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SUSTAINABLE HOUSING DESIGN AS A SOLUTION FOR IMPROVING INDOOR ENVIRONMENTAL QUALITY IN RESPONSE TO CLIMATE CHANGE IN LAGOS, NIGERIA

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Abstract

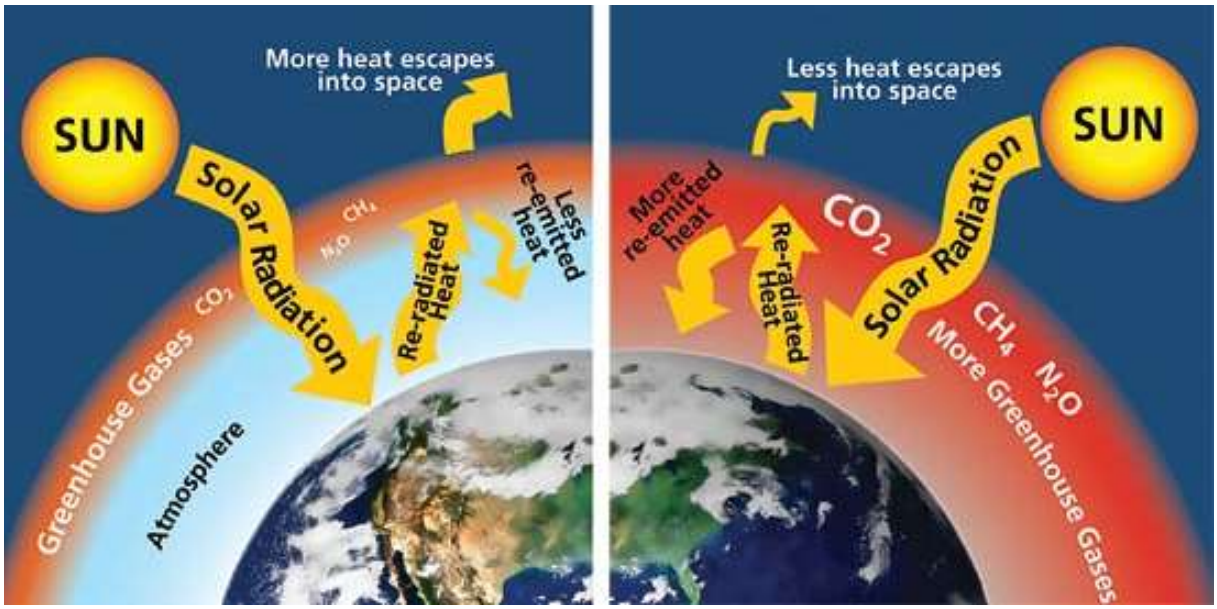
Climate change presents a pressing challenge with far-reaching implications for the built environment and human well-being, particularly in the rapid urbanisation of cities such as Lagos, Nigeria. This paper underscores the critical role of sustainable housing design as a pivotal solution for mitigating the adverse impacts of climate change on indoor environmental quality (IEQ) in residential buildings. Through a comprehensive review of the literature, this study elucidates the interconnectedness between sustainable design principles and the factors influencing IEQ, including thermal comfort, air quality, lighting, and noise levels. Emphasising the imperative for collaborative efforts between the public and private sectors, the findings underscore the need for government leadership to promote sustainable housing practices. Furthermore, leveraging actionable frameworks by international bodies and organisations to incentivise sustainable design behaviours has emerged as a crucial strategy to foster resilience against climate change while ensuring the well-being and comfort of occupants. This paper contributes to the discourse by providing actionable insights for policymakers, practitioners, and stakeholders to advance sustainable development goals (SDG), particularly Sustainable Cities and Communities (SDG 11) and Climate Action (SDG 13), towards building resilient and liveable urban environments in Lagos.

Keywords: climate action; indoor environmental quality; residential building; sustainable design; sustainable development goals

Introduction

Climate change stands as one of the most pressing challenges of our time, profoundly impacting the built environment and human well-being worldwide. The implications are particularly pronounced in rapidly urbanizing areas such as Lagos, where the convergence of population growth, infrastructure development, and environmental vulnerability magnifies the urgency for sustainable solutions. As temperatures rise and extreme weather events become more frequent, the imperative to address climate change's multifaceted impacts on urban populations intensifies.

Acknowledging the interconnectedness between human activities and climate variability is essential. While natural fluctuations have historically influenced climatic patterns, contemporary scientific consensus attributes approximately 90% of current climate change to anthropogenic sources, notably the combustion of fossil fuels (Redlin & Gries, 2021; Ondiko et al., 2022). The resulting accumulation of greenhouse gases, such as carbon dioxide, as illustrated in Figure 1, exacerbates the greenhouse effect, contributing to global warming and its attendant consequences (Letcher, 2019; Kabir et al., 2023).



(a) (b)

Figure 1. (a) Natural atmospheric phenomenon (b) human-enhanced greenhouse effect
Source: National Park Service

Despite mounting evidence and heightened public awareness, substantive action to curb emissions remains insufficient (Ahmed Ali et al., 2020; Chen et al., 2022; United Nations, 2022). The pervasive reliance on fossil fuels underscores the entrenched challenges in transitioning to sustainable energy systems advanced by Sustainable Development Goals (SDGs) 7 targeted at Affordable and Clean Energy and mitigating greenhouse gas emissions effectively (Tucho & Kumsa, 2020; Jayachandran et al., 2022; Kay Lup et al., 2023).

Understanding the imperative for sustainable housing design necessitates a comprehensive grasp of climate change dynamics and their implications for the built environment. Košir (2019) advocates for a paradigm shift towards bioclimatic building design and passive energy strategies, positing them as essential measures to both mitigate climate change impacts on built infrastructure and cultivate healthy indoor environments through eco-conscious housing designs.
In Lagos, the pursuit of sustainable housing design emerges as an anchor strategy to foster resilience and enhance the quality of urban life (Ajayi et al., 2023). By aligning internationally with the SDGs, particularly Sustainable Cities and Climate Action, stakeholders can leverage synergistic efforts to forge a path towards inclusive, sustainable urban development to foster quality indoor environments for Lagos residents (Lawanson et al., 2021; Kehinde et al., 2024).

This paper endeavours to explore the nexus between sustainable housing design, climate change, and IEQ in Lagos, Nigeria. Through an interdisciplinary lens encompassing architectural, environmental, and socio-economic dimensions, it seeks to provide actionable insights for policymakers, practitioners, and stakeholders to advance sustainable housing designs and build climate-adaptive residential buildings in urban cities and communities in the face of this globally experienced climate change.

Changes in the Climate

Climate change, driven predominantly by anthropogenic activities, presents a formidable challenge to global sustainability, with ramifications spanning ecological, social, and economic domains (Loucks, 2021). The exacerbation of this phenomenon is particularly evident in cities such as Lagos, where urbanization compounds the vulnerability of communities to its adverse effects (Lydia, 2021). Understanding the dynamics of climate change is paramount to formulating effective strategies for mitigating its impacts and fostering adaptation.

The assessment of global climate patterns reveals a steady increase in average temperatures over the past century, indicative of the overarching trend of global warming. Research conducted by the Intergovernmental Panel on Climate Change (IPCC) underscores this alarming trajectory, projecting a potential rise in global temperatures by 1.4°C to 5.8°C over the period 1990 to 2100 (IPCC, 2014); (Pachauri et al., 2014). Such projections, as depicted in Figure 2, underscore the urgency of concerted efforts to curtail greenhouse gas emissions and mitigate the drivers of climate change (Kabir et al., 2023).
The rate at which the earth's climate has changed as a result of this temperature shift is unprecedented, such that there has been a significant change in every variable used to define the climate.

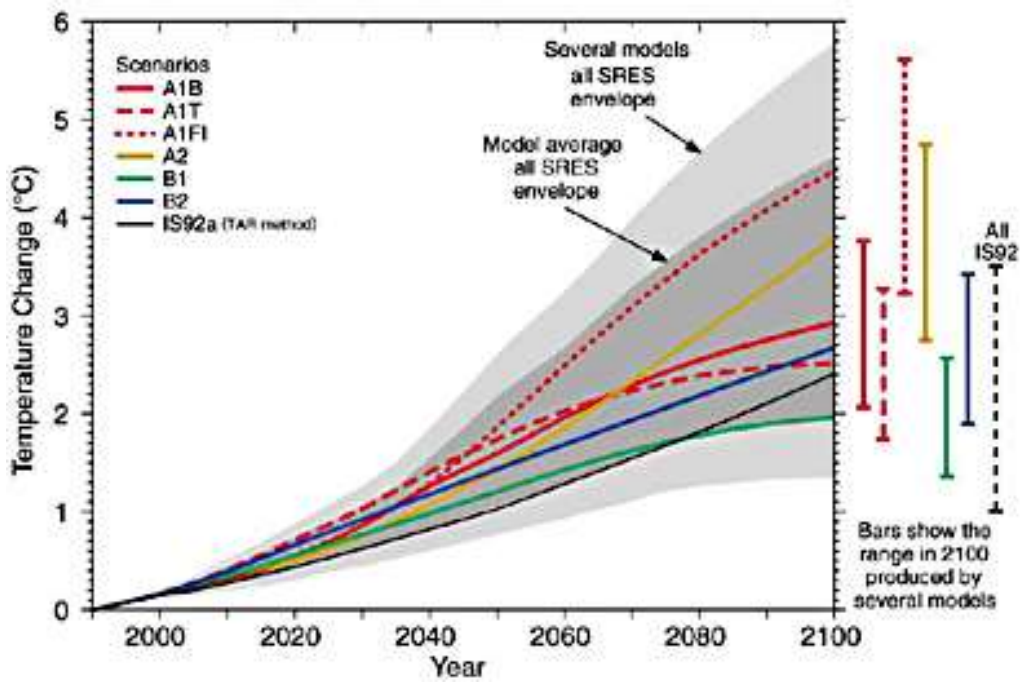


Figure 2. Projections of temperature change, based on the IPCC emission scenarios 2006.
Source: *(*IPCC *Data Distribution Centre)*

In Lagos, the implications of climate change are manifold, posing multifaceted challenges to sustainable development. Elias & Omojola (2015) in their case study of the challenges of climate change for Lagos, Nigeria enumerated flooding, sea level rise, storm surge, high temperature and high rainfall intensity as constituting notable hazards.
Intense heat, altered rainfall patterns, and increased frequency of extreme weather events jeopardize the livelihood and well-being of the inhabitants of the state (Sojobi et al., 2016; Emetere et al., 2021). Moreover, these aggravate thermal discomfort and escalate energy consumption for cooling purposes in residences, further exacerbating carbon emissions due to fossil fuel combustion for alternative power supply as a result of the epileptic electricity from the national grid (Emodi & Boo, 2015).

Addressing the nexus between climate change and sustainable housing design necessitates a multifaceted approach, encompassing policy interventions, technological innovations, and community engagement initiatives (Elias & Omojola, 2015). SDG 11, which focuses on sustainable cities and communities, assumes heightened significance in the context of climate change adaptation and mitigation efforts. By promoting inclusive urban planning, adaptive infrastructure development, and affordable housing initiatives, SDG 11 provides a holistic framework for fostering climate-adaptive urban environments. Furthermore, SDG 13, centred on climate action, underscores the imperative of global cooperation in combating climate change and

its adverse impacts. Through concerted efforts to reduce greenhouse gas emissions, enhance adaptive capacity, and promote sustainable practices, SDG 13 serves as a linchpin for realizing the broader agenda of sustainable development (Iwueke & Alagoa, 2018).

The imperativeness for addressing the adverse impact of climate change through sustainable housing design in Lagos is therefore underscored by its potential to enhance IEQ while reducing carbon emissions. By integrating passive design strategies, renewable energy systems, and green building materials, sustainable housing design initiatives can mitigate the urban heat island effect, optimize energy efficiency, and improve thermal comfort, daylighting and the overall indoor environmental experience for residents (Sijakovic & Peric, 2020; Thabit et al., 2020). Moreover, the adoption of nature-based solutions, such as green roofs and urban green spaces, can ameliorate air quality, mitigate flood risks, and enhance urban biodiversity, thereby fostering climate-adaptive communities, thereby ensuring the well-being and prosperity of present and future generations (Thabit et al., 2020; Ruíz & Mack-Vergara, 2023).

Signs of Changes in Climate

The evidence of climate change is incontrovertible, with myriad indicators revealing the Earth's warming atmosphere. Scientists employ diverse methodologies including historical records, data collection, and monitoring of environmental parameters such as temperature, weather patterns, and sea levels to discern these changes. Matawal & Maton (2013), Kenney & Janetos (2020) and Mukherjee & Siddique (2024) elucidated several prominent signs of climate change, each bearing profound implications for global ecosystems and human societies.

According to their reports, Glaciers and ice caps exhibit significant retreat annually, contributing to a steady rise in sea levels, averaging 0.8 millimeter per year. Moreover, a notable decline in snow cover in the northern hemisphere, approximately 2% every decade compared to the preceding ten years, underscores the intensifying impact of climate change on terrestrial landscapes. Concurrently, observations indicate a reduction in ice duration on lakes and rivers, with an annual decrease of 12 ice-covered days during winter compared to records from 150 years ago. This trend signals profound alterations in hydrological cycles with implications for water resource management and biodiversity.

Permafrost regions, critical for stabilizing landscapes and storing carbon, are experiencing diminishing extents, diminishing by 7% compared to levels observed in 1900. Such changes not only jeopardize infrastructure stability but also release stored greenhouse gases, exacerbating climate change feedback loops. Furthermore, phenological shifts, including early leaf emergence, avian migration, and altered breeding seasons, highlight ecological disruptions reverberating across terrestrial ecosystems.

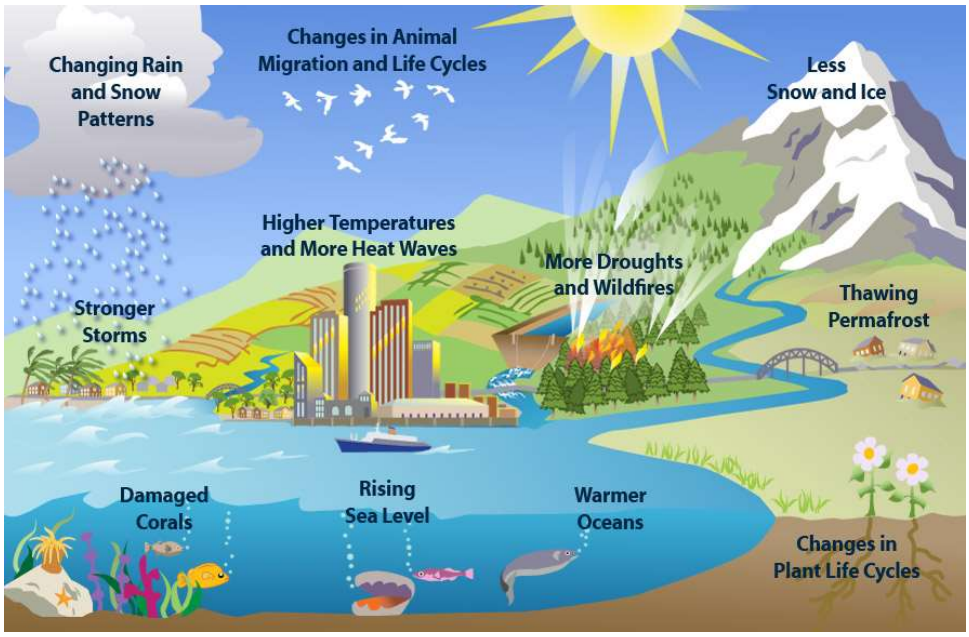


Figure 3. Signs of climate change

Source: https://archive.epa.gov/climatechange/kids/scientists/clues.html

Whereas, Lagos State is susceptible to various manifestations of climate change, as evidenced by empirical studies and observational data. One prominent indicator is the rise in average temperatures, documented through meteorological records and satellite data analysis. According to a study by Ogunjo et al. (2021), Lagos has experienced a steady increase in temperature over the past few decades, leading to prolonged heat waves and elevated heat stress among urban residents.

Moreover, changes in precipitation patterns represent another conspicuous sign of climate change in Lagos. Ogunrinde et al. (2019) highlight a discernible shift in rainfall distribution, characterized by more intense rainfall events and prolonged dry spells, exacerbating the risk of flooding and water scarcity each period in urban areas. These trends align with global projections of climate models by the IPCC, indicating a heightened vulnerability to extreme weather events in coastal regions like Lagos (IPCC, 2014).

The incontrovertible reality of global warming necessitates profound adaptations in human societies, particularly in the realm of infrastructure and building design. While buildings traditionally serve as shelters from climatic elements, evolving climate conditions mandate re-evaluation and adaptation of architectural practices. Importantly, the impacts of climate change extend indoors, as outdoor environmental changes permeate indoor spaces, accentuated by higher pollutant concentrations indoors relative to ambient air quality. As emphasized by the Institute of Medicine (IOM) indoor environments are not immune to the influences of climate change, with implications for human health and well-being (Spengler, 2012). The imperative to mitigate indoor climate risks necessitates proactive measures in sustainable housing design, aligning with global agendas.

Sustainable housing design serves as a critical component of creating adaptable and liveable urban environments. By integrating climate-responsive architectural strategies, such as passive solar design, natural ventilation, daylighting, and green infrastructure, residential buildings can mitigate energy consumption, enhance thermal comfort, and promote IEQ for inhabitants (UN-Habitat, 2019). Energy-efficient buildings reduce greenhouse gas emissions associated with fossil fuel consumption, thereby supporting global climate action targets (Min et al., 2022).

Impact of Climate Change on Indoor Environmental Quality

Climate change presents multifaceted challenges, profoundly influencing the IEQ of residential buildings. Mansouri et al. (2022) delineate two primary pathways through which climate change impacts IEQ. Foremost, direct responses to climate change, including energy-saving measures, can lead to an increase in indoor air contaminants, thereby deteriorating IEQ. Secondly, climate change-induced alterations in outdoor air quality exacerbate indoor air pollution levels. Additionally, climate change fosters the proliferation of problematic organisms within indoor environments, further compromising the IEQ (Spengler, 2012).

The health ramifications of climate change-induced alterations in IEQ are profound. Table 1 illustrates potential scenarios wherein climate change affects building occupants' health, comfort, and productivity. Moreover, the Committee on the Effect of Climate Change on Indoor Air Quality and Public Health, IOM, identifies key research elements pertinent to IEQ and occupants' health. These elements encompass indoor air quality, dampness, moisture, flooding, infectious agents, pests, thermal stress, building ventilation, weatherization, and energy use (Spengler, 2012).

Table 1: Scenarios where climate changes impact buildings and could affect occupant health, comfort, and productivity (Source: Spengler, 2012)

Potential direct and indirect consequence of climate change	Potential impact on the indoor environment	Potential impact on health
1. Increase incidence of extreme temperature events	Change in load of HVAC system Increase energy consumption	Increase mortality and decrease productivity from temperature extremes Altered infectious respiratory disease transmission
2. Increased incidence of hurricane and other respiratory events in some locations Higher sea level	Damage to and degradation of building materials	Exposure to chemical emissions from damaged materials
	Flooding and water damage Displaced persons during evacuations	Water and vector-borne diseases

			Dampness/mold-associated symptoms or illnesses Physical and psychological stress from displacement
3.	Increased incidence of drought in some locations Increased incidence of wildfires Possible changes in irrigation practices	Increase airborne particulates from crustal dust and combustion	Respiratory distress and illness
4.	Increase outdoor ozone level	Increase indoor ozone levels Increased release of other pollutants from ozone-initiated chemistry	Respiratory distress and illness Other distress and illness from chemical exposures
5.	Increased outdoor pollen levels Changes in the geographic range of pests	Alteration in indoor allergen levels Greater use of pesticides	Allergen-mediated distress and illness Distress and illness from pesticide exposure
6.	More frequent interruptions in electrical power from extreme weather events or overstressing of the electrical grid	Loss of mechanical ventilation Loss of mechanical cooling or heating	Exposure to excessive heat or cold Exposure to CO from backup electrical generator

These findings underscore the urgent need for proactive measures to mitigate the adverse impacts of climate change on IEQ. Addressing climate change requires not only altering energy consumption patterns but also reimagining building practices and design principles to enhance IEQ. Sustainable housing design emerges as a pivotal solution, integrating climate-resilient features to mitigate indoor air pollution, maintain thermal comfort, and ensure adequate ventilation (Smith, 2012; Kinnane et al., 2017; Suryandari, 2019; Abbakyari et al., 2023). These initiatives foster resilient and liveable environments (UN-Habitat, 2019; United Nations, 2022).

What is been done

Efforts in Lagos, Nigeria, have been directed towards leveraging sustainable housing design to improve IEQ as a critical response to the multifaceted challenges posed by climate change. The strategic urban design initiatives in Lagos involve a comprehensive approach that incorporates master planning and the management of urban spaces and structures. According to Carmona et al. (2018), effective urban design and planning consider environmental, social, and economic

dimensions to create resilient urban environments. This includes optimizing the location and design of urban elements to enhance energy efficiency and reduce environmental impact, a practice that is particularly pertinent in a rapidly urbanizing city like Lagos.

Sustainable housing design in Lagos has focused on adopting passive design principles to improve thermal comfort within residential buildings, thereby reducing the reliance on energy-intensive cooling systems. The use of renewable energy systems, such as solar panels, has been encouraged to decrease dependence on non-renewable energy sources, contributing to reduced greenhouse gas emissions. The implementation of green building materials and technologies also plays a significant role in enhancing indoor air quality, thus promoting the health and well-being of occupants (UN-Habitat, 2019). Furthermore, the promotion of compact and mixed-use development patterns has been a key strategy in minimizing urban sprawl and enhancing walkability, which contributes to sustainable urban living (IPCC, 2014).

International frameworks and organizations have been instrumental in guiding and supporting these sustainable development efforts in Lagos. The United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) provide platforms for collaborative climate action and policy-making, offering scientific assessments and recommendations for climate mitigation and adaptation (IPCC, 2014). Additionally, initiatives like the New Urban Agenda and the Sustainable Development Goals (SDGs) have established global standards and objectives for sustainable urban development. These frameworks emphasize the importance of integrating sustainable housing practices to achieve goals related to climate action (SDG 13) and sustainable cities and communities (SDG 11) (United Nations, 2022; UN-Habitat, 2019).

In Lagos, the collaboration between the public and private sectors has been pivotal in promoting sustainable housing practices. Government leadership is crucial in enacting policies and regulations that incentivize the adoption of sustainable design principles. Moreover, partnerships with international bodies and organizations help to align local initiatives with global best practices, fostering resilience against climate change while ensuring the well-being of urban residents (Elias & Omojola, 2015). Through these collective efforts, Lagos is making significant strides towards building a sustainable and liveable urban environment that can withstand the impacts of climate change.

Sustainable Principles

Sustainable housing design stands as a fundamental solution to address the challenges posed by climate change while simultaneously enhancing IEQ in residential settings. This section reviews key principles of sustainable housing design as outlined in the literature, emphasizing their relevance in the context of climate action and the promotion of sustainable cities and communities.

i. Site Analysis and Building Footprint

Sustainable housing design begins with thorough site analysis, emphasizing the preference for brownfield areas over undeveloped green fields to minimize environmental impact. Gathering data on climatic parameters such as temperature, humidity, and solar radiation for at least a year facilitates informed decision-making in building placement and orientation. Compliance with ground covering regulations and optimizing plot usage is imperative (King & Rudder, 2000).

ii. Building Orientation and Form

Optimal building orientation plays a crucial role in reducing heat gain and enhancing energy efficiency. Aligning the building's long axis East-West minimizes direct solar radiation penetration. The design of the building form should be adapted to the local climate zone, with considerations for maximizing natural light and ventilation while minimizing heat gain (Fadeyi et al., 2024).

iii. Space Allocation and Openings

Strategic allocation of spaces within the building contributes to thermal comfort and daylight utilization. Placing service areas on East and West facing walls acts as buffer zones against heat gain and promotes daylighting. Proper sizing and placement of windows, along with limited window-to-wall ratios, optimize natural lighting and energy efficiency (Wang & Chiou, 2020).

iv. Daylighting and Solar Protection

Sustainable housing design integrates daylighting strategies such as North-South oriented openings, narrow floor layouts, and light shelves to maximize natural light penetration. Solar protection measures including roof overhangs and vertical shading components mitigate heat gain, ensuring indoor thermal comfort (Ogunyemi et al., 2015; Saad, 2016).

v. Natural Ventilation and Cooling

Effective natural ventilation strategies are essential for maintaining indoor air quality and thermal comfort. Incorporating cross and vertical ventilation pathways, thermal chimneys, and roof vents facilitates air flow and passive cooling. Additionally, passive cooling systems such as evaporative cooling features contribute to energy efficiency in hot and arid climates (Attalage & Viraj Nimarshana, 2021).

vi. Renewable Energy and Water Conservation

Integration of renewable energy systems like solar, wind, and biogas aligns with climate action goals, reducing dependency on fossil fuels. Furthermore, water conservation measures such as rainwater harvesting and greywater recycling promote sustainability and resilience against water scarcity (Ramaswamy & Al-Saadi, 2019; Yüksek & Karadag, 2021).

vii. Waste Management and Landscaping

Sustainable housing design incorporates waste management practices including waste separation and on-site sorting to minimize environmental impact. Utilizing native plants for landscaping and permeable pavement materials contributes to water conservation and biodiversity preservation (Umar et al., 2020; Chen, 2023).

Sustainable Housing Design

The literature on sustainable housing design emphasizes the significance of incorporating environmentally friendly principles to enhance IEQ while addressing the challenges posed by climate change. (Ogunyemi et al., 2015) highlight the importance of understanding and adapting to the environment, along with the utilization of passive techniques in building design. This underscores that design quality extends beyond aesthetics to encompass technical functionality and the fulfilment of social, economic, and environmental needs (Alabi et al., 2015).

Sustainable housing design principles encompass various factors that impact IEQ, including air quality, lighting quality, noise quality, and thermal sensation. These principles and their associated IEQ parameters are further discussed.

i. Site allocation plays a crucial role in determining IEQ by considering factors such as air quality, lighting quality, noise quality, and thermal sensation. Adequate setback and airspaces, avoidance of building overcast, and the potential for both hard and soft landscapes contribute to overall design quality.
ii. Building footprint design affects IEQ through considerations such as air quality, lighting quality, noise quality, and thermal sensation. Factors like the adequacy of setbacks and airspaces, avoidance of building overcast, and potential for landscape integration influence the quality of the indoor environment.
iii. Building orientation impacts IEQ parameters such as air quality, lighting quality, and thermal sensation. Factors such as land orientation and slope influence the effectiveness of sustainable design in promoting a desirable indoor environment.
iv. Building form and shape affect IEQ factors like air quality, lighting quality, and thermal sensation. The form design of the building influences overshadowing and thereby impacts indoor environmental quality.
v. Allocation of spaces within the building influences lighting quality and thermal sensation. Considerations regarding structures and objects that may overshadow certain areas affect the overall IEQ.
vi. Openings in buildings impact IEQ parameters including air quality, lighting quality, noise quality, and thermal sensation. The installation of openings involves upfront costs and considerations for maintaining a desirable indoor environment.
vii. Daylighting contributes to lighting quality and thermal sensation within buildings. Careful consideration of structures and objects that may overshadow areas is crucial for effective daylighting strategies.

viii. Solar protection influences air quality, lighting quality, and thermal sensation. Factors such as upfront installation costs and considerations regarding roof orientation and shading impact the effectiveness of solar protection measures.

ix. Natural ventilation affects multiple IEQ parameters, including air quality, lighting quality, noise quality, and thermal sensation. Incorporating natural ventilation into building design from the outset is essential, as retrofitting can be challenging for apartment buildings.

x. Passive cooling strategies impact IEQ factors such as air quality, lighting quality, noise quality, and thermal sensation. Integration of passive cooling measures is crucial for promoting a comfortable indoor environment.

xi. Building envelope and material selection influence IEQ parameters including air quality, lighting quality, noise quality, and thermal sensation. Considerations for upfront installation costs and the effects of different materials on indoor environmental quality are essential.

xii. Renewable energy systems contribute to lighting quality and thermal sensation within buildings. Factors such as upfront installation costs and considerations regarding roof orientation and shading impact the effectiveness of renewable energy integration.

xiii. Landscape design affects IEQ parameters such as air quality, lighting quality, noise quality, and thermal sensation. Ongoing maintenance is essential for sustaining the benefits of landscape integration in promoting a desirable indoor environment.

This review underscores the intricate relationship between sustainable housing design principles and their impact on indoor environmental quality, thus highlighting the importance of adopting such approaches to address climate change challenges and promote sustainable development goals.

Sustainable Future

The imperative for sustainable development resonates profoundly in the context of addressing climate change, particularly concerning the built environment. Buildings stand at the nexus of this challenge, as they consume a significant portion of natural resources and energy, and emit greenhouse gases. According to the United Nations Environment Programme (UNEP) and the International Energy Agency (IEA), buildings utilize 40% of natural resources, contribute to 32% of total energy consumption, and produce 19% of greenhouse gas emissions, alongside 30% of black carbon emissions (UNEP, 2011; IEA, 2011). Despite widespread scientific consensus on climate change, buildings persist in being constructed and operated inefficiently, reflecting a disconnection between technological advancements and sustainable practices (Kinnane et al., 2017).

The evolution of housing design over recent decades has been marked by a pursuit of sustainability, driven by advancements in technology, and materials, and a growing consciousness of environmental impact. However, the current trajectory of construction and design falls short of addressing the long-term challenges posed by climate change. Studies indicate that even buildings constructed with present socioeconomic and environmental considerations may not adequately

serve future generations or climates (Hooff et al., 2015). The lifespan of contemporary construction aligns closely with the timeframe anticipated for significant climate shifts, emphasizing the urgent need for transformative action within the architecture, engineering, and building sectors (Gustavsson et al., 2015).

In this milieu, sustainable housing design emerges as a pivotal solution, offering a pathway towards reducing the carbon footprint of buildings while simultaneously enhancing IEQ. Sustainable housing design encompasses a holistic approach that integrates principles of energy efficiency, resource conservation, and resilience to climate impacts. By optimizing thermal comfort, air quality, lighting, and noise levels, sustainable housing design mitigates environmental impact and also fosters healthier and more livable indoor environments for occupants (Smith, 2012).

In Lagos, Nigeria, characterized by rapid urbanization and vulnerability to climate change, the promotion of sustainable housing practices becomes even more pressing. Collaborative efforts between the public and private sectors are essential in driving policy interventions and incentivizing sustainable design behaviours. Leveraging actionable frameworks established by international bodies and organizations can further catalyze progress towards building resilient and liveable urban environments (Ajayi et al., 2023).

Sustainable housing design stands as a panacea for addressing the intertwined challenges of climate change and indoor environmental quality. By embracing sustainable design principles and fostering collaboration across sectors, stakeholders can pave the way for a sustainable future characterized by resilient, equitable, and thriving urban communities (Niza et al., 2023).

Conclusions and Recommendations

The literature reviewed reveals a consensus among researchers that government intervention is crucial in addressing climate change and promoting sustainable practices (Cimato & Mullan, 2010) (Stoddart et al., 2012). There is a widespread belief that the government should lead the way in implementing policies and regulations that encourage behaviour change and promote sustainable design (Salvador & Sancho, 2021). Moreover, the literature emphasizes the need for collaboration between the public and private sectors to achieve meaningful progress in sustainability (Alzubaidy, 2018).

However, despite the acknowledgement of the government's role, there remains a disconnect between policy objectives and actual construction practices (Carmona et al., 2018). The quality of design in many housing developments falls short, with a significant proportion failing to meet sustainability standards (CABE, 2007). This raises questions about the effectiveness of current regulatory frameworks in promoting sustainable design practices.

In light of these findings, it is recommended that building construction permits in Lagos, Nigeria, incorporate requirements for sustainable design elements. Applicants should be required to provide

a separate report detailing how their proposed structures integrate sustainable design principles (Bragança et al., 2014). This approach aims to improve indoor environmental quality, enhance occupant comfort, and minimize the negative environmental impact of buildings (Al horr et al., 2016).

By integrating sustainable design requirements into building permits, policymakers can incentivize developers to prioritize sustainability and resilience in their projects (Dzebo & Shawoo, 2023). This aligns with global sustainability goals, such as SDGs 11 and 13, and also ensures a more sustainable future for Lagos, Nigeria, amidst the challenges of climate change (United Nations, 2022).

In conclusion, addressing climate change and promoting sustainable housing design requires collaborative efforts from the government, private industry, and other stakeholders. By implementing policies that incentivize sustainable practices and integrating sustainability into the building permit process, Lagos can move towards sustainable housing provision for a more resilient and liveable urban environment, aligning with global sustainable development goals.

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