

# Achieving Sustainability in Civil Engineering Projects in Nigeria: A Case For Climate Change

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## Abstract

This paper investigates the nexus between infrastructure and climate change in Nigeria, particularly amidst rapid urbanization. Employing a qualitative methodology, the study delves into industry perspectives, prevailing sustainable practices, and recommendations through in-depth interviews with ten seasoned professionals spanning Nigeria's six geopolitical zones. Study findings underscore a growing awareness of climate change, manifested through tangible impacts like flooding, heatwaves, loss of livelihood, biodiversity loss, desertification, and health repercussions. However, a noticeable knowledge gap persists, particularly concerning the implications for the built environment. Encouragingly, participants are already incorporating certain sustainable practices such as green land conservation, renewable energy, and low-carbon materials, albeit predominantly in highway and building projects. The study highlights an urgent imperative to expedite the construction industry's shift toward climate-conscious practices. This necessitates robust interventions encompassing awareness campaigns, legislative measures, incentives, and fostering public-private collaboration. The study underscores that as Nigeria progresses towards its infrastructure development ambitions, overlooking the sector's environmental implications risks exacerbating emissions.

## Keywords

Climate Change, Civil Engineering Projects, Construction, Emissions, Greenhouse gases., Nigeria, Sustainability

## 1. Introduction

Civil engineering projects worldwide, ranging from railways to skyscrapers, play a crucial role in a nation's development, impacting the economy, society, and the environment. Recognizing the environmental consequences, the global community, through the United Nations Sustainable Development Goals (SDGs), emphasizes the integration of sustainable practices in construction to mitigate climate change effects (UN 2019). Nigeria, as the most populous black nation, faces the challenge of meeting infrastructure needs amid rapid population growth, necessitating sustainable approaches to prevent exacerbating climate change impacts. The UN World Commission on Environment and Development defines sustainable development as meeting current needs while preserving the ability of future generations to meet their own. The 2030 Agenda for Sustainable Development underscores the importance of inclusive development, with SDG 13 specifically addressing the need to tackle climate change and its impacts (UN, 2019). Civil engineering projects contribute significantly to global CO<sub>2</sub> emissions, necessitating a shift towards sustainable practices to address climate change (UN, 2022).

Nigeria, facing rapid population growth, aims to address its infrastructure deficit through the National Integrated Infrastructure Master Plan, projecting a substantial contribution to GDP by 2043. However, this growth may lead to increased carbon emissions, exacerbating climate change impacts already evident in extreme weather events (FGN, 2020). This study aims to investigate the sustainability of civil engineering projects in Nigeria and its implications for climate change. Specifically, the study seeks to address the following key questions.

- 1) How do civil engineering professionals in Nigeria perceive the significance of climate change in the built environment?
- 2) What sustainable practices are currently being employed in civil engineering projects, specifically in highway and building projects, in Nigeria concerning climate change?

- 3) What recommendations can be put forward to stakeholders to effectively reduce greenhouse gas emissions in civil engineering projects and foster sustainability in Nigeria?

## **2. Background/literature review**

### **2.1 Climate Change Impacts in Nigeria**

Climate change has had profound impacts in Nigeria, evident in rising temperatures, fluctuating rainfall patterns, elevated sea levels, and extreme weather events. Anabaraonye et al. (2022) described these changes as serious threats to the country's environment, economy, health, and security. Climate change impacts various sectors in Nigeria, including agriculture, construction, health, and the economy. Desert encroachment threatens livestock production, while coastal regions suffer from erosion and flooding, impacting agricultural productivity. These challenges contribute to projections of significant GDP reduction by 2050, particularly affecting agriculture and overall economic stability (World Bank, 2021).

At the heart of the climate change discourse lies the Intergovernmental Panel on Climate Change (IPCC), a collaborative platform where scientists, policymakers, and stakeholders converge to assess the evolving science, address climate risks, and inform mitigation and adaptation strategies. International agreements like the Sustainable Development Goals (SDGs) and the Paris Agreement reflect global recognition of the crisis, setting ambitious targets for transitioning towards low-carbon economies and building resilience to climate impacts. However, challenges abound in translating these commitments into tangible progress. The case of Nigeria exemplifies this struggle, where climate policies exist but achieving emission reduction targets remains a work in progress, highlighting the intricate dance between good intentions and the complexities of implementation (CAT, 2023). In summary, climate change in Nigeria manifests through various impacts on the environment, economy, health, and security.

### **2.2 Civil Engineering Projects Relationship with Climate Change**

The relationship between civil engineering projects and climate change is a critical aspect of sustainable development. Infrastructure projects have been recognized as fundamental drivers of economic progress since the 1960s, serving as metrics for growth and indicators of a nation's competitiveness and overall standard of living (UN, 2022). However, the creation of civil engineering projects comes with significant impacts on society, the economy, and the environment.

Environmental impacts of these projects include the emission of greenhouse gases (GHGs) such as CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O (UN, 2019). The civil engineering sector contributes over 40% of the world's carbon emissions, with GHG emissions arising from the production and movement of construction materials, construction equipment energy consumption, resource processing, and construction waste disposal (Zhou et al., 2018). Despite Africa, including Nigeria, having a relatively low carbon footprint compared to developed countries, meeting mitigation targets remains a challenge (CAT, 2023).

To address the environmental impacts and reduce carbon emissions in civil engineering projects, sustainable practices are crucial (Jackson, 2020). One key approach is the adoption of green infrastructure, defined by National Construction Sector Lead U.S in 2009 as projects that ensure a healthier and safer environment while making effective use of water, energy, land, and materials. Green infrastructure practices aim to mitigate CO<sub>2</sub> emissions and energy consumption in construction.

One sustainable practice is the use of assessment tools or rating systems, such as Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment (BREEAM). These tools measure and compare the environmental performance of construction structures, providing benchmarks for global sustainability in construction practices (Akinyemi et al., 2017). The construction process itself plays a vital role in emissions reduction. Alternative construction materials and energy-efficient practices are recommended to minimize embodied carbon structures. Additionally, optimizing transportation and logistics, waste management through the 3Rs (reducing, reusing, and recycling), and efficient energy usage on project sites contribute to emissions reduction (National Construction Sector Lead U.S., 2009).

Green land conservation and afforestation further aid in reducing carbon emissions, showcasing the importance of site preservation and responsible tree management. Quantifying the carbon footprint of civil engineering projects is essential for monitoring and managing emissions (Minnemeyer & Octavia, 2017). While some developed countries have made strides in adopting sustainable practices in civil engineering, there is a need for increased awareness and implementation in developing countries, including Nigeria (Akinyemi et al, 2017).

Despite global advocacy for reduced greenhouse gas emissions, comprehensive research addressing the challenge in Nigeria is lacking. Daniel et al (2018) paper focused on the barriers to sustainable construction for developing countries with some emphasis on the effect of climate change, despite uncovering issues like lack of strategy and expertise they overlooked actual measures to reduce emissions in construction activities. Additionally, existing research in Nigeria primarily relied on secondary datasets, and efforts to understand the reasons behind high emission percentages were insufficient (Akande, 2015). Although Akinyemi et al. (2017) provided insights into types of sustainable practices applicable to construction, they did not investigate which of these practices are currently adopted within Nigeria.

This study aims to fill critical gaps unearthed in the literature through understanding the intersection of civil engineering and climate change in Nigeria. Utilizing a qualitative methodology centered around in-depth interviews with industry professionals, the research captures insights into the sector's perceptions of climate change. It also identifies current sustainable practices being adopted and proposes targeted recommendations to significantly reduce greenhouse gas emissions within the construction industry.

### 3. Research Design and Methodology

The methodology employed in the research used a systematic approach to address the research objectives. A qualitative research design was used to investigate the sustainability of civil engineering projects in Nigeria with a focus on climate change. The methodology is aligned with the research onion model and paradigm, ensuring a comprehensive exploration of the research questions (Creswell, 2014).

**Table 1. Research Design Summary**

Research design	Qualitative approach
Data Collection	One on One Interviews
Sampling	Purposive Sampling
Participants	10 experienced professionals
Data Analysis	Thematic Coding

#### 3.1 Sampling and Data Collection

The study employed purposive sampling to select participants to ensure relevance to the research objectives, enhance the depth of analysis, and achieve representation of diverse perspectives within the construction industry. The participants' profiles are shown in Table 2 below

**Table 2. Respondent demography**

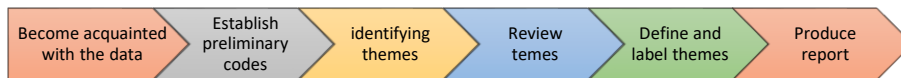
Current Job Title/Sector	Years of Experience	Educational Background	Affiliation with Professional bodies	Code Name	Geopolitical Zone
Environmentalist/Private Sector	21	Masters of Business Administration and Doctor of Philosophy	NES and COREN	EVM001	Southwest
Civil Engineer/Private Sector	27	Master of Science	NSE and COREN	CVE002	Southwest
Civil Engineer/Public Sector	23	Bachelor of Science	NSE and COREN	CVE003	Northcentral
Civil Engineer/Private Sector	25	Bachelor of Engineering and Master of Business Administration	COREN	CVE004	Northcentral
Builder/Private Sector	20	Bachelor of Science	CORBON	BLD005	Southsouth
Quantity Surveyor/Private sector	23	Master of Science	NIQS and QSRBN	QS006	Southsouth
Urban and Regional Planner/Public sector	24	Master of Science	COREN	URP007	Southeast
Civil Engineer/Public sector	28	Bachelor of Science	COREN	CVE008	Southeast
Civil Engineer/Public sector	33	Master of Science	COREN and NSE	CVE009	Northeast

Primary data was collected via recorded interviews using Microsoft Teams and telephone calls. Participants provided personal details and job roles. Pre-interview briefings on study objectives, consent approval, privacy, and confidentiality were assured.

### 3.2 Data Analysis procedure

The data analysis employed thematic coding, following the six stages outlined by Braun and Clarke (2006).

Figure 2: Flowchart of Qualitative Analysis Adapted from Braun and Clarke (2006)



## 4. Results and implication

This study explores the perception of climate change significance among Civil engineering professionals in Nigeria, identifies current sustainable practices in highway and building projects, and offers recommendations to stakeholders for reduction of greenhouse gas emissions.

### 4.1 Perception of Civil Engineering Professionals Regarding the Significance of Climate Change

The discussion of civil engineering professionals' perceptions concerning the significance of climate change discourse is structured around these themes;

#### Climate Change a Reality

The global community acknowledges the undeniable reality of climate change, supported by authoritative sources such as the Intergovernmental Panel on Climate Change (IPCC) reports. Discussions surrounding this pressing issue have permeated various aspects of human life, as highlighted by statements from individuals such as EVM001, who aptly acknowledges, "I believe climate change is real." QS006 emphasizes the observable changes, noting that they are "visible to the blind" unless intentionally disregarded, while CVE008 affirms that "Nigeria's climate is definitely changing," aligning with broader global discourse and research. CVE010 references Abdulkadir et al. (2017), asserting that "climate change is a serious problem for us in this region," reflecting a consensus that climate change is a tangible and significant phenomenon requiring immediate global attention and action, as underscored by research from Smith et al. (2009).

#### Knowledge Gap in Awareness

The discussion on the knowledge gap in awareness within the global construction industry reveals multifaceted insights. Hurlimann et al. (2019) and Allu and Ebohon (2015) identify deficiencies in understanding climate change within the Australian and Nigerian construction sectors, respectively. Akinola et al. (2020) present a contrasting view, suggesting professionals possess an understanding, yet EVM001's assertion, "I strongly believe that the sector is not yet doesn't have a full understanding of what climate change is," resonates with the acknowledgment of a discernible knowledge gap. Overall, these viewpoints emphasize the urgency for initiatives to bridge this gap and elevate awareness surrounding climate change in the construction sector.

#### Impacts of Climate Change

The IPCC report (2022) outlines numerous impacts of climate change worldwide, a stance corroborated by this research, which also provides substantial evidence of the diverse impacts of climate change in Nigeria. These are discussed under these codes.

**Biodiversity Loss:** Anabaraonye et al. (2022) study about the biodiversity loss caused by climate change aligns with participants such as EVM001 and CVE004, highlighting significant biodiversity loss in Nigeria due to climate change, with EVM001 stating, "we've over the years we've witnessed a significant increase in floods In temperature witnessed a lot of biodiversity lost cause I from my experience working on reforestation, afforestation projects, we've seen the loss in the forest which has reduced". CVE004 adds, "In northern Nigeria where I practice there has been massive drought, desertification, and loss of water bodies which is detrimental to every life in the north both plants and animals."

**Agricultural and Economic Impacts:** Studies by Anabaraonye et al. (2022) underscore the detrimental effects of climate change on agriculture and the subsequent economic implications. Participants like CVE002 state, "Some key impacts of climate change in the southwest is the increased rainfall and flooding that has affected agricultural produce," while BLD005 adds, "The impact of climate change in Nigeria in recent times includes flooding, sea-level rise, and economic consequences from the loss of crops due to flooding or drought."

**Extreme Weather Events:** The research reveals a heightened frequency of extreme weather events, including droughts, floods, and heatwaves, aligning with global trends outlined by the IPCC (2022). Participants like QS006 discuss the broad impacts on construction projects, stating, “Bayelsa state witnessed a terrible flood last year, halting socio-economic activities and construction projects.” CVE003 adds, “Rising temperatures and erratic weather patterns are leading to more frequent and intense droughts, floods, and heatwaves, affecting agriculture, water resources, and human health.”

**Livelihood Loss:** Climate change introduces considerable challenges to livelihoods and resources in Nigeria, as noted by participant URP007, who states, “it has led to loss of livelihood in Nigeria,” reflecting the swift erosion of livelihoods outlined by the IPCC (2022) report.

**Water Scarcity and Access Issues:** Water scarcity and access challenges lead to conflicts and issues, especially in construction, due to climate change. Participants like CVE004 discuss drought, desertification, and water scarcity, stating, “It has even led to some crisis between farmers and in the construction sector we are finding it difficult to even access water for our projects.” CVE010 adds, “we have shrinkage of water bodies, desertification, drought, and famine because of climate change. We have constantly been battling heat waves for a long period of time now. Even water for construction purposes is becoming hard to get.” This aligns with the global impacts of climate change as outlined in the report of IPCC in 2022.

**Region-Specific Impacts:** Climate change impacts vary across regions within Nigeria, with participants like CVE003 highlighting region-specific vulnerabilities, stating, “Rising temperatures and erratic weather patterns are leading to more frequent and intense droughts, floods, and heatwaves, affecting agriculture, water resources, and human health,” aligning with discussions by the Federal Ministry of Environment in 2014. Similarly, CVE009 acknowledges diverse impacts affecting different regions, aligning with the concept of localized climate effects in IPCC reports of 2022.

### **Significant Role of the Civil Engineering Sector**

The pivotal role of the civil engineering sector in achieving carbon neutrality is affirmed by Zhou et al. (2018), who highlight its responsibility for over 40% of global carbon emissions. This perspective finds unanimous agreement among participants, with each emphasizing Nigeria’s civil engineering sector’s influence in striving for net-zero greenhouse gas emissions. EVM001 stresses the importance of adopting sustainable practices, stating, “I think it’s very important that the engineering and construction sector in Nigeria begins to look into climate change and how it can adopt sustainable practices.” CVE003 echoes this sentiment, affirming, “Oh Yes, I believe the impacts are now obvious and frequent in Nigeria now and I strongly agree that the civil engineering sector has a significant role to play in slowing down climate change through carbon reduction efforts seeing that we also emit carbon dioxide in our construction process.” These viewpoints align with the research of Akinola et al. (2020), emphasizing the essential role of the civil engineering sector in mitigating global warming.

### **4.2 Current Sustainable Practices in Nigeria in Building and Highway Projects as Regards Climate Change**

In 2020, Jackson stressed the urgency for the construction industry to adopt sustainable practices to meet emission reduction targets. This research delves into the existing sustainable practices within Nigeria’s construction sector, highlighting their significance in lowering CO<sub>2</sub> emissions. Here are key themes extracted from their statements:

**Greenland conservation and Afforestation:** Greenland conservation and afforestation, as emphasized by ICE (2020) and Minnemeyer and Octavia (2017), are crucial for lowering GHG emissions. These methods are integrated into civil engineering projects in Nigeria, as evidenced by excerpts from EVM001, BLD005, CVE009, QS006, CVE010, and CVE002. Akinola et al. (2020) also support this approach, stating that developing countries often promote conservation and afforestation in construction. Notable statements such as EVM001’s mention of “revegetation exercises” and BLD005’s suggestion of “adding green areas around buildings instead of block wall fencing” illustrate their adoption within Nigeria’s civil engineering sector, responsible for highway and building projects.

**Alternative Use of Low Carbon Materials:** National Construction Sector Lead U.S. (2009) acknowledges that conventional construction materials have led to a notable presence of embodied carbon structures. Consequently, exploring and adopting alternative low-carbon materials becomes imperative. This study specifically introduces the use of palm kernel shells, bamboo, and cold asphalt as substitutes for traditional materials in both highway and building construction. Statements from URP007 such as, “Use of eco-friendly materials for construction—for example, I am aware of the use of palm kernel in replacement of coarse aggregate in concrete works,” and “I am aware of the use of cold asphalt in some private estate projects I worked on,” along with EVM001’s mention, “also that I’ve

seen used is using Palm canal shells for concrete, which has proved to be strong," and CVE004's insight, "For instance, we use bamboo now for some of our housing projects and palm kernel shells for some walkways in my region," and CVE002's contribution, "also use of palm kernel shells for aggregates in concrete" collectively affirm the presence and utilization of these practices.

Tagbor et al. (2022) emphasize palm kernel shells as effective low-carbon alternatives for coarse aggregates in construction. Similarly, Yu et al. (2021) demonstrated with experiments the viability of sustainable cold asphalt mix in civil engineering projects, echoing participants' perspectives. Furthermore, Yada and Mathur (2021) highlight bamboo's eco-friendly nature as a sustainable alternative construction material

**Waste Management:** Waste management on construction sites, as highlighted by National Construction Sector Lead U.S. (2009) is crucial for optimizing energy use and reducing GHG emissions in civil engineering. The principles of Reduce, Reuse, and Recycle (3Rs) are evident in both building and road projects across Nigeria. QS006, BLD005, and CVE003 affirm the effective implementation of waste management practices, with QS006 stating, "we try to ensure that we maximize materials and use the right quantity on site now," CVE003 committing to "Implementation of green construction practices, such as waste reduction," and BLD005 emphasizing "Proper waste management on construction sites." These statements validate the consistent presence of these practices within Nigerian civil engineering projects.

**Renewable Energy Usage:** In line with ICE (2020), the integration of renewable energy stands out as a potent strategy for curbing emissions in civil engineering projects. This approach finds tangible expression in both building and highway projects within Nigeria, as succinctly conveyed by BLD005's affirmation: "Renewable energy integration (solar energy)" emerges as a viable alternative energy source within the construction site context in Nigeria's construction space.

**Transportation and Logistics:** The movement of materials, equipment, and workers to and from project sites emits greenhouse gases. However, curtailing vehicle and machinery distances can significantly reduce fuel consumption and emissions, notes the National Construction Sector Lead U.S. (2009). EVM001 adds, "one of the things that we do is to reduce our carbon footprint when constructing...is to first source raw materials more locally so that way we are reducing the travel our mileage."

These findings demonstrate that Nigeria has existing sustainable practices within its construction sector, serving as a beacon of hope for promoting sustainability in building and highway projects.

#### **4.3 Recommendations for reduction of greenhouse gas emissions and promoting sustainability in civil engineering projects in Nigeria.**

The key recommendations from the participants are as follows;

- 1) Promote comprehensive awareness campaigns, training, and continuous learning for civil engineering professionals to enhance understanding of climate change and sustainable practices.
- 2) Invest in research and development to identify and fund local alternatives for construction projects, focusing on eco-friendly materials aligned with local contexts to reduce carbon emissions.
- 3) Develop and implement a sustainable framework and guidelines for construction projects at all government levels, incorporating universal principles and clauses for sustainable practices in project contracts with penalties for non-compliance by contractors.
- 4) Establish economic incentives for contractors committed to reducing carbon emissions and promote the adoption of internationally recognized certification standards like ISO 14001 as selection criteria for civil engineering projects, emphasizing the long-term benefits and positive outcomes of sustainability standards
- 5) Implement financial mechanisms and support structures to assist construction firms, especially in small-scale projects, in overcoming financial barriers to adopting sustainable practices. Encourage public-private partnerships that allocate funds for sustainability initiatives in civil engineering projects.

#### **5. Conclusion**

This study underscores the urgent need for Nigeria's construction sector to undergo a transformative shift towards sustainability to slow climate change. Incremental changes are no longer sufficient; radical transformation is now an imminent imperative to safeguard our future. The journey toward low-carbon and resilient infrastructure demands immediate, well-coordinated, and multi-faceted initiatives. The insights gained can inform policy reforms, inspire industry-driven initiatives, and guide professionals toward climate-conscious decision-making. However, acknowledging certain limitations, including the need to incorporate emerging voices beyond experienced professionals, opens avenues for further research. Also, because the study is based on interviews its results cannot be generalized.

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