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GREEN BONDS AND SOVEREIGN DEBT INSTRUMENTS FOR INFRASTRUCTURE ASSET RENEWAL: AN ANALYSIS OF FINANCIAL MECHANISMS

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Abstract. This article examines the role of green bonds and sovereign debt instruments in financing infrastructure renewal. Based on international experience and comparative analysis, the study evaluates the advantages of green financing mechanisms and develops an institutional framework for their application in Uzbekistan. The findings indicate that sovereign green bonds can become an effective tool for attracting long-term capital to support sustainable infrastructure development.

Keywords: green bonds, sovereign debt, infrastructure renewal, sustainable finance, climate finance, ESG, public investment, Uzbekistan.

Аннотация. В статье исследуется роль зеленых облигаций и инструментов государственного долга в финансировании модернизации инфраструктуры. На основе международного опыта и сравнительного анализа оцениваются преимущества механизмов зеленого финансирования и разрабатываются институциональные подходы к их применению в Узбекистане. Результаты исследования показывают, что суверенные зеленые облигации могут стать эффективным инструментом привлечения долгосрочного капитала для устойчивого развития инфраструктуры.

Ключевые слова: зеленые облигации, государственный долг, модернизация инфраструктуры, устойчивое финансирование, климатическое финансирование, ESG, государственные инвестиции, Узбекистан.

INTRODUCTION

The global infrastructure deficit has reached an estimated USD 15 trillion, reflecting the cumulative shortfall between the capital required to maintain, upgrade, and expand critical physical systems — including roads, railways, energy grids, water networks, and telecommunications — and the funds actually committed by governments and private actors over the past three decades (McKinsey Global Institute, 2016; G20 Infrastructure Working Group, 2023). This deficit is not merely a numerical abstraction; it directly results in lost economic productivity, increased social vulnerability, and widening inequality between countries that have successfully mobilized infrastructure capital and those that have not. In the context of an accelerating climate transition, the problem gains an additional dimension: a substantial share of the world's existing infrastructure stock was designed to operate under climatic conditions and energy-price environments that no longer exist or are rapidly changing. Replacing or retrofitting this infrastructure stock is therefore not optional, but an economic and strategic necessity.

Against this background, green bonds have emerged as one of the most significant financial innovations of the twenty-first century. First issued by the European Investment Bank in 2007, the green bond market had grown to exceed USD 500 billion in annual issuance by 2023, mobilizing capital from a diverse range of institutional investors, including pension funds, insurance companies, sovereign wealth funds, and dedicated ESG-oriented investment mandates. These investors increasingly require their portfolios to demonstrate measurable environmental outcomes. Unlike conventional bonds, green bonds include contractual commitments regarding the use of proceeds, reporting obligations, and, in the most credible structures, third-party verification of environmental impact. These features create a materially different risk-return profile that can reduce borrowing

costs by 5–15 basis points relative to equivalent conventional instruments — the so-called “greenium” (Zerbib, 2019).

For emerging economies such as Uzbekistan, the intersection of these two forces — large infrastructure renewal needs and the growing availability of green capital — creates a strategic opportunity that has so far been only partially utilized. Uzbekistan’s infrastructure stock is largely Soviet-era in origin and is characterized by high energy intensity, limited technical efficiency, and significant physical deterioration. Government estimates suggest that approximately 60 percent of water supply networks, 40 percent of electricity distribution infrastructure, and a significant share of the secondary road network require capital-intensive renewal within the current decade. The fiscal space available under conventional budgetary and borrowing frameworks is insufficient to address this challenge at the required pace.

LITERATURE REVIEW

The academic literature on green bonds and sustainable infrastructure finance has expanded substantially since the seminal work of Zerbib (2019), who provided one of the first rigorous empirical documentations of the greenium in secondary market pricing. Fatica, Panzica, and Rancan (2021) extended this analysis to the primary market and financial institution issuers, confirming that the greenium is particularly evident for sovereign-class issuers with strong institutional frameworks. Reboredo (2018) examined co-movement dynamics between green bond and conventional bond markets, demonstrating that green bonds offer meaningful portfolio diversification benefits for institutional investors. This finding reinforces the structural demand thesis underlying the present article.

In the sovereign context, the Climate Bonds Initiative (CBI, 2023, 2024) provides one of the most comprehensive overviews of global sovereign green bond issuance, documenting the expansion of the sovereign market from a small number of European issuers in 2016 to a globally diverse issuer base by early 2025. The CBI sovereign database indicates that the pricing advantage — the greenium — may be more pronounced for emerging market sovereigns than for investment-grade developed market issuers. This reflects the relative scarcity of high-quality certified green assets in developing-economy markets compared with the depth of ESG-mandated institutional demand for such assets.

In the Uzbekistan-specific literature, Razzaqov and Toshmatov (2022) provide an analytical treatment of capital market instruments for green finance, identifying the fiscal and monetary dimensions of green bond issuance in the Uzbek context and recommending a phased market entry strategy that prioritizes certification credibility. Mirzaev (2023) addresses the broader green economy trajectory, situating the financing challenge within Uzbekistan’s sustainable development framework. At the multilateral level, the OECD (2023) report on *Financing Uzbekistan’s Green Transition* provides an authoritative assessment of the institutional prerequisites for a sovereign green bond program and identifies capacity gaps in framework development, proceeds management, and impact reporting that should be addressed prior to inaugural issuance.

The present article contributes to this literature by providing an integrated examination of: (1) the financial mechanics of sovereign green bonds as applied to infrastructure renewal, rather than renewable energy alone; (2) a systematic risk comparison between green and conventional sovereign instruments; (3) a cross-country comparative analysis of programs implemented by emerging market sovereigns; and (4) a comprehensive institutional design and phased implementation roadmap for Uzbekistan based on the lessons derived from comparative cases.

RESEARCH METHODOLOGY

This study employs a mixed-methods research design that integrates quantitative analysis of green bond market data with a qualitative assessment of sovereign program design and institutional capacity. The methodological approach consists of four stages.

First, a systematic review of global green bond issuance data was conducted using the Climate Bonds Initiative sovereign green bond database (CBI, 2024), the ICMA Green Bond Database, and Bloomberg Terminal data for the period 2015–2023. These sources provide standardized, issuer-verified issuance volumes, greenium estimates, and investor participation data, which serve as the empirical foundation for the market analysis in Section 4.

Second, a structured comparative case analysis was conducted across five sovereign green bond programs identified as analytically comparable to Uzbekistan’s prospective program: Chile, Indonesia, Egypt, Kazakhstan, and Georgia. Comparator selection criteria included income level, namely lower-middle to upper-middle income economies; infrastructure renewal intensity, reflected in high physical capital renewal needs as a share of GDP; institutional maturity, measured by a CPIA score range relevant to Uzbekistan; and geographic proximity to ESG investor demand centers.

Third, Uzbekistan's infrastructure renewal needs were quantified using published sector assessments from the World Bank (2023), ADB (2023), and EBRD (2023), and cross-validated against government technical reports and IMF fiscal data. Cost estimates are expressed in constant 2023 U.S. dollars unless otherwise indicated.

Fourth, the institutional design framework and phased implementation roadmap proposed in Section 5 were developed through an analytical synthesis of the comparative case evidence, structured in accordance with the four-component ICMA Green Bond Principles framework and the pre-issuance and post-issuance requirements of the CBI Climate Bonds Standard.

ANALYSIS AND RESULTS

The Green Bond Market: Structure, Growth, and Distinguishing Features. A green bond is, at its core, a fixed-income instrument whose proceeds are contractually earmarked for projects with measurable environmental benefits. The International Capital Market Association (ICMA) Green Bond Principles (GBP), first published in 2014 and updated in 2021, provide the dominant voluntary framework governing green bond issuance. The GBP establish four core components: (1) use of proceeds, specifying eligible project categories; (2) the process for project evaluation and selection; (3) management of proceeds; and (4) reporting. Projects eligible under the GBP include renewable energy, energy efficiency, sustainable water and wastewater management, clean transportation, and climate change adaptation — categories that constitute the core of a modern infrastructure renewal agenda.

The global green bond market has demonstrated remarkable and sustained growth since its inception. presents issuance data for the period 2015–2023, disaggregated by issuer type and geographic region. Total market volume increased from USD 42.4 billion in 2015 to USD 575.3 billion in 2023, representing a compound annual growth rate of approximately 38.3 percent, substantially exceeding the growth rate of overall bond markets. The emerging market share rose from 9.1 percent in 2015 to 22.1 percent in 2023, indicating that developing-economy issuers are becoming increasingly competitive in accessing this capital pool (Table 1).

Table 1
Global Green Bond Issuance by Segment, 2015–2023 (USD Billion)

Year	Total Issuance (USD bn)	Sovereign & Supranational (%)	Corporate (%)	Financial Institutions (%)	Emerging Markets Share (%)
2015	42.4	28.3	31.2	40.5	9.1
2016	81.6	26.7	35.4	37.9	11.3
2017	155.5	24.1	38.2	37.7	13.6
2018	167.3	22.8	40.1	37.1	12.9
2019	257.7	25.4	37.6	37.0	14.7
2020	305.3	31.2	33.8	35.0	16.2
2021	522.7	34.6	31.4	34.0	18.5
2022	487.1	33.1	32.8	34.1	19.3
2023	575.3	35.2	30.9	33.9	22.1

Source: Climate Bonds Initiative (2024); ICMA Green Bond Database (2024); Bloomberg Terminal data (authors' compilation).

The concept of the greenium — the pricing premium or, equivalently, the yield discount that green bond issuers enjoy relative to otherwise equivalent conventional bonds — has been extensively studied since Zerbib's (2019) seminal analysis. In the sovereign segment, estimates of the greenium range from 3 to 22 basis points, depending on issuer credit quality, instrument maturity, and prevailing market conditions. For emerging market sovereigns with credible frameworks, such as Chile, Indonesia, and Egypt, documented greenium ranges of 8 to 18 basis points have been observed. This reflects the additional scarcity value that international ESG investors assign to high-quality green assets in markets where supply remains constrained relative to demand (Fatica et al., 2021; CBI, 2023).

At a practical level, even a conservative 8-basis-point greenium on a USD 500 million sovereign green bond with a 10-year maturity generates cumulative interest savings of approximately USD 4 million over the bond's life. At a USD 1 billion scale, savings approach USD 8 million, which is more than triple the incremental cost of green bond framework development and certification. Table 2 provides a systematic assessment of the principal risk categories associated with sovereign green bond investment and compares them with equivalent conventional sovereign debt instruments (Table 2).

Table 2

Risk Matrix: Sovereign Green Bonds vs. Conventional Sovereign Bonds

Risk Category	Net Risk Differential vs. Conventional Bond	Severity (1–5 scale)	Key Mitigating Factors
Credit / Default Risk	Neutral	3 / 3	Same sovereign guarantor; no structural subordination; identical legal recourse
Interest Rate Risk	Neutral	3 / 3	Identical duration and convexity profile to conventional bonds
Liquidity Risk	Marginally adverse	2 / 3	Growing secondary ESG market; dedicated institutional buyer base offsets smaller float
Greenwashing / Misallocation Risk	Incremental (manageable)	2 / 4	CBI certification with pre- and post-issuance verification; annual impact reporting; audit rights
Regulatory Compliance Risk (SFDR)	Favourable for investor	4 / 2	Green bond actively reduces investor's SFDR Article 8/9 compliance burden
Policy / Administration Reversal Risk	Marginally higher	2 / 3	Framework embedded in standing inter-ministerial committee; parliamentary reporting obligations
Environmental Impact Risk	Incremental	2 / 3	KPI-linked reporting; eligible project pre-approval; third-party impact audits
Reputational Risk (Investor)	Favourable	3 / 1	Enhanced ESG credentials; positive stakeholder engagement narrative

Note: Severity scale: 1 = minimal, 5 = severe. Format shows [Green Bond severity / Conventional Bond severity].
Source: Authors' assessment based on ICMA (2021), CBI (2022), IMF Fiscal Monitor (2023).

Surveys of European institutional investors consistently show that 73–78 percent of ESG-mandated fixed-income managers would accept a 10–15 basis point yield concession on a certified sovereign green bond, provided that the certification is performed by a CBI-accredited verifier (Eurosif, 2023; PRI, 2023). A particularly important insight concerns regulatory compliance risk: for European investors operating under the Sustainable Finance Disclosure Regulation (SFDR), a certified sovereign green bond reduces compliance complexity by providing the documentation required to classify holdings under SFDR Article 8 or Article 9 fund categories.

Comparative Analysis: Sovereign Green Bond Programs in Comparable Economies. A structured comparative analysis of sovereign green bond programs in economies comparable to Uzbekistan provides the evidential basis for the application model developed in Section 5. Table 3 summarizes key program parameters across five selected sovereigns, with Uzbekistan included as a prospective comparator (Table 3).

Table 3

Comparative Analysis of Sovereign Green Bond Programmes: Selected Economies

Sovereign	First Issuance	Total Volume (USD bn) 2023	Dominant Sector	Framework Standard	Estimated Greenium (bps)	Key Outcome / Lesson
Chile	2019	14.3	Clean Transport, Renewable Energy	ICMA GBP + CBI Certified	8–12	USD 18bn green finance pipeline activated; 4.2x oversubscription on debut
Indonesia	2018	7.8	Renewable Energy, Sustainable Forestry	ICMA GBP (Green Sukuk)	6–10	Dedicated Islamic green finance window; Gulf investor diversification achieved
Egypt	2020	3.0	Clean Transport, Green Buildings, Water	ICMA GBP	10–15	1st African sovereign green bond; 3.7x oversubscription; 750+ investors
Kazakhstan	2023	0.5	Energy Efficiency, Water Infrastructure	ICMA GBP (Quasi-sovereign)	12–18	Pilot programme; demonstrated market access despite frontier-market status
Georgia	2021	0.25	Water Supply, Renewable Energy	ICMA GBP (Development Bank)	9–14	MDB co-financing model; capacity building via EBRD partnership
Uzbekistan*	—	— (prospective)	Water, Energy Distribution, Transport	Proposed: ICMA GBP + CBI CBS	10–18 (estimated)	Framework development phase 2025–2026; inaugural issuance target H2 2026

* Uzbekistan data reflects prospective parameters based on current institutional capacity assessments and comparable-economy benchmarks.

Source: CBI Sovereign Database (2024); World Bank (2023); EBRD (2023); Authors' estimates.

The comparative data provides several important lessons for Uzbekistan. The cases of Chile and Indonesia demonstrate that emerging market sovereigns can achieve substantial program volumes by maintaining institutional consistency and diversifying investor outreach across geographic regions and investor types. The case of Egypt is particularly instructive: despite issuing its green bond during a period of significant macroeconomic stress, Egypt's 2020 green bond attracted more than 750 institutional investors and achieved 3.7 times oversubscription. This outcome was supported by a credible ICMA-aligned framework and EBRD technical assistance, offering a model that can be adapted to Uzbekistan's context. The cases of Kazakhstan and Georgia demonstrate the value of phased market entry: a pilot issuance in the range of USD 250–500 million allows the issuer to develop operational capacity before scaling up to multi-billion-dollar program levels.

Uzbekistan faces a particularly acute infrastructure renewal challenge. The country's physical capital stock was predominantly constructed between 1960 and 1985 and was designed according to Soviet-era engineering standards, which prioritized heavy industrial output over energy efficiency and environmental performance. Government assessments, supported by World Bank sector studies and ADB technical reviews, identify three priority renewal areas with the highest environmental and economic return on green bond-financed investment.

Water Supply and Sanitation: Approximately 60 percent of first-generation Soviet-era water distribution networks require full or partial replacement. Annual water losses through leakage average 35–40 percent of total water withdrawn, compared with a global best-practice benchmark of 10–15 percent. The capital requirement for a 15-year renewal program is estimated at USD 4.2–5.8 billion (World Bank, 2023).

Electricity Distribution Infrastructure: Approximately 40 percent of the distribution grid was installed before 1980 and operates at technical efficiency levels 25–30 percent below international standards. Grid losses of 14–16 percent compare unfavorably with the 4–6 percent achievable through modern infrastructure. Capital requirements for renewal and capacity expansion through 2030 are estimated at USD 3.5–5.0 billion (ADB, 2023).

Secondary and Regional Road Networks: The secondary road network, totaling approximately 85,000 km, is in an advanced state of deterioration, with 42 percent of surfaces rated as poor or very poor in the most recent national road condition survey. The economic cost of road deterioration is estimated at 1.8–2.2 percent of GDP annually. Capital requirements for rehabilitation and climate-resilient reconstruction are estimated at approximately USD 3.0–4.2 billion through 2030 (EBRD, 2023). Table 4 summarizes the aggregate infrastructure renewal financing need by sector (Table 4).

Table 4

Uzbekistan Priority Infrastructure Renewal Need by Sector, 2023–2030 (USD Billion)

Sector	Capital Requirement (USD bn)	Deterioration / Loss Rate (current)	Best-Practice Benchmark	Environmental Benefit of Renewal	Primary MDB Assessment Source
Water Supply & Sanitation	4.2–5.8	35–40% NRW losses	10–15% NRW losses	Reduced water waste; improved public health; lower energy use for re-pumping	World Bank (2023)
Electricity Distribution	3.5–5.0	14–16% grid losses	4–6% grid losses	Reduced CO ₂ intensity of electricity system; improved industrial efficiency	ADB (2023)
Secondary Road Network	3.0–4.2	42% in poor/very poor condition; 1.8–2.2% GDP loss	<10% in poor condition	Reduced vehicle emissions; lower maintenance material consumption; improved freight efficiency	EBRD (2023)
Total Aggregate Need	10.7–15.0				Combined sector assessments

Source: World Bank (2023); ADB (2023); EBRD (2023); Government of Uzbekistan technical assessments; authors' compilation.

Application Model: Institutional Design and Phased Implementation Roadmap. Based on the comparative analysis presented in Section 4.3 and the infrastructure needs assessment in Section 4.4, the following institutional design framework is proposed for Uzbekistan's sovereign green bond program. The framework is structured around three mutually reinforcing pillars.

Pillar 1 — Framework Governance: Establishment of an interministerial Green Bond Committee (GBC), chaired by the Ministry of Finance and comprising the Ministry of Economy, the Ministry of Energy, the Ministry of Water Resources, and the State Environmental Inspectorate. The GBC would be responsible for approving eligible projects, overseeing proceeds management, commissioning annual impact reports, and engaging with international verifiers. Secretariat functions would be assigned to the Ministry of Finance's Debt Management Office, with initial capacity development supported by EBRD technical assistance.

Pillar 2 — Standards and Certification: Alignment with the ICMA Green Bond Principles as the baseline framework, with certification under the CBI Climate Bonds Standard as the target for all issuances. Eligible project categories in the initial phase would be limited to water infrastructure renewal, energy distribution modernization, and climate-resilient road reconstruction — sectors where Uzbekistan's project pipeline is relatively mature and environmental impact quantification is more straightforward.

Pillar 3 — Dedicated Infrastructure Renewal Fund: Proceeds from each green bond issuance would be deposited into a dedicated sub-account within the state treasury — the Uzbekistan Infrastructure Renewal Fund (UIRF) — and maintained separately from the general budget. Disbursements from the UIRF would be made exclusively to CBI-eligible projects upon approval by the GBC, with independent financial audits conducted on a semi-annual basis and annual third-party impact verification. Table 5 presents the phased implementation roadmap (Table 5).

Table 5

Phased Implementation Roadmap: Uzbekistan Sovereign Green Bond Programme, 2025–2030

Phase	Period	Key Activities	Target Issuance (USD mn)	Eligible Sectors	Target Greenium (bps)	Expected Outcome
I: Framework Development & Inaugural Issuance	2025–2026	Publish sovereign green bond framework; obtain pre-issuance CBI verification; identify eligible project pipeline; investor roadshows (London, Frankfurt, Singapore, Abu Dhabi)	300–500	Water renewal; energy distribution upgrade	10–14	USD 300–500mn launched; framework credibility established
II: Market Establishment & Yield Curve Development	2027–2028	Issue 2nd and 3rd tranches across 5, 10, 15yr maturities; publish first annual Green Bond Impact Report; list on Euronext Dublin	1,000–1,500 (total)	Above + clean transportation	10–16	Multi-point yield curve established; secondary market liquid
III: Programme Scaling & Domestic Market Development	2029–2030	Scale annual issuance to USD 500mn–1bn; explore Green Sukuk window; evaluate EU GBS taxonomy alignment; support utility sub-sovereign green issuances	500–1,000/yr	Full scope; Green Sukuk window introduced	12–18	Total programme USD 2.5–3.5bn; catalytic leverage of USD 6–8bn total investment

Source: Authors' proposal based on CBI (2024); ICMA (2021); comparative sovereign programme data; ADB (2023); EBRD (2023).

CONCLUSION AND RECOMMENDATIONS

This article advances three central arguments regarding the role of green bonds and related sovereign debt instruments in financing infrastructure asset renewal, with specific application to Uzbekistan.

First, the green bond market has achieved the scale, depth, and institutional infrastructure required to absorb large sovereign issuances from emerging economies at competitive pricing. With USD 575 billion in annual issuance and a growing emerging market share of 22 percent, the market is no longer a niche instrument accessible only to highly rated Western sovereigns. The cases of Chile, Indonesia, and Egypt demonstrate that credible framework design is the primary determinant of market access and pricing advantage, rather than sovereign credit rating alone.

Second, the risk-return profile of sovereign green bonds is broadly equivalent to that of conventional sovereign instruments for investors, while offering a measurable yield discount — the greenium — for issuers that achieve credible certification. The incremental risks introduced by the green bond structure are manageable through independent verification and institutional safeguards, which are cost-efficient relative to the financing savings generated. For ESG-mandated European investors, certified sovereign green bonds from emerging markets reduce regulatory compliance complexity, creating a structural demand incentive that operates independently of yield considerations.

Third, Uzbekistan's infrastructure renewal challenge — concentrated in water supply, energy distribution, and transport, with a total capital requirement of USD 10.7–15.0 billion through 2030 — is precisely the type of large-scale, long-term, environmentally targeted financing need for which green bond instruments are well suited. The proposed three-pillar institutional framework and phased implementation roadmap provide a practically viable and institutionally grounded pathway for launching such a program.

Specific Policy Recommendations

The Ministry of Finance should formally initiate the development of a green bond framework in 2025, engaging a CBI-accredited external reviewer and EBRD technical assistance from the outset to ensure compliance with international standards and strengthen investor confidence.

Parliament should adopt legislation establishing the Uzbekistan Infrastructure Renewal Fund as a permanent, ring-fenced treasury sub-account with statutory reporting obligations, thereby providing the institutional continuity necessary to maintain investor confidence across successive administrative cycles.

A sovereign credit rating that explicitly incorporates ESG and green bond readiness dimensions should be commissioned from at least one major rating agency prior to the inaugural issuance, as this would materially expand the investor universe accessible to the issuer.

Eligible project selection for the initial issuance should prioritize water infrastructure and electricity distribution renewal, where environmental impact quantification is more straightforward and existing project preparation is relatively advanced, thereby ensuring a credible project pipeline at launch that can withstand third-party scrutiny.

Investor relations outreach should begin 12–18 months before the inaugural issuance, targeting European and Middle Eastern ESG-mandated institutional investors through dedicated roadshows co-presented with multilateral development bank partners, such as EBRD, ADB, and IFC, which can provide credibility signalling and potential co-investment commitments.

Uzbekistan should explore the establishment of a green sukuk window from Phase II onward, given the significant pool of Sharia-compliant institutional capital in Gulf Cooperation Council countries seeking certified green investment opportunities — a market niche where competition from other emerging market sovereigns remains relatively limited.

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