

Financing Low-Carbon Urban Transport through Subnational Green Bonds: A Review in Emerging Economies

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Abstract

Subnational green bonds offer promising potential to finance low-carbon urban transport in emerging economies but remain underutilized due to a range of systemic barriers. This study uses a narrative literature review to examine how green bonds have evolved globally and how they are applied at the municipal level in the transport sector. Drawing from academic literature, multilateral reports, and real-world case studies, it identifies six persistent challenges: fragmented project pipelines, weak MRV systems, difficulties with ESG integration, legal and regulatory hurdles, low municipal credit ratings, and limited investor appetite. Despite the growth of the global green bond market, only a small share supports subnational urban transport projects. Cases such as Mexico City and Johannesburg demonstrate that the absence of enabling frameworks hinders feasibility but broader replication. This review contributes to the climate finance literature by advancing its scholarship by shifting attention from national-level instruments to local institutional realities and proposing five future research directions to support more inclusive and viable green bond mechanisms for sustainable transport in emerging markets.

Keywords: Subnational Green Bonds; Low-Carbon Urban Transport; Emerging Economies; Climate Finance; Municipal Finance; Urban Climate Policy

A. INTRODUCTION

The urgent need to address climate change demands transformation across all sectors, with urban transport emerging as a critical area (Robin, 2021). Climate finance, resources aimed at supporting mitigation and adaptation, plays a vital role in this transition. Transport is a major and growing source of greenhouse gas (GHG) emissions, contributing 24% of global emissions, with road vehicles making up nearly three-quarters. Achieving net zero by 2050 requires halving transport emissions by 2035 through shifts in mobility and increased electric vehicle use (Welle & Zhang, 2025). Despite global targets, financing remains insufficient. Annual climate finance for transport stands at around \$334 billion but needs to rise to \$2.7 trillion globally by 2050. For developing countries (excluding China), the annual need is \$575 billion by 2030 (Welle & Zhang, 2025). While climate finance is conceptually clear, actual disbursement, especially for urban transport in emerging economies, remains limited, indicating deeper systemic constraints.

Green bonds have emerged as a key tool to mobilize sustainable finance. These fixed-income instruments fund projects with environmental benefits, such as clean transport. As of Q3 2022, the global sustainable debt market reached USD 3.5 trillion, with green bonds making up about USD 2 trillion (CBI, 2022). Since the 2015 Paris Agreement, demand for climate-aligned investments has grown significantly. However, emerging markets account for only 16% of total Green, Social, Sustainability, and Sustainability-linked (GSSS) bond issuance, with limited uptake in low- and middle-income countries (World Bank, 2024a). This disparity indicates that structural barriers within EMDEs prevent them from fully leveraging this growing financial tool despite immense climate finance needs (Robin, 2021).

While sovereign and corporate green bonds are well studied, research on subnational green bonds, especially for transport, is limited. Most literature focuses on national-level or cross-sector analysis, often missing key sector-specific design features and local governance needs. This creates a "last mile" problem: subnational governments in emerging economies often lack the fiscal autonomy, project pipelines, and regulatory frameworks needed to issue green bonds for transport decarbonization (Bisultanova, 2023; Muhammad et al., 2022). This raises a key question: What are the key knowledge

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and design gaps in the application of subnational green bonds for financing low-carbon urban transport in emerging market contexts?

This study synthesizes existing literature on subnational green bonds and their role in financing low-carbon urban transport in emerging markets. It contributes to climate finance scholarship by spotlighting the underexplored intersection of municipal governance and sustainable transport investment and by outlining a targeted agenda for future research. The study is organized into four sections: an introduction (section A), a methodology (section B), a literature review (section C), findings and future research direction (section D), and a conclusion (section E).

B. METHODS

This study uses a narrative literature review to examine the challenges and research gaps in using subnational green bonds to finance low-carbon urban transport in emerging economies. This method is suitable because it allows for flexible analysis across different disciplines, especially when data is limited or scattered (Cortellini & Panetta, 2021; White & Wahba, 2019). Given the complexity of climate finance (which involves infrastructure, governance, and capital markets), a narrative review helps bring together a wide range of insights. It is also useful for identifying design and implementation issues that are common in public finance and infrastructure projects, especially in emerging economies (Mello & Ter-Minassian, 2024; White & Wahba, 2019). These reviews help to clarify systemic challenges that often emerge at the intersection of financial mechanisms and public sector implementation, especially in emerging markets. This study builds on that foundation by focusing specifically on the subnational context, where the application of green bonds to urban transport remains largely under-researched (Herrera, 2024).

To collect relevant materials, both academic and grey literature were reviewed. Sources were gathered using Google Scholar and public search engines, including peer-reviewed journals, reports from development banks, case studies, and policy briefs. Keyword selection is focused on both topic and context:

- Primary keywords: "Low-Carbon Urban Transport," "Subnational Green Bonds," "Emerging Economies," "Sustainable Finance," "Climate Finance"
- Secondary keywords: "Urban Mobility," "Municipal Bonds," "Green Infrastructure," "Bond Markets," "Climate Change Mitigation," "Financial Innovation," "Policy Framework"

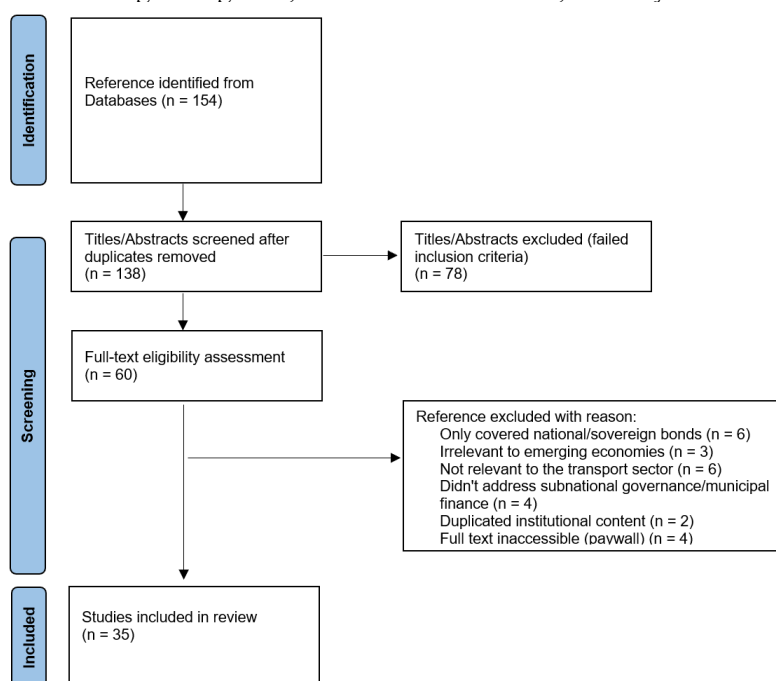


Figure 1. PRISMA Flow Diagram

Sources: Research Data, 2025

The literature was filtered based on relevance to three inclusion criteria: (1) applicability to urban transport, (2) focus on subnational or municipal-level financing, and (3) emphasis on developing or emerging economy contexts. A total of 154 records were initially identified through keyword-based searches (2015–2025). After removing 16 duplicate entries, 138 unique records remained for title and abstract screening. From this stage, 78 records were excluded for lacking relevance to green finance, urban transport, or subnational governance (title/abstract). The remaining 60 full-text articles were assessed for eligibility, and 25 were excluded based on predefined criteria. A total of 35 studies were selected for in-depth review and thematic synthesis. The full screening process is summarized in Figure 1 using a PRISMA flow diagram (Page et al., 2021).

Following this process, 35 studies were included in the final review. The review process is organized into four thematic sections to support the study's objectives: 1) Green Bonds: Evolution and Use in Climate Infrastructure; 2) Subnational Finance for Transport in Emerging Economies; 3) Green Bonds in the Transport Sector; and 4) Barriers to Subnational Green Bonds for Transport Projects in Emerging Economies.

C. RESULTS AND DISCUSSION

Green Bonds: Evolution and Use in Climate Infrastructure

Green bonds are financial instruments designated for environmentally beneficial projects, commonly referred to as "use-of-proceeds" debt. They are specifically structured to fund initiatives that contribute measurable environmental outcomes, such as renewable energy, sustainable water systems, and low-emission urban transport. The concept was pioneered by the European Investment Bank (EIB) in 2007 and soon after adopted by the World Bank in 2008. Since then, the green bond market has grown rapidly. By 2024, annual issuance had surpassed USD 700 billion, with the total volume of outstanding green bonds nearing USD 3 trillion (Demski et al., 2025; EIB, n.d.; World Bank, 2024b). This remarkable growth reflects both the growing urgency of climate action and the rising investor appetite for sustainability-aligned financial products. Today, green bonds are a central pillar of climate infrastructure finance. They are especially relevant to the urban transport sector, which contributes approximately 24% of global greenhouse gas emissions (Welle & Zhang, 2025). In this context, green bonds fund initiatives such as electric bus fleets, urban rail systems, dedicated cycling infrastructure, and multimodal transport hubs. These investments align urban mobility planning with decarbonization goals and support broader sustainable development agendas.

Multilateral Development Banks (MDBs), including the World Bank and International Finance Corporation (IFC), have been instrumental in developing this market. They have collectively issued over USD 35 billion in green bonds and have established benchmarks, taxonomies, and technical assistance frameworks to support bond issuers, especially in developing countries (IFC, 2025; World Bank, 2024b). Despite this progress, emerging markets and developing economies (EMDEs) still face considerable obstacles. As of Q2 2024, EMs accounted for just 16% of total Green, Social, Sustainability, and Sustainability-linked (GSSS) bond issuance. Although green bonds dominate in both EM and advanced economies (70% and 66% of their respective GSSS markets), public sector participation in EMs remains significantly lower at 23%, compared to 43% in advanced economies (World Bank, 2024a). These figures highlight institutional and market-readiness constraints at the subnational level. The OECD underscores that bond markets hold substantial potential for enabling low-carbon transitions but stresses that localized design and regulatory support are essential to overcome challenges in EMDEs, such as weak credit ratings, underdeveloped capital markets, and limited project pipelines (ACT, n.d.). While green bonds have evolved into a robust financing tool for climate infrastructure globally, their application at the subnational level in emerging economies, particularly for urban transport, remains constrained, presenting a critical gap for further exploration.

Subnational Finance for Transport in Emerging Economies

Cities are at the heart of the global climate response. Urban areas already house over half of the world's population, with the majority of future growth expected to occur in emerging markets. As hubs of economic activity and energy consumption, cities are responsible for more than 70% of global greenhouse gas emissions (Dasgupta et al., 2022). Local government decisions have a profound influence on emission

trajectories, making municipalities indispensable actors in meeting national climate targets and delivering urban co-benefits such as improved air quality and public health (Hoomweg et al., 2020; O'Garra et al., 2024). Recognizing this, international coalitions such as C40 Cities, United Cities and Local Governments (UCLG), and the Global Covenant of Mayors (GCoM) have promoted city-level climate action and facilitated access to finance. These platforms enhance vertical coordination between national and subnational actors, support project pipeline development, and help address both the supply- and demand-side constraints of urban climate finance (Bhandary, 2024; Phuong Nguyen et al., 2020). However, the urban climate finance landscape is marred by a persistent gap, particularly in emerging economies, indicating systemic governance issues and deficiencies within the financial frameworks accessible to municipalities (Ko & Prakash, 2022).

In many low- and middle-income countries (LMICs), municipalities face substantial urban infrastructure investment needs, particularly for low-carbon transport systems. However, current financial flows are insufficient to meet demand. The core constraints are multifaceted: limited fiscal autonomy, low creditworthiness, weak project preparation capacity, and regulatory or institutional barriers that restrict direct access to capital markets (Demskei et al., 2025; Youssef, 2022). Cities often rely heavily on central government transfers or guarantees to access funding, but these are increasingly constrained due to fiscal pressures and concerns over moral hazard. As a result, public sector participation in the GSSS (Green, Social, Sustainability, and Sustainability-linked) bond market in emerging markets remains low, only 23%, compared to 43% in advanced economies (World Bank, 2024a). The fiscal and institutional gap is especially acute for secondary cities, which frequently struggle with fragmented mandates, low technical capacity, and small-scale projects that are unattractive to institutional investors due to high transaction costs. These cities are often caught in a "creditworthiness trap": they lack the ratings required to access private capital markets but cannot rely on consistent sovereign guarantees or concessional funding. This condition perpetuates their exclusion from blended finance opportunities and widens the infrastructure investment gap (Jessie Press-Williams et al., 2024). Consequently, even though cities are central to achieving low-carbon transport objectives, they are structurally under-equipped to mobilize and manage repayable climate finance. There is a growing need to explore de-risking strategies, aggregation mechanisms, and capacity-building initiatives that can unlock subnational access to capital markets without overburdening national governments. These solutions must go beyond traditional funding channels and enable scalable, locally anchored investments aligned with national transport decarbonization goals.

Green Bonds in the Transport Sector

Green bonds are increasingly recognized as essential instruments for financing low-carbon transport infrastructure. Defined by their exclusive use for environmentally beneficial projects, green bonds have been used to support initiatives such as clean public transit, electric vehicle (EV) procurement, rail electrification, and multimodal mobility systems. Both the World Bank and the International Finance Corporation (IFC) include sustainable transport as a core mitigation area under their green bond frameworks, acknowledging its significant role in climate action (IFC, 2025; World Bank, 2024b).

In emerging economies, several subnational governments have successfully issued green bonds for urban transport projects (see Table 1). Mexico City raised US\$50 million through its municipal green bond to support its Climate Action Program, including BRT development and LED public lighting (C40 Cities, 2017). Johannesburg issued a ZAR1.5 billion (~US\$143 million) green bond to finance new biogas buses and retrofits (C40 Cities, 2016). São Paulo secured over US\$248 million in financing from the World Bank to move toward a fully zero-emission bus fleet by 2038 (World Bank, 2025). These examples demonstrate technical feasibility, investor interest, and growing subnational innovation in sustainable transport finance.

Table 1 Case Studies of Subnational Green Bonds for Urban Transport in Emerging Economies

City (Issuance Date)	Issuance Amount (Original Currency & USD Equivalent)	Specific Transport Projects Funded	Reported Impacts/Co-benefits	Key Success Factors
Mexico City, Mexico (2016)	\$50 million	New bus rapid transit (BRT) lines and LED street lighting	Enhanced city resilience health benefits from bike- ability/walkability	First of its kind in a Latin American city, oversubscribed 2.5x,

City (Issuance Date)	Issuance Amount (Original Currency & USD Equivalent)	Specific Transport Projects Funded	Reported Impacts/Co-benefits	Key Success Factors
			(82% improved quality of life for bike-sharing users)	online monitoring system
Johannesburg, South Africa (2014)	ZAR1.5 billion (~\$143 million)	150 new dual-fuel buses and the conversion of 30 buses to biogas	New funding source for climate mitigation strategy, moves city towards low-carbon infrastructure, diversifies investor base	Political leadership support, investment- grade credit rating
São Paulo, Brazil (2025 - financing approved)	\$248.3 million (World Bank loan, co-financed by IDB)	Electrification and modernization of urban transport system, acquisition of e- buses, strengthening transport management, expanding cycling infrastructure	Aims for fully zero- emission bus fleet by 2038, expected to prevent >5,000 premature deaths/year; save up to \$15.1 billion/year in health and productivity costs	Partnership with the World Bank and Inter-American Development Bank (IDB), alignment with the city's Climate Change Law and Brazil's Country Partnership Framework (CPF)

Sources: Research Data, 2025

Despite these advances, green bond financing for public and sustainable transport remains limited. A recent review by the World Resources Institute (WRI) found that of 839 transport-related climate finance projects, 75% were directed toward land transport infrastructure. However, within that segment, nearly one-third focused on traditional assets such as roads, bridges, and multimodal connectivity (Welle & Zhang, 2025). By contrast, only 130 projects supported public transport systems, and just 60 focused on EVs, highlighting a disproportionate allocation favoring "hard" infrastructure over clean mobility and integrated urban transit. This imbalance suggests that while the green bond market is growing, its application in sustainable urban mobility remains limited by sectoral biases, institutional complexity, and access constraints, especially for subnational issuers. A striking example is the cancellation of Mexico's US\$6 billion green bond for the New Mexico City Airport (NAICM), withdrawn after a government change. Although the project met technical and environmental requirements, it was halted by a public referendum amid concerns over corruption and social impact. The case illustrates legal and regulatory risk, where political shifts and weak institutional continuity undermined investor confidence (Krebbbers, 2019). In contrast, Mexico City's other green bond issuance for BRT and LED lighting succeeded due to strong local ownership, transparency, and policy alignment. These divergent outcomes from the same city underscore how governance conditions ultimately shape green bond success.

Many cities, especially in low- and middle-income countries, struggle with limited creditworthiness, insufficient technical capacity, and a lack of standardized issuance procedures. As a result, replication of successful green bond models in the transport sector has been slow and uneven. These findings underscore the need for further research into tailored design pathways for subnational green bonds in transport. Issues such as project size aggregation, institutional capacity-building, regulatory harmonization, and credit enhancement mechanisms require attention if green bonds are to become a more inclusive tool for scaling urban transport decarbonization.

Barriers to Subnational Green Bonds for Transport Projects in Emerging Economies

Despite the increasing relevance of green bonds in supporting climate infrastructure, subnational issuers in emerging economies face persistent structural and institutional challenges. These barriers exist across the full project lifecycle, from pipeline development to investor engagement, and prevent many cities from translating climate commitments into investable projects. Table 2 below summarizes these challenges and their consequences across six key barrier categories: project pipeline, MRV frameworks, ESG integration, legal and regulatory issues, credit ratings, and investor appetite.

Project Pipeline (Aleksandrova-Zlatanska & Kalcheva, 2019; Deschryver & Mariz, 2020)

One of the core obstacles to expanding green bond use in the urban transport sector lies in the limited supply of well-prepared, climate-compatible projects. Subnational authorities often lack the technical capacity to formulate and package infrastructure proposals that fulfill the criteria for green bond funding. This challenge is further complicated by a limited understanding of the issuance procedures and underutilization of opportunities to refinance current infrastructure through green finance mechanisms. In smaller municipalities or secondary urban centers, projects are frequently too small in scale to be attractive to large investors due to the relatively high transaction costs involved. To bridge this size mismatch and make these opportunities more appealing to capital markets, experts have suggested bundling multiple projects into unified, larger investment vehicles.

MRV Frameworks (Deschryver & Mariz, 2020; Herrera, 2024; Magale, 2021)

Strong Monitoring, Reporting, and Verification (MRV) systems are essential to uphold the environmental credibility of green bonds and reassure investors about their impact. However, in many developing and emerging economies, MRV capacity at the local level remains weak. Contributing factors include technical limitations, inadequate funding, and fragmented data systems. In the absence of robust MRV frameworks, investors face difficulties in assessing the environmental performance of funded projects, which can heighten perceived risk and raise concerns about greenwashing. Innovative tools like Nigeria's Climate Action Index demonstrate the potential of vertically integrated MRV systems that align with international climate reporting frameworks.

ESG Integration (Deschryver & Mariz, 2020; Herrera, 2024)

Bringing environmental, social, and governance (ESG) criteria into local public finance is increasingly important for appealing to sustainability-minded investors. However, many subnational entities in EMDEs still face major barriers, such as inadequate ESG data and a lack of local expertise in tracking and reporting non-financial performance. This limits the ability to align project outcomes with investor expectations. Frameworks developed for advanced economies often fail to reflect the contextual realities of emerging markets, creating a misalignment that deters impact investors. Improving local capacity to identify and communicate the broader co-benefits of transport projects, such as public health, air quality, and social inclusion, can help strengthen the ESG case for municipal green bonds.

Legal and Regulatory (Klimanov & Kazakova, 2022; Zhou & Cui, 2019)

Weak enabling environments often deter subnational issuance. Many municipal governments operate within legal frameworks that either restrict borrowing or do not support green finance instruments. There is also a lack of harmonized regulations for sustainable finance, with gaps in public-private partnership (PPP) policies and limited understanding among local regulators. This "policy-practice chasm" hinders the translation of national green finance strategies into local action. Legislative reforms, supported by technical assistance, are needed to clarify the legal authority of subnational entities to issue green bonds and engage with blended finance instruments.

Credit Ratings (Gilchrist et al., 2021)

Most municipal governments in emerging economies lack investment-grade credit ratings, which are essential for accessing private capital markets. This results in higher borrowing costs and places additional burdens on issuers to meet certification and reporting standards for green bonds. Subnational green municipal bonds (GMBs) are, therefore, less competitive than conventional bonds, especially in contexts where perceived EMDE risk is high. This creates a "risk perception multiplier," where low creditworthiness and regulatory uncertainty drive up capital costs and limit market access.

Investor Appetite (Deschryver & Mariz, 2020; Ma, 2023; Monk & Perkins, 2020; Zhou & Cui, 2019)

While global interest in sustainable finance has surged, investor demand for subnational green bonds in EMDEs remains modest. Institutional investors often require large issuance volumes, clear project pipelines, and high liquidity, conditions that subnational issuers rarely meet. Poor visibility of upcoming green transport projects, coupled with low capacity for disclosure, makes it difficult for investors to assess opportunities. This leads to information asymmetry and deters long-term participation.

De-risking tools, aggregation platforms, and clearer SDG-aligned signaling are critical to expanding investor participation and improving liquidity.

Table 2 Key Barriers to Subnational Green Bond Issuance in Emerging Economies (Transport Focus)

Barrier Category	Specific Challenge	Impact/Consequence
Project Pipeline	• Lack of bankable transport projects • Limited issuer capacity pipeline readiness • Small-scale projects with high transaction costs	• Hinders investment readiness • Reduces issuance volume • Deters institutional investors
MRV Frameworks	• Weak subnational MRV systems • Budgetary and technical limitations • Fragmented environmental data systems	• Undermines impact credibility • Increases greenwashing risk • Erodes investor confidence
ESG Integration	• Weak local ESG data coverage • Insufficient knowledge to assess co-benefits • Inappropriate use of Global North ESG models	• Misaligned investor expectations • Limits impact-based investment • Undervalues broader project benefits
Legal/Regulatory	• Borrowing restrictions for municipalities • Weak PPP frameworks • Lack of enabling green finance laws	• Legal uncertainty • Slows policy reforms • Reduces subnational access to sustainable finance tools
Credit Ratings	• Low/absent subnational credit ratings • High certification/reporting costs for GMBs • High perceived EMDE risk	• Increases borrowing costs • Limits access to private capital • Reduces competitiveness of GMBs
Investor Appetite	• Limited demand for GMBs in EMDEs • Poor visibility of pipelines/SDG alignment • Low liquidity in local markets	• Investor hesitancy • High transaction barriers • Excludes smaller cities and projects

Sources: Research Data, 2025

Discussion

This review has highlighted the growing relevance of green bonds as a mechanism to finance climate-aligned infrastructure, particularly in the transport sector. As discussed in the "Green Bonds: Evolution and Use in Climate Infrastructure" section, the global green bond market has evolved significantly, with over USD 3 trillion in outstanding issuances by 2024 (Demski et al., 2025; World Bank, 2024b). Urban transport, accounting for nearly a quarter of global GHG emissions increasingly been targeted through green bond-financed projects such as electric buses, metro systems, and transit-oriented development (Welle & Zhang, 2025). However, despite the maturity of the green bond market globally, its application at the subnational level in emerging economies remains highly limited.

Building on this foundation, the "Subnational Finance for Transport in Emerging Economies" section examined how subnational governments in emerging markets face deep-rooted challenges in mobilizing green finance for transport. Municipalities often lack the creditworthiness, fiscal autonomy, and institutional capacity needed to issue bonds or access blended finance. Small project sizes, limited bankable pipelines, and underdeveloped local capital markets compound these challenges. Even as global institutions and investors show growing interest in climate finance, cities in LMICs remain largely excluded due to a "readiness gap" that goes beyond access to financial instruments and into technical, legal, and administrative deficiencies (Demski et al., 2025).

The gap becomes more evident in the "Green Bonds in the Transport Sector" section, where even within climate finance flows to transport, the majority still supports conventional infrastructure like roads, while far fewer funds are directed toward electric mobility or public transit. Although cities like Mexico City and Johannesburg have successfully issued green bonds for sustainable transport, these remain isolated cases, often supported by international donors or guarantees. Without scalable models or institutionalized pathways, such efforts struggle to reach replication in other subnational contexts.

"Barriers to Subnational Green Bonds for Transport Projects in Emerging Economies" section further synthesized barriers to subnational green bond issuance across six categories: project pipeline and aggregation limitations, MRV frameworks, ESG integration, legal and regulatory constraints, creditworthiness and perceived risk, and investor appetite. These challenges reveal that the ecosystem required to support green bond deployment in cities is still nascent. While MDBs and international

networks have made significant contributions to standard-setting and technical assistance, tailored solutions for subnational transport projects are sparse.

In light of these findings, this study contributes to the climate finance literature by focusing on the intersection of subnational governance and green bond design in the transport sector, an area that remains underexplored. It provides a sector-specific synthesis of barriers that prevent emerging market municipalities from accessing or scaling green bond instruments for transport decarbonization. By identifying these gaps, the study offers practical direction for both researchers and policymakers seeking to unlock green finance at the local level. Based on the literature and synthesis presented, five future research directions are proposed to strengthen the deployment of subnational green bonds in the transport sector:

1. Development of standardized transport-specific green bond frameworks: Investigate how to create adaptable design templates for municipal green bonds targeting urban transport, including clear eligibility criteria, use-of-proceeds definitions, and impact metrics. Methodological Reference: Design science research (Gregor & Hevner, 2013) provides a structured approach to creating practical and transferable artifacts, such as standardized bond templates, that are both rigorously developed and applicable to real-world subnational contexts.
2. Design of fiscal enablers and blended finance models for subnational green bonds: Explore innovative fiscal tools, credit enhancement mechanisms, and blended finance structures that can improve municipal creditworthiness and de-risk transport-related green bonds. Methodological Reference: "Blended finance in the poorest countries: The need for a better approach" (Attridge & Engen, 2019) applies blended finance principles in low-income settings, offering a methodological foundation for analyzing how concessional and commercial capital can be combined to unlock municipal investment through green bonds.
3. Establishment of MRV systems aligned with green bond frameworks for urban mobility: Develop practical, cost-effective Measurement, Reporting, and Verification (MRV) methodologies tailored to the transport sector and suited for resource-constrained municipalities to strengthen transparency and investor confidence. Methodological Reference: Action research (Kemmis et al., 2014) is well-suited for co-developing MRV systems with local stakeholders, allowing iterative refinement of indicators and tools to ensure they are context-specific and practically implementable.
4. Legal and regulatory reforms for enabling sub-national bond issuance in transport: Identify regulatory bottlenecks and propose reforms that clarify municipal borrowing authority and streamline approval processes for issuing transport-focused green bonds. Methodological Reference: Regulatory impact assessment (Radaelli, 2005) provides a methodological foundation for analyzing how political and institutional contexts shape the adoption of legal reforms. This approach is well-suited for identifying how regulatory frameworks can be adapted or aligned to support municipal access to green bond markets.
5. Development of readiness assessment tools for subnational green bond issuance in transport: Design diagnostic frameworks or toolkits to help municipalities evaluate their technical, administrative, and fiscal preparedness for green bond issuance, with a focus on sustainable transport infrastructure. Methodological Reference: The Analytic Hierarchy Process (AHP) (Saaty, 2008) supports structured decision-making by prioritizing readiness criteria through expert input, making it a useful method for developing robust self-assessment tools for local governments.

By addressing these areas, future research can help close the gap between green finance potential and practical implementation at the local level. Strengthening subnational green bond ecosystems will not only unlock finance for low-carbon transport but also support broader sustainable urban development goals in emerging markets. To conclude, Figure 2 summarizes the key relationships identified in this review and the proposed research agenda to advance subnational green bond applications for low-carbon transport.

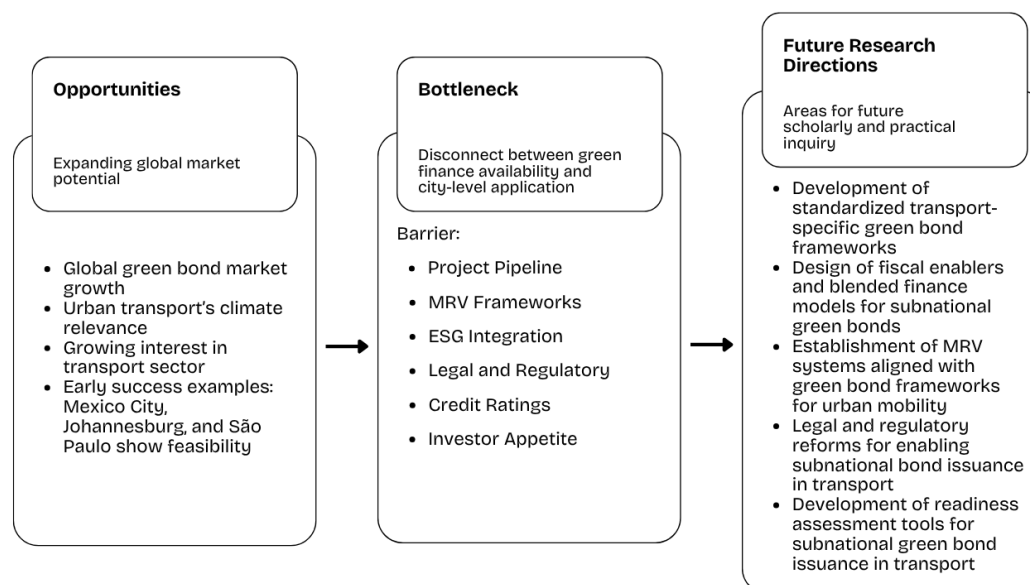


Figure 2. Conceptual Framework: From Global Market Opportunities to Subnational Application of Green Bonds for Urban Transport

Sources: Research Data, 2025

D. CONCLUSION

This study examined the role of subnational green bonds in financing low-carbon urban transport in emerging economies. While green bonds have gained global traction, their use by city governments (especially for transport) remains limited. Through a narrative literature review, the study identified six key barriers: fragmented project pipelines, weak MRV systems, challenges in ESG integration, legal and regulatory constraints, low municipal credit ratings, and limited investor appetite. By focusing on subnational finance for a specific high-emission sector, this study advances climate finance scholarship by shifting attention from national-level instruments to local institutional realities. It highlights the structural misalignments between global financial mechanisms and the capacities of emerging-market cities, a dimension often underexplored in the existing literature. Rather than prescribing fixed solutions, this study proposes a future research agenda aimed at bridging these gaps, calling for the development of transport-specific frameworks, fiscal models, MRV tools, regulatory diagnostics, and readiness assessments. These priorities can help inform more grounded, context-sensitive approaches to climate finance that are capable of unlocking urban transformation where it is most urgently needed.

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