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# Evaluation of energy efficiency and functional space in Nigeria museums: A case study of selected museum in Lagos State

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## Article Info

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**Abstract**
The preservation and promotion of cultural heritage through museums are vital for nations to connect with their history and identity. Nigeria, with its rich cultural diversity, faces energy challenges impacting the efficiency of its museums. Energy-intensive museums in Nigeria contend with issues related to energy efficiency, affecting artifact preservation and sustainability. Additionally, the concept of functional space in Nigerian museums is influenced by decolonization, technological advancement, and universal design compliance. The study aims to analyze the infrastructure and practices within the Lagos Museum, focusing on energy-efficient measures and functional spaces. It seeks to assess the utilization of measures such as natural ventilation, thermal insulation, efficient lighting systems, and renewable energy sources. Additionally, it evaluates various functional spaces within the museum, encompassing exhibition galleries, educational workshops, auditoriums, outdoor spaces, research libraries, and cafes/restaurants. Qualitative and quantitative research methods were employed, utilizing selected case studies (Nike Centre for Art and Culture Lekki and the National Museum Lagos), questionnaire-based survey, review of existing literature, and statistical descriptive methods were utilized for data collection and analysis. Survey results reveal a significant awareness of energy efficiency and functional spaces among museum communities. The majority acknowledges the importance of these aspects for artifact preservation and overall sustainability. Positive findings indicate prevalent energy-efficient measures and functional spaces, with room for improvement in specific categories. The evaluation demonstrates a positive trend in awareness and implementation of sustainable practices in museums. Challenges and opportunities for improvement, especially in the National Museum Lagos, highlight the need for increased utilization of functional spaces and further integration of energy-efficient measures. Recommendations include promoting awareness through educational programs and outreach initiatives.

**Keywords:** energy efficiency, functional space, and museum

## 1. Introduction

The cultural heritage sector plays a crucial role in preserving and showcasing a nation's history, art, and identity. Museums, as repositories of cultural artifacts and knowledge, are integral to this endeavor. However, the effective management of museums requires attention to both conservation and operational aspects. Nigeria, with its rich cultural diversity and historical heritage, hosts numerous museums that house artifacts, artworks, and historical objects. These museums play a pivotal role in preserving and promoting the nation's cultural identity. Nigeria faces energy challenges, including power shortages and unreliable energy infrastructure. Museums, as energy-intensive institutions, often grapple with issues related to energy efficiency, which can impact the preservation of artifacts and the overall sustainability of these cultural institutions.

Energy efficiency in buildings involves minimizing energy input, balancing energy consumption and costs, and reducing environmental impact through factors such as thermal envelope transmittance, compactness, and the use of technologies. Energy efficiency in buildings is defined as the reduction of energy production, delivery, distribution, and consumption, leading to long-run sustainability (Danish & Senjyu, 2020) [6].

Energy-efficient buildings reduce energy consumption and allow sustainable development by accurately forecasting their thermal performance under various weather conditions (Al-Addous & Albatayneh, 2020) [3]. In museums various energy conservation methods such as the use of domes, clerestory windows, atriums, light tubes, and anti-solar glass/windows were considered adequate daylighting features sufficient for daylighting designs and energy efficiency optimization to museums in the tropical climatic regions (Kokulu & ÖZGÜNLER, 2023) [8]. Energy efficiency guarantees decreased energy consumption for heating and cooling, diminished maintenance needs, lowered building operation costs, and heightened comfort for occupants within a space (Fadayiro, 2022) [7]. The energy utilization of building materials is a crucial element in determining the overall energy efficiency of the structure (Akinluyi *et al*., 2021) [2].

Museums can be transformed into living arts experiences by incorporating theatre and more functional space, addressing the misconception of museums. Museums are designed spaces with the primary purpose of preserving and sharing knowledge about diverse peoples and cultures (SOGBESAN, 2022) [16]. They serve as repositories holding items that stand as tangible evidence of historical events and cultural identity, essentially preserving these aspects in time for educational purposes. The origin of museums can be traced back to elites showcasing their collections and cabinets of curiosity in their homes, captivating visitors with the wonders of these displays. Over time, what began as private collections evolved into institutionalized museums, becoming proud symbols of national heritage for various nation-states (Brulon Soares, 2020) [5]. The concept of functional space in Nigerian museums is a complex one, influenced by factors such as decolonization (Sogbesan, 2022) [16], technological advancement, and universal design compliance. Sogbesan (2022) [16] emphasizes the need for a local model that aligns with African ideology, The importance of functional space in Nigerian museums is underscored by some key factors. Emphasizes the role of science and technology in transforming museums, while Sogbesan (2022) [16] calls for the decolonization of these spaces to better reflect local history and culture. These functional spaces include museum theatre making museums relevant to modern reality and evolving into a functional/applied theatre form, enhancing museum visits in Nigeria. Functional space in museum architecture is important as adaptive and conventional methods have been used in the past (Lupo, 2020) [11].

Energy efficiency is critical for museums not only to reduce operational costs but also to minimize the environmental impact of their activities. Sustainable energy practices can contribute to the long-term viability of these institutions and ensure the preservation of cultural heritage for future generations. Museums must carefully manage their space to create engaging and informative exhibits, provide adequate conservation facilities, and offer spaces for educational programs and events. The allocation and utilization of space are key factors in enhancing the visitor experience and maintaining the integrity of collections. Therefore, the key objective of the study is to analyze the infrastructure and practices within the Lagos Museum using the respective case study, specifically focusing on the availability and utilization of energy-efficient measures such as natural ventilation, thermal insulation, efficient lighting systems, and renewable energy sources. Additionally, the research aims to examine the variety and adequacy of functional spaces within the museum, encompassing exhibition galleries, educational workshops, auditoriums, outdoor spaces, research libraries, and cafes/restaurants.

## 2. Literature Review

### 2.1. Energy Efficiency in Museum

In Nigeria several studies have explored energy efficiency in Nigeria museums. The importance of integrating relevant energy efficiency features, such as domes, clerestory windows, and light tubes, into museum designs (Aderonmu *et al*., 2019) [1]. The use of efficient building materials in selected museums, identifying a need for more energy-efficient materials, and the potential for significant energy savings in new museum buildings, with a focus on natural daylighting and mixed-mode ventilation systems were also studied (Fadayiro, 2022) [7]. Underscored the role of building orientation in energy demand, with a preference for North-South orientation. Optimizing daylight in museums and art galleries using passive design strategies can improve sustainability, energy consumption, and perseveration while preserving artifacts and promoting global warming reduction. A range of factors influence energy efficiency in Nigerian museums. Aderonmu (2019) [1] emphasizes the importance of integrating relevant energy efficiency features, such as natural daylighting, into architectural designs. Fadayiro (2022) [7] underscores the role of building materials in energy efficiency, with only a few materials in selected museums meeting energy-efficient criteria. Suggests that energy demand reduction in residential buildings can be achieved through innovative materials, methods, and technologies. The impact of building orientation, glazing, and shading devices on energy consumption in residential buildings, with potential for significant reductions (Ochedi & Taki, 2019) [14]. Energy efficiency in buildings can be improved through sustainable design strategies, such as building envelope, wall and window shading, and natural cooling, which can improve energy efficiency in Nigeria's warm, humid climate.

### 2.2. Evolution of Functional Space in the Museum

Museums serve as institutions entrusted with preserving the cultural and artistic heritage of societies for the benefit of future generations. Evolving economic, social, cultural, and philosophical perspectives globally have significantly influenced the field of museology (Ataoğlu, 2020) [4]. The early 20th century witnessed a transformation in the traditional museum typology, with modern architects introducing novel expansions.

In the 1970s, museums began garnering attention not just for their cultural significance but also as prominent landmarks and meeting places within cities. This shift extended beyond the confines of museum buildings to encompass the surrounding open spaces, such as courtyards, squares, and gardens. These external areas underwent notable transformations, integrating into city life and evolving into new social hubs. The study has analyzed museums and their open spaces, both in Turkey and globally, categorizing them into traditional and contemporary contexts. The examination will encompass various aspects, including form, style, materials, boundary elements, planting design, activity areas, urban furniture, and function. The concept of functional space in museums has evolved, with a shift towards creating experience spaces (Li *et al*., 2020) [9]. This evolution has been facilitated by the use of digital technologies and multimedia

systems, which have transformed the design of exhibitions and buildings. The role of open spaces in museums has also changed, with a focus on their design and function as part of the museum's identity (Ataoğlu *et al*., 2020) [4].

### 2.3. Functional Space Planning in Museums

Research on functional space planning in museums has highlighted the importance of architectural composition and spatial treatments in shaping user experiences. The role of mixed-use spaces in museums, particularly in building community (Purski, 2022) [15], Museums play a crucial role in shaping the cultural space of both large and small cities, preserving historical knowledge and traditions, while also providing accessible cultural centers for citizens. Museum spaces can promote social transformation by incorporating diverse art/educational practices that promote social, political, and historical reflection, with a decolonial direction. Key principles of functional space planning in museums include Rational planning, interdisciplinary cooperation, and extensive knowledge of building and collection features that can ensure conservation and human comfort in museum buildings (Lucchi, 2020) [10]. Museum spaces should also focus on educational value, interculturality, and accessibility for all types of public, incorporating ICTs that improve interaction and learning (Naval *et al*., 2023) [13]. Functional space planning such as User-centered space planning in museums involves involving citizens in the design process, focusing on their understanding and insight, and incorporating their suggestions for service goals. The design principles of daylight systems in museums are connected to the spatial concept, light control system, and daylight quality, influencing the perception of space and exhibit reception (Stach, 2021) [17].

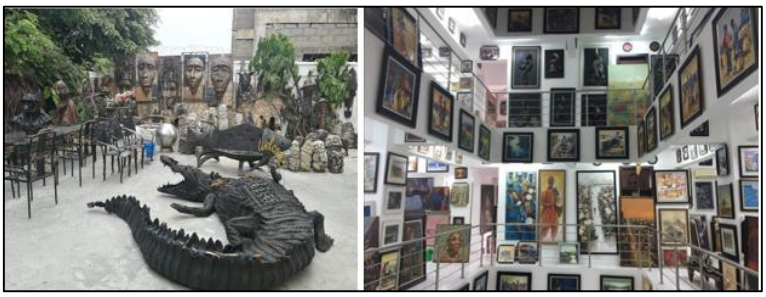
## 3. Methodology

The study was conducted to evaluate the level of energy efficiency and functional space in museums in Nigeria. As described in the introduction, the study focuses on assessing the current energy consumption patterns of Nigerian museums and evaluating the energy efficiency and functional spaces using various factors, Therefore, the study employed the uses of a selected case study to assess its functional spaces and energy efficiency measure been adopted. Qualitative and Quantitative research method was adopted for the study. The study frame and population focus on selected respondents (purposive sampling) both for the questionnaires and review of existing papers on museums in Nigeria. The questionnaires were created in a way that addresses the factors being considered. The questionnaires were divided into two sections, the first section, described the demographic of the respondents which included gender, and age, and also told the respondents eligibility for the study. While the section addresses several factors such as the awareness of energy efficiency. It features the importance of functional spaces in the Museum. Based on the study area comprises selected case study includes, Nike Centre for Art and Culture Lekki Lagos state, and the National Museum Lagos. The total study size and population comprises 80 questionnaires with 67 questionnaires filled and returned. The study also uses statistical descriptive methods and observation to analyze the data.

## 4. Study Finding and Data Analysis

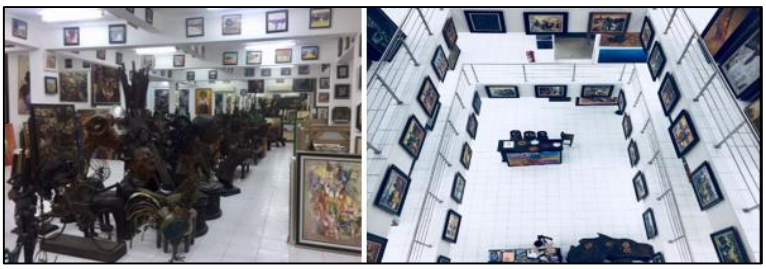
### 4.1.1 Case Study 1: Nike Centre for Art and Culture Lekki, Lagos State

**Energy Efficiency and Functional Space Available in Nike Centre for Art and Culture**



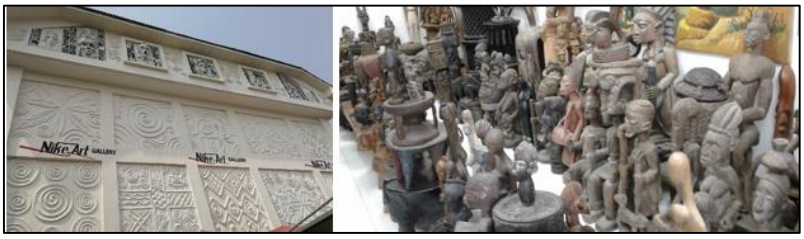
***Source*:** Field survey

**Plate 1:** Outdoor spaces and iterative exhibit in Nike Art and Culture



***Source*:** Field survey

**Plate 2:** Lighting system in Nike Museum

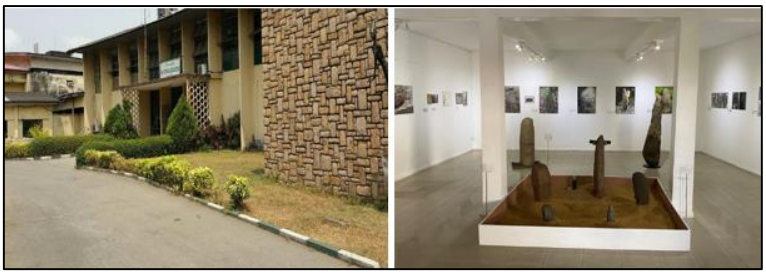



***Source*:** field survey

**Plate 3:** Building material and collection storage In Nike Museum

The museum which is located at Lekki, Lagos state is a five-story buildings museum comprised of various art collections, and artifacts and features about 7000 pieces from the textile museum. The building energy efficiency measures put in place include various renewable energy sources, HAVC system configurations, adaptable and proper lighting systems, and so many others, while its functional spaces are very diverse such as theatre, collection stores, large open spaces, and green spaces, a well design and plan entrance lobby with an interactive exhibit at every corner of the building.

### 4.1.2 Case Study II: National Museum Onikan, Lagos



***Source*:** Field survey

**Plate 4:** Building material and Interactive space in National Museum, Lagos

The National Museum of Lagos was built in 1957 by Kenneth Murray. It includes various amazing Nigerian artworks such as sculptures, carvings, and archaeological and anthropological exhibitions. The National Museum in Lagos stands as a notable fact for its proper uses of building material and its high natural ventilation and lightening efficiency, the museum building is divided into various sections such as its collection room, research library, and archives. The building is also known for its high thermal insulation facilities and holds various open spaces. Although various advanced functional spaces are not available the available spaces are rarely used except for the festive period.

### 4.2. Questionnaire Study Finding

### 4.2.1. Demographic profiles of respondent

Table 1 contains the summary of findings for the demographics of the respondents used in evaluating the study. It contains the gender, age brackets, occupation, and how frequently they visit the museum.

**Table 1:** Summary of findings for the demographics

| Demographics of the respondent | Frequency(N=67) | Percentage (%) |
|---|---|---|
| **Gender** | | |
| Male | 42 | 63 |
| Female | 25 | 37 |
| **Age bracket** | | |
| 18-35 | 21 | 27 |
| 35-45 | 35 | 57 |
| 45 and above | 11 | 16 |
| **Occupation** | | |
| Museum professional | 21 | 32 |
| Architect and building professional | 11 | 16 |
| Conservationist | 4 | 6 |
| Student | 6 | 9 |
| Visitor | 25 | 37 |
| **How frequently do you visit the Museum** | | |
| Rarely | 3 | 5 |
| Occasionally | 33 | 49 |
| Frequently | 21 | 31 |
| Always | 10 | 15 |

The demographic profile of the respondents, consisting of 67 total respondents, from the survey from the two-case study shows the gender distribution with 63% being male and 37% female. In terms of age, a significant proportion falls within the 35-45 age bracket, constituting 57%, while those between 18-35 and 45 and above make up 27% and 16%, respectively. Occupationally, the survey captured a diverse range, with museum professionals forming the largest group at 32%, followed by architects and building professionals at 16%, conservationists at 6%, students at 9%, and visitors constituting the highest percentage at 37%. Regarding the frequency of museum visits, the majority of respondents visit occasionally (49%), followed by frequent visitors at 31%, occasional visitors at 15%, and a small percentage who rarely visit at 5%. The data suggests a varied and engaged audience, particularly in the 35-45 age group, with diverse professional backgrounds contributing to the study.

### 4.3. Respondent's Knowledge of Energy Efficiency and Functional Space in Museum

**Table 2:** Details of the survey results regarding the awareness of energy efficiency and functional space

| | | |
|---|---|---|
| **1. Awareness of energy efficiency and functional space in a museum** | | |
| Not aware at all | 7 | 10 |
| Slightly aware | 19 | 29 |
| Moderate aware | 12 | 18 |
| Very aware | 21 | 31 |
| Extremely aware | 8 | 12 |
| **2. The importance of energy efficiency and functional space in preserving artifacts and ensuring sustainability in museum** | | |
| Not important | 0 | 0 |
| Somewhat important | 17 | 26 |
| Important | 9 | 13 |
| Very important | 41 | 61 |
| **3. Availability of energy efficient and functional space in Nigeria museum** | | |
| Yes | 54 | 81 |
| No | 13 | 19 |
| **4. What functional spaces are available within the case study** | | |
| Interactive exhibit (Exhibition Galleries) | 56 | 84 |
| Educational workshops | 31 | 46 |
| Performance spaces (Auditoriums and Theaters) | 64 | 96 |
| Outdoor open spaces | 65 | 97 |
| Research Libraries and Archives | 39 | 58 |
| Entrance and Lobby Areas | 61 | 91 |
| Collections Storage | 54 | 81 |
| Cafes, Restaurants and Restrooms: | 18 | 27 |
| **5. what energy efficiency measures are available within the case study** | | |
| Natural ventilation | 45 | 67 |
| Excellences building material | 47 | 72 |
| Thermal Insulation | 38 | 57 |
| Efficient lighting system | 42 | 63 |
| High-Performance Glazing | 29 | 43 |
| HVAC Systems Optimization | 33 | 49 |
| Renewable Energy Sources | 18 | 27 |
| Occupancy Sensors and Automation | 10 | 15 |

### 4.4. Discussion of Result

Table 2 provided details of the survey results regarding the awareness of energy efficiency and functional space within the museum community of both of the case studies. The majority of respondents fall within the categories of "Very Aware" (31%) and "Extremely Aware" (12%), indicating a substantial level of awareness regarding these aspects. Conversely, a smaller percentage falls under the "Not Aware at All" and "Slightly Aware" categories, with 10% and 129% respectively. This suggests that while a significant portion of the museum community is well-informed, there is room for improvement in raising awareness among a portion of the respondents. Regarding the importance of energy efficiency and functional space in preserving artifacts and ensuring sustainability, the survey underscores a strong consensus on their significance, a notable percentage, 61%, categorizes these aspects as "Very Important." In contrast, the categories of "Not Important" and "Somewhat Important" receive minimal representation, with 0% and 26% respectively. This implies a widespread acknowledgment among respondents of the critical role that energy efficiency and well-designed functional spaces play in the long-term preservation of artifacts and the overall sustainability of museums.

In assessing the availability of energy-efficient measures and functional spaces within the case study the results depict a positive scenario. The majority of respondents, 81%, affirm the presence of such measures, indicating a significant incorporation of energy-efficient strategies and diverse functional spaces in the surveyed frame. This suggests a proactive approach to aligning museum infrastructure with sustainable practices. Functional spaces such as interactive exhibits (84%), performance spaces such as auditoriums and theatres (96%), and outdoor spaces (97%) are reported to be widely available with functional spaces like café, restrooms, and restaurants (27%) and educational workshop (46%) having low availability. Similarly, various energy efficiency measures, including natural ventilation, excellent building materials, and efficient lighting systems, are reported to be

prevalent (67%,72%, and 63% respectively) although there is room for improvement in certain categories such as renewable energy sources and occupancy sensors. Overall, the findings reflect a positive trend toward awareness and integration of sustainable practices within the surveyed museums.

## 5. Conclusion and Recommendation

In conclusion, the evaluation of energy efficiency and functional spaces in the selected museums, which include the Nike Centre for Art and Culture in Lekki and the National Museum Lagos, provides valuable insights into the current state of awareness and implementation of sustainable practices within these cultural institutions. The findings indicate a positive trend with a high level of awareness among respondents regarding energy efficiency and functional spaces. The availability of energy efficiency measures and functional spaces was also carried out and various measures and spaces were noted such as iterative exhibits, performance spaces, outdoor spaces, and limited café, restaurants, and educational workshop spaces were discovered from the study found. Measures such as natural lighting, thermal insulation, and excellent building materials were well noted in both of the case studies.

However, challenges and opportunities for improvement are identified, particularly in the National Museum Lagos, which faces limited utilization of available functional spaces. The survey underscores the importance of continuous efforts to enhance sustainability and visitor engagement in museums. Recommendations based on the study's outcomes include the need for increased utilization of advanced functional spaces, especially in the National Museum Lagos, and further integration of energy-efficient measures in both museums. Strategies to promote awareness, such as educational programs and outreach initiatives, can contribute to a more comprehensive understanding of the significance of sustainable practices in preserving artifacts and ensuring the long-term sustainability of museums.

Moreover, the positive trends observed in both cases suggest that the adoption of energy-efficient measures and diverse functional spaces is achievable and aligns with global sustainability goals. The recommendations extend to similar cultural institutions in Nigeria, emphasizing the importance of incorporating sustainable practices, raising awareness, and continuously assessing and improving infrastructure to enhance overall energy efficiency. Future research endeavors should consider expanding the scope to cover more museums across different geopolitical zones to provide a broader understanding of the materials used and their influence on energy efficiency in museums throughout Nigeria. This inclusive approach will contribute to the development of comprehensive guidelines for professionals, policymakers, and stakeholders in the building sector, fostering a sustainable and energy-efficient future for museums in the country.

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