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| **RESEARCH ARTICLE**

**Green Bonds and Emerging Economies: Leveraging Green Bonds to unlock finance for Renewable Energy**

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| **ABSTRACT**

This article examines the critical role of green bonds in addressing the renewable energy financing gap in emerging economies. Through comprehensive analysis of market developments, policy frameworks, and empirical evidence from 2015-2021, this study demonstrates how green bonds serve as innovative financial instruments that can mobilize capital for sustainable energy infrastructure. The research reveals that while green bonds offer significant potential for emerging markets, structural challenges including regulatory frameworks, market liquidity, and institutional capacity remain key barriers. The findings suggest that targeted policy interventions and international cooperation are essential for maximizing the effectiveness of green bonds in accelerating renewable energy deployment in developing countries.

| **KEYWORDS**

Green bonds, renewable energy, emerging economies, sustainable finance, climate finance.

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**1. Introduction**

The global transition toward renewable energy systems represents one of the most pressing challenges of the 21st century, particularly for emerging economies that face the dual burden of meeting growing energy demands while addressing climate change commitments. Traditional financing mechanisms have proven inadequate in bridging the substantial investment gap required for renewable energy infrastructure in developing countries. In this context, green bonds have emerged as innovative financial instruments that hold considerable promise for mobilizing capital toward sustainable energy projects (Sachs, Woo, Yoshino, & Taghizadeh-Hesary, 2019).

Green bonds represent a specialized segment of the fixed-income market where proceeds are exclusively allocated to projects with environmental benefits, including renewable energy, energy efficiency, and climate adaptation initiatives (Flammer, 2021). Since the first green bond issuance by the European Investment Bank in 2007, this market has experienced exponential growth, reaching unprecedented levels of issuance and attracting diverse investor categories seeking sustainable investment opportunities (Maltais & Nykvist, 2020).

For emerging economies, green bonds present unique opportunities to address critical financing constraints that have historically limited renewable energy deployment. These economies typically face challenges including limited access to international capital markets, currency risks, regulatory uncertainties, and insufficient institutional capacity for project development (Taghizadeh-Hesary & Yoshino, 2020). Green bonds offer potential solutions by providing

access to dedicated pools of environmentally conscious capital, often at favorable terms compared to conventional financing instruments.

**2. Understanding Green Bonds in the Context of Emerging Economies**

The conceptual framework underlying green bonds extends beyond traditional debt instruments by incorporating explicit environmental criteria and impact measurement requirements. Ehlers and Packer (2017) define green bonds as debt securities where proceeds are earmarked specifically for projects that provide environmental benefits, with issuers committing to transparent reporting on the use of proceeds and environmental outcomes. This definition encompasses various bond structures including sovereign green bonds, corporate green bonds, and supranational issuances, each serving different segments of the renewable energy financing ecosystem.

The emergence of green bonds reflects broader shifts in global capital markets toward sustainable finance, driven by increasing awareness of climate risks and opportunities among institutional investors (Baker, Bergstresser, Serafeim, & Wurgler, 2018). For emerging economies, this trend represents a potential inflection point in accessing international capital for renewable energy projects, as investors increasingly seek exposure to sustainable assets in growing markets.

The theoretical foundation for green bonds rests on several key principles that distinguish them from conventional debt instruments. First, the use of proceeds must be directed toward projects with clear environmental benefits, typically verified through recognized standards such as the Green Bond Principles established by the International Capital Market Association (Bhutta, Tariq, Farrukh, Raza, & Iqbal, 2021). Second, issuers must demonstrate transparent governance frameworks for project selection and monitoring, ensuring accountability in the deployment of capital. Third, regular reporting on environmental impacts and financial performance provides ongoing transparency to investors and stakeholders.

**Table 1: Green Bond Issuance by Region (2015-2021, USD Billions)**

Region	2015	2016	2017	2018	2019	2020	2021
Developed Markets	38.5	72.1	142.8	159.4	238.9	245.2	398.5
Emerging Markets	2.8	8.9	19.7	31.2	47.8	68.4	94.3
China	1.2	5.6	15.2	24.1	32.4	45.8	67.2
Other EM	1.6	3.3	4.5	7.1	15.4	22.6	27.1

Source: Climate Bonds Initiative, Bloomberg New Energy Finance

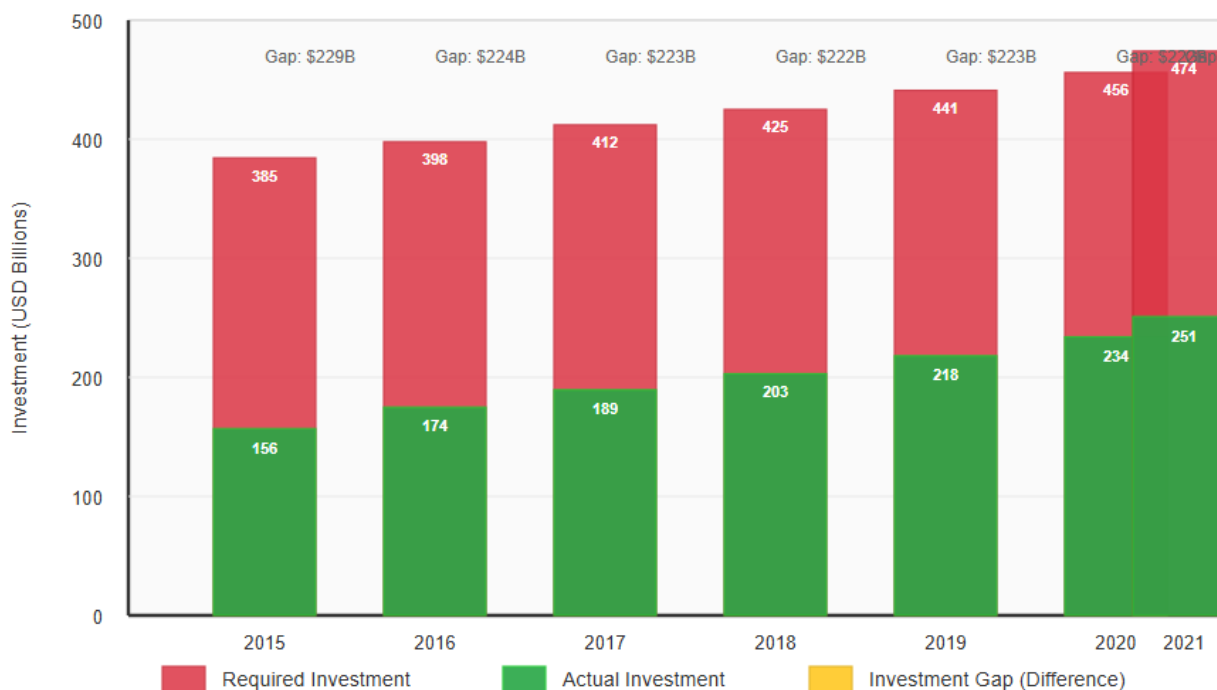
**3. The Renewable Energy Financing Gap in Emerging Markets**

Emerging economies face substantial financing challenges in developing renewable energy infrastructure, with the International Energy Agency estimating annual investment requirements of approximately \$500 billion through 2030 to achieve sustainable energy goals. Traditional financing mechanisms, including development finance institutions and commercial banks, have proven insufficient to meet these requirements, creating persistent investment gaps that limit renewable energy deployment (Rasoulinezhad & Taghizadeh-Hesary, 2021).

The financing gap in emerging markets stems from multiple interconnected factors that create systematic barriers to renewable energy investment. Currency risks represent a primary concern for international investors, as renewable energy projects typically generate revenues in local currencies while requiring significant foreign currency debt service. This mismatch creates exposure to exchange rate fluctuations that can significantly impact project returns and investor confidence (Yoshino, Taghizadeh-Hesary, & Nakahigashi, 2019).

Regulatory and policy uncertainties further compound financing challenges in emerging economies. Many developing countries lack comprehensive regulatory frameworks for renewable energy development, creating uncertainty around project permitting, grid connection procedures, and long-term policy support. This uncertainty translates into higher perceived risks for investors, resulting in elevated capital costs or complete withdrawal from potential investments (Tu, Rasoulinezhad, & Sarker, 2020).

**Figure 1: Renewable Energy Investment Gap in Emerging Markets (2015-2021)**



Source: International Renewable Energy Agency (IRENA), United Nations Environment Programme

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The institutional capacity constraints prevalent in many emerging economies create additional barriers to renewable energy financing. Limited technical expertise in project development, inadequate legal frameworks for complex financing structures, and insufficient local capital market depth restrict the ability of these countries to develop bankable renewable energy projects. These capacity constraints often result in higher transaction costs and longer development timelines, further deterring private sector investment (Tolliver, Keeley, & Managi, 2020).

#### 4. Green Bond Market Development and Growth

The green bond market has experienced remarkable growth since its inception, with total cumulative issuance exceeding \$1.6 trillion by 2021. This expansion reflects increasing recognition among issuers and investors of the potential for green bonds to address environmental challenges while generating competitive financial returns (Gianfrate & Peri, 2019). The market's evolution has been characterized by diversification across issuer types, geographic regions, and underlying project categories, with renewable energy consistently representing the largest use of proceeds category.

Market development patterns reveal significant regional variations in green bond adoption and growth trajectories. Developed markets, particularly Europe and North America, dominated early market development through large-scale issuances by established corporations and government entities. However, emerging markets have demonstrated accelerating growth rates, with China emerging as a major issuer and other developing countries beginning to establish domestic green bond markets (Wang, Chen, Li, Yu, & Zhong, 2020).

The pricing dynamics of green bonds have evolved considerably as the market has matured and investor demand has increased. Early studies documented the existence of a "greenium" or negative yield premium for green bonds relative to comparable conventional bonds, suggesting that investors were willing to accept lower returns for environmental benefits (Zerbib, 2019). However, recent research indicates that pricing differentials have become

more variable and dependent on specific issuer characteristics, market conditions, and bond structures (Larcker & Watts, 2020).

**Table 2: Green Bond Use of Proceeds Distribution (2019-2021)**

<b>Use of Proceeds Category</b>	<b>2019 (%)</b>	<b>2020 (%)</b>	<b>2021 (%)</b>
Renewable Energy	34.2	31.8	29.4
Energy Efficiency	18.6	19.2	20.1
Clean Transportation	15.4	17.3	18.8
Sustainable Water Management	12.8	13.1	13.7
Waste Management	8.9	9.2	8.9
Climate Adaptation	6.2	5.8	5.6
Other Environmental	3.9	3.6	3.5

Source: Climate Bonds Initiative Annual Reports

The institutional investor base for green bonds has expanded significantly, encompassing pension funds, insurance companies, asset managers, and central banks seeking to align investment portfolios with sustainability objectives. This diversification has provided greater market stability and liquidity, although challenges remain in emerging market contexts where local institutional investor capacity may be limited (Reboredo & Ugolini, 2020).

### **5. Mechanisms for Unlocking Renewable Energy Finance**

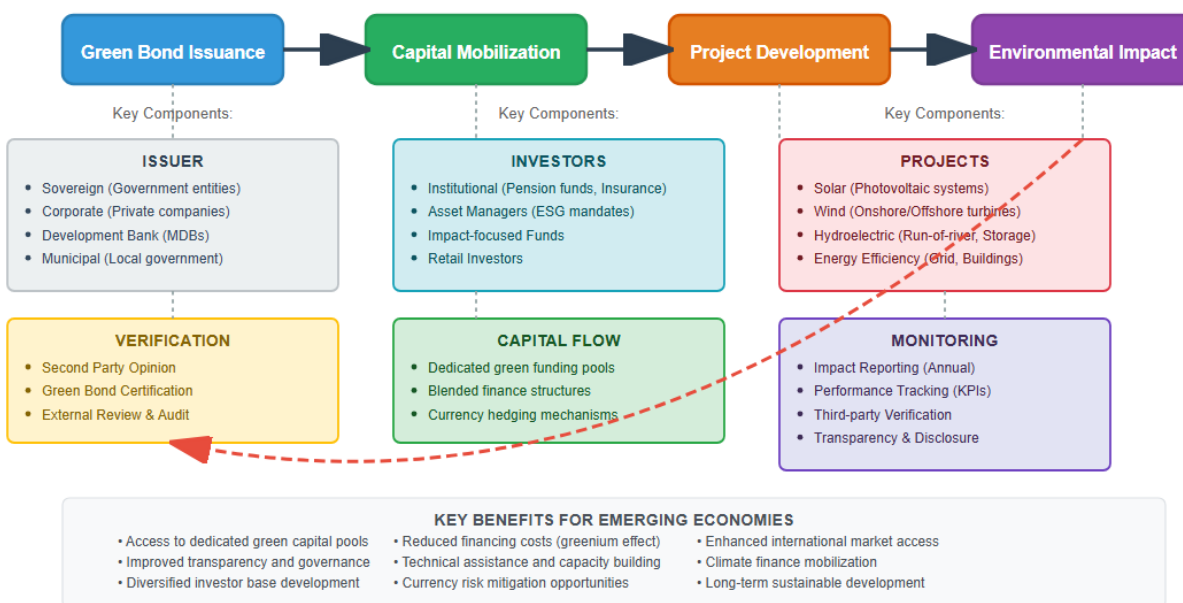
Green bonds facilitate renewable energy financing in emerging economies through several distinct mechanisms that address specific market failures and investment barriers. The use of proceeds structure ensures that capital raised through green bond issuances is directed exclusively toward projects with measurable environmental benefits, providing investors with confidence that their capital contributes to sustainable development objectives while generating financial returns (Tang & Zhang, 2020).

The certification and verification processes associated with green bonds create additional credibility and transparency that can help overcome information asymmetries between issuers and investors. Independent verification of green credentials and ongoing monitoring of environmental impacts provide assurance to investors while establishing accountability mechanisms for issuers (Hachenberg & Schiereck, 2018). This enhanced transparency can be particularly valuable in emerging market contexts where information availability and quality may be limited.

Green bonds also facilitate the development of local capital markets by creating new instruments that attract both domestic and international investors. The establishment of green bond frameworks and listing requirements can help emerging economies develop more sophisticated capital market infrastructure while building institutional capacity for sustainable finance (Ng, 2018). This market development function extends beyond individual transactions to create lasting improvements in financial system capacity.

**Figure 2: Green Bond Financing Mechanisms for Renewable Energy**

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The blended finance approach represents another mechanism through which green bonds can unlock renewable energy financing in emerging markets. Development finance institutions and multilateral organizations can provide credit enhancement, first-loss protection, or technical assistance to improve the risk-return profile of green bond issuances, making them more attractive to private investors (Sartzetakis, 2020). This approach can help bridge the gap between development finance and commercial investment while building market confidence in emerging market green bonds.

### 6. Challenges and Barriers

Despite the significant potential of green bonds to address renewable energy financing gaps in emerging economies, several structural challenges limit their effectiveness and adoption. Market liquidity constraints represent a primary barrier, as secondary markets for green bonds remain underdeveloped in many emerging economies, creating concerns among investors about exit opportunities and price discovery (Febi, Schäfer, Stephan, & Sun, 2018).

The lack of standardized definitions and classification systems for green bonds creates uncertainty and complexity for both issuers and investors. While international standards such as the Green Bond Principles provide guidance, variations in implementation and interpretation across jurisdictions can create confusion and limit cross-border investment flows (Kapraun & Scheins, 2019). This challenge is particularly acute in emerging markets where regulatory frameworks for sustainable finance may be nascent or inconsistent with international standards.

Currency and credit risks continue to pose significant challenges for emerging market green bond issuances targeting renewable energy projects. International investors may require local currency exposure to align with project cash flows, but may be reluctant to accept currency risk without appropriate hedging mechanisms. Similarly, sovereign and corporate credit risks in emerging markets can limit investor appetite and require higher yields to compensate for perceived default risks (Dorry & Schulz, 2018).

**Table 3: Key Barriers to Green Bond Development in Emerging Markets**

<b>Barrier Category</b>	<b>Specific Challenges</b>	<b>Impact Level</b>	<b>Mitigation Strategies</b>
Market Infrastructure	Limited secondary market liquidity	High	Market maker programs, exchange listing
Regulatory Framework	Inconsistent green definitions	Medium	Standardization, harmonization efforts
Currency Risk	Local currency exposure requirements	High	Currency hedging, multilateral guarantees
Institutional Capacity	Limited technical expertise	Medium	Capacity building, training programs
Credit Risk	Sovereign/corporate risk premiums	High	Credit enhancement, blended finance

Source: Author's analysis based on literature review

The limited institutional capacity for green bond structuring and management in emerging economies creates additional barriers to market development. Many potential issuers lack the technical expertise required to develop compliant green bond frameworks, obtain necessary certifications, and implement ongoing monitoring and reporting systems. This capacity constraint can result in higher transaction costs and longer development timelines that may discourage green bond issuance (Taghizadeh-Hesary, Rasoulinezhad, & Yoshino, 2019).

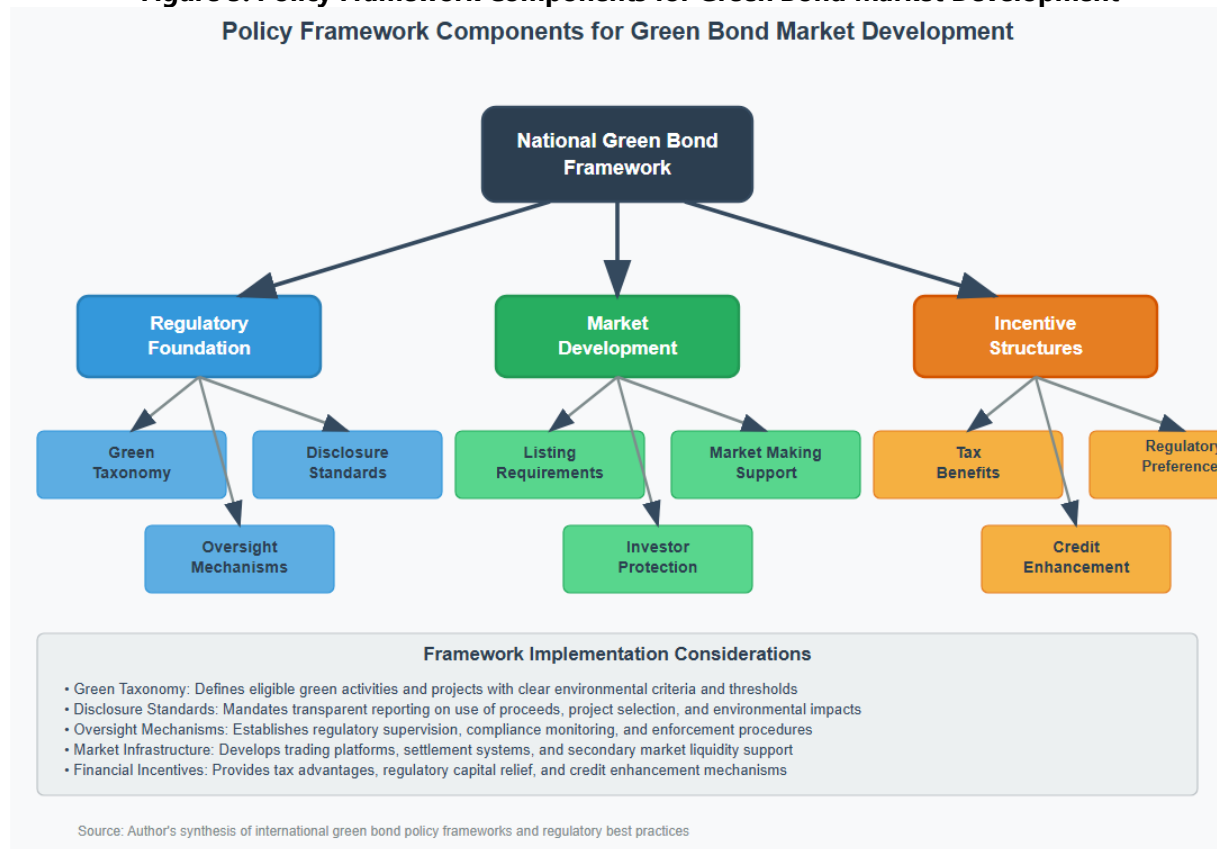
**7. Policy Frameworks and Institutional Support**

Effective policy frameworks play a crucial role in enabling green bond markets to function efficiently and support renewable energy financing in emerging economies. Government policies can address market failures, reduce transaction costs, and create incentives for both issuers and investors to participate in green bond markets. The design and implementation of these frameworks require careful consideration of local market conditions, regulatory capacity, and development priorities (Bhutta et al., 2021).

Regulatory frameworks for green bonds typically encompass several key components including taxonomy development, disclosure requirements, and oversight mechanisms. A clear taxonomy defines which projects and activities qualify as green, providing certainty for issuers and investors while ensuring environmental integrity. Disclosure requirements mandate transparent reporting on the use of proceeds and environmental impacts, creating accountability and enabling investor due diligence (Flammer, 2021).

Tax incentives and other fiscal measures can help stimulate green bond market development by improving the relative attractiveness of sustainable finance instruments. These may include tax exemptions for green bond interest income, reduced withholding taxes for international investors, or preferential regulatory treatment for financial institutions investing in green bonds. However, the design of such incentives must balance market development objectives with fiscal sustainability and equity considerations (Yoshino et al., 2019).

**Figure 3: Policy Framework Components for Green Bond Market Development**



International cooperation and technical assistance programs have proven essential for supporting green bond market development in emerging economies. Multilateral development banks, international organizations, and bilateral cooperation agencies provide technical expertise, capacity building, and financial support to help emerging economies establish green bond frameworks and develop institutional capacity. These programs often combine knowledge transfer with financial incentives to encourage early market development (Tu et al., 2020).

### 8. Case Studies and Evidence

China's experience with green bond market development provides valuable insights into the potential and challenges of using these instruments to finance renewable energy in emerging economies. Since establishing its green bond market in 2016, China has become the world's second-largest issuer of green bonds, with cumulative issuance exceeding \$150 billion by 2021. The Chinese market has demonstrated how domestic policy support, including regulatory frameworks and tax incentives, can rapidly scale green bond issuance (Wang et al., 2020).

The Chinese green bond market reveals both opportunities and challenges in emerging market contexts. On the positive side, rapid market growth has provided significant funding for renewable energy projects, including solar, wind, and hydroelectric developments. The domestic investor base has expanded to include banks, insurance companies, and asset managers seeking sustainable investment opportunities. However, differences between Chinese and international green standards have limited foreign investor participation and created concerns about environmental additionality (Karpf & Mandel, 2018).

India's sovereign green bond program illustrates another approach to leveraging green bonds for renewable energy financing. The government launched its inaugural sovereign green bond issuance in 2021, but the groundwork laid in preceding years demonstrates how emerging economies can develop frameworks for sovereign green debt. The Indian approach emphasizes transparency in use of proceeds allocation, regular impact reporting, and alignment with national sustainable development objectives (Taghizadeh-Hesary & Yoshino, 2020).

**Table 4: Green Bond Market Development Indicators - Selected Emerging Economies (2019-2021)**

Countries	Cumulative Issuance (USD Billions)	Number of Issuers	Avg. Deal Size (USD Millions)	Renewable Energy Share (%)
China	134.2	198	287	42%
India	12.4	31	156	38%
Brazil	8.9	18	201	29%
Mexico	3.2	9	178	35%
Indonesia	2.8	7	165	44%
South Africa	1.9	5	142	31%

Source: Climate Bonds Initiative, Bloomberg New Energy Finance

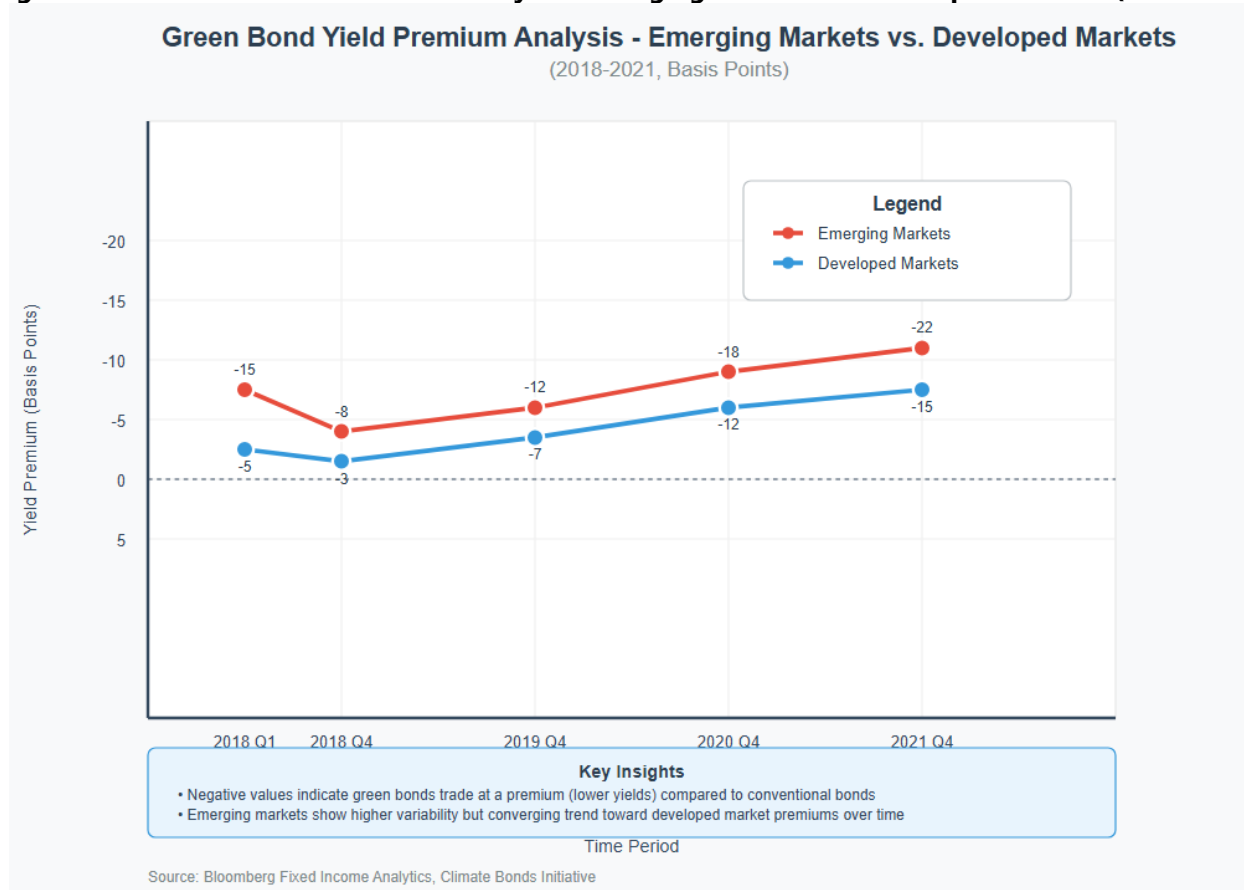
The experience of multilateral development banks in issuing green bonds for emerging market renewable energy projects provides additional evidence of the potential for these instruments. The International Finance Corporation, Asian Development Bank, and other institutions have successfully used green bonds to mobilize private capital for renewable energy projects across developing countries. These transactions often incorporate blended finance structures that combine development bank funding with private investment, demonstrating how green bonds can serve as platforms for innovative financing approaches (Rasoulinezhad & Taghizadeh-Hesary, 2021).

**9. Market Performance and Investor Perspectives**

Analysis of green bond performance relative to conventional bonds reveals important insights into investor behavior and market dynamics in emerging economies. Research by Zerbib (2019) documents the existence of negative yield premiums for green bonds in developed markets, suggesting that investors accept lower returns in exchange for environmental benefits. However, evidence from emerging markets presents a more complex picture, with pricing differentials varying significantly across issuers, maturities, and market conditions.

The liquidity characteristics of green bonds in emerging markets present both challenges and opportunities for investors seeking exposure to sustainable assets. While secondary market trading volumes remain relatively low compared to conventional bonds, the dedicated investor base for green bonds can provide stability during periods of market stress. Reboredo and Ugolini (2020) find evidence of lower correlation between green bonds and broader financial markets during crisis periods, suggesting potential diversification benefits for investors.

Institutional investor perspectives on emerging market green bonds reflect growing interest balanced against traditional concerns about credit quality and market infrastructure. Surveys of asset managers and pension funds indicate increasing allocation mandates for sustainable assets, with green bonds representing an attractive avenue for emerging market exposure while meeting environmental, social, and governance (ESG) requirements. However, concerns about verification standards, impact measurement, and secondary market liquidity continue to influence investment decisions (Baker et al., 2018).

**Figure 4: Green Bond Yield Premium Analysis - Emerging Markets vs. Developed Markets (2018-2021)**

Source: Bloomberg Fixed Income Analytics, Climate Bonds Initiative

The impact of green certification on investor demand provides insights into the value of environmental credentials in emerging market contexts. Studies examining the market reaction to green bond announcements find generally positive responses, with greater effects observed for first-time issuers and bonds with strong environmental credentials (Tang & Zhang, 2020). This evidence suggests that green labeling creates tangible value for issuers while attracting dedicated investor interest.

## 10. Innovation and Future Developments

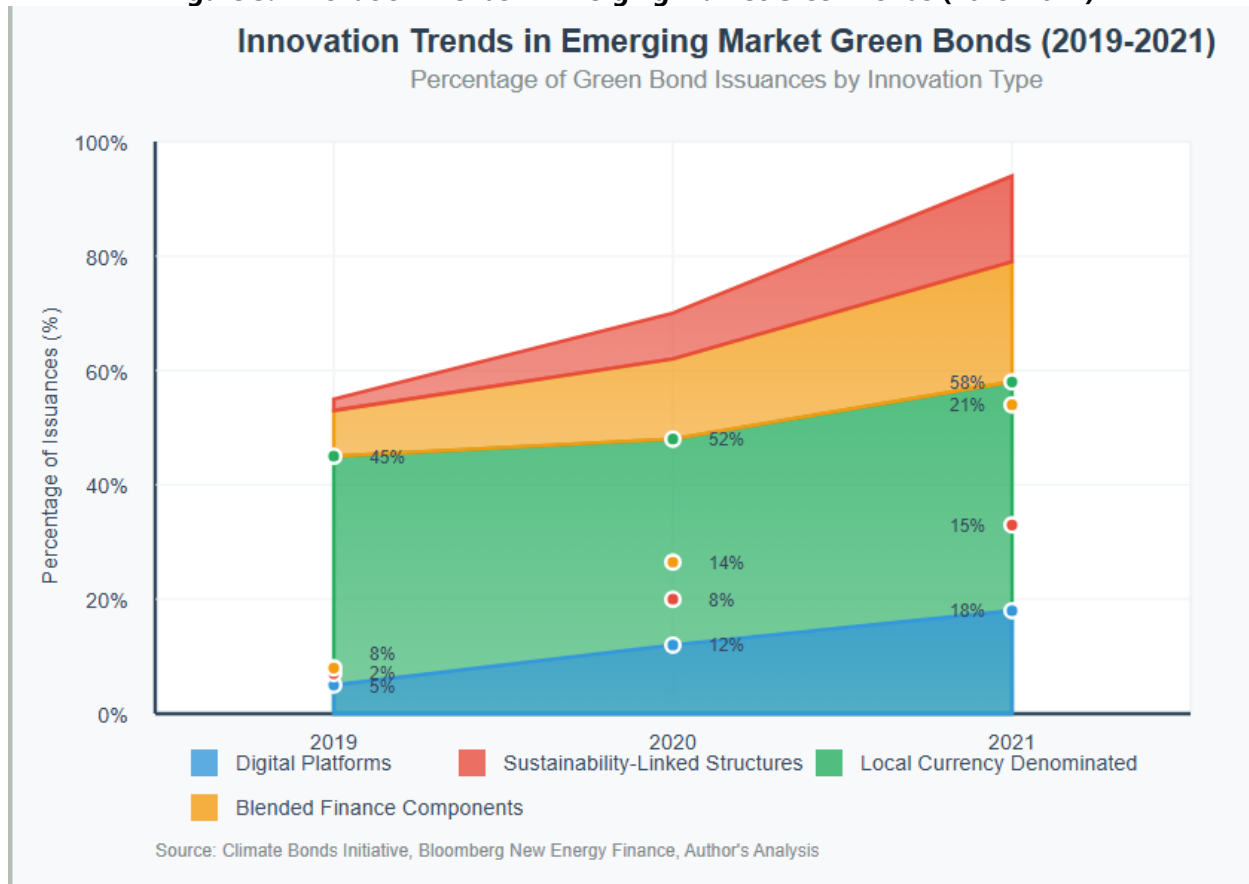
The evolution of green bond structures continues to create new opportunities for addressing renewable energy financing challenges in emerging economies. Sustainability-linked bonds represent an innovative approach that ties coupon payments to achievement of specific environmental targets, providing incentives for issuers to exceed baseline sustainability performance. This structure can be particularly relevant for renewable energy projects where performance improvements over time create additional environmental benefits (Maltais & Nykvist, 2020).

Blockchain technology and digital platforms are beginning to transform green bond issuance and monitoring processes, potentially reducing transaction costs and improving transparency. These innovations can be especially valuable in emerging market contexts where traditional financial infrastructure may be limited. Digital platforms can facilitate smaller-scale green bond issuances, enabling mid-sized renewable energy developers to access capital markets while providing investors with enhanced due diligence capabilities (Tolliver et al., 2020).

The development of local currency green bond markets represents another frontier for innovation in emerging economies. By issuing green bonds in domestic currencies, emerging market borrowers can reduce currency mismatch risks while attracting local institutional investors seeking long-term assets. Central banks in several

emerging economies have begun exploring green bond purchases as part of monetary policy operations, potentially providing additional liquidity and market support (Gianfrate & Peri, 2019).

**Figure 5: Innovation Trends in Emerging Market Green Bonds (2019-2021)**



Climate-resilient infrastructure bonds represent an emerging category that addresses the intersection of climate adaptation and renewable energy development. These instruments finance projects that both generate renewable energy and enhance climate resilience, addressing dual challenges faced by many emerging economies. The integration of adaptation and mitigation objectives in single financing instruments can improve project economics while addressing comprehensive sustainability objectives (Sartzetakis, 2020).

### 11. Policy Recommendations and Implementation Strategies

The successful deployment of green bonds to unlock renewable energy finance in emerging economies requires coordinated policy interventions addressing multiple market and institutional barriers. Governments should prioritize the development of comprehensive national green bond frameworks that establish clear taxonomies, disclosure requirements, and oversight mechanisms aligned with international standards while reflecting local development priorities. These frameworks should be developed through multi-stakeholder processes involving financial regulators, environmental agencies, and private sector participants to ensure practical implementation (Ehlers & Packer, 2017).

Capacity building initiatives represent critical components of green bond market development strategies. Emerging economies should invest in technical assistance programs that enhance the ability of local financial institutions, corporations, and government entities to structure and manage green bond issuances. These programs should encompass project development skills, financial structuring expertise, and impact measurement capabilities while fostering knowledge transfer between international experts and local practitioners (Tu et al., 2020).

International cooperation mechanisms should be strengthened to facilitate cross-border green bond investment and knowledge sharing. Multilateral development banks can play enhanced roles in providing credit enhancement, technical assistance, and market development support for emerging market green bonds. Bilateral cooperation agreements between developed and emerging economies can facilitate technology transfer and investment partnerships while supporting capacity building initiatives (Sachs et al., 2019).

The establishment of regional green bond markets and cooperation frameworks can help achieve economies of scale while reducing transaction costs for smaller issuers. Regional initiatives can harmonize standards, facilitate cross-border investment, and create platforms for knowledge sharing among emerging economies facing similar challenges. These collaborative approaches can accelerate market development while building regional expertise in sustainable finance (Bhutta et al., 2021).

## **12. Conclusion**

This comprehensive analysis demonstrates that green bonds possess significant potential to address renewable energy financing gaps in emerging economies, while highlighting the complex challenges that must be addressed to realize this potential fully. The evidence reveals that green bonds can mobilize substantial capital for sustainable energy projects, provide access to dedicated investor pools, and create frameworks for transparent environmental impact reporting. However, the effectiveness of these instruments depends critically on supportive policy frameworks, adequate institutional capacity, and appropriate risk mitigation mechanisms.

The experience of early-adopting emerging economies illustrates both the opportunities and challenges associated with green bond market development. Rapid market growth in countries such as China and India demonstrates the scalability of green bond financing, while highlighting the importance of domestic policy support and regulatory clarity. The variation in market development outcomes across different emerging economies underscores the need for context-specific approaches that reflect local financial market conditions, regulatory capacity, and development priorities.

The analysis reveals that successful green bond programs require integrated policy approaches that address multiple dimensions of market development simultaneously. Regulatory frameworks must provide clarity and consistency while maintaining alignment with international standards. Institutional capacity building is essential for both public and private sector participants in green bond markets. Risk mitigation mechanisms, including currency hedging and credit enhancement, are necessary to attract international investment while managing emerging market-specific risks.

Looking forward, continued innovation in green bond structures and supporting infrastructure offers promise for expanding the reach and effectiveness of these instruments in emerging economies. Digital platforms, blended finance approaches, and local currency markets can address specific barriers while creating new opportunities for sustainable energy financing. However, realizing these opportunities requires sustained commitment from governments, international organizations, and private sector participants to build robust and inclusive green bond markets.

The implications of this analysis extend beyond the immediate realm of renewable energy financing to encompass broader questions of sustainable development finance and climate change mitigation. Green bonds represent one component of a comprehensive approach to mobilizing finance for sustainable development, requiring integration with other policy instruments and financing mechanisms. The success of green bonds in emerging economies will ultimately depend on their ability to contribute to broader development objectives while delivering measurable environmental benefits and financial returns to investors.

The path forward requires recognition that green bond market development is a gradual process that requires patience, persistence, and adaptive management approaches. Emerging economies must balance the imperative for rapid renewable energy deployment against the need to build sustainable and credible green bond markets that

can attract long-term investor commitment. International support should focus on building endogenous capacity while providing appropriate technical and financial assistance during market development phases.

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