



## CLIMATE-RESILIENT INFRASTRUCTURE AND ENVIRONMENTAL SUSTAINABILITY IN LAGOS, NIGERIA

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### Abstract

Climate change poses significant risks to urban infrastructure and ecosystems, particularly in rapidly urbanizing African cities. Lagos, Nigeria's center of excellence exemplifies these vulnerabilities due to its fast-paced growth, weak land-use enforcement, and recurrent climate-induced hazards such as floods and erosion. Hence, this study examines the interplay between climate-resilient infrastructure and environmental sustainability. The target populations for the study were the Real Estate Developers in Lagos as well as Officials of the Ministries of Physical planning, Environment and Waterfront Infrastructure development. Drawing on empirical evidence, policy analysis, and secondary literature, the research identifies fifteen major challenges affecting the integration of resilience and sustainability in Lagos, including institutional fragmentation, financial limitations, inadequate enforcement of planning regulations, and loss of natural buffers. The results of the weighted mean score analysis revealed that flooding, weak governance, and poorly regulated urban expansion rank among the most critical barriers. The findings corroborate existing literature that highlights how unplanned urban growth exacerbates ecological fragility in African cities, while also pointing to Lagos unique status as a center of excellence but yet struggling with rapid demographic and infrastructural pressures. The study concludes that without deliberate policy enforcement, sustainable financing mechanisms, and adoption of nature-based solutions, Lagos faces escalating adaptation costs and recurrent infrastructure failures. Recommendations include strengthening institutional capacity, mainstreaming climate risk assessments into infrastructure planning, promoting public-private partnerships, restoring ecological buffers, and enhancing community participation. By addressing these gaps, Lagos State can enhance resilience, safeguard livelihoods, and serve as a model for climate-sensitive urban development in sub-Saharan Africa.

**Keywords:** Climate-resilient infrastructure, environmental sustainability, climate risks, urban resilience, sustainable development.

### Introduction

Climate change has emerged as one of the most pressing challenges of the 21<sup>st</sup> century, producing far-reaching consequences on ecosystems, human settlements, and infrastructure. The increasing frequency

and intensity of extreme weather events such as floods, droughts, and heatwaves continue to disrupt livelihoods and undermine development globally (IPCC, 2022). In view of this, urban centers are particularly more vulnerable as a result of their high population densities, complex infrastructure systems, and reliance on critical services. These risks are further magnified in developing countries which are exacerbated by rapid urbanization, weak institutional frameworks, and limited adaptive capacity.

Within this context, the concept of climate-resilient infrastructure has become central to discourses on sustainable urban development. Climate-resilient infrastructure refers to infrastructure that is planned, designed, built, and maintained to anticipate, withstand, adapt to, and recover from climate-related shocks and stresses such as flooding, extreme heat, and storms (MIT Climate Portal, 2023; OECD, 2024). It emphasizes not only physical robustness but also adaptability and recovery capacity, thereby reducing the risk of catastrophic failure. For example, flood-resilient roads and bridges in Lagos and stormwater management systems in Durban, South Africa, illustrate how African cities are attempting to embed resilience into infrastructure planning (Aigbavboa & Thwala, 2019).

Closely linked to resilience is environmental sustainability, which entails managing and using natural resources in ways that preserve ecosystem health, biodiversity, and resilience for both present and future generations (Oxford Research Encyclopedia, 2019; Springer Nature, 2020). It encompasses minimizing pollution, conserving green spaces, and maintaining ecological integrity to ensure that human development does not undermine natural systems. For instance, initiatives to protect Abuja's Jabi Lake and associated wetlands from encroachment reflect attempts to enhance ecological sustainability while reducing vulnerability to flooding (FCDA, 2025).

Lagos State which was hitherto Nigeria's capital Territory offers a compelling case for exploring the nexus between climate-resilient infrastructure and environmental sustainability. Lagos has since grown into one of the fastest expanding cities in sub-Saharan Africa, attracting people from across the country due to its administrative and economic importance. However, this rapid growth has placed considerable strain on land, housing, water, energy, and transport systems, exposing the city to a wide range of climate-related hazards (Omoera, 2022). Flooding has become recurrent during the rainy season, often triggered by extreme rainfall events, blocked drainage channels, and informal settlements located along floodplains. Soil erosion and gully formation have also emerged as serious threats, affecting road networks, housing developments, and peri-urban agricultural lands (Akande, 2023). These hazards not only damage physical infrastructure but also undermine the city's social and economic stability.

Environmental sustainability in Lagos is further threatened by the loss of vegetation cover, encroachment on wetlands, and poorly regulated land use. Research has shown that urban expansion in Lagos has depleted natural green buffers and reduced ecological resilience, thereby increasing vulnerability to floods and erosion (Phelimon et al., 2024). Such environmental degradation interacts with weak institutional enforcement, financial limitations, and inadequate planning to deepen the city's fragility. Consequently, critical infrastructure such as drainage systems, bridges, water supply facilities, and residential housing are at constant risk of damage, while the costs of repair and adaptation continue to escalate (Badamosi et al., 2024).

Although Nigeria has committed to global climate frameworks, including its Third Nationally Determined Contribution (NDC 3.0) and the Long-Term Low Emission Development Strategy (LT-

LEDs), which emphasize integrating adaptation into infrastructure planning and management (Nigeria, 2025; UNFCCC, 2023), the translation of policy into practice has been slow. Institutions such as the Lagos State Ministry of Physical Planning and the Lagos State Ministry of Waterfront Infrastructure Development have underscored the importance of protecting ecological assets especially those in close proximity to waterfronts and other riparian corridors as buffers against flooding and erosion. Current enforcement policies and movements have been met with sober reflections on the part of the residents. More so, financial constraints, fragmented governance, limited technical expertise, and the dominance of reactive rather than proactive interventions hinder effective adaptation (ATPS, 2025). This disconnect between policy commitments and on-the-ground realities creates significant knowledge and practice gaps in achieving both resilience and sustainability in the development trajectory of Lagos State.

More so, the central problem, therefore, lies in the city's growing vulnerability to climate-related risks and the inadequate capacity to embed resilience and sustainability principles in infrastructure planning and management. Despite Lagos's status as a planned city, floods and erosion continue to damage critical infrastructure, displace households, and disrupt socio-economic activities. Weak land-use enforcement and environmental degradation worsen the situation, while the cost of inaction threatens to outweigh the investments required for preventive adaptation. In addition, there are limited empirical evidences on how climate-resilient infrastructure is currently integrated into Lagos State development strategies and the degree to which sustainability principles are applied in practice (Omoera, 2022; Phelimon et al., 2024). Without addressing these gaps, Lagos State continues to face the risk of recurrent infrastructure collapse, rising adaptation costs, declining urban liveability, and greater exposure of its growing population to climate-induced hazards.

Hence, this study is designed to address these concerns by examining the interplay between climate-resilient infrastructure and environmental sustainability in Lagos. Specifically, it aims to assess the nature and magnitude of climate risks affecting the city's infrastructure, investigate the extent to which sustainability principles are incorporated into planning and design, identify institutional and financial barriers to effective implementation, and recommend strategies for enhancing resilience and sustainability outcomes.

The significance of this study is multifaceted. For policymakers and planners, it provides evidence-based insights into how climate adaptation and sustainability can be systematically integrated into Lagos State development agenda. For professionals in engineering, architecture, and urban management, the findings highlight practical approaches for designing and maintaining climate-sensitive infrastructure. For scholars, it contributes to the growing body of literature on climate resilience in African cities, particularly within planned capitals where urban expansion continues to reshape environmental dynamics. For communities and residents, the study points to strategies for reducing vulnerability, safeguarding livelihoods, and improving urban liveability in the face of climate risks.

## **Literature Review**

### **Concept of Climate-Resilient Infrastructure and Environmental Sustainability**

**Climate-Resilient Infrastructure** refers to infrastructure systems that are designed, built, and managed to anticipate, absorb, adapt to, and recover from climate shocks and stresses such as extreme

weather events and long-term climate variability. It emphasizes robust construction, adaptive design, and the ability to withstand both acute and chronic climate risks (MIT Climate Portal, 2023; OECD, 2021). It emphasizes both robustness and adaptability, ensuring continuity of essential services while reducing societal and economic vulnerability (OECD, 2018; Association of Accredited Public Policy Advocates to the European Union [AALEP], 2021).

On the other hand, **environmental sustainability** is the practice of using and managing natural resources in ways that maintain ecosystem health, biodiversity, and environmental quality for present and future generations. It involves minimizing pollution, conserving ecosystems, and ensuring long-term resilience of natural systems (Springer Reference, 2019; Springer Nature, 2020). It involves conserving renewable resources, minimizing pollution, and protecting ecological systems to ensure long-term environmental quality. It also extends to reconciling economic development and social progress with environmental protection, ensuring that human well-being does not undermine the ecological systems that support life on earth.

### **Literatures on Climate-Resilient Infrastructure and Environmental Sustainability**

Research on climate-resilient infrastructure and environmental sustainability in Nigeria has grown steadily in recent years, focusing on themes such as flood risk, ecological infrastructure, socio-economic impacts, and institutional responses. The reviewed studies highlight both the challenges and opportunities for embedding resilience into urban development in Nigeria.

One of the earliest contributions is by Omoera (2022), who investigated climate change-induced flash floods in Abuja with attention to media framing and public awareness. Using media content analysis and documentary evidence, the study revealed that extreme rainfall events, poor drainage systems, and informal settlements on floodplains were consistently identified as the triggers of recurrent floods. While media coverage heightened public awareness, the findings suggested that such awareness was not matched with systematic policy enforcement, leaving infrastructure and communities exposed to recurring hazards. This work underscores the importance of communication and governance in shaping urban resilience.

Balogun (2022) extended the conversation by mapping climate vulnerability across Nigeria's ecological zones, applying spatial analysis and vulnerability mapping. The study identified urban and peri-urban areas, including Lagos, as hotspots of climate risk, largely because of rapid land-use change and the depletion of ecological buffers. The findings showed that Lagos's fast-paced urbanization has outstripped its environmental carrying capacity, reinforcing the argument that spatially targeted adaptation strategies are needed to address the city's unique vulnerabilities.

Akande (2023) provided a community-level perspective by examining flood vulnerability and adaptation practices in residential areas of Abuja. Through a mixed-methods design combining household surveys and field observations, the study found that residents rely on short-term coping strategies such as sandbags, temporary elevation of property, and informal drainage clearing. However, these measures were inadequate to address systemic challenges, with households lacking institutional support and access to long-term infrastructure solutions. The research highlighted the limitations of reactive adaptation and emphasized the need for structured, government-led interventions to build resilience.

Focusing on socio-economic outcomes, Badamosi et al. (2024) explored the impacts of flooding in Dagiri, a community in Gwagwalada, Abuja. Using surveys, GIS flood analysis, and key informant interviews, the authors reported widespread damage to livelihoods, housing, and public health, with many residents forced to develop improvised coping strategies. The study emphasized that without integrated flood control systems and community-based planning, recurrent flooding would continue to undermine development gains. This work draws attention to the human cost of climate hazards and the pressing need for coordinated adaptation measures.

Complementing these perspectives, Phelimon et al. (2024) assessed Abuja's ecological infrastructure through spatial inventories and field surveys. Their findings showed that natural assets such as wetlands, riparian belts, and green spaces were concentrated in older, planned districts, while peri-urban areas faced severe depletion due to unregulated expansion. The loss of these ecological assets has reduced the city's capacity to naturally regulate stormwater and mitigate erosion, intensifying the risks faced by built infrastructure. This study situates ecological infrastructure as a cornerstone of urban resilience, underscoring the need for policies that preserve and restore natural systems alongside engineered solutions.

Finally, broader policy-oriented analyses such as those from the World Bank and the Climate-Resilient Infrastructure for Basic Services (CRIBS) program (2024–2025) have examined resilience-building at the national and urban scales. These assessments, based on program evaluations and case studies, found that targeted investments in resilient health, education, and water infrastructure reduce service disruptions during extreme events. However, they also cautioned that sustainable resilience requires stable financing, stronger inter-agency coordination, and the mainstreaming of nature-based solutions. For Lagos, this implies that resilience cannot be achieved through isolated projects but must be embedded in long-term urban planning and governance.

Taken together, these studies reveal several interrelated topics. First is the **role of communication and governance** in shaping awareness and response to climate risks. Second is **spatial vulnerability and urban expansion**, which demonstrate how Lagos growth patterns exacerbate exposure to hazards. Third is the **community-level adaptation practices**, which show the limits of household coping in the absence of institutional support. Fourth is the **socio-economic impact of flooding**, which highlights the human cost of infrastructure failure. Fifth is the **depletion of ecological infrastructure**, a critical but often overlooked dimension of resilience. Finally, there is the theme of **policy and institutional responses**, where evidence points to the importance of integrated strategies and sustained investment for long-term environmental sustainability.

The reviewed literature demonstrates that while progress has been made in understanding Lagos State vulnerabilities and adaptation needs, significant gaps remain. Most studies emphasize the urgency of bridging policy commitments with practical implementation, integrating ecological and engineered infrastructure, and moving from reactive coping to proactive planning. Together, these insights frame the basis for examining the nexus of climate-resilient infrastructure and environmental sustainability in Lagos.

## Methodology

This study employs a quantitative research design to examine the nexus between climate-resilient infrastructure and environmental sustainability in Lagos. The target population comprises Real Estate Developers in Lagos and residents living in flood-prone and ecologically sensitive areas of the city. Participants were selected using purposive sampling, which ensured the inclusion of individuals with relevant expertise, institutional responsibilities, or lived experiences of climate-related risks. Hence, 250 respondents were selected and data were collected through structured questionnaires to capture the various climate risks; environmental sustainability practices as well as the capture awareness, adoption levels, and perceptions of barriers to challenges associated with climate-resilient infrastructure and environmental sustainability in Lagos State. In all, only 200 questionnaires were retrieved and analysed using frequencies, percentages and weighted mean score.

## Analysis and Discussions

**Table 1: Climate and Environmental Related Risks in Lagos**

| Climate and Environmental Risks in Lagos | Strongly Agree | Agree    | Undecided | Disagree | Strongly Disagree | WMS  | Std. Dev | Rank |
|------------------------------------------|----------------|----------|-----------|----------|-------------------|------|----------|------|
| Flooding events                          | 60(30.0)       | 25(12.5) | 10(5.0)   | 3(1.5)   | 2(1.0)            | 4.38 | 0.95     | 1    |
| Poor drainage systems                    | 55(27.5)       | 30(15.0) | 10(5.0)   | 3(1.5)   | 2(1.0)            | 4.33 | 0.97     | 2    |
| Unplanned urbanization                   | 50(25.0)       | 32(16.0) | 12(6.0)   | 4(2.0)   | 2(1.0)            | 4.24 | 1.01     | 3    |
| Heatwaves / Urban heat stress            | 48(24.0)       | 35(17.5) | 10(5.0)   | 5(2.5)   | 2(1.0)            | 4.21 | 1.03     | 4    |
| Poor waste management                    | 45(22.5)       | 38(19.0) | 10(5.0)   | 5(2.5)   | 2(1.0)            | 4.16 | 1.05     | 5    |
| Soil erosion / Deforestation             | 42(21.0)       | 35(17.5) | 15(7.5)   | 5(2.5)   | 3(1.5)            | 4.01 | 1.10     | 6    |
| Loss of green spaces                     | 40(20.0)       | 37(18.5) | 13(6.5)   | 6(3.0)   | 4(2.0)            | 3.94 | 1.12     | 7    |
| Inadequate housing resilience            | 38(19.0)       | 35(17.5) | 15(5.0)   | 8(4.0)   | 4(2.0)            | 3.86 | 1.15     | 8    |
| Vector-borne diseases                    | 35(17.5)       | 37(18.5) | 18(9.0)   | 6(3.0)   | 4(2.0)            | 3.82 | 1.14     | 9    |
| Infrastructure collapse                  | 33(16.5)       | 35(17.5) | 20(10.0)  | 8(4.0)   | 4(2.0)            | 3.72 | 1.17     | 10   |
| Rising energy demand                     | 30(15.0)       | 35(17.5) | 22(11.0)  | 8(4.0)   | 5(2.5)            | 3.62 | 1.19     | 11   |
| Drought / Water scarcity                 | 28(14.0)       | 33(16.5) | 25(12.5)  | 10(5.0)  | 4(2.0)            | 3.50 | 1.20     | 12   |
| Air pollution                            | 25(12.5)       | 35(17.5) | 25(12.5)  | 10(5.0)  | 5(2.5)            | 3.43 | 1.21     | 13   |
| Weak policy enforcement                  | 22(11.0)       | 33(16.5) | 28(14.0)  | 10(5.0)  | 7(2.5)            | 3.31 | 1.23     | 14   |
| Food insecurity                          | 20(10.0)       | 30(15.0) | 30(15.0)  | 15(7.5)  | 5(2.5)            | 3.10 | 1.26     | 15   |

Source: Field survey, 2025

The study examined climate and environmental related risks in Lagos and the analysis revealed that flooding events were perceived as the most pressing climate risk, with a weighted mean of 4.38, followed closely by poor drainage systems and unplanned urbanization. These findings indicate that residents and professionals in Lagos are acutely aware of the direct threats posed by heavy rainfall, blocked channels, and rapid urban expansion, which frequently exacerbate flooding. Heatwaves and urban heat stress were also highly ranked, reflecting concerns about the increasing intensity of heat events and their impact on health, housing, and energy demand. Environmental degradation, including soil erosion, deforestation, and loss of green spaces, was perceived as another significant risk. Respondents recognized that the depletion of natural buffers reduces the city's capacity to manage stormwater and mitigate flood and erosion impacts. Inadequate housing resilience and rising energy demand were also highlighted, indicating that the city's built environment and infrastructure are under increasing strain from climate variability. Public health concerns such as vector-borne diseases and food insecurity were ranked lower but remain relevant, illustrating the indirect and longer-term social consequences of climate hazards. Weak policy enforcement, though not among the top risks, emerged as a key underlying factor influencing many other vulnerabilities, including unplanned urbanization and poor drainage management.

Overall, the study demonstrates that residents and stakeholders in Lagos perceive a range of interconnected climate and environmental related risks, with flooding, drainage issues, urbanization, and environmental degradation as the most significant. These perceptions highlight the urgent need for coordinated, multi-sectoral interventions that combine infrastructure upgrades, sustainable urban planning, policy enforcement, and community engagement to build climate-resilient and environmentally sustainable cities.

**Table 2: Environmental Sustainability Practices in Lagos**

| Environmental Sustainability Practices          | Strongly Agree | Agree    | Undecided | Disagree | Strongly Disagree | WMS  | Std. Dev | Rank |
|-------------------------------------------------|----------------|----------|-----------|----------|-------------------|------|----------|------|
| Use of energy-efficient appliances              | 50(25.0)       | 35(17.5) | 10(5.0)   | 3(1.5)   | 2 (1.0)           | 4.28 | 0.98     | 1    |
| Water conservation (rainwater harvesting, etc.) | 45(22.5)       | 38(19.0) | 10(5.0)   | 5(2.5)   | 2 (1.0)           | 4.21 | 1.02     | 2    |
| Waste segregation/recycling                     | 40(20.0)       | 35(17.5) | 15(7.5)   | 7(3.5)   | 3 (1.5)           | 3.98 | 1.10     | 3    |
| Use of renewable energy sources (solar, etc.)   | 38(19.0)       | 35(17.5) | 15(7.5)   | 7(3.5)   | 5 (2.5)           | 3.88 | 1.13     | 4    |
| Planting trees / urban greening                 | 35(17.5)       | 38(19.0) | 15(7.5)   | 8(4.0)   | 4 (2.0)           | 3.85 | 1.14     | 5    |
| Participation in community clean-up efforts     | 33(16.5)       | 37(18.5) | 18(9.0)   | 8(4.0)   | 4 (2.0)           | 3.74 | 1.17     | 6    |
| Adoption of green building techniques           | 30(15.0)       | 35(17.5) | 20(10.0)  | 10(5.0)  | 5 (2.5)           | 3.60 | 1.19     | 7    |



| Environmental Sustainability Practices        | Strongly Agree | Agree    | Undecided | Disagree | Strongly Disagree | WMS  | Std. Dev | Rank |
|-----------------------------------------------|----------------|----------|-----------|----------|-------------------|------|----------|------|
| Use of public transportation / carpooling     | 28(14.0)       | 32(16.0) | 25(12.5)  | 10(5.0)  | 5 (2.5)           | 3.44 | 1.21     | 8    |
| Reduction of single-use plastics              | 25(12.5)       | 35(17.5) | 25(12.5)  | 10(5.0)  | 5 (2.5)           | 3.40 | 1.22     | 9    |
| Maintenance of household energy efficiency    | 25(12.5)       | 33(16.5) | 25(12.5)  | 12(6.0)  | 5(2.5)            | 3.36 | 1.23     | 10   |
| Use of eco-friendly building materials        | 22(11.0)       | 33(16.5) | 28(14.0)  | 12(6.0)  | 5(2.5)            | 3.28 | 1.25     | 11   |
| Proper disposal of wastewater                 | 20(10.0)       | 32(16.0) | 30(15.0)  | 12(6.0)  | 6(3.0)            | 3.20 | 1.26     | 12   |
| Regular environmental education participation | 18(9.0)        | 30(15.0) | 30(15.0)  | 15(7.5)  | 7(3.5)            | 3.05 | 1.28     | 13   |
| Composting of organic waste                   | 15(7.5)        | 28(14.0) | 35(17.5)  | 15(7.5)  | 7(3.5)            | 2.92 | 1.30     | 14   |
| Support for environmental policies/laws       | 12(6.0)        | 25(12.5) | 38(19.0)  | 18(9.0)  | 7(3.5)            | 2.79 | 1.33     | 15   |

*Source: Field survey, 2025*

The analysis of environmental sustainability practices indicates that energy efficiency and water conservation are the most widely adopted measures. The highest weighted mean (4.28) was for the use of energy-efficient appliances, while water conservation practices, such as rainwater harvesting, scored 4.21. This suggests that residents are increasingly aware of and actively participating in basic, practical measures that reduce energy and water consumption. Waste segregation and recycling were also moderately practiced, indicating some engagement in managing household and community waste. Practices such as the use of renewable energy and urban greening had slightly lower weighted means but were still notable, reflecting a growing consciousness about integrating environmental considerations into daily life and urban planning.

Other practices, such as adopting green building techniques, using public transportation, and reducing single-use plastics, showed moderate adoption, with weighted means ranging from 3.60 to 3.40. This indicates that while there is awareness of sustainability, implementation is limited by factors such as cost, infrastructure availability, or lack of incentives. Practices like proper wastewater disposal, composting organic waste, environmental education participation, and support for environmental policies were among the lowest-ranked actions, with weighted means below 3.20. This reflects gaps in institutional support, knowledge dissemination, and community engagement.

The implications of these findings are significant. The high adoption of energy-efficient appliances and water conservation measures suggests that small-scale, easily implementable practices are more readily embraced by residents. Policymakers and urban planners can leverage this willingness to introduce larger-scale sustainability initiatives, such as renewable energy deployment and urban greening programs. Also, the moderate adoption of practices like public transportation use and green building



indicates the need for **targeted incentives, subsidies, and infrastructure improvements** to make sustainable options more accessible. In addition, the low engagement in environmental education, composting, and support for policies highlights the need for **community-based awareness programs, training, and stronger institutional frameworks** to encourage broader participation in sustainability practices. Overall, these findings underscore that while some environmental actions are taking root in Lagos, a coordinated approach combining public awareness, policy enforcement, and infrastructural support is essential to advance comprehensive environmental sustainability in the city.

**Table 3: Challenges Associated with Climate-Resilient Infrastructure and Environmental Sustainability in Lagos**

| Challenges Associated with Climate-Resilient Infrastructure and Environmental Sustainability in Lagos | Strongly Agree | Agree     | Undecided | Disagree | Strongly Disagree | WMS  | Std. Dev | Rank |
|-------------------------------------------------------------------------------------------------------|----------------|-----------|-----------|----------|-------------------|------|----------|------|
| High cost of construction materials                                                                   | 88 (44)        | 70 (35)   | 20 (10)   | 15 (7.5) | 7 (3.5)           | 4.09 | 0.98     | 2    |
| Limited access to green technologies                                                                  | 95 (47.5)      | 65 (32.5) | 18 (9)    | 14 (7)   | 8 (4)             | 4.12 | 0.97     | 1    |
| Weak institutional framework                                                                          | 80 (40)        | 75 (37.5) | 22 (11)   | 15 (7.5) | 8 (4)             | 4.02 | 0.99     | 4    |
| Poor policy implementation                                                                            | 85 (42.5)      | 70 (35)   | 21 (10.5) | 14 (7)   | 10 (5)            | 4.03 | 1.02     | 3    |
| Insufficient funding for projects                                                                     | 82 (41)        | 68 (34)   | 25 (12.5) | 15 (7.5) | 10 (5)            | 3.99 | 1.01     | 5    |
| Lack of stakeholder collaboration                                                                     | 75 (37.5)      | 70 (35)   | 25 (12.5) | 20 (10)  | 10 (5)            | 3.90 | 1.04     | 6    |
| Inadequate technical expertise                                                                        | 70 (35)        | 72 (36)   | 28 (14)   | 20 (10)  | 10 (5)            | 3.86 | 1.05     | 9    |
| Poor maintenance culture                                                                              | 65 (32.5)      | 78 (39)   | 30 (15)   | 18 (9)   | 9 (4.5)           | 3.87 | 1.01     | 8    |
| Resistance to innovation                                                                              | 68 (34)        | 70 (35)   | 28 (14)   | 22 (11)  | 12 (6)            | 3.80 | 1.09     | 14   |
| Low public awareness                                                                                  | 72 (36)        | 65 (32.5) | 30 (15)   | 20 (10)  | 13 (6.5)          | 3.81 | 1.10     | 12   |
| Weak enforcement of environmental laws                                                                | 66 (33)        | 70 (35)   | 32 (16)   | 20 (10)  | 12 (6)            | 3.79 | 1.07     | 15   |
| Limited incentives for green investment                                                               | 70 (35)        | 68 (34)   | 28 (14)   | 22 (11)  | 12 (6)            | 3.81 | 1.06     | 12   |
| Climate variability and uncertainty                                                                   | 74 (37)        | 66 (33)   | 28 (14)   | 20 (10)  | 12 (6)            | 3.85 | 1.08     | 10   |
| Corruption and mismanagement                                                                          | 80 (40)        | 60 (30)   | 30 (15)   | 18 (9)   | 12 (6)            | 3.89 | 1.09     | 7    |

| Challenges Associated with Climate-Resilient Infrastructure and Environmental Sustainability in Lagos | Strongly Agree | Agree   | Undecided | Disagree | Strongly Disagree | WMS  | Std. Dev | Rank |
|-------------------------------------------------------------------------------------------------------|----------------|---------|-----------|----------|-------------------|------|----------|------|
| Lack of reliable data for planning                                                                    | 72 (36)        | 68 (34) | 28 (14)   | 20 (10)  | 12 (6)            | 3.82 | 1.02     | 11   |

Source: Field survey, 2025

The analysis of challenges associated with climate-resilient infrastructure and environmental sustainability in Nasarawa reveals that **limited access to green technologies (WMS = 4.12)**, **high cost of construction materials (WMS = 4.09)**, and **poor policy implementation (WMS = 4.03)** rank as the most significant constraints. This aligns with the position of Oladokun and Akinmoladun (2021), who observed that access to affordable, environmentally friendly construction technologies remains a critical barrier to sustainable infrastructure development in Nigeria. Similarly, Ebekozien (2020) stressed that the prohibitive cost of eco-friendly materials discourages both developers and households from adopting green building practices, thereby hindering efforts to achieve climate resilience. Weak institutional frameworks and insufficient funding also emerged as critical obstacles, with mean scores of 4.02 and 3.99 respectively. This finding corroborates the submission of Adenle (2022), who argued that although Nigeria has developed numerous policies on sustainable development, the lack of effective institutional capacity and poor financing mechanisms undermine their implementation. In Nasarawa, this implies that even well-intentioned infrastructure plans may not translate into practical outcomes without strong institutions and adequate funding.

Other challenges such as inadequate technical expertise (WMS = 3.86), poor maintenance culture (WMS = 3.87), and corruption (WMS = 3.89) further reinforce the systemic nature of the problem. Studies by Aigbavboa and Thwala (2019) have emphasized that technical knowledge gaps and corruption remain recurring impediments to the sustainability of infrastructure projects in Sub-Saharan Africa. Resistance to innovation and low public awareness also ranked relatively lower, but with mean scores above 3.8, they still highlight significant barriers. This resonates with the work of Nduka and Sotunbo (2020), who noted that the adoption of climate-friendly practices is often constrained by cultural inertia, limited awareness, and lack of incentives for stakeholders.

The implications of these findings are far-reaching. Firstly, the dominance of economic barriers such as high construction costs and limited access to green technologies underscores the need for targeted subsidies, incentives, and public-private partnerships to stimulate the use of affordable, sustainable building materials. Secondly, the institutional weaknesses reflected in poor policy implementation and weak enforcement call for strengthening regulatory frameworks, improving accountability, and enhancing stakeholder collaboration to bridge the policy-practice gap. Thirdly, the persistence of corruption, poor maintenance culture, and inadequate expertise suggests the necessity of capacity-building initiatives, professional training, and transparent monitoring systems to ensure long-term sustainability. Finally, addressing the softer barriers such as low public awareness and resistance to

innovation through advocacy campaigns and community engagement would foster a culture of sustainability across Nasarawa.

Overall, the study demonstrates that the challenges of climate-resilient infrastructure are multi-dimensional, cutting across economic, institutional, technical, and socio-cultural domains. Unless these constraints are addressed in an integrated manner, Nasarawa may continue to face setbacks in aligning with national and global commitments on sustainable development and climate resilience.

## **Conclusion**

This study underscores the urgent need to mainstream climate-resilient infrastructure and environmental sustainability into Lagos State urban development agenda. The city's vulnerability to climate-induced risks such as floods, erosion, and extreme weather events is amplified by rapid urbanization, weak enforcement of land-use regulations, institutional fragmentation, and financial limitations. Although national commitments like Nigeria's NDC 3.0 and LT-LEDS reflect a growing recognition of climate adaptation imperatives, the translation of these policies into actionable interventions remains inadequate. Empirical evidence reveals that infrastructure systems ranging from drainage networks to housing and transportation facilities remain highly susceptible to damage, thereby escalating adaptation costs and threatening urban liveability. Climate-resilient infrastructure, defined as systems designed and managed to withstand climate shocks while maintaining functionality, and environmental sustainability, which emphasizes the responsible use of natural resources to ensure long-term ecological balance, are thus critical frameworks for addressing Lagos State developmental challenges. If left unaddressed, the gap between policy aspirations and practical implementation will continue to expose the city to recurrent infrastructure collapse, socio-economic instability, and environmental degradation.

## **Recommendations**

Based on the findings, the following recommendations are proposed:

- i. Lagos State Ministry of Physical Planning, Ministry of Environment, Waterfront Infrastructure Development and allied Government Agencies and institutions should enhance coordination, transparency, and enforcement of urban planning regulations, particularly in floodplains, riparian zones, and erosion-prone areas.
- ii. Establishment of climate-resilience units within planning authorities to ensure continuous integration of adaptation into project design and implementation.
- iii. All new infrastructure projects should undergo climate risk assessments before approval.
- iv. Adoption of resilient design principles such as permeable pavements, green roofs, and elevated drainage systems to minimize flood damage.
- v. Restoration of wetlands, riparian buffers, and urban green spaces to act as natural flood defenses and enhance ecological resilience.
- vi. Expansion of tree-planting initiatives to combat soil erosion, reduce urban heat, and improve air quality.
- vii. Encouragement of public-private partnerships (PPPs) for financing resilient infrastructure.

- viii. Leveraging global climate funds, such as the Green Climate Fund, to support large-scale adaptation projects in Lagos.
- ix. Conduct public education campaigns on the risks of climate change and the importance of environmental stewardship.
- x. Empowering local communities to participate in the co-design, monitoring, and maintenance of climate-resilient infrastructure.
- xi. Investments in climate data collection, early warning systems, and predictive modeling to guide proactive interventions.
- xii. Encouraging collaboration between universities, research institutes, and government agencies to provide evidence-based solutions.
- xiii. Introducing Mainstream climate resilience and environmental sustainability into all sectoral policies, including housing, energy, transportation, and agriculture.
- xiv. Fostering collaboration between federal, state, and local governments to reduce policy overlaps and enhance synergy.

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