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Full Length Research Article

EVALUATING SUSTAINABLE FEATURES OF SELECTED UNIVERSITY FEMALE HOSTELS IN KADUNA STATE, NIGERIA

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ABSTRACT
This research investigates the sustainable design features of selected female university hostels in Kaduna state, Nigeria, with a focus on identifying strengths and weaknesses in their current sustainability practices. The objectives are to analyse selected existing female hostels in Kaduna, Nigeria, and develop design recommendations to improve their sustainability. The study employs a case study research design, collecting data through field observations and architectural assessments. Findings reveal that while the buildings are strategically oriented along the north-south axis to optimize natural light and energy efficiency, there is significant untapped potential for renewable energy integration. Additionally, Waste management practices are inadequate, with improper disposal observed on or near the sites. Although natural ventilation and daylighting strategies, such as window openings and courtyards, were successfully implemented, the hostels lack appropriate landscaping. Thermal comfort is generally well-managed, but noise control measures are absent. The construction relied solely on concrete blocks, which offer high thermal mass, yet no recycled materials were utilized, and water management practices were not implemented. While most building materials were locally sourced, the absence of modular coordination indicates inefficiencies in design. The study underscores the need for a more integrated approach to sustainable design in university hostels, offering targeted recommendations that prioritize environmental responsibility while addressing the specific needs of female students in Kaduna state, Nigeria.

Keywords: Case Study; Hostels; Kaduna State; Sustainable Design Principles.

INTRODUCTION

Building sustainability

Building sustainability refers to the process of designing, constructing, and operating buildings in a way that minimizes their negative environmental impact while improving energy efficiency, occupant health, and overall comfort. It involves using various strategies and technologies to reduce the ecological footprint of buildings, lower energy use and greenhouse gas emissions, conserve resources, and promote well-being (Luanda et al., 2021; Schiavon & Altomonte, 2018). The growing emphasis on sustainability is driven by increased awareness of the environmental and social effects of the built environment.

Sustainable buildings not only reflect environmental stewardship but also provide economic benefits and healthier living conditions. As noted by Akadiri et al. (2012), Bergman (2012), and Bainbridge (2004), an ideal sustainable building should have lower construction costs, a long lifespan with minimal maintenance, and biodegradable when no longer in use. These buildings often incorporate technologies such as solar panels, green roofs, and energy-efficient HVAC systems to reduce energy use and emissions. Additionally, adopting sustainable practices can result in substantial long-term savings through reduced utility and maintenance costs (U.S. Green Building Council, 2021). As sustainability becomes increasingly integral to the construction industry, it is evolving into a standard practice. Akadiri et al. (2012), Bergman (2012), and Cassidy (2003) identify five key principles of sustainable building design and construction, which are essential for creating environmentally responsible and cost-effective buildings. These principles are discussed in detail below.

Sustainable site planning

Sustainable site planning is a strategic approach to designing and developing outdoor spaces that minimize negative environmental impact and maximize resource efficiency. It involves carefully assessing and utilizing the natural features of a site to achieve ecological balance while meeting human needs (Luanda et al., 2021; Wang et al., 2019; Bergman, 2012). Key aspects of sustainable site planning include preserving natural habitats, reducing stormwater runoff through techniques like permeable paving and green infrastructure, minimizing disturbance to existing vegetation and wildlife, and promoting energy efficiency through proper building orientation and landscaping (Bergman, 2012). Additionally, sustainable site planning emphasizes incorporating green spaces, such as parks and gardens, into urban environments to enhance biodiversity, air quality, and overall quality of life for residents (Bergman, 2012). This approach integrates principles of sustainability into the early stages of site development, ensuring that the built environment harmonizes with its surroundings and contributes positively to both ecological health and human well-being.

Energy efficiency

Energy efficiency in sustainable buildings involves designing and constructing structures that minimize energy consumption while maintaining comfort and functionality. Key strategies for achieving energy efficiency include incorporating high-performance insulation, using energy-efficient windows and doors, optimizing building orientation to maximize natural light and reduce heat gain, and integrating efficient heating, cooling, and ventilation systems (Feria & Amado, 2019). Additionally, sustainable buildings often utilize renewable energy sources such as solar panels or wind turbines to further reduce reliance on fossil fuels. Energy-efficient design considers the entire life cycle of a building, from construction to operation and maintenance, aiming to minimize energy use, reduce greenhouse gas emissions, and lower overall negative environmental impact (Bergman, 2012). By prioritizing energy efficiency, sustainable buildings not only reduce operating costs but also contribute to global efforts to combat climate change and promote environmental sustainability.

Water management and conservation

Sustainable water management and conservation involves implementing strategies to efficiently manage and preserve water resources in various settings, including buildings, landscapes, and communities. This approach aims to reduce water consumption, minimize waste, and promote the use of alternative water sources (Bergman, 2012). Key practices for sustainable water conservation include installing water-efficient fixtures and appliances such as low-flow toilets and faucets, implementing rainwater harvesting systems to capture and reuse precipitation for irrigation or non-potable uses, and designing landscapes with native and drought-resistant plants that require less water. Additionally, water conservation efforts may involve treating and reusing wastewater for non-drinking purposes, such as irrigation or industrial processes, to reduce reliance on freshwater sources. Sustainable water conservation strategies contribute to water security, resilience to drought, and the overall sustainability of communities and ecosystems by promoting responsible water use and reducing the strain on finite water resources (Okon et al. 2021; Bergman, 2012).

Indoor environmental quality (IEQ)

IEQ which refers to the quality of a building's environment in relation to the health and wellbeing of occupants, is one of the major issues affecting the general well-being of building occupants in terms of their health and productivity (Altomonte & Schiavon, 2013; Heinzerling et al., 2013; Kim & de Dear, 2012). Major aspects of IEQ include indoor air quality (IAQ), which involves minimizing pollutants and ensuring adequate ventilation to provide clean and healthy air for breathing. This can be achieved through proper HVAC system design, use of low-emission building materials, and regular maintenance of ventilation systems. Additionally, IEQ considers factors such as thermal comfort, which involves maintaining appropriate temperatures and humidity levels to ensure comfort and productivity. Lighting design is also important, as access to natural light and well-designed artificial lighting can enhance visual comfort and reduce eye strain. Other aspects of IEQ include noise control, which aims to minimize disruptive noise levels within indoor spaces, and ergonomic considerations to optimize the comfort and usability of furniture and equipment. Improving IEQ contributes to occupant satisfaction, health, and productivity while supporting overall building sustainability and performance.

Materials and resources

Sustainable building materials and resources refer to materials and practices that minimize negative environmental impact throughout their life cycle, from extraction and production to use and disposal (Akadiri et al., 2012; Bergman, 2012). This approach involves selecting materials that are renewable, recycled, locally sourced, or have a low environmental footprint. Examples include using certified wood from sustainably managed forests, incorporating recycled content such as recycled concrete or steel, and choosing materials with low embodied energy. Sustainable building materials also focus on reducing waste by optimizing construction processes and utilizing efficient material reuse and recycling practices (Akadiri et al., 2012; Bergman, 2012; Bainbridge, 2004). Additionally, sustainable resource management involves strategies like water-efficient landscaping, waste reduction and recycling programs, and implementing energy-saving technologies to promote overall resource conservation within the built environment. Additionally, modular coordination which involves designing buildings and their components in standard, modular dimensions to optimize material usage, minimize waste, and simplify construction processes (Bergman, 2012). By prioritizing sustainable building materials and resources, construction projects can reduce negative environmental impacts, conserve natural resources, and contribute to long-term environmental and economic sustainability.

University hostel accommodation

The provision of university hostel accommodation is crucial for students during their time at the university, serving as a residence, study space, and social hub (Wong & Wei Jie, 2022). To create an environment that fosters academic growth, development, and student support, it is imperative to consider students' needs. Despite this, there is a notable shortage of suitable student accommodation in public tertiary institutions in Nigeria (Adama, 2018). This shortage not only concerns quantity but also encompasses issues related to the quality and satisfaction derived from existing facilities (Adilieme & Michael, 2019).

Female hostel facilities within university campuses are essential components of the educational environment, fostering a supportive and secure atmosphere for female students. However, the majority of existing hostel structures often lack holistic integration of sustainable design principles, resulting in missed opportunities to reduce energy consumption, conserve water, minimize waste generation, enhance indoor air quality, and promote social well-being (Bebu, 2023; Buba et al., 2019; Jameel, 2018). This deficiency not only contributes to heightened environmental degradation but also limits the potential for creating a healthy and inspiring living space for female students (Bebu, 2023; Buba et al., 2019; Abubakar et al., 2016; Ochanya Adio-Moses, 2016).

Study's Aim and objectives

This research aims to investigate the sustainable design features of female university hostels in the Kaduna state, Nigeria. Analyzing existing university hostels in Kaduna state will provide valuable insights into sustainable features and best practices that can be adapted to improve the environmental and operational performance of female hostel facilities. This comparative analysis will establish a baseline understanding of current sustainability initiatives in university hostels and identify successful strategies applicable to the local context. By leveraging these insights, the research also aims to develop targeted design recommendations that prioritize sustainability while meeting the unique needs and challenges of university accommodation in northern Nigeria.

This study is thus conducted to fulfill the following objectives:

1. To analyse selected existing university female hostels in Kaduna state while identifying and evaluating their sustainable features.
2. To develop design recommendations for a sustainable university hostel based on outcomes from case studies.

METHODS AND MATERIALS

Research design

This study adopted a qualitative research approach to achieve a comprehensive understanding of sustainable design in university female hostels. The research is a qualitative analysis of case studies of selected existing university female hostels in Kaduna, Northern part of Nigeria. Data was collected through field observations and architectural assessments. The qualitative data

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was analysed to identify and evaluate the sustainable design features of these hostels.

Sampling Method
For this study, a purposive sampling method was used. This non-probability sampling technique is suitable because it allows for the intentional selection of case study sites/buildings and participants who have specific characteristics relevant to the research objectives. Thus for the case studies of existing university hostels, **s**election criteria includes: The hostel type (Female hostels), location (within Kaduna state), and their incorporation of sustainable features.

Method of Data collection
To fulfill the study's objective, site visitation, observation and assessment of necessary architectural building documents of the selected case study hostels (Queen Amina hostel in ABU Zaria, female hostel KASU main campus, and KASU female hostel Kafanchan campus) was done. Sustainable passive techniques under the five key sustainable design principles were evaluated; these principles are: 1. Sustainable site selection and planning, 2. Enegy efficiency, 3. Water managemnt and conservation, 4. Indoor environmental quality, and 5. Sustainable material selection. The factors evaluated under each principles as disscussed by Bergman (2012) are further highlighted in Table 1.

Table 1: Check list of Sustainable design principles that was evaluated (Bergman, 2012 pg. 39)

Sustainable Principles		Elements studied
A. Site selection and planning	1.	Siting and orientation.
	2.	Renewable energy potential.
	3.	Proximity infrastructures
	4.	Proximity to waste disposal.
B. Energy Efficiency	5.	Solar heat gain/loss control
	6.	Passive Ventilation
	7.	Insulation
	8.	Daylighting
	9.	Renewable energy generation
C. Water management and Conservation	10.	Waste water treatment
	11.	Rain water harvesting system
	12	Water Management measures
D. Indoor Environmental Quality	13.	Thermal comfort consideration
	14	Indoor air quality consideration
	15.	Mitigation of heat island effect
	16.	Glare control
	17.	Noise pollution control
E. Material Selection	18.	Recycled materials
	19.	Locally sources materials
	20.	Modular coordination

Study Location: Climate overview of Kaduna State
Kaduna State situated in northern Nigeria has a tropical savanna climate (Köppen climate classification Aw). This climate is characterized by distinct wet and dry seasons. The wet season is characterized by significant rainfall, peaking in July and August. According to the Nigerian Meteorological Agency (NiMet), average annual rainfall in Kaduna ranges from 800 mm to 1,200 mm (NiMet, 2020). The humidity levels during this period can be quite high, often exceeding 80% due to increased rainfall. The dry season sees minimal rainfall, with December to February being particularly dry. During this period, the Harmattan wind, originating from the Sahara Desert, influences the weather, bringing cooler temperatures and dust; with humidity levels dropping significantly, often falling below 30%.. The average annual temperature in Kaduna typically ranges from 20°C at night to about 35°C during the day (World Bank, 2018). The hottest months are generally March and April, with temperatures occasionally exceeding 40°C (104°F). The climate supports a mix of grassland and savanna, with vegetation including tall grasses and scattered trees (World

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Bank, 2018).

RESULTS AND DISCUSSION

Description of the Case Study buildings

Case study building One: Queen Amina hostel, ABU Zaria

Queen Amina is located within the main campus of Ahmadu Bello University, Zaria. The hostel is situated near key academic and social facilities. Its proximity to major campus roads and infrastructure makes it easily accessible. The structure is three storey building organized into multiple blocks that create an efficient layout, enabling easy access to rooms and common areas (Figure 1B). The building blocks oriented along the NS axis and are arranged to form courtyards (Figure 1A), which act as communal spaces for students to interact and relax. Large windows are placed strategically in rooms to allow for effective natural ventilation and daylighting. The corridors are open, with balconies overlooking the courtyards, ensuring that fresh air circulates throughout the hostel. The rooms, which serve as the primary private spaces for the students, are arranged in a linear fashion along the corridors. The layout ensures that students can access shared facilities, such as the kitchen, toilets, and laundry areas, without excessive walking distance, promoting convenience. The kitchen, toilets, bathrooms, and laundries are located at strategic points along the corridors, usually shared by a specific number of rooms.

Queen Amina Hostel is constructed primarily from concrete, the design also includes shading elements (Figure 1D), such as overhangs and balconies that reduce direct sunlight, preventing excessive heat gain and minimizing glare inside the rooms. However, there is minimal attention given to landscaping as green spaces are sparse, and there are few landscaped areas around the hostel that could enhance its visual appeal and provide students with outdoor recreational areas.

Figure 1 Queen Amina hostel. A: The courtyard, B: The building block, C: The corridor and D: Shading device (Source: Author's field work).

Case Study Building Two: Female hostel KASU main campus. Also a three storey building, the hostel is located within the main campus of KASU, Kaduna. The building is situated near major

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academic and social facilities and also in close proximity to major private owned hostels. The building is oriented with its entrance facing the West and rooms are arranged in a linear format along wide corridors opening into a central courtyard (Figure 2 and 3). This facilitates easy movement while maintaining a sense of separation between private and communal areas. The building consist a total of 45 rooms which accommodates three students each. Each room is equipped with a private toilet, bathroom and kitchen. The only shared spaces in the building are the common room and two provision stores located along the entrance on the ground floor. The rooms are provided with two large windows for effective ventilation and lighting. The building's exterior features a simple design, with elements such as wide windows and shading devices.

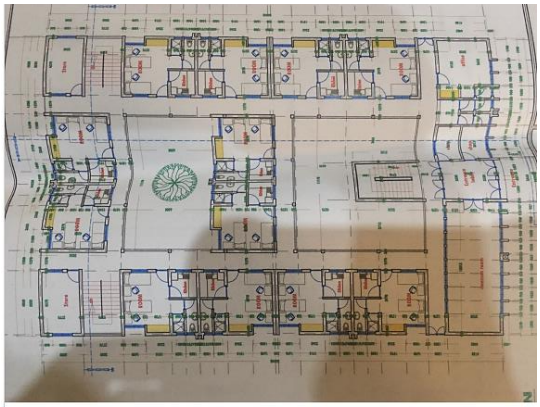

Figure 2 Ground floor plan: Female Hostel KASU main campus (Source: KASU, Physical Planning department's archive)

Figure 3 KASU main campus female hostel. A: Approach view, B: Corridor, C: The courtyard (Source: Author's field work).

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Case Study Building Three: KASU Kafanchan campus Hostel
The hostel is a two storey building with its entrance facing south. It is located close to other educational facilities such as the lecture theater, classrooms, departmental buildings and the students' social center. The hostel building consists of 22 rooms on each floor, each floor equipped with a common room, laundry facilities, and a kitchen. A central courtyard, connected to each room via a wide corridor (Figure 4) is located in the center of the building. The courtyard's strategic placement allows for effective natural ventilation and daylight, facilitated by perforated walls along its edges and the internal corridor (Figure 5). Each room, attached to a private toilet is designed to accommodate double bunk for a total of four students. The rooms feature windows for natural ventilation and lighting, along with ceiling fans for improved airflow.

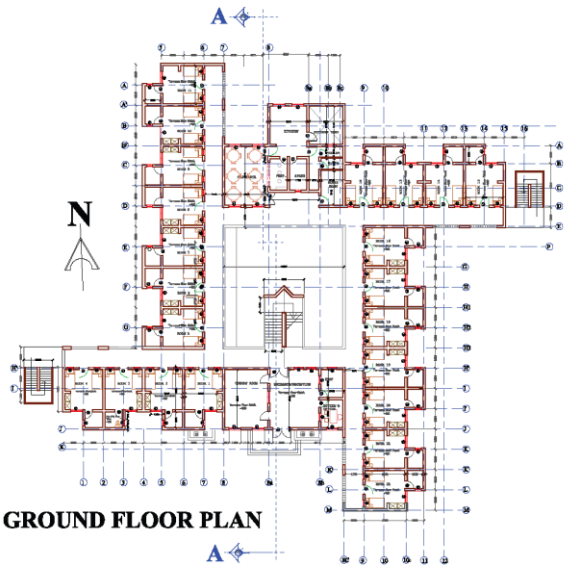

Figure 4 KASU kafanchan campus female hostel: Ground floor plan (Source: KASU, Physical Planning department's Archive)

Figure 5 KASU kafanchan campus female hostel. A: Northern view, B: The corridor, C: The courtyard (Source: Author's field work).

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Evaluation of Case Studies

Evaluating the case study buildings in relation to sustainable features involves an in-depth analysis of how these structures incorporate and perform in terms of environmental responsibility and resource efficiency. This study evaluated sustainable passive techniques/principles incorporated in these case study buildings under sustainable site selection and planning, enegy consumption, water conservation, indoor environmental quality, and sustainable material selection. Table 2 is the result from the three case study buildings (Amina hostel ABU Zaria, KASU main campus female hostel Kaduna and KASU Kafanchan campus hostel) that was evaluated.

Table 2: Evaluation Case Study Buildings

Sustainable Principles	Elements studied	QUEEN AMINA, ABU ZARIA	FEMALE HOSTEL KASU MAIN CAMPUS	KASU KAFANCHAN CAMPUS HOSTEL
A. Site selection and planning	1. **Siting and orientation.**			
	a. Is the site situated within the campus?	Yes	Yes	Yes
	b. Topography of the site.	Relatively flat	Relatively flat	Relatively flat
	c. The building's orientation.	Rooms are arranged along the NS axis.	Rooms are arranged along the NS axis.	Rooms are arranged along the S, W, and E direction.
	2. **Renewable energy potential:** Can the site offer significant potential for renewable energy generation under the following factors?			
	a. Abundant sunlight for solar generation.	Yes	Yes	Yes
	b. Available land and roof space.	Yes	Yes, only roof space, limited land space	Yes
	3. Proximity infrastructures: How close is the site to related infrastructures?			
	a. Lecture Theatre	1 – 1.4km	260-800m	900m
	b. School library	950m	200m	8000m
	c. Classrooms	850-1.4km	120m-1km	7500m
	d. ICT hub	1.3km	550m	4500m
	e. Social Center	1.2km	600m	4500m
	f. Mini Mart/School market	1.2km	600m	1km

	4. Proximity to waste disposal.				
	a. Is the site close to exits for effective evacuation of waste?	Yes		Yes	Yes
	b. What is the current waste disposal practice on site?		Waste disposed on the site.	Waste disposed on the site. 	Waste disposed at the site next to the hostel. 
B. Energy Efficiency	5. **Solar heat gain/loss control:** Was the following considered in the building?				
	a.				
	b. Shading with trees.	Yes	Yes		No
	c. Shading with shading elements.			Recesses along the exterior walls 	Recesses along the exterior walls 
	d. Construction materials with high thermal mass.	Concrete wall construction.		Concrete wall constructio n.	Concrete wall construction.
	6. Passive Ventilation: How was the following considered for effective ventilation in the building?				
	a. Window openings.	Yes	Yes	Yes	
	b. Courtyard.	Yes	Yes	Yes	
	c. Corridors	Yes	Yes	Yes	
	d. Perforated walls:	Yes	Yes	Yes	
	7 Insulation Any insulation installed?	No	No	No	
	8. Daylighting: Was the following considered for effective lighting in the building?				
	a. Window openings	Yes	Yes	Yes	
	b. Courtyard:	Yes	Yes	Yes	
	c. Perforated walls	Yes	Yes	Yes	
	9. **Renewable energy generation**	No	No	No	
C. Water Management	**10. Waste water treatment**	No	No	No	
	11. Rain water harvesting system	No	No	No	
	12. Water Management measures	No	No	No	

D. IEQ	13. **Thermal comfort consideration**	As seen in item B (Energy)	As seen in item B (Energy)	As seen in item B (Energy)
	14. **Indoor air quality consideration**: Was the following considered for air quality in the building and on site?			
	a. Cross ventilation	No	Yes	Yes
	b. Trees on site	Yes	Yes	No
	c. Proper landscaping	No	No	No
	15. **Mitigation of heat island effect**: Was heat island addressed through the followings?			
	a. Green roofs	No	No	No
	b. Green walls (vertical landscape)	No	No	No
	c. Water bodies/features	No	No	No
	d. Adequate soft landscape	No	No	No
	16. **Glare**: Was glare addressed through the use of:			
	a. Shading devices/elements?	Yes	Yes	Yes
	17. **Noise pollution control**	No	No	No
E. Material selection	18. **Recycled materials**	No	No	No
	19. **Locally sources materials**	Yes	Yes	Yes
	20. **Modular coordination**	No	No	No

Deductions from the Case Study

Site Selection and Planning

The findings reveal that the case study buildings are strategically oriented along the north-south axis to maximize natural light and energy efficiency. However, the potential for harnessing renewable energy on these sites remains untapped. While the buildings are located near certain essential infrastructure, they are further away from key amenities like provision stores and the school market. Another issue of concern is the absence of parks or garden; the presence of which could positively impact daily living conditions and the potential for social interaction among students. Additionally, despite their proximity to major exits, waste disposal is poorly managed, with waste being discarded improperly on or near the site.

The implication of these findings is that despite careful consideration of the building orientation, the lack of renewable energy integration and improper waste management undermines the sustainability potential of the sites. The distance from essential amenities may inconvenience users, reducing the overall functionality and accessibility of the buildings. While the absence of parks or garden could negatively impact the potential for social interaction among students. Furthermore, the poor waste management practices could lead to environmental degradation and health risks, indicating a need for more comprehensive planning that addresses not only energy efficiency but also infrastructure connectivity, waste disposal, and renewable energy utilization to fully achieve sustainable development goals.

Energy Efficiency

Natural ventilation and daylight were successfully incorporated into the buildings through features like window openings, courtyards, perforated blocks, and corridors. The buildings are made entirely of concrete blocks, a material with high thermal mass that helps regulate indoor temperatures by absorbing and releasing heat efficiently. The implication of these findings is that the integration of natural ventilation and daylight through architectural features like window openings, courtyards, and perforated blocks effectively enhances energy efficiency by reducing the reliance on artificial cooling and lighting. The use of concrete, with its high thermal mass, further supports this by helping to stabilize internal temperatures, potentially lowering energy demands for heating and cooling. However, the exclusive use of concrete may raise concerns about embodied energy and carbon emissions, indicating a need to balance thermal efficiency with the negative environmental impact of materials in future designs.

Water Management and Conservation

None of the case study buildings implemented any water management or conservation measures. The lack of water management or conservation measures in the case study buildings presents a major gap in their sustainability approach. This could result in excessive water consumption and wastage, contributing to higher utility costs and unnecessary strain on local water supplies. Additionally, failing to implement water-saving strategies, such as rainwater harvesting, grey water reuse, efficient plumbing fixtures, limits the buildings' environmental performance and resilience, which are crucial elements of sustainable design.

Indoor Environmental Quality (IEQ)

Thermal comfort was adequately addressed with proper natural ventilation. However, all the case study sites lack appropriate landscaping. While glare was managed through shading, no noise control measures were implemented in all case study buildings. While thermal comfort is well-managed through natural ventilation, the absence of proper landscaping at the case study sites reduces opportunities for improving IEQ through natural cooling, shade, and aesthetic enhancement. Although glare is controlled with shading devices, the lack of noise control measures leaves occupants vulnerable to acoustic discomfort, particularly in noisy

environments. This oversight could negatively impact occupant well-being and productivity, emphasizing the need for a more comprehensive approach to IEQ that prioritize both visual and acoustic comfort alongside thermal regulation.

Materials Selection

No recycled materials were used in the construction of the case study buildings; however, most of the building materials were locally sourced. Additionally, modular coordination of spaces was not considered in the design. The findings suggest that while the use of locally sourced materials in the construction of the case study buildings reduces transportation-related carbon emissions and supports the local economy, the absence of recycled materials reflects a missed opportunity to enhance sustainability through waste reduction and resource efficiency. Additionally, the lack of modular coordination in space design indicates inefficiencies in design and construction that could lead to increased material waste and higher construction costs. This indicates a need for a more integrated approach that prioritizes both recycling and efficient spatial organization to enhance overall sustainability in future projects.

Design Recommendations for a Sustainable University Female Hostel

1. **Site Selection and Planning**
   i. **Proximity to Amenities**: Ensure the hostel is located close to essential services like markets, restaurants, and academic buildings to reduce commuting time and improve convenience for students.
   ii. **Utilization of Renewable Energy**: Incorporate renewable energy sources such as solar panels and wind turbines. This would leverage the site's potential for energy generation, reducing dependence on non-renewable sources.
   iii. **Waste Management**: Implement an effective waste disposal system with designated waste collection points, recycling stations, and composting areas to encourage sustainable waste management on-site.
   iv. **Creation of Outdoor Common Areas**: Create landscaped outdoor common spaces for students such as parks and gardens to socialize or relax, enhancing the connection to nature and improving overall well-being.
2. **Energy Efficiency**
   i. **Enhanced Natural Ventilation**: Encourage the use of architectural features like courtyards, perforated blocks, and large windows, but supplement these with strategically placed operable windows to maximize airflow, especially in hotter seasons.
   ii. **Thermal Insulation**: Incorporate additional thermal insulation materials or use eco-friendly construction techniques like green roofs to enhance temperature regulation during both hot and cold seasons.
   iii. **Daylight Optimization**: Expand the use of daylighting techniques such as skylights and light wells to further reduce the reliance on artificial lighting, particularly during the day.
3. **Water Management and Conservation**
   i. **Water Recycling**: Install greywater systems to recycle water from sinks, showers, and laundry for use in landscaping or toilet flushing.
   ii. **Rainwater Harvesting**: Implement rainwater collection systems to reduce dependence on external water supplies and improve water availability for non-potable uses.
   iii. **Water-Efficient Fixtures**: Incorporate low-flow taps, dual-flush toilets, and sensor-based faucets to minimize water wastage.
   iv. **Reliable Water Supply**: Address the issue of poor water supply by installing backup water storage systems, such as underground tanks or water towers, to ensure continuous water availability.
4. **Indoor Environmental Quality (IEQ)**
   i. **Acoustic Comfort**: Improve noise insulation by using sound-absorbing materials for walls, ceilings, and windows. Include soft landscaping and green walls to dampen outdoor noise.
   ii. **Enhanced Shading and Glare Control**: Enhance the use of shading devices by introducing adjustable blinds or louvers to provide more user control over glare and sunlight.
   iii. **Landscaping for Microclimate**: Introduce trees, shrubs, and green spaces around the hostel to improve microclimatic conditions, reduce heat island effects, and improve air quality.
   iv. **Noise Control**: Implement buffer zones with vegetation or soundproofing techniques between communal areas and sleeping areas to improve acoustic comfort.
5. **Materials Selection**
   i. **Use of Recycled Materials**: Incorporate recycled materials in construction, such as reclaimed wood, recycled concrete, or eco-friendly alternatives to reduce the carbon footprint.
   ii. **Modular Construction**: Adopt modular design principles for flexible spaces that can adapt to future needs. This can also allow for easier maintenance and lower construction waste.

Conclusions

This study highlights the urgent need for enhanced sustainable design practices in female university hostels in Kaduna state, Nigeria. The analysis of selected case study hostels reveals a combination of strengths and weaknesses in their sustainability features. While the buildings' strategic orientation effectively maximizes natural light and thermal comfort, there are significant missed opportunities for improving energy efficiency through renewable energy integration. Additionally, inadequate waste management practices and the absence of water conservation measures highlight the necessity for more comprehensive environmental management strategies. The findings also emphasize the importance of addressing spatial and infrastructural challenges, particularly the distance of these hostels from essential amenities, which negatively impacts the living experience for female students. Although certain features, such as natural ventilation and locally sourced materials, are commendable, the lack of recycled materials and modular design indicates the need for a more holistic approach to construction and planning.

In response to these insights, the study presents targeted design recommendations aimed at promoting sustainability in university hostel facilities. Key suggestions include the integration of renewable energy solutions, improving landscaping, the

implementation of effective waste management systems, and the enhancement of water conservation strategies, along with the incorporation of noise control measures. Ultimately, this research serves as a foundation for future initiatives aimed at transforming university accommodations into more sustainable spaces. By prioritizing these design recommendations, stakeholders can enhance the environmental performance of female hostels, creating a healthier, more resilient living environment that meets the needs of students while promoting sustainable practices in the region.

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