

The Impact of Green Building Design on Indoor Air Quality and Occupant Experience: A Case Study of Heritage Place, Ikoyi, Lagos State

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Abstract

This study examines the impact of green building design on indoor air quality (IAQ) and occupant experience, using Heritage Place in Ikoyi, Lagos, as a case study. Green buildings are known for incorporating sustainable practices such as the use of eco-friendly materials, advanced ventilation systems, and biophilic design elements, all aimed at enhancing environmental sustainability and occupant well-being. A descriptive survey methodology was employed, with data gathered through a questionnaire administered to 50 occupants of the building to assess their perceptions of IAQ, health, comfort, and overall satisfaction. The findings indicate that the majority of respondents reported high levels of satisfaction with IAQ, attributing improvements in their health, productivity, and comfort to the building's green design features. Specifically, low-emission materials and enhanced ventilation systems were highly praised for reducing pollutants and maintaining a healthy indoor environment. However, a few respondents expressed concerns about inconsistent thermal comfort in certain areas. These results underscore the importance of sustainable design in creating healthier, more productive indoor environments. Recommendations for future green building projects include fine-tuning HVAC systems to improve thermal comfort and enhancing occupant education on the benefits of sustainable features.

Keywords: Green Building Design, Indoor Air Quality (IAQ), Occupant Experience, Sustainable Architecture, Heritage Place.

Introduction

According to Agbajor & Mewomo (2024), Green building design has gained significant momentum in recent years as a response to the growing concerns about environmental sustainability and public health. This approach integrates eco-friendly materials and practices aimed at reducing the environmental footprint of buildings while simultaneously improving the indoor environment for occupants (Khoshnava, Rostami, Mohamad Zin, Štreimikienė, Mardani & Ismail, 2020). A critical aspect of green building design is its potential to enhance indoor air quality (IAQ), which is a major determinant of occupant health, comfort, and overall experience within a building (Wei, Wargocki, Zirngibl, Bendžalová & Mandin, 2020; Elnaklah, Walker & Natarajan, 2021).

Poor IAQ has been linked to a variety of health issues, including respiratory conditions, headaches, fatigue, and cognitive impairment, making it a central focus of sustainable

building practices (Dutton et al., 2020; U.S. Environmental Protection Agency, 2021; Chelang'at & Lawrence, 2024). The design and operational strategies of green buildings are specifically tailored to mitigate these adverse effects by reducing the presence of indoor pollutants, increasing ventilation rates, and optimizing humidity levels (Megahed & Ghoneim, 2021; Owoha, Simpeh, Fapohunda, Ahadzie & Mensah, 2022). Key green design interventions include the use of low-emission construction materials, natural ventilation systems, energy-efficient HVAC systems, and the incorporation of biophilic elements like indoor plants to naturally filter air contaminants (González & Navarro, 2021; Omopariola, Olanrewaju, Albert, Oke & Ibiyemi, 2024).

Studies have shown that such measures can significantly improve IAQ, thereby contributing to the well-being and productivity of building occupants (Browning, Ryan, & Clancy, 2018). Moreover, green buildings are designed with occupants' experience in mind, considering not just air quality but also thermal comfort, natural lighting, and acoustic performance, which collectively shape user satisfaction (Fisk, 2017; Elnaklah, Walker & Natarajan, 2021; Kanda, Lusweti, Ngugi, Irungu, Omondi & Waweru, 2023). Indoor air quality is particularly important because the average person spends up to 90% of their time indoors, where pollutant concentrations are often higher than outdoors (Leung, 2015; Agyekum, Hammond & Salgin, 2021). As a result, even minor improvements in IAQ can have substantial health and productivity benefits (Palacios, Eichholtz & Kok, 2020).

For instance, research indicates that individuals working in green-certified buildings report fewer sick days and higher levels of satisfaction with their work environments compared to those in conventional buildings (Allen et al., 2016). This correlation between green building features and occupant experience highlights the importance of sustainable design in creating healthier, more efficient indoor spaces (Mirzaei, Kamelnia, Islami, Kamyabi, & Assadi, 2020; Nkini, Nuyts, Kassenga, Swai & Verbeeck, 2022).

Problem Statement

Despite the growing implementation of green building designs, there is still a limited understanding of their direct impact on indoor air quality and how this, in turn, affects occupants' health and satisfaction. In regions like Lagos, where urban pollution levels are high, addressing indoor air quality through sustainable building practices becomes crucial. The problem this study aims to solve is the lack of empirical data on how green building features, particularly those targeting IAQ, influence occupant well-being and comfort in a tropical urban environment. Understanding this relationship is vital for advancing environmental sustainability and improving the quality of life in densely populated cities.

Research Objectives

The primary objective of this study is to assess the impact of green building design on indoor air quality and occupant experience, with a focus on Heritage Place in Ikoyi, Lagos. Specifically, this study seeks to:

- i. Evaluate the effectiveness of green building features in improving IAQ.
- ii. Investigate the relationship between IAQ and occupant health, comfort, and satisfaction.
- iii. Identify any potential areas of concern, such as thermal discomfort, that may require further optimization in green building designs.

Literature Review

Research has increasingly focused on understanding the relationship between sustainable building practices and the indoor environment, with particular attention to IAQ as a key factor in both environmental sustainability and human health. This section reviews the relevant literature on the key components of green building design and their effects on IAQ.

Green Building Design and Indoor Air Quality

Green building design prioritizes environmental sustainability by incorporating eco-friendly materials and energy-efficient systems (Omole, Olajiga & Olatunde, 2024). A significant aspect of green buildings is their focus on improving IAQ, which has been shown to directly affect the health and comfort of building occupants (Elnaklah, Walker & Natarajan, 2021). According to Dutton et al. (2020), one of the core features of green buildings is the use of low-emission materials, which help reduce the concentration of volatile organic compounds (VOCs) and other harmful indoor pollutants. These materials are essential in mitigating indoor pollution, which is often more concentrated in conventional buildings due to poor ventilation and the presence of toxic construction materials (Allen et al., 2016).

Another major contributor to improved IAQ in green buildings is enhanced ventilation systems (Elnaklah, Walker & Natarajan, 2021). Studies have consistently shown that increased ventilation rates, especially those that rely on natural airflow, can significantly reduce indoor pollutant concentrations (Leung, 2015). Fisk (2017) found that buildings with advanced ventilation systems that comply with green standards exhibit lower levels of indoor pollutants, leading to fewer occurrences of Sick Building Syndrome (SBS) symptoms among occupants. This aligns with the findings of the U.S. Environmental Protection Agency (2021), which emphasizes the role of green ventilation strategies in promoting healthier indoor environments.

Impact of IAQ on Occupant Health and Well-Being

The importance of IAQ for occupant health and well-being cannot be overstated. Research indicates that poor IAQ is linked to a wide range of health issues, including respiratory illnesses, allergies, headaches, and decreased cognitive function (Wargocki et al., 2017). In contrast, buildings designed with a focus on improving IAQ have been shown to enhance occupants' physical and mental health (Awada et al., 2022). For instance, Allen et al. (2016) conducted a study that demonstrated how green buildings with optimized IAQ reduced the number of sick days reported by office workers and improved overall work performance.

Furthermore, González and Navarro (2021) emphasize the importance of thermal comfort and air quality in shaping occupant experience. Their study found that IAQ is not only a determinant of health outcomes but also influences occupants' perception of comfort and satisfaction with their indoor environment. Occupants in green-certified buildings reported higher levels of comfort and productivity compared to those in conventional buildings. This is particularly relevant in workspaces and educational institutions, where productivity is directly linked to environmental conditions.

Role of Biophilic Design in Enhancing IAQ

Biophilic design, which integrates natural elements such as plants, natural light, and water features into indoor environments, is a fundamental principle of green building design (Dalay, 2020). Browning et al. (2018) argue that biophilic elements, especially indoor plants, can improve IAQ by filtering pollutants and increasing oxygen levels. Studies have explored the role of plants in green building design, concluding that they are effective in removing harmful compounds such as carbon dioxide, formaldehyde, and other VOCs from the air (Luttik, 2020). The incorporation of these natural elements also contributes to the overall aesthetic and psychological well-being of building occupants, creating a more harmonious and health-promoting environment (Vera Suarez, 2023).

Occupant Experience and Satisfaction in Green Buildings

Occupant experience and satisfaction are critical measures of the success of green building designs (Nkini et al., 2022). Research has demonstrated that green-certified buildings consistently receive higher ratings in terms of user satisfaction due to improved air quality, natural lighting, and thermal comfort (Kim et al., 2020). These buildings are designed not only to reduce energy consumption and environmental impact but also to create more habitable and enjoyable spaces for users.

According to Fisk (2017), occupants in green buildings are more likely to report higher levels of satisfaction with their indoor environment, citing factors such as reduced noise levels, improved air quality, and access to natural light as key contributors. Similarly, Allen et al. (2016) highlight that employees working in green office buildings experience lower stress levels, higher productivity, and overall better health outcomes compared to those working in traditional office settings. These findings suggest that green building design has a significant impact on the occupant experience, with positive effects on both health and satisfaction.

Regional Applications of Green Building Standards in Developing Countries

While much of the literature focuses on green building design in developed countries, the application of green standards in developing regions such as Sub-Saharan Africa faces distinct challenges. One major issue is the economic feasibility of implementing green building strategies on a wide scale, particularly in regions with limited financial resources

(González & Navarro, 2021). Developing countries, such as Nigeria, often face budgetary constraints, making it difficult to incorporate advanced green technologies like energy-efficient HVAC systems and low-emission construction materials without significant cost implications. Additionally, the lack of sufficient policy frameworks and incentives to support green construction further hinders adoption in these regions (Omole et al., 2024). Despite these challenges, there is growing recognition of the need for region-specific green building standards that account for local environmental conditions, economic capacities, and socio-cultural contexts. For instance, leveraging traditional materials and design practices, such as natural ventilation, can reduce reliance on energy-intensive mechanical systems while maintaining indoor air quality (Nkini et al., 2022). These localized strategies could make green building design more accessible and cost-effective for developing regions, offering sustainable solutions that are tailored to their specific needs.

However, there remains a gap in empirical studies focusing on the long-term viability and effectiveness of these green building interventions in developing countries. Research is needed to evaluate the performance of regionally adapted green buildings in terms of indoor air quality, energy efficiency, and occupant well-being. Addressing these gaps could provide a clearer pathway for sustainable construction in developing regions, ensuring that green building design contributes not only to environmental sustainability but also to the health and well-being of local populations.

Research Gaps

While there is substantial evidence supporting the positive effects of green building design on IAQ and occupant experience, several gaps remain in the literature. First, there is a need for more empirical studies that explore the long-term health impacts of living and working in green buildings. Most studies to date have focused on short-term outcomes, leaving open the question of whether the benefits of green design are sustained over time (Wargocki et al., 2017). Additionally, research on the economic feasibility of implementing green building design at scale, especially in developing countries, is limited. This gap highlights the need for more region-specific studies that assess the practicality and cost-effectiveness of green design strategies in diverse environmental and economic contexts (González & Navarro, 2021).

Methodology

This study employs a descriptive research design to understand the perceptions of building occupants regarding indoor air quality (IAQ) and the influence of green building features on their overall experience. The descriptive design is well-suited for identifying trends, patterns, and relationships between green building attributes and user satisfaction, providing a framework for analyzing the respondents' views on IAQ in a LEED-certified building.

The target population consists of individuals working in Heritage Place, a LEED-certified green building located in Ikoyi, Lagos. Heritage Place is home to a variety of businesses, and its occupants include professionals from different fields who interact with the building's green features on a daily basis. These features provide an ideal setting for exploring perceptions of IAQ and occupant satisfaction.

A simple random sampling technique was applied to select 50 respondents from among the building's occupants. This sampling method ensured that every occupant had an equal chance of being chosen, thus reducing selection bias and increasing the representativeness of the sample. Although the sample size is relatively small, it is deemed sufficient to capture a range of perspectives and provide meaningful insights.

A structured questionnaire served as the primary data collection tool for this study. The questionnaire was divided into several sections: Demographic Information, Perception of Indoor Air Quality, Impact on Occupant Health and Well-being, Productivity and Occupant Experience and Satisfaction with Green Features.

To ensure the reliability and validity of the questionnaire, it was reviewed by professionals in the fields of architecture, green building design, and environmental psychology. These experts provided feedback on the clarity, relevance, and structure of the questions. Based on their input, adjustments were made to eliminate any ambiguity, enhance the focus on key variables (such as IAQ and occupant satisfaction), and ensure that the questions accurately captured the study's objectives. This professional review process helped establish both the content validity and construct validity of the questionnaire, ensuring that it effectively measured the intended variables.

The collected data were analyzed using descriptive statistical methods. The analysis focused on:

- i. Ratings of IAQ: Respondents' assessments of the quality of air within Heritage Place.
- ii. Satisfaction with Green Features: Analysis of how respondents perceived the building's sustainable features.
- iii. Perceived Impact on Well-being and Productivity: An exploration of the relationship between the building's features, IAQ, and occupant health, productivity, and overall satisfaction.

Case Study: Heritage Place, Ikoyi

Heritage Place is a notable office tower that combines modern design with sustainable practices, making it an ideal case study for this research. The building is the first commercial development in Lagos to achieve LEED certification, emphasizing energy efficiency, environmental sustainability, and occupant well-being.



Figure 1: Heritage Place, Ikoyi

Source: <https://archinaija.blogspot.com/2014/12/heritage-place-ikoyi-lagos-nigeria.html>

(Retrieved September 2024)

Key features of the building include: a 30-40% reduction in energy use, facilitated by natural light, ventilation, and mixed-mode HVAC systems, rainwater harvesting and condensate recovery from cooling units to minimize potable water demand, high-efficiency lighting systems and motion sensor controls to reduce energy consumption and an advanced ventilation system designed to optimize indoor air quality and thermal comfort.

These elements make Heritage Place a benchmark for understanding the practical implications of green building designs on IAQ and occupant experience.

Potential Biases and Limitations

Despite the strengths of the methodology, several limitations and potential biases were considered:

- i. Sample Representativeness: The sample size of 50 respondents may limit the generalizability of the findings.
- ii. Respondent Biases: The reliance on self-reported data introduces the possibility of social desirability bias, where respondents may provide answers they believe are favorable or expected rather than reflecting their true experiences.

- iii. Questionnaire Limitations: Although efforts were made to validate the questionnaire, some questions might still have been interpreted differently by respondents, leading to potential inconsistencies in the data.

Findings and Discussions

The findings are based on the responses from 50 participants. The data were analyzed using descriptive statistics to calculate frequencies, percentages, and mean values for different variables such as IAQ perception, health outcomes, and productivity. Correlation analysis was also performed to explore relationships between the respondents' perceptions of IAQ and other dependent variables like health improvements and productivity levels. The analysis was performed using SPSS, and the following key findings emerged: A positive correlation ($r = 0.72$, $p < 0.05$) was found between improved IAQ and better health outcomes. A moderately strong correlation ($r = 0.63$, $p < 0.05$) was identified between IAQ satisfaction and reported productivity gains.

Indoor Air Quality Perception

From the results presented in Table 1, 80% of respondents rated the IAQ in Heritage Place as either "very good" or "good." This suggests that the green building features, such as enhanced ventilation systems and eco-friendly materials, have significantly contributed to improving IAQ. This observation aligns with Dutton et al. (2020), who noted that low-emission materials and well-designed ventilation systems in green buildings reduce indoor pollutants and enhance air quality.

Table 1: Respondents' Perception of Indoor Air Quality (IAQ)

IAQ Rating	No. of Respondents	Percentage (%)
Very Good	25	50%
Good	15	30%
Average	7	15%
Poor	3	5%

Source: Authors Fieldwork (2023)

The 15% of respondents who rated the IAQ as "average" and the 5% who expressed dissatisfaction highlighted concerns with temperature fluctuations in specific areas, such as meeting rooms. This finding is consistent with Fisk's (2017) study, which also noted occasional ventilation inefficiencies even in well-designed green buildings.

Impact on Occupant Health and Well-being

As shown in Table 2, 70% of respondents reported improvements in their health, citing reduced fatigue, headaches, and respiratory issues. These improvements can be attributed to the green design features of Heritage Place, particularly its advanced HVAC systems and

use of non-toxic, sustainable materials. These results support the findings of Wargocki et al. (2017), who highlighted the positive correlation between good IAQ and occupant health.

Table 2: Reported Impact of IAQ on Health

Health Impact	No. of Respondents	Percentage (%)
Improved Health	35	70%
No Change	12	25%
Negative Impact	3	5%

Source: Authors Fieldwork (2023)

However, 25% of respondents did not notice any significant changes in their health, and 5% mentioned minor issues related to thermal discomfort. This reinforces the need for further fine-tuning of HVAC systems to ensure consistent comfort, as identified by González and Navarro (2021) in their research on thermal comfort.

Productivity and Occupant Experience

From Table 3, 65% of respondents reported an increase in productivity since moving to Heritage Place, largely attributing this to improved IAQ, natural lighting, and better overall workspace comfort. This aligns with Allen et al. (2016), who found that IAQ and environmental quality significantly influence occupant productivity.

Table 3: Productivity Levels

Productivity Impact	No. of Respondents	Percentage (%)
Increased Productivity	32	65%
No Change	18	35%
Decreased Productivity	0	0%

Source: Authors Fieldwork (2023)

Meanwhile, 35% of respondents reported no noticeable change in their productivity. However, these respondents still expressed general satisfaction with the building’s design, echoing Fisk’s (2017) findings that, on the whole, green buildings result in higher levels of occupant satisfaction.

Satisfaction with Green Features

A large majority (85%) of respondents were aware of and satisfied with the green features of Heritage Place, particularly its energy-efficient lighting and water-saving systems. This satisfaction reflects the conclusions of Kim et al. (2020), who found that green buildings are generally associated with higher user satisfaction due to their holistic approach to sustainability and comfort.

10% of respondents were only vaguely aware of these features, while 5% were indifferent, highlighting a potential gap in occupant education. Better communication about the

building's sustainable features, as recommended by Allen et al. (2016), could enhance engagement and utilization.

The results indicate that the green building features of Heritage Place have had a substantial positive impact on IAQ and occupant experience. The findings support existing literature on the benefits of sustainable building practices, particularly in terms of health, productivity, and satisfaction. However, the minority of respondents who reported temperature inconsistencies suggest that further refinements to the HVAC systems could improve thermal comfort, as emphasized by González and Navarro (2021).

Conclusion and Recommendations

Conclusion

The study confirms that green building design, exemplified by Heritage Place in Ikoyi, substantially improves indoor air quality (IAQ) and enhances occupant experience. Most respondents expressed satisfaction with the building's sustainable features, highlighting positive effects on health, productivity, and overall comfort. The integration of low-emission materials, advanced ventilation systems, and biophilic design elements has effectively promoted a healthier indoor environment. Although there were minor concerns regarding temperature fluctuations and inconsistent air circulation in certain areas, Heritage Place's green design principles have largely succeeded in creating a sustainable and user-friendly environment. These findings align with existing literature, which underscores the significant role green buildings play in enhancing environmental sustainability and human well-being.

Recommendations

To optimize the benefits of green building design and further improve IAQ and occupant satisfaction, the following specific recommendations are made:

- i. **Enhance HVAC System Calibration and Maintenance:** Fine-tune the existing HVAC systems to address thermal comfort inconsistencies, particularly in areas like meeting rooms where respondents reported occasional discomfort. Incorporating smart ventilation controls that adjust air circulation based on real-time indoor air quality measurements can ensure more uniform temperature and air distribution across the building.
- ii. **Increase Use of Smart Sensors for Real-time IAQ Monitoring:** Implement smart IAQ monitoring systems that track key parameters such as volatile organic compounds (VOCs), carbon dioxide (CO₂), and humidity levels. These systems would provide real-time data to facility managers, enabling quicker responses to indoor air quality fluctuations and enhancing overall occupant comfort.
- iii. **Strengthen Occupant Education and Engagement Initiatives:** Develop informative campaigns or interactive workshops that educate building users on the sustainable features of the building, such as the energy-efficient lighting systems and water-

saving fixtures. Encouraging greater awareness of these features could foster better occupant interaction with the building's green design, leading to more mindful energy usage and increased satisfaction.

- iv. Expand Biophilic Design Elements: Enhance the biophilic design features by incorporating more natural elements, such as green walls or indoor plants, especially in spaces where occupants spend extended periods. Studies show that integrating more greenery can further improve both air quality and occupant well-being, contributing to a more comfortable and productive indoor environment.
- v. Continuous IAQ Monitoring and Feedback Mechanisms: Establish a feedback loop where occupants can continuously provide input on IAQ and comfort issues. Regular surveys or digital feedback platforms would allow for the ongoing adjustment of building systems to better meet occupant needs.
- vi. Future Green Building Design Considerations: In future green building projects, it is recommended to prioritize the use of eco-friendly materials that have been tested for low emissions, while also focusing on energy-efficient HVAC and lighting systems. Incorporating more passive design strategies, such as natural ventilation and shading devices, will further reduce energy consumption and enhance thermal comfort.

In conclusion, this study reaffirms that green building design, when implemented effectively, can significantly improve indoor air quality and occupant satisfaction. Heritage Place serves as a model for such design, providing a framework for the development of future high-performance buildings in urban settings.

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