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GREEN PROCUREMENT PRACTICES FOR BUILDING CLIMATE-RESILIENT TRANSPORT INFRASTRUCTURE IN NIGERIA

Summary. Climate change increasingly threatens transport infrastructure in Nigeria through flooding, erosion, extreme heat, and sea-level rise, exposing a persistent gap between policy commitments and procurement practice. This study investigates how green procurement can be operationalized to enhance climate resilience in transport infrastructure delivery. A mixed-methods approach was adopted, combining policy analysis, multi-case evaluation of ten projects, and thirty stakeholder interviews across federal and state levels. Findings indicate that while the Public Procurement Act (2007) ensures transparency and competition, it lacks mandatory provisions for climate risk assessment, life-cycle costing (LCC), and enforceable environmental performance criteria. A benchmarking analysis yields an Integrated Procurement-Resilience Performance Score (IPRPS) of approximately 42%, reflecting moderate-to-low alignment with global best practices, with resilience integration largely driven by donor-funded initiatives rather than institutionalized frameworks. To address these gaps, the study proposes a Green Procurement Implementation Model (GPIM) integrating LCC, resilience

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benchmarks, supplier compliance systems, and innovation incentives. The study repositions procurement as a strategic governance instrument for climate resilience and provides actionable insights for policymakers and practitioners seeking to deliver durable, low-carbon, and climate-resilient transport infrastructure in developing economies.

Keywords: green procurement, climate-resilient infrastructure, life-cycle costing (LCC), transport infrastructure, climate adaptation

1. INTRODUCTION

Climate change represents one of the most pressing global challenges of the 21st century, exerting profound impacts on infrastructure systems worldwide. Rising global temperatures, sea level rise, and increased frequency and intensity of extreme weather events such as floods, storms, and heatwaves are disrupting critical infrastructure networks, threatening lives, livelihoods, and economic stability [1,2]. Infrastructure, which forms the backbone of modern economies, is inherently vulnerable to climate hazards due to its fixed location, long service life, and interdependent nature [3]. Transport infrastructure, such as roads, bridges, railways, ports, and airports, is particularly at risk, as it is exposed to environmental stresses that can compromise functionality, increase maintenance costs, and shorten asset lifespans [4,5]. The resilience of these systems is therefore critical to ensuring the continuous movement of goods, services, and people, which underpins sustainable economic growth.

Globally, the transport sector is both a victim of and contributor to climate change. It accounts for approximately 23% of global energy-related CO_2 emissions [6], and climate-related disruptions to transport systems can have cascading impacts on trade, supply chains, and national economies. In developing countries, including Nigeria, the challenges are amplified by limited adaptive capacity, inadequate infrastructure maintenance, and insufficient investment in resilience [7]. According to a World Bank report, without adaptation, climate change could reduce GDP by around 9.6% in low-income countries by 2050 [8].

In Nigeria, the vulnerabilities of the transport sector are well-documented. The emerging evidence of [9] highlights that road networks, which carry over 90% of passenger and freight traffic, are frequently damaged by flooding, erosion, and heat stress, with more than 80% of rural roads reported to be in poor condition [10,11]. Bridges face structural risks from scouring and flood-induced erosion, while coastal ports, such as Lagos Port Complex, are exposed to storm surges and sea level rise [12,13]. The rail network, though undergoing revitalization through projects such as the Abuja-Kaduna and Lagos-Ibadan lines, remains vulnerable to flooding of low-lying corridors and heat-induced track buckling and flooding risks, which are widely recognized vulnerabilities in climate-exposed transport infrastructure systems [5]. Airports also face operational disruptions from extreme heat and rainfall variability, affecting both passenger safety and cargo logistics [14]. These vulnerabilities threaten Nigeria's ability to achieve sustainable development and economic diversification, as transport infrastructure is central to industrial growth, agricultural market access, and regional integration. Climate-proofing transport assets is therefore not a matter of choice but an economic imperative.

The Nigerian government has recognized the urgency of addressing climate risks through its commitments to international and national sustainability frameworks. Nigeria is a signatory to the Paris Agreement (2015), committing to reduce greenhouse gas emissions by 20% unconditionally and 45% conditionally by 2030, relative to business-as-usual levels as highlighted by the updated report of the Federal Ministry of Environment, 2021 [15].

The country's Nationally Determined Contribution (NDC) includes adaptation targets that emphasize resilient infrastructure in the transport sector. Furthermore, the Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action), are embedded in national policy instruments.

Key domestic policies include the National Climate Change Policy (2021-2030), the National Transport Policy (2017), and sector-specific initiatives like the Rural Access and Agricultural Marketing Project-Scale Up (RAAMP-SU), which integrates resilience into road infrastructure development. However, while these policies acknowledge climate risks, the operationalization of resilience measures often lags. A critical factor in this gap is the procurement process, in terms of the set of rules, practices, and decisions that govern how infrastructure projects are planned, financed, designed, and implemented. Public procurement accounts for an estimated 10 -15% of Nigeria's GDP and over 60% of public expenditure [16], making it one of the most powerful levers for embedding sustainability into infrastructure delivery.

Sustainable, or "green," procurement involves incorporating environmental considerations, such as low-carbon materials, energy efficiency, and life-cycle costing (LCC), into procurement decisions (UNECE, 2021). In the context of transport infrastructure, green procurement can ensure that projects not only meet immediate functional needs but also perform reliably under future climate conditions. This may involve specifying climate-resilient design standards, sourcing sustainable construction materials, and requiring suppliers to meet environmental performance benchmarks [17]. Green procurement aligns financial efficiency with long-term asset durability, reducing the need for costly retrofits and repairs caused by climate impacts [18].

Despite its potential, the integration of green procurement into Nigeria's transport sector remains inconsistent. Studies have found that while the Public Procurement Act (2007) provides a legal framework for competitive and transparent procurement, it does not explicitly mandate climate resilience criteria in tender evaluations [19,20]. Capacity gaps among procurement officers, limited awareness among suppliers, and inadequate monitoring mechanisms further hinder implementation [11]. Consequently, procurement processes often prioritize upfront cost minimization over long-term performance, perpetuating infrastructure vulnerability to climate hazards. This reveals a structural disconnect between climate policy ambition and procurement execution, where resilience objectives are not systematically embedded in tender design, evaluation criteria, or contractual enforcement. While policy commitments to resilient infrastructure exist, the translation of these commitments into procurement requirements, evaluation criteria, and contractual obligations remains weak. Without reforming procurement practices, Nigeria risks continued investment in infrastructure that is ill-prepared for the realities of a changing climate.

The purpose of this paper is to address this gap by examining current procurement policies and practices in Nigeria's transport sector, identifying strengths and weaknesses in their ability to support climate resilience, and proposing a practical Green Procurement Implementation Model (GPIM). This model will draw on LCC, environmental performance benchmarks, and supplier compliance monitoring as core components. By aligning procurement with resilience objectives, the study seeks to contribute to both policy reform and practical guidance for infrastructure delivery.

The objectives of this study are:

1. To examine existing procurement policies, regulations, and practices in Nigeria's transport sector with respect to climate resilience.

2. To identify gaps and challenges in integrating sustainability and resilience into procurement processes.
3. To propose a green procurement implementation model tailored to Nigeria's transport infrastructure needs.

These objectives lead to the following research questions:

1. How can public procurement in Nigeria's transport sector be structured to systematically support climate resilience?
2. What are the current challenges, such as policy, institutional, technical, and market-related, in entrenching sustainability into procurement?
3. Which green procurement strategies are most applicable to Nigeria's climate, infrastructure, and governance context?

In addressing these questions, the paper situates green procurement as both a policy instrument and a technical strategy for achieving climate-resilient transport infrastructure. The contribution is twofold: first, to extend the literature on the intersection of procurement and climate resilience in developing countries; and second, to offer a context-specific, actionable model to guide Nigerian policymakers, procurement professionals, and contractors in delivering infrastructure that supports sustainable economic growth under changing climatic conditions.

2. LITERATURE REVIEW

Green procurement, sometimes referred to as sustainable procurement, has evolved as a critical tool for integrating environmental and social considerations into purchasing decisions. In the infrastructure sector, the concept extends beyond the acquisition of goods and services to encompass the entire life-cycle of infrastructure assets; from material sourcing and design specifications to construction methods, operation, maintenance, and end-of-life disposal. Influential definitions, such as those articulated by the OECD, UNEP, and formalized in the [21] Sustainable Procurement standard, position green procurement as a shift from a lowest-bid mentality towards a "best value" approach that accounts for environmental, social, and economic performance over the asset's lifetime. [22] broaden this understanding by framing procurement decisions as socio-ecological interventions, capable of enhancing the adaptive capacity of transport systems through the choice of climate-resilient materials, innovative design approaches, and supplier selection criteria that incentivize low-carbon performance. Empirical studies further show that the effectiveness of supplier selection is strongly influenced by the incorporation of structured risk management strategies.

In the specific context of infrastructure, green procurement can be understood as a governance mechanism that aligns planning, design, construction, and maintenance processes with broader sustainability and climate objectives. [17] have shown that in developing countries, where institutional and fiscal constraints often limit resilience investment, procurement instruments such as performance-based specifications, environmental benchmarks, and mandatory LCC, play a pivotal role in ensuring that transport projects are built to withstand the impacts of climate change while minimizing whole-life costs. For this study, green procurement is defined as the systematic incorporation of life-cycle, performance-based, and environmental criteria into all stages of public procurement for transport works and services, with the explicit aim of minimizing climate risk, reducing long-term costs, and maintaining service reliability in the face of environmental extremes. Beyond environmental

considerations, procurement literature increasingly emphasizes the integration of risk management into supplier evaluation processes.

The theoretical foundation for climate-resilient infrastructure further contextualizes the relevance of green procurement in this domain. [23] conceptualize infrastructure as an interconnected "system of systems" in which resilience is derived from robustness, redundancy, resourcefulness, and the rapidity of recovery following disruption. They highlight that transport systems, because of their spatial distribution and operational interdependencies, require resilience planning at multiple scales, from individual asset design to regional network integration. [2] advance this theoretical lens by quantifying the welfare losses resulting from climate-related disruptions, particularly in developing countries where infrastructure gaps and vulnerability are more pronounced. Their work introduces the notion of the "resilience dividend," arguing that investments in resilience yield benefits even in the absence of climate shocks, by reducing maintenance costs, improving service reliability, and fostering investor confidence. Together, these frameworks emphasize three principles directly relevant to this paper's objectives: the need to design for extremes, the imperative of managing performance across the full life-cycle, and the necessity of embedding resilience into institutional frameworks, including procurement policy.

Global experience provides compelling evidence of the role of procurement as a driver of resilience in the transport sector. For example, the European Union's Green Public Procurement (GPP) criteria for road construction incorporate specifications for recycled materials, low-carbon binders, and reduced life-cycle emissions, while allowing functional performance specifications to encourage innovation. In Australia and New Zealand, resilience screening tools are embedded into procurement gateways for major transport projects, enabling climate risk assessments to influence supplier proposals before contract award. [24] show how coastal cities have introduced resilience clauses into design-build contracts for port infrastructure, requiring that assets be able to withstand specified storm surges and sea-level scenarios without functional degradation. [25] document a similar approach in low-income countries, where resilience appraisal templates have been piloted within donor-funded projects to ensure that climate adaptation measures are costed, specified, and monitored through the procurement process rather than added post-construction.

Despite these successes, the translation of global best practices into the Nigerian transport sector has been uneven. The Public Procurement Act (PPA) of 2007 remains the primary legal instrument governing public procurement in Nigeria, establishing the Bureau of Public Procurement (BPP) as the oversight authority. The Act's emphasis on transparency, competitiveness, and value for money represents a significant improvement over pre-2007 practices, yet it contains no explicit mandate for climate resilience or sustainability criteria in tender evaluations. While environmental considerations can be included at the discretion of procuring entities, there is no standardized mechanism to ensure that they are consistently applied or given appropriate weighting. Consequently, procurement processes often prioritize the lowest upfront cost, a tendency that perpetuates vulnerability by neglecting the long-term costs of climate-induced degradation.

The National Transport Policy (2017) recognizes the importance of sustainable transport infrastructure and calls for multimodal integration, improved maintenance, and sustainable financing. However, its operationalization in procurement practice remains limited. The climate resilience objectives articulated in the policy are not systematically embedded into bidding documents, evaluation criteria, or contract clauses. Similarly, Nigeria's Nationally Determined Contribution (NDC) under the Paris Agreement and the National Climate Change Policy (2021-2030) identify resilient infrastructure as a priority for adaptation, but these commitments are

rarely translated into binding procurement requirements. Initiatives such as the Rural Access and Agricultural Marketing Project-Scale Up (RAAMP-SU) illustrate the potential for integrating resilience into road infrastructure development, yet such examples remain exceptions rather than the norm. The result is a persistent policy-practice gap in which climate ambition is expressed in strategic documents but not consistently enacted through the procurement mechanisms that determine the specifications, materials, and performance standards of actual projects.

Empirical research from Nigeria and other developing economies reinforces this observation. [11] Assess Nigeria's preparedness for climate-resilient infrastructure delivery, identifying procurement governance gaps, particularly the absence of LCC enforcement and climate-related performance benchmarks, as critical impediments. [26], in a systematic review of climate resilience in Nigerian construction, find that projects incorporating sustainable material selection and environmental tender criteria are more likely to meet resilience objectives, yet such practices are inconsistently applied. [13], examining Lagos's transport infrastructure, conclude that procurement-driven design standards are essential for coastal adaptation but note that current processes rarely mandate such requirements.

Other African studies echo these findings. [27] links urban resilience outcomes in Nigerian cities to the quality of procurement governance, arguing that resilient designs are less likely to be implemented where procurement officers lack climate literacy or where contract documents fail to specify performance requirements. [20] emphasize the role of resilient infrastructure as an adaptive measure but highlight enforcement gaps in procurement regulation as a major barrier. In the roads sector, [17] demonstrate in multiple developing country contexts that performance-based contracting and LCC can significantly improve infrastructure durability and reduce life-cycle emissions, yet note that such approaches are rarely institutionalized in national procurement frameworks.

Studies beyond Nigeria also provide relevant lessons. [25] identify the absence of standardized procurement tools for climate risk appraisal as a barrier in both Africa and South Asia, while [25] link inclusive transport resilience outcomes to participatory procurement processes that engage local communities and suppliers. [22] show that a socio-ecological framing of resilience in transport leads to performance specifications that reward adaptive designs, while [18] argue that shifting from a robustness-only paradigm to a resilience-as-service model requires embedding resilience KPIs in contracts. [24] find that resilience clauses in coastal transport contracts significantly improve asset performance under extreme conditions.

Evidence from Southern Africa further illustrates procurement's influence on resilience. [29] document integration challenges in Johannesburg's transport infrastructure projects, concluding that e-procurement platforms and supplier prequalification for sustainability can mitigate such challenges. [30] highlights rural road procurement models that empower communities to maintain and adapt infrastructure, enhancing resilience and access. [31] Identify institutional and procedural impediments to sustainable urban transport in Harare, calling for procurement reforms that penalize non-compliance and reward resilient design. [32] advocate for harmonized cross-border procurement standards to scale resilient transport corridors in West Africa.

Even outside Africa, the procurement-resilience link is evident. [33] shows that contractor and procurement officer capacity gaps weaken resilience uptake in Ghana, recommending targeted training and standardized tender templates. [34] finds that sustainability-weighted evaluations in Saudi Arabia's transport sector improve long-term asset performance, suggesting potential transferability to African contexts. [35] demonstrates in Oman that resilience-oriented

supplier selection reduces climate-related disruptions in logistics networks. [36] synthesize global evidence linking infrastructure sustainability tools to procurement practices that normalize resilient design across project portfolios. Across these diverse studies, a consistent pattern emerges: where procurement processes explicitly require and reward resilience - through specifications, evaluation weightings, supplier requirements, and contractual KPIs - transport infrastructure is more likely to perform under climate stress. Conversely, where procurement is silent on resilience or treats it as an optional add-on, assets remain vulnerable, and adaptation opportunities are lost.

The literature, therefore, identifies a clear research gap in Nigeria's transport sector. While the Public Procurement Act and sectoral policies create an enabling environment for environmental considerations, no integrated procurement framework systematically embeds climate resilience across all stages of infrastructure delivery. Such a framework would mandate climate risk appraisal at project inception, operationalize LCC with standardized evaluation weightings, incorporate measurable resilience KPIs into contracts, and enforce supplier environmental performance through compliance monitoring. Without these mechanisms, policy commitments to resilience will continue to be undermined by procurement practices that prioritize short-term cost savings over long-term service reliability and climate adaptation. This paper addresses that gap by proposing a GPIM tailored to Nigeria's transport sector, translating resilience theory into actionable procurement instruments that bridge the policy-practice divide and deliver durable, low-carbon, and climate-resilient transport infrastructure.

3. METHODOLOGY

This study adopts a mixed-methods research design that integrates policy analysis, case study evaluation, and qualitative inquiry through stakeholder engagement. The approach recognizes that procurement for climate-resilient infrastructure is both a policy-driven process, framed by laws, regulations, and institutional mandates, and a practice-oriented process shaped by project-level decision-making, supplier capacity, and contextual risk factors.

The research is structured into three sequential phases. The first phase involves a desk-based review of Nigeria's procurement and climate resilience frameworks, including the Public Procurement Act (2007), the National Transport Policy, and the National Climate Change Policy (2021-2030), alongside project-specific tender documents from selected federal and state transport projects. This establishes the baseline for assessing the extent to which resilience considerations are embedded within the procurement framework. International benchmarks, such as the European Union's Green Public Procurement criteria and selected global transport resilience guidelines, are also reviewed to provide a comparative standard.

The second phase comprises in-depth case studies of transport infrastructure projects purposively selected based on the following criteria: procurement under the Public Procurement Act (2007), initiation or completion within the last five years, and the incorporation of explicit resilience features in the design or construction. Federal projects are drawn from national highway and bridge programs, while State projects are selected from diverse climate-risk contexts, such as flood-prone coastal states and erosion-affected inland corridors. This approach allows for comparative insights into how procurement for resilience is operationalized in differing environmental and institutional contexts.

The third phase involves field-based data collection through semi-structured interviews with procurement officers, engineers, and contractors associated with the selected projects, alongside direct field observations of project sites. Interviews were designed to capture practical

experiences, challenges, and opportunities in embedding resilience criteria into procurement processes. Field observations focus on verifying the presence and quality of resilience features such as drainage systems, erosion control structures, and durable, low-carbon materials. To enhance clarity and accessibility, the methodological process is summarized in Tab. 1.

Tab. 1

Summary of Research Phases, Activities, and Outputs

Research Phase	Key Activities	Expected Outputs
Phase I: Policy and Document Review	- Conduct desk-based review of Nigeria's Public Procurement Act (2007), National Transport Policy (2017), and National Climate Change Policy (2021-2030). - Examine project-specific tender documents from selected Federal and State transport projects. - Review international benchmarks such as EU Green Public Procurement (GPP) criteria and global transport resilience guidelines.	- Baseline understanding of current procurement and climate-resilience frameworks. - Identification of policy strengths and gaps in Nigeria's transport procurement system. - Comparative benchmark against global best practices.
Phase II: Case Study Evaluation	- Select representative Federal and State transport infrastructure projects based on defined criteria (e.g., under PPA 2007, completed within 5 years, incorporating resilience features). - Conduct detailed analysis of project documentation and procurement implementation. - Compare resilience integration across diverse climate-risk contexts (flood-prone vs. erosion-prone areas).	- Case-specific insights into the practical application of green procurement principles. - Cross-case comparison highlighting the strengths, weaknesses, and contextual variations in procurement for resilience.
Phase III: Field Data Collection and Stakeholder Engagement	- Conduct semi-structured interviews with procurement officers, engineers, and contractors involved in the selected projects. - Undertake field observations to verify the existence and quality of resilience measures (e.g., drainage systems, erosion control, material durability). - Thematically code qualitative data for analysis.	- Empirical data on operational realities and challenges in implementing resilience through procurement. - Field-validated assessment of resilience features. - Practical insights to inform the proposed Green Procurement Implementation Model (GPIM).
Analytical Approach	_	- Synthesized findings through thematic analysis, comparative policy review, and benchmarking against international best-practice frameworks to derive policy and practical insights.

The analysis integrates thematic coding for qualitative data, comparative policy analysis to contrast Nigerian frameworks with global benchmarks, and a benchmarking exercise to measure the degree to which procurement processes reflect internationally recognized

resilience-oriented practices. This methodological combination ensures a balanced and evidence-based assessment, linking policy provisions with practical realities in the field.

3.1. Data analysis procedures

The analysis combined three complementary analytical techniques, namely thematic analysis, comparative policy review, and quantitative benchmarking, to ensure a comprehensive and evidence-based interpretation of findings.

1. Thematic Analysis:

Qualitative data from interviews and observations were transcribed and analyzed using thematic coding in NVivo 12. The process followed [37] a six-step approach - familiarization, coding, theme development, review, definition, and interpretation.

Open codes were generated around recurring issues such as material selection, supplier monitoring, innovation incentives, and capacity constraints, which were later refined into thematic clusters reflecting both policy and operational dimensions of green procurement.

2. Comparative Policy Analysis:

Nigerian procurement and climate policies were systematically compared with international benchmarks (EU GPP, OECD, and global transport resilience standards) through a structured matrix.

This facilitated the identification of policy alignment levels, enforcement weaknesses, and institutional capacity gaps, thus linking domestic regulatory frameworks to global resilience standards.

3. Quantitative Benchmarking:

A benchmarking exercise was conducted to assess the degree of alignment between Nigeria's procurement practices and internationally recognized resilience-oriented standards. Six practice areas were evaluated: sustainable material selection, supplier compliance monitoring, innovation incentives, LCC application, procurement officer capacity, and institutional coordination.

Each practice area was scored on a 0-100 scale based on triangulated evidence from document review, interview responses, and field observations, using a structured scoring rubric.

To ensure methodological transparency and avoid subjective weighting bias, all indicators were treated as equally important. The overall Integrated Procurement-Resilience Performance Score (IPRPS) was therefore computed using a simple arithmetic mean of the six practice area scores as shown in eq. (1).

To enhance scoring consistency, a standardized rubric was applied across all case study projects. Scores for each practice area were derived as follows:

- 0-39% (Low): No evidence or very weak implementation across the majority of projects,
- 40-59% (Moderate): Partial or inconsistent implementation across projects,
- 60-79% (High): Substantial implementation, though not yet fully institutionalized,
- 80-100% (Very High): Systematic and institutionalized implementation across projects.

Scores were assigned based on the proportion of projects demonstrating each practice, supported by qualitative validation from interview data and field observations.

3.2. Empirical scope and data collection

To ensure empirical rigor and replicability, the study draws on a structured multi-case design comprising ten transport infrastructure projects across federal and state levels in Nigeria. The projects were purposively selected based on the following criteria: (i) procurement conducted

under the Public Procurement Act (2007) framework; (ii) project initiation or completion between 2019 and 2024; and (iii) exposure to climate-related risks such as flooding, erosion, or heat stress.

The selected projects include five federal projects (national highways and bridge programs) and five state-level projects (urban and rural agricultural access road infrastructure). To capture geographical and climatic variation, the projects were distributed across five geopolitical zones: South-West (Lagos), South-South (Rivers), North-Central (Federal Capital Territory and Benue), North-West (Kaduna), and South-East (Anambra).

Primary data were collected through thirty semi-structured interviews with key stakeholders directly involved in procurement and project implementation. The sample comprised ten procurement officers, twelve engineers, and eight contractors. Respondents were selected using purposive and snowball sampling techniques to ensure that only participants with direct decision-making or operational roles were included.

In addition, field observations were conducted across all ten project sites, guided by a structured checklist focusing on the presence and quality of resilience features, including drainage systems, erosion control measures, and material durability.

4. RESULTS

4.1. Policy and document review

The review of Nigeria's procurement and climate resilience frameworks revealed notable strengths in existing legal and policy provisions. The Public Procurement Act (2007) provides a transparent framework for competitive bidding, including provisions for technical specifications and evaluation criteria that could accommodate sustainability and resilience requirements. The National Transport Policy references the need for sustainable infrastructure, while the National Climate Change Policy (2021-2030) recognizes transport as a key sector for adaptation measures.

However, gaps remain in terms of explicit climate resilience integration. Neither the Public Procurement Act nor most sectoral guidelines contain mandatory climate risk assessments at the tendering stage, nor do they prescribe minimum environmental performance benchmarks for transport projects. LCC is mentioned in some donor-funded project documentation, but it is not a statutory requirement. Furthermore, supplier compliance monitoring is inconsistently enforced, with no unified reporting system across the federal and state levels.

Tab. 2

Summary of Policy Strengths and Gaps

Policy/Framework	Identified Strengths	Identified Gaps or Weaknesses
The Public Procurement Act (PPA, 2007)	- Provides a transparent and competitive framework for public procurement. - Establishes Bureau of Public Procurement (BPP) as oversight authority. - Includes provisions for technical specifications and	- Lacks explicit mandate for climate resilience or environmental performance criteria in tender evaluation. - No requirement for LCC or climate risk assessment. - Inconsistent enforcement and absence of binding environmental clauses.

	evaluation criteria that could integrate sustainability aspects.	
The National Transport Policy (2017)	- Recognizes the need for sustainable and resilient transport infrastructure. - Promotes multimodal integration and improved maintenance culture.	- Does not operationalize resilience or sustainability criteria in procurement processes. - Lacks binding guidance on climate risk assessment or material performance standards.
The National Climate Change Policy (2021-2030)	- Identifies transport as a key sector for adaptation measures. - Aligns with Paris Agreement and Nationally Determined Contributions (NDCs).	- Does not link climate objectives to procurement procedures or infrastructure project tendering. - Lacks an implementation mechanism for integrating resilience into procurement documentation.
Donor-Funded Transport Projects (e.g., The Rural Access and Agricultural Marketing Project – Scale Up (RAAMP-SU), World Bank)	- Integrate climate-resilient design and environmental safeguards into procurement documentation. - Apply LCC and sustainability-weighted evaluation during tendering.	- Practices not institutionalized in domestically funded projects. - Dependence on donor-driven conditionalities rather than national regulations.
Institutional and Regulatory Environment	- The existence of multiple agencies (e.g., BPP, Federal Ministry of Works, and Federal Ministry of Environment) with roles in procurement and sustainability oversight.	- Poor inter-agency coordination and an absence of a unified reporting system. - Limited capacity among procurement officers to implement green or resilience-oriented procurement. - Inconsistent supplier compliance monitoring.
Overall Policy Landscape	- Existence of a broad legal and policy framework supporting sustainability.	- Absence of integration across frameworks and weak institutional coordination hinder the operationalization of resilience.

4.2. Field and interview findings

Interviews with procurement officers, engineers, and contractors, along with field observations, provided insight into the operational realities of green procurement in Nigeria's transport sector.

1. Sustainable Material Selection Practices

Across the selected federal and state projects, sustainable material selection is inconsistently applied. Some projects, especially those with donor involvement, specified climate-resilient materials such as polymer-modified asphalt, corrosion-resistant steel, and geotextile reinforcement in embankments. However, domestically funded projects more frequently relied

on cost-minimization approaches, favoring locally available but less durable materials without documented performance testing for climate adaptation.

2. Supplier Compliance Monitoring

Compliance monitoring of suppliers was found to be weak and ad hoc. While tender documents often included clauses requiring adherence to environmental standards, enforcement was dependent on the diligence of supervising engineers and contract managers. In only 40% of reviewed projects were there documented site inspection reports explicitly assessing resilience-related specifications.

3. Innovation Incentives

Innovation was rarely incentivized in procurement processes. Interviewees noted that bid evaluation criteria prioritized price and delivery time over resilience-oriented design or technology adoption. Only donor-funded projects introduced bonus points or additional evaluation weight for bidders proposing innovative, sustainable solutions. This indicates a structural deficiency in procurement evaluation frameworks, where the absence of risk-adjusted and performance-based criteria systematically suppresses innovation and resilience-oriented supplier participation.

Tab. 3

Field Findings on Procurement Practices for Resilience

Practice Area	Observed Findings	Key Challenges Identified	Implications for Climate-Resilient Infrastructure
Sustainable Material Selection	- Application of sustainable and climate-resilient materials (e.g., polymer-modified asphalt, corrosion-resistant steel, geotextiles) was more common in donor-funded projects. - Domestically funded projects often prioritize cost over material performance.	- Limited awareness and technical guidance on climate-resilient materials. - Budgetary constraints promote the cheapest material selection.	- Reduces infrastructure lifespan and increases maintenance costs. - Weakens adaptation to heat, flooding, and erosion.
Supplier Compliance Monitoring	- Environmental and resilience clauses are included in the tender documents but inconsistently enforced. -Approximately 40% of the reviewed projects had documented site inspection reports assessing resilience-related criteria.	- Weak oversight and absence of standardized compliance reporting tools. - Reliance on the engineer's discretion for monitoring.	- Low accountability for suppliers' environmental performance. -Limited institutionalization of green procurement standards.
Innovation and Technology Adoption	- Innovation is rarely incentivized in procurement evaluation. - Donor-funded projects occasionally are awarded extra points for sustainability-driven proposals.	- Evaluation criteria are heavily price-based, discouraging innovative bids. - Lack of policy-driven incentives for innovation.	- This limits the adoption of new technologies and materials that enhance resilience. - This hinders transition to low-

			carbon construction methods.
Procurement Officer Capacity	- Officers demonstrated a strong understanding of procedural compliance but a weak grasp of LCC and climate risk assessment tools.	- Limited training in resilience-oriented procurement practices. - Absence of institutionalized capacity development programs.	- Reinforces a traditional cost-minimization mindset. - Slows the mainstreaming of resilience across procurement cycles.
Institutional Coordination and Data Management	- Fragmented data on supplier performance and environmental compliance. - Lack of integration between BPP, transport agencies, and climate policy institutions.	- Weak communication channels among relevant agencies. - No centralized database for resilience performance tracking.	- Prevents evidence-based decision-making and performance benchmarking. - Reduces policy feedback for continuity.
E-Procurement and Digital Monitoring	Limited use of e-procurement tools with embedded sustainability tracking modules.	Lack of digital compliance dashboards and supplier performance tracking systems.	Limits data-driven oversight and weakens transparency in resilience monitoring.

4. Integrated Performance Assessment

To synthesize the findings, an Integrated Procurement-Resilience Performance Score was developed, benchmarking the observed practices against global best-practice standards in green procurement for climate-resilient infrastructure.

The IPRPS is calculated as:

$$IPRPS = (S_1 + S_2 + S_3 + S_4 + S_5 + S_6) / 6 \quad (1)$$

where S_1 - S_6 represent the scores for the six procurement-resilience practice areas.

The scoring confirms a moderate-to-low alignment with global standards, with the strongest performance in material selection (driven largely by donor conditions) and the weakest in innovation incentives.

Tab. 4

Procurement-Resilience Performance Score by Practice Area

Practice Area	Global Best-Practice Benchmark	Observed Nigerian Practice	Performance Score (%) *a	Interpretation
Sustainable Material Selection	Use of certified low-carbon, durable materials specified through mandatory LCC and resilience screening.	Partial adoption in donor-funded projects; limited in domestic projects with weak performance testing.	65%	Moderate alignment - performance driven largely by donor conditions rather than national enforcement.
Supplier Compliance Monitoring	Continuous, technology-supported environmental and resilience monitoring across the project lifecycle.	Inconsistent enforcement; no standardized compliance reporting tools.	40%	Low alignment - monitoring remains ad hoc and discretionary.
Innovation and Technology Incentives	Tender evaluation includes weighted scoring for innovation and resilience-oriented solutions.	Rarely included; price remains the dominant selection criterion.	35%	Weak alignment - innovation not systematically incentivized.
Life-Cycle Costing (LCC) Application	Mandatory inclusion of total-cost-of-ownership and LCC analysis in bid evaluation and design optimization.	Applied sporadically; not required under current national procurement regulations.	30%	*Very low alignment* - absence of statutory LCC requirements limits cost-efficiency and sustainability.
Procurement Officer Capacity and Climate Literacy	Officers trained in LCC, climate risk appraisal, and sustainable procurement management.	Capacity gaps remain; training is mostly through external (donor) programs.	55%	Moderate alignment - knowledge base improving but not institutionalized.
Institutional Coordination and Policy Integration	Harmonized procurement-climate governance structure with a centralized performance database for decision-making	Fragmented coordination; absence of integrated data systems and unified reporting platforms.	25%	*Very low alignment* - data fragmentation and weak inter-agency collaboration undermine systemic resilience.

Average Integrated Procurement-Resilience Performance Score (IPRPS)	-	-	≈ 42%	*Overall moderate-to-low alignment* - clear policy-practice gap in embedding resilience within procurement governance.

(0-39% = Low, 40-59% = Moderate, 60-79% = High, 80-100% = Very High).
*a = *Scores represent unweighted values*.
Note: Scores derived from comparative benchmarking against EU Green Public Procurement (GPP), OECD Sustainable Procurement Frameworks, and World Bank Transport Resilience Indicators.

5. DISCUSSION

The findings provide robust empirical support for the argument that procedural strength in procurement systems does not inherently translate into resilience outcomes unless explicitly aligned with climate-responsive performance mechanisms [11,27]. The review of the Public Procurement Act (2007), National Transport Policy, and climate adaptation policies revealed strengths in transparency and competitive bidding, but these strengths have not been leveraged to address emerging climate risks. This aligns with [2], who note that many developing countries adopt strong procurement laws without adapting them to meet the dynamic challenges posed by climate change.

5.1. Explaining the gaps

The absence of mandatory climate risk assessments and LCC in Nigeria's procurement regulations can be attributed to three interconnected factors. First, institutional capacity limitations remain a major constraint, particularly in developing procurement systems where regulatory enforcement, technical expertise, and organizational coordination are still evolving [38]. Interviews revealed that procurement officers and engineers often lack formal training in climate risk assessment tools, leading to a reliance on conventional cost-minimization approaches rather than resilience-based decision-making. Second, policy enforcement gaps weaken the integration of sustainability clauses. While environmental compliance language exists in some tender documents, enforcement is inconsistent and largely dependent on the supervising engineer's discretion, echoing the concerns raised by [13] on weak oversight in African transport procurement. Third, budgetary limitations lead to trade-offs between upfront investment in resilient materials and the need to award contracts to the lowest bidder. This practice undermines long-term cost savings, consistent with findings by [17] on sustainable road infrastructure development in developing countries.

5.2. Comparison to international models

International evidence demonstrates that procurement systems can be strategically designed to embed climate resilience through enforceable standards, multi-criteria evaluation, and institutional integration. Increasingly, public procurement is recognized as a strategic governance instrument for delivering sustainability and resilience outcomes in infrastructure systems [17,25]. In this context, three influential frameworks - the EU's GPP criteria,

Singapore's innovation-weighted procurement system, and the World Bank's transport resilience frameworks - provide critical benchmarks for evaluating Nigeria's procurement practices and informing the proposed GPIM.

The EU's GPP framework remains one of the most comprehensive and institutionalized models for integrating sustainability into procurement systems. The EU GPP criteria for transport infrastructure explicitly incorporate LCC, environmental performance requirements, and material sustainability benchmarks into procurement processes [39]. These criteria are structured across the full project lifecycle, from design and construction to maintenance and end-of-life, ensuring that environmental considerations are embedded at every stage.

More recent studies confirm that GPP plays a critical role in reducing emissions in high-impact sectors such as construction and transport by shifting procurement from a lowest-cost approach to a "most economically advantageous tender" (MEAT) framework, which integrates environmental and lifecycle performance into decision-making [40]. This transition allows contracting authorities to evaluate bids based on total cost of ownership and long-term resilience performance, rather than initial capital cost alone.

A key strength of the EU model lies in its regulatory coherence and standardization, supported by evolving legislative instruments and sector-specific criteria. However, the findings of this study reveal that Nigeria's procurement system lacks such binding mechanisms, particularly in relation to LCC enforcement and environmental benchmarks. While full replication of the EU framework may be constrained by institutional capacity and enforcement limitations, specific components - such as standardized LCC templates, environmental threshold criteria, and model tender clauses - are highly transferable and could significantly enhance procurement consistency and accountability in Nigeria.

Singapore's procurement system provides a complementary model that emphasizes innovation-driven evaluation and performance-based procurement, reflecting broader evidence that procurement systems can actively stimulate technological innovation and sustainability outcomes when appropriate incentives are embedded [42,41]. As highlighted in *Climate Resilient, Green and Low Carbon Built Environment*, sustainable infrastructure systems require the integration of advanced materials, low-carbon technologies, and circular design principles into procurement and project delivery processes. Singapore operationalizes this through multi-criteria tender evaluation systems, where cost is balanced with technical quality, sustainability performance, and innovation potential [39].

This approach aligns closely with global shifts toward value-based procurement, where long-term efficiency and resilience are prioritized over short-term cost savings. The relevance of this model to Nigeria is particularly evident in the study's finding that innovation is rarely incentivized, with procurement decisions dominated by price-based evaluation. However, direct replication is limited by differences in institutional capacity and market maturity. A more feasible pathway involves phased implementation of weighted evaluation criteria, allowing Nigeria to gradually introduce sustainability and innovation metrics while strengthening institutional capacity [25].

The World Bank's transport resilience frameworks offer a third model that is particularly suited to developing country contexts. These frameworks emphasize climate risk screening, resilience appraisal, and performance-based contracting mechanisms at early stages of project development [25]. A defining feature is the use of mandatory safeguard policies, which ensure that climate risks are systematically identified, quantified, and incorporated into procurement decisions.

Evidence from this study indicates that donor-funded projects in Nigeria - many of which adopt World Bank procurement procedures - demonstrate higher levels of resilience integration, particularly in material selection and design standards. This observation is consistent with broader findings that externally supported procurement systems often achieve stronger sustainability outcomes due to stricter compliance and monitoring requirements [33, 29]. However, such practices remain externally driven and weakly institutionalized within Nigeria's domestic procurement framework, limiting their scalability.

Comparatively, the three international models offer complementary strengths. The EU GPP framework provides a regulatory and standardization foundation, Singapore's system introduces innovation-based market incentives, and the World Bank framework delivers a risk-based implementation approach tailored to developing economies. Nigeria's procurement system, as evidenced in this study, lacks systematic integration of these elements - specifically, binding resilience standards (EU gap), structured innovation incentives (Singapore gap), and mandatory climate risk appraisal tools (World Bank gap).

The proposed GPIM addresses these deficiencies by synthesizing key elements from these international frameworks while adapting them to Nigeria's institutional realities. It integrates (i) standardized LCC and environmental benchmarks derived from EU GPP; (ii) innovation-weighted evaluation mechanisms inspired by Singapore's model; and (iii) climate risk screening and performance-based monitoring systems aligned with World Bank practices. By combining regulatory structure, market incentives, and risk-based planning, the GPIM provides a context-sensitive and scalable pathway for transitioning Nigeria's procurement system toward climate-resilient infrastructure delivery.

5.3. Implications for transport sector resilience

The gaps identified in Nigeria's procurement framework have direct implications for the resilience, cost efficiency, and environmental footprint of transport infrastructure. In particular, the absence of digital risk intelligence systems limits the ability of procuring entities to proactively identify and mitigate supplier-related risks, thereby weakening infrastructure resilience outcomes [21]. Without formalized resilience criteria, projects remain vulnerable to damage from flooding, erosion, and heat-related material degradation - risks that are projected to intensify under current climate change scenarios [28]. Field observations showed that projects using climate-resilient materials, such as polymer-modified asphalt and corrosion-resistant steel, exhibited superior performance in drainage capacity and structural integrity. This is consistent with [22], who highlight the role of material innovation in extending infrastructure lifespans.

From a cost perspective, the absence of LCC in procurement decisions results in short-term savings but higher long-term maintenance and rehabilitation expenses. Evidence from international case studies shows that integrating LCC into procurement can reduce total asset LCC by 10-20% while enhancing performance [43]. Nigeria's reliance on lowest-bid selection criteria thus risks locking in higher cumulative costs over the lifespan of transport assets [24].

On environmental performance, limited enforcement of sustainable material use and the lack of supplier innovation incentives constrain opportunities to lower greenhouse gas emissions in the sector. The transport sector's carbon footprint could be significantly reduced through wider adoption of low-carbon materials and design innovations, an upshot supported by studies in Ghana and South Africa [33,29].

5.4. Strategic significance

Closing the identified gaps will require a shift from procurement as a procedural compliance exercise to procurement as a strategic tool for climate resilience. This would involve embedding resilience clauses in tender documentation, mandating LCC as part of bid evaluation, strengthening supplier compliance monitoring, and establishing innovation incentives. By aligning procurement practices with global best-practice models, Nigeria could achieve not only enhanced climate resilience but also measurable cost savings, greater asset durability, and reduced emissions, thereby delivering on both national development priorities and international climate commitments.

5.5. Synthesis: Addressing the research questions

This subsection explicitly revisits the three research questions to consolidate the study's contributions and reinforce analytical coherence.

RQ1: How can public procurement in Nigeria's transport sector be structured to systematically support climate resilience?

The findings demonstrate that procurement can be structured to support climate resilience through the institutionalization of three core mechanisms: (i) mandatory climate risk assessment at the project inception and tendering stages; (ii) the integration of LCC into bid evaluation to shift decision-making from upfront cost to total asset performance; and (iii) the inclusion of enforceable resilience performance standards within technical specifications and contractual clauses. Evidence from donor-funded projects shows that when such mechanisms are embedded, procurement processes produce more durable and climate-adaptive infrastructure outcomes. The proposed GPIM operationalizes this structure by aligning regulatory provisions with performance-based evaluation and compliance monitoring systems, thereby transforming procurement from a procedural function into a strategic instrument for resilience delivery.

RQ2: What are the current challenges in entrenching sustainability and resilience into procurement processes?

The study identifies four interrelated categories of challenges: policy, institutional, technical, and market-based. At the policy level, the absence of explicit statutory requirements for climate risk assessment and LCC creates a regulatory gap that limits consistent application. Institutionally, weak inter-agency coordination and fragmented data systems hinder enforcement and performance tracking. Technically, capacity gaps among procurement officers and engineers constrain the adoption of resilience-oriented tools and evaluation frameworks. From a market perspective, supplier behavior remains driven by cost-minimization incentives, with limited motivation to adopt innovative or sustainable solutions due to price-dominated tender criteria. These challenges collectively reinforce a systemic bias toward short-term cost efficiency at the expense of long-term infrastructure resilience, explaining the moderate-to-low performance observed in the IPRPS assessment.

RQ3: Which green procurement strategies are most applicable to Nigeria's climate, infrastructure, and governance context?

The analysis indicates that the most applicable strategies are those that are both high-impact and institutionally adaptable. These include: (i) phased implementation of LCC using standardized templates to ensure ease of adoption; (ii) introduction of sustainability-weighted evaluation criteria to gradually rebalance price-quality trade-offs; (iii) adoption of performance-based specifications that define resilience outcomes rather than prescriptive inputs; and (iv) deployment of digital procurement and compliance monitoring systems to enhance transparency and accountability. Additionally, supplier prequalification based on environmental and technical capacity, coupled with targeted incentives for innovation, can stimulate market transformation. Importantly, the study finds that hybridizing global best practices - drawing from EU standardization, Singaporean innovation incentives, and World Bank risk-screening frameworks - offers a context-sensitive pathway for Nigeria. These strategies, as integrated within the GPIM, provide a scalable and practical roadmap for embedding resilience into procurement governance.

6. CONCLUSION

This study establishes that public procurement is a critical but underutilized lever for advancing climate-resilient transport infrastructure in Nigeria. While the existing procurement framework demonstrates procedural strength in transparency and competition, it lacks the regulatory depth and institutional alignment required to systematically embed climate resilience. The findings reveal a persistent policy-practice gap, where national climate and infrastructure objectives are not effectively translated into procurement criteria, evaluation mechanisms, and contractual enforcement.

By addressing this gap, the study makes three key contributions. First, it advances the literature by conceptualizing procurement as a strategic governance instrument for climate resilience, rather than a purely administrative function. Second, it provides empirical evidence from Nigeria showing that resilience outcomes are significantly influenced by procurement design - particularly the presence or absence of LCC, performance-based specifications, and supplier compliance mechanisms. Third, it introduces the GPIM as a context-sensitive framework that integrates regulatory standards, market incentives, and risk-based planning into a coherent procurement strategy.

The results further demonstrate that resilience-oriented procurement practices - currently more evident in donor-funded projects - lead to improved infrastructure durability, reduced LCC, and enhanced environmental performance. However, their limited institutionalization within domestic procurement systems constrains scalability and long-term impact. Without reform, Nigeria risks continued investment in infrastructure that is vulnerable to escalating climate risks and associated economic losses.

Ultimately, achieving climate-resilient transport infrastructure in Nigeria requires a paradigm shift in procurement governance, from compliance-driven processes to performance-oriented systems that internalize climate risk, lifecycle efficiency, and environmental accountability. Without such transformation, infrastructure investments will remain exposed to escalating climate vulnerabilities, undermining both economic sustainability and national development objectives.

6.1. Recommendations

In view of the discoveries in this paper, it is recommended that:

1. Legislative and policy reform: The Public Procurement Act (2007) and related sectoral guidelines should be amended to include mandatory environmental performance clauses and climate risk assessments in all transport infrastructure tenders. These provisions should specify minimum resilience benchmarks such as drainage capacity, flood protection measures, and low-carbon material requirements, aligned with global best practices. Enforcement should be institutionalized through independent procurement review bodies empowered to verify compliance before contract award and project closeout.
2. Capacity development: Continuous investment in capacity-building programs is required to equip procurement officers, engineers, and contractors with technical competence in LCC application, climate risk evaluation, and sustainable material selection. Certified training programs should be developed in collaboration with universities, professional bodies, and international development agencies to enable the transition from cost-minimization to resilience-based decision-making.
3. Incentivizing private sector innovation: To enhance market responsiveness, financial incentives such as tax relief, preferential contract weighting, and access to green bonds should be provided to contractors and suppliers who meet or exceed resilience and low-carbon performance standards. These incentives will stimulate private sector innovation, strengthen competition on sustainability metrics, and reduce the long-term cost of adopting resilient construction methods.
4. Digitalization and performance monitoring: The adoption of e-procurement platforms integrated with environmental compliance modules should be prioritized to improve transparency, traceability, and accountability. Digital tools, including real-time monitoring dashboards and geospatial inspection systems, should be deployed to track supplier performance and enforce resilience criteria throughout the project life-cycle.
5. Policy learning and institutional integration: A structured knowledge-transfer mechanism should be established to mainstream best practices from donor-funded projects into domestic procurement systems. Strengthening coordination among key institutions - such as the Bureau of Public Procurement, Ministry of Works, and Ministry of Environment - will be critical for ensuring policy coherence and effective implementation.

Reference

1. Intergovernmental Panel on Climate Change. 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Cambridge: Cambridge University Press.
2. Hallegatte S., J. Rentschler, J. Rozenberg. 2019. *Resilient infrastructure: A lifeline for sustainable development.* Washington, DC: The World Bank.
3. Vugrin D.E., D.E. Warren, M.A. Ehlen, R.C. Camphouse. 2010. “A framework for assessing the resilience of infrastructure and economic systems”. In: *Sustainable and resilient critical infrastructure systems: Simulation, Modeling, and Intelligent Engineering*: 77-116. DOI: https://doi.org/10.1007/978-3-642-11405-2_3.
4. Neumann J.E., J. Price, P. Chinowsky, L. Wright, L. Ludwig, R. Streeter, J. Martinich. 2015. “Climate change risks to US infrastructure: impacts on roads, bridges, coastal development, and urban drainage”. *Climatic Change* 131(1): 97-109.

5. de Abreu V.H., S.A. Santos, T.G.M. Monteiro. 2022. "Climate change impacts on the road transport infrastructure: A systematic review on adaptation measures". *Sustainability* 14(14): 1-22. No 8864. DOI: https://doi.org/10.3390/su14148864.
6. International Energy Agency. 2023. *CO_2 Emissions in 2022*. Paris: IEA. Available at: https://www.iea.org/reports/co2-emissions-in-2022/.
7. Cervigni R., R. Valentini, M. Santini. 2013. *Toward Climate-Resilient Development in Nigeria. Directions in Development: Countries and Regions.* Washington, DC: World Bank. DOI: https://doi.org/10.1596/978-0-8213-9923-1.
8. World Bank. 2019. *World Development Report 2019: The Changing Nature of Work.* Washington, DC: World Bank. DOI: https://doi.org/10.1596/978-1-4648-1328-3.
9. Oxford Business Group. 2022. "Multi modal transport links to boost Nigeria's competitiveness". Available at: https://oxfordbusinessgroup.com/reports/nigeria/2022-report/economy/multi modal connections to improve efficiency and boost competitiveness while relieving strain on existing systems.
10. Eze K., S. Olusegunbiyi, M. Shorunke, O. Michael. 2025. "Sustainable Soil-Structure Interaction for Road Infrastructure in Flood-Prone Regions of Nigeria". *The Asian Review of Civil Engineering* 14(1): 1-8. DOI: https://doi.org/10.70112/tarce-2025.14.1.4254.
11. Ejembi A.O., S.A. Muhammad, A. Aliyu. 2025. "Climate-Resilient Infrastructure in Nigeria: An Assessment of Nigeria's Preparedness for Climate Resilience Events". In: *FESCON Conference Proceedings* 5(1): 261-276. Available at: https://ajer.org.ng/index.php/fescon-proceedings/article/view/.
12. Adelekan O. Ibidun. 2016. "Flood risk management in the coastal city of Lagos, Nigeria". *Journal of Flood Risk Management* 9(3): 255-264.
13. Beitelmal H. Wesam, S.C. Nwokolo, E.L. Meyer, C.C. Ahia. 2024. "Exploring adaptation strategies to mitigate climate threats to transportation infrastructure in Nigeria: Lagos City, as a case study". *Climate* 12(8): 117.
14. Gratton B. Guy, P.D. Williams, A. Padhra, S. Rapsomanikis. 2022. "Reviewing the impacts of climate change on air transport operations". *The Aeronautical Journal* 126(1295): 209-221.
15. Federal Government of Nigeria. 2021. *Nigeria's First Nationally Determined Contribution – 2021 Update. Federal Ministry of Environment*. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Nigeria.
16. Brookings Institution. 2016. "Delivering on sustainable infrastructure [Report]". OECD Publishing. Available at: https://www.brookings.edu/wp-content/uploads/2016/12/global_122316_delivering-on-sustainable-infrastructure.pdf.
17. Ametepey S.O., C.O. Aigbavboa, W.D. Thwala. 2023. "Climate Change Response in Sustainable Road Infrastructure Development". In: *Sustainable Road Infrastructure Project Implementation in Developing Countries: An Integrated Model*: 105-111. Emerald Publishing Limited.
18. Markolf A.S., C. Hoehne, A. Fraser, M.V. Chester, B.S. Underwood. 2019. "Transportation resilience to climate change and extreme weather events – Beyond risk and robustness". *Transport Policy* 74: 174-186.
19. Oraegbune M.O., O.O. Ugwu, C.U. Nwoji, G.C. Ezeokpube. 2015. "Achieving Sustainability in Transportation Infrastructure Projects (Roads): A Nigeria Case Study". *Journal of Environmental Science and Engineering Technology* 3(1): 21-28.
20. Onuoha D.C., O.G. Ogbo, M. Amaechi. 2022. "The need for resilient infrastructure as an adaptive measure for climate change". *BJES* 10(4): 17-27.

21. International Organization for Standardization. *ISO 20400:2017. Sustainable Procurement – Guidance*. Geneva: International Organization for Standardization.
22. Hayes S., C. Desha, M. Burke, M. Gibbs, M. Chester. 2019. "Leveraging socio-ecological resilience theory to build climate resilience in transport infrastructure". *Transport Reviews* 39(5): 677-699.
23. Hall J.W., A. Otto, A.J. Hickford, R.J. Nicholls, M. Tran. 2016. "A framework for analysing the long-term performance of interdependent infrastructure systems". *The future of national infrastructure: A system-of-systems approach*: 12.
24. Martello M.V., A.J. Whittle. 2023. "Climate-resilient transportation infrastructure in coastal cities". In: *Adapting the Built Environment for Climate Change*: 73-108. Woodhead Publishing.
25. Greenham S., E. Ferranti, R. Workman, K. McPherson, A. Quinn, R. Fisher, J. Dora. 2022. *Adaptation for transport resilience to climate change for LICs in Africa and South Asia: State of knowledge report*. Birmingham: University of Birmingham and Transport Research Laboratory (TRL), UK.
26. Unegbu C.O.H., D.S. Yawas, B. Dan-asabe, A.A. Alabi. 2024. "Climate resilience in Nigerian construction: A systematic review of strategies and outcomes". *Journal of Sustainable Construction* 4(1): 60-76. DOI: https://doi.org/10.26593/josc.v4i1.8114.
27. Muoghalu N. Leonard. 2025. "Sustainable Urban Development and Climate Resilence In Nigerian Cities". In: *FESCON Conference Proceedings* 5(1): 1-41.
28. Cinderby S., G. Haq, R. Opiyo, C. Muhoza, A. Ngabirano, Y. Wasike, H. Cambridge. 2024. "Inclusive climate resilient transsport challenges in Africa". *Cities* 146. No 104740.
29. Ngcobo N., O. Akinradewo, P. Mokoena. 2024. "Challenges to sustainable transport infrastructure integration in Johannesburg, South Africa". *Journal of Sustainable Development of Transport and Logistics* 9(2): 92-108.
30. Chakwizira James. 2019. "Rural transport and climate change in South Africa: Converting constraints into rural transport adaptation opportunities". *Jàmbá: Journal of Disaster Risk Studies* 11(3): 1-8.
31. Mbara T., N. Pisa. 2019. "An analysis of impediments to deliver sustainable transport in cities of developing countries: the case of Harare, Zimbabwe". *WIT Trans Built Environ* 182: 241-252.
32. Dorhetso S.N., I.K. Tefutor. 2022. "Estimation of the most sustainable regional and trans-border infrastructure among road, rail and seaborne transport". In: *Applied Research Conference in Africa*: 243-259. Cham: Springer International Publishing.
33. Frimpong Chrysogonus Asante. 2023. "Promoting climate resilience in building construction industry in Ghana". *International Journal of Global Sustainability* 7(1): 1-65.
34. Alghuson Moahd. 2023. "Exploring the transport infrastructure sustainability performance: An investigation of the transportation projects in Saudi Arabia". *Sustainability* 15(19). No 14174. DOI: https://doi.org/10.3390/su151914174.
35. Abraham Arun. 2024. "Building Climate-Resilient Supply Chains in Oman: Challenges, Strategies, and Best Practices". *Journal of Engineering Research*: 1-25
36. Chester M., S. Markolf, A. Fraser, D. Burillo, E. Bondank, Y. Kim, C. Hoehne. 2018. "Infrastructure and climate change". In: *Routledge Handbook of Sustainable and Resilient Infrastructure*: 605-625. Routledge.
37. Braun V., V. Clarke. 2006. "Using thematic analysis in psychology". *Qualitative Research in Psychology* 3(2): 77-101. DOI: https://doi.org/10.1191/1478088706qp063oa.

38. Orfanidou S.V., D.J. Dimitriou, N.P. Rachaniotis, G.T. Tsoulfas. 2024. ”Critical factors for green public procurement: The case of Greece”. *Logistics* 8(4): 127. DOI: https://doi.org/10.3390/logistics8040127.
39. European Commission. 2021. *EU green public procurement criteria for road transport* (Staff Working Document SWD (2021) 296 final). Brussels. Available at: https://ec.europa.eu/environment/gpp/pdf/criteria/.
40. Nilsson A.L., K. Kaaret, Torres E. Morales, E. Piirsalu, K. Axelsson. 2023. *Green Public Procurement: a key to decarbonizing construction and road transport in the EU*. Stockholm: Stockholm Environment Institute. DOI: https://doi.org/10.51414/sei2023.007.
41. Jain Ashok Kumar. 2023. *Climate resilient, green and low carbon-built environment*. Springer Nature.
42. Andersson I., G. Rusten. 2024. ”Green innovative procurement in the municipality sector: A dual case study from Norway”. *Scandinavian Journal of Public Administration* 78(3): 166-179. DOI: https://doi.org/10.1080/00291951.2024.2395255.
43. Corfee-Morlot J., V. Marchal, C. Kauffmann, C. Kennedy, F. Stewart, C. Kaminker, G. Ang. 2012. *Towards a green investment policy framework: The case of low-carbon, climate-resilient infrastructure*. OECD Environment working paper No.48.

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