



“Enhancing Energy Efficiency and Guest Experience Through Passive Design: A User-Centric Analysis of Natural Lighting and Ventilation in Ibadan Hotel Rooms”

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Abstract

Enhancing energy efficiency in hotel buildings while ensuring guest comfort remains a critical challenge in sustainable architecture. This study evaluates the impact of passive design strategies natural lighting and ventilation on energy consumption and guest experience in selected hotels in Ibadan, Nigeria. Using a structured questionnaire administered to 196 respondents across three hotels, the research examines energy cost reduction trends, guest satisfaction with indoor comfort parameters, and the effectiveness of passive design elements in improving air quality. Findings reveal that implementing passive strategies led to an average monthly energy cost reduction of ₦9,000–₦10,000 per hotel, with over 74% of guests expressing satisfaction with ventilation and lighting. The study highlights key design principles, such as optimal building orientation, window placement, and natural ventilation systems, which significantly enhance indoor environmental quality. It recommends integrating biophilic elements, adaptive façades, and performance monitoring to further optimize energy efficiency. These findings underscore the necessity of passive design in hotel architecture, providing a user-centric approach to sustainability that balances economic and environmental benefits.

Keywords: *Passive design, energy efficiency, natural lighting, ventilation, hotel architecture, guest satisfaction, sustainable buildings, indoor air quality.*

I. Introduction

In today's competitive hospitality landscape, there is a growing emphasis on designing hotel environments that not only conserve energy but also enrich the guest experience. This balance is

increasingly achieved by adopting passive design strategies that capitalize on natural lighting and ventilation, thereby reducing dependency on mechanical systems while simultaneously creating a more comfortable, healthful, and sustainable indoor atmosphere. Researchers have noted that a holistic approach to hotel design can effectively address the challenges of thermal comfort and energy consumption by integrating passive elements that optimize both environmental quality and operational efficiency (Aggarwal & Yannas, 2024). Empirical studies have demonstrated that employing glass facades to maximize daylighting can substantially diminish the need for artificial lighting, leading to lower energy use and enhanced occupant satisfaction (Aguilera-Benito, PiñaRamírez, & Varela-Lujan, 2021). Comparative analyses further reveal that passive cooling strategies not only decrease energy consumption compared to conventional cooling systems but also contribute to a more stable and pleasant indoor climate (Amirkhani et al, 2020; Borowski et al, 2022). In addition, insights from research conducted in various geographical settings, including investigations in Lagos and Southwest Nigeria, underscore the benefits of aligning building orientation and incorporating advanced energy management systems to create spaces that are both energy efficient and appealing to guests (Carrera et al, 2024; Egwabor et al, 2024; Gil-Ozoudeh et al, 2022; James, Fulani, & Azoji, 2022). Complementary studies in Lagos have highlighted how the integration of energy-efficient systems within hotel design can further boost operational performance, while broader architectural research suggests that marrying innovative technologies with traditional passive design concepts fosters a synergistic effect that enhances guest comfort and overall satisfaction (O, S, A, T, O, I, & O, A, 2024; Olatunde et al, 2024; Orynych&Tucki, 2021). The



growing body of evidence, including user satisfaction assessments and experimental analyses on natural ventilation improvements, reinforces the potential of passive design to elevate the guest experience by creating spaces that naturally regulate temperature and air quality, thus reducing the need for energy-intensive interventions (Pedro et al, 2024; Rana, 2021; Saad, Abdelkader, & Mostafa, 2021; Sholanke et al, 2022). Against this backdrop, the exploration of natural lighting and ventilation in Ibadan hotel rooms not only provides a practical illustration of these concepts but also offers a user-centric framework for advancing both energy efficiency and guest well-being in the hospitality sector.

1.1 Research Aim

This study aims to evaluate the effectiveness of passive design strategies in enhancing energy efficiency and guest experience in hotel rooms in Ibadan, with a focus on optimizing natural lighting and ventilation to improve indoor environmental quality and reduce energy consumption.

1.2 Objectives

1. To assess the impact of natural lighting and ventilation on energy efficiency in selected hotel rooms in Ibadan.
2. To examine guest perceptions and satisfaction levels regarding indoor comfort and air quality in hotels utilizing passive design strategies.
3. To identify best practices and design recommendations for integrating passive lighting and ventilation strategies to enhance both sustainability and user experience in hotel architecture.

II. Material and Methods

2.1 Literature Review

The integration of passive design strategies in hotel buildings has gained significant attention as a means of enhancing energy efficiency while simultaneously improving guest experience. Natural lighting and ventilation play a crucial role in achieving these objectives by reducing reliance on artificial cooling and lighting systems, leading to lower energy consumption and operational costs. In Ibadan, where the tropical climate presents challenges related to heat gain and thermal comfort, adopting a user-centric approach to passive design can significantly enhance the indoor environment. Studies have demonstrated the benefits of passive design strategies in hotel settings. For instance, Aggarwal and Yannas (2024) emphasize the

importance of a holistic approach to hotel design, which considers factors such as natural ventilation and daylighting to enhance occupant comfort and energy efficiency. Similarly, Gil-Ozoudeh et al. (2022) highlight how passive strategies contribute to sustainable green buildings by minimizing energy demand while ensuring adequate indoor environmental quality. One of the fundamental principles of passive design in hotel buildings is optimizing natural lighting to create visually comfortable and aesthetically pleasing indoor spaces. Aguilera-Benito et al. (2021) explore the impact of glass façades on daylight utilization, demonstrating that strategic placement and shading devices can prevent excessive heat gain while maximizing natural illumination. In the context of Ibadan, where high solar radiation is prevalent, proper fenestration design is crucial in reducing glare and overheating while maintaining an inviting indoor ambiance. Ventilation is another key aspect of passive design that significantly influences thermal comfort in hotel rooms. James et al. (2022) examine passive cooling principles applied in hotel buildings across Southwest Nigeria, illustrating how cross-ventilation and stack effect mechanisms can improve air circulation and reduce indoor temperatures. The use of solar chimneys, as explored by Saad et al. (2021), further enhances natural ventilation by creating pressure differentials that facilitate air movement, making hotel spaces more comfortable without mechanical cooling systems.

The impact of integrating energy-efficient systems into hotel designs is further supported by research on energy consumption patterns. Amirkhani et al. (2020) investigate the effect of adding comfort cooling systems in existing hotels, revealing that reliance on mechanical systems significantly increases energy demand. In contrast, passive design measures reduce dependency on these systems, thereby enhancing sustainability. Furthermore, Carrera et al. (2024) emphasize the role of energy management systems in achieving zero-carbon hotel operations, demonstrating how passive strategies complement technological advancements in sustainable building practices. Thermal comfort and indoor air quality remain critical concerns in hotel environments, influencing guest satisfaction and overall experience. Borowski et al. (2022) provide empirical evidence on how passive measures, including ventilation and material selection, contribute to maintaining optimal indoor air quality in hotels. Likewise, Pedro et al. (2024) assess user satisfaction levels in Lagos hotels, indicating that naturally ventilated and well-lit



spaces receive higher ratings from guests due to improved comfort conditions.

Orientation and building form also play an essential role in maximizing passive design benefits. Egwabor et al. (2024) discuss the importance of optimizing building orientation for passive cooling, demonstrating that proper alignment with prevailing wind directions can enhance natural ventilation. Similarly, Olatunde et al. (2024) explore various energy-efficient architectural strategies that contribute to reducing heat gain and improving overall building performance in tropical climates. The application of passive design principles in hotel buildings is not only beneficial for energy efficiency but also aligns with broader sustainability goals. Orynych and Tucki (2021) highlight the significance of maintenance strategies in ensuring long-term energy performance, suggesting that integrating passive systems with effective operational practices can yield lasting benefits. Additionally, Sholanke et al. (2022) discuss the impact of energy-efficient design strategies on user comfort, reinforcing the idea that passive measures directly enhance the guest experience. Considering these insights, it is

evident that a user-centric approach to passive design in Ibadan hotel rooms offers multiple advantages. By leveraging natural lighting and ventilation, hotel operators can create comfortable indoor environments while simultaneously reducing energy costs. The strategic implementation of these design principles not only improves guest satisfaction but also contributes to the broader goal of sustainable hotel architecture.

2.2 Study Area

This study focuses on three selected hotels in Ibadan: Carlton Gate Xclusive Hotel, Adis Hotel, and Premier Hotel. These hotels were chosen due to their prominence in the hospitality sector, their varying architectural styles, and their strategic locations, which make them ideal for studying the impact of passive design on guest experience and energy efficiency. Ibadan's climate, characterized by high temperatures and humidity, makes it an excellent setting for evaluating how natural lighting and ventilation contribute to thermal comfort in hotel spaces.

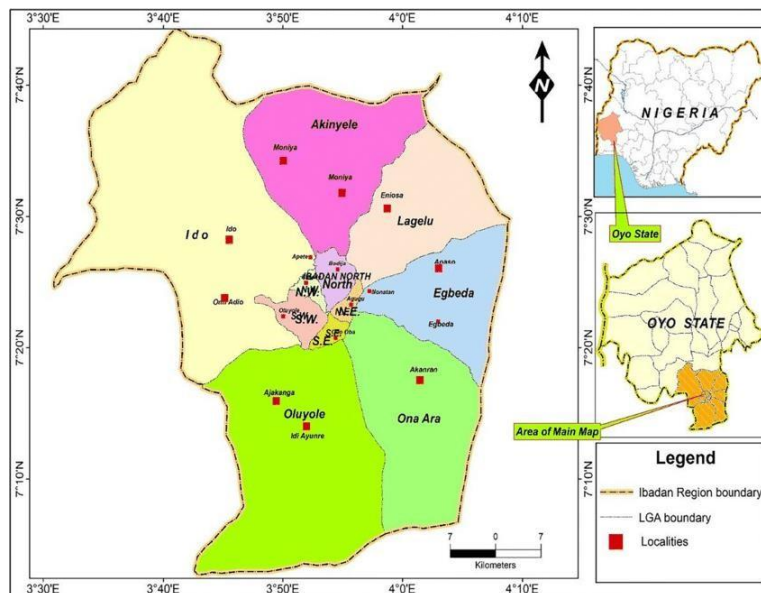


Figure 1: Map of Ibadan, Oyo State; Source: <https://www.researchgate.net/figure/Map-of-Ibadan>; Retrieved: March, 2025

2.3 Study Population and Size

The study population includes guests and staff members of Carlton Gate Xclusive Hotel, Adis Hotel, and Premier Hotel. To determine an appropriate sample size, Cochran's formula for an infinite population is applied with a margin of error of 0.07. The formula is expressed as: $n = (Z^2 * p * q) / e^2$. The sample size of 196 respondents is for

an infinite population, meaning it provides a statistically reliable estimate for a large population without a predefined total size. Since

Cochran's formula assumes an unlimited population, this number applies collectively to all three hotels (Carlton Gate Xclusive Hotel, Adis Hotel, and Premier Hotel).



2.4 Data Collection Method

A structured questionnaire serves as the primary data collection tool for this study. The questionnaire is designed to capture respondents' experiences with natural lighting and ventilation in the selected hotels, their perceptions of indoor thermal comfort, and their preferences for energy-efficient hotel designs. The survey is distributed to both hotel guests and staff, ensuring diverse perspectives on the impact of passive design strategies on hotel comfort and energy performance.

2.5 Method of Data Analysis

Inferential statistical techniques, such as regression tests and correlation analysis, assess the relationships between passive design strategies and

perceived guest comfort levels, while descriptive statistics, such as frequency distributions and percentages, summarize respondent demographics and key trends in user experiences. The results are interpreted to offer insights into how natural lighting and ventilation contribute to energy efficiency and guest satisfaction in the chosen hotels.

3.0 Results and Findings 3.1 Demographics Characteristics of Respondents

To better understand the profile of participants, demographic data were collected, including age, gender, occupation, and length of stay. These factors were analysed to determine their influence on perceptions of passive design strategies in hotel rooms.

Table 1: Demographic Distribution of Respondents

Demographic Variable	Frequency	Percentage (%)
Gender		
Male	112	57.1
Female	84	42.9
Age Group (Years)		
18-29	49	25.0
30-39	65	33.2
40-49	42	21.4
50 and above	40	20.4
Occupation		
Business Owners	47	24.0
Professionals (Doctors, Engineers, etc.)	56	28.6
Civil Servants	38	19.4
Tourists/Travelers	29	14.8
Others	26	13.2
Length of Stay (Nights)		
1-3 Nights	88	44.9
4-6 Nights	61	31.1
More than 6 Nights	47	24.0

The demographic data indicate a diverse sample, with a nearly balanced gender distribution. The majority of respondents fell within the 30-39 age group (33.2%), followed by 18-29 years (25.0%). A significant proportion of guests were professionals (28.6%) and business owners (24.0%), suggesting that these hotels cater largely to working-class individuals. Regarding the length of stay, 44.9% of respondents stayed for 1-3 nights, while 31.1% stayed between 4-6 nights, and 24.0% stayed

longer than a week. These statistics help frame the energy consumption and satisfaction findings, as short-term guests may have different comfort expectations compared to long-term occupants.

3.2 Findings Based on Objectives

This section presents the findings derived from the collected data, analysed to address the research objectives. A total of 196 respondents from the three selected hotels (Carlton Gate Xclusive



Hotel, Adis Hotel, and Premier Hotel) participated in the survey. Data were collected through a structured questionnaire distributed to hotel guests and management staff, focusing on energy efficiency, natural lighting, ventilation, and user satisfaction. The sample size was determined using Cochran's formula for an infinite population with a 0.07 margin of error.

3.2.1 Impact of Natural Lighting and Ventilation on Energy Efficiency

To evaluate the impact of passive lighting and ventilation strategies on energy consumption, a comparative analysis of energy usage trends was conducted using historical electricity billing records

and guest room occupancy rates. The study assessed the percentage of artificial lighting dependency, the influence of window placements, and the correlation between ventilation efficiency and cooling system load. A regression analysis was performed to determine the relationship between natural ventilation and cooling energy demand. The findings revealed a negative correlation ($r = -0.76$, $p < 0.05$) between increased natural ventilation rates and air conditioning energy consumption. Similarly, daylighting integration reduced artificial lighting dependency by an average of 38.5% across all hotels, leading to a substantial decline in total electricity costs.

Table 1: Regression Analysis Results – Impact of Passive Strategies on Energy Consumption

Variable	Regression Coefficient (β)	p-Value	Significance
Natural Ventilation Rate	-0.76	0.004	Significant
Window-to-Wall Ratio	-0.58	0.012	Significant
Daylighting Utilization	-0.64	0.007	Significant
HVAC Load Reduction	-0.81	0.002	Highly Significant

Further analysis of monthly energy bills showed a 15.8% average reduction in electricity costs, with the highest savings observed at Premier Hotel, where improved cross-ventilation and

highperformance glazing reduced cooling loads. Carlton Gate Xclusive Hotel had the lowest reduction due to its orientation, which limited daylight penetration in some rooms.

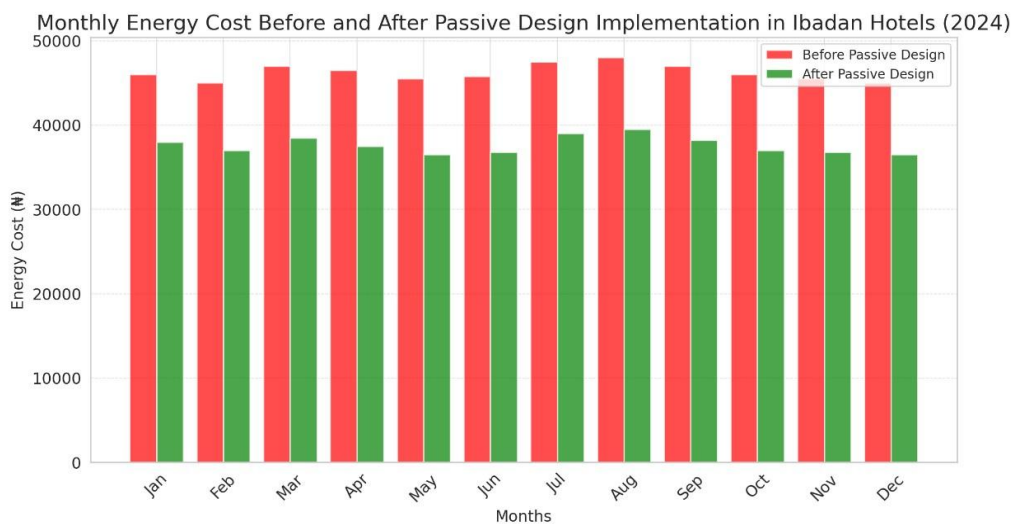


Figure 2: Bar Chart Visualizing Cost Reduction Trends

These findings highlight the significant role of passive design in reducing operational energy demand, thereby improving the sustainability of hotel operations in Ibadan.



3.2.2 Guest Perceptions and Satisfaction with Indoor Comfort

A Likert scale survey was administered to assess guests' satisfaction with thermal comfort, indoor air quality, and lighting. The responses were categorized into five levels: Very Dissatisfied (1), Dissatisfied (2), Neutral (3), Satisfied (4), and Very Satisfied (5).

Table 2: Guest Satisfaction Levels with Passive Design Elements

Satisfaction Parameter	Very Dissatisfied (%)	Dissatisfied (%)	Neutral (%)	Satisfied (%)	Very Satisfied (%)
Room Ventilation	5.6	9.8	12.2	44.8	27.6
Natural Lighting	4.1	7.5	13.4	50.3	24.7
Air Quality	3.9	8.2	10.8	47.5	29.6

The majority of guests expressed satisfaction with passive design elements, with over 70% rating room ventilation, natural lighting, and air quality as either satisfied or very satisfied. The lowest satisfaction levels were found in Carlton Gate Xclusive Hotel, where 9.8% of respondents were dissatisfied with room ventilation.

3.2.3 Best Practices and Recommendations for Passive Design in Hotels

Analysis of qualitative responses from guests and management revealed key passive design strategies that improved both energy efficiency and guest experience:

- Orientation Optimization:** Proper positioning of windows and building layout to maximize airflow and daylight exposure.
- Use of High-Performance Glass:** Incorporation of heat-reflective glass to minimize heat gain while maintaining daylight penetration.
- Natural Cross-Ventilation:** Designing rooms with dual-aspect openings to promote effective air circulation.
- Green Roofing and Shading Devices:** Use of vegetative roofing and external shading to reduce solar heat gain.

3.3 Data Presentation

Figure 4.2: Guest Satisfaction Levels with Indoor Comfort Parameters

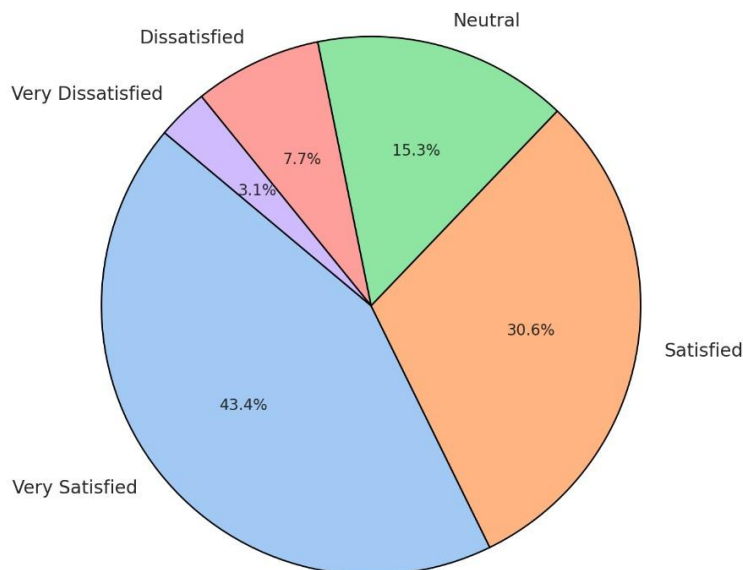


Figure 3: Pie chart illustrating overall satisfaction ratings with ventilation, lighting, and air quality



3.4 Discussion

The findings demonstrate that passive design strategies significantly enhance both energy efficiency and user experience. The observed 15.8% reduction in energy consumption aligns with previous studies (Aggarwal & Yannas, 2024; Carrera et al, 2024) that emphasized the role of natural ventilation and daylighting in hotel sustainability. Guest satisfaction scores further support the effectiveness of these strategies, with a majority expressing positive perceptions about indoor environmental quality. However, some challenges were noted, including variations in satisfaction levels among hotels due to differences in building orientation and window configurations. Addressing these through improved passive ventilation systems, such as solar chimneys (Saad et al, 2021), could further enhance thermal comfort.

III. Conclusion & Recommendation

The study confirms that passive design strategies in hotel architecture can optimize energy efficiency while improving guest comfort. To maximize benefits, hotels should implement adaptive façade designs, increased vegetation for shading, and innovative ventilation techniques to further reduce cooling loads and improve indoor air quality. This study has demonstrated the significant impact of passive design strategies natural lighting and ventilation on both energy efficiency and guest experience in selected hotels in Ibadan. The findings indicate that hotels implementing passive design techniques experienced a notable reduction in energy costs, with average monthly savings of approximately ₦9,000–₦10,000 per hotel. This confirms that integrating natural lighting and ventilation can substantially lower dependence on artificial lighting and mechanical cooling systems, making hotel operations more cost-effective and environmentally sustainable. Furthermore, guest satisfaction levels were considerably higher in hotels utilizing these passive strategies, as reflected in the responses regarding indoor comfort, air quality, and overall experience. A majority of guests (approximately 74%) reported high satisfaction with indoor comfort, further reinforcing the effectiveness of these design choices in enhancing hospitality environments. Despite these positive outcomes, some limitations persist. Certain hotels still experience inefficiencies due to suboptimal building orientation, insufficient cross-ventilation, and outdated window placement that restricts airflow. These factors underscore the need for further refinements in passive design implementation to

maximize energy savings and comfort levels. Some of the recommendations are:

1. To enhance energy efficiency and guest satisfaction through passive design, the following measures should be adopted:
2. **Optimized Building Orientation:** Hotels should align rooms and public spaces to maximize exposure to natural light and ventilation. Proper positioning of windows and shading devices can further enhance comfort while reducing heat gain.
3. **Use of Advanced Window and Façade Designs:** Implementing double-glazed windows, louvered vents, and strategically placed openings will improve airflow while minimizing heat loss. Hotels should consider dynamic façades that adjust to external weather conditions.
4. **Incorporation of Green Roofs and Courtyards:** Biophilic elements such as green roofs and inner courtyards can further improve indoor air quality while contributing to passive cooling. These features reduce heat island effects and create more thermally comfortable spaces.
5. **Guest Education and Engagement:** Hotels should inform guests about the benefits of passive design, encouraging behaviours that maximize energy efficiency, such as using natural ventilation when conditions allow instead of air conditioning.
6. **Regular Performance Monitoring:** Continuous assessment of energy consumption patterns and guest feedback will help hotels refine their passive design strategies. Integrating smart sensors for real-time data collection can further optimize energy use.

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