



Charting a Resilient Future: Climate Change as a Catalyst for Sustainable National Development
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CLIMATE – RESILIENT INFRASTRUCTURE IN NIGERIA: AN ASSESSMENT OF NIGERIA’S PREPAREDNESS FOR CLIMATE RESILIENCE EVENTS

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Abstract

Climate change poses significant challenges to infrastructure systems worldwide, particularly in developing nations like Nigeria, where rapid urbanization and weak institutional frameworks exacerbate vulnerabilities. This paper examines Nigeria’s preparedness for climate-resilient infrastructure by assessing existing policies, implementation strategies, and adaptive capacities. Using a mixed-methods approach, including policy analysis, case studies, and stakeholder interviews, the study evaluates critical infrastructure sectors such as transportation, energy, water supply, and housing. Findings indicate gaps in policy enforcement, inadequate funding, and limited technical expertise as major barriers to resilience. The paper proposes strategic interventions, including policy reforms, climate-smart engineering practices, and increased investment in resilient infrastructure. Strengthening institutional coordination and integrating climate resilience into development planning are crucial for mitigating climate-related disruptions and ensuring sustainable infrastructure in Nigeria.

Keywords: Climate resilience, infrastructure, Nigeria, climate adaptation, policy assessment

1. INTRODUCTION

Climate change is an imminent global challenge that is reshaping environmental conditions and impacting human livelihoods. As the effects of climate change is becoming an alarming situation, the construction industry is faced with the challenge of designing and constructing critical infrastructure that can withstand and acclimatise to changing environmental conditions. The emerging evidence of climate change, as detailed in the consensus report by the Intergovernmental Panel on Climate Change (IPCC, 2014), highlights the importance of considering climate change impacts on both current and future infrastructural designs. This arising challenge needs to be tackled by government policies ensuring that all infrastructure developments and projects must incorporate predictive climate change effects on infrastructure. Climate change poses a significant threat to infrastructure systems in the world and Nigeria is no exception. In Nigeria, the repercussions of climate change are becoming increasingly evident with the rise in frequency and intensity of extreme weather events such as floods, droughts, and heatwaves. The country's geographical diversity, spanning arid regions in the north to humid tropical zones in the south, makes it susceptible to various climate-

related impacts. Nigeria's infrastructure is highly vulnerable to the adverse effects of climate change in the following areas;

The transportation sector comprising roads, bridges, and rail networks. These infrastructure faces severe disruptions from flooding and erosion. According to the World Bank (2013), over 80% of rural roads in Nigeria are in poor condition, largely due to inadequate maintenance and climate-related damages. The Picture below depicts the current realities against a constructed resilient road infrastructure.



Plate 1: Dilapidated Road versus an ongoing road construction designed for resilience

The energy sector which is heavily reliant on hydropower and fossil fuels, is also at risk given that variability in rainfall patterns affects hydropower generation and pose a great challenge

Rising temperatures increases the demand for electricity, straining the already overburdened power grid (Cervigni et al., 2013) as seen in plate 2.



Plate 2: (a) Kainji dam at low capacity (b) Unsustainable grid system versus (c) Resilient energy

source:

The health sector faces additional pressures, as climate change exacerbates health vulnerabilities, leading to increased incidences of vector-borne diseases (Leadership, 2024). Illustration is presented in plate 3.



Plate 3: vulnerabilities arising from poor infrastructure

Building or constructing a climate-resilient infrastructure is crucial for combating the adverse effects of climate change and ensure sustainable development. Climate-resilient infrastructure is designed to withstand, adapt to, and recover from the impacts of climate change, ensuring continued functionality and safety for communities. This involves using durable materials, incorporating flexible design principles, and adopting innovative construction techniques. Investing in climate-resilient infrastructure not only reduces the economic costs associated with repair and maintenance but also enhances the overall quality of life for communities. (Agard & Schipper, 2014).

Interventions by Nigerian Government to enhance resilient Infrastructure

In recognition of the challenges and need for climate-resilient infrastructure, Nigeria has undertaken several initiatives in collaboration with international organizations. Some of such initiatives includes, The Nigeria Erosion and Watershed Management Project (NEWMAP), aimed at addressing land degradation and reduce vulnerability to erosion in targeted areas, Rural Access Agricultural Marketing Project-Scale Up (RAAMP-SU) focused on rehabilitating and upgrading rural roads to enhance their resilience to climate impacts (World Bank, 2024). Similarly, The National Council on Climate Change (NCCC) collaborates with various stakeholders, including government agencies, the private sector, and civil society organizations, to implement climate-resilient infrastructure projects (NCCC, 2021).

Despite these efforts, Nigeria faces several challenges in achieving climate-resilient infrastructure. The primary problem is the insufficient understanding and implementation of climate-resilient infrastructure practices in Nigeria. This gap manifests in several ways, such as lack of localized risk assessments, inadequate design and planning, limited knowledge integration, policy and regulatory gaps, and lack of awareness and capacity.

Addressing these challenges requires a multi-faceted approach, as such this paper aims to assess the current state of infrastructure, explore design and planning strategies to enhance resilience, and evaluate Nigeria's capacity to anticipate, prepare for, respond to, and adapt to climate hazards. The study will emphasis on

localized risk assessments, and the integration of traditional knowledge into resilience strategies. By addressing these issues, Nigeria can build a more resilient infrastructure capable of withstanding the impacts of climate change and ensuring sustainable development for future generations.

2. CLIMATE-RESILIENT INFRASTRUCTURE

Climate-resilient infrastructure is essential for reducing the negative effects of climate change, especially in vulnerable areas like Nigeria. This infrastructure encompasses sectors such as energy, water, telecommunications, transport, and waste management, all of which provide critical services to users (Hall; Tran; Nicholls, 2016). These services are vital to modern society and support the Sustainable Development Goals (Thacker, et al., 2019). The relationship between climate and infrastructure is significant for several reasons: (i) infrastructure systems are susceptible to climate hazards (Hallegatte; Rentschler; Rozenberg, 2019), (ii) climate changes affect the demand for infrastructure services (e.g., increased energy use for cooling) (Miranda, et al., 2023; Deroubaix, et al., 2021), and (iii) adapting infrastructure to climate change is crucial for protecting economic development (Millner, Dietz, 2015; Tanner, et al., 2015)

Infrastructure systems in Nigeria are increasingly vulnerable to climate hazards such as flooding, extreme heat, and storms. Quantitative risk assessments are essential for understanding these vulnerabilities and developing targeted adaptation strategies (Verschuur, et al., 2024).

2.1 Current State of Infrastructure in Nigeria

2.1.1 Transportation infrastructure

Nigeria's transportation infrastructure includes roads, railways, airports, and seaports. The road network, which is the most extensive mode of transport, is in poor condition due to inadequate maintenance and funding (Oxford Business Group, 2024). The railway system, once a major mode of transport, has seen some revitalization efforts. The Nigerian Railway Corporation (NRC) has undertaken projects to rehabilitate existing lines and construct new ones, such as the Lagos-Ibadan and Abuja-Kaduna rail lines (Infrastructure Africa, n.d.). Airports in Nigeria have also seen improvements, with upgrades to major airports like Murtala Muhammed International Airport in Lagos and Nnamdi Azikiwe International Airport in Abuja (Nedozi, Obasanmi, & Ighata, 2021). Seaports are critical for Nigeria's trade, but they face challenges such as congestion, inefficiency, and inadequate infrastructure. The Nigerian Ports Authority (NPA) has been working on port reforms and expansion projects to enhance capacity and efficiency (National Integrated Infrastructure Master Plan, 2020).

How Climate affects Infrastructure

Increased Flooding: Rising sea levels and more intense rainfall can lead to flooding, which damages roads, bridges, and tunnels. Coastal areas are particularly vulnerable, with significant portions of infrastructure at risk (Nguyen et al., 2022).

Heat Stress: Higher temperatures can cause pavement to soften and expand, leading to rutting and buckling. Rail tracks can also warp under extreme heat, disrupting train services (Mills, 2021).

Storm Damage: Extreme weather events, such as hurricanes and superstorms, can cause significant damage to transportation networks, leading to prolonged service disruptions (Nguyen et al., 2022; Nedozi; Obasanmi & Ighata, 2021).

Economic Impacts: Disruptions in transportation can have widespread economic effects, affecting the movement of goods and people (Nedozi; Obasanmi & Ighata, 2021).

To mitigate these impacts, transportation planners and engineers are incorporating climate resilience into their designs and maintenance practices. This includes using more durable materials, elevating infrastructure, and improving drainage systems (Mills, 2021).

2.1.2 Energy infrastructure

Nigeria's energy sector is plagued by inadequate generation, transmission, and distribution infrastructure. Despite having the largest natural gas reserves in Africa, Nigeria struggles with frequent power outages and an unreliable electricity supply (National Planning Commission, 2022). The power sector's inefficiencies are attributed to outdated infrastructure, poor maintenance, and financial constraints. Efforts to improve the energy sector include the privatization of power generation and distribution companies and the development of renewable energy projects. The government has also launched initiatives like the National Integrated Power Project (NIPP) to enhance power generation and distribution.

How Climate affects Energy Infrastructure

Disruptions to Energy Supply: Extreme weather events, such as superstorms, can cause significant disruptions to energy supply.

Interruptions to Electricity Transmission: Climate change threatens the ways in which power reaches homes and businesses. Transmission lines are prone to damage during extreme weather, leading to interruptions in electricity transmission.

Strain on the Energy System: Increased temperatures and heatwaves can strain the energy system by increasing demand for cooling. This can lead to power outages and reduced efficiency in power generation and transmission (Council on Foreign Relations, 2024).

Wildfires: Warmer, drier conditions caused by climate change are expected to make wildfires more frequent and intense. These wildfires can damage energy infrastructure, such as power lines and substations, leading to service disruptions (U.S. Environmental Protection Agency, 2023).

2.1.3 Water and Sanitation infrastructure

Access to clean water and adequate sanitation remains a significant challenge in Nigeria. Many urban and rural areas lack reliable water supply systems, leading to reliance on unsafe water sources. The water infrastructure is often characterized by aging pipes, inadequate treatment facilities, and poor maintenance (WaterAid, 2023). Sanitation infrastructure is also inadequate, with many communities lacking proper sewage systems and waste management facilities. This has led to environmental pollution and health issues.

How Climate affects Water and Sanitation Infrastructure

Reduced Water Availability: Climate change can lead to reduced water availability due to decreased rainfall and increased evaporation rates. This can result in water scarcity, affecting both drinking water supplies and agricultural needs (UNICEF, 2022).

Increased Contamination: More frequent and intense rainfall can lead to flooding, which can contaminate water sources with pollutants and pathogens. This poses significant health risks, particularly in areas with inadequate sanitation facilities (UNICEF, 2022).

Damage to Infrastructure: Extreme weather events, such as heavy rainfall, can damage water supply and sanitation infrastructure. This includes the destruction of pipes, pumps, and treatment facilities, leading to service disruptions

2.1.4 Telecommunication Infrastructure

Nigeria's telecommunications sector has seen significant growth over the past two decades, driven by the liberalization of the sector and the entry of private operators. Mobile phone penetration has increased dramatically, and internet access has expanded. The government has launched initiatives to improve broadband infrastructure and promote digital inclusion. The National Broadband Plan aims to increase broadband penetration and enhance internet access across the country.

How Climate affects Telecommunication Infrastructure

Damage from Extreme Weather: Extreme weather events, such as storms, can cause significant damage to telecommunication infrastructure, including cell towers, cables, and data centres.

Heat Stress: Higher temperatures can affect the performance and reliability of telecommunication equipment. Heatwaves can lead to overheating of data centres and other critical infrastructure, resulting in service disruptions (Riverside Technology, Inc. & Acclimatise, 2014).

Flooding: Increased rainfall and rising sea levels can lead to flooding, which can damage underground cables and other telecommunication infrastructure. This can result in prolonged service outages and increased maintenance costs

Supply Chain Disruptions: Climate change can also impact the supply chains for telecommunication equipment and materials. Extreme weather events can disrupt the production and transportation of critical components, leading to delays and increased costs (Riverside Technology, Inc. & Acclimatise, 2014).

2.1.5 Housing Infrastructure

Nigeria faces a severe housing deficit, estimated at around 17 million units (Nigerian Institute of Architects, 2013). The housing stock is characterized by informal settlements, inadequate housing conditions, and a lack of basic services. Rapid urbanization and population growth have exacerbated the housing crisis. Efforts to address the housing deficit include government housing schemes, public-private partnerships, and the

development of affordable housing projects. However, challenges such as land acquisition, funding, and regulatory issues continue to hinder progress.

Nigeria's infrastructure development faces numerous challenges, including inadequate funding, poor maintenance, and rapid urbanization. While there have been efforts to improve infrastructure across various sectors, significant investment and strategic planning are required to meet the country's growing needs. Continued collaboration between the government, private sector, and international organizations is essential to drive sustainable infrastructure development in Nigeria.

How Climate affects Housing Infrastructure

Increased Risk of Flooding: Climate change leads to more frequent and intense rainfall, which increases the risk of flooding. This can damage homes, particularly those in flood-prone areas, and lead to costly repairs and insurance claims

Heat Stress: Higher temperatures can affect the structural integrity of buildings. Prolonged heatwaves can cause materials like concrete and asphalt to expand and crack, leading to maintenance issues and reduced lifespan of housing infrastructure

Wildfires: Warmer and drier conditions increase the frequency and intensity of wildfires, which can destroy homes and entire communities. This is particularly problematic in areas with dense vegetation and dry climates

Sea Level Rise: Rising sea levels threaten coastal housing by increasing the risk of flooding and erosion. Homes in low-lying coastal areas are particularly vulnerable, and this can lead to displacement of communities and loss of property

Economic Impacts: Climate-related disasters can lead to increased housing costs and decreased property values. This affects housing affordability and can exacerbate existing housing crises, particularly in vulnerable communities (Center for Climate and Energy Solutions, 2021).

2.2 Climate -Resilience

Climate resilience refers to the ability of systems, communities, and individuals to withstand, adapt to, and recover from climate-related shocks and stresses. Climate resilience is often defined as the capacity of social, economic, and environmental systems to cope with hazardous events, trends, or disturbances related to climate change, while maintaining essential functions, structures, and feedbacks (IPCC, 2014). The concept encompasses both the ability to absorb shocks and the capacity to adapt and transform in response to long-term changes (Folke et al., 2010).

2.2.1 Key strategies for Enhancing Climate Resilience

- i. **Community-Based Adaptation:** Engaging local communities in resilience planning and implementation is crucial. This approach leverages local knowledge and ensures that interventions are context-specific and culturally appropriate (Reid et al., 2009).

- ii. *Ecosystem-Based Adaptation*: Utilizing biodiversity and ecosystem services to help communities adapt to the adverse effects of climate change. This includes the restoration of wetlands, mangroves, and forests to buffer against extreme weather events (Munang et al., 2013). Also Given the uncertainty surrounding climate projections, our infrastructure must be flexible and capable of accommodating a wide range of future scenarios.
- iii. *Sustainable Infrastructure Development*: Building resilient infrastructure that can withstand climate impacts is essential. This includes designing buildings, roads, and bridges that are resistant to flooding, heatwaves, and other climate-related hazards (World Bank, 2020).
- iv. *Inclusivity*: Resilient infrastructure must serve all members of society equitably, with particular attention to the needs of the marginalized and vulnerable populations.
- v. *Cost-Effectiveness*: While resilience may entail higher initial investments, it is crucial to demonstrate the long-term economic benefits of reduced disaster recovery costs and enhanced service life.
- vi. *Policy and Governance*: Effective policies and governance structures are necessary to support climate resilience. This includes integrating climate risks into national planning, creating regulatory frameworks, and ensuring adequate funding for resilience projects (UNDP, 2011).

2.3 Some Case study examples of climate resilience mitigation efforts in Nigeria:

2.3.1 Eko Atlantic City:

Objective: To create a new coastal city on reclaimed land to address the chronic shortage of real estate in Lagos and protect the coastline from erosion.

Approach: The project involves dredging approximately 90 million cubic meters of sand to reclaim 900 hectares of land. It includes the construction of a 7 km long rock revetment to protect the shoreline from the sea.

Results: Eko Atlantic City aims to provide a sustainable urban environment with modern infrastructure, reducing the vulnerability of Lagos to sea-level rise and coastal erosion (Spaces for Change, 2012)

2.3.2 Great Green Wall:

Objective: To combat desertification and land degradation, enhance food security, and build resilience to climate change in the Sahel region.

Approach: The initiative involves afforestation, reforestation, and sustainable land management practices across 11 countries, including Nigeria. It aims to restore 100 million hectares of degraded land by 2030.

Results: In Nigeria, the project has led to the restoration of degraded lands, improved livelihoods, and increased resilience of communities to climate impacts (National Agency for the Great Green Wall, 2023)

2.3.3 Kano Irrigation Project (ACReSAL):

Objective: To enhance agro-climatic resilience in semi-arid landscapes and improve sustainable landscape management.

Approach: The project focuses on sustainable land management practices, including afforestation, reforestation, and community climate resilience initiatives. It is supported by the World Bank and targets 19 northern states in Nigeria.

Results: The project has successfully planted over 1.5 million trees, restored thousands of hectares of land, and benefited millions of people by promoting sustainable agricultural practices and reducing the impacts of climate change (ACReSAL, 2024)

2.3.4 Nigeria Erosion and Watershed Management Project (NEWMAP):

Objective: To reduce vulnerability to soil erosion in targeted sub-watersheds.

Approach: The project combines civil engineering, vegetative land management, watershed protection measures, and community-led livelihood enhancements. It involves engagement from government at national, state, and local levels, as well as community and non-state actors.

Results: Over 1,558.62 hectares of degraded land have been reclaimed, benefiting over 9,318 people. The project has also developed 15 participatory sub-watershed management plans in various states (World Bank, 2019)

2.3.5 National Adaptation Plan (NAP):

Objective: To address Nigeria's climate challenges through a framework for different sectors of the economy to work together.

Approach: The NAP focuses on improving food and economic resilience, preventing deeper crises, and enhancing stakeholder engagement.

Results: The plan has helped raise awareness and understanding of climate change impacts among key stakeholders, although challenges in governance and collective action remain (Nwankpa, 2022)

2.3.6 Community-Based Adaptation Projects:

Objective: To enhance resilience at the community level through local actions.

Approach: These projects involve local communities in planning and implementing adaptation measures, such as improved agricultural practices, water management, and reforestation.

Results: These initiatives have helped communities better cope with climate impacts, although systemic risks and governance challenges persist (APRI, 2023)

3. METHODOLOGY

This involves conducting a comprehensive evaluation of existing infrastructure to identify vulnerabilities. Methods include visual inspections, surveys and interviews with stakeholders, and the use of instruments for quantitative data collection.

Data Collection sources include academic journals, government reports, World Bank publications, and field surveys. Techniques such as structured and semi-structured questionnaires, GIS analysis, and environmental monitoring systems are employed for the assessment. Data analysis includes condition assessment, vulnerability analysis, performance evaluation and Risk assessments to identify potential risks and prioritize them based on likelihood and severity. Below in Table 1 is a sequential detailed methodology for assessment of infrastructure and data collection

3.1 Methodology on Data Collection

Table 1a: sequential methodology steps for assessment of Nigeria critical infrastructure

S/N	RESEARCH STEPS	PROCEDURES
1	Literature Review	<ul style="list-style-type: none"> - Objective: Gather existing knowledge and background information. - Sources: Academic journals, government reports, and relevant literature. - Approach: Systematic review of literature.
2	Survey and Interviews	<ul style="list-style-type: none"> - Objective: Collect qualitative and quantitative data from stakeholders. - Target Respondents: Engineers, urban planners, government officials, and community leaders. - Tools: Structured and semi-structured questionnaires, interviews. - Approach: Purposive sampling to select respondents.

Table 1b: sequential methodology steps for assessment of Nigeria critical infrastructure

S/N	RESEARCH STEPS	PROCEDURES
3	Field Observations	<ul style="list-style-type: none"> - Objective: Assess the current state of infrastructure. - Locations: Key infrastructure sites. - Tools: Cameras, GPS devices, observation checklists. - Approach: Systematic observation and documentation.
4	Environmental Data Collection	<ul style="list-style-type: none"> - Objective: Gather data on environmental factors. - Sources: Meteorological stations, remote sensing data. - Tools: Weather stations, satellite imagery. - Approach: Continuous monitoring and recording.
5	Geospatial Analysis	<ul style="list-style-type: none"> - Objective: Analyse spatial data. - Sources: GIS databases, satellite imagery, maps. - Tools: GIS software (e.g., ArcGIS, QGIS). - Approach: Overlay analysis to identify hotspots of vulnerability.

6	Document Analysis	<ul style="list-style-type: none"> - Objective: Review existing infrastructure plans and records. - Sources: Government agencies, infrastructure management bodies. - Tools: Document review checklists. - Approach: Systematic review and extraction.
7	Focus Group Discussions	<ul style="list-style-type: none"> - Objective: Gain insights from stakeholders. - Participants: Diverse groups of stakeholders. - Tools: Discussion guides, recording devices. - Approach: Facilitate guided discussions.
8	Secondary Data Collection	<ul style="list-style-type: none"> - Objective: Complement primary data with existing datasets. - Sources: National Bureau of Statistics, World Bank, UN agencies. - Tools: Databases, statistical software. - Approach: Retrieve and analyse secondary data.

4. FINDINGS AND RESULTS

4.1 Assessment of available infrastructure in Nigeria.

Below is an assessment of Nigerian Infrastructure for the five key climate resilient areas; transportation, energy, water and sanitation, telecommunication and housing sector

Table 3a: Nigerian Infrastructure assessment

S/N	Infrastructure	Assessment of challenges	Reference
Transportation Sector			
i	Road network	Many roads are characterized by potholes, erosion, and general disrepair, leading to high transportation costs and accidents	Oxford Business Group, 2024
ii	Railway network	The railway network still requires significant investment to meet the country's growing transportation needs	Infrastructure Africa, n.d.
iii	Regional airports	Despite these upgrades, many regional airports still lack modern facilities and efficient operations (Nedozi, Obasanmi, & Ighata, 2021)	Nedozi, Obasanmi, & Ighata, 2021/ Field work
iv	Seaports	Seaports are critical for Nigeria's trade, but they face challenges such as congestion, inefficiency, and inadequate infrastructure	National Integrated Infrastructure Master Plan, 2020
v	Energy Sector	The power sector's inefficiencies are attributed to outdated infrastructure, poor maintenance, and financial constraints	(National Planning Commission, 2022) / Field work
vi	Water and Sanitation Sector	The government and international organizations have been working on	Public record

		projects to improve water and sanitation infrastructure, but progress has been slow	
vii	Telecommunication Sector	There are still challenges related to network coverage, quality of service, and affordability.	Public record/ Field work

Table 3b: Nigerian Infrastructure assessment

S/N	Infrastructure	Assessment of challenges	Reference
	Housing Sector	Challenges such as land acquisition, funding, and regulatory issues continue to hinder progress. Also, rapid urbanization and population growth have exacerbated the housing crisis.	(Nigerian Institute of Architects, 2013)

4.2 Nigeria's Ability to Anticipate, prepare for, respond to, and adapt to climate events.

Below are the findings on Nigeria's Preparedness for Climate events

S/N	Issues	Findings	Results
1	Early Warning Systems	Implementation of early warning systems for floods; gaps in coverage in rural areas	Reduced impact in some regions, but many communities lack timely access to warnings.
2	Climate Accountability and Governance	Need for greater accountability and transparency in climate governance.	Better monitoring and reporting but challenges remain in enforcement.
3	Community-Led Solutions	Importance of community participation in resilience efforts.	Success in some areas; need for widespread implementation.
4	Capacity Building and Training	Essential for improving disaster preparedness and response	Implemented training programs; need for more comprehensive efforts.
5	Funding and Resource Allocation	Challenges in accessing and using climate finance.	Efforts to secure funding; need for robust management frameworks.
6	Policy and Regulatory Frameworks	Developed policy frameworks; need for stronger enforcement.	Foundation for resilience; need for increased funding and enforcement.

4.3 Challenges, Barriers to achieving Climate Resilient Infrastructure in Nigeria

Building climate-resilient infrastructure in Nigeria is not without its challenges. Despite concerted efforts to make progress, there are several challenges and barriers to achieving climate-resilient infrastructure in Nigeria that has to be overcome. Among them are:

Funding: Securing adequate financial resources remains a significant challenge. Infrastructure projects often require substantial investment, and climate-resilient designs can be more costly upfront.

Capacity and Expertise: There is a need for enhanced technical capacity and expertise among professionals; engineers, urban planners, and other stakeholders involved in infrastructure development.

Enforcement of Building Codes: While Nigeria has developed policies and building codes aimed at promoting resilience, enforcement remains inconsistent, leading to non-compliance and substandard construction practices.

Public Awareness and Engagement: There is a need for greater public awareness and engagement on the importance of climate-resilient infrastructure. Communities must be involved in planning and implementation processes to ensure local relevance and acceptance.

4.4 Presented Opportunities to achieving Climate Resilient Infrastructure

However, these challenges also present opportunities for innovation and growth. For instance, public-private partnerships can mobilize the necessary funding and expertise, while community-based approaches can ensure that solutions are context-specific and widely accepted.

Emerging technologies also offer exciting possibilities. From advanced geospatial mapping for risk assessment to the use of artificial intelligence in predictive maintenance, the tools at our disposal are more powerful than ever. Leveraging these tools effectively requires a commitment to research and development, as well as an enabling policy environment (Onuoha; Ogbo & Amaechi, 2022).

6. RECOMMENDATIONS

To further enhance climate resilience, Nigeria needs to:

- i. *Invest in Research and Development:* Funding research into innovative materials and construction techniques that enhance resilience.
- ii. *Strengthen Policies and Regulations:* Ensure robust enforcement of building codes and standards.
- iii. *Capacity Building:* Provide training and education for professionals in the construction industry to enhance their understanding of climate resilience.

- iv. *Community Engagement*: Foster collaboration with local communities to integrate traditional knowledge and practices into resilience strategies.
- v. *Leverage Technology*: Utilize advanced technologies such as GIS and remote sensing for better planning and monitoring.
- vi. By addressing these challenges and implementing strategic measures, Nigeria can build a more resilient infrastructure capable of withstanding the impacts of climate change, ensuring the safety and well-being of its population.

7. CONCLUSION

Climate-resilient infrastructure is not merely an option; it is an existential necessity. It is a pathway to safeguarding our communities, preserving our environment, and ensuring sustainable development for future generations.

While Nigeria has made progress in preparing for, responding to, and adapting to climate events, challenges remain in enhancing early warning systems, improving accountability, supporting community-led solutions, building capacity, and securing funding. Addressing these areas is crucial for long-term climate resilience.

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