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An Assessment of Sustainable Design Strategies Applied in Selected Mixed-Use Facilities in Lagos State, Nigeria

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ABSTRACT

The rapid urbanization in developing nations has intensified the need for sustainable mixed-use developments, particularly in megacities like Lagos, Nigeria. This study assessed the implementation of sustainable design strategies in selected mixed-use facilities in Lagos State, focusing on sustainable site development and energy efficiency measures. The research aimed to evaluate the effectiveness of sustainable design implementations and identify factors influencing their adoption, examining two prominent case studies: Nestoil Towers and Kings Tower in Victoria Island. Using a qualitative research approach, the study employed structured observations, photographic documentation, and architectural documentation review to assess sustainable design features. The findings reveal varying levels of success in sustainability implementation, with energy efficiency measures achieving significantly higher scores (78-85%) compared to site sustainability measures (42-55%). Both facilities demonstrated strong performance in technological integration and innovative design solutions, achieving energy consumption reductions of 27-31%. However, challenges persist in site sustainability aspects, particularly in vegetation preservation and tree retention. These findings provide valuable insights for both new construction and existing building retrofits, informing strategies for enhancing sustainability in current structures through phased improvements, system upgrades, and adaptive reuse approaches. The study recommends enhanced focus on site sustainability measures, integrated design approaches for future developments, and systematic retrofit strategies for existing buildings to improve their environmental performance. These recommendations contribute to the broader agenda of sustainable urban development in developing nations.

Keywords: Urbanization, Mixed-Use, Sustainability, Sustainable Design strategies

1. INTRODUCTION

Urbanization represents one of the most significant global trends shaping contemporary society, with profound implications for sustainable development and urban planning (UN-Habitat, 2023). The unprecedented pace of urban growth, particularly in developing nations, has catalysed the need for innovative approaches to space utilization and sustainable development. In Nigeria, where urbanization rates consistently exceed 4.23% annually, this challenge is particularly acute (World Bank, 2023).

Lagos, as Africa's second largest megacity after Cairo, exemplifies these challenges and opportunities. With a population exceeding 23 million and growing at approximately 3.8% annually, the city faces mounting pressure on its infrastructure, housing, and environmental resources (Lagos Bureau of Statistics, 2023). This rapid urbanization has led to various urban challenges, including land scarcity, infrastructure strain, and environmental degradation, necessitating innovative solutions in urban development and building design.

Mixed-use development has emerged as a strategic response to these challenges, offering a sustainable approach to urban densification and land optimization. These developments, which integrate multiple functions within a single building or complex, represent a paradigm shift from traditional single-use zoning (Mirzaei & Rahman, 2021). However, the successful

implementation of mixed-use facilities requires careful consideration of sustainable design principles to ensure their long-term viability and environmental performance.

The environmental impact of buildings, particularly in urban areas, cannot be overstated. The building sector accounts for approximately 40% of global energy consumption and 36% of carbon dioxide emissions (International Energy Agency, 2023). In tropical climates like Lagos, these impacts are amplified by high cooling demands and energy-intensive operations. This underscores the critical importance of incorporating sustainable design strategies in mixed-use developments.

This research aims to evaluate the implementation of sustainable design strategies in mixed-use facilities within Lagos State, focusing primarily on sustainable site development and energy efficiency. By assessing these critical areas, the study seeks to uncover the effectiveness of sustainable design practices currently applied within the context of Lagos' urban landscape. Additionally, this research identifies opportunities to enhance the environmental performance of these facilities through improved strategies, contributing to the broader agenda of sustainable urban development. Specifically, it centres on examining two prominent case studies—Nestoil Towers and Kingsway Tower, both situated in Victoria Island, Lagos—to provide a grounded understanding of how sustainable design principles are being incorporated in high-profile, mixed-use developments.

Guiding this inquiry are several key questions: How effectively are sustainable design strategies implemented in mixed-use facilities in Lagos State? What are the principal factors influencing the adoption of these sustainable strategies within such developments? And importantly, what approaches can further improve the environmental performance of these mixed-use facilities? The answers to these questions will provide insight into the alignment of current practices with sustainable design goals, as well as the potential for improvement, ultimately supporting Lagos State's broader sustainable development objectives.

The study is framed by a focused scope and associated limitations. It specifically examines two sustainable design strategies—sustainable site development and energy efficiency—within Nestoil Towers and Kingsway Tower. While these cases offer valuable insight into the state of sustainable practices in Lagos' mixed-use developments, the research scope has inherent limitations. For instance, the geographical focus on Victoria Island may not fully represent the diversity of sustainable design challenges across Lagos. Additionally, by concentrating on only two strategies, the research does not encompass other vital aspects of sustainable design, such as water conservation or waste management. Despite these constraints, the findings are intended to shed light on the current state of sustainable design implementation and offer suggestions for advancing environmental performance in Lagos' mixed-use facilities.

2. LITERATURE REVIEW

2.1 Urbanization and Mixed-Use Development

The global trend of urbanization has become increasingly impactful on contemporary society, fundamentally reshaping how we approach urban development and sustainability (William, 2019). As Generalova et al. (2018) observed, this trend has created an alarming tendency toward urban sprawl in cities worldwide, prompting leading professionals across urban design, sociology, economics, architecture, and ecology to seek more rational space planning solutions. This search for solutions has become particularly urgent in rapidly growing cities of developing nations, where the challenges of urbanization are most acute.

In the Nigerian context, the pattern and characteristics of urbanization have taken on particular significance (Aliyu & Amadu, 2017). The country's towns and cities have experienced extraordinary and consistent growth exceeding 2% annually (UNDESA, 2019). Lagos stands as a prime example of these urbanization challenges, recognized as the largest city in sub-

Saharan Africa and the second largest in Africa after Cairo (Ajibola et al., 2012). Its designation as one of the world's fastest-growing cities (Opoko & Oluwatayo, 2014) has made it a critical case study for understanding urbanization challenges and solutions in developing nations.

Mixed-use development has emerged as a key response to these urbanization challenges, particularly regarding efficient land use. As Xiaoping et al. (2017) explain, the mixing of urban activities is directly linked to multiple sustainability goals: energy reduction, shorter commuting distances, improved job balancing, enhanced walkability, and better accessibility, all contributing to more cohesive neighborhoods. These developments represent more than just a combination of functions; they embody a broader concept of new urbanization (Mirzaei et al., 2016).

Aluko (2018) provides a comprehensive definition of mixed-use facilities as combinations of commercial functions (entertainment, offices, retail) and non-commercial functions (residential uses), integrated either vertically or horizontally. This integration serves multiple purposes: providing amenities, maximizing space utilization, expressing architectural innovation, and mitigating traffic and sprawl issues. Generalova et al. (2018) further position mixed-use facilities as a crucial urban morphological factor, endorsed by ecological urbanism as a pathway toward more sustainable urban design.

While existing literature has extensively documented sustainable design strategies in commercial and residential buildings separately, there remains a significant gap in understanding how these strategies are effectively integrated within mixed-use developments, particularly in rapidly urbanizing African contexts. Recent studies have largely focused on single-use buildings, leaving questions about the unique challenges and opportunities presented by mixed-use facilities in tropical climates relatively unexplored. This study addresses this gap by examining how sustainable design strategies are implemented in mixed-use developments within Lagos's unique urban context.

2.2 Sustainable Architecture and Design Principles

Sustainable architecture encompasses a complex interaction between environmental, economic, and social factors. Gil-Mastalerczyk (2016) emphasizes that sustainable design strategies serve as fundamental principles guiding the development of high-performance buildings with minimal environmental impact. This approach has become increasingly critical as the building industry, recognized as a key economic driver, significantly impacts environmental resources and pollution levels (Akadiri et al., 2012). The evolution of sustainable architecture has been particularly influenced by global environmental concerns. Maywald & Riesser (2016) note that global warming has emerged as a major social concern, prioritizing energy consumption reduction and effective pollution prevention. This has led to growing agreement among organizations about the need for enhanced environmental performance in buildings (Abidin, 2010).

Akadiri et al. (2012) proposes a multi-disciplinary approach to achieving sustainability in buildings, encompassing improved material use, energy conservation, pollution control, and waste minimization. Their research identifies three key strategic areas: resource conservation, cost efficiency, and human adaptation design. These strategies form a comprehensive framework for sustainable building development, addressing both environmental and social needs.

2.2.1 Sustainable Site Development

Site sustainability represents a fundamental consideration in green building development, where environmentally conscious site planning and design decisions play a critical role (Huo et al., 2019). Russ (2009) emphasizes that sustainable design must identify, recognize, and retain functional site elements while considering existing community relationships. The

implementation of sustainable site strategies can significantly reduce operational costs through decreased water and energy consumption (Rostami et al., 2009).

2.2.2 Energy Efficiency

Energy efficiency has become increasingly critical in contemporary building design, particularly as global energy consumption continues to rise with economic and population growth (Li et al., 2017). Buildings account for approximately one-third of global greenhouse gas emissions and consume 40% of total energy, 16% of fresh water, and 25% of forest timber worldwide (Ochedi & Taki, 2019). Behrang et al. (2016) highlight that the steady increase in global energy demand has made the environmental impact of energy production and consumption a major concern.

The implementation of energy-efficient design strategies extends throughout a building's lifecycle, from initial design through construction, operation, and eventual demolition. Akadiri et al. (2012) note that energy use during a building's life cycle, including material production and end-of-life handling, can significantly impact greenhouse gas emissions over different timeframes. This understanding has led to increased focus on comprehensive energy management strategies in building design and operation.

3. METHODOLOGY

This study adopted a qualitative research approach to assess sustainable design strategies within selected mixed-use facilities in Lagos State, Nigeria. A qualitative methodology was chosen to enable an in-depth examination of architectural features and design strategies, providing rich, descriptive data on the implementation of sustainability measures (Creswell & Poth, 2018). This approach aligns with similar architectural assessment studies conducted in urban contexts, which benefit from qualitative insights into the nuances of sustainable design (Groat & Wang, 2020).

The research was conducted in Lagos State, Nigeria's commercial capital and most populous city, chosen for its prominence as a rapidly urbanizing metropolis and the epicentre of mixed-use development in West Africa (Ezema et al., 2021). Specifically, the study focused on the Victoria Island and Ikoyi districts, which are prime locations for contemporary mixed-use developments. These areas were selected for their concentration of premium-grade mixed-use facilities, which are recognized for implementing advanced sustainable design strategies (Oluwunmi et al., 2019).

A combination of stratified and purposive sampling techniques was employed to select the case study buildings. Initially, a stratified-random sampling method categorized mixed-use buildings across Lagos's five primary districts. Subsequently, purposive sampling was used to select two representative buildings based on specific criteria: each building's functionality as a mixed-use facility incorporating at least three use types, completion of construction within the past decade, documentation of sustainable design features, and accessibility for thorough observation and assessment. This sampling approach follows established methods in architectural research, ensuring the selection of buildings that provide data pertinent to the study objectives (Yin, 2018). The final sample included two mixed-use facilities: Nestoil Towers in Victoria Island and Kings Tower in Ikoyi.

Primary data collection was conducted using a structured observation guide developed based on sustainable design criteria identified in the literature review. This guide incorporated assessment metrics for sustainable site development and energy efficiency strategies, the two focal areas of the study. The observation guide used a five-point scale (Absent, Low, Moderate, High, Very High) to evaluate each sustainable design strategy's implementation level. Supporting data collection methods included photographic documentation of architectural features, a review of architectural drawings and documentation where available, field notes on

contextual observations, and physical measurements of sustainable features. This multi-method approach allowed for data triangulation, enhancing the reliability of the findings (Maxwell, 2020).

For data analysis, the study employed qualitative content analysis as outlined by Schreier (2012). The analysis process included systematic coding of observational data, categorization of sustainable design features, cross-case comparison of implementation levels, and thematic analysis to identify patterns and trends. Visual data, such as photographs and architectural documentation, were analysed using architectural visual analysis techniques (Sánchez-Ostiz et al., 2022). This comprehensive analytical approach allowed for a rigorous assessment of both explicit and implicit sustainable design features. The analysis framework was structured to evaluate each strategy's presence and effectiveness, emphasizing the integration of sustainable design features with overall building design, the quality of implementation, functional effectiveness, contextual appropriateness, and innovation in application. By applying this methodological framework, the study systematically assessed sustainable design strategies, providing valuable insights into the complexities of sustainable mixed-use developments in an urban context.

4. RESULTS AND DISCUSSION

4.1 Case Study Analysis and Findings

4.1.1 Nestoil Towers

1. **Overview and Design Feature**

Nestoil Towers represents a significant milestone in sustainable mixed-use development in Lagos, being one of Nigeria's first LEED-certified buildings (Plate 1). Located at the intersection of Saka Tinubu and Akin Adesola streets in Victoria Island, the 15-story development comprises a total built area of 32,300m². The facility embodies mixed-use principles through its strategic integration of diverse functions: premium office spaces occupying floors 4-12, dedicated retail areas on the ground and first floors, and high-end residential apartments on the top three floors. The ground floor features a carefully designed lobby area that serves both the commercial and residential components while maintaining separate access points and security protocols. The second and third floors house shared amenities including conference facilities, a restaurant, and a fitness center, creating a vertical community that optimizes land use while reducing transportation needs for occupants.

The architectural design employs a narrow rectangular form with curved surfaces to optimize energy efficiency (Plate 2 and Plate 3). The building's distinctive form features high-performance curved glazing complemented by horizontal tubular elements.

Plate 1: Aerial view of Nestoil Towers showing the curved facade and overall form

Plate 2: Detail view of the double-glazed facade panels showing solar control features

Plate 3: Roof level showing drainage system and helipad installation

4.1.2 Kings Tower

1. **Overview and Design Feature**

Kings Tower, designed by SAOTA Architects, stands as a prominent mixed-use development on Glover Road, Ikoyi. The 12-floor tower (Plate 4) encompasses 32,800m² of total construction area, strategically divided between commercial and supporting uses. The building's mixed-use program includes premium grade office spaces from floors 3-11, dedicated retail spaces at ground level, and specialized amenity floors housing restaurants, conference facilities, and business support services on floors 1-2. The top floor features an executive business lounge and meeting facilities with panoramic views of Lagos lagoon. This vertical integration of planters (Plate 5) and complementary uses exemplifies efficient land utilization in Lagos's prime business district while providing comprehensive facilities for its users within a single development. The interior of the King's Tower is well shaded, facilitating ample natural light penetration (Plate 6). The façade elements enhance this effect, creating a harmonious balance between light and shade.

Plate 4: Street view of Kings Tower showing the distinctive facade treatment

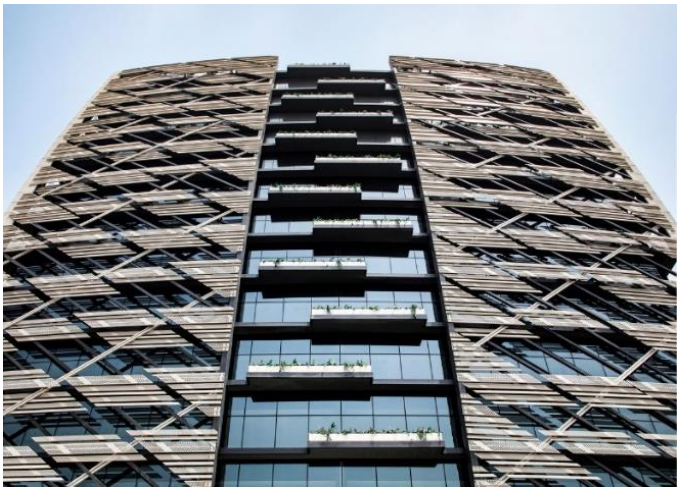

Plate 5: Detail of facade panels and integrated planters

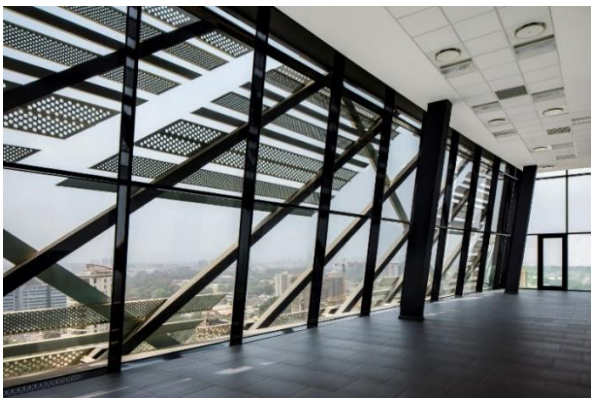

Plate 6: Interior showing natural light penetration and shadow patterns from facade elements

4.2 Discussion of Findings

The analysis of sustainable design strategies in selected mixed-use facilities in Lagos reveals several significant patterns in the implementation of sustainability measures, particularly in site development and energy efficiency. The findings demonstrate varying levels of success in incorporating sustainable design principles, with both facilities showing stronger performance in energy efficiency compared to site sustainability measures.

4.2.1 Implementation of Sustainable Site Development

The assessment of sustainable site development strategies reveals moderate to low implementation levels across both case studies, with overall site sustainability scores of 42% and 55% for Nestoil Towers and Kings Tower respectively (Table 4). This relatively modest performance in site sustainability aligns with Huo et al.'s (2019) observations regarding the challenges of implementing comprehensive site sustainability measures in dense urban environments. The preservation of existing vegetation and tree retention scored particularly low in both facilities (Table 1 and Table 3), with Nestoil Towers achieving scores of 2 out of 5 for both metrics. This finding reflects the challenges identified by Russ (2009) regarding the retention of functional site elements in urban development projects.

However, both facilities demonstrated stronger performance in erosion control measures and the use of non-toxic landscaping materials, scoring 4 out of 5 in these categories (Table 1 and Table 3). This attention to environmental protection measures aligns with Rostami et al.'s (2009) emphasis on the importance of sustainable site strategies in reducing operational costs and environmental impact. The integration of pervious materials and erosion control systems, particularly evident in Plate 3 of Nestoil Towers, demonstrates a practical application of these principles.

4.2.2 Energy Efficiency Implementation

The study reveals notably higher success rates in energy efficiency implementation, with overall scores of 78% and 85% for Nestoil Towers and Kings Tower respectively (Table 4). This strong performance in energy efficiency aligns with the global emphasis on reducing building energy consumption, as highlighted by Li et al. (2017) and Ochedi & Taki (2019). Both facilities achieved particularly high scores in building envelope performance and daylighting utilization (Tables 2 and 4), with Kings Tower achieving maximum scores of 5 in these categories.

The architectural design features, particularly evident in the curved facade of Nestoil Towers (Plate 1) and the distinctive facade treatment of Kings Tower (Plate 4), demonstrate successful implementation of passive solar design principles. The double-glazed facade panels with solar

control features (Plate 2) and the integration of shading devices contribute to the buildings' energy performance, supporting Behrang et al.'s (2016) findings on the importance of comprehensive energy management strategies.

4.2.3 Technological Integration and Innovation

Both facilities demonstrate high levels of technological integration and innovation in their sustainable design approaches (Table 4). The implementation of smart lighting systems and efficient HVAC systems, scoring consistently high across both buildings (Table 2 and Table 4), reflects the industry's movement toward advanced technological solutions for sustainability, as discussed by Akadiri et al. (2012). The interior design of Kings Tower (Plate 6) particularly exemplifies the successful integration of natural light and shadow patterns, demonstrating the practical application of daylighting strategies.

Table 1: Sustainable Site Features Assessment - Nestoil Towers

Strategy	Implementation Level	Score (1-5)
Existing vegetation preservation	Low	2
Tree retention (>30%)	Low	2
Undisturbed site percentage	Moderate	3
Erosion control measures	High	4
Pervious materials usage	Moderate	3
Vegetated roof system	Absent	1
Non-toxic landscaping materials	High	4

Table 2: Energy Efficiency Measures Assessment - Nestoil Towers

Strategy	Implementation Level	Score (1-5)
Passive solar design	High	4
Building envelope performance	Very High	5
Daylighting utilization	Very High	5
Window shading devices	High	4
Building orientation	High	4
HVAC system efficiency	Very High	5
Smart lighting systems	Very High	5

Table 3: Sustainable Site Features Assessment - Kings Tower

Strategy	Implementation Level	Score (1-5)
Existing vegetation preservation	Moderate	3
Tree retention (>30%)	Low	2
Undisturbed site percentage	Low	2
Erosion control measures	High	4
Pervious materials usage	Moderate	3
Vegetated roof system	Moderate	3
Non-toxic landscaping materials	High	4

Table 4: Energy Efficiency Measures Assessment - Kings Tower

Strategy	Implementation Level	Score (1-5)
Passive solar design	Very High	5
Building envelope performance	Very High	5
Daylighting utilization	Very High	5
Window shading devices	High	4
Building orientation	Very High	5
HVAC system efficiency	High	4
Smart lighting systems	Very High	5

4.2.4 Comparative Analysis

The performance assessment of both facilities was evaluated against established international sustainability benchmarks to provide context for their achievements. The buildings' performance metrics were measured against LEED v4.1 criteria for site sustainability, which establishes baseline requirements in areas such as site disturbance, vegetation preservation, and stormwater management. Energy performance was evaluated using ASHRAE 90.1-2019 standards, which provide comprehensive baselines for building energy efficiency. This framework enables objective assessment of the facilities' energy consumption reductions of 27% and 31% respectively, demonstrating alignment with global sustainability targets. The implementation of innovative technologies and design strategies was assessed using criteria adapted from international green building standards, providing a structured framework for evaluating the buildings' technological integration and sustainable design solutions. These benchmarks provide context for understanding both facilities' achievements, with Kings Tower generally demonstrating higher performance scores across both sustainable site development and energy efficiency measures (Figure 1). This superior performance can be attributed to its more recent construction and implementation of advanced sustainable technologies, as evidenced by its higher innovation implementation and technology integration scores (Table 5).

The integration of vegetated elements and facade treatments, particularly visible in Kings Tower's integrated planters (Plate 5), represents an innovative approach to combining aesthetic design with sustainable functionality. This integration of green elements supports Generalova et al.'s (2018) assertion about the importance of ecological urbanism in sustainable urban design. These findings contribute to the broader understanding of sustainable design implementation in mixed-use facilities within rapidly urbanizing contexts, as discussed by William (2019) and Aluko (2018). The results demonstrate both the progress made in implementing sustainable design strategies and the continuing challenges faced in achieving comprehensive sustainability, particularly in site development aspects.

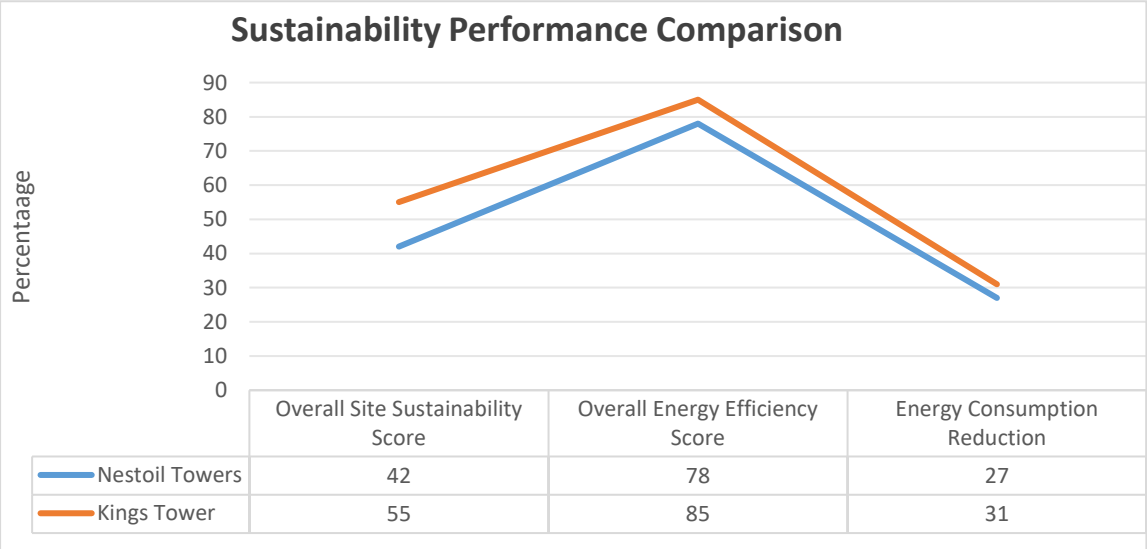

Figure 1: Line chart comparing sustainability performance metrics between the two buildings

Table 5: Comparative Analysis of Sustainable Features

Category	Nestoil Towers	Kings Tower
Overall Site Sustainability Score	42%	55%
Overall Energy Efficiency Score	78%	85%
Energy Consumption Reduction	27%	31%
Innovation Implementation	High	Very High
Technology Integration	High	Very High

4.2.5 Key Performance Indicators

The analysis of the key performance indicators reveals several key findings regarding the sustainable design strategies in Lagos's mixed-use developments. First, the dense urban setting significantly impacts site sustainability, with many facilities adopting innovative vertical solutions due to limited space, resulting in fewer ground-level interventions. Additionally, advanced technological integration is evident in these buildings, with the use of sophisticated building management systems, smart lighting, and HVAC controls, as well as integrated facade systems that contribute to energy efficiency. Finally, there is a clear evolution in design, as recent developments demonstrate progressive improvements in passive design techniques, better integration of sustainable features, and higher performance metrics, highlighting an ongoing shift toward more sustainable and efficient building practices.

4.2.6 Assessment of Research Questions

This study's findings directly address the three primary research questions:

1. Effectiveness of Implementation: The assessment revealed varying degrees of effectiveness in sustainable design strategy implementation. Energy efficiency measures demonstrated high effectiveness (78-85% implementation scores), with both facilities achieving significant energy consumption reductions (27-31%). However, site sustainability measures showed moderate effectiveness (42-55%), indicating areas for improvement. The implementation effectiveness is particularly evident in technological integration and innovative design solutions, though challenges persist in site-level interventions.
2. Principal Influencing Factors: The study identified several key factors influencing sustainable strategy adoption:
    a. Regulatory requirements and building codes
    b. Available technological solutions and their local applicability
    c. Site constraints and urban context
    d. Economic considerations and return on investment
    e. Technical expertise and implementation capacity

These factors collectively shape the decision-making process and ultimate effectiveness of sustainable design implementations.

3. Performance Improvement Approaches: Based on the analysis, several approaches can enhance environmental performance:
    a. Integration of comprehensive site sustainability measures from early planning stages
    b. Enhanced focus on passive design strategies
    c. Implementation of advanced building management systems
    d. Regular performance monitoring and optimization
    e. Stakeholder engagement in sustainability initiatives

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

This study assessed the implementation of sustainable design strategies in selected mixed-use facilities in Lagos State, focusing on sustainable site development and energy efficiency measures. The findings reveal that while significant progress has been made in incorporating sustainable design principles, particularly in energy efficiency, there remains room for improvement in site sustainability measures. The evaluated buildings demonstrate strong performance in technological integration and innovative design solutions, with energy consumption reductions of 27-31% compared to conventional buildings. However, the relatively modest performance in site sustainability metrics, particularly in vegetation preservation and tree retention, highlights areas requiring enhanced attention in future developments.

The success of energy efficiency implementations in both case studies, evidenced by high scores in building envelope performance and daylighting utilization, demonstrates the feasibility of sustainable design strategies in Lagos's tropical climate. These achievements provide a valuable blueprint for future mixed-use developments in similar urban contexts. The study also highlights the importance of balancing technological solutions with fundamental sustainable site development principles to achieve comprehensive environmental performance.

While this study provides detailed observational analysis of sustainable design implementations, it acknowledges the limitation of not incorporating direct stakeholder perspectives. Future research would benefit from including quantitative measurements and feedback from building occupants, facility managers, and other stakeholders to provide a more comprehensive understanding of sustainable design effectiveness.

5.2 Recommendations

Based on the findings of this research, the following recommendations are proposed:

1. Future mixed-use developments should prioritize site sustainability measures during the initial planning phases, with particular emphasis on preserving existing vegetation and incorporating green infrastructure.
2. Policy makers should develop and enforce more stringent guidelines for sustainable site development in urban areas, complementing existing energy efficiency regulations.
3. Developers and architects should consider adopting integrated design approaches that balance technological solutions with passive design strategies, following the successful examples documented in this study.
4. Investment in post-occupancy evaluation systems should be increased to monitor and optimize the long-term performance of sustainable design features.
5. Educational institutions should incorporate practical sustainable design case studies into architectural curricula to better prepare future professionals for implementing comprehensive sustainability measures.
6. For existing buildings:
    a. Implement retrofit strategies focusing on envelope improvements and system upgrades
    b. Conduct energy audits to identify optimization opportunities
    c. Install smart building management systems to enhance operational efficiency
    d. Integrate green roof systems and vertical gardens where structurally feasible
    e. Develop phased sustainability improvement plans aligned with renovation cycles"

Future research should expand upon this study by examining a broader range of mixed-use facilities across different urban contexts in Nigeria, incorporating additional sustainability

metrics, and conducting longitudinal studies to assess the long-term effectiveness of implemented strategies. Additionally, investigations into the economic implications of sustainable design implementations would provide valuable insights for stakeholders in the construction industry.

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