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# ASSESSING THE BENEFITS AND LIMITATIONS OF BIOINTEGRATED DESIGN IN RESIDENTIAL BUILDINGS IN LAGOS STATE

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**ABSTRACT**
*Bioarchitecture plays an important role in reducing the effects of the urban heat island, however, there is a dearth in studies showing how rapid urbanization and climate changes negatively affect users of modern buildings and structures. This study specifically examines the socioeconomic characteristics of people using buildings with biointegrated architecture, and assessing the level of awareness of residents within these buildings. A total of eleven condominiums were purposively selected in Ikoyi, Victoria Island and Lekki. A total of 170 questionnaires were distributed to respondents across the selected condominiums with all questionnaires retrieved and analyzed with descriptive statistics and MWVs.*

*Findings reveal that respondents demonstrated a generally good level of awareness and knowledge of biointegrated design, with Mean Weighted Values ranging from 3.61 to 3.70 and an overall Average Weighted Value (AWV) of 3.65. Respondents were most aware of residential buildings incorporating biointegrated design features (MWV = 3.70) and demonstrated a good understanding of Vertical Green Systems (MWV = 3.68). The perceived benefits of biointegrated design were also high, with an overall AWV of 4.00. Reducing energy consumption (MWV = 4.07), improving air quality and building appearance (MWV = 4.04 each), and enhancing thermal comfort (MWV = 3.99) were identified as the leading benefits. Overall, the findings indicate that residents recognise the environmental, functional, aesthetic, and wellbeing benefits of biointegrated design, although greater awareness and professional advocacy are required to promote its wider adoption in residential development across Lagos State.*

**KEYWORDS**: Biointegrated Designs, Bioarchitecture, Biomimicry, Climate Change, Lagos State

## I. INTRODUCTION

Due to rapid urbanization and the impacts of climate change particularly in tropical megacities Lagos, Nigeria there is a need for the integration of Bioarchitecture (Guo, Di, Zhang, Lin, Chen, and Molla, 2022). However, climate change poses a more significance threat by worsening environmental problems through heat waves and increased intensity of rainfall (Bandh, Shafi, Peerzada, Rehman, Bashir, Wani and Dar, 2021). When combined with lack of green spaces, hot temperature and paved surfaces, this leads to increase in mortality rate due to health issues. Bioarchitecture incorporates design principles from the onset of a project by blending biomimetics, art and architecture together (Xiao and Seong, 2025).

In rapidly growing cities like Lagos, integrating bioarchitecture principles into the design of building envelopes contribute to overall more sustainable cities (Barekat, 2024). Recent research by Chayaamore-Heil (2023) further reveals that bioarchitecture focuses on introducing living organisms such as plants or biological materials into design. This is particularly evident in the use of Vertical Greenery Systems (VGS) which serve in reducing the challenges posed by climate change and rapid urbanization (Afshari, 2017).

While buildings within Lagos continue to face compounded stress from heat waves, consistent rainfall and rapid urbanization (Makvandi et al., 2024; Guo et al., 2022), there is little to no research on how biointegrated solutions perform within tropical regions particularly Lagos. Research by Shashwat, Zingre, Thurairajah, Kumar, Panicker, Anand, and Wan, 2023 reveal that biointegrated solutions through green facades, living walls alongside other bioinspired building envelope treatments have the potential to lengthen the life span of buildings.

## II. LITERATURE REVIEW

Biomimicry, as a theoretical lens, is grounded in the emulation of nature's time-tested patterns and strategies to solve complex human challenges (Dhungana, 2025). According to Zari (2018), biomimicry avances the principle that design solutions should reflect the adaptability, efficiency, and resilience found in ecosystems. Biomimicry promotes decentralized and localized approaches, drawing on how organisms thrive within specific environmental contexts while still benefiting from broader ecological networks (Metwally, 2025).

Urban metabolism offers a systemic framework for understanding the flow of materials, energy, and water through urban environments (Zhang, Yang and Yu, 2015). Originally rooted in industrial ecology, the concept of urban metabolism views cities as organisms that consume resources and produce much like living beings (Newell and Cousins, 2015). This analogy facilitates the quantification and optimization of resource use to support sustainability goals.

In its industrial ecology variant, urban metabolism employs tools such as material flow analysis (MFA), energy synthesis, and life cycle analysis (LCA) to assess urban sustainability through inputs and outputs (Galychyn, 2022). The "Vienna School" further expands this with socioeconomic metabolism, connecting material flows to transitions in economic and social structures (Gandy, 2025).

## 2.1 The Building Envelope in Urban Architecture

Previous studies by Lovel (2013) reveal that the building envelope plays an integral role in the skeletal framework of a structure often comprising elements such as the foundation, walls, lintel, roof, thermal insulation among others. Baker and Steemers (2019) also explicitly stated that it plays a key role in protecting a building from environmental stressors such as penetration of moisture, ultraviolet rays, and thermal fluctuations while improving the energy efficiency and overall aesthetics of a structure which in turn improves occupants comfort.

In a city like Lagos, Nigeria which suffers from immensely high temperatures, particularly during March and April, the building envelope serves a protective shield by regulating temperature within buildings through the reduction of solar heat gain while reducing the pressures of consistent rainfall (Obamoh, Udeala and Obamoh, 2025). A good building envelope is designed in such a way that it prolongs the lifespan of a building by reducing the wear and tear due to the impact of rain or heat on building elements resulting in overall reduction of maintenance costs over time (Joshi, 2024).

## 2.2Incorporating Bioarchitecture into Building Envelope Designs

According to Shahamat (2025) most biointegrated building envelopes especially those that are inspired by biomimicry often alleviate performance and functionality issues posed by urban architecture. Wang, Wang, Kaloush and Shacat (2021) further revealed that nature-inspired materials pose greater benefits in terms of reducing environmental or structural degradation while improving the aesthetics of building facades.

There are various natural materials which are used in bioarchitecture particularly in Urban architecture. While most people focus on Vertical Greenery systems (VGS), Zhuge and Liu (2024) recently revealed that the polar bear fur structure mitigates the impact of solar radiation by serving as a thermal insulator. Due to this, there's been a surge in the use of artificial furs and fiber as building materials. However, that's not all, the structure of a butterfly's wings and spiders webs have also inspired numerous designs for building facades particularly in urban architecture.

## 2.3 Bioarchitecture in Lagos

In recent times, Lagos, Nigeria's former capital and one of the world's rapidly growing urban centers has faced numerous challenges due to the effects of climate change and its rapidly growing population among other things. According to Adelekan (2010), Lagos currently grows at over 3.3% annually with green areas depleting consistently. Numerous buildings have been brought down to accommodate newer structures while skyscrapers have become the order of the day. However, there are still numerous informal developments in Lagos.

In light of these challenges, there is a need for integrating bioarchitecture in urban spaces in Lagos particularly through the use of Vertical Greenery Systems (VGS). VGS helps in reducing the environmental stressors brought about by rapid urbanization such as poor indoor air quality, thermal discomfort, and lack of green areas (Ajayi, 2022). The integration of bioarchitecture in structures within Lagos State shows an increased interest in climate-adaptive urban structures which aligns with both the local and the global sustainability agenda.

## III. RESEARCH METHODOLOGY

### 3.1 Research Design

Mixed-method was adopted for this study featuring both quantitative and qualitative approach to examine the benefits and limitations of biointegrated designs. Quantitative data was obtained using structured questionnaires which were administered to residents within this buildings based on findings by (Okanlawon and Odunjo; 2016; Odunjo, Arotiowa, Amao, Ayejuyo and Daniel, 2026). Qualitative data was also obtained from respondents alongside direct observation of selected condominiums.

Case studies were also conducted in order to examine the types of biointegrated features available within buildings, building orientation, type of material used and design guidelines. The use of questionnaire responses alongside professional input of people within the construction industry who are familiar with biomimicry and bioarchitecture provided a broader basis for evaluating the benefits of bioarchitecture in urban spaces and identifying the limitations of biointegrated architecture.

### 3.2 Data Sources and Collection

The study utilized both primary and secondary data. Primary data were obtained through questionnaires administered to patients and healthcare professionals within selected orthopaedic sections, supplemented by field observations of the physical and environmental conditions of the facilities. Secondary data were obtained from relevant academic literature, institutional documents, standards, reports, and previous studies on hospital ventilation, indoor environmental quality, and healthcare design.

### 3.3 Sampling Frame

The sampling frame comprises of occupants within identified residential buildings within Lagos State which incorporate elements of bioarchitecture. Buildings within Eti Osa local government areas were selected because they feature numerous high rise buildings as seen in Table 1.

**Table1: Sample Frame and Sample Size Distribution**

| S/N | Location | Selected Condominium / Building | Estimated Resident Population | Proportion (%) | Sample Size |
|---|---|---|---|---|---|
| 1 | Ikoyi | 4 Bourdillon | 700 | 14.0 | 24 |
| 2 | Banana Island, Ikoyi | George Residence | 500 | 10.0 | 17 |
| 3 | Banana Island, Ikoyi | Echina Court | 450 | 9.0 | 15 |
| 4 | Victoria Island | Titanium Towers | 550 | 11.0 | 19 |
| 5 | Victoria Island | Eko Court Complex | 600 | 12.0 | 20 |
| 6 | Lekki Phase 1 | Paramount Twin Towers | 500 | 10.0 | 17 |
| 7 | Lekki Phase 1 | Oxygen Waterfront Residences | 400 | 8.0 | 14 |
| 8 | Lekki Phase 1 | The Overlook Condominiums | 350 | 7.0 | 12 |
| 9 | Lekki Peninsula II | Primewater View Gardens 1 Estate | 450 | 9.0 | 15 |
| 10 | Lekki Phase 2 | Springville Estate | 250 | 5.0 | 9 |
| 11 | Ajah, Lekki | Urban Retreat Luxury Apartments | 250 | 5.0 | 8 |
| Total | | | 5,000 | 100.0 | 170 |

**Source: Author's Compilation (2025)**

A total of 5,000 respondents were estimated to be within the study area. To ensure feasibility and statistical reliability, the sample size was determined using Slovin's formula:

$$n = \frac{N}{(1+Ne^2)}$$

Where:

n = sample size

N = population size (core area of Ogbomoso)

e = margin of error (0.05)

Therefore:

$$n = \frac{5000}{1 + (5000)\ (0.5)^2}$$

$$n = \frac{5000}{1 + 12.5}$$

$$n = \frac{5000}{13..5}$$

$$n=170$$

Thus, an initial sample size of 170 respondents was obtained.

## IV. DATA ANALYSIS

A field investigation of biointegrated design features within selected condominiums in South-West Nigeria was conducted. It features data obtained from 170 respondents across the selected condominiums. The responses obtained were used in assessing the residents' awareness and knowledge of biointegrated designs and their perceived benefits of biointegrated design elements alongside the limitations to applying biointegrated design features.

### 4.1Demographic Characteristics of Respondents

The socioeconomic characteristics of the respondents including gender, age, marital status, occupation, residential area, and length of residence were examined. Table 2 presents the socio-economic characteristics of respondents within the study. Females consisted the majority of the participants at 52.9%(90 respondents), while males accounted for 46.5% (79 respondents), and 0.6%(1 respondent) preferred not to state their gender.

The largest proportion of respondents were within the 20-30 years and 31-40 years old category with each amounting to 29.4% (50 respondents), while respondents aged 41-50 years constitute 19.4% (33 respondents), while 13.5% (23 respondents) fell between 51-60 years. The lowest proportion of respondents are those below the age of 20 and those above 60 years with 5.3% (9 respondents) and 2.9% (5 respondents) respectively.

Majority of the respondents were married (54.1%) while 40.6% were single. On the other hand, 2.4% were divorced while 2.9% were widowed. The largest proportion of the respondents (39.4%) had a bachelor's degree, while 22.9% have postgraduate degrees. They were closely followed in frequency by respondents with secondary education (13.5%). The lowest proportion of respondents were those with primary education amounting to 0.6%.

Findings from the study reveal that private sector employees were the largest group (26.5%), while civil servants amounted to 24.7% with self-employed respondents amounting to 23.5%. On the other hand, students amounted to 14.1% with retirees amounting to 4.7% and people in other occupation amounting to 6.5%. In terms of building type, blocks of flats were most common (24.1%), followed by semi-detached houses and bungalows (20.6% each). Most respondents were tenants (56.5%), while 37.6% were owner-occupiers. Regarding length of residence, the largest proportion (41.2%) had lived in their neighbourhood for 1–5 years, followed by those residents for 6–10 years (21.2%).

**Table 2: Socio-Economic Characteristics of Respondents (n = 170)**

| S/N | Variable | Frequency | Percentage (%) |
|---|---|---|---|
| 1 | Gender | | |
| | Male | 79 | 46.5 |
| | Female | 90 | 52.9 |
| | Prefer not to say | 1 | 0.6 |
| | Total | 170 | 100.0 |
| 2 | Age | | |
| | Below 20 years | 9 | 5.3 |
| | 20–30 years | 50 | 29.4 |
| | 31–40 years | 50 | 29.4 |
| | 41–50 years | 33 | 19.4 |
| | 51–60 years | 23 | 13.5 |
| | Above 60 years | 5 | 2.9 |
| | Total | 170 | 100.0 |
| 3 | Marital Status | | |
| | Single | 69 | 40.6 |
| | Married | 92 | 54.1 |

| | | | |
|---|---|---|---|
| | Divorced | 4 | 2.4 |
| | Widowed | 5 | 2.9 |
| | Total | 170 | 100.0 |
| 4 | Highest Educational Qualification | | |
| | Primary | 1 | 0.6 |
| | Secondary | 26 | 15.3 |
| | Diploma/NCE | 32 | 18.8 |
| | Bachelor's Degree | 67 | 39.4 |
| | Postgraduate Degree | 39 | 22.9 |
| | Other | 5 | 2.9 |
| | Total | 170 | 100.0 |
| 5 | Occupation | | |
| | Civil Servant | 42 | 24.7 |
| | Private Sector Employee | 45 | 26.5 |
| | Self-employed | 40 | 23.5 |
| | Student | 24 | 14.1 |
| | Retired | 8 | 4.7 |

| | | | |
|---|---|---|---|
| | Other | 11 | 6.5 |
| | Total | 170 | 100.0 |
| 6 | Residential Area | | |
| | Magodo | 22 | 12.9 |
| | Surulere | 22 | 12.9 |
| | Maryland | 18 | 10.6 |
| | Ajah | 17 | 10.0 |
| | Ikeja | 17 | 10.0 |
| | Lekki | 17 | 10.0 |
| | Ogba | 15 | 8.8 |
| | Ikorodu | 15 | 8.8 |
| | Yaba | 14 | 8.2 |
| | Epe | 13 | 7.6 |
| | Total | 170 | 100.0 |
| 7 | Type of Residential Building | | |
| | Detached House | 21 | 12.4 |
| | Semi-detached House | 35 | 20.6 |
| | Duplex | 23 | 13.5 |

| | | | |
|---|---|---|---|
| | Block of Flats | 41 | 24.1 |
| | Bungalow | 35 | 20.6 |
| | High-rise Apartment | 12 | 7.1 |
| | Other | 3 | 1.8 |
| | Total | 170 | 100.0 |
| 8 | Ownership Status | | |
| | Owner Occupier | 64 | 37.6 |
| | Tenant | 96 | 56.5 |
| | Caretaker | 7 | 4.1 |
| | Other | 3 | 1.8 |
| | Total | 170 | 100.0 |
| 9 | Length of Residence | | |
| | Less than 1 year | 32 | 18.8 |
| | 1–5 years | 70 | 41.2 |
| | 6–10 years | 36 | 21.2 |
| | Above 10 years | 32 | 18.8 |
| | Total | 170 | 100.0 |

**Source: Author's Field Survey (2025).**

### 4.2 Awareness and Knowledge of Biointegrated Design

The findings indicate a generally good level of awareness and knowledge of biointegrated design among residents in Lagos State, with Mean Weighted Values (MWV) ranging from 3.61 to 3.70 and an overall Average Weighted Value (AWV) of 3.65 as seen in Table 3. The highest-rated indicator was respondents' exposure to residential buildings incorporating biointegrated design features (MWV = 3.70), followed by understanding of Vertical Green Systems (VGS) (MWV = 3.68). Respondents also recognised the contribution of biointegrated design to environmental sustainability (MWV = 3.65) and the capacity of green building features to improve residential quality (MWV = 3.64).

Although respondents expressed interest in learning more about bioarchitecture (MWV = 3.62), familiarity with the specific concept of bioarchitecture recorded the lowest score (MWV = 3.61). This suggests that residents may be more familiar with the practical applications of biointegrated design than with its technical terminology. Overall, the results demonstrate increasing awareness of sustainable residential design in Lagos, while also highlighting the need for greater public education and professional advocacy to deepen knowledge and promote wider adoption of biointegrated design principles.

**Table 3: Awareness and Knowledge of Biointegrated Design among Residents in Lagos State (n = 170)**

| S/N | Variables | 1 | 2 | 3 | 4 | 5 | TWV | MWV | AWV | Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I have seen residential buildings with biointegrated design features | 11 | 16 | 35 | 59 | 49 | 629 | 3.70 | 104.83 | 1st |
| 2 | I understand the purpose of Vertical Green Systems (VGS) | 17 | 17 | 30 | 45 | 61 | 626 | 3.68 | 104.33 | 2nd |
| 3 | Biointegrated design contributes to environmental sustainability | 12 | 23 | 33 | 47 | 55 | 620 | 3.65 | 103.33 | 3rd |
| 4 | Green building features improve residential quality | 11 | 21 | 32 | 61 | 45 | 618 | 3.64 | 103.00 | 4th |
| 5 | I would like to learn more about bioarchitecture | 15 | 20 | 31 | 53 | 51 | 615 | 3.62 | 102.50 | 5th |
| 6 | I am familiar with the concept of bioarchitecture | 14 | 19 | 34 | 55 | 48 | 614 | 3.61 | 102.33 | 6th |

**Source: Author's Field Survey (2025)**.

### 4.3 Benefits and Limitations of Biointegrated Design

The findings in Table 4 reveal a high level of agreement among respondents regarding the benefits of biointegrated design in residential buildings, with Mean Weighted Values (MWV) ranging from 3.92 to 4.07 and an overall Average Weighted Value (AWV) of 4.00. The most highly rated benefit was its ability to reduce energy consumption (MWV = 4.07), followed by improving air quality and enhancing building appearance (MWV = 4.04 each). Respondents also recognised its contributions to thermal comfort and reduced heat absorption (MWV = 3.99 each), property value enhancement (MWV = 3.98), and occupants' health and well-being (MWV = 3.95). Promoting biodiversity recorded the lowest, though still positive, rating (MWV = 3.92).

Overall, the results demonstrate that residents perceive biointegrated design as providing significant environmental, functional, economic, aesthetic, and health-related benefits. In particular, the strong ratings for energy efficiency, air quality, and thermal performance highlight its relevance to the climatic conditions of Lagos. The findings therefore support the promotion of biointegrated design as a viable strategy for achieving more sustainable, comfortable, and environmentally responsive residential development in rapidly urbanising areas.

**Table 4: Perceived Benefits of Biointegrated Design Elements (n = 170)**

| S/N | Variables | 1 | 2 | 3 | 4 | 5 | TWV | MWV | AWV | Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Reduces energy consumption | 5 | 14 | 22 | 52 | 77 | 692 | 4.07 | 86.50 | 1st |
| 2 | Improves air quality around buildings | 4 | 11 | 29 | 56 | 70 | 687 | 4.04 | 85.88 | 2nd |
| 3 | Improves the visual appearance of buildings | 6 | 9 | 25 | 63 | 67 | 686 | 4.04 | 85.75 | 3rd |
| 4 | Enhances thermal comfort | 8 | 12 | 24 | 56 | 70 | 678 | 3.99 | 84.75 | 4th |
| 5 | Reduces heat absorption by buildings | 7 | 15 | 28 | 43 | 77 | 678 | 3.99 | 84.75 | 5th |
| 6 | Increases property value | 10 | 14 | 16 | 60 | 70 | 676 | 3.98 | 84.50 | 6th |
| 7 | Improves occupants' health and well-being | 11 | 12 | 21 | 57 | 69 | 671 | 3.95 | 83.88 | 7th |
| 8 | Promotes biodiversity within residential environments | 11 | 11 | 21 | 65 | 62 | 666 | 3.92 | 83.25 | 8th |

**Source: Author's Field Survey (2025).**

## V. CONCLUSION

The study established that biointegrated design can significantly enhance the sustainability, environmental performance, comfort, and aesthetic quality of residential buildings in Lagos State. Respondents demonstrated a generally good level of awareness and knowledge of biointegrated design, with an overall AWV of 3.65, although familiarity with the technical concept of bioarchitecture was comparatively lower.

The perceived benefits of biointegrated design were high, with an overall AWV of 4.00. Reduced energy consumption, improved air quality, enhanced building appearance, thermal comfort, increased property value, and improved occupant well-being were identified as major benefits. The findings therefore demonstrate the relevance of biointegrated design as a climate-responsive strategy for addressing environmental and energy challenges associated

with residential development in Lagos. However, increased public awareness, professional capacity, and supportive policies are required to encourage wider adoption.

**Recommendations**

1. Promote biointegrated design through the incorporation of green roofs, Vertical Green Systems, green balconies, landscaped courtyards, and vegetated façades in residential developments.
2. Increase public awareness through educational programmes that improve understanding of bioarchitecture and its environmental and social benefits.
3. Prioritise thermal and energy performance by using vegetation strategically for shading, heat reduction, and improved indoor comfort.
4. Strengthen professional capacity through training for architects, developers, and other built-environment professionals on biointegrated design and maintenance.
5. Develop supportive policies and guidelines that encourage or incentivise the integration of biointegrated features into residential developments.
6. Encourage further research into the long-term environmental, economic, and performance benefits of biointegrated design within Lagos and other Nigerian cities.

**REFERENCES**

Afshari, A. (2017). A new model of urban cooling demand and heat island application to vertical greenery systems (VGS). *Energy and Buildings, 157*, 204–217.

Adelekan, I. O. (2010). Vulnerability of poor urban coastal communities to flooding in Lagos, Nigeria. *Environment and Urbanization, 22*(2), 433–450. https://doi.org/10.1177/0956247810380141

Ajayi, B. (2022). *The present and the future potential effect on urban air quality of the use of electric vehicles: A case study of Lahti and Lagos* [Master's thesis, University of Applied Sciences].

Baker, N., & Steemers, K. (2019). *Healthy homes: Designing with light and air for sustainability and wellbeing*. Routledge.

Bandh, S. A., Shafi, S., Peerzada, M., Rehman, T., Bashir, S., Wani, S. A., & Dar, R. (2021). Multidimensional analysis of global climate change: A review. *Environmental Science and Pollution Research, 28*(20), 24872–24888.

Barekat, M. (2024). Principles of ecological and biophilic architecture in the design of Iranian residential complexes in order to improve their quality. *Современное строительство и архитектура*, (2[45]).

Chayaamor-Heil, N., Perricone, V., Gruber, P., & Guéna, F. (2023). Bioinspired, biobased and living material designs: A review of recent research in architecture and construction. *Bioinspiration & Biomimetics, 18*(4), 041001.

Dhungana, H. (2025). Biomimicry as a decision-making methodology in condition monitoring. *Frontiers in Artificial Intelligence, 8*, 1485489.

Galychyn, O. (2022). *Towards sustainable cities: A multi-criteria assessment framework for studying urban metabolism*.

Gandy, M. (2025). Urban metabolism redux. *Urban Studies, 62*(8), 1483–1511.

Guo, L., Di, L., Zhang, C., Lin, L., Chen, F., & Molla, A. (2022). Evaluating contributions of urbanization and global climate change to urban land surface temperature change: A case study in Lagos, Nigeria. *Scientific Reports, 12*(1), 14168.

Joshi, A. M. M. (2024). *Introductory approach to green buildings*. Academic Guru Publishing House.

Lovel, J. (2013). *Building envelopes: An integrated approach*. Princeton Architectural Press.

Makvandi, M., et al. (2024). *[Complete bibliographic details required]*.

Metwally, W. M. (2025). Biomimicry and green architecture: Nature-inspired innovations for sustainable buildings. *Sustainability, 17*(16), 7223.

Newell, J. P., & Cousins, J. J. (2015). The boundaries of urban metabolism: Towards a political–industrial ecology. *Progress in Human Geography, 39*(6), 702–728.

Obamoh, H. Y., Udeala, E. R. C. U., & Obamoh, Q. S. O. (2025). Passive cooling techniques in building design for hot climates: A Nigerian perspective. *Academic World Journal of Scientific and Engineering Innovation, 2*(1), 1–6.

Odunjo, O., Arotiowa, P., Amao, F., Ayejuyo, O., & Daniel, J. G. (2026). Evaluation of Factors Influencing User's Satisfaction with Visual Comfort in Lagos State Nigeria, as Well as the Challenges Impeding its Utilization in Modern Cinema Design. International Journal of Advanced Academic Research, 12(5), 88-100. https://doi.org/10.46654/spje8q47

Okanlawon, S. A., & Odunjo, O. O. (2016). Residents' evaluation of road utilization as space for holding social ceremonies in indigenous residential area of Ogbomoso, Nigeria. *Procedia - Social and Behavioral Sciences, 216*, 316–329.

Shahamat, H. (2025). Advancing bio-integrated building systems: A systematic review of architectural, structural and mechanical–electrical challenges in photobioreactor façades. *Smart and Sustainable Built Environment*, 1–32.

Shashwat, S., Zingre, K. T., Thurairajah, N., Kumar, D. K., Panicker, K., Anand, P., & Wan, M. P. (2023). A review on bioinspired strategies for an energy-efficient built environment. *Energy and Buildings, 296*, 113382.

Wang, C., Wang, Z. H., Kaloush, K. E., & Shacat, J. (2021). Cool pavements for urban heat island mitigation: A synthetic review. *Renewable and Sustainable Energy Reviews, 146*, 111171.

Xiao, C., & Seong, D. (2025). Research on the application of biomimetic design in art and design. *Biomimetics*, *10*(8), 541.

Zari, M. P. (2018). *Regenerative urban design and ecosystem biomimicry*. Routledge.

Zhang, Q., Yang, Z., & Yu, X. (2015). Urban metabolism: A review of current knowledge and directions for future study. *Environmental Science & Technology*, *49*(19), 11247–11263.

Zhuge, Y., & Liu, F. (2024). Recent progress of bionic hierarchical structure in the field of thermal insulation protection. *Journal of Bionic Engineering*, *21*(1), 1–18.