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Innovative financing for sustainable transport infrastructure in Africa: The role of green bonds and public-private partnerships

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Abstract. Africa's transport infrastructure financing gap, projected to exceed USD 400 billion annually by 2030 amid rising public debt and intensifying climate risks, created an urgent need to reassess the effectiveness of emerging financing mechanisms. The study aimed to evaluate how green bonds and public-private partnerships (PPPs) performed in mobilising and delivering sustainable transport infrastructure finance across South Africa, Nigeria, and Kenya, with particular attention to the role of institutional capacity and policy coherence. The study employed a mixed-methods design, combining quantitative data from the African Development Bank, World Bank, and national sources covering green bond issuances (2013-2024) and PPP investments (2008-2024), with comparative case analysis and semi-structured stakeholder interviews. South Africa recorded USD 545 million in green bond issuance and an 82% project completion rate, reflecting stronger regulatory alignment and capital market depth. Nigeria and Kenya recorded lower completion rates of 65% and 61%, respectively, with weaker integration between financing instruments and transport-sector priorities. PPPs mobilised over USD 4 billion across major projects, including the Lagos-Ibadan Railway, Gautrain Rapid Rail, and Nairobi Expressway. Nigeria exhibited high capital mobilisation with execution delays and cost overruns, Kenya demonstrated relatively efficient delivery supported by emerging risk-sharing mechanisms, while South Africa showed stronger institutional coordination but higher long-term operational costs. The study found that institutional capacity, regulatory coherence, and project preparation quality were more decisive in shaping project outcomes than the scale of financing mobilised. It concluded that fragmented regulatory frameworks and weak inter-agency coordination systematically undermined both green bond effectiveness and PPP performance. The findings indicated that strengthening institutional frameworks, standardising project preparation processes, and aligning financing instruments with sectoral policies are critical to scaling sustainable transport infrastructure finance in Africa

Keywords: institutional capacity; policy coherence; infrastructure finance; project completion rates; climate-resilient transport; blended finance; risk allocation

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Introduction

Financing sustainable transport infrastructure in Africa remains unresolved, not because financing instruments are absent, but because the systems through which finance is mobilised, allocated, and governed are fundamentally misaligned with the realities of infrastructure delivery and climate exposure. Transport infrastructure is inherently long-term, capital-intensive, and highly sensitive to environmental risk, yet prevailing financing approaches are often short-term, fragmented, and weakly integrated into sectoral planning. This creates a structural contradiction: while the demand for resilient and interconnected transport systems continues to grow, the mechanisms used to finance them fail to adequately address risk, coordination, and implementation complexity. As climate pressures intensify and infrastructure systems become more vulnerable to disruption, this misalignment deepens, resulting in delayed projects, escalating costs, and suboptimal outcomes. The central problem, therefore, is not simply one of insufficient capital, but of how financing mechanisms interact with institutional capacity, regulatory coherence, and project execution realities in shaping infrastructure outcomes.

Studies have examined different aspects of this problem, particularly in relation to climate finance constraints, green financial instruments, and institutional performance. K.P. Gallagher *et al.* (2024) analysed debt dynamics in Sub-Saharan Africa and demonstrated that rising debt servicing obligations significantly constrain public investment in infrastructure. While their work established the macro-fiscal limitations facing governments, it did not examine how these constraints translate into sector-specific financing outcomes, particularly in transport infrastructure. F. Taghizadeh-Hesary *et al.* (2022) investigated the potential of green bonds to mobilise sustainable finance and found that their effectiveness depends on local currency markets, risk mitigation instruments, and regulatory support. However, their analysis remained largely financial in orientation and did not assess how green bond financing performs in terms of infrastructure delivery or project outcomes.

F. Antwi *et al.* (2024) explored the relationship between financial development, green investment, and institutional quality, concluding that weak institutional environments undermine the effectiveness of green finance by reducing transparency and investor confidence. Although this study highlighted the importance of governance, it did not specify how institutional quality affects performance across different financing instruments. T. Molokwane *et al.* (2023) examined public-private partnerships in African infrastructure and found that deficiencies in contract management and regulatory oversight contribute to inefficiencies and delays in project execution. Their findings underscored governance challenges in PPP implementation but were largely based on single-country or sectorally broad analyses, limiting comparative insights.

E. Ünalan Karakuş (2023) focused on the institutional dimensions of PPP governance and concluded that coherent regulatory frameworks and clearly defined responsibilities are critical for achieving efficiency and public value. While this provided a strong theoretical basis for understanding PPP performance, it did not empirically assess how such institutional conditions influence outcomes across different national contexts. T. Lavitt & H. Sargeant (2024) analysed green infrastructure financing in developing economies and identified risk perception, weak project pipelines, and limited investor confidence as key barriers to private capital mobilisation. However, their study did not examine how these barriers interact with specific infrastructure sectors such as transport.

J. Demski *et al.* (2025) investigated the growth of the global green bond market and showed that expansion in issuance does not necessarily correspond to measurable environmental impact, particularly in contexts with weak monitoring and reporting systems. This finding raised important concerns about the effectiveness of green finance but did not address sector-level performance. Similarly, S. Mutarindwa *et al.* (2024) examined certification challenges in emerging green bond markets and found that weak verification mechanisms increase the risk of greenwashing and reduce investor trust. While their study highlights regulatory gaps, it did not connect these issues to infrastructure delivery outcomes or comparative country performance.

Across these studies, three patterns emerge. First, existing research tends to treat financing constraints, financial instruments, and institutional factors as separate domains rather than interconnected elements shaping infrastructure outcomes. Second, much of the evidence remains either macro-level or instrument-specific, with limited attention to sectoral dynamics, particularly in transport infrastructure. Third, comparative, multi-country analyses that link institutional capacity and policy coherence to measurable project performance remain scarce. As a result, the relationship between financing mechanisms and actual infrastructure outcomes, especially in terms of project completion, efficiency, and sustainability, remains insufficiently understood. This study addressed these limitations by examining how variations in institutional capacity and policy alignment shape the performance of green bonds and public-private partnerships in financing transport infrastructure across South Africa, Nigeria, and Kenya, with a focus on explaining cross-country differences in implementation outcomes.

Materials and Methods

This study adopted a mixed-methods research design to examine how green bonds and public-private partnerships (PPPs) perform in financing sustainable transport infrastructure across South Africa, Nigeria, and Kenya. The choice of this design was driven by the need to combine measurable financial performance with institutional and regulatory dynamics that shape implementation outcomes. The quantitative component enabled systematic comparison of financing scale, efficiency, and delivery across countries, while the qualitative component provided contextual

explanation of how institutional arrangements, risk allocation practices, and governance structures influence these outcomes. The integration of both approaches ensured that observed performance differentials were not only measured but also analytically explained.

The quantitative analysis relied on secondary data obtained from publicly accessible and verifiable sources. These included the African Development Bank's African Economic Outlook reports (African Development Bank Group, 2025), the World Bank Public-Private Infrastructure (PPI) Database (World Bank, 2024a; 2024b; 2025), IMF Article IV consultation reports (International Monetary Fund, 2023), and national treasury and finance publications from South Africa, Nigeria, and Kenya. Quantitative evidence on green bond issuance and public-private partnership (PPP) investments was compiled from these sources, with the most recent complete and verified datasets available up to 2024; data for 2025 were not yet consolidated across the referenced databases at the time of analysis.

The temporal scope covered green bond issuances from 2013 to 2024, reflecting the emergence and consolidation of green finance instruments in African markets, and PPP investments from 2008 to 2024, allowing for longitudinal assessment of project delivery cycles. The dataset was not extended to 2025–2026 because complete and validated data for those years were not yet available in the referenced databases at the time of analysis (Mukasa & Simpasa, 2024; World Bank, 2025). This constraint ensures that all reported data are consistent, comparable, and verified.

The variables analysed included total funds mobilised, number of financed projects, project completion status, planned and actual implementation timelines, and selected socio-economic and environmental indicators derived from project documentation, such as employment generation and mobility improvements. To enable standardised comparison, three performance ratios were constructed. The project completion rate measured delivery effectiveness and was calculated as:

$$\text{Completion Rate (\%)} = (\text{Number of Completed Projects} / \text{Total Number of Funded Projects}) \times 100. \quad (1)$$

The capital deployment ratio assessed financing efficiency and was defined as:

$$\text{Capital Deployment Ratio} = (\text{Value of Completed Projects} / \text{Total Capital Mobilised}). \quad (2)$$

The implementation efficiency ratio evaluated adherence to project timelines and was calculated as:

$$\text{Implementation Efficiency} = (\text{Planned Duration} / \text{Actual Duration}). \quad (3)$$

These ratios were selected because they capture distinct dimensions of performance, delivery, financial utilisation, and timeliness, and are suitable for cross-country comparison in contexts with heterogeneous project scales. Descriptive statistics and ratio-based comparisons were computed using Microsoft Excel to generate comparable indicators across the three countries. The qualitative component consisted of semi-structured interviews conducted with twelve purposively selected stakeholders directly involved in infrastructure financing and implementation. Participants included three policymakers from national ministries of finance and transport, three PPP unit officials, two financial regulators, two institutional investors, and two project managers. Interviews were conducted between March and July 2024 in Abuja and Lagos (Nigeria), with additional remote interviews involving participants based in Johannesburg (South Africa) and Nairobi (Kenya). All interviews were conducted individually to allow detailed responses and were carried out either face-to-face or via secure virtual platforms.

The interview protocol was designed to capture institutional and operational dynamics and included the following core questions:

1. What factors determine the success or failure of transport PPP projects?
2. How are financial and operational risks allocated between public and private actors?
3. What constraints affect the issuance and utilisation of green bonds?
4. How do regulatory frameworks influence investor participation?
5. What challenges arise during project implementation?
6. How is project performance monitored and evaluated?

Additional probing questions were used to clarify and deepen responses. All interviews were audio-recorded with consent, transcribed verbatim, and analysed using NVivo qualitative data analysis software. An inductive thematic coding approach was applied. Initial open coding generated a set of first-order codes from the transcripts, which were subsequently grouped through axial coding into broader categories such as institutional coordination, regulatory quality, risk allocation, and project preparation. Selective coding was then used to consolidate these categories into overarching analytical themes. Coding frequency and co-occurrence analysis were employed to identify dominant patterns across stakeholder responses, ensuring systematic interpretation of qualitative data.

Benchmarking was conducted using the EU Green Bond Standard (EU Platform on Sustainable Finance, 2025) and the OECD (2020). Specific assessment dimensions included regulatory transparency, project preparation processes, risk-sharing structures, and monitoring mechanisms. These criteria were applied to evaluate the alignment of observed practices with established international standards. Triangulation was achieved by cross-validating quantitative indicators with qualitative insights and benchmarking results, thereby enhancing the robustness and internal consistency of the analysis.

All ethical procedures were strictly followed. Participants provided informed consent before participation, and confidentiality was maintained by anonymising all responses. Ethical approval was not required under the applicable institutional guidelines, as the study involved non-invasive expert interviews without sensitive personal data. This methodological framework ensures transparency, replicability, and alignment between analytical procedures and the results presented in the subsequent section.

Results

Green bond issuance volumes, sectoral allocation, and project completion rates are presented in Table 1.

Table 1. Green bond issuance and project completion metrics in selected African countries (2013-2024)

Country	Total issuance ($million)	Primary sectors	Completion rate (%)
South Africa	545	Renewable energy, water, transit	82
Nigeria	135	Forestry, solar energy	65
Kenya	68	Urban transport, water infrastructure	61

Source: A. Mukasa & A. Simpasa (2024), World Bank (2024)

Green bond-financed projects show differentiated sectoral allocation across countries. South Africa exhibits a diversified allocation across energy, water, and transport; Nigeria is concentrated in forestry and solar energy, with limited transport linkages; while Kenya shows a targeted allocation toward transport and water infrastructure. Completion outcomes differ across sectors. Projects in energy and water show more stable delivery patterns, whereas transport projects exhibit greater variability in completion rates and implementation efficiency, reflecting greater coordination and execution complexity.

There is no consistent positive relationship between financing volume and completion rates, consistent with evidence that expansion in green bond markets does not necessarily translate into measurable infrastructure or sustainability outcomes (Bajra & Wagner, 2024). South Africa records the highest completion rate (82%) alongside the largest issuance (USD 545 million), while Nigeria (USD 135 million) and Kenya (USD 68 million) record lower completion rates of 65% and 61%, respectively. These differences indicate that financing scale alone does not determine delivery performance. Completion rates reflect differences in underlying project pipelines, with South Africa associated with a larger volume of completed projects relative to Nigeria and Kenya, while Nigeria's lower completion rate reflects a smaller proportion of completed projects relative to those initiated. Kenya's outcomes reflect a smaller but more stable project base. Although precise project counts vary across reporting sources, these patterns indicate that percentage indicators must be interpreted alongside project scale.

Across the period 2013-2024, completion rates do not follow a uniform temporal trend. South Africa maintains consistently high performance, Nigeria exhibits variability associated with implementation delays, and Kenya shows relatively stable but moderate outcomes. Completion performance varies with project timelines and institutional conditions rather than following a linear temporal trend. The average completion rate of 69.3%, calculated as the arithmetic mean of national completion rates, provides an aggregate measure but conceals substantial variation across countries, sectors, and project scales. The evidence shows that completion performance is not determined by financing volume alone but varies with sectoral distribution and implementation conditions. PPP investment volumes and project-level outcomes are presented in Table 2.

Table 2. Public-private partnership investment and infrastructure outcomes (2008-2024)

Country	Project	Investment ($million)	Key outcomes
Nigeria	Lagos-Ibadan Railway	2,000	Employment generation: delayed implementation
South Africa	Gautrain Rapid Rail	1,300	Operational success; high operational costs
Kenya	Nairobi Expressway	680	Timely delivery; toll-based revenue model

Source: World Bank (2024a), World Bank (2024b), World Bank (2025)

Derived performance ratios enable direct comparison of delivery outcomes across countries. The project completion rate is 82% in South Africa, 65% in Nigeria, and 61% in Kenya, corresponding to differences of 17, 21, and 4 percentage points, respectively. The implementation efficiency ratio is above unity in South Africa, below unity in Nigeria, and close to unity in Kenya, indicating on-schedule delivery in South Africa, delays in Nigeria, and relatively stable timelines in Kenya. The capital deployment ratio follows the same ordering, with South Africa highest, Kenya intermediate, and Nigeria lowest, although precise values are not uniformly reported across sources.

These patterns are reflected in project-level evidence. The Lagos–Ibadan Railway (Nigeria) experienced delays linked to procurement processes, coordination challenges, and contract execution issues reported in project documentation (World Bank, 2024). The Gautrain Rapid Rail (South Africa) achieved operational completion within

planned timelines but shows higher operating costs, while the Nairobi Expressway (Kenya) was delivered on schedule under a toll-based concession model.

Differences are also evident across project types. The railway project (Nigeria) shows lower implementation efficiency, the urban rail system (South Africa) shows high completion performance, and the road concession (Kenya) shows stable timelines, indicating variation in delivery performance across project categories. There is no consistent relationship between investment size and implementation efficiency. Nigeria records the largest investment (USD 2,000 million) with the lowest efficiency, South Africa combines USD 1,300 million with the strongest performance, and Kenya records USD 680 million with moderate but stable outcomes. Implementation performance, therefore, varies with execution conditions rather than financing scale.

Figure 1 presents the comparative distribution of green bond issuance across South Africa, Nigeria, and Kenya, with values of USD 545 million, USD 135 million, and USD 68 million, respectively. Corresponding completion rates, reported separately in the dataset, are 82%, 65%, and 61%, differing by 17 percentage points (South Africa–Nigeria), 21 percentage points (South Africa–Kenya), and 4 percentage points (Nigeria–Kenya). These differences indicate that higher issuance does not consistently translate into stronger delivery outcomes. Project-level outcomes reinforce these differences: the Lagos–Ibadan Railway (Nigeria) experienced delays linked to procurement delays, inter-agency coordination challenges, and contract execution issues reported in project documentation (World Bank, 2024), while the Gautrain Rapid Rail (South Africa) achieved timely completion despite higher operating costs, and the Nairobi Expressway (Kenya) was delivered on schedule under a toll-based concession. Variation across railway, urban rail, and road concession projects further indicates differences in implementation efficiency by project type. These patterns indicate no consistent relationship between financing scale and implementation efficiency across the three countries.

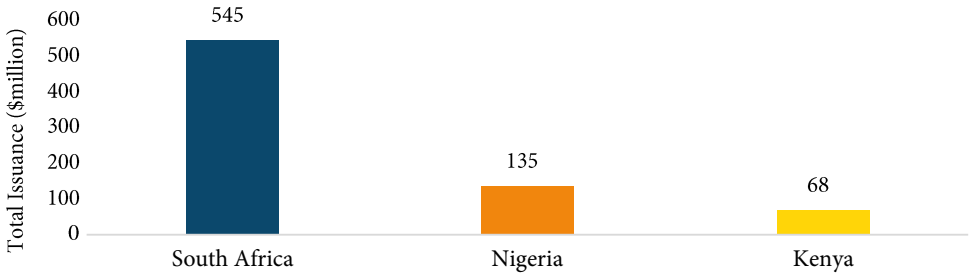

Figure 1. Comparative project completion rates for green bond-funded projects in South Africa, Nigeria, and Kenya (2013-2024)

Source: author's compilation based on A. Mukasa & A. Simpasa (2024), World Bank (2024a), World Bank (2024b)

Figure 1 presents green bond issuance across South Africa, Nigeria, and Kenya (USD 545 million, USD 135 million, and USD 68 million, respectively). Corresponding completion rates are 82%, 65%, and 61%, differing by 17, 21, and 4 percentage points. The figure shows that higher issuance does not consistently correspond to higher completion performance. This divergence is reflected in project-level outcomes. The Lagos-Ibadan Railway (Nigeria), despite the largest investment, experienced implementation delays and cost pressures, representing a contrasting case with lower implementation efficiency relative to investment scale. In contrast, the Gautrain Rapid Rail (South Africa) achieved timely operational completion with higher capital deployment efficiency, while the Nairobi Expressway (Kenya) was delivered on schedule under a toll-based concession model. These cases illustrate that variation in outcomes is not explained by financing scale alone.

Over the period 2013-2024, this pattern remains consistent. South Africa maintains relatively high completion performance, Nigeria exhibits variability associated with delays, and Kenya shows moderate but stable outcomes. This consistency indicates that the observed divergence reflects persistent differences in implementation conditions rather than isolated outcomes. Higher completion rates and efficiency ratios are associated with stronger institutional coordination and regulatory clarity. In this study, institutional coordination is operationalised using observable proxies, including project completion rates (Table 1), implementation efficiency ratios, procurement timelines, and coordination-related constraints identified in stakeholder interviews, consistent with proxy-based measurement of institutional performance in infrastructure systems (Ogunseye & Oladipo, 2025). These indicators reflect the alignment of planning, financing, and implementation functions.

The relationship is evident across countries. South Africa's higher completion rate (82%) corresponds with centralised PPP oversight within the National Treasury and structured green finance processes. Kenya's intermediate performance reflects coordination through its PPP Unit and transport regulatory framework. Nigeria's lower completion rate (65%) coincides with procurement delays, inter-agency coordination challenges, and execution constraints, with institutional coordination identified as a dominant issue in stakeholder interviews. This pattern appears across both instruments but in different forms: in green bonds, through alignment of issuance and project

selection; in PPPs, through procurement design and contract execution. The evidence indicates a consistent correlation between institutional coordination and performance, without establishing causality. In contrast, lower performance indicators correspond with fragmented governance structures and weaker risk allocation frameworks. The results indicate a consistent association between institutional capacity and financing effectiveness.

Table 3. Thematic coding of interview responses on institutional coordination and project performance (NVivo analysis, n = 14)

Theme	Frequency (%)	Manifestation in practice	Representative quotation
Institutional coordination	79 (11 of 14 interviews)	Delayed approvals; overlapping mandates; rework cycles	"Approvals move across multiple agencies at the federal level without clear ownership, which extends timelines." (Policymaker)
Regulatory clarity	71 (10 of 14 interviews)	Inconsistent requirements; delayed permits	"Regulatory requirements change during implementation, creating uncertainty for investors." (Investor)
Risk allocation	64 (9 of 14 interviews)	Cost escalation; financing constraints	"Demand and regulatory risks are not clearly defined, increasing financing costs." (Investor)
Project preparation	57 (8 of 14 interviews)	Weak feasibility studies; contract revisions	"Projects enter procurement without complete feasibility, leading to adjustments during execution." (Project manager)

Source: compiled by the authors based on interviews

Interview results indicate that institutional coordination is the most frequently cited constraint (79%), followed by regulatory clarity (71%) and risk allocation (64%). In practice, weak coordination manifests through multi-stage approval processes, overlapping institutional mandates, and inconsistent implementation decisions, which extend procurement timelines and reduce implementation efficiency. These patterns correspond with lower completion rates and implementation delays reported in Table 1, particularly in Nigeria. Risk allocation issues are reported primarily by investors and are reflected in unclear assignment of demand and regulatory risks, which increases financing costs and reduces project viability. Project managers emphasise deficiencies in feasibility preparation, resulting in contract revisions and execution delays. Differences across respondent groups are evident. Policymakers emphasise coordination and regulatory constraints, investors focus on risk allocation and return predictability, while project managers highlight implementation bottlenecks. This distribution indicates that performance constraints arise at multiple stages of the project cycle.

Cross-country variation is also observed. Kenya's relatively stable implementation performance corresponds with structured procurement procedures and defined risk-sharing frameworks within its PPP Unit, while Nigeria's lower performance reflects coordination failures, regulatory inconsistency, and weak feasibility planning. While interview evidence for South Africa is limited, its higher completion rates indicate stronger institutional alignment relative to the other cases. Benchmarking against international standards further reinforces these patterns consistent with recent empirical applications of benchmarking frameworks in infrastructure governance analysis (Gonzalez *et al.* 2025). Comparative assessment using the EU Green Bond Standard and OECD PPP Principles is presented in Table 4.

Table 4. Comparative benchmarking of green finance and PPP frameworks

Domain	Global standard (EU/OECD)	Observed practice (Africa)
Regulatory framework	Unified taxonomy, pre-issue reporting	Fragmented and inconsistent
Risk-sharing tools	Advanced guarantee instruments	Limited and uneven
Project pipelines	Standardised and transparent	Ad hoc and non-standardised
Monitoring systems	Independent verification and audits	Weak and under-resourced

Source: OECD (2020), A. Mukasa & A. Simpasa (2024), EU Platform on Sustainable Finance (2025)

Benchmarking shows the highest alignment in South Africa, followed by Kenya, with Nigeria lowest. This ordering is consistent with observed completion rates (82%, 61%, 65%) and implementation efficiency patterns. Across criteria, regulatory clarity, project preparation, and risk allocation show the strongest association with outcomes, while institutional coordination and procurement consistency represent the main constraints, particularly in Nigeria. Kenya shows moderate gaps in regulatory standardisation, while South Africa's limitation lies in operational cost efficiency rather than implementation performance.

Completion rate, implementation efficiency, and capital deployment were selected as they directly measure delivery outcomes and are consistently reported across infrastructure performance studies (Chapman, 2024; Olatunde *et al.*, 2026). Alternative indicators were not applied due to data inconsistency. Completion rate has the strongest explanatory power, as it captures realised outcomes and aligns with efficiency patterns observed in infrastructure performance literature (Munday *et al.*, 2023). The results are consistent with prior evidence on institutional effects in infrastructure delivery. A composite

efficiency index is feasible but not constructed due to comparability constraints.

Across all three countries, these indicators consistently show that institutional capacity, regulatory coherence, and project preparation quality are more decisive determinants of infrastructure delivery outcomes than the scale of capital mobilisation alone. The variation in completion rates and implementation efficiency across countries reflects differences in regulatory, financial, and institutional conditions. The observed misalignment between green bond issuance and transport investment corresponds with the absence of clearly defined eligibility criteria and reporting structures in some cases. Differences in implementation timelines are associated with fragmented approval processes and weak inter-agency coordination, while variation in project delivery reflects differences in project preparation and risk allocation practices.

These patterns are consistent with established international frameworks, including green finance taxonomies and recent OECD guidance on infrastructure governance (OECD, 2020; European Commission, 2025), which emphasise eligibility criteria, risk allocation, and institutional coordination as key determinants of financing effectiveness. The distribution of responsibilities across ministries of finance, PPP units, and financial regulators corresponds with the observed variation in implementation outcomes. The evidence indicates that performance differences occur at multiple levels. At the national level, variation in regulatory structure and institutional coordination is associated with differences in completion rates. At the sectoral and project levels, variation in feasibility assessment, procurement design, and contract structuring corresponds with differences in implementation efficiency.

Across cases, lower completion rates and delays are associated with weak project preparation, inconsistent procurement processes, and unclear risk-sharing arrangements, while stronger performance corresponds with more structured coordination mechanisms and defined allocation of responsibilities. These patterns align with the performance indicators reported in this study. These measures align with established international standards, including green bond taxonomy frameworks and OECD PPP principles, which provide guidance on eligibility criteria, risk allocation, and governance structures. Implementation responsibility rests with ministries of finance, PPP units, and financial regulators, with support from development finance institutions.

Implementation is required at the national level (regulatory frameworks and coordination), and at sectoral and project levels (feasibility assessment, procurement design, and contract structuring). The expected impact is a reduction in implementation delays, improvement in completion rates, and stronger capital deployment efficiency, consistent with the performance indicators used in this study. Operationalisation requires strengthened project preparation systems, standardised procurement processes, and clearly defined risk-sharing mechanisms within PPP contracts. Potential barriers include institutional capacity constraints, regulatory inconsistency, and coordination failures, which may limit effectiveness if not addressed.

Discussion

The results point to a consistent pattern across the three countries: the effectiveness of green bonds and PPPs in transport infrastructure is not determined by how much capital is mobilised, but by how that capital is governed, coordinated, and translated into implementation. This becomes most visible when comparing Nigeria and South Africa. Nigeria mobilises larger volumes of capital through PPPs, yet records weaker completion and efficiency outcomes, while South Africa, with comparatively moderate financing volumes, achieves higher delivery performance. This divergence suggests that financing instruments do not operate independently of institutional conditions; rather, they are mediated by them, consistent with recent empirical evidence on PPP governance and infrastructure performance in emerging economies (Nguyen *et al*., 2025; Ariana *et al*., 2026).

This reading sits within, but also sharpens, a growing body of work on institutional quality in sustainable finance. F. Antwi *et al*. (2024) showed that weak institutional environments reduce the effectiveness of green investment by undermining transparency and investor confidence. What the present findings add is a clearer link between institutional conditions and *project-level outcomes*. Completion rates and implementation efficiency were not abstract indicators; they were the points at which institutional weaknesses become operational. In this sense, the study moved beyond macro-level associations and demonstrates how institutional constraints materialise in delayed delivery, cost overruns, and fragmented project execution.

A similar pattern emerges in the literature on PPP governance, although often treated in isolation from green finance. T. Molokwane *et al*. (2023) identified deficiencies in contract enforcement and regulatory oversight as central to PPP underperformance in African contexts. The results here were consistent with that diagnosis but extended it in two ways. First, they showed that these governance issues are not confined to PPPs; they also shaped the performance of green bond-financed projects. Second, they suggested that the problem is less about the choice of instrument and more about the institutional environment within which different instruments are deployed. E. Ünalan Karakuş (2023) emphasised the importance of regulatory coherence and clearly defined institutional roles in PPP systems. The relatively stronger performance observed in South Africa reflects precisely these conditions, although the evidence here indicates that such coherence must be sustained across both financing and sectoral policy domains to be effective.

The findings on green bonds complicate some of the more optimistic claims in the literature. F. Taghizadeh-Hesary *et al*. (2022) argued that green bonds can mobilise long-term capital for sustainable infrastructure, particularly when supported by appropriate financial and regulatory

frameworks. Recent studies similarly show that green bond issuance does not automatically translate into sectoral infrastructure outcomes (Khan & Vismara, 2025). While this was not contradicted, the results suggest that mobilisation alone is an insufficient metric of success. In Nigeria, for instance, green bond issuance remains largely disconnected from transport infrastructure, limiting its relevance for sectoral outcomes. This raised a question that is often overlooked: not whether green bonds exist, but whether they are "embedded" within sector-specific investment strategies. S. Mutarindwa *et al.* (2024) highlighted the risks associated with weak certification and verification systems, particularly in emerging markets. The present findings reinforced this concern, but also showed that the consequences extend beyond market credibility to affect the actual delivery of infrastructure projects.

There is also an important nuance in how PPPs perform under different institutional configurations. T. Lavitt & H. Sargeant (2024) identified risk perception and weak project pipelines as key barriers to private investment in developing economies. The interview evidence supported this, particularly in relation to risk allocation and feasibility planning. However, the comparison with Kenya suggested that these constraints are not uniform. Kenya's relatively stable implementation performance, despite moderate institutional capacity, points to the role of targeted interventions such as structured risk-sharing mechanisms and external guarantees. This did not contradict the broader literature but indicates that institutional capacity is not a fixed condition; it can be partially compensated for through specific design choices in project structuring.

The broader implication is that financing scale and financing effectiveness should not be conflated. U.Q. Bajra & N. Wagner (2024) showed that the expansion of green bond markets globally has not always translated into measurable environmental impact. The results here reflected a similar disconnect at the level of infrastructure delivery. Higher levels of capital mobilisation do not necessarily produce better outcomes, and in some cases may obscure underlying inefficiencies. S.K. Kogi *et al.* (2025) attributed the slow development of green finance in Africa to weak disclosure standards and fragmented regulatory systems. The benchmarking results confirmed these structural gaps, but also suggest that the issue is not simply one of absence, but of misalignment between financial frameworks and sectoral implementation systems.

What emerges across both the quantitative and qualitative evidence is a convergence around institutional variables, consistent with recent multi-level analyses of sustainable infrastructure systems (Li, 2025). J. Xie *et al.* (2023) and K. Zhou *et al.* (2024) emphasised the importance of aligning financial systems with sustainability objectives through coherent governance structures. The present findings supported this, but also indicate that alignment must occur at multiple levels, financial, regulatory, and sectoral, to produce measurable outcomes. Where this alignment is partial, as in Kenya, performance is uneven but improving. Where it is weak, as in Nigeria, financing mechanisms operate in isolation, reducing their effectiveness. Where it is more fully developed, as in South Africa, financing instruments are more consistently translated into completed infrastructure.

At the same time, the findings challenged a common assumption in the literature that increasing private sector participation will automatically improve infrastructure delivery. The evidence suggests that without clear institutional frameworks, private capital does not reduce risk but redistributes it in ways that can delay or complicate implementation. This is particularly evident in the qualitative data, where issues of coordination and contractual clarity repeatedly emerge as constraints. In this respect, the study did not reject the role of PPPs or green bonds, but reframes their effectiveness as contingent rather than inherent.

The results reposition the discussion on sustainable infrastructure finance in Africa. Rather than asking how to mobilise more capital, the more pressing question is how to ensure that existing and future financing is embedded within institutional systems capable of delivering outcomes. The contribution of this study lies in making that distinction empirically visible. By linking financing instruments to measurable performance indicators and grounding these in institutional dynamics, it shows that the effectiveness of green bonds and PPPs is not a function of their design alone, but of the environments in which they are implemented.

Conclusions

Performance across the three countries does not track the volume of financing mobilised; it tracks the capacity to organise, govern, and execute projects. South Africa combines moderate green bond issuance with the strongest delivery record, reflected in completion rates above four-fifths and higher conversion of capital into operating assets. Nigeria mobilises the largest PPP volumes, exceeding USD 2 billion in the Lagos–Ibadan corridor, yet translates less of that capital into completed infrastructure, with lower completion rates and weaker schedule adherence. Kenya sits between these positions: smaller financing envelopes but steadier delivery, with timelines closer to plan and moderate completion outcomes. Taken together, completion rates cluster around roughly seven in ten projects across the sample, masking wide national differences in how finance becomes infrastructure.

The pattern is consistent across indicators. Where institutional coordination is tight, regulatory expectations are clear, risks are allocated predictably, and projects are well prepared upstream, completion rates are higher, timelines are closer to plan, and capital deployment is more efficient. Where these conditions are weak or fragmented, delays, renegotiations, and cost pressures erode performance. The interview evidence mirrors this distribution: coordination failures, unclear mandates, and thin feasibility work recur where quantitative indicators are weakest; clearer roles, firmer rules, and disciplined preparation coincide with more reliable delivery.

The central implication is unambiguous. Financing instruments, green bonds and PPPs alike, do not deliver outcomes on their own. Their effectiveness is governed by institutional capacity, regulatory coherence, and the quality of project preparation. Increasing the scale of finance, in isolation, does not improve delivery; it often amplifies existing weaknesses. Embedding financing within coherent sector strategies and enforceable rules is what converts capital into completed, functioning infrastructure. The findings point to the need for strengthened regulatory frameworks, improved project preparation systems, expanded risk-mitigation instruments, and greater regional coordination in transport infrastructure financing.

Future work should extend the dataset beyond 2024 as verified releases become available, track projects at finer granularity (including stage-by-stage timelines and cost revisions), and broaden the country set to test the stability of these relationships. Further analysis of how specific governance arrangements, particularly risk-sharing structures, approval processes, and feasibility standards, shape outcomes would deepen understanding of how institutional design conditions the performance of both green bonds and PPPs in transport infrastructure.

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Інноваційне фінансування сталої транспортної інфраструктури в Африці: роль зелених облігацій та державно-приватного партнерства

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Анотація. Дефіцит фінансування транспортної інфраструктури в Африці, який, за прогнозами, до 2030 року перевищить 400 млрд доларів США на рік на тлі зростання державного боргу та посилення кліматичних ризиків, створив нагальну потребу в переоцінці ефективності нових механізмів фінансування. Мета полягала в оцінці ефективності «зелених» облігацій та державно-приватних партнерств (ДПП) у мобілізації та наданні фінансування для сталого розвитку транспортної інфраструктури в Південній Африці, Нігерії та Кенії, з особливою увагою до ролі інституційної спроможності та узгодженості політики. Застосовано змішаний метод, що поєднував кількісні дані Африканського банку розвитку, Світового банку та національних джерел, що охоплюють випуски зелених облігацій (2013-2024 рр.) та інвестиції в ДПП (2008-2024 рр.), з порівняльним аналізом конкретних випадків та напівструктурованими інтерв'ю із зацікавленими сторонами. Південна Африка зафіксувала випуск зелених облігацій на суму 545 млн доларів США та рівень завершення проектів у 82 %, що засвідчило про кращу узгодженість регуляторних норм та глибину ринку капіталу. Нігерія та Кенія зафіксували нижчі показники завершення проектів – 65 % та 61 % відповідно – при слабшій інтеграції між інструментами фінансування та пріоритетами транспортного сектору. ДПП залучили понад 4 млрд доларів США на реалізацію великих проектів, включаючи залізницю Лагос-Ібадан, швидкісну залізницю Gautrain та швидкісну автомагістраль у Найробі. Нігерія продемонструвала високий рівень мобілізації капіталу, однак із затримками у виконанні та перевищенням витрат. Кенія продемонструвала відносно ефективну реалізацію, підкріплену новими механізмами розподілу ризиків. Південна Африка продемонструвала сильнішу інституційну координацію, але вищі довгострокові операційні витрати. Дослідження показало, що інституційна спроможність, узгодженість регуляторних норм та якість підготовки проектів мали вирішальне значення для формування результатів проектів, ніж масштаб залученого фінансування. Фрагментовані регуляторні рамки та слабка міжвідомча координація систематично підривали як ефективність зелених облігацій, так і результати діяльності ДПП. Результати вказали, що зміцнення інституційних рамок, стандартизація процесів підготовки проектів та узгодження інструментів фінансування з галузевою політикою мають вирішальне значення для розширення масштабів фінансування сталого транспортного інфраструктурного розвитку в Африці

Ключові слова: інституційна спроможність; узгодженість політики; фінансування інфраструктури; показники завершення проектів; транспорт, стійкий до кліматичних змін; змішане фінансування; розподіл ризиків