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# Assessment of Climatic Design Strategies for Enhancing Indoor Air Quality in a Proposed Heritage Center in Badagry, Lagos State

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**Abstract** **Original Research Article**

This study investigates the application of climatic design strategies to enhance indoor air quality (IAQ) in a proposed heritage center in Badagry, Lagos State. Recognizing the health and conservation challenges posed by high humidity and inadequate ventilation in tropical heritage buildings, the research evaluates passive architectural techniques suitable for the region. The study is guided by three core objectives: examining Badagry's climatic conditions and their influence on IAQ; assessing building forms and orientation strategies that support natural ventilation and daylighting; and exploring sustainable materials and construction methods that align with both environmental and cultural preservation goals.

Using a quantitative research design rooted in positivist philosophy, data were collected through structured questionnaires distributed to 303 respondents, including architects, curators, cultural heritage professionals, and visitors. Statistical analysis using SPSS revealed strong stakeholder agreement on the role of orientation, cross-ventilation, large windows, and traditional forms in improving IAQ. Findings also highlighted widespread support for sustainable materials and adaptive construction methods that honor heritage conservation while enhancing thermal comfort.

The study underscores the importance of climate-responsive design in heritage architecture, advocating for passive cooling techniques, local low-emission materials, and green buffers. It concludes with strategic recommendations to integrate environmental performance with cultural sustainability, promoting healthier indoor environments and resilient heritage spaces.

**Keywords:** Indoor Air Quality (IAQ), Climate-Responsive Architecture, Passive Design Strategies, Heritage Center, Natural Ventilation, Building Orientation.

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## 1.0 INTRODUCTION

Indoor air quality (IAQ) has become a critical concern in contemporary building design due to its significant impact on occupant health, comfort, and productivity. As climate change continues to alter temperature and humidity patterns, climate-responsive architecture becomes essential for managing indoor pollutants and maintaining healthy indoor environments (Mannan & Al-Ghamdi, 2021; Mansouri et al., 2022). Poor IAQ has been linked to reduced cognitive performance and increased health risks, necessitating adaptive ventilation strategies (Tejani, 2024).

In Lagos State, the tropical climate presents challenges like high humidity and intense solar radiation. Addressing these through sustainable design not only enhances IAQ but also supports heritage conservation efforts. Implementing ultra-low energy solutions and integrating smart systems can improve comfort, reduce energy use, and cut emissions (Mi, 2024). Additionally, green building envelopes help manage heat and rainwater, supporting urban resilience and biodiversity (MacKinnon et al., 2021). Heritage sites play a vital role in fostering community identity, underscoring the importance of balancing modern sustainability with cultural preservation.

Museums and heritage buildings in tropical climates like Lagos face major challenges in achieving thermal comfort and energy efficiency due to high temperatures and humidity (Egwabor et al., 2024). Poor IAQ is a common issue in older structures that lack modern ventilation systems, posing health risks to staff and visitors. Studies have linked inadequate ventilation to symptoms of sick building syndrome (SBS) (Vasile et al., 2023), with nearly 20% of museum visitors reporting health issues, particularly those with pre-existing conditions (Ilies et al., 2023).

Optimal building design is key for conserving energy, enhancing user experience, and protecting artifacts. Passive strategies, such as proper building orientation, can improve thermal comfort, but research specific to Lagos remains limited (Egwabor et al., 2024). Most heritage buildings underexploit local climatic advantages, especially in humid areas like Badagry, leading to accelerated artifact deterioration.

The importance of addressing indoor air quality (IAQ) and climate-adaptive architecture in cultural centers—especially in areas with harsh environmental circumstances like Badagry, Lagos State—justifies this study. Since they serve as guardians of history, passing down cultural values and memories to future generations, heritage buildings are essential to maintaining cultural history and building community identity (Trad et al., 2024)

This study aligns closely with two United Nations Sustainable Development Goals (SDG). It supports SDG 11 by promoting the design of a heritage center that enhances indoor air quality through climate-responsive architecture, thereby fostering sustainable urban development, cultural preservation, and inclusive spaces. Additionally, it contributes to SDG 13 by encouraging passive cooling, the use of sustainable materials, and reduced reliance on energy-intensive systems, all of which help lower carbon emissions and support climate-resilient building practices.

## Aim and Objectives

### Aim

This study aims to assess climatic design strategies for enhancing indoor air quality in a heritage center in Badagry, Lagos State

### Objectives

The specific objectives of the study are considered to:

i. Investigate the climatic conditions of Badagry and their influence on indoor air quality in the heritage center context;
ii. Identify and assess building forms and orientation techniques that enhance natural ventilation and light for improved indoor air quality;
iii. Explore sustainable materials and construction methods that honor heritage conservation while meeting modern environmental standards.

## 2.0 LITERATURE REVIEW

### 2.1 Concept of Heritage Centers

Heritage centers are institutions established to preserve and promote the cultural legacy of a community or nation (Susanti et al., 2022). They serve as educational, cultural, and historical repositories, fostering identity and continuity (Piaia et al., 2022). These centers exist at both local and international levels, with examples like the Arusha Cultural Heritage Centre (African Sahara, 2024) and the Smithsonian Institution demonstrating varied scopes of impact (Bilotta et al., 2021).

### 2.2 Historical Evolution of Heritage Conservation

Heritage preservation has ancient roots, as seen in civilizations such as Egypt and Rome, where monuments and sacred sites were maintained as symbols of identity (Li & Tang, 2023). The practice advanced through religious institutions in the medieval era and was formalized during the rise of nationalism in the 19th century. Today, preservation integrates digital tools and adaptive reuse for sustainability (Mendoza et al., 2023).

### 2.3 Historical Background of Heritage Center in Nigeria

Nigeria's rich cultural and historical past has been preserved and showcased thanks in large part to the construction of heritage centers. To ensure that Nigeria's varied customs, artifacts, and historical accounts are passed down to future generations, these centers operate as guardians.

### Early Preservation Efforts

Before the advent of formal museums, the preservation of culturally significant items in Nigeria was managed by traditional institutions (Emifoniye, 2023). Items of religious, political, and social importance were safeguarded in shrines, palaces, and sometimes caves (Onyejegbu, 2024). Custodians such as community leaders and priests acted as early curators, maintaining these artifacts within their communities.

### Colonial Era Developments

The formalization of heritage preservation began in the early 20th century during the colonial period. In 1943, the Nigerian Antiquities Service was inaugurated, marking the official commencement of structured efforts to conserve Nigeria's cultural artifacts. This initiative led to the establishment of the National Department of Antiquities in 1953, which was tasked with the exploration, care, and preservation of antiquities and works of art (Hellman, 2023). The department also regulated the exportation of cultural artifacts, ensuring that Nigeria's heritage remained within its borders.

### Post-Colonial Advancements

Following Nigeria's independence, there was a renewed focus on cultural preservation. In 1979, the National Commission for Museums and Monuments (NCMM) was established, replacing the former Antiquities Commission (Fajemirokun, 2021). The NCMM expanded the network of museums and heritage sites across the country, including notable institutions such as the National Museum in Lagos houses extensive collections of archaeological discoveries and historical documents.

## 2.4 Types of Heritage Center

Depending on their emphasis, mission, or the kind of legacy they preserve and exhibit, heritage centers can be divided into different categories. Cultural legacy can be classified as either tangible or intangible. Both transportable items like paintings, sculptures, and furniture, as well as immovable assets like historical buildings, monuments, and archaeological sites, are included in tangible cultural property. These concrete representations serve as a bridge to historical narratives and architectural traditions. Conversely, non-material aspects of culture that embody a community's cultural identity and traditions—like oral traditions, social rituals, and traditional skills—are referred to as intangible cultural heritage. This dual classification highlights the need for thorough preservation methods that take into account both material objects and living practices in order to preserve cultural legacies for future generations. Below is a graphical representation of the types of heritage centers:

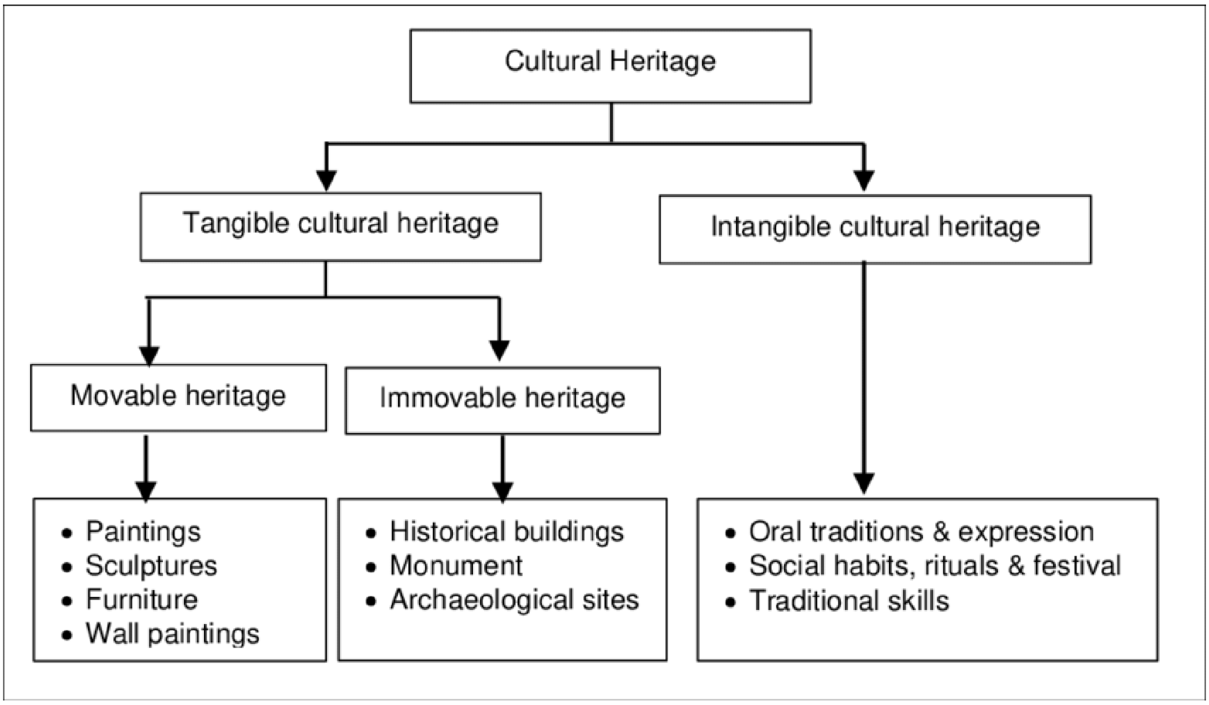


*Figure 1.0: Types of Heritage Center*

Source: https://www.researchgate.net/figure/Cultural-Heritage-Classification-from UNESCO-21_fig1_329878297 (Retrieved June 2025)

## 2.5 Challenges in Heritage Center Design

Heritage center design and upkeep pose several difficulties. In many older or remodeled buildings, structural deterioration, high humidity, inadequate ventilation, and high energy expenditures are persistent problems. Inadequate ventilation and temperature control can hasten the degradation of organic artifacts, including paper, wood, and textiles (Li et al., 2021).

As a result, smart technologies and ecologically conscious design are being incorporated into more and more contemporary cultural centers. According to Blavier et al. (2023), modular designs and material selections that support future maintenance and growth are recommended. Similarly, contextual design techniques that address local climate circumstances, cultural aesthetics, and user demands are suggested by Gholamzadehmir et al. (2020). Long-term sustainability depends on these adaptive measures, particularly in areas susceptible to climate stress.

## 2.6 Climate Responsiveness and Indoor Air Quality

The importance of climate-responsive architecture in improving indoor air quality (IAQ), particularly in humid and tropical settings, is becoming more widely acknowledged (Li, 2025). In order to control interior conditions without the usage of mechanical systems, passive techniques, including building orientation, cross ventilation, thermal massing, and vegetal shading devices, are being utilized more and more (Oleiwi & Mohamed, 2022). According to Mi

(2024), incorporating such tactics lowers operating expenses and energy dependency while simultaneously increasing occupant comfort.

Research on the use of climate-responsive design in Nigerian historical institutions is few, despite this worldwide trend. Little is known about the precise effects of these tactics on visitor experience, artifact preservation, and IAQ. This study addresses that gap by evaluating the relevance and effectiveness of climate-sensitive design elements in the context of Badagry, Lagos State.

## 2.7 Review of relevant case study

### Heritage Museum, Badagry

From Google satellite images, it has been determined that the Heritage Museum in Badagry is oriented on average 30 degrees south and east. The building can efficiently use natural light and passive cooling since this orientation matches the ideal angle for passive solar architecture. In order to maximize daylight penetration and reduce solar heat absorption, the museum's windows are oriented strategically toward the equator.

Two important components of passive design tactics are the museum's brightly colored roof and large overhangs. Artificial cooling is less necessary because of the deep overhangs, which offer shade and protection from direct sunshine. By reflecting sunlight, the brightly colored roof lowers the building's overall thermal coefficient and stops heat absorption.

In addition to adding to the museum's visual appeal, its orientation, deep overhangs, and reflecting roof guarantee both the preservation of artifacts and a comfortable indoor environment for visitors.

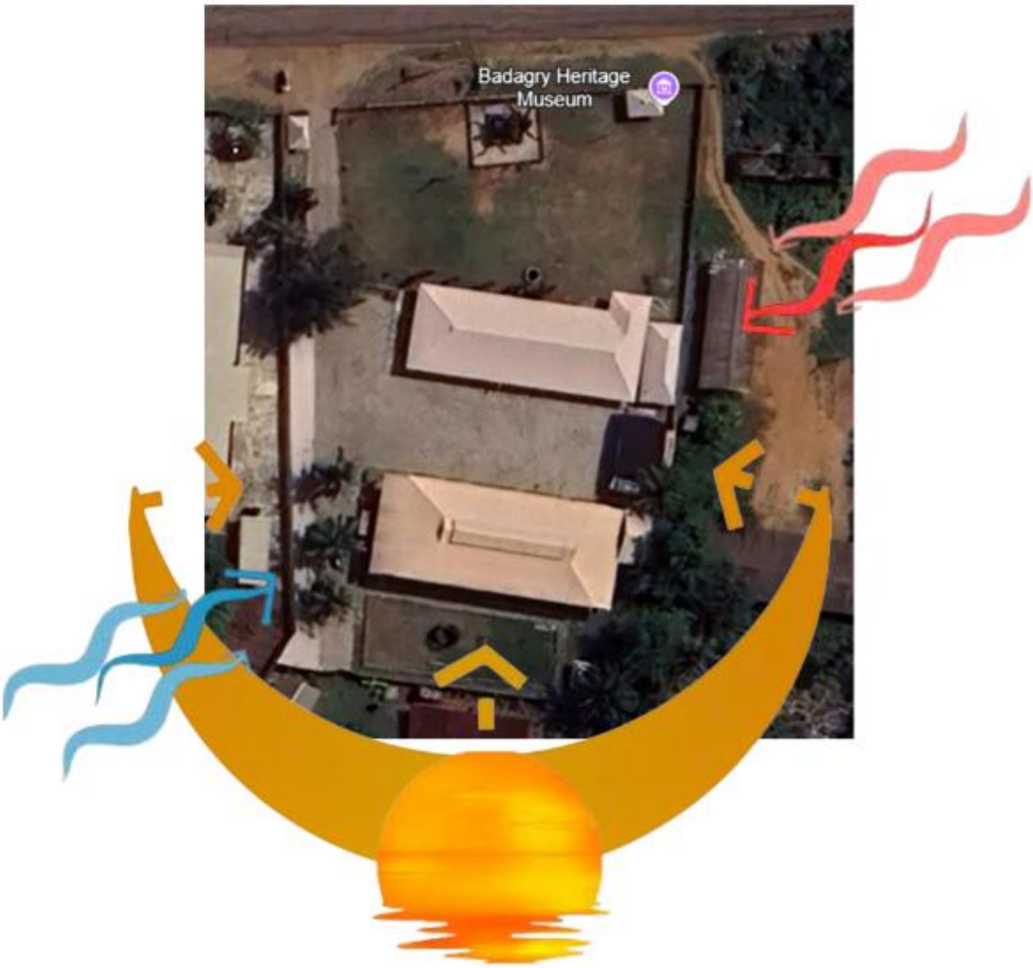


*Figure 2.0: Orientation of Heritage Museum, Badagry*
Source: Author
(Retrieved June 2025)

## 3.0 METHODOLOGY

### 3.1 Research design

With an emphasis on the Heritage Center in Badagry, Lagos State, this study uses a quantitative research technique to evaluate the efficacy of climatic design solutions for improving indoor air quality (IAQ) in heritage institutions. The methodology uses statistical analysis and standardized tools to collect numerical data from a designated population.

### 3.2 Research Philosophy

The research is rooted in positivist philosophy, which emphasizes observable and measurable facts. This aligns with the objective nature of quantitative research, allowing for generalizable results based on empirical data collected from respondents.

### 3.3 Study Population

The target population includes curators, operational staff, and visitors to heritage centers in Lagos State. These respondents were selected for their experience and interaction with heritage buildings and their environmental conditions.

### 3.4 Sampling Method and Sample Size

The study used stratified random sampling to ensure representation across different respondent categories. A sample size of 384 participants was determined using Cochran's formula to ensure statistical significance and reliability.

### 3.5 Unit of Data Collection

The units of data collection were individual respondents, specifically heritage building users and staff who are directly affected by IAQ conditions.

### 3.6 Data Collection Instrument

Primary data was collected through a structured questionnaire designed to capture information on the respondents' awareness, experiences, and opinions regarding climatic design strategies (e.g., natural ventilation, building orientation, and passive cooling techniques) and their perceived effect on IAQ.

### 3.7 Data Analysis

The collected data were analyzed using descriptive statistics (such as frequencies, means, and percentages) and inferential statistics (such as chi-square tests and regression analysis) using SPSS software. These analyses helped determine the relationships between design strategies and IAQ outcomes as perceived by respondents.

### 3.8 Ethical Considerations

Informed consent was obtained from all participants. The study maintained confidentiality and anonymity, and participation was entirely voluntary. Ethical approval was sought and obtained from relevant academic oversight bodies.

## 4.0 FINDINGS AND DISCUSSIONS

The main conclusions of the quantitative survey of stakeholders involved in Lagos State's heritage centers are presented in this section. The information shows respondents' knowledge, opinions, and preferences on climatic design techniques and how they affect indoor air quality. Additionally, demographic factors like age, occupation, and frequency of visits are looked at in order to evaluate user behavior and contextualize responses. The results are examined in light of previous research, pointing out both similarities and differences and suggesting approaches that will help Badagry's cultural center be designed to be climate-responsive.

### 4.1 Demographic Data

Table 1: Summary of Respondents' Demographic Characteristics (N = 303)

| Variable | Categories | Frequency (n) | Percentage (%) | Mode | Median |
|---|---|---|---|---|---|
| Gender | Male | 177 | 58.4 | 1 | 1.00 |
| | Female | 126 | 41.6 | | |
| Age Group | 18 – 25 | 58 | 19.1 | 2 | 3.00 |
| | 26 – 35 | 91 | 30.0 | | |
| | 36 – 45 | 90 | 29.7 | | |
| | 46 – 55 | 58 | 19.1 | | |
| | 56 and above | 6 | 2.0 | | |

| | | | | | |
|---|---|---|---|---|---|
| Occupation of respondents | Architect | 127 | 41.9 | 1 | 2.00 |
| | Curator | 70 | 23.1 | | |
| | Cultural Heritage Professional | 28 | 9.2 | | |
| | Visitor | 78 | 25.7 | | |
| Frequency of Heritage Center visits | Frequently | 79 | 26.1 | 2 | 2.00 |
| | Occasionally | 106 | 35.0 | | |
| | Rarely | 99 | 32.7 | | |
| | Never | 19 | 6.3 | | |
| | **TOTAL** | 303 (For each variable) | 100% | | |

*Source: Author's analysis of primary data collected through questionnaires and processed using SPSS (2025)*

A total of 303 respondents participated in the survey, offering valuable insights into the user profile for heritage centers. The sample was 58.4% male and 41.6% female, suggesting a gender imbalance that may influence spatial and cultural engagement patterns. The majority of respondents were within the 26–35 age group (30.0%), closely followed by those aged 36–45 (29.7%), indicating that most participants were young to middle-aged professionals.

Occupationally, architects formed the largest group (41.9%), followed by visitors (25.7%), curators (23.1%), and cultural heritage professionals (9.2%). This composition offered a well-rounded perspective across technical, managerial, and user viewpoints relevant to heritage design.

Regarding visitation habits, 35.0% of respondents visit heritage centers occasionally, while 32.7% visit rarely, and 26.1% are frequent visitors. Only 6.3% reported never visiting. This suggests moderate public engagement with heritage spaces, indicating room for improvement in accessibility, programming, or spatial appeal through climate-responsive and culturally engaging design.

## 4.2 Analysis based on research Objectives

### 4.2.1 OBJECTIVE I: Investigate the climatic conditions of Badagry and their influence on indoor air quality.

Table 2: Descriptive Statistics of Individual Items

| Statement | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | Total (n=303) |
|---|---|---|---|---|---|---|
| Climate affects IAQ | 10 (3.3%) | 21 (6.9%) | 105 (34.7%) | 158 (52.1%) | 9 (3.0%) | 100% |
| Humidity causes discomfort | 6 (2.0%) | 13 (4.3%) | 58 (19.1%) | 207 (68.3%) | 19 (6.3%) | 100% |
| Poor ventilation | 7 (2.3%) | 14 (4.6%) | 49 (16.2%) | 194 (64.0%) | 39 (12.9%) | 100% |
| Temperature affects comfort | 8 (2.6%) | 14 (4.6%) | 52 (17.2%) | 179 (59.1%) | 50 (16.5%) | 100% |
| Climatic design improves IAQ | 3 (1.0%) | 13 (4.3%) | 58 (19.1%) | 180 (59.4%) | 49 (16.2%) | 100% |

*Source: Author's analysis of primary data collected through questionnaires and processed using SPSS (2025)*

Overall, many respondents agree or strongly agree with all statements, especially on humidity (74.6%), ventilation (76.9%), and temperature effects (75.6%). Neutral responses are highest for the "Climate affects IAQ" item (34.7%), suggesting a potential knowledge gap among respondents or varied perceptions across roles. These results confirm strong perceived links between climatic stressors (humidity, ventilation, temperature) and IAQ in heritage settings.

### 4.2.2 OBJECTIVE II: Identify and assess building forms and orientation techniques that enhance natural ventilation and light

Table 3: Descriptive Statistics

| Design Feature Evaluated | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | Design Feature Evaluated |
|---|---|---|---|---|---|---|
| Orientation improves natural ventilation | 3.6% | 3.6% | 15.5% | 69.3% | 7.9% | Agree |
| Courtyards and open spaces enhance airflow | 1.3% | 5.3% | 16.2% | 63.7% | 13.5% | Agree |
| Traditional forms provide effective lighting | 1.7% | 3.3% | 15.8% | 61.1% | 18.2% | Agree |
| Large windows/screens enhance indoor air quality (IAQ) | 2.3% | 4.3% | 12.9% | 58.4% | 22.1% | Agree |
| Cross-ventilation improves IAQ | 2.0% | 4.0% | 13.9% | 57.8% | 22.4% | |

*Source: Author's analysis of primary data collected through questionnaires and processed using SPSS (2025)*

All five features had over 55% of respondents selecting "Agree", and another 13–22% selecting "Strongly agree." Neutral responses hovered around 13–16%, suggesting a moderate level of uncertainty or contextual variability. Very low disagreement rates (mostly under 5%) show a strong consensus on the effectiveness of climate-responsive design elements.

Respondents overwhelmingly acknowledged the effectiveness of passive design strategies, particularly orientation, courtyards, cross-ventilation, and traditional forms in enhancing indoor air quality (IAQ) and daylighting. This reflects a solid user preference for environmentally responsive architecture.

### 4.2.3 OBJECTIVE III: Explore sustainable materials and construction methods

Table 4: Descriptive Statistics, general level of agreement (on a 5-point Likert scale) across all respondents

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| Local materials improve thermal comfort and IAQ | 303 | 1 | 5 | 3.73 | .869 |
| Sustainable construction should be prioritized | 303 | 1 | 5 | 3.87 | .703 |
| Integrating modern standards preserves heritage | 303 | 1 | 5 | 3.95 | .816 |

| | | | | | |
|---|---|---|---|---|---|
| Energy-efficient materials support IAQ | 303 | 1 | 5 | 3.95 | .833 |
| Adapt traditional methods for sustainability | 303 | 1 | 5 | 3.92 | .884 |
| Valid N (listwise) | 303 | | | | |

*Source: Author's analysis of primary data collected through questionnaires and processed using SPSS (2025)*

All means fall between 3.73 and 3.95, indicating positive attitudes toward sustainable methods. Highest agreement: Modern standards + heritage and energy-efficient materials. Most variability: Local materials and traditional techniques, showing some professional or experiential differences in opinion.

## 5.0 CONCLUSION AND RECOMMENDATION

This study assessed climatic design strategies for enhancing indoor air quality (IAQ) in a proposed heritage center in Badagry, Lagos State. The findings confirmed that climate-responsive architecture, particularly through orientation, passive ventilation, material selection, and landscape integration, plays a significant role in improving IAQ, reducing energy consumption, and enhancing user comfort in heritage buildings. The study also highlighted the importance of aligning design strategies with both environmental performance goals and cultural preservation imperatives.

Quantitative responses revealed strong support for passive cooling techniques, such as cross ventilation and shaded openings, and validated the need for sustainable materials that offer thermal mass and low emissions. The involvement of architects, curators, and heritage visitors provided a holistic perspective that reinforced the practicality and relevance of these strategies in real-world applications.

To guide future practice and policy, the following recommendations are proposed:

i. Integrate Passive Design Principles: Designers of heritage buildings in tropical climates should prioritize natural ventilation, optimized orientation, and solar shading to reduce indoor pollutants and temperature fluctuations.

ii. Utilize Climate-Appropriate Materials: Local, low-emission materials like earth blocks or adobe should be encouraged to improve thermal performance and promote sustainable construction.

iii. Promote Green Buffers and Landscape Elements: Vegetative shading and buffer zones can significantly enhance microclimatic conditions, thereby contributing to both improved air quality and enhanced aesthetic value.

iv. Encourage Stakeholder Collaboration: Future heritage center projects should involve interdisciplinary teams—including environmental experts, architects, and cultural custodians—to ensure that both climatic responsiveness and cultural significance are fully addressed.

v. Enhance Public Engagement and Access: Improved spatial design and user-centered planning can encourage more frequent visitation and deeper cultural interaction within heritage spaces.

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