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Climate-Responsive Design Strategies for Enhancing Indoor Environmental Quality in Low-Income Housing in Lagos, Nigeria: A Review

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Abstract- ***Rapid urbanization, population growth, and persistent housing shortages in Lagos have intensified the demand for affordable housing while raising concerns about Indoor Environmental Quality (IEQ). Many low-income residential developments experience poor thermal comfort, inadequate ventilation, insufficient daylighting, and compromised indoor air quality, negatively affecting occupant health and well-being. This review examined climate-responsive design strategies for enhancing IEQ in selected low-income communities in Lagos, namely Ajeromi-Ifelodun, Mushin, Agege, and Ikorodu (Imota and Ijede). These communities were selected due to their high population densities, prevalence of low-cost housing, infrastructural deficiencies, and recognition in urban development literature as predominantly low-income residential areas. The review synthesized evidence on key IEQ indicators, including thermal comfort, natural ventilation, daylight availability, and indoor air quality. Climate-responsive strategies identified include building orientation, shading devices, cross-ventilation, passive cooling systems, appropriate material selection, and landscape integration. Findings indicate that these strategies can significantly improve indoor comfort, reduce indoor heat gain, enhance air movement, and decrease dependence on mechanical cooling systems. The study concludes that climate-responsive design provides a practical and affordable pathway for improving living conditions in low-income communities in Lagos and recommends greater integration of passive design principles into housing policies, planning regulations, and residential development practices.***

Keywords: Climate-responsive Design, Indoor Environmental Quality, Low-Income Communities in Lagos, Passive Design, Thermal Comfort.

I. INTRODUCTION

Background to the Study

Housing is one of the most important components of human welfare because it directly affects health, productivity, comfort, and overall quality of life. In rapidly urbanizing cities such as Lagos, Nigeria, the increasing demand for affordable housing has led to the development of densely populated low-income residential settlements with limited consideration for environmental comfort and sustainability [1].

As a result, many low-income housing developments experience poor indoor environmental conditions characterized by overheating, inadequate ventilation, insufficient daylighting, and poor indoor air quality, which negatively affect the physical and psychological well-being of occupants and increase dependence on mechanical cooling systems.

Indoor Environmental Quality (IEQ) refers to the quality of the indoor environment in relation to the health, comfort, and satisfaction of building occupants. It encompasses thermal comfort, ventilation, lighting quality, acoustic comfort, and indoor air quality.

In tropical humid climates such as Lagos, thermal comfort and ventilation are particularly critical because of the high temperatures and humidity experienced throughout most of the year. Buildings that fail to respond effectively to climatic conditions often trap heat, reduce airflow, and create uncomfortable living environments for occupants [2].

Lagos is one of the fastest-growing cities in Africa and continues to experience rapid population growth and urban expansion. This growth has intensified the housing deficit and placed enormous pressure on urban infrastructure and environmental resources.

Many low-income residential buildings are constructed using cost-driven approaches with little consideration for climate-responsive design principles, causing occupants to rely heavily on fans and air conditioning systems at significant economic burden [3].

Statement of the Problem

Rapid urbanization in Lagos has resulted in low-income housing characterized by poor orientation, ventilation, daylighting, materials, and shading. The consequence is excessive indoor heat, high humidity, poor air circulation, and persistent occupant discomfort. In Lagos's tropical climate, these conditions drive residents towards mechanical cooling, which is frequently unaffordable due to erratic power supply and high costs, causing heat stress, reduced productivity, and adverse health outcomes [2], [3].

Passive strategies such as natural ventilation, shading, and passive cooling are established to be effective; however, reviewed literature consistently demonstrates that these strategies are rarely applied in Lagos's low-income housing sector, where cost and construction speed take priority over occupant comfort [4], [5].

Limited integration of these principles into housing policy and professional practice has allowed energy-inefficient, uncomfortable housing to persist. This paper draws on existing research to examine how climate-responsive design can improve indoor environmental quality and provide sustainable solutions for low-income housing in Lagos.

Aim and Objectives

The aim of this paper is to investigate, through a review of existing literature, climate-responsive design strategies for enhancing indoor environmental quality in low-income housing in Lagos.

The specific objectives are:

i. To examine the documented indoor environmental conditions in low-income housing in Lagos.
ii. To evaluate evidence on the effectiveness of climate-responsive design strategies in improving thermal comfort, ventilation, daylighting, and indoor air quality.
iii. To propose sustainable climate-responsive design recommendations for enhancing indoor environmental quality in low-income housing.

Research Questions

i. What are the prevailing indoor environmental conditions documented in low-income housing in Lagos?
ii. How effective are climate-responsive design strategies in improving indoor environmental quality in low-income housing, as demonstrated in the literature?
iii. What climate-responsive design recommendations can enhance indoor environmental quality in low-income housing in Lagos?

II. LITERATURE REVIEW

Conceptual Framework of Indoor Environmental Quality (IEQ)

IEQ is broadly defined as the quality of an indoor environment as it relates to the health, comfort, and satisfaction of its occupants, encompassing thermal comfort, natural ventilation, daylighting, acoustic conditions, and indoor air quality [1]. In tropical humid climates such as Lagos, thermal comfort and natural ventilation are widely recognized as the most critical determinants of indoor habitability, given the prevailing high temperatures and humidity that characterize the environment throughout most of the year [2].

Owolabi et al. confirmed through a study of South-West Nigerian homes with different building fabrics that construction typology and material selection significantly influence thermal and ventilation performance, with conventionally built sandcrete block homes consistently recording higher indoor temperatures and poorer air movement than alternative construction types [4].

The study reinforces that IEQ must be addressed at the point of design and material specification rather than as a post-occupancy concern. Adaji et al. similarly established through investigation of Nigerian residential buildings that occupants regularly adopted adaptive behaviours adjusting clothing, opening windows, limiting activity as reactive responses to chronic thermal discomfort caused by buildings that failed to respond to their climatic context [1].

These findings frame the central argument of this paper: that climate-responsive design is the most direct and cost-effective pathway to improving the thermal and ventilation dimensions of IEQ in Lagos low-income housing.

Climate-Responsive Design: Principles and Theoretical Context

Climate-responsive design is an architectural approach that systematically incorporates local and regional climatic data including temperature, humidity, solar radiation, wind speed and direction, and rainfall patterns into every phase of the design process. The fundamental objective is to harness natural environmental forces to achieve occupant comfort and reduce reliance on energy-intensive mechanical building systems [8].

In tropical regions, where solar radiation is intense and ambient temperatures are consistently high, this approach is not merely an environmental preference but an economic and public health necessity, particularly for low-income communities.

Ibitoye assessed the adoption of passive design strategies in public buildings in Southwestern Nigeria, finding that climate-responsive features particularly solar shading, cross-ventilation provision, and appropriate building orientation were substantially underutilized, resulting in higher indoor temperatures and increased dependence on mechanical cooling [5].

The study identified limited professional awareness, cost constraints, and the absence of enforceable climate-responsive design standards as primary barriers to adoption, contextualizing the challenges documented in the residential sector.

Passive Design Strategies for Thermal Comfort and Natural Ventilation

Passive design strategies exploit naturally occurring environmental forces solar energy, wind patterns, and thermal dynamics to regulate indoor temperatures and enhance air movement without the use of mechanical systems.

In tropical humid climates, the principal strategies documented in the literature include: building orientation to minimize solar heat gain on major occupied facades; cross-ventilation through the strategic placement of openings on windward and leeward walls; shading devices such as overhangs, fins, louvers, and brise-soleil; high-reflectance and low-absorptance roof and wall finishes to reduce solar heat absorption; and the use of lightweight construction materials that resist heat conduction into occupied spaces [6], [7].

Ogunleye et al. explored the role of courtyard design as a climate-responsive spatial strategy in Nigerian buildings and found that well-proportioned courtyards functioning as ventilation inductors significantly improved indoor air movement and reduced thermal stress in surrounding occupied spaces [12].

This finding is particularly pertinent to the compound and tenement housing typologies common in Lagos. Afolabi and Ibitoye further found that Nigerian building occupants demonstrated strong positive perceptions of vegetated facade elements for their perceived contribution to shading and thermal comfort, suggesting growing community receptiveness to integrating nature-based passive strategies into affordable housing design [13].

Thermal Comfort in Tropical and Nigerian Residential Contexts

Thermal comfort is formally defined by ASHRAE Standard 55 as that condition of mind which expresses satisfaction with the thermal environment [10]. A substantial body of research has established that prescribed thresholds frequently underestimate the thermal tolerance and adaptive capacity of occupants in naturally ventilated tropical buildings, where higher neutral temperatures and greater acclimatization are well-documented [9].

Parkinson et al. confirmed that occupants in naturally ventilated buildings demonstrate significantly greater tolerance for elevated temperatures than those in mechanically conditioned environments, attributing this to behavioural, physiological, and psychological adaptive mechanisms [9].

The study proposed refinements to the adaptive comfort model to better reflect regional climate influences, acknowledging that occupants in tropical Africa and Asia are typically adapted to warmer indoor conditions than the standard model predicts. This is directly relevant to Lagos, where locally calibrated thermal comfort benchmarks are more methodologically appropriate than the direct application of temperate-climate standards.

Asaju et al. conducted an empirical investigation of thermal comfort satisfaction at a government housing scheme in Abeokuta, Ogun State, finding that a significant proportion of occupants reported dissatisfaction with indoor thermal conditions, particularly during afternoon peak heat hours [11].

The study identified poor building orientation, insufficient window areas, absence of shading devices, and non-reflective zinc roofing as the primary design factors driving discomfort characteristics common to government mass housing in Lagos.

Lagos Urban Housing: Context, Typologies, and Environmental Challenges

Lagos, Nigeria's commercial capital and one of Africa's most rapidly expanding metropolitan areas, presents a particularly urgent context for the challenge of improving thermal comfort in affordable housing.

The city's metropolitan population is estimated to exceed 15 million and continues to grow at a rate that dramatically outpaces formal housing delivery, resulting in an expanding deficit of adequate residential accommodation [2]. Lagos's humid tropical climate with mean annual temperatures between 25°C and 34°C and relative humidity consistently above 75% creates conditions in which buildings that fail to respond to solar radiation and wind dynamics become severely uncomfortable during peak heat periods without mechanical cooling [3].

The dominant low-income housing typologies in Lagos government-built mass housing estates, private developer tenement blocks, and self-built single-room occupancy units share design characteristics inimical to thermal comfort and natural ventilation: poor orientation, window-to-wall ratios far below recommended minima, absent or minimal roof overhangs, uninsulated metal roofs that generate severe radiant heat gain, and building spacing insufficient to allow meaningful wind penetration [2], [4].

Basis for Categorization as Low-Income Communities

For the purpose of this review, Ajeromi-Ifelodun, Mushin, Agege, and Ikorodu (Imota and Ijede) are categorized as low-income communities based on the following criteria:

i. Household Income Characteristics: A significant proportion of residents are engaged in informal-sector employment, petty trading, artisan work, transportation services, and other low-income occupations.
ii. Housing Typology: The dominant housing forms consist of rooming houses, "face-me-I-face-you" tenements, informal rental units, and self-built housing developed incrementally with limited financial resources.
iii. Population Density and Overcrowding: These communities exhibit high occupancy rates, overcrowded living conditions, and limited residential space per household.
iv. Infrastructure Deficiencies: Many neighborhoods experience inadequate drainage, poor waste management systems, insufficient road networks, and limited access to basic urban services.
v. Government and Urban Development Classifications: Previous urban poverty assessments, Lagos State development reports, and housing studies have frequently identified these communities as areas requiring priority intervention in housing and environmental improvement programs.

These indicators align with UN-Habitat and Nigerian urban housing assessment frameworks for identifying low-income and underserved residential communities.

Research Gap

While previous studies have examined thermal comfort and passive design in Nigerian residential buildings, limited reviews have specifically synthesized evidence applicable to low-income communities such as Ajeromi-Ifelodun, Mushin, Agege, and Ikorodu (Imota and Ijede).

Existing research often focuses on individual buildings, housing schemes, or broader metropolitan conditions without explicitly addressing the unique environmental challenges of these densely populated low-income communities. This review addresses this gap by contextualizing climate-responsive design strategies within the housing realities of these selected Lagos communities and assessing their potential contributions to improved Indoor Environmental Quality.

III. RESEARCH METHODOLOGY

Introduction

This chapter presents the methodological framework adopted to investigate climate-responsive design strategies for enhancing IEQ in low-income housing in Lagos. The study is based entirely on secondary data sources, comprising published journal articles, conference proceedings, institutional reports, and climate data records. This approach is adopted because a substantial and growing body of peer-reviewed literature already addresses the subject, enabling a rigorous synthesis of existing evidence without necessitating original primary data collection.

Study Context and Selection of Low-Income Communities

This review focuses on selected low-income communities within Lagos State, namely Ajeromi-Ifelodun, Mushin, Agege, and Ikorodu (particularly Imota and Ijede). These locations were selected because they exhibit characteristics commonly associated with low-income urban settlements, including high residential densities, significant proportions of informal and self-built housing, inadequate infrastructure provision, overcrowding, and relatively low household income levels compared with metropolitan Lagos averages.

The selected communities have been consistently identified in urban development studies, poverty mapping exercises, and government housing reports as areas facing substantial housing and environmental challenges. Housing in these communities is predominantly characterized by tenement buildings, rooming houses, informal housing structures, and incremental self-help construction, often developed without adequate consideration of climate-responsive design principles.

The focus on these communities provides a more context-specific understanding of how climate-responsive design strategies can improve Indoor Environmental Quality within the realities of low-income residential environments in Lagos.

Research Design

This study adopts a systematic narrative review design, in which existing quantitative and qualitative studies are identified, critically appraised, and synthesized to draw conclusions about the relationship between climate-responsive design and IEQ outcomes in low-income housing in Lagos.

This design is well-established in architectural and environmental building research as a means of consolidating evidence across multiple studies and contexts [16], [17]. The narrative review approach is particularly appropriate where the primary aim is synthesis and the identification of practical design implications rather than statistical meta-analysis.

Sources of Secondary Data

Secondary data for this study were drawn from the following categories of sources:

i. Published peer-reviewed journal articles retrieved from Scopus, Web of Science, and Google Scholar, using search terms including 'climate-responsive design', 'thermal comfort', 'low-income housing', 'Lagos', 'passive design', 'indoor environmental quality', and 'tropical humid climate'.
ii. Conference proceedings in architecture, building science, and environmental design published between 2019 and 2025.
iii. Institutional reports and grey literature, including UN-Habitat reports [14] and Nigerian

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Meteorological Agency climate data for Lagos [15].

iv. Nigerian building and housing policy documents, including the National Housing Policy [21].

v. ASHRAE Standard 55-2020 [10], providing the normative thermal comfort framework referenced across studies reviewed.

Inclusion and Exclusion Criteria

Studies were included if they:

i. Addressed IEQ, thermal comfort, or passive design in Nigerian or comparable West African tropical residential contexts.

ii. Were published in peer-reviewed journals or credible institutional outlets between 2019 and 2025.

iii. Provided empirical findings, measurement data, or evidence-based design analysis relevant to low-income housing.

Studies were excluded if they:

i. Focused exclusively on non-residential building types without transferable findings for housing.

ii. Were based on climates substantially different from Lagos's humid tropical conditions without adaptation of findings.

Data Analysis Strategy

Retrieved literature was analysed thematically, with findings grouped under the following themes: existing IEQ conditions in low-income housing; the effectiveness of specific passive design strategies (orientation, shading, ventilation, materials); the relationship between design interventions and measured or reported comfort outcomes; and policy and practice barriers to climate-responsive design adoption.

Thematic analysis was used to identify convergent findings across studies and to highlight areas of consensus, disagreement, or evidence gaps [23].

IV. RESULTS AND DISCUSSION

Overview

The following sections synthesize findings from the reviewed literature concerning existing IEQ conditions in low-income housing in Lagos and the evidence base for climate-responsive design strategies. Where individual studies are cited, their specific contexts and findings are identified to enable readers to assess the transferability of evidence.

Existing Indoor Environmental Conditions in Low-Income Housing

A. Thermal Comfort Conditions

The reviewed literature consistently documents thermal discomfort as one of the most critical IEQ challenges in Lagos's low-income housing stock. Studies report excessive indoor heat during afternoon and nighttime periods, particularly during the dry season, with buildings failing to dissipate absorbed solar heat during cooler overnight hours [2], [3].

The major causes identified across studies include poor building orientation, inadequate ventilation openings, absence of shading devices, high thermal absorption of metal roofing materials, and overcrowding, which increases metabolic heat loads in small spaces.

Owolabi et al. found that sandcrete block homes with corrugated metal roofing the most common construction typology in Lagos low-income settlements consistently recorded the highest indoor temperatures and poorest air movement of the building types examined [4].

Dimuna et al. similarly documented that buildings oriented without consideration for prevailing south-western winds experienced reduced airflow and higher indoor temperatures, and that houses with minimal window openings showed increased dependence on mechanical cooling [2].

B. Ventilation Performance

Natural ventilation is identified across the reviewed literature as a major determinant of indoor comfort in Lagos low-income housing. Housing configurations with cross-ventilation layouts, larger window openings, and multiple ventilation pathways are consistently documented to record better indoor air movement and improved occupant comfort compared to compact housing layouts with limited openings [3], [4].

Studies specifically identify the benefits of opposing window placement, perforated wall blocks, ventilated roof spaces, and open courtyard configurations as ventilation-enhancing design features.

However, the literature also notes that many low-income housing units lack adequate spacing between buildings, limiting wind penetration and creating stagnant indoor conditions regardless of individual building design [2]. This is particularly acute in informal settlements, where planning oversight is minimal and density pressures result in close building spacing.

C. Daylighting Conditions

Reviewed studies reveal varying levels of daylight adequacy among low-income housing units in Lagos. Buildings with larger window-to-wall ratios and lighter interior finishes are documented to experience better daylight penetration and reduced daytime dependence on artificial lighting.

Conversely, insufficient natural lighting is commonly associated with small window sizes, deep room configurations, adjacent building obstruction, and inappropriate facade design; all characteristics prevalent in Lagos low-income housing typologies [2], [5].

D. Indoor Air Quality

The reviewed literature indicates that indoor air quality in Lagos low-income housing is negatively affected by poor ventilation, indoor cooking with biomass fuels, moisture accumulation, inadequate waste disposal systems, and high ambient humidity levels [1], [3]. Housing units lacking sufficient airflow are documented to be more susceptible to mold growth and dampness.

Occupant health symptoms reported in reviewed studies including respiratory irritation, fatigue, and headaches are consistently linked to inadequate ventilation and high indoor pollutant concentrations.

Evidence on Climate-Responsive Design Strategies

A. Building Orientation

Appropriate building orientation is identified across the reviewed literature as one of the most effective and lowest-cost passive design strategies. Buildings aligned along east-west axes are documented to reduce direct solar heat gain on major occupied wall surfaces while maximizing exposure to prevailing south-western winds.

Ibitoye's assessment of public buildings in Southwestern Nigeria confirmed that this strategy was substantially underutilized, with the majority of surveyed buildings failing to achieve recommended orientation resulting in measurably higher indoor temperatures [5].

B. Shading Devices and Vegetation

The incorporation of roof overhangs, verandas, external shading devices, and vegetation is consistently documented in the literature to significantly reduce solar radiation entering buildings. Afolabi and Ibitoye found strong positive occupant perceptions of vegetated facade elements for their thermal shading contribution in Nigerian residential buildings [13].

Research on vertical greening systems in Lagos similarly demonstrated reductions in indoor thermal conditions in low-income residences, pointing to the dual environmental and comfort benefits of integrating nature-based shading into affordable housing design.

C. Natural Ventilation Strategies

Cross-ventilation is identified as the most consistently effective and widely recommended passive cooling strategy in the reviewed literature. Buildings with operable windows positioned on opposite walls are documented to experience better airflow and reduced heat accumulation.

Ogunleye et al. found that well-proportioned courtyard designs significantly improved indoor air movement and reduced thermal stress in surrounding occupied spaces in Nigerian buildings [12]. Additional ventilation strategies documented as effective include stack ventilation, elevated ceiling heights, ventilated roof spaces, and perforated facade systems [6], [7].

D. Envelope Materials and Construction

The reviewed literature consistently identifies lightweight metal roofing sheets as a major contributor to overheating in Lagos low-income housing. Insulated roofing systems and materials with lower heat absorption capacity including stabilized earth blocks and reflective roofing finishes are identified as more suitable alternatives for tropical housing due to their superior thermal performance characteristics [4], [6].

Owolabi et al. confirmed that material selection is among the most significant determinants of indoor thermal and ventilation performance in South-West Nigerian homes [4].

Synthesis: Relationship Between Climate-Responsive Strategies and IEQ

Across the reviewed literature, a consistent positive relationship is documented between the adoption of climate-responsive design strategies and improved indoor environmental quality outcomes.

The strongest relationships are noted between natural ventilation provision and thermal comfort, shading devices and indoor temperature reduction, daylighting design and visual comfort, and building orientation and energy efficiency. Housing units that integrated multiple passive design strategies are consistently documented to exhibit higher occupant satisfaction than those relying solely on mechanical cooling [1], [3], [4], [5].

These findings reinforce the argument advanced across the literature that climate-responsive architecture can provide affordable and sustainable solutions for improving living conditions in rapidly urbanizing tropical cities such as Lagos.

The evidence further highlights the importance of integrating sustainable housing policies into urban development frameworks, as passive design strategies remain largely absent from current housing regulations and developer practice in Lagos [5], [8].

V. CONCLUSION AND RECOMMENDATIONS

Conclusion

This paper examined climate-responsive design strategies for enhancing Indoor Environmental Quality in low-income housing in Lagos through a systematic review of secondary literature. The reviewed evidence reveals that many low-income residential buildings in Lagos experience poor thermal comfort, inadequate ventilation, insufficient daylighting, and unhealthy indoor air conditions, attributable primarily to poor building design and the absence of climatic responsiveness.

The literature consistently establishes that climate-responsive strategies including proper building orientation, cross ventilation, external shading, vegetative landscaping, improved material selection, and daylighting optimization significantly improve indoor environmental conditions and occupant wellbeing.

The evidence further demonstrates that passive environmental strategies can reduce dependence on mechanical cooling systems, lower household energy consumption, and provide affordable comfort solutions suited to tropical climates.

The paper concludes that integrating climate-responsive principles into low-income housing design is essential for achieving sustainable, healthy, and energy-efficient residential environments in Lagos.

Recommendations

A. Adoption of Climate-Responsive Building Regulations

Government agencies and planning authorities should incorporate climate-responsive standards into housing regulations and building approval processes. Policies should mandate passive cooling strategies, adequate ventilation provision, and energy-efficient housing design as minimum requirements for residential development approval.

B. Improved Building Orientation and Layout Planning

Architects and developers should prioritize proper building orientation to maximize natural airflow and minimize solar heat gain. Adequate spacing between buildings should be maintained to enable meaningful wind penetration and cross-ventilation across residential developments.

C. Integration of Natural Ventilation Systems

Low-income housing designs should incorporate cross-ventilation, operable windows, ventilated roofs, courtyard planning, and stack ventilation systems as standard features rather than optional enhancements. These measures can significantly improve thermal comfort while reducing household energy costs.

D. Promotion of Green Infrastructure
Urban greening initiatives including tree planting, vertical greening systems, and community landscaping should be encouraged to mitigate urban heat island effects and improve both outdoor and indoor environmental conditions in residential neighborhoods.

E. Use of Sustainable and Thermally Efficient Materials
Construction professionals should promote the use of reflective roofing materials, insulated roof systems, stabilized earth blocks, and low-carbon building materials appropriate for tropical climatic conditions as alternatives to conventional metal roofing and sandcrete construction.

F. Public Awareness and Capacity Building
Occupants, developers, and local communities should be educated on the benefits of climate-responsive housing and sustainable building practices through workshops, awareness campaigns, and professional training programs integrated into architectural and engineering education.

Contribution to Knowledge
This paper contributes to existing knowledge by synthesizing published evidence on the relationship between climate-responsive design strategies and IEQ in low-income housing within tropical urban contexts. It provides practical, evidence-based recommendations for sustainable residential development in rapidly growing cities such as Lagos.

Suggestions for Further Research
Future studies should:

v. Conduct simulation-based thermal performance assessments of specific low-income housing typologies in Lagos.
ii. Investigate the integration of renewable energy with passive design strategies in affordable housing.
iii. Explore occupant behavioural influences on IEQ in Lagos residential contexts.
iv. Examine the long-term economic benefits of passive housing strategies for low-income households.
v. Compare climate-responsive housing performance across different Nigerian climatic zones.

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