

Climatic Change, the Built Environment, and Urban Resilience: Global Insights and Nigerian Perspectives

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Abstract

Climate change presents an escalating global threat to ecosystems, economies, and human settlements. The built environment encompassing buildings, neighborhoods, and infrastructure both contributes significantly to greenhouse gas emissions and remains among the most vulnerable sectors to climate-related disruptions. In Nigeria, rural areas experience increasing drought, desertification, and food insecurity, while urban centers face challenges such as rising temperatures, water scarcity, flooding, and sea-level rise.

This paper adopts a literature-based analytical approach to explore how architecture can serve as a critical tool for climate adaptation and urban resilience. International and local case studies were examined, including Rotterdam's floating architecture in the Netherlands, which demonstrates how innovative design responds to rising water levels, and the Makoko Floating School in Lagos, which exemplifies community-driven adaptation in a low-resource context. Findings indicate that climate change alters the built environment through intensified heatwaves, flooding, and structural degradation, with unregulated urbanization amplifying exposure. Adaptation strategies such as resilient design, green infrastructure, modular construction, and water-sensitive urban planning are essential to safeguard cities. Complementary mitigation strategies emphasizing low-carbon materials, passive design, and urban vegetation further reduce environmental impact. Both high-technology approaches in developed contexts and low-cost innovations in developing regions provide replicable pathways toward resilience.

In conclusion, architecture plays a pivotal role in addressing climate change through sustainable design and planning. While Nigeria's progress in climate-responsive architecture remains limited by high construction costs and weak regulatory enforcement, these barriers can be overcome by strengthening building codes, investing in resilient infrastructure, promoting sustainable materials, improving climate data collection, and enhancing institutional and community capacity for adaptation.

Keywords: Climate Change, Architectural Adaptation, Built Environment, Urban Resilience, Sustainable Architecture, Climate Policy

1. Introduction

Climate change is a significant challenge that comes with numerous negative environmental, social, and economic effects all around the world (Obada, 2014). Unlike rainfall, snowfall and other natural weather conditions that we're actually used to, climate change occurs over a long period of time. It is usually driven by rising concentrations of greenhouse gases (GHGs) such as carbon dioxide, methane, and nitrous oxide from fossil fuel use, industrial processes, agriculture, and deforestation (IPCC, 2021; Abbass, 2022). These emissions trap heat in the atmosphere, resulting in global warming and wide-ranging disruptions to ecological and human systems. Since the industrial era, global surface temperatures have increased by about 1.1°C above pre-industrial levels, with projections suggesting a rise beyond 1.5°C by mid-century if urgent mitigation is not achieved (IPCC, 2021). The effects of climate change are not uniformly distributed, disproportionately impacting vulnerable regions such as Sub-Saharan Africa, small island nations, and coastal cities (Change, 2007). Physical manifestations include more frequent heatwaves, floods, droughts, and hurricanes, as well as sea-level rise, biodiversity loss, and ecosystem degradation (UNEP, 2022; Jha &

Dev, 2024).

Moreover, Flooding, drought and hurricane storms among others can sometimes lead to food and water scarcity, decline in public health, destruction of numerous amenities and a sharp decline in the economy. Developing nations are particularly more at risk of these occurrences because fast population growth, and limited technology can make it hard for them to develop the kind of buildings or structures that'll protect them from their natural environment. As a result, this built environment which includes buildings, infrastructure, and urban systems is one of the sectors most exposed to climate risks. In rapidly developing countries like Nigeria, inadequate infrastructure and limited expertise on sustainable architecture further increase our vulnerability to flooding, drought and other negative effects of climate change, making climate adaptive architecture an urgent priority.

This is the central reason why the built environment is both the cause and the solution to climate change. Through green architecture, modular construction, and water-sensitive urban planning and other solutions such as low-carbon construction materials, and passive design, we can protect numerous communities from the negative effects of climate change. Drawing lessons from advanced technological approaches in developed nations and low-cost, community-driven initiatives in developing contexts provides valuable pathways for resilience. In light of these challenges, this study examines the impacts of climate change on the built environment and identifies adaptation and mitigation strategies to strengthen urban resilience, with emphasis on global insights and Nigerian perspectives. It also examines climate risks on different scales, while evaluating strategies that reduce our vulnerability to global warming effects, and assesses the barriers to effective adaptation, with the goal of proposing measures that support climate-responsive, sustainable urban development.

2. Methodology

This study makes use of a literature-based analytical approach, which relies on secondary data to examine the impacts of climate change on the built environment alongside the best adaptive strategies to better protect ourselves from the negative effects of climate change. Sources include international reports such as the Intergovernmental Panel on Climate Change (IPCC), the United Nations Environment Programme (UNEP), and the World Bank, as well as peer-reviewed articles, books, and scholarly publications that provide theoretical perspectives, empirical findings, and policy insights. To show the different adaptive methods adopted in different communities, comparative case studies were also used which features Rotterdam in the Netherlands representing a developed city with advanced institutional and technological capacity, and Makoko in Lagos, Nigeria, representing an informal settlement in a developing region where adaptation is largely community-driven and resource-constrained. These two regions were chosen to capture the diversity of climate adaptation strategies, ranging from high-tech innovations to low-cost grassroots solutions, and to extract transferable lessons relevant to both global discourse and Nigerian realities. A thematic synthesis guided the analysis, focusing on four core areas which include the impact of climate change on the built environment, how we can adapt to it, how to reduce its effects, and the barriers to adoptive effective mitigation and adaptation strategies. The use of this method is justified because it allows us to gain insights from different regions while comparing different adaptive strategies to find out which one is the best and how it can be applied to different regions.

3. Findings And Results

3.1 Impacts of Climate Change on the Built Environment

The built environment, which includes buildings, infrastructure, and urban systems, plays a central role in supporting human activity and protecting us from being wiped off due to cyclones, earthquakes, flooding among other effects of global warming. However, the built environment is getting more and more threatened by the multifaceted impacts of climate change. Rising temperatures, changing rainfall patterns, the rise sea-level, and more frequent extreme weather events compromise the safety, durability, and livability of cities (UN-Habitat, 2020; IPCC, 2021). These risks are particularly potent in rapidly urbanizing regions such as Nigeria, where the population continues to grow at a rapid rate while the economy takes a downward plunge.

The effects of climate change manifest in multiple ways. Urban heat, intensified by the Urban Heat Island effect, raises indoor temperatures, increases cooling energy demand, and heightens risks of heat stress (Demisse *et al.*, 2024). Flooding and coastal inundation from intense rainfall and sea-level rise cause

property damage, population displacement, erosion, and saltwater intrusion (Wang et al., 2025; IPCC, 2021). Tropical storms and cyclones disrupt power and transport networks while damaging structures. Rising temperatures also increase energy consumption through the use of fans and air conditioners, which places additional stress on the electrical system (IEA, 2022). Furthermore, climate stressors such as heat, humidity, and salinity degrade building materials, while poor ventilation and moisture accumulation reduce indoor environmental quality, exposing occupants to health risks. Informal settlements, common in many developing cities, face the greatest threats because of their location in hazard-prone areas, inadequate services, and weak resilience mechanisms.

Table 1: Climate Hazards and Their Impacts on the Built Environment

S/N	Impact Area	Climate Harzard	Built Environment Effect
1	Urban Heat	Heatwaves, Urban heat Island	Higher indoor temps, energy use, heat stress (Demisse et. al., 2024)
2	Flooding	Intense rainfall	Water damage, displacement, infrastructure overload IPCC (2021),
3	Sea-Level Rise	Coastal inundation	Erosion, saltwater intrusion, housing loss (Wang, et. al., 2025).
4	Storms/Wind	Tropical cyclones, tornadoes	Structural damage, power loss, transport disruption
5	Energy Demand	Temperature rise	Increased cooling loads and emissions (IEA, 2022).
6	Material Durability	Heat, humidity, salinity	Degradation of construction materials
7	Indoor Environmental Quality	Heat, mold, poor ventilation	Health impacts, poor air quality
8	Informal Settlements	All climate hazards	High exposure, low resilience, housing insecurity

Source: Authors' compilation, 2025

3.2 Adaptation Strategies in the Built Environment

Adaptation strategies are important in order to increase the resistance of the built environment to the effects of climate changes. Climate-responsive architecture, especially through passive design, aligns buildings with local environmental conditions to enhance indoor comfort while lowering dependence on mechanical cooling and heating. Techniques such as strategic orientation, shading devices, natural ventilation, and use of thermal mass reduce energy demand and extend building lifespan. Similarly, the use of climate-responsive designs such as solar panels and green architecture gives us the flexibility we need to adapt to different weather conditions. Its also important to design social amenities such as pipelines, roads, bridges and public transit in such a way that they can withstand climate stresses. Advanced drainage systems, roof gardens, and permeable pavements, are all climate-responsive strategies that can help in reducing the impact of flooding while improving air quality. This would ensure that cities remain functional during and after climatic disruptions.

3.3 Mitigation Strategies in the Built Environment

While the use of adaptive measures such as climate responsive technology and materials can help us in building long-lasting structures such as buildings, roads and bridges, mitigation addresses the built environment's role in increasing emissions. Construction technology and the built environment is no doubt one of the greatest contributors to carbon emission but the use of sustainable materials such as recycled steel, bricks, bamboo, and sustainably sourced timber can reduce carbon emission. The use of fly ash and slag in cement and concrete construction can also reduce the carbon footprint of the built environment (Petrova, 2024). Green elements such as trees, green roofs, and walls, also helping in cooling the surrounding environment while reducing carbon emission. Climate-sensitive urban design further integrates

ecological systems into cities, while making them more resistant to harsh weather conditions. Finally, modular and prefabricated construction reduces waste by cutting down on wasted materials, and leads to development of sustainable practices.

3.4 Case Studies of Adaptation Strategies in the Built Environment

The cases studied also give valuable insights on how different communities have developed their built environment in such a way that its resistant to the effects of climate change. By choosing two regions with different historical and social backgrounds, this study provides broader narratives and technical solutions to the negative impacts of climate change. The two cases studied are Rotterdam in the Netherlands and Makoko in Lagos, Nigeria which show how developed and developing regions address climate risks differently.

3.4.1 Rotterdam's Floating Architecture (Netherlands)

After undergoing one of the most terrifying floods in history, Netherlands has invested heavily in advanced water management strategies. After the 1953 North sea flood, the Dutch have been relying heavily on dikes, canals, and giant dams to protect their land against flooding (van Koningsveld *et al.*, 2008). Rotterdam, one of the country's most important port cities, is one of the regions within the country that is highly prone to flooding. The North Sea Flood of 1953, which killed more than 1,800 people, marked a turning point for the Dutch who were so determined to never lose so many lives and properties to flooding that they developed the Delta Works, a large engineering system of dams and storm surge barriers considered one of the world's largest infrastructural defenses (Gerritsen, 2005).

However, as climate change and the rise in the sea-level threatened to break through the Dutch's defenses, Rotterdam adopted a new strategy. Instead of “fighting water” they started “living with water” (Bos & Zwaneveld, 2017). Floating architecture was the result of this development. The Floating Pavilion in Rijnhaven, completed in 2010, is a prime example of adaptive design which features strong foundation, lightweight ETFE envelopes, and integrated solar and water systems make it sturdy and sustainable (Neumann, 2011). Similarly, the Waterwoningen (Water Dwellings) in IJburg also show how an entire neighborhood can adapt to an area with fluctuating water levels (Koen Olthuis & Keuning, 2010). The history of Rotterdam's floating architecture and how its government invested heavily in adaptive measures is now a global model for deltaic and coastal cities, combining adaptation with urban reinvention (OECD, 2014).



Plate 1: Floating Pavilion in Rijnhaven
Source: Google scholar (2025)



Nigeria's largest city, Lagos has experienced rapid urban growth, with its population increasing from 5 million in 1991 to over 20 million (World Bank, 2020). Located along the Atlantic coast, Lagos suffers from flooding every single year and its all thanks to tidal surges, heavy rainfall, and inadequate drainage infrastructure (Adelekan, 2010). The flooding in Lagos is so serious that it has become abnormal for it not to occur within a year. Within Lagos, Makoko a small fishing community founded in the 19th century is highly at risk of flooding. Over 100,000 people live in houses built above the Lagos Lagoon. To make matters worse, these people have no access to a properly functioning drainage system or basic sanitation (Agboola *et al.*, 2023).

Despite the fact that the government continues to turn a blind eye to their problem, the residents of Makoko were able to come up with some super impressive adaptation strategies. Timber stilt houses, lightweight locally sourced materials, and canoe-based transport are some of the means by which the locals cope with their riverine environment (Ajibade, 2017). In 2013, the Makoko Floating School, designed by architect Kunlé Adeyemi, brought international attention to community-led adaptation. Constructed with timber, plastic barrels, and an A-frame system, the modular building adjusted to fluctuating water levels and incorporated solar panels (Adeyemi, 2013). Though the school collapsed in 2016, the project raised a global discussion on the importance of low-cost climate responsive architecture particularly in rural settlements with little or no funding (Boano & Hunter, 2012; Adegun, 2017). Its successor, MFS II, improved on structural stability and has been replicated in other parts of Africa and Southeast Asia (Adeyemi, 2017).

It also shows the underground struggles of small communities with bad governing systems. Unlike Rotterdam citizens who enjoyed the financial support of their government, Makoko featured bottom-up innovation rooted in necessity which goes a long way in showing the role of vulnerable communities in global adaptation discourses (Satterthwaite *et al.*, 2020).



Plate 3: Makoko Floating School, Lagos Nigeria
Source: Google scholar (2025)

3.5 Challenges and Barriers to Climate Adaptation in the Built Environment

While its becoming more and more obvious how badly we need to develop built environments that are resistant to climate, the use of effective adaptive strategies come with some challenges of its own. These challenges do not only involve the technical knowhow of advanced construction methods but they're also economic, institutional, and informational in nature, and they collectively slow down the transition toward climate-responsive designs (Slovic *et al.*, 2024). The most critical obstacles include cost and technology gaps, weak policy enforcement, lack of localized climate data, and systemic institutional limitations.

The major challenge affecting the use of climate responsive designs is the high cost required and lack of the necessary technology. While energy-efficient buildings, green infrastructure, and renewable energy systems promise long-term benefits, their high upfront costs often discourage people from using them, particularly in low- and middle-income countries (Shah *et al.*, 2024). Solutions such as solar panels, greywater recycling, and passive cooling systems require greater initial investment than conventional construction, while advanced options like green roofs or permeable pavements require specialized expertise and maintenance.

Another major challenge is the lack of localized climate data for design and planning. Most available climate information is produced at national or global scales, which often masks the microclimatic variations within cities that shape heat, flood, and storm vulnerabilities (Eisenack *et al.*, 2014). This gap is particularly acute in rapidly growing urban centres where localized phenomena such as the Urban Heat Island (UHI) effect can exacerbate heat risks, yet remain underreported due to the absence of fine-grained monitoring systems (Iping *et al.*, 2019). Moreover, the absence of downscaled climate projections forecasts that provide neighborhood-level insights into future rainfall, temperature, or sea-level trends limits the ability of architects and planners to design infrastructure capable of withstanding future climate conditions.

4. Conclusions

Climate change is a major concern in the 21st century, as it continues to wreck havoc on the built environment. In the past five years, we've seen an increase in flooding particularly in Afghanistan and Pakistan. Cities are dealing with higher temperatures, flooding, and decaying infrastructure, but they also produce a lot of greenhouse gas emissions. This study shows that adapting to climate change and reducing emissions are both crucial. Examples from around the world, such as Nigeria, show that sometimes we don't have to wait for the government to aid us in doing the needful. However, challenges like high cost, lack of data, and gaps in organizations make progress difficult, especially in developing areas.

- i. Climate change is a big threat to buildings and cities.
- ii. Buildings contribute to emissions but can also help with resilience.
- iii. We need both adaptation and mitigation strategies to protect cities.
- iv. Solutions should mix advanced technology with local community effortsProblems like cost, weak policies, and lack of data are major hurdles to action.

5. Recommendations

To create a built environment that is resistant to the impacts of harsh weather, we need teamwork across government, design, and community levels. Policies and investments must be locally relevant while aligned with global sustainability goals. Priority should be given to making resilience affordable, inclusive, and technologically adaptable.

- i. Strengthen and enforce climate-responsive building codes, policies, and urban planning frameworks.
- ii. Invest in resilient and green infrastructure, integrating nature-based solutions such as wetlands, permeable pavements, and urban forests.
- iii. Promote climate-responsive and passive design principles in both new construction and retrofitting of existing buildings.
- iv. Enhance localized climate data collection and dissemination to guide planning and architectural decisions.
- v. Build institutional and community capacity through training, knowledge-sharing, and inclusive participation.

Conflict of interests

The authors have not declared any conflict of interests.

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