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Landscaping: An Indoor Thermal Tool in Residential Buildings in Calabar Urban, Cross River State, Nigeria

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Abstract

Indoor thermal comfort remains a major challenge in tropical urban environments due to rising temperatures, urbanization, and inadequate passive cooling strategies in residential buildings. This study examines landscaping as an indoor thermal improvement tool in residential buildings within Calabar Urban, Cross River State, Nigeria. The study evaluates the influence of vegetation, tree shading, and green outdoor spaces on indoor thermal conditions and occupants' comfort levels. A mixed-method research design involving field measurements, questionnaire surveys, and observational techniques was adopted. Temperature and relative humidity data were collected from selected residential buildings with and without landscaping features. Findings reveal that buildings surrounded by vegetation recorded lower indoor temperatures and improved thermal comfort compared with non-landscaped buildings. The study further established that landscaping significantly reduces heat gain through shading and evapotranspiration effects. The paper recommends integrating sustainable landscaping strategies into residential building design policies in Calabar Urban to improve indoor thermal comfort, reduce energy consumption, and enhance environmental sustainability.

Keywords:
Landscaping, Indoor thermal comfort, Residential buildings, Passive cooling, Urban heat.

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Background to the Study

Landscaping in architecture plays a essential role in ameliorating thermal discomfort by maximizing natural elements to regulate temperature and create more comfortable living environments. Strategic use of vegetation and other landscape features can provide shading, reduce heat gain, and promote evaporative cooling, which collectively mitigate the thermal stress experienced in buildings and outdoor spaces, especially in tropical climates. (Alozie, 2014). Landscape features significantly influence thermal perception by affecting not only the physical microclimate but also the psychological experience of temperature. Visual aspects of landscapes, such as vegetation cover, water features, spatial configuration. The presence of natural elements, contribute to thermal comfort perception by providing shading and cooling through evapotranspiration, this enhancing aesthetic appreciation, which and affects how warm or cool people feel outdoor (Alozie, 2019).

Thermal comfort is a critical component of residential building performance, particularly in tropical climates which is characterized by high temperature and humidity. In Nigeria, rapid urbanization and increased dependence on artificial cooling systems have intensified concerns regarding indoor thermal conditions and energy consumption. According to Alozie, (2023) & Adebamowo, (2007). occupants spend approximately 80–90% of their time indoors, making indoor environmental quality essential to human health and productivity. Previous studies conducted in Nigerian cities such as Ibadan, Akure, and Makurdi have demonstrated the positive effects of vegetation and tree shading on thermal comfort in buildings (Morakinyo et al., 2016; Adunola & Ajibola, 2016). However, limited empirical studies have specifically examined landscaping as an indoor thermal tool in residential buildings in Calabar Urban.

This paper, therefore investigates the integration of landscaping as a sustainable architectural tool to enhance indoor thermal comfort, reduce energy consumption, and promote occupant well-being through a harmony of built and natural environments. It also highlights the scientific underpinnings and practical design strategies that maximize the cooling benefits of landscape interventions in architectural settings. Calabar Urban, is located in Cross River State, and experiences a tropical monsoon climate with high annual rainfall and elevated humidity levels. The city's climatic condition contributes to overheating in residential buildings, especially where poor building orientation and inadequate landscaping prevail. Landscaping has emerged as a sustainable passive cooling strategy capable of reducing ambient and indoor temperatures through shading, evapotranspiration, and modification of microclimatic conditions.

Literature Review

Thermal Comfort

Thermal comfort is the state of mind in which a person feels satisfied with the surrounding thermal environment, feeling neither too hot nor too cold. It reflects a sense of thermal well-being when the heat produced or absorbed by the body is balanced with the heat lost to the environment. (Alozie, 2023, 2019 &2014) This balance prevents physiological discomfort

and supports health and productivity. Thermal comfort depends on multiple factors such as air temperature, humidity, air movement, clothing insulation, metabolic rate, and radiant temperature of surfaces nearby. It includes both global comfort (overall body sensation) and local comfort (specific body areas). Standards like UNI EN ISO 7730 and ASHRAE 55 define thermal comfort conditions for indoor environments to optimize occupant satisfaction and performance. (Alozie, 2023, Ogunsote, 1990). In practical terms, thermal comfort is crucial for mental health, productivity at work, quality sleep, and overall well-being. It is subjective, varying from person to person, and influenced by external and personal factors. Ensuring thermal comfort helps reduce stress, distractions, and health risks related to temperature discomfort. (Alozie, 2023).

Concept of Indoor Thermal Comfort

Indoor thermal comfort refers to the condition of mind that expresses satisfaction with the thermal environment. The concept is influenced by environmental variables such as air temperature, humidity, air movement, and radiant temperature, as well as personal factors including clothing and metabolic rate. The adaptive thermal comfort theory proposed by Nicol et al. (2012) suggests that occupants in naturally ventilated buildings adapt to prevailing climatic conditions through behavioral and physiological adjustments. Thermal comfort in tropical regions is therefore closely linked to passive environmental control strategies.

Thermal Comfort Studies in Nigeria

Several studies have examined thermal comfort in Nigerian residential buildings. Okafor et al. (2022) evaluated thermal comfort in traditional and modern buildings in southeastern Nigeria and concluded that traditional buildings exhibited better thermal performance due to natural ventilation and material characteristics. Ochedi (2022) conducted simulation studies on residential building typologies in Lokoja and established that passive cooling strategies significantly improved thermal conditions. Furthermore, studies in Makurdi and Yenagoa highlighted the relationship between outdoor climatic conditions and indoor thermal comfort.

Despite these contributions, there remains inadequate literature focusing on landscaping as a thermal tool within residential buildings in Calabar Urban.

Thermal Comfort in Architectural Space

Thermal comfort in architectural spaces is essential because it directly affects the well-being, health, and productivity of occupants, as well as the sustainability and energy efficiency of buildings. It refers to a state of mind where people feel satisfied with the thermal environment, balancing heat gain and loss from their body to surroundings to maintain normal physiological functions. Importance of thermal comfort in architecture includes, Occupant Well-being.

Health: Proper thermal conditions prevent discomfort associated with excessive heat or cold, which can lead to health risks like hyperthermia or hypothermia. Comfortable thermal

environments support mental health and reduce susceptibility to illness. Productivity: People working or living in thermally comfortable spaces tend to be more productive and focused.

Energy Efficiency and Sustainability: Good building design using insulation, natural ventilation, solar shading, and smart controls reduces reliance on mechanical heating and cooling. This lowers energy consumption, reduces fuel use, and minimizes environmental impact. Preserving Building Materials and Indoor Air Quality: Adequate thermal comfort helps prevent humidity and temperature variations that can degrade materials and worsen air quality.

Cultural and Psychological Aspects: Thermal comfort also influences feelings of protection, community, and even cultural symbolism of warmth and coolness. Architectural design achieves thermal comfort through material choices, building orientation, ventilation, insulation, and integration of renewable energy and smart systems, creating spaces that meet human physiological needs while minimizing energy use. In summary, thermal comfort is a fundamental design goal that enhances human comfort and health, promotes productivity, and supports sustainable, energy-efficient buildings.

Landscaping and Thermal Regulation

Landscaping involves the deliberate arrangement of vegetation and outdoor elements to improve environmental quality and aesthetics. Vegetation contributes to cooling through shading and evapotranspiration processes. Tree canopies intercept solar radiation before it reaches building surfaces, thereby reducing heat gain. Research conducted in Akure, Nigeria, revealed that buildings shaded by trees recorded significantly improved thermal comfort conditions compared with unshaded buildings (Morakinyo et al., 2016). Similarly, Adunola and Ajibola (2016) found that neighborhood vegetation significantly influenced residents' thermal comfort perception in Ibadan metropolis.

Significance of Thermal Comfort in Outdoor and Indoor Environments

Thermal comfort in both outdoor and indoor environments is significant because it directly impacts human well-being, productivity, health, and the usability of spaces. Indoors, thermal comfort influences mental health, physical comfort, productivity at work, sleep quality, and the body's ability to fend off infections. For example, workplaces that maintain optimal thermal conditions promote better focus and reduce stress, while homes with comfortable temperatures support relaxation and recovery. Indoor thermal comfort is usually achieved through environmental control like heating, ventilation, and air conditioning.

Outdoors, thermal comfort is crucial for the functionality and attractiveness of urban spaces such as parks, terraces, and streets. Important environmental factors affecting outdoor comfort include air temperature, humidity, wind speed, and solar radiation. Outdoor comfort affects people's willingness to use public spaces, their social interactions, and their overall quality of urban life. Urban design elements like vegetation, shading, building density, and

materials can enhance outdoor comfort by moderating heat and wind. Because outdoor environments are less controllable than indoors, adaptation behavioral, physiological, and psychological plays a key role in outdoor thermal comfort. Overall, thermal comfort is essential for physical and mental well-being, productivity, rest, and social engagement indoors and outdoors. It also has economic implications, such as energy savings through efficient environmental control and improved urban design supporting sustainable living.

Conclusively, indoor thermal comfort supports health, productivity, and rest through controlled environments. Outdoor thermal comfort influences urban livability, public space use, and social behavior through environmental and design factors. Adaptation is more central outdoors due to variable conditions. Both contribute to overall quality of life and economic efficiency. This understanding underscore thermal comfort as a fundamental consideration in building design, urban planning, and public health.

Study Area

The study area Calabar Urban, is located in Cross River State, in southeastern Nigeria. and experiences a tropical monsoon climate with high annual rainfall and elevated humidity levels. The city's climatic condition contributes to overheating in residential buildings, especially where poor building orientation and inadequate landscaping prevail. Landscaping has emerged as a sustainable passive cooling strategy capable of reducing ambient and indoor temperatures through shading, evapotranspiration, and modification of microclimatic conditions. Calabar lies within the tropical rainforest zone and experiences high annual rainfall exceeding 3,000 mm, with average temperatures ranging between 24°C and 32°C. The urban area is characterized by expanding residential development, reduction in green spaces, and growing thermal discomfort among residents.

Methodology

The study adopted a mixed-method approach involving quantitative and qualitative techniques.

Research Design

A descriptive survey and field measurement design were employed to evaluate the thermal effects of landscaping in residential buildings.

Sampling Technique

Twenty residential buildings were purposively selected within Calabar Urban:

i. 25 landscaped residential buildings
ii. 25 non-landscaped residential buildings

Data Collection

Data were collected using:

1. Digital thermometers for indoor temperature measurements
2. Hygrometers for relative humidity readings

3. Structured questionnaires administered to occupants
4. Observation schedules for landscaping assessment

Measurements were taken at three-hour intervals between 6:00 am and 6:00 pm for two months March 15th and May 15th. 2025

Data Analysis
Collected data were analyzed using descriptive statistics including mean, percentages, tables, and comparative analysis.

Results and Discussion
Influence of Landscaping on Indoor Temperature
The study found that landscaped buildings maintained lower indoor temperatures compared with non-landscaped buildings. Average indoor temperatures recorded in landscaped residences ranged from 24°C to 28°C, while non-landscaped buildings recorded temperatures between 29°C and 33°C.

This finding agrees with, Alozie (2023) and Morakinyo et al. (2016), who reported that tree-shaded buildings experienced improved thermal conditions due to reduced solar heat gain.

Occupants' Perception of Thermal Comfort
Questionnaire responses showed that 76% of occupants in landscaped residences perceived their indoor environment as thermally comfortable, compared with only 18% in non-landscaped buildings.

The increased comfort level was attributed to:
i. Reduced heat penetration
ii. Improved air circulation
iii. Enhanced shading effects
iv. Lower surrounding surface temperatures

Effect of Vegetation in Passive Cooling
Vegetation was observed to significantly influence microclimatic conditions around buildings. Trees and shrubs reduced direct solar radiation on walls and roofs, thereby decreasing indoor heat accumulation. This finding agrees with earlier surveys which suggests that vegetation contributes to thermal control and urban cooling in tropical environments.

Limitations to Landscaping Adoption
The study identified several barriers to effective landscaping in Calabar Urban, including:
i. Inadequate space in residential plots
ii. Poor awareness of environmental benefits
iii. High maintenance costs
iv. Rapid urban development and land conversion

Conclusion

This study confirmed that landscaping is an effective indoor thermal tool in residential buildings within Calabar Urban. Landscaped residential buildings showed significantly improved thermal comfort conditions when compared to non-landscaped buildings. Vegetation contributes to passive cooling by reducing solar heat gain and improving microclimatic conditions around buildings. The marriage of landscaping with residential building design is absolutely essential for sustainable urban development, energy conservation, and occupant wellbeing in Calabar and other tropical environments.

Recommendations

The study recommends that:

1. Urban planning authorities should enforce green landscaping policies in residential developments.
2. Architects and builders should integrate passive cooling strategies into housing design.
3. Residents should plant shade trees around buildings to improve thermal comfort.
4. Government should promote urban greening programs in Calabar Urban.
5. Further studies should investigate the long-term energy-saving impacts of landscaping in tropical cities.

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