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Designing for Maintainability: Maintenance Considerations in Sustainable High-Rise Office Design in Tropical Nigeria

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Abstract
This study explores the integration of maintenance design features in the planning and design of high-rise office buildings, using a proposed office complex in Kano, Nigeria, as a case study. The research identifies a critical gap in architectural practice, where maintenance considerations, such as facade access, material durability, environmental responsiveness, and building form simplicity, are often overlooked during design stages. Through a review of literature, case studies, and practical design applications, the study highlights that architects frequently prioritise aesthetics and functionality without embedding maintenance solutions, leading to increased lifecycle costs and operational challenges for facility managers. The findings align with existing research advocating for maintenance-inclusive design approaches to enhance building sustainability and user safety. The study underscores the need for policymakers, architects, and stakeholders to mandate maintenance design integration as part of the building approval process. It further provides practical recommendations for material selection, environmental alignment, and accessibility planning to foster long-term building performance. The research concludes by emphasising the necessity for future studies to develop standardised maintenance design frameworks and expand investigations across different climatic zones. Overall, this study contributes to the growing discourse on sustainable architectural practices and offers valuable insights for improving high-rise building maintainability.

Keywords: Maintenance Design, High-Rise Office Buildings, Building Maintainability, Architectural Design Integration, Sustainable Building Practices

Introduction

The maintenance of high-rise office buildings has emerged as a critical concern in contemporary architecture and sustainable urban development. As cities expand vertically, particularly in tropical and subtropical regions, the need to integrate maintenance considerations into the design phase becomes increasingly essential. High-rise buildings require significant resources for their upkeep due to their scale, environmental exposure, and complex systems. Yet, in many cases, maintenance design features are neglected at the conceptual and planning stages, resulting in operational inefficiencies, increased lifecycle costs, and early building deterioration (Kensek, 2014). This study focuses on the integration of maintenance-friendly design in high-rise office buildings in hot, dusty climates such as Kano and Abuja, Nigeria. In these environments, harsh climatic conditions—including high solar intensity, dust storms, and temperature extremes—accelerate material degradation, compounding the challenges of building upkeep (Leung et al., 2020). Despite these conditions, designers often prioritise aesthetics, internal layouts, and visual appeal, with little consideration for long-term maintenance requirements (Aule, 2024; White et al., 2018). This disconnect imposes operational challenges on facility managers, who must implement retroactive solutions that are often costly and intrusive. The primary aim of this study is to evaluate the extent to which maintenance design features are integrated into high-rise office buildings and how such integration affects the durability, sustainability, and cost-efficiency of these structures. By identifying best practices and gaps in current designs, the research seeks to inform design guidelines and policy frameworks for improving building performance in extreme climates. This research is significant to a wide range of stakeholders—including policymakers, architects, developers, and facility managers—by providing evidence-based recommendations for sustainable and maintainable high-rise architecture in tropical and subtropical contexts.

Literature Review

Research on maintenance design in high-rise buildings has increasingly highlighted its importance to sustainable architecture, yet it remains an underexplored area in architectural discourse, especially in the tropics. According to Kensek (2014), design decisions made at the conceptual stage profoundly impact a building's long-term maintainability. Neglecting maintenance-friendly features—such as facade access systems, modular component replacements, or weather-resistant materials—leads to premature wear and increased operational costs.

White et al. (2018) argue that maintenance integration is essential for enhancing operational performance and user satisfaction. However, their findings reveal that designers often lack the tools or frameworks to evaluate maintainability during the design process. Similarly, Shohet (2003) proposes that post-occupancy evaluations be institutionalised to refine maintenance-responsive design strategies. The absence of these practices contributes to the performance gap often observed between design intent and building functionality.

In tropical environments, where buildings are exposed to severe environmental conditions, maintenance becomes even more crucial. Leung et al. (2020) underscore the need for region-specific material choices and construction systems that are resilient to dust, humidity, and solar radiation. However, few studies have contextualised maintenance integration within hot, arid regions like Northern Nigeria. This geographic gap limits the applicability of broader international design standards.

Emerging technologies, such as Building Information Modelling (BIM) and predictive maintenance tools, offer promising solutions for integrating maintenance at the design phase (Volk et al., 2014). These innovations allow for simulations and lifecycle analyses, enhancing foresight in maintenance planning.

Despite the growing recognition of maintainability as a dimension of sustainable design, there remains a paucity of empirical studies, particularly in African contexts, that document practical applications and stakeholder perspectives. This study contributes to closing that gap by focusing on Kano and Abuja, offering context-specific insights and paving the way for policy and educational reforms.

Materials and Methods

This chapter outlines the procedures used to achieve the research objectives. A structured methodology is essential for producing valid, reliable findings (Creswell & Creswell, 2018). This study adopts a mixed-methods approach (Aule, 2023), combining qualitative and quantitative tools to analyse the maintenance conditions of high-rise office buildings, a growing concern due to urbanisation and ageing infrastructure (Fellows & Liu, 2015; Sagada, 2016). The aim is to provide actionable recommendations for improving facility management practices in Kano. Given the increasing deterioration of high-rise buildings, Kano City was selected as the study focus, where poor maintenance exacerbates urban blight and strains public resources (Egbu, 1999; Yin, 2018). Addressing these issues is crucial for sustainable urban development (Aule et al., 2022; Ibem & Aduwo, 2013). The study employed purposive sampling to select buildings meeting specific criteria such as size, height, and complexity (Etikan et al., 2016). Cases were drawn from Kano and international examples for broader comparison and systematically analysed (Love et al., 2012). The study population included multi-storey buildings like hotels, malls, and universities, which typically require facility management (Olanrewaju & Abdul-Aziz, 2015), with ownership ranging from public to private (Ali et al., 2009). Random sampling selected buildings with five or more storeys, ensuring diverse maintenance conditions were represented (Acharya et al., 2013). This strategy minimises selection bias and enhances the generalizability of findings (Groat & Wang, 2013). Data were collected using checklists, reports, sketch pads, and photo cameras to assess

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maintenance conditions by respondents on a standardised 1–5 scale, as recommended by Shohet (2003), Lavy and Shohet (2007). This multi-instrument approach ensured consistency, objectivity, and reliability across all inspections. The data was analysed using simple descriptive statistics in the form of cross-tabulations.

Results

Case Study One: Gidan Murtala Complex, Kano

The analysis of Table 1 on the Gidan Murtala Complex highlights critical failures in integrating maintenance-oriented design features, reflecting broader issues in public office buildings in Kano. Built in 1974, the structure shows little foresight for long-term maintenance, especially regarding material selection, maintenance access, and environmental adaptation. Although its simple, rectilinear form (rated 3 - Acceptable) should support easier maintenance, the use of inferior glazing and easily degradable paint (rated 2 - Not Acceptable) severely undermines sustainability. As Sagada (2013), Shohet (2003) and Olanrewaju and Abdul-Aziz (2015) emphasise, durable, climate-appropriate materials significantly lower maintenance frequency and costs.

Environmental resilience is another major flaw. The building's east-west orientation exposes it to intense solar radiation, while adjacency to roadways subjects it to pollution, accelerating deterioration. Chew (2016) stresses that urban buildings need shading devices and robust finishes to withstand such conditions, yet Gidan Murtala's limited shading devices and fragile glazing fall short. Furthermore, there is no integration of maintenance technologies like facade access systems or designated maintenance corridors, an omission Al-Shiha (1993) notes increases long-term maintenance costs and risks.

Table 1: Summary of the Gidan Murtala Complex in Kano highlights critical shortcomings in integrating maintenance-oriented design features.

Case study 1: Conducted at Gidan Murtala Complex, BUK Road, Kano, used as Ministry offices				
Background: Gidan Murtala, which currently houses the Kano state Ministry of Education, was built in 1974 by Audu Bako, a police officer and the first governor of the state from 1967 to 1975.				
Variable	Features	Method	Scale (5)	Remark
Building form, shape and complexity	Rectilinear and straightforward plan, cubical form with elevations.	The building form is rectangular with protrusions and perforations at intervals.	3	Acceptable
Materials Used	Qualitative materials that are easily replaceable.	Excess glazing, painted walls and columns that easily deteriorated	2	Not acceptable
Maintenance Access	Access to roofs and various strategic elevations, especially where they will be prone to maintenance.	Access to the roof and floors is provided only through stairs. No access to exterior elevation	2	Not acceptable
Considering Environment and Weather Conditions	The building is not exposed to radiation and pollution from roads, rail, etc.,	The building is adjacent to the road, making it	2	Not acceptable

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	that may compromise the materials.	exposed to pollution		
Relating Exterior Material Selection to Climatic Conditions	Use of materials that have little or no effect when exposed to solar radiation and humidity.	Glass and painted wall, affected by solar radiation.	2	Lack of protective devices from direct exposure.
Integrating Maintenance Technology in the building	Incorporating parts of the maintenance equipment into the building	Not integrated. But ample space is provided for external.	2	Lack of consideration for maintenance equipment.

Maintenance access is also poor, as presented in Figure 1. While internal staircases provide roof access, there is no safe provision for maintaining the building's exterior without costly external equipment such as dumpers, ladder trucks or a complex network of scaffolding. According to Wai (2024), the Chartered Institution of Building Services Engineers (CIBSE) advocates for accessible design to ensure regular, low-disruption maintenance, which Gidan Murtala fails to provide. Additionally, strategic features like modular design or durable finishes, which Pitt and Tucker (2008) suggest for affordable upkeep, are absent.

Figure 1: No Safe Provision for Maintaining the Building's External Components at Gidan Murtala Complex, Kano

Broadly, Gidan Murtala illustrates the urgent need to integrate maintenance considerations from the design stage. As Lavy and Shohet (2007) argue, adopting a lifecycle approach is essential for sustainable, cost-effective urban development. Without this shift, Kano's office buildings will continue to deteriorate prematurely, burdening facility management and diminishing the urban environment.

Case Study Two: Gidan Ado Bayero Complex, Kano

The evaluation of Gidan Ado Bayero Complex highlights significant gaps in integrating maintenance design features in Kano's office buildings. Findings from Table 2 reveal critical deficiencies, stressing the importance of incorporating

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maintenance considerations early in design to achieve sustainability, minimise lifecycle costs, and enhance performance (Shohet, 2003).

Table 2: The evaluation of Gidan Ado Bayero Complex in Kano highlights significant deficiencies in the building's design relative to maintenance considerations.

Case study 2: Conducted at Gidan Ado Bayero complex, Ibrahim Taiwo Road, Kano, used as the city campus of Maitama Sule University, Kano.

Background: Gidan Ado Bayero was founded by the first civilian governor, Alhaji Muhammadu Abubakar Rimi, in the early 1980s, completed on 14 September 2001 and commissioned on 24 May 2003. The building is currently serving as a city campus of Maitama Sule University, Kano.

Variable	Features	Method	Scale	Remark
Building form, shape and complexity	Rectilinear and straightforward plan, cubical form with elevations.	The building form is rectangular with an altered shape	3	Acceptable
Materials Used	Qualitative materials that are easily replaceable.	painted walls and columns that easily deteriorated	2	Not acceptable
Maintenance Access	Access to roofs and various strategic elevations, especially where they will be prone to maintenance.	Access to the roof and floors is provided only through stairs. No access to exterior elevation	2	Not acceptable
Considering Environment and Weather Conditions	The building is not exposed to radiation and pollution from roads, rail, etc., that may compromise the materials.	The building is not adjacent to the road; it has a good orientation for direct exposure.	4	Acceptable
Relating Exterior Material Selection to Climatic Conditions	Use of materials that have little or no effect when exposed to solar radiation and humidity.	Glass and painted wall, affected by solar radiation.	2	Lack of protective devices from direct exposure.
Integrating Maintenance Technology in the building	Incorporating parts of the maintenance equipment into the building	Not integrated. But ample space is provided for external.	2	Lack of consideration for maintenance equipment.

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The building's Y-shaped form, combined with vertical and horizontal shading devices, shows some adaptation to Kano's hot, arid climate (Olgyay, 2015). However, the absence of external maintenance access systems undermines these benefits. As Chew (2016) argues, facade maintenance must be anticipated during design through catwalks, gondolas, or cleaning systems—elements missing here, leading to costly, inefficient maintenance.

Material choices further compound the challenges, as presented in Figure 2. While reinforced concrete and precast shading elements are robust, reliance on painted walls and poor-quality glazing exposed the building to rapid deterioration. In Kano's climate, material durability against UV radiation and dust is essential. As Olanrewaju and Abdul-Aziz (2015) emphasise, inappropriate materials drive up maintenance needs and costs. More durable coatings and high-performance glazing, as recommended by Straube and Burnett (2005), would have reduced upkeep requirements significantly. Though lifts and staircases allow roof access, no external maintenance systems exist, contradicting principles of "designing for maintenance" (Chanter & Swallow, 2007). Without easy exterior access, routine upkeep becomes difficult, leading to deferred maintenance and expensive repairs.

Figure 2: Massive painted walls and poor-quality glazing expose the building to deterioration at Gidan Ado Bayero Complex, Kano

While pollution exposure was somewhat managed through building orientation, the east-west facing facades still expose the structure to severe solar radiation. Better material choices and dynamic shading systems, according to Yaman (2021), would have improved environmental resilience. Generally, the lack of embedded maintenance technologies and durable materials in the Gidan Ado Bayero Complex underscores a broader issue. Future designs must prioritise maintainability to ensure building longevity, cost-effectiveness, and user satisfaction (Saliu et al., 2023; Shohet, 2003; Pitt et al., 2009).

Case Study Three: Petroleum Products Pricing Regulatory Agency (PPPRA), Abuja

The analysis of Table 2 regarding the Petroleum Products Pricing Regulatory Agency (PPPRA) Complex highlights key gaps in integrating maintenance design features in contemporary office buildings. Though the PPPRA Complex shows modest improvements over Kano examples, significant deficiencies remain, particularly in proactive maintenance planning, essential for building longevity and operational efficiency (Shohet, 2003).

The building's simple rectilinear form with minor protrusions is advantageous, minimising structural complexity and easing maintenance tasks. As Preiser and Vischer (2006) note, simple forms age better and demand less intensive maintenance. Material choices show a mixed strategy: while toughened glazing, marble tiles, and Aluco-board cladding are durable and suited for Abuja's tropical climate, the use of dark-colored materials increases heat absorption and highlights dust accumulation, thus raising maintenance demands (Straube & Burnett, 2005).

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Table 2: Analysis of the PPPRA Complex offers critical insights into the integration of maintenance design features in contemporary office buildings

Case study 3: Conducted at the Petroleum Products Pricing Regulatory Agency (PPPRA Complex), Cadastral Zone, central area, Abuja, used as corporate offices

Background: The building is a property of the Petroleum Products Pricing Regulatory Agency (PPPRA) of Nigeria. It is a complex with tenancy for offices and commercial activities, such as banks.

Variable	Features	Method	Scale	Remark
Building form, shape and complexity	Rectilinear and straightforward plan, cubical form. Deviating from complex elevations.	The building form is rectangular with protrusions and perforations at intervals.	3	Acceptable
Materials Used	Qualitative materials that are easily replaceable.	Excess glazing, marble tile finishing and aluco-bond on strategic external columns.	3	Acceptable
Maintenance Access	Access to roofs and various strategic elevations, especially where they will be prone to maintenance.	Access to the roof and floors is provided through stairs and lifts. No access to exterior elevation	3	Acceptable
Considering Environment and Weather Conditions	The building is not exposed to radiation and pollution from roads, rail, etc., that may compromise the materials.	Building aligned to the north-south direction.	4	Acceptable
Relating Exterior Material Selection to Climatic Conditions	Use of materials that have little or no effect when exposed to solar radiation and humidity.	Glass and marble tiles are affected by solar radiation. Darker glasses that attract dust.	2	Lack of protective devices from direct exposure.
Integrating Maintenance Technology in the building	Incorporating parts of the maintenance equipment into the building	Not integrated. But ample space is provided for external.	2	Lack of consideration for maintenance equipment.

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Internal vertical mobility through lifts and staircases is sufficient, but crucially, no dedicated external maintenance systems—such as gondola rails or fixed scaffolding supports—were incorporated. Modern practices (Shohet, 2003) recommend facade maintenance technologies for safety and efficiency, and their absence increases reliance on risky, costly external equipment. Environmental considerations were partially addressed through a north-south building orientation, mitigating east-west solar heat gain (Olgyay, 2015). However, external finishes, particularly marble cladding, remain vulnerable to pollution and weathering, necessitating frequent maintenance.

As presented in Figure 3, the omission of permanent maintenance technologies reflects a broader trend of sidelining facility management during the design phase. In contrast, scholars emphasise that embedding maintenance strategies early is crucial for sustainable building performance (Olawuyi et al., 2022; Lavy & Shohet, 2007). While space provision for external equipment is a minor positive, fully integrated systems like Building Maintenance Units (BMUs) would have demonstrated more profound lifecycle management foresight. In brief, the PPPRA Complex shows progress but underscores the need for stronger integration of maintenance design in Nigeria's evolving office architecture.

Figure 3: Durable Materials, Good Form and Orientation, No External Maintenance Systems at Petroleum Products Pricing Regulatory Agency (PPPRA), Abuja

Discussion

This study provides a critical examination of the integration of maintenance design features in high-rise office buildings, revealing several key findings that have significant implications for the built environment. One of the major findings is that maintenance considerations are often overlooked in the early stages of the design process. Designers typically focus on aesthetic appeal, functional layout, and maximising space usage, neglecting the long-term maintainability of the building. This results in buildings that are difficult and costly to maintain, particularly concerning the building's exterior and systems such as glazing, facades, and roofs. Additionally, the study found that many multi-storey buildings do not incorporate adequate provisions for maintenance access, such as designated areas for storing cleaning equipment or specific pathways for maintenance personnel to access high areas. This echoes findings from previous research, such as those by White et al. (2018) and Kensek (2014), which emphasise the importance of designing buildings with long-term operational efficiency in mind. Furthermore, the study highlights that facility managers often face challenges due to the lack of proper maintenance manuals, which can lead to further complications in maintaining the building efficiently.

These findings have profound practical implications for multiple stakeholders, including government bodies, property developers, and building owners. From a governmental perspective, the study suggests the need for regulatory frameworks that mandate the integration of maintenance considerations into building designs. Governments could implement building codes or standards that require architects to address maintenance in their designs, ensuring that buildings are more sustainable and cost-effective in the long run. This would reduce the financial burden on property owners and facility managers, who otherwise might need to retrofit buildings to accommodate maintenance needs.

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Property developers and building owners could also benefit by incorporating maintenance-friendly features into their buildings. While this may involve additional upfront costs, it would ultimately reduce the need for expensive renovations or retrofits and lower ongoing operational costs. Facility managers, too, would see significant benefits from the integration of maintenance-friendly designs, making their tasks more straightforward and less resource-intensive.

For building occupants, the study suggests that easier maintenance could result in more comfortable and functional work environments. A well-maintained building typically offers better air quality, improved lighting, and an overall more secure and pleasant atmosphere, which can boost employee morale and productivity. Furthermore, the study's findings stress the importance of considering environmental and weather conditions in the design process. In climates like that of Kano, for instance, the building's materials and form must be selected to withstand extreme temperatures, dust, and solar radiation, while also ensuring the building remains energy efficient. This emphasis on environmental compatibility could be extended to other regions with different climates, ensuring that buildings remain functional and energy-efficient throughout their lifespan.

This study, while insightful, has notable limitations. The small number of case studies restricts the generalisability of findings to broader urban or building contexts. The absence of primary data from key stakeholders—such as facility managers and architects—limits the depth of practical understanding. Additionally, the geographic focus on Kano and Abuja may not reflect conditions in other Nigerian regions with differing climates. The study also did not examine emerging technologies like BIM or predictive maintenance tools.

In brief, while the findings underscore the urgent need to embed maintainability in design, the study's limitations should inform future investigations. Broader geographic coverage, inclusion of stakeholder perspectives, and exploration of digital innovations will enhance the scientific rigour and practical relevance of future work in this critical area of sustainable building design.

Conclusion

This study investigated the integration of maintenance design features in the planning and design of high-rise office buildings, focusing on a proposed development in Kano, Nigeria. It highlighted the critical need for architects to embed maintenance considerations—such as access systems, material selection, environmental responsiveness, and durable construction methods—into their designs. Findings revealed that current practices largely neglect these aspects, forcing facility managers to retrofit buildings at high costs and often compromising aesthetics and functionality. The research also found that material choices, building form simplicity, and environmental orientation are crucial in enhancing a building's maintainability. The study aligns with previous research, such as Kensek (2014) and White et al. (2018), emphasising that proactive maintenance integration leads to better lifecycle performance and reduced operational costs. The practical implications are significant for multiple stakeholders. Governments can use the insights to revise building regulations, promoting safer, longer-lasting structures. Developers and architects can design more sustainable, cost-effective buildings, while facility managers and users benefit from easier maintenance, lower costs, and safer environments. Maintenance considerations must shift from being an afterthought to an integral part of the design process for high-rise buildings. The study underscores the need for mandatory maintenance design guidelines at the approval stage. Future research should explore the development of standardised maintenance integration frameworks and evaluate the long-term performance of buildings designed with such features. Additionally, a broader geographic study could enhance the generalizability of these findings across different climatic and urban conditions.

Recommendations

Based on the research findings, it is therefore recommended that:

i. Architects and designers should prioritise maintenance considerations during the design phase by incorporating accessible features such as BMU tracks, recessed windows, and durable materials suitable for the local climate.
ii. Government authorities should enforce regulations mandating maintenance manuals and design provisions for building upkeep.
iii. Facility managers must be involved early in the design process to ensure practical maintenance access.

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iv. Stakeholders should invest in training and awareness programs to emphasise the long-term benefits of maintenance-friendly designs.
v. Further research is encouraged to explore innovative maintenance technologies and to develop standard guidelines that integrate maintainability into the architectural design of high-rise office buildings.

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