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CHALLENGES AND OPPORTUNITIES IN LIGHTING DESIGN FOR CULTURAL CENTERS: A CASE FOR SUSTAINABLE AND ENERGY-EFFICIENT SOLUTIONS IN LEKKI, LAGOS

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Abstract

Lighting design is critical in determining the functionality, aesthetics, and visitor experience of cultural centers. However, in Lagos, issues such as excessive energy usage, maintenance costs, and insufficient sustainability measures impede efficient lighting solutions. This project investigates the use of smart technologies in lighting design to increase energy efficiency and improve the overall experience in cultural facilities. The study identifies the advantages of smart lighting solutions, such as LED advances, daylight harvesting, and automated lighting controls, while also addressing implementation problems, such as high costs, infrastructure constraints, and a lack of governmental support. The study takes a qualitative approach, reviewing current literature and case studies to identify best practices and recommend effective techniques for incorporating smart lighting into cultural spaces. The findings show that a hybrid lighting system that combines smart technology with sustainable design principles can dramatically cut energy consumption and improve display visibility while protecting cultural items. The report suggests increasing investment in renewable energy sources, implementing automated lighting controls, and providing policy-driven support for sustainable lighting programs. By following these ideas, cultural institutions in Lagos can achieve a balance between sustainability, operational efficiency, and increased visitor engagement.

Keywords: Automated Lighting, Cultural Centers, Daylight Harvesting, Energy Efficiency, LED Technology, Lagos, Lighting Design, Smart Lighting, And Sustainability.

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INTRODUCTION

Lighting is important in cultural facilities because it affects the visual appeal and practicality of areas used for concerts, exhibitions, and art (Pidlisna *et al.,* 2023). Well-designed lighting produces an atmosphere, improves artwork visibility, and enhances the entire visitor experience. Energy-efficient and sustainable lighting options have become more popular in recent years because of their potential cost savings and environmental advantages (Oyeyipo *et al.,* 2024). Lagos, Nigeria, is a fast-growing metropolis with a thriving cultural scene that includes performance venues, museums, and art galleries. However, the lack of adequate infrastructure, high energy prices, and an unstable power supply make it difficult for the city to provide effective lighting solutions (Ekhaese *et al.* 2022). These difficulties call for investigating creative lighting techniques that might strike a balance between aesthetic demands and energy and sustainability. With an emphasis on sustainable and energy-efficient solutions, this study attempts to evaluate the opportunities and problems in lighting design for cultural facilities in Lagos.

Several problems, like as irregular power supplies, dependence on non-renewable energy sources, expensive maintenance expenses, and poor infrastructure, frequently make it difficult to design lighting systems for cultural facilities in Lagos (Olujobi *et al.*, 2021). Furthermore, traditional lighting options might not be the best for environmental sustainability, energy efficiency, or art preservation.Investigating creative lighting options that improve cultural centers' use and beauty while using less energy is imperative given the growing emphasis on sustainability and the rising price of electricity. Cultural spaces in Lagos run the risk of being ineffective, having poor visibility, and being environmentally unsustainable if lighting design is not approached strategically (Oluwasina et al., 2024). This study looks at these issues and considers practical ways to install sustainable and energy-efficient lighting options.

This study underscores the often-overlooked role of lighting in cultural center design, emphasizing its contribution to visual comfort, creative expression, and visitor experience. By focusing on sustainable and energy-efficient solutions, it addresses broader issues of cost-effective energy use and environmental sustainability within Nigeria’s cultural sector. The findings aim to guide architects, facility managers, lighting designers, and policymakers in adopting effective strategies that support energy conservation and reduce carbon footprints, in line with the Sustainable Development Goals (SDGs) (Tavares *et al.,* 2021). While the research emphasizes indoor lighting for exhibition and performance spaces in Lagos, its recommendations may be shaped by financial, technological, and contextual limitations, and may not fully apply to other regions with differing conditions.

The study aims to examine the opportunities and problems related to lighting design in Lagos’ cultural centers by exploring how lighting affects visitor perception, usability and aesthetics, while also determining how energy-efficient and sustainable lighting options can be incorporated.

Literature Review

Overview of Lighting Design in Cultural Centers

In cultural facilities, lighting design is essential to improving the appearance, use, and experience of areas used for concerts, exhibitions, and art. To ensure that artwork and performances are presented in the best possible light, cultural facilities need specialized lighting systems that strike a balance between illumination and artistic intent (Dewangan *et al.,* 2025).

Cultural facilities have historically used traditional lighting techniques, such as fluorescent and incandescent lighting. To improve energy efficiency while preserving high-quality illumination, contemporary lighting designs now include LED systems, adaptive lighting options, and smart controls thanks to technological breakthroughs (Wang, 2025). To save energy and enhance the atmosphere of cultural spaces, the incorporation of natural lighting techniques, such as skylights and clerestory windows, has also become more popular in modern designs (Oyeyipo *et al.*, 2024).

The Role of Lighting in Art and Cultural Spaces

In art and cultural venues, lighting has a variety of effects that affect not only vision but also perception, mood, and the general experience of visitors. An immersive performance environment, improved artwork display, and audience visual comfort are all made possible by well-designed lighting (Gobbato, 2023).

Lighting for exhibition venues is carefully chosen to ensure accurate color rendering while avoiding glare and shadows. Specialized lighting methods, such as accent lighting and wall washing, are frequently used in museums and galleries to draw attention to exhibits without endangering them with extreme heat or ultraviolet (UV) radiation (Trishina, 2023). Stage lighting is utilized in performance venues to draw attention, produce dramatic effects, and improve narrative. Furthermore, lighting enhances a space's architectural and cultural identity. Lighting can reflect regional artistic expressions and cultural traditions while also supporting exhibition themes and narratives through creative design (Duan, 2022).

Sustainable and Energy-Efficient Lighting Strategies

Because of worries about energy use and its effects on the environment, sustainable lighting solutions have grown in importance in cultural center design. The goal of energy-efficient lighting techniques is to use less electricity without sacrificing illumination quality. The following are important tactics for cultural centers' sustainable lighting:

LED Technology: When compared to conventional incandescent bulbs, LEDs provide greater energy efficiency, a longer lifespan, and lower heat emissions.

Daylight Integration: Reliance on artificial lighting can be greatly decreased by maximizing natural illumination through architectural features like skylights, big windows, and light shelves.

Smart Lighting Controls: Motion sensors, dimmable fixtures, and automated lighting systems enable dynamic lighting level adjustment according to occupancy and activity.

Renewable Energy Sources: Hybrid energy solutions and solar-powered lighting systems ensure a steady supply of electricity while also promoting sustainability.

Low-Impact Materials: Cultural institutions can reduce their environmental impact by using recyclable materials and eco-friendly lighting systems.

Challenges of Lighting Design in Developing Urban Environments

Notwithstanding the advantages of cutting-edge lighting technologies, there are difficulties in putting good lighting design into practice in emerging urban settings like Lagos. These consist of:

Unreliable Power Supply: It is challenging to rely on energy-intensive lighting solutions in Lagos' cultural centers because power outages frequently occur there.

High Energy Costs: The price of electricity is a major issue that makes it difficult to keep the best lighting options.

Limited Access to Advanced Technology: Because of high import prices and a lack of local knowledge, many cultural centers find it difficult to purchase and maintain contemporary lighting equipment.

Environmental Factors: The longevity and functionality of lighting systems are impacted by Lagos' tropical climate, which features considerable humidity and temperature swings.

Issues with Infrastructure and Urban Planning: Outdated electrical infrastructure and inadequate urban planning can reduce the efficiency of lighting installations.

Case Studies of Cultural Centers with Innovative Lighting Solutions

This section looks at case studies of cultural institutions that have effectively incorporated energy-efficient and sustainable lighting solutions to identify best practices in lighting design.

Case Study 1: Paris's Louvre Museum

To improve the visual quality of displays while using less energy, the Louvre has combined LED lighting with natural light integration. The lighting system in the museum is meant to reduce UV rays, protecting the artwork.

Case Study 2: Australia's Sydney Opera House

The Sydney Opera House, a world-renowned cultural hub, has implemented LED technology and smart lighting controls to lower operating costs and increase energy efficiency. The lighting system is made to dynamically adjust to various visitor activities and performances.

Case Study 3: Lagos's Nike Art Gallery

One of Lagos' most well-known cultural venues, Nike Art Gallery, creates an eye-catching exhibition space by combining artificial and natural illumination. High energy expenditures and power supply issues, however, draw attention to the need for more environmentally friendly alternatives.

Case Study 4: New York's Guggenheim Museum

Energy-efficient lighting technologies and creative daylighting techniques are used by the Guggenheim Museum to improve visitor satisfaction while lessening its environmental effect. Energy conservation has greatly improved with the incorporation of motion sensors and smart lighting controls.

Methodology

This study uses a qualitative research technique, combining a comprehensive literature review and case study analysis, to investigate the problems and potential in lighting design for Lagos cultural institutions. The literature review looks at key ideas such as sustainable lighting, energy efficiency, and smart technology integration, using academic papers and industry sources. Furthermore, case studies of selected cultural facilities provide real-world

insights into existing lighting strategies, evaluating their efficacy in terms of energy usage, maintenance, and overall visitor experience. By combining these data, the study identifies important gaps and recommends options for improving lighting design, with an emphasis on sustainability, efficiency, and increased user involvement.

Research Approach

This study takes a qualitative approach to investigating the challenges and potential in lighting design for cultural centers, with an emphasis on sustainable and energy-efficient solutions in Lagos. The qualitative method is appropriate because it allows for a better knowledge of user experience, environmental considerations, and practical applications of lighting schemes in architectural contexts. It enables an in-depth study of themes coming from expert opinions, case studies, and literature, as opposed to depending solely on numerical data.

Data Collection Methods

Data were gathered using case studies, expert interviews, and secondary sources. The case studies included an observational investigation of existing cultural hubs in Lagos, such as the National Arts Theatre in Iganmu and the Nike Art Gallery in Lekki. These centers were chosen for their architectural significance, public accessibility, and relation to the study's goals.The observations concentrated on lighting methods, energy efficiency, spatial quality, and visitor interaction with illuminated surroundings.

Study Area and justification

Lagos was chosen as the study location due to its cultural diversity, fast urbanization, and increasing demand for sustainable public infrastructure. The city is home to some of Nigeria's most important cultural centers, but it also has significant energy and environmental concerns. Studying Lagos offers great insights into the practical implementation of sustainable lighting in a dynamic metropolitan context.

Data Analysis Techniques

Thematic analysis was utilized to interpret the data gathered from the literature, interviews, and case studies. The responses and observations were organized into areas such as energy efficiency, sustainability, illumination quality, cost, and user experience. Patterns and repeating ideas were identified, allowing the researcher to correlate difficulties with recommended solutions for lighting design in cultural institutions.

Limitations of the Study

This study has significant limitations, including restricted access to some structures and technical documentation, as well as a scarcity of energy efficiency data for private buildings. Interviewees also possessed various levels of technical knowledge, which could have added subjective bias. Despite these limitations, the data collected provided enough information to address the study's aims.

Result & Discussion

Summary of Revived Literature

S/N	Title of Article	Authors	Aims and Objectives	Methodology	Results
1.	Optimizing Cultural Tourism Through Effective Lighting Design	Ayobami, F. E., & Ayeni, D. A. (2024)	To explore the role of lighting in enhancing visitor experience in museums and how balancing natural and artificial lighting can improve cultural tourism.	Qualitative research using case studies, interviews, and literature reviews on museum lighting strategies.	Findings highlight the importance of controlled daylighting through orientation, treated glazing, shading devices, and indirect openings to improve visitor experience and artifact preservation.
2.	Evaluation of Users' Satisfaction with Lighting Strategies in Selected Art Museum and Galleries in Nigeria	Sholanke, A. B., & Oyeyipo, F. J. (2023)	To assess the effectiveness of current lighting strategies in Nigerian museums and galleries based on visitor satisfaction.	Mixed-method approach: qualitative observations of lighting strategies and quantitative analysis of survey responses from 175 visitors across three museums and galleries.	Users were generally satisfied with artificial lighting but recommended integrating controlled daylighting to improve visual comfort while maintaining artifact safety.
3.	Users' Perception of Lighting in Selected Arts and Craft Exhibition Centers in Nigeria	Ediae, O. J., Babalola, O. D., Pela, O. E., & Aduwo, E. (2023)	To examine how lighting affects visitor experience in exhibition spaces and assess the balance between artificial and natural lighting.	Survey-based research with 50 visitors from four prominent art galleries/museums in Nigeria.	Artificial lighting was preferred due to its controllability, but findings suggest natural lighting could be better managed using modern control strategies to improve ambiance and visibility.
4.	Imo State Museum (Enhancing Natural Lighting in Museums Space)	Eduozor, A., & Daminabo, F. O. (2023)	To identify and recommend daylighting strategies that enhance exhibition spaces while preserving artifacts.	Case study analysis of existing museums, focusing on climate conditions, sun path, and spatial design.	Findings emphasize proper orientation, optimized fenestration, shading devices, and glass treatments as key strategies to improve daylighting in exhibition spaces.
5.	An Assessment of the Implementation of Green Design Strategies in Selected Museums in Abuja, Nigeria	Adewale, B. A., & Ene, V. O. (2024)	To evaluate the extent to which green design strategies are applied in Nigerian museums and propose improvements.	Observational assessment and comparative analysis of three museums based on sustainability criteria.	Museums incorporate some green features like solar PV panels and thermal mass walls but lack holistic solutions like insulation, water recycling, and comprehensive daylighting integration.
6.	Comparative Analysis of Finishing Materials Utilized in the Construction of Cultural Centres	Abraham, O. O., & Ololade, F. M. (2024)	To analyze the selection and effectiveness of finishing materials in cultural centers, particularly their impact on user experience and aesthetics.	Observational assessment of three major cultural centers in Lagos.	Findings reveal a mix of traditional and modern finishing materials, but durability, cultural relevance, and long-term sustainability need further research.

7.	Renovation of Public Lighting Systems in Cultural Landscapes	Valetti, L., Floris, F., & Pellegrino, A. (2021)	To assess the impact of LED technology on energy efficiency and visual perception in historic and cultural landscapes.	Comparative study analyzing lighting performance before and after implementing LED systems.	LED lighting significantly improves energy efficiency and reduces maintenance costs but alters the nocturnal visual perception of historical sites, requiring careful design considerations.
8.	Energy Performance Indicators for Air-Conditioned Museums in Tropical Climates	Lucchi, E. (2024)	To propose key energy performance indicators (EPIs) that optimize lighting and air conditioning efficiency in tropical museum buildings.	Literature review and development of an evaluation framework tailored to tropical climates.	Recommended indicators, such as Average Illuminance Ratio and Energy Use Intensity, provide guidelines for balancing energy efficiency with visitor comfort and artifact preservation.
9.	Energy-Efficient Lighting Technologies for Building Applications	Riffat, S., Ahmad, M. I., & Shakir, A. (2024)	To explore modern lighting technologies that reduce energy consumption while maintaining indoor environmental quality.	Literature review of energy-efficient lighting solutions, including LED, CFL, and hybrid solar lighting.	Findings show that integrating advanced lighting technologies, such as smart lighting controls and daylight harvesting, significantly enhances energy efficiency in residential, commercial, and institutional buildings.

Discussion

The incorporation of smart technology in cultural centers and museums has both advantages and disadvantages. One significant advantage is its capacity to improve energy efficiency and sustainability. Smart lighting systems and LED technologies use much less energy while retaining good visual quality. This is especially important in tropical settings like Lagos, where optimizing lighting and air conditioning is crucial to ensuring tourist comfort and protecting valuable cultural artifacts. Another benefit of smart technology is its ability to enhance visitor experiences and satisfaction. Well-designed lighting solutions have a profound impact on the atmosphere of exhibition spaces, influencing how visitors perceive and interact with cultural artifacts. Integrating artificial lighting with modern day lighting techniques can improve visual comfort and boost the entire user experience.Several hurdles, however, prevent the proper deployment of smart technologies in cultural facilities. While some green design methods, such as solar panels and thermally huge walls, are being used, their full potential is hampered by a lack of integrated lighting solutions. Insufficient use of smart automation and day lighting controls, as well as poor building orientation and insufficient fenestration design, frequently compromises both energy efficiency and artifact preservation. To overcome these difficulties, a strategic strategy is required, which includes hybrid lighting systems that combine advanced LED technology with controlled natural lighting. This not only ensures energy efficiency but also preserves the historical and cultural significance of these areas. Sensors, daylight harvesting, and responsive lighting controls can dramatically improve the sustainability, adaptability, and functionality of cultural venues.

Conclusion and Recommendations

This study investigated the benefits and drawbacks of using smart technology in lighting design for cultural facilities in Lagos, with a focus on sustainability and energy efficiency. The study found that smart lighting solutions, such as LED breakthroughs, daylight

harvesting, and responsive control systems, considerably improve energy efficiency and visitor enjoyment. Additionally, improving daylight integration while maintaining artifact preservation remains an important topic. Despite these benefits, constraints such as high implementation costs, a lack of holistic design methods, and a slow acceptance of green technology limit the full potential of smart lighting. Addressing these difficulties necessitates a deliberate approach that balances modern innovation with contextual sustainability requirements.

To enhance the adoption of smart lighting solutions, this study recommends the following strategies:

i. Hybrid Lighting Systems - To optimize energy consumption and improve exhibition visibility, cultural centres should integrate both smart LED technology and regulated natural lighting.
ii. Advanced Lighting Controls - Motion sensors, dimmable LEDs, and daylight-responsive systems can help enhance energy efficiency while also providing appropriate lighting conditions for exhibits.
iii. Sustainable Design Integration - To regulate daylight without degrading artifacts, architectural design should include passive techniques such as optimal building orientation and shading devices.
iv. Investing in Renewable Energy: Solar-powered lighting and other renewable energy options can minimize reliance on traditional electricity and enhance sustainability in cultural facilities.
v. Policy and Stakeholder Engagement: Government policies and private sector investments should promote the development of smart lighting technology for long-term sustainability and cost-effectiveness.

References

Abraham, O. O., & Ololade, F. M. (2024). Comparative Analysis of Finishing Materials Utilized in the Construction of Cultural Centres. *Covenant Journal of Research in the Built Environment*.

Adewale, B. A., & Ene, V. O. (2024). An assessment of the implementation of green design strategies in selected museums in Abuja, Nigeria. Civil Engineering and Architecture, 12(3A), 2461–2481. https://doi.org/10.13189/cea.2024.121337

Ayobami, F. E., & Ayeni, D. A. (2024). Optimizing cultural tourism through effective lighting design. British Journal of Multidisciplinary and Advanced Studies, 5(5), 1–27. https://doi.org/10.37745/bjmas.2022.04181

Dewangan, S., & Kapadia, Q. (2025). Lighting strategies to enhance artwork visibility in Earth-Bermed art galleries. International Journal for Multidisciplinary Research, 7(3). https://doi.org/10.36948/ijfmr.2025.v07i03.43896

Duan, H. (2022). Application and expression of artificial light source design in exhibition space. Highlights in Art and Design, 1(2), 48–51. https://doi.org/10.54097/hiaad.v1i2.2023

Eduozor, A., & Daminabo, F. O. (2023). Imo State Museum (Enhancing Natural Lighting in Museums Space). International Journal of Innovative Environmental Studies Research, 11(3), 186–200. https://www.seahipublications.org/wp-content/uploads/2024/06/IJIESR-S-26-2023.pdf

Ekhaese, E. N., & Solaja, A. O. (2022). Assessment of lighting strategies in art galleries: A comparative case study of selected art galleries in Lagos State. IOP Conference Series Earth and Environmental Science, 1054(1), 012028. https://doi.org/10.1088/1755-1315/1054/1/012028

Gobbato, V. (2023). Illuminating museums. From design to experience. Ambiances. https://doi.org/10.4000/ambiances.4495

Lucchi, E. (2024). Energy Performance Indicators for Air-Conditioned museums in tropical Climates. Buildings, 14(8), 2301. https://doi.org/10.3390/buildings14082301

Olujobi, O. J., & Olusola-Olujobi, T. (2021). Nigeria: Advancing the Cause of Renewable Energy in Nigeria's Power Sector Through its Legal Framework. Environmental Policy and Law, 50(4–5), 433–444. https://doi.org/10.3233/epl-200246

Oluwasina, B. T., Yussuff, O. A., &AdeniyI, V. D. (2024). Evaluation of energy efficiency and functional space in Nigeria museums: A case study of selected museum in Lagos State. International Journal of Multidisciplinary Research and Growth Evaluation, 05(04), 2582–7138. https://www.allmultidisciplinaryjournal.com/uploads/archives/20240712203857_D-24-50.pdf

Oyeyipo, F. J., Sholanke, A. B., & Anosike, D. I. (2024). Review of Lighting Strategies for Enhancing Users' Experience and Achieving Environmental Sustainability in Art Museums. Institute of Electrical and Electronics Engineers, 1–8. https://doi.org/10.1109/seb4sdg60871.2024.10630022

Pidlisna, O., Simonova, A., Ivanova, N., Bondarenko, V., & Yesipov, A. (2023). Harmonisation of the urban environment by means of visual art, lighting design, and architecture. Acta Scientiarum Polonorum Administratio Locorum, 22(1), 59–72. https://doi.org/10.31648/aspal.8214

Riffat, S., Ahmad, M. I., & Shakir, A. (2024). Energy-Efficient lighting technologies for building applications. In Lecture notes in energy (pp. 185–218). https://doi.org/10.1007/978-3-031-78853-6_4

Sholanke, A. B., & Oyeyipo, F. J. (2023). Evaluation of Users' Satisfaction with Lighting Strategies in Selected Art Museum and Galleries in Nigeria. *Covenant Journal of Research in the Built Environment*.

Tavares, P., Ingi, D., Araújo, L., Pinho, P., & Bhusal, P. (2021). Reviewing the role of outdoor lighting in achieving sustainable development goals. Sustainability, 13(22), 12657. https://doi.org/10.3390/su132212657

Trishina, T. V. (2023). Invisible Power of Light: Spectral Engineering experience in exhibition lighting. Light & Engineering, 01–2023, 81–86. https://doi.org/10.33383/2022-060

Users perception of lighting in selected arts and craft exhibition centres in Nigeria. (2023). In International Journal of Advances in Engineering and Management (IJAEM) (Vol. 5, Issue 4, pp. 861–873). https://doi.org/10.35629/5252-0504861873

Valetti, L., Floris, F., & Pellegrino, A. (2021). Renovation of public lighting systems in cultural landscapes: lighting and energy performance and their impact on nightscapes. Energies, 14(2), 509. https://doi.org/10.3390/en14020509

Wang, R. (2025). Explainable Artificial-Intelligence-Based Power Conservation: A benefit analysis of Energy-Saving artistic lighting in museums. IEEE Systems Man and Cybernetics Magazine, 11(1), 48–56. https://doi.org/10.1109/msmc.2023.3295933