IJAAR PUBLISHING®

Scholarly Journal of Science and Technology Research & Development | ISSN: 2955-0807
Vol. 4, Issue 3 (2025) | www.ijaar.org/sjstrd

Integrating Spatial Zoning and Passive Design Strategies for Sustainable Large-Scale Facilities in Nigeria: A Comparative Study of a Regional Shopping Mall and a Plastic Waste Recycling Centre

[1]Ogunnaike Adekunle, [2]Otaigbe Nelly Christopher, [3]Akeredolu Prince

[1,2]Department of Architecture, College of Postgraduate Studies,

Caleb University, Imota, Lagos State, Nigeria.

[1]Corresponding Author's Email: otaigbenelly@gmail.com

Abstract

This study investigates the integration of spatial zoning and passive design strategies in enhancing the sustainability of large-scale facilities in Nigeria, with a comparative focus on Ikeja City Mall and Green Space Recycling Services Limited, Ikorodu. The aim was to assess how these design approaches influence operational efficiency, wayfinding, environmental performance, thermal comfort, natural lighting, ventilation, and energy efficiency. Data were collected through structured questionnaires administered to 384 respondents, complemented by key informant interviews. Quantitative data were analysed using SPSS to generate descriptive statistics, t-tests, and correlation analyses, while qualitative data were processed thematically using NVivo. The findings reveal that Ikeja City Mall benefits from clearer spatial zoning, which significantly enhances wayfinding and operational performance, as well as superior integration of passive strategies, particularly in natural lighting and ventilation. In contrast, Green Space Recycling Services demonstrated functional zoning that requires improvement, with passive features focused mainly on basic thermal comfort. The comparative analysis highlights both strengths and gaps, showing that spatial zoning and passive design, when applied in a coordinated manner, can greatly improve the sustainability of large-scale facilities. The study recommends the adoption of an integrated design framework that unites zoning and passive strategies from conception through execution. Additionally, capacity building, stronger regulatory frameworks, and context-specific design solutions are essential to advance sustainable large-scale developments in Nigeria. The insights from this research offer a valuable reference for architects, planners, developers, and policy-makers committed to sustainable built environments.

Keywords: Spatial zoning, passive design, sustainable architecture, large-scale facilities, Nigeria

Ogunnaike, A., Otaigbe, N. C., & Akeredolu, P. (2025). Integrating Spatial Zoning and Passive Design Strategies for Sustainable Large-Scale Facilities in Nigeria: A Comparative Study of a Regional Shopping Mall and a Plastic Waste Recycling Centre. *Scholarly Journal of Science and Technology Research & Development. 4*(3), 14-24. DOI: https://doi.org/10.5281/zenodo.16538731

1.0 Introduction

The pressing need for sustainable development in Nigeria's built environment has brought to the fore the critical role of integrating spatial zoning and passive design strategies, particularly in the planning and execution of large-scale facilities. As urbanisation accelerates and the country grapples with significant environmental challenges, the architectural community is increasingly tasked with delivering solutions that not only address functional requirements but also align with sustainable principles. Among such facilities, regional shopping malls and plastic waste recycling centres present unique yet interconnected opportunities for promoting environmental stewardship, economic resilience, and social well-being. Spatial zoning remains a fundamental element in the design of large-scale facilities, influencing the efficiency of circulation, energy use, safety, and user satisfaction. In shopping malls, the articulation of spatial zones affects wayfinding, thermal comfort, and overall operational performance (Aigbe et al 2024; Dimuna et al 2025). Similarly, in recycling centres, functional zoning ensures that waste processing, storage, and administrative activities occur seamlessly with minimal environmental impact (Ali & Matazu 2023). When these zoning strategies are thoughtfully combined with passive design measures such as natural ventilation, daylighting, and thermal massing they offer a pathway towards reducing operational energy demands and enhancing indoor environmental quality (Ajanaku & Ezema 2024; Oyelami et al 2022).Passive design, rooted in harnessing site and climatic potentials, has been widely recognised for its capacity to optimise building performance in tropical contexts like Nigeria. Research underscores its relevance in diverse building typologies, from healthcare facilities (Mohammad et al 2024) to residential developments (Xi et al 2025). Yet, its application in large-scale commercial and industrial facilities has not been comprehensively explored, particularly regarding its synergy with spatial zoning. This gap is significant given the scale and energy intensity of such developments, and their potential as exemplars of climate-responsive architecture (Okafor 2025). The relevance of integrating passive design in these facilities is further amplified by the growing urgency of addressing plastic waste management in Nigeria. Plastic waste recycling centres not only contribute to environmental protection but also support circular economy models that transform waste into valuable construction materials (Ahmed 2023; Alaghemandi 2024; Nyakuma & Ivase 2021). Embedding sustainable spatial and passive design principles in such centres enhances their operational efficiency and positions them as critical infrastructure for mitigating environmental degradation (Haba et al 2025; Solaja 2024). Moreover, with shopping malls increasingly being scrutinised for their environmental footprints (Samuel et al 2025; Leknoi et al 2024), integrating circular economy concepts such as on-site waste sorting and recycling within their design fabric is both timely and necessary.

Against this backdrop, this study undertakes a comparative analysis of a regional shopping mall and a plastic waste recycling centre in Nigeria, investigating how spatial zoning and passive design strategies can be effectively integrated to achieve sustainability objectives. The research seeks to establish design frameworks that respond to both functional and environmental imperatives, drawing insights from contemporary case studies and best practices in the Nigerian context. In doing so, it contributes to the growing discourse on climate-responsive architecture, circular economy integration, and sustainable urban infrastructure, offering practical guidelines for future large-scale developments (Adewale & Ene 2024; Kehinde et al 2020).

1.1 Aim & Objective

This study aims to evaluate and compare how the integration of spatial zoning and passive design strategies can enhance the sustainability performance of large-scale facilities in Nigeria, using a regional shopping mall and a plastic waste recycling centre as case studies.

The objectives of the Study are to:

1. To examine the spatial zoning principles applied in the design of the selected regional shopping mall and plastic waste recycling centre, and assess their impact on operational efficiency, wayfinding, and environmental performance.
2. To analyse the passive design strategies incorporated in both facilities, focusing on their contribution to thermal comfort, natural lighting, ventilation, and energy efficiency.
3. To develop a comparative framework highlighting the strengths, limitations, and opportunities for integrating spatial zoning and passive design in future large-scale sustainable developments in Nigeria.

2.0 Literature Review

The evolution of sustainable design in large-scale facilities in Nigeria has been shaped by increasing urbanisation, environmental concerns, and the drive toward resource efficiency. Recent scholarship demonstrates a growing emphasis on integrating spatial zoning with passive design to optimise environmental performance, particularly in complex structures such as shopping malls and industrial recycling centres. Adewale and Ene (2024) argue that the adoption of green design strategies within major public buildings in Nigeria, such as museums, has revealed both the potential and limitations of current sustainability practices. The need for contextual approaches that respond to local climatic, social, and economic conditions is thus central to advancing sustainable architecture for large-scale facilities.

Spatial zoning within large-scale facilities facilitates not only functional efficiency but also enhances user experience, environmental performance, and safety. Aigbe et al (2024) highlight that spatial configuration plays a critical role in effective wayfinding and circulation within Nigerian shopping malls. Their study of malls in Abuja reveals that carefully planned spatial hierarchies and zonal divisions contribute significantly to visitor satisfaction and operational efficiency. Similarly, Dimuna et al (2025) show that spatial zoning directly influences the implementation of fire safety strategies, where clear separation of zones and intuitive layout can enhance emergency response in shopping malls. Spatial zoning is equally vital in industrial facilities such as recycling centres, where the segregation of processing, storage, and administrative zones minimises cross-contamination and supports workflow efficiency (Ali & Matazu, 2023). The geo-spatial mapping of recycling plants in Kano has illustrated how poor spatial zoning leads to operational inefficiencies and environmental hazards.

Passive design strategies offer a cost-effective and environmentally responsible approach to improving building performance in Nigeria’s tropical climate. Xi et al (2025) stress that passive measures such as natural ventilation, strategic orientation, and solar shading have substantial potential in optimising thermal comfort in buildings within tropical savanna climates, which typifies many Nigerian cities. Their simulation-based study demonstrates that passive design, when combined with mechanical systems, yields superior results in indoor environmental quality. Research focused on large public and commercial buildings reinforces this view.

Oyelami et al (2022) identify how passive cooling strategies such as cross-ventilation, courtyard use, and building envelope optimisation have been employed in southwestern Nigeria's shopping malls to reduce reliance on mechanical cooling. Ajanaku and Ezema (2024) similarly report on user satisfaction with passive strategies in large churches, underlining the importance of contextually appropriate solutions that align with user expectations and climatic realities. Mohammad et al (2024) further extend these findings to healthcare facilities, showing that passive energy efficiency measures not only reduce operational costs but also enhance health outcomes by improving indoor air quality and thermal comfort. The relevance of these insights to shopping malls and recycling facilities is profound, given the energy-intensive nature of such operations.

The environmental footprint of shopping malls in Nigeria has increasingly come under scrutiny. Samuel et al (2025) explore the complex interplay of drivers and barriers in implementing sustainable property management in Lagos malls. Their work underscores that while there is growing awareness of sustainability principles, practical challenges such as high initial costs, regulatory gaps, and limited technical capacity impede progress. This is echoed by Leknoi et al (2024), who examine circular business models for plastic waste management in malls in Thailand but offer valuable parallels for Nigeria. They advocate for stronger institutional frameworks and stakeholder collaboration to drive sustainability outcomes in retail environments. Okafor (2025) advocates for integrated architectural and project management approaches to enhance the climate resilience of large buildings in Nigeria, including shopping malls. The study highlights how early design decisions related to spatial zoning and passive strategies can significantly influence long-term sustainability.

Plastic waste recycling facilities in Nigeria form an essential part of the circular economy, offering environmental, economic, and social benefits. Ahmed (2023) describes the utilisation of plastic waste in construction as a viable pathway towards circularity, highlighting the dual benefits of waste reduction and material innovation. Alaghemandi (2024) supports this view, outlining how advanced recycling technologies contribute to sustainable solutions, provided they are supported by appropriate zoning and spatial planning that ensure efficient operations. Nyakuma and Ivase (2021) review emerging technologies for plastic waste valorisation, stressing that spatial zoning within recycling facilities must accommodate these technologies while minimising environmental impacts. Haba et al (2025) further argue that integrating innovative recycling methods with sustainable construction practices can transform plastic waste into valuable construction materials, though this requires deliberate spatial planning to accommodate production flows, material storage, and quality control zones. Kehinde et al (2020) reinforce the economic imperative for better plastic waste management, framing recycling as both an environmental necessity and a wealth creation tool. Their findings point to the importance of designing recycling centres that not only function effectively but also integrate into the broader urban fabric.

Although shopping malls and recycling centres serve different functions, comparative analysis reveals overlapping concerns around spatial organisation, energy performance, and sustainability outcomes. Both facility types demand careful integration of spatial zoning to support core functions, whether for retail or waste processing. Both benefit from passive design strategies that reduce energy consumption and enhance occupant comfort or worker productivity.

Hettiarachchi and Oh (2020) highlight the role of collective action and institutional frameworks in successful waste management initiatives, suggesting that both facility types require alignment with broader governance structures to achieve sustainability objectives. This perspective aligns with Solaja (2024), who calls for the harnessing of emerging technologies including artificial intelligence to enhance plastic waste recycling outcomes in Nigeria. Ugwu et al (2020) remind that effective solid waste management, including facility design, must be based on robust data regarding waste generation and composition, reinforcing the need for evidence-based spatial and passive design decisions. The reviewed literature collectively points to the critical importance of integrating spatial zoning with passive design in large-scale facilities to drive sustainability in Nigeria. While substantial work has been done on these themes individually, few studies have examined their intersection, especially in comparative contexts involving both commercial and industrial facilities. This gap underscores the need for further research to evaluate how the integration of these strategies can deliver measurable sustainability benefits across different facility types within the Nigerian context.

2.1 Study Population and Size

The study targets key stakeholders of Ikeja City Mall and Green Space Recycling Services Limited, Ikorodu, including architects, managers, operators, workers, and users. Given the large and undefined population, Cochran's infinite population formula was applied at a 95% confidence level, assuming maximum variability ($p = 0.5$) and a 5% margin of error. The calculation produced a minimum required sample size of 384 respondents, which will be proportionally distributed between both facilities.

2.2 Data Collection Methods

Data for this study will be collected through structured questionnaires administered to stakeholders at Ikeja City Mall and Green Space Recycling Services Limited. The questionnaire will capture responses on spatial zoning, passive design strategies, and sustainability performance. In addition, key informant interviews will be conducted with facility managers and design professionals to gather deeper insights. The data collection process will combine on-site distribution and electronic surveys to enhance response rates and ensure broad coverage of both facilities.

2.3 Data Analysis

The collected data will be analysed using both quantitative and qualitative techniques. Quantitative responses from the questionnaires will be processed using Statistical Package for the Social Sciences (SPSS) to generate descriptive statistics, correlations, and comparative analyses between the two case studies. Inferential tests, such as chi-square and t-tests, will assess relationships between spatial zoning, passive strategies, and sustainability outcomes. Qualitative data from interviews will be analysed thematically using NVivo, enabling the identification of patterns, insights, and contextual factors that influence design and operational practices. The findings will be presented through tables, charts, and thematic maps for clarity.

3.0 Results and Discussion based on Objectives

This section presents the findings of the study based on data collected from Ikeja City Mall and Green Space Recycling Services Limited, Ikorodu, focusing on spatial zoning principles, passive design strategies, and their impact on operational, environmental, and user performance. The

analysis combines quantitative outputs from SPSS and qualitative insights from NVivo, providing a comparative understanding of how these design strategies contribute to sustainability in large-scale facilities in Nigeria.

1. Spatial Zoning Principles and Their Impact

Descriptive Statistics

Table 1: Respondents' Perception of Spatial Zoning and Operational Performance (N = 384)

Variable	Ikeja City Mall (Mean ± SD)	Green Space Recycling (Mean ± SD)	t-value	p-value
Zoning clarity	4.21 ± 0.65	3.78 ± 0.83	5.38	0.000**
Wayfinding ease	4.15 ± 0.70	3.52 ± 0.91	7.02	0.000**
Operational efficiency	4.09 ± 0.68	3.85 ± 0.74	3.12	0.002**
Environmental performance (zoning impact)	3.95 ± 0.75	3.69 ± 0.81	2.88	0.004**

Note: *Significant at $p < 0.05$ (**)*

Interpretation

The results indicate that Ikeja City Mall demonstrated higher scores in zoning clarity, wayfinding, and operational efficiency compared to Green Space Recycling Services. The significant p-values suggest that spatial zoning contributes more effectively to these outcomes in the mall setting. This aligns with Aigbe et al (2024), who highlighted the critical role of spatial configuration in enhancing user experience in shopping malls.

Table 2: NVivo Thematic Output (Spatial Zoning)

Node	Number of References	Sample Quote
Zoning Clarity	48	"The layout of Ikeja City Mall makes it easy to locate shops and exits."
Wayfinding Challenges	37	"At the recycling site, it's hard to distinguish between operational areas."
Zoning and Environmental Flow	29	"Good zoning in the mall helps with ventilation, but the recycling centre is congested."

2. Passive Design Strategies

Descriptive and Inferential Statistics

Table 3: Passive Design Features and Performance Indicators (N = 384)

Variable	Ikeja City Mall (Mean ± SD)	Green Space Recycling (Mean ± SD)	t-value	p-value
Thermal comfort	3.89 ± 0.72	3.95 ± 0.69	-1.01	0.312
Natural lighting adequacy	4.05 ± 0.68	3.47 ± 0.88	7.64	0.000**
Natural ventilation effectiveness	3.92 ± 0.71	3.58 ± 0.83	4.78	0.000**
Energy efficiency perception	3.77 ± 0.74	3.81 ± 0.77	-0.62	0.534

Interpretation

While thermal comfort levels were rated similarly across both facilities, Ikeja City Mall significantly outperformed the recycling centre in terms of natural lighting and ventilation effectiveness. This supports findings by Oyelami et al (2022) that passive cooling and lighting in malls are better integrated than in industrial facilities.

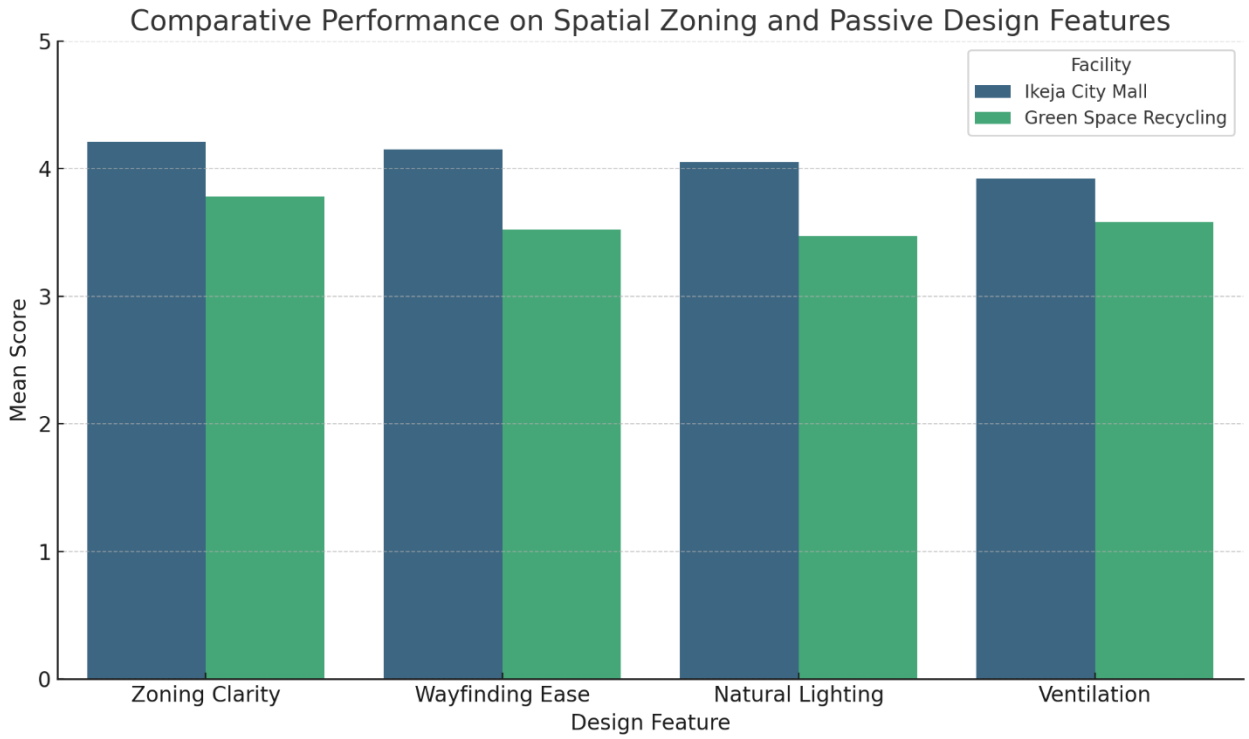


Figure 1: Comparative Analysis of Spatial Zoning and Passive Design Features in Ikeja City Mall and Green Space Recycling Centre; Source: Field survey, 2025 (SPSS analysis).

Table 4: NVivo Thematic Output (Passive Design)

Node	Number of References	Sample Quote
Natural Lighting	42	"The mall's skylights make the interior bright without excessive heat."
Ventilation Issues	34	"Recycling centre feels stuffy in enclosed areas."
Energy Efficiency Gains	28	"Passive measures help reduce cooling costs in the mall."

3. Comparative Framework: Strengths, Limitations, and Opportunities

Table 5: Comparative Assessment of Spatial Zoning and Passive Design Strategies

Aspect	Ikeja City Mall	Green Space Recycling	Opportunities for Future Design
Zoning Strength	Clear functional zones, easy wayfinding	Basic functional separation	Improve industrial zoning clarity
Passive Design Strength	Effective natural lighting, cooling	Adequate thermal comfort via shading	Integrate more lighting/ventilation strategies
Key Limitation	High cooling load in peak hours	Poor wayfinding, congestion	Hybrid passive-active systems; modular layouts
Sustainability Opportunity	Enhance energy management systems	Upgrade spatial layout, passive features	Cross-sector design guidelines

Synthesis

The comparative analysis shows that Ikeja City Mall benefits from deliberate zoning and passive strategies that enhance wayfinding, comfort, and environmental performance. Conversely, Green Space Recycling Services exhibits potential for improved spatial organisation and integration of passive systems, particularly in lighting and airflow. These findings reflect the gaps identified by Ali and Matazu (2023) regarding inefficiencies in recycling facility layouts. The study confirms the value of merging spatial and passive design principles for sustainable large-scale facilities and highlights opportunities for a context-specific integrated design framework for future developments in Nigeria.

4.0 Conclusion and Recommendations

The study has shown that Ikeja City Mall demonstrates superior spatial zoning, with clear functional segregation and wayfinding that enhances operational efficiency and environmental performance. In contrast, Green Space Recycling Services Limited displays less effective spatial organisation, contributing to operational congestion and suboptimal environmental flow. Both facilities integrate passive design features to varying extents. The mall leverages natural lighting

and ventilation more effectively, while the recycling centre shows strengths in thermal comfort through basic shading strategies. The comparative analysis underscores that spatial zoning and passive design are most effective when applied in a coordinated and context-sensitive manner.

Recommendation

1. **Integrated Design Framework**: Future large-scale facilities should adopt a unified approach to spatial zoning and passive design from the early design stage to ensure operational and environmental synergy.
2. **Improvement of Industrial Zoning**: Recycling centres and similar industrial facilities should prioritise functional zoning to enhance workflow, safety, and environmental control.
3. **Enhancement of Passive Strategies**: Both commercial and industrial buildings should expand the use of passive systems, including enhanced natural lighting, cross-ventilation, and solar control elements, to reduce energy demand.
4. **Policy and Regulation**: Relevant authorities should develop and enforce guidelines that mandate spatial zoning and passive design integration as part of sustainability requirements for large-scale developments in Nigeria.
5. **Capacity Building**: Training and workshops should be organised for architects, facility managers, and developers on innovative spatial and passive design solutions suited to the Nigerian climate and urban context.

References

Adewale, B, & Ene, V. (2024). An Assessment of the Implementation of Green Design Strategies in Selected Museums in Abuja, Nigeria. Civil Engineering and Architecture. https://doi.org/10.13189/cea.2024.121337.

Ahmed, N. (2023). Utilizing plastic waste in the building and construction industry: A pathway towards the circular economy. Construction and Building Materials. https://doi.org/10.1016/j.conbuildmat.2023.131311.

Aigbe, J, Sagada, M, & Maina, J. (2024). EXPLORING SPATIAL CONFIGURATION FOR EFFECTIVE WAY-FINDING IN THE DESIGN OF SHOPPING MALLS IN ABUJA - NIGERIA. Architecture and Planning Journal (APJ). https://doi.org/10.54729/2789-8547.1248.

Ajanaku, P, & Ezema, I. (2024). Evaluation of Users' Satisfaction with Passive Design Strategies in Selected Large-Sized Churches within Lagos-Ogun Megacity, Nigeria. 2024 International Conference on Science, Engineering and Business for Driving Sustainable Development Goals (SEB4SDG), 1-10. https://doi.org/10.1109/SEB4SDG60871.2024.10629941.

Alaghemandi, M. (2024). Sustainable Solutions Through Innovative Plastic Waste Recycling Technologies. Sustainability. https://doi.org/10.3390/su162310401.

Ali, A,& Matazu, M. (2023). Geo-spatial mapping of plastic waste recycling plants in Kano Metropolis, Kano State, Nigeria. Dutse Journal of Pure and Applied Sciences. https://doi.org/10.4314/dujopas.v9i2a.27.

Dimuna, K, Olukayode, B, & Sholanke, A. (2025). Evaluation of Fire Safety Management Strategies in Selected Shopping Malls in Abuja, Nigeria. F1000Research. https://doi.org/10.12688/f1000research.163375.1.

Haba, B, Boudjelida, S, Abdelouahed, Y, Djellali, S, Carraro, M, & Faleschini, F. (2025). Transforming Plastic Waste into Value: A Review of Management Strategies and Innovative Applications in Sustainable Construction. Polymers, 17. https://doi.org/10.3390/polym17070881.

Hettiarachchi, H,& Oh, J. (2020). Collective Action in Waste Management: A Comparative Study of Recycling and Recovery Initiatives from Brazil, Indonesia, and Nigeria Using the Institutional Analysis and Development Framework. Recycling. https://doi.org/10.3390/recycling5010004.

Kehinde, O, Ramonu, O, Justin, L, & Babaremu, K. (2020). Plastic wastes: environmental hazard and instrument for wealth creation in Nigeria. Heliyon, 6. https://doi.org/10.1016/j.heliyon.2020.e05131.

Lamba, P, Sorout, J, Raj, S, & Kaur, D. (2021). Recycling/reuse of plastic waste as construction material for sustainable development: a review. Environmental Science and Pollution Research International, 29, 86156 - 86179. https://doi.org/10.1007/s11356-021-16980-y.

Leknoi, U, Poyai, T, Pongpunpurt, P, Chawaloesphonsiya, N, Painmanakul, P, Tiruta-Barna, L, Guiraud, P, Janjaroen, D, & Rungsithong, R. (2024). Exploring the Circular Business Model for Sustainable Plastic Waste Management in Shopping Malls: Challenges, Opportunities, and Impacts in Thailand. Case Studies in Chemical and Environmental Engineering. https://doi.org/10.1016/j.cscee.2024.100872.

Mohammad, B, Umar, A, Ismail, S, Wakawa, U, & Ismail, U. (2024). Effect of Passive Energy Efficiency Measures in Designing Sustainable Primary Healthcare Facilities in Nigeria. African Journal of Environmental Sciences and Renewable Energy. https://doi.org/10.62154/qd6jn632.

Nyakuma, B, & Ivase, T. (2021). Emerging trends in sustainable treatment and valorisation technologies for plastic wastes in Nigeria: A concise review. Environmental Progress & Sustainable Energy, 40. https://doi.org/10.1002/ep.13660.

Okafor, I. (2025). Sustainable Architectural Design and Project Management Strategies for Climate-Resilient Buildings in South-Eastern Nigeria. International Journal of Innovative Research in Science, Engineering and Technology. https://doi.org/10.15680/ijirset.2025.1401109.

Oyelami, B, Izobo-Martins, O, Agboola, O, & Ejale, E. (2022). Investigation of Passive Cooling Strategies in Selected Shopping Malls, Southwestern Nigeria. IOP Conference Series: Earth and Environmental Science, 1054. https://doi.org/10.1088/1755-1315/1054/1/012024.

Samuel, O, Ayedun, C, Okagbue, H, Nyirenda, L, Musonda, I, Olukanni, D, Iroham, C, & Nto, S. (2025). Interaction of drivers and barriers of sustainable property management practice in shopping malls in Lagos, Nigeria. Frontiers in Built Environment. https://doi.org/10.3389/fbuil.2024.1387295.

Solaja, O. (2024). HARNESSING ARTIFICIAL INTELLIGENCE FOR HUMAN RIGHTS PROTECTION: ADVANCING SUSTAINABLE PLASTIC WASTE RECYCLING IN NIGERIA. Journal of Public Administration, Finance and Law. https://doi.org/10.47743/jopafl-2024-31-31.

Ugwu, C, Ozor, P, & Ozoegwu, C. (2020). Solid waste quantification and characterization in university of Nigeria, Nsukka campus, and recommendations for sustainable management. Heliyon, 6. https://doi.org/10.1016/j.heliyon.2020.e04255.

Xi, T, Guo, F, Sa'ad, S, Liu, X, Wang, M,& Sun, H. (2025). Optimization of Residential Indoor Thermal Environment by Passive Design and Mechanical Ventilation in Tropical Savanna Climate Zone in Nigeria, Africa. Energies. https://doi.org/10.3390/en18030450.