural concepts and the reuse of sustainable materials in construction to better enhance living conditions while reducing waste materials obtained from construction sites and improving the economy.

- SCOPE OF THE STUDY

the scope of the study covers construction sites in Nigeria adopting green design concepts, considering the buildings that respond to green architecture standards, understanding the use of sustainable materials and how they can be utilized to achieve a circular economy.

- AIM AND OBJECTIVES OF THE STUDY

The study aims to achieve a sustainable circular economy using green architecture design practices for buildings in Nigeria. The following are the objectives of the study;

1. To examine how green architecture can aid in the attainment of a sustainable circular economy
2. To enhance green architectural practices in the building industry
3. To evaluate the effect of green architecture on the circular economy

II. LITERATURE REVIEW

- EFFECT OF GREEN ARCHITECTURE ON CIRCULAR ECONOMY

The time aspect of building projects is also challenging for adopting CE principles within the building industry for several reasons. Firstly, CE has mainly been focused on short- and medium-lived consumer goods (3), whereas buildings are often unique long-lived products with a possible change in use during their service life leading to increased uncertainty about future circumstances e.g. reuse of

building materials and components (4). Additionally, building parties frequently concentrate on the legal structure for how they will be held accountable beyond an insurance and warranty term. The project's completion, which typically takes place after 5 years and after which no liability for the building is accepted, is inconsistent with CE's long-term goals (3). Due to the discontinuity of stakeholders across the building's life cycle, stakeholders find it difficult to take control of building material flows. Due to the multiplicity of CE conceptualizations and the absence of a widely recognized definition or strategy throughout the supply chain, CE may be misunderstood, interpreted incorrectly, or used inappropriately by many industry players (3)(11). This is supported by those who discovered various levels of CE adoption by various businesses in various industrial practices with various views. As a result, there is a dearth of understanding on how to apply effective CE in the building business (3). The design phase of a building project plays a vital role in guaranteeing resource efficiency because the majority of environmental, social, and economic cost aspects have already been assessed, often up to 80% (4). Research to until has mostly been focused on waste management, leading to well-established high recycling rates of building and demolition waste within the sector, but with low value owing to down-cycling, while waste prevention in the design process is being more explored (3).

RELEVANCE OF 3Rs IN ACHIEVING A SUSTAINABLE GREEN BUILT ENVIRONMENT AND A CIRCULAR ECONOMY

Some academics disagree that social or behavioural difficulties have anything to do with circular economies. As an illustration, consider how (3) frames CE as a system that concentrates on reuse and recycling as alternatives to raw virgin resources rather than having any social purpose. The work of (4), who put recycling at the centre of a macroeconomic model for circular economies, has some similarities. However, (3) does have a social objective function which aims to maximize social welfare by optimizing resource consumption and pollution. Some academics believe that the economic aspect of sustainable supply chain management plays a vital role in enabling these flows of materials and resources while ensuring economic growth (e.g., (4); While (4) appear to be leaning toward improving present "green" SCM methods, (12)anticipate and actively strive toward a complete rethinking of the SCM status quo to address the new challenges offered by CEs. A strong economic dimension also emerges from the work of (13) who feel that an environmentally beneficial activity has to be first economically viable and profitable. Slightly different is the framing of (13), which has a strong focus on environmental issues (both at impact and resource scarcity levels) whilst however, acknowledging an important role of the economic benefits. The substantial contribution from (14) keeps a strong focus on the competitive advantage companies would achieve if they embraced a CE perspective, which the authors call the ‘circular advantage’(15)(16). Their work is deeply rooted in an analysis of waste in our society, which they identify in four different forms: wasted resources, wasted lifecycles, wasted capability and wasted embedded values. These are then tackled through five circular business and supply chain management models which require a radical “rethink of the relationships between markets, customers, and natural resources” (14) Whilst their work is instrumental towards the practical implementation of successful CE models, it looks incomplete to frame CE as a new paradigm that would benefit society at large (17). A practical example of such narrow focus is that of considering a remarkable success diverting 150 tons of daily food waste for a US company that was “a major cost in terms of lost revenue and disposal fees” into “inexpensive and clean energy that powers 49-acre campus housing offices” (14)

III. METHODOLOGY

The use of case studies in defining and implementing processes has shown to be quite helpful (Cropper, 1986). A case study is a research strategy that may be compared to an experiment, a history, or a simulation, claims Rule (1986). He clarifies that this does not necessitate the use of any certain strategy for obtaining proof or information. Quantitative and qualitative information, bolstering techniques, verbal descriptions, and observations—either separately or collectively—will be used to make the decision. Having an analytical framework and guiding hypothesis through a literature review will prevent the

case study from being cognitively too open-ended, it was also proposed.

IV. CASE STUDIES

The study will analyze certain buildings that use green architectural design concepts and explore possibilities of regenerative architecture in its design and construction process.

PANAL SUSTAINABLE REGENERATIVE CONDOMINIUM

CASE STUDY 1
PROJECT INFORMATION
Architects: AYMA Arquitectura y Medio Ambiente LTDA.
Project Location: Santiago, Chile.
Project Area: 11840 ft²
Project Year: 2019
Photography: Pablo Blanco Barros

Seven mixed-use units make up the micro-neighbourhood master plan for PANAL, which is designed like a sponge. This improves the quality of life for those who live there by cutting down on commute time between their houses and places of employment or leisure, and it has areas for residences, workshops, showrooms, and offices.

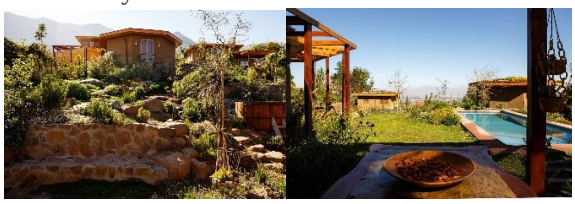
Aerial view of the condominium

The units, which are all unique, are set out according to the hill's natural slope, with an easterly view of the Andes Mountains and a westerly view of Santiago. The arrangement of gardens and grills to the northwest and the south façade with regulated openings and stone walls (material excavated on the site) for land confinement, borders, and landscaping are also determined by each unit's position.

Landscaping features for one of the units

REGENERATIVE DESIGNS

The surfaces of the project were designed with percolating pavements, regenerative native gardens, and green roofs in mind so that they would be completely absorbent and able to catch all of the rainfall naturally via the ground. In addition, the green spaces, which cover 90% of the project's land area, provide an ecological corridor that connects the Arboretum Park, which connects the Andes Mountains with the city and ensures the biodiversity that pre-human intervention existed. Additionally, the complex is interconnected by a central plaza that houses a wetland-style treatment facility that cleans wastewater before dispersing it to irrigate gardens, green roofs, and common spaces in each home, cutting down on water use by 80%.



Through the use of natural materials, green roofs, deciduous shade, and native vegetation, the condominium blends in with its surroundings and harmonizes with the environment, giving back to the earth what was taken from it at the time of construction.

- DEDUCTIONS

The project greatly Increased the circular economy based on the adoption of regenerative design processes, which is the practice of engaging the natural world as the medium for, and generator of the architecture. It responds to and utilizes the living and natural systems that exist on a site that become the "building blocks" of the architecture (18). The wetland-style water treatment reduces water costs, the 90% green vegetative coverage increases the quality of life of the inhabitants by reducing the finance that will be spent on health-related issues and also helps reduce the dependency on non-governmental healthcare facilities. The green design of the Panal enhances building sustainability.

- GUSHAN FISH MARKET

CASE STUDY 1
PROJECT INFORMATION
Architects: C.M. Chao Architect & Planners
Project Location: Taiwan
Project Area: 2468 ft²
Project Year: 2023
Photography: Yi-Hsien Lee, Rex Chu

The base is the Gusan Fish Market, which is nearly 100 years old. In 1927, it was a fishing port and a significant regional transportation hub that saw the height of Hamasen's prosperity. However, the lucrative offshore fishing sector progressively took over the fish market's economic role. The design team changed the Gushan Fish Market into the Kaohsiung Agricultural and Fishery Products Exhibition and Sales Center by demolishing the hazardous structures and enhancing the surrounding area to restore the market's previous splendour. The exterior of the glass box-like structure has a view of the open ocean, and the building's features include images of boats and the sea.

aerial view of the Gushan fish market

The base is 7243.64 square meters, and the building area is 2468.38 square meters. During the opening period, it attracted more than 30,000 visitors on a single day. The entire site is divided into the Fishery Office at the entrance, Gushan Fish Market, and the Plaza. The market is divided into Gushan Ferry Station and Kaohsiung Agriculture and Fishery Products Exhibition and Sales Center.

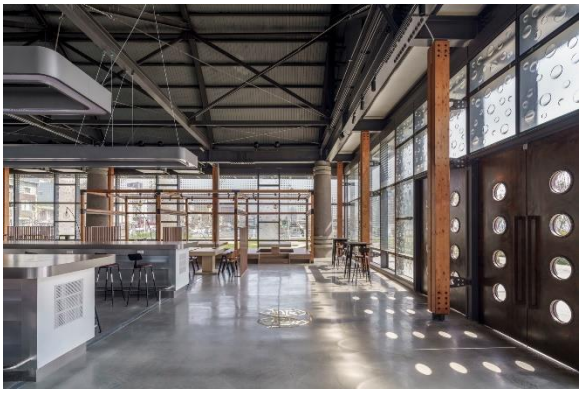
The route was specifically re-planned by the design team to keep people and cars apart. To minimize risk, motorcycle and bicycle passengers can board the boat from the previous ferry station's waiting area, while other passengers can enter from the new waiting area. This draws visitors and fish merchants to the Gushan Fish Market. Preserving and recreating historic structures is essential to their renovation. The project makes use of environmentally friendly, heat-resistant building components, such as double glazing, waterproof paint, wind-resistant glued laminated wood, insulation panels, paints, and flooring with a

monolithic finish. Only the waterproofing was improved throughout the repair; the old brick construction was kept, making it possible for everyone to witness the remnants of history.

Interior view showing the roof members, double glazing and monolithic finish flooring

"Transparent structures and hazy borders." - The design team tries to obfuscate everything around the building, including borders, the sea, activity, flowing light, boats, and the environment. It is to appreciate a mood to look at the water. Varied appearances of sunshine, temperature, and reflection angles convey different moods via "fused glass" and "double sandblasted glass walls." Every day, the water changes its face and hues. The renovation's goal is to maintain Gushan Fish Market's historical legacy. The design team improved, moulded, and restored the architectural elegance while maintaining many of the original components within structural requirements. The accessibility of the nearby commercial district and the Dutch-style masonry bricks, which are both open to view and explore by the general public, further energize the neighbourhood's economic strength.

- REUSE OF BUILDING ELEMENTS



Environmental protection is another theme of the project. The translucent box design is used to reproduce the 330-meter-long structure. To address thermal pollution and ventilation, the design team added paint overlays and panels of thermal insulation to the roof. The central half of the structure is open, with double-layer glass walls for thermal insulation, and sandblasted glass to minimize light transmission, allowing the front and rear of the building to be ventilated and heat-blocked. The roof ridge is also fitted with ventilation windows. Plants are used to beautify the exterior of the building to offer a varied visual experience and fresh air. The wind-resistant walls are constructed from glued laminated wood that is recyclable. There is a 270-degree sea vista from the base. The building has a distinct appearance during the day and at night thanks to the usage of the idea of a "transparent box" to generate a sensation of light. Fused glass on the external walls produces a bubble that resembles water, and the middle portion of the double-layer glass may conserve energy simultaneously. The glass is precisely treated to create a distinctive bubble appearance that resembles bubbles from the waves shining in the sunshine. The most beautiful fish market in Taiwan is made up of sandblasted glass walls coated with mesh printing, whose overlapping shading effect mimics the freshness of fish scales.

A century-old brick building in the Dutch style serves as the entryway. The design team has improved the building's outside while preserving the old structure so that when people enter, they can appreciate the market's history. Gushan Fish Market was a parking lot that underwent renovations with a focus on preserving the original building's structure and partially using light-transmitting materials for the exterior of the new building. This created brightness

and highlighted the structural beauty of both the old and new buildings. The Yancheng, Asian New Bay Area, Kaohsiung Music Center, Kaohsiung Port Warehouse No. 2, and Penglai Pier will all be connected by the "Gushan Fish Market" ancient building renovation project. The core area, which creates the Kaohsiung waterfront tourist zone, is the greatest place for tourism planning. The design team also wants to keep the century-old structures.

- DEDUCTIONS

Despite the Gushan fish market being an economic hotspot because of the fish market and the transit arm of the facility the building incorporates in its design a high degree of green design practices and eco-friendly design principles. The space conceptualization and material selection in the facility follow going-green ideologies to enhance the comfortability of users. The building instead of being completely demolished, was preserved keeping the historic relevance of the existing building, the brick wall was also preserved reducing the amount of waste that could be generated from the site. The use of landscaping features to promote aesthetics and increase tourist attraction to increase the economic viability of the facility was another key eco-friendly concept considered and effectively done on the site. The project solved the problem of environmental pollution which helps in reducing the cost incurred by the government on environmental protection.

V. FINDINGS AND DISCUSSIONS

From the study, it was discovered that the reuse of building materials has a great impact on the economy and this automatically impacts the circular economy, aside from the other benefits of regenerative design concepts used in the design, it was discovered that green architecture is a great contributor to the economy by reducing the overall cost incurred in the construction of a building while still enhancing livability and quality of health of the users of such facilities. Green architecture is greatly underutilized in Nigeria and should be incorporated into the building laws and codes to increase dividends from the circular economy. The recycled material usage if implemented will go a long way in enhancing the reduction of environmental waste in the country Nigeria construction teams, engineers and architects should adopt an ideology of reusing building parts, elements and components for new designs this will not only promote preservation and conservation of building elements but also reduce greatly the rate at which building elements are imported into the nation Nigeria, this helps the circular economy of the nation and increases the wealth of the nation through the built industry, seeing that the building industry contributes greatly to the cause of the growth or poverty of any nation's economy. Government policies should be updated to incorporate the 3Rs in the built industry which are reusing, reducing and recycling materials to achieve a greener and more sustainable environment while revitalizing the economy

CONCLUSION

A case study that was intended for disassembly corroborated the findings of the literature review that more reuse might further boost potential environmental impact savings as well as economic advantages. Furthermore, by selecting the best material combinations, such as wood, steel, and glass, the building might potentially reduce its total environmental effect, making it simpler to disassemble for recycling and reuse. A mix of several life cycle design and construction solutions tailored to various material and component groups and their inherent features is encouraged, with the argument that some circular economy principles may work better along with particular building types, materials, and components. By tackling the circular economy in the built environment on a more understandable level for its stakeholders and supporting decision-making in the design stage of new structures to grasp inherent circular economy potentials, this heuristic technique may be able to reduce the key obstacles outlined in the literature study. Embracing green architectural design

concepts in the built environment for all building types will have a positive effect on the circular economy with some being higher than others.

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