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Mapping sustainability in Latin America and the Caribbean

Sectoral and energy transition insights from sustainable bonds, 2014–2024

Helvia Velloso
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This document was prepared by Helvia Velloso, Officer in Charge of the Economic Commission for Latin America and the Caribbean (ECLAC) office in Washington, D.C., Daniel E. Perrotti, Research Assistant and Rudá Sobreira, intern. The authors wish to thank Silvia Eugenia Felipe Calle, Hubert H. Humphrey Fellow, for her input on the energy sector during her time with the office.

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Abstract

This study examines the role of green, social, sustainable, and sustainability-linked (GSSS) bonds in financing the energy transition in Latin America and the Caribbean (LAC). It combines a descriptive assessment of sectoral bond issuance patterns from 2014 to 2024 with an econometric exercise focusing on the region's top five issuers. The results indicate that GSSS bonds have contributed to the expansion of renewable energy capacity but have not yet produced a structural shift in the overall energy mix. These findings underscore both the opportunities and limitations of sustainable finance, highlighting the importance of complementary policies, market reforms, and effective governance to maximize its transformative potential.

Introduction

Latin America and the Caribbean (LAC) is emerging as a frontrunner in the global energy transition. According to the International Renewable Energy Agency (IRENA), more than 60% of the region's installed capacity already comes from renewable sources, and the International Labour Organization (ILO) estimates that investments in this sector have generated over 1.2 million jobs in the past five years. These advances position LAC as a leader in moving toward a low-carbon economy while fostering employment and industrial opportunities (IRENA, 2024).

Yet the region also faces a challenging development moment. Structural "development traps"—low capacity to grow, high levels of inequality, limited social mobility, and weak institutions—continue to hinder the construction of an inclusive and sustainable productive model (Salazar-Xirinachs, 2023). At the same time, uneven progress toward the 2030 Agenda highlights the urgency of mobilizing resources for strategic transformations, particularly the energy transition (ECLAC, 2023).

ECLAC has stressed the need for a "big push for sustainability," a comprehensive strategy that simultaneously promotes productivity, social inclusion, and environmental sustainability (ECLAC, 2024a; Salazar-Xirinachs, 2023). Meeting this objective requires scaling up investment through fiscal reforms, improvements in the international financial architecture, and a stronger role for development banks. Within this broader financing agenda, green, social, sustainability, and sustainability-linked (GSSS) bonds have become an increasingly important channel to mobilize capital and align it with development priorities.

This paper analyses the sectoral distribution of LAC's international GSSS bond issuances between 2014 and 2024 and assesses their role in supporting the energy transition. The analysis draws on a dedicated dataset developed and maintained by the ECLAC office in Washington D.C. in the framework of its periodic *Capital Flows to Latin America and the Caribbean* reports.[1] This unique resource compiles detailed information on international bond issuances from sovereign, corporate, and supranational entities in the region, disaggregated by sector, issuer type, and instrument. On the basis of this dataset, the paper maps issuance

[1] The most recent *Capital Flows to Latin America and the Caribbean: 2024 Year in Review and Early 2025 Developments* report (May 2025), underpins the specialized dataset used in this study. Available at: https://www.cepal.org/en/publications/81550-capital-flows-latin-america-and-caribbean-2024-year-review-and-early-2025..

patterns and examines empirically whether energy-sector debt issuances (with proceeds financing energy projects) are associated with measurable outcomes in renewable capacity and the energy mix among the region's top five issuers.[2]

Examining sectoral distribution is particularly relevant because it shows how sustainable finance is being directed into areas with different development impacts. Issuances from the sovereign sector provide fiscal space for social and environmental programs, while growth in sectors such as energy, forestry, and industry can create productive linkages, generate quality jobs, and advance the transition to low-carbon economies. By highlighting these sectoral patterns, the study helps identify where GSSS bonds are most likely to support structural change and where complementary policies are needed to maximize their contribution to sustainable development.

The paper is structured in four chapters. The first outlines the region's development challenges and financing needs. The second presents a descriptive analysis of international GSSS bond issuances between 2014 and 2024, broken down by sector, issuer type, and instrument. The third applies a panel robust fixed-effects model (PARFEM) to examine the relationship between energy-sector debt issuances and energy transition indicators in the region's top five issuers. The fourth offers concluding remarks and policy reflections, drawing lessons from the evidence and outlining measures that could enhance the role of sustainable finance in supporting structural transformation.

[2] The top five issuers are, in alphabetical order, Brazil, Chile, Colombia, Mexico, and Peru.

I. Development challenges and financing

Latin America and the Caribbean (LAC) faces a challenging moment in its development trajectory. The region continues to grapple with a set of structural constraints that ECLAC calls "development traps": low capacity to grow, high levels of inequality, limited social mobility, and weak institutions, which make building an inclusive and sustainable productive model very challenging (Salazar-Xirinachs, 2023). These traps are closely tied to historically persistent gaps in productive capacity, infrastructure, public goods, and equality, rooted in long-standing institutional dynamics and patterns of unequal opportunities. At the same time, progress toward the 2030 Agenda remains uneven: halfway to the deadline, only 25% of the goals are on track, nearly half show insufficient progress, and more than a quarter are regressing (ECLAC, 2023).

Yet this challenging outlook coexists with opportunities to promote strategic transformations that combine productivity, social inclusion, and environmental sustainability. ECLAC has stressed the need to rethink the region's development model through a "big push for sustainability," which articulates economic, social, and environmental objectives (ECLAC, 2024a; Salazar-Xirinachs, 2023). Within this framework, energy transition stands out as a central mobilizing sector, capable of generating productive linkages, driving technological ecosystems, and addressing the global challenge of climate change —whose unchecked trajectory could cost the region up to 8% of GDP annually within the next decade (Salazar-Xirinachs, 2023).

The region's current energy structure illustrates both vulnerabilities and advantages. About two-thirds of primary energy supply still comes from fossil fuels, while one-third is provided by renewables. At the same time, nearly 60% of electricity in LAC is generated from renewable sources (ECLAC, 2023). This combination of fossil fuel reliance and relative strength in renewable electricity generation creates both a challenge and an opportunity to accelerate the energy transition.

To overcome development traps, ECLAC has proposed eleven major transformations supported by new productive development policies. These combine horizontal and vertical efforts to transform productive structures, diversify economies, and raise productivity (ECLAC, 2024a; Salazar-Xirinachs, 2023). Examples include advancing the energy transition and promoting electromobility and sustainable transport. Success will require multilevel and multi-actor governance, where governments, the private sector, civil society, and

international cooperation converge, aligning the "what" (strategic objectives) with the "how" (implementation capacities).

Building on this framework, ECLAC has also identified fourteen priority sectors with transformative potential, including the energy transition, electromobility, the circular economy, and the bioeconomy (ECLAC, 2024a). The energy transition is conceived not only as a climate imperative but also as a vector for regional development, calling for accelerated deployment of renewables, the creation of new productive ecosystems, and policies designed to maximize their use (ECLAC, 2023). Critical minerals such as lithium, copper, nickel, cobalt, and graphite are recognized as strategic assets that could generate significant regional linkages (Salazar-Xirinachs, 2023), while regional electricity integration and the development of green hydrogen value chains are also key components of this agenda (ECLAC, 2024b).

A cross-cutting element of all these proposals is financing. ECLAC has stressed that, to overcome the development traps, the region must urgently mobilize resources along three axes: a transformative fiscal policy, reform of the international financial architecture, and an expanded role for development banks (ECLAC, 2025a). Multilateral, regional, and national development banks have already played countercyclical and inclusionary roles, but their catalytic function in strategic sectors needs to be reinforced through instruments such as guarantees, local currency financing, and co-investment schemes (Salazar-Xirinachs, 2025; Cipoletta Tomassian and Pérez Caldentey, 2024). Meeting climate commitments will require annual investment of 3.7%–4.9% of GDP through 2030—well beyond the capacity of public budgets alone (Cipoletta Tomassian and Pérez Caldentey, 2024). Development banks provided about 45% of climate financing in LAC between 2013 and 2020, underscoring their importance but also the need for complementary sources. These challenges are compounded by limited fiscal space and persistently high financing costs (ECLAC, 2023), making innovative approaches all the more essential.

In this context, innovative instruments such as debt-for-climate swaps, specialized funds, and the incorporation of environmental criteria into international investment are becoming increasingly relevant financing options (ECLAC, 2025b; ECLAC, 2023). While official development assistance (ODA) remains important, it is insufficient to meet the scale of needs. A sustainable financing strategy therefore requires combining public, private, and multilateral resources with new sustainability-oriented alternatives capable of leveraging larger volumes of resources.

Among these innovative alternatives, green, social, sustainability, and sustainability-linked (GSSS) bonds have emerged as a complementary channel for resource mobilization. Since 2021, these instruments have accounted for about one-third of the region's international debt issuances and, in 2024, reached US$ 33 billion (ECLAC, 2025c). Substantial issuances in the energy sector illustrate how GSSS bonds can directly support the transition.

II. LAC sustainable bonds, 2014–2024: sectoral insights

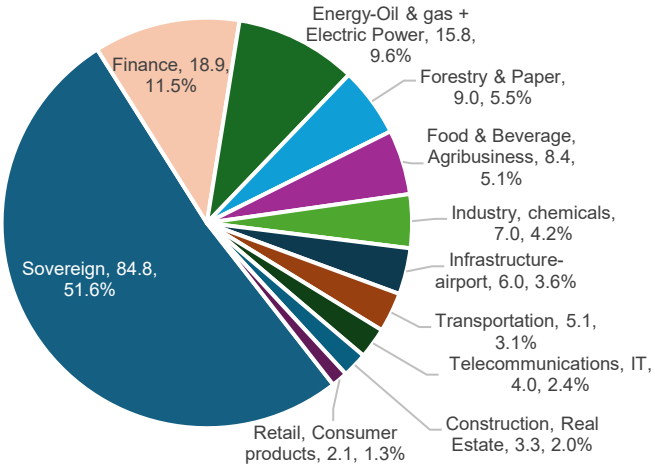
The transition toward a green economy in LAC represents an environmental imperative and a transformative opportunity to redefine the region's economic future. LAC possesses unparalleled natural resources, biodiversity, and renewable energy potential, which are pivotal for a sustainable economic transformation. By leveraging these advantages, the region can position itself as a global leader in renewable energy production, sustainable agriculture, and circular economy practices (Martínez et al., 2025).

In the ten-year period between December 2014 (when the region issued its first green bond in global markets to finance renewable energy) and December 2024, 106 LAC debt issuers issued 278 international green, social, sustainability and sustainability-linked (GSSS) bonds in 16 different currencies, totalling US$ 164.41 billion. Eighty of those issuances came from the sovereign sector (including sub-sovereign issuers), 126 from private bank and non-bank issuers, and 72 from supranational entities and state-owned (quasi-sovereign) enterprises. Most of these bonds issued during this period were directed at financing renewable energy, sustainable agricultural and forestry, as well as social initiatives (Velloso and Perrotti, 2023; updated to December 2024).

According to the sectoral distribution of LAC's international GSSS bond issuances from December 2014 to December 2024, 52% of the region's international GSSS debt issuance came from the sovereign sector, primarily due to Chile's large sovereign GSSS bond issuances. Not including the sovereign sector, the top 5 sectors in the ten-year period were: finance (11.5%), energy (9.6%), forestry and paper (5.5%), food and beverage, agribusiness (5.1%), and industry, chemicals (5.1%). Together with the sovereign sector they accounted for 87.5% (US$ 143.91 billion) of all international GSSS bond issuances from the region in the ten-year period (figure 1).

Chile (61.5%) and Mexico (15.6%) accounted for the largest share of international GSSS bond issuances in the sovereign sector. In finance, supranational entities dominated with 43.3% of issuances, followed by Brazilian companies with 34.7%.

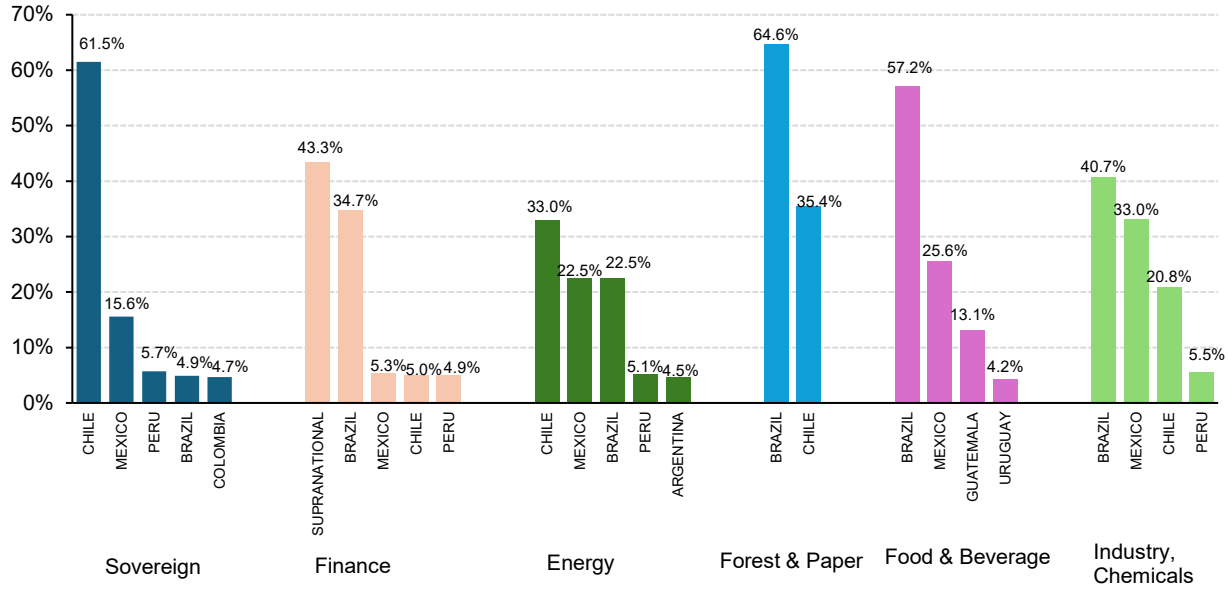
Figure 1
Distribution of LAC international GSSS bond issuances by sector, 2014–2024
(Billions of U.S. dollars, Percentage)



Source: Velloso and Perrotti (2023), figure 17, p. 30. Updated by authors to December 2024. Total LAC GSSS bond issuance from 2014 to 2024 was US$ 164.41 billion. The infrastructure sector includes four green bond issuances (totalling US$ 6 billion) from the Mexico City Airport Trust to finance the construction of a new airport. They took place in 2016 and 2017, but the sustainable project was cancelled in 2018. The sovereign sector includes three sub-sovereign green bond issuances by Argentina's provinces of La Rioja and Jujuy totalling US$ 510 mill.

In the energy sector, issuers from Chile (33.0%), Mexico (22.5%), and Brazil (22.5%) led activity. Forestry and paper issuances were concentrated in Brazil (64.6%) and Chile (35.4%). Brazilian issuers also stood out in food and beverages, with 57.2% of the total, followed by Mexico (25.6%), and in industry/chemicals, with 40.7%, ahead of Mexico (33.0%) and Chile (20.8%) (figure 2).

Figure 2
Top sectors' country distribution, 2014–2024
(Percentages)

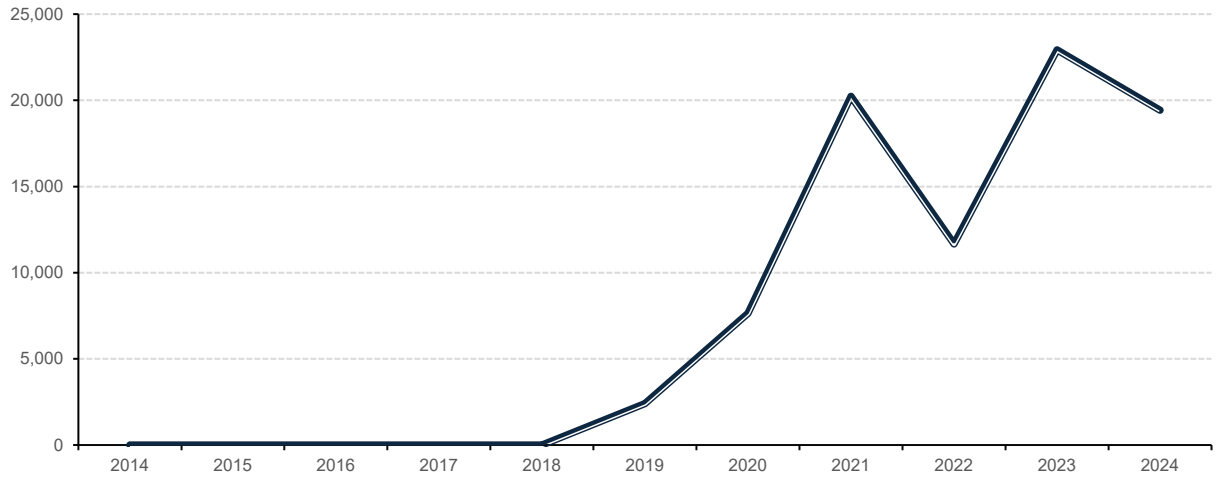


Source: ECLAC, based on data compiled by the ECLAC office in Washington D.C. for the Capital Flows to Latin America and the Caribbean reports. The data includes only bonds issued in the international market and is based on market sources, including Dealogic, LatinFinance and Bloomberg, among others. The sovereign sector includes sub-sovereign green bond issuances.

A. Sectoral growth trends

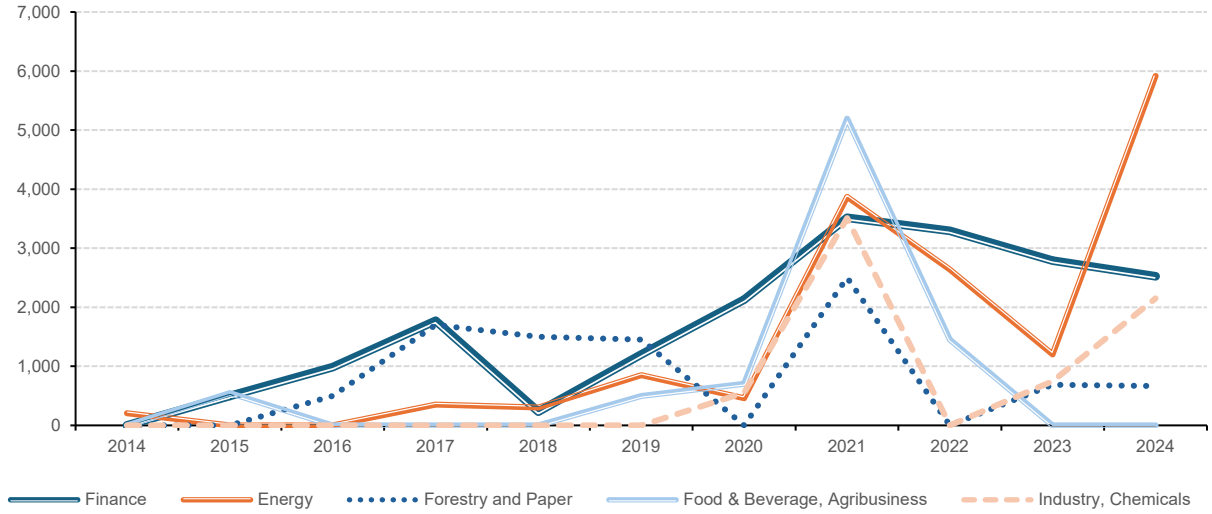
Growth trends in the ten-year period show that the sovereign sector has experienced the fastest growth since the region's inaugural sovereign green bond was issued in international markets in mid-2019 (figure 3). Of the following top five sectors (figure 4), the financial sector showed the steadiest growth trend, while the energy sector experienced significant growth in 2024, surpassing the financial sector to become the region's top GSSS bond issuer that year after the sovereign sector.

Figure 3
LAC international GSSS bond issuances by sector: sovereign sector growth trends, 2014–2024
(Millions of U.S. dollars)



Source: ECLAC, based on data compiled by the ECLAC office in Washington D.C. for the Capital Flows to Latin America and the Caribbean reports The data includes only bonds issued in the international market and is based on market sources, including Dealogic, LatinFinance and Bloomberg, among others. Chart does not include sub-sovereign issuances.

Figure 4
LAC international GSSS bond issuances by sector: top 5 sectors growth trends, 2014–2024
(Millions of U.S. dollars)



Source: ECLAC, based on data compiled by the ECLAC office in Washington D.C. for the Capital Flows to Latin America and the Caribbean reports The data includes only bonds issued in the international market and is based on market sources, including Dealogic, LatinFinance and Bloomberg, among others. Chart does not include the sovereign sector, which is shown in figure 3.

The forestry and paper sector also maintained a relatively steady presence in international GSSS debt issuances from the region, but both in 2020 and 2022 there were no issuances from this sector. GSSS bond issuances from the food & beverage sector reached a peak in 2021 but have since declined significantly, with no issuances taking place in 2023 and 2024,[3] while industry, chemicals experienced rapid growth in 2023 and 2024.[4]

Sustainable bond issuances from these top sectors offer a potential path for financing LAC's sustainable economic transformation and goals:

1. Financial sector: the region's GSSS international bond issuances from this sector reflect a growing trend where financial institutions raise capital by offering bonds specifically designed to fund projects with environmental, social, or governance impacts, aiming to align financial resources with sustainability goals and attract investors who prioritize them.
2. Energy sector: GSSS corporate bonds have emerged as a key tool for channelling financing to projects that support the energy transition and decarbonization, including renewable energy projects, energy efficiency upgrades, and transmission and distribution improvements.
3. Forestry and paper: GSSS bonds offer a potential avenue for financing sustainable practices supporting conservation, responsible forest management, and environmentally sound manufacturing processes.
4. Food and beverage: proceeds from international GSSS bond issuances can be allocated to circular economy and plastic waste reduction, decarbonization and climate resilience within operations and value chain, pursuing net positive water impact, and regenerative agriculture. By investing in such projects, companies and investors can contribute to building a more sustainable and resilient food system.
5. Industry, chemicals: GSSS bonds are playing a growing role in financing industrial initiatives related to decarbonization and a circular economy, especially in the chemical industry.

B. Type of issuer by sector

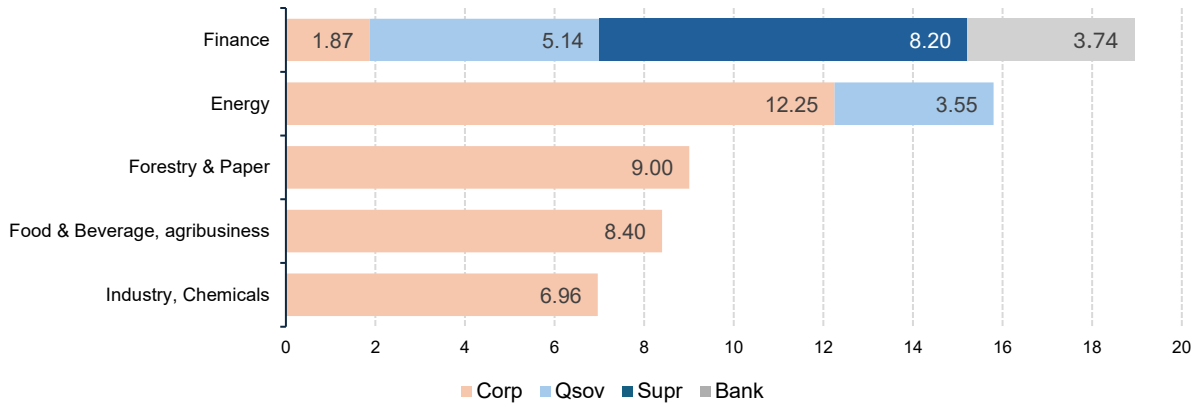
Different types of issuers predominated in each of the top five sectors, not including the sovereign sector, between 2014 and 2024. Private non-bank issuers (corporate issuers) dominated in the energy sector with a share of 78%, and in forestry & paper, food & beverage, and industry, chemicals with a share of 100%. In the financial sector they accounted for 10% of the total, however, while private banks represented 20%, quasi-sovereign issuers 27% and supranational entities 43%. In the energy sector, quasi-sovereign issuers represented 22% of the total (figure 5).[5]

[3] Higher investor scrutiny may have contributed to the recent decline in international GSSS bond issuances in the food & beverage sector. Some large Brazilian food and beverage companies, such as JBS, have faced considerable scrutiny over their sustainability practices, particularly regarding deforestation and supply chain emissions. This makes it more challenging for them to attract investors for sustainable debt. Brazilian companies accounted for almost 60% of all issuances from the food & beverage sector in the ten-year period analyzed.

[4] Government programs, such as the New Industry Brazil, launched in early 2024, support the revitalization of the Brazilian industry with a focus on innovation and sustainability. The program encourages the development of new markets, particularly in renewable industries, where chemical companies can play a role. Brazilian companies accounted for 74% of all GSSS international issuances from the Industry, Chemicals sector in 2023-2024, and 41% for the ten-year period.

[5] In the financial sector, supranational entities included CAF-Development Bank of Latin America, CABEI-Central American Bank for Economic Integration and FONPLATA-Fondo Financiero para el Desarrollo de la Cuenca del Plata, while quasi-sovereign issuers included Banco do Brasil, BNDES-Brazilian Development Bank, Banco del Estado de Chile (BancoEstado), NAFIN-Mexico's Nacional Financiera, Peru's Fondo MIVIVIENDA and COFIDE-Corporación Financiera de Desarrollo. In the energy sector, quasi-sovereign issuers included Mexico's Comisión Federal de Electricidad-CFE and Costa Rica's Instituto Costarricense de Electricidad (ICE).

Figure 5
LAC international GSSS bond issuances: type of issuer by sector, 2014–2024
(Billions of U.S. dollars)



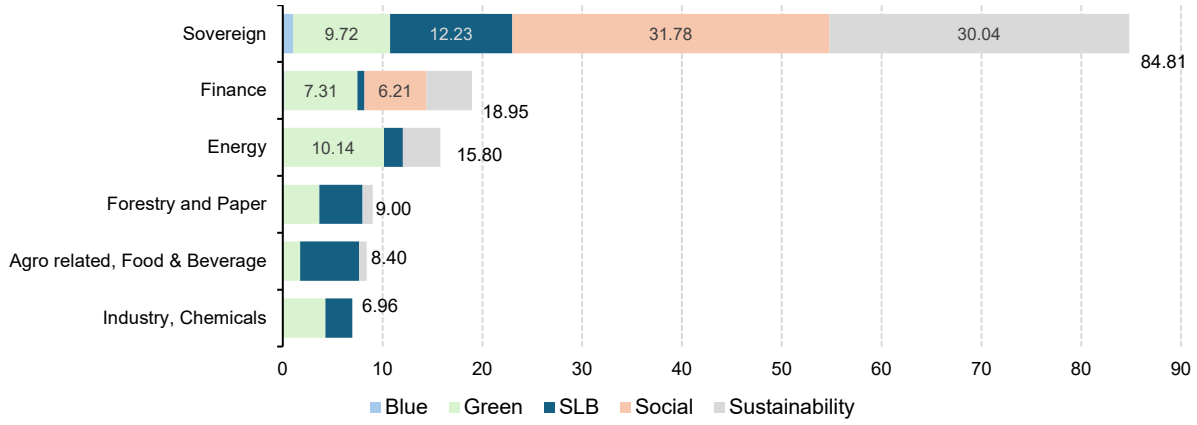
Source: ECLAC, based on data compiled by the ECLAC office in Washington D.C. for the Capital Flows to Latin America and the Caribbean reports. The data includes only bonds issued in the international market and is based on market sources, including Dealogic, LatinFinance and Bloomberg, among others.

Private corporate issuers thus dominated issuances from the energy, forestry & paper, food & beverage, and industry, chemicals sectors in the ten-year period. In the financial sector there was a mix of private banks, quasi-sovereign issuers, and supranational entities, and in the energy sector, 78% of the issuers came from the corporate (private nonobank) sector, while 22% were quasi-sovereign issuers.

C. Type of instruments by sector

Green bonds accounted for the highest share (28.3%) of all international GSSS bonds issued by LAC issuers from 2014 to 2024. They were followed by sustainability (25.21%), social (23.51%), SLBs (22.19%) and blue (0.74%) bonds. Green bonds were issued by all sectors, with the energy sector issuing a total of US$ 10.14 billion of green bonds in the period, 22% of all green bonds issued and the highest share, followed by the sovereign (US$ 9.71, 21%) and the financial (US$ 7.31, 16%) sectors (figures 6 an 7a).

Figure 6
LAC international GSSS bond issuances: type of instrument by sector, 2014–2024
(Billions of U.S. dollars)



Source: ECLAC, based on data compiled by the ECLAC office in Washington D.C. for the Capital Flows to Latin America and the Caribbean reports. The data includes only bonds issued in the international market and is based on market sources, including Dealogic, LatinFinance and Bloomberg, among others. Chart includes only the top sectors, which accounted for US$ 143.91 billion (87.5%) of the total amount of international GSSS bonds issued by LAC issuers from 2014-2024.

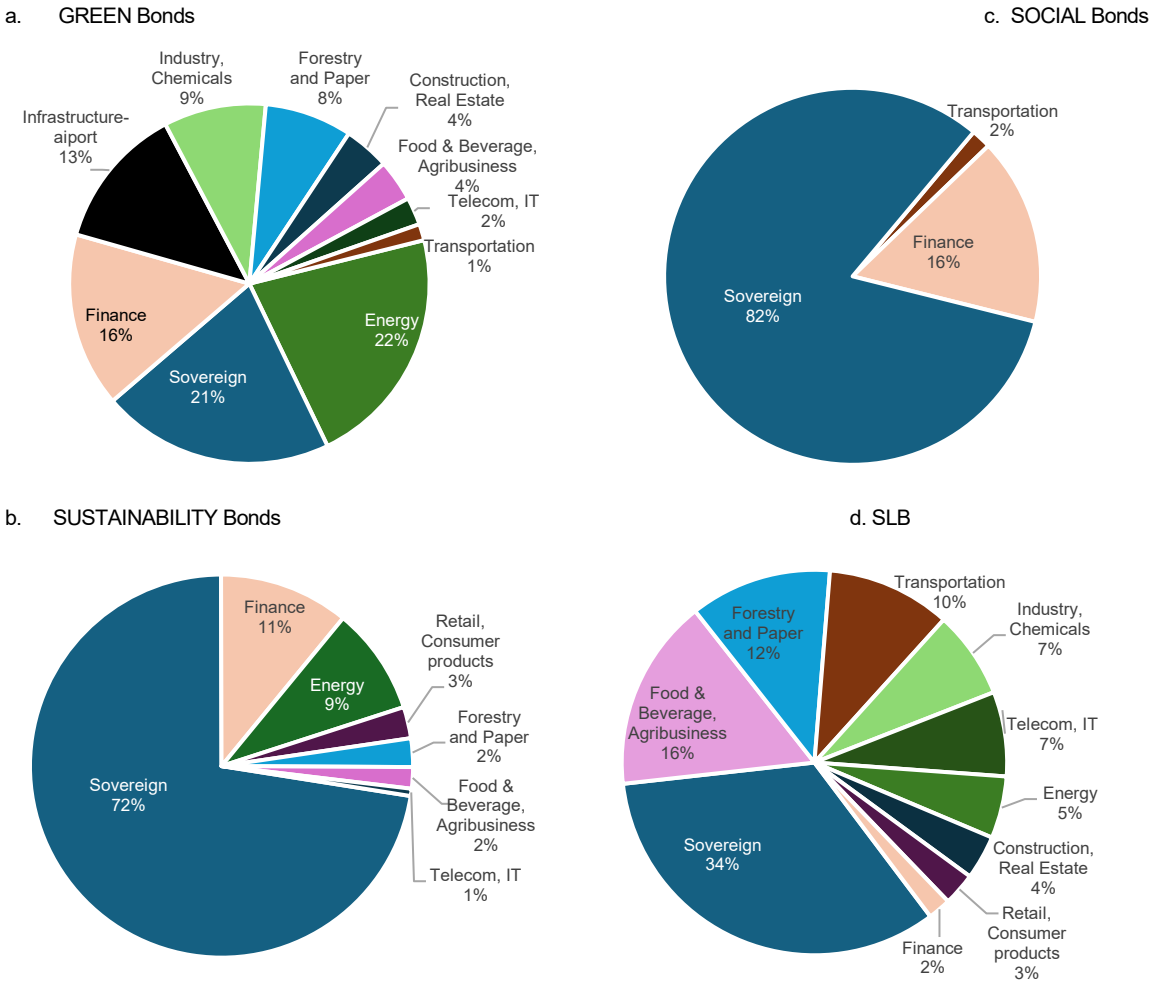
Sustainability bonds were issued by seven sectors, with the top issuers being the sovereign, financial and energy sectors (figure 7b). The sovereign sector issued US$ 30 billion in the period (72.5% of sustainability bons issued by LAC issuers), followed by the financial sector with US$ 4.5 billion (11%) and the energy sector with US$ 3.8 billion (9%).

Social bonds were issued by the sovereign, financial and transportation sectors, with the sovereign sector accounting for US$ 31.78 billion and the top share (82%), while the financial sector accounted for US$ 6.21 billion, (16%) and the transportation sector for US$ 658 million (1.7%) (figure 7c).

SLBs were issued by 10 sectors (figure 7d), and the top three sectors were the sovereign sector, issuing US$ 12,23 billion (33.5%) of the total SLBs issued in the period, food and beverage, US$ 5.9 billion (16%) and forestry and paper, US$ 4.34 billion (12%).

Finally, blue bonds were issued by the sovereign and financial sectors. Sovereign issuers accounted for 86% of all blue bonds issued in the period, and supranational issuers for the rest.

Figure 7
LAC international GSSS bond issuances: sectoral distribution by type of instrument, 2014–2024
(Percentages)



Source: ECLAC, based on data compiled by the ECLAC office in Washington D.C. for the Capital Flows to Latin America and the Caribbean reports The data includes only bonds issued in the international market and is based on market sources, including Dealogic, LatinFinance and Bloomberg, among others.

The energy sector was thus the top issuer of green bonds, while the sovereign sector was the top issuer of blue, social, sustainability and sustainability-linked bonds. The sectoral distribution of the region's international issuance of green bonds and SLBs shows more diversity of issuers, while social, sustainability and blue bonds are for the most part issued by the sovereign sector.

From a private sector perspective, the SLB structure's attractiveness was its diversity, not only sectoral but also in terms of credit quality. The highest share of issuers of SLBs in the region was of non-investment grade (high-yield) issuers, who accounted for 66% of the SLB total. However, according to an April 2024 report by Fitch, the SLB structure has faced scrutiny and criticism due to credibility concerns, including lack of aggressive green improvements made after these bonds are issued, which has led some investors to refocus on green bonds.[6]

Green bonds have also attracted a variety of sectors and issuers of different credit quality, with about 67% of the region's green bond issuers being in the non-investment grade category. However, since the region's sovereign issuers started to issue GSSS bonds in international markets, social and sustainability bonds gained ground as a share of the total. For social and sustainability bonds, the largest share of LAC issuers are investment grade (76% and 81%, respectively).

D. Key messages

LAC has great potential for leading in renewable energy, sustainable agriculture, and the circular economy. The transition to a green economy offers both environmental benefits and economic growth opportunities for the region, and sustainable bonds are critical for financing the region's green transition.

The sovereign sector dominated (51.5%) the international GSSS bond issuances in the 2014-2024 period. Sovereign issuers' preferred instruments were social, sustainability, and sustainability-linked bonds. However, private sector participation has also been significant in the ten-year period, especially in the issuance of green and SLB bonds. The top 5 sectors (excluding sovereign) were finance, energy, forestry & paper, food & beverage and industry, chemicals. Combined with the sovereign sector, they accounted for 87.5% of the region's total international GSSS bond issuances in the 2014-2024 period. These sectors are key for further sustainable growth in the region.

[6] Sustainable Fitch, "Enel's Missed Targets Could Support Maturing SLB Market" 29 April 2024 [online]. In April, the Italian energy company Enel, which issued the inaugural SLB in global markets, announced it had failed to meet one of its sustainability performance targets, a 2023 goal to cut emissions by more than a third compared with 2022. This triggered a 25-basis points step-up in the affected bonds, posing a new test for the SLB market, which, according to Fitch, may help it to mature by refocusing attention on credible aims and incentives.

III. Empirical insights on sustainable bonds and energy transition in LAC

The previous chapters outlined the structural challenges and financing needs framing the energy transition in Latin America and the Caribbean, as well as the sectoral patterns of international GSSS bond issuances between 2014 and 2024. Together, they highlight both the urgency of mobilizing resources for sustainable development and the growing role of GSSS instruments, particularly in the energy sector. This chapter develops an econometric analysis to assess whether such financing has translated into measurable outcomes, testing the relationship between energy-sector GSSS issuances and indicators of the energy transition in the region's top five issuers (Brazil, Chile, Colombia, Mexico, and Peru).

A. Literature review

In recent years, sustainable finance has emerged as a key instrument to support environmentally oriented projects worldwide. A growing body of literature has investigated the impact of green bond issuance on CO_2 emissions and renewable energy generation. Although approaches and regional focus vary, these studies offer important insights into the effectiveness of green bonds in advancing climate goals.

Several studies have examined the relationship between green bond issuance and carbon emissions. Flammer (2023), using panels of U.S. states and an international sample of countries (2000–2016), and employing fixed-effects regressions to control for unobserved heterogeneity or instance, finds that green bond issuance is significantly associated with reductions in CO_2 emissions: specifically, an increase of US$ 1,000 in green bond issuance per capita is linked to a 1.4% decrease in emissions in the following period. In the European context, Bestvina Bukvic et al. (2023) report that in EU-27, between 2013 and 2017, green bond issuance rose sharply, from approximately US$ 5 billion to US$ 75 billion, while total CO_2 emissions in the region fell by 3.7% over the same period, suggesting a potential link between the two.

Other research examines heterogeneity across sectors and time. Kartal et al. (2025) analyse data from China and the United States using daily sectoral CO_2 emissions and green bond activity indices. Applying nonlinear quantile regressions, they show that the effectiveness of green bonds depends on emission levels

and sectoral context. For example, in the transportation sector, green bond activity is associated with greater reductions in CO_2 emissions during periods of high bond issuance. In China, greater issuance is also associated with growth in solar and wind electricity generation.

Alamgir and Cheng (2023) apply the Generalized Method of Moments (GMM) to explore the links between green bond issuance, CO_2 emissions, and renewable generation across both pre- and post-Paris Agreement periods. They find that only countries reaching a "critical mass" of issuance experience measurable reductions in emissions alongside increases in renewable energy output.

Muchiri et al. (2024) adopt a Panel Robust Fixed Effect Model (PARFEM) for 29 developed and developing countries. Their approach, which incorporates controls such as GDP per capita, population, and government environmental expenditure, is particularly relevant for this document's analysis because it relies on similar annual, country-level data structures. Their results reveal a negative relationship between issuance and CO_2 emissions, with a 1% increase in issuance corresponding to a 0.003% reduction in emissions.

Despite this expanding literature, there is still a notable gap in the context of Latin America and the Caribbean. Most research focuses on developed economies or large emitters such as China, the United States, and the European Union. Empirical evidence and research on the impact of GSSS bonds on CO_2 emissions and renewable energy development in LAC remain limited.

This study narrows the focus to the energy sector, which is among the most significant contributors to CO_2 emissions both regionally and globally. Assessing whether green and sustainable finance instruments such as GSSS bonds are effectively supporting low-carbon transitions in this sector is essential. The energy sector also provides clear, measurable indicators—such as renewable capacity and its share in total energy consumption—that facilitate empirical analysis. Accordingly, this empirical section contributes to the literature by examining the relationship between GSSS bond issuance and renewable energy development in LAC, with a specific focus on the energy sector.

B. Methodology

This report applies a Panel Robust Fixed Effects Model (PARFEM) to examine the relationship between LAC international GSSS bond issuance from 2014 to 2024 and two indicators of the energy transition: (i) installed renewable energy capacity per capita and (ii) the share of renewables in total primary energy consumption. The PARFEM is well suited to this analysis as it controls for unobserved, time-invariant country characteristics—such as geography, institutional frameworks, or historical energy mixes—that could otherwise lead to biased estimates. Its robust specification also accounts for heteroskedasticity and mitigates the influence of outliers, thereby improving the reliability of estimates. This methodological choice builds on Muchiri et al. (2024), whose dataset and research design closely resemble those employed here.

The model incorporates two control variables: CO_2 emissions per capita, capturing broader environmental pressures, and foreign direct investment (FDI, net inflows as a share of GDP), reflecting the investment climate and access to external financing. Including these controls helps isolate the specific contribution of International GSSS bond issuance from other economic and environmental factors affecting renewable energy outcomes.

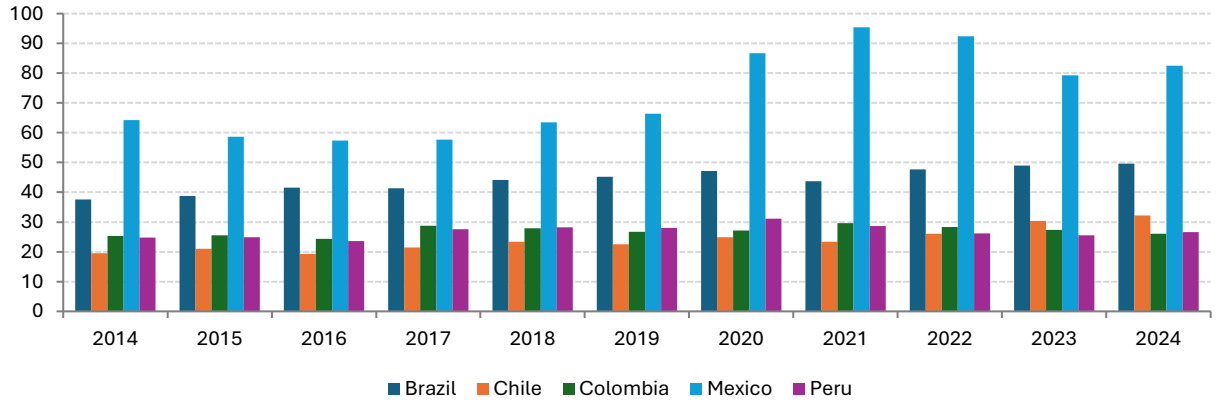
The dataset consists of a balanced panel covering the top five GSSS issuers in the region —Brazil, Chile, Colombia, Mexico, and Peru—over a ten-year period. A fixed-effects specification was chosen over random effects because country-specific characteristics—such as geography, institutional quality, or historical energy mixes—are likely correlated with explanatory variables (e.g., GSSS issuance or FDI), violating the random-effects assumption. This was also confirmed by the F-test presented in the Annex .

C. Descriptive analysis

The following figures present the trajectories of the dependent and explanatory variables for the top five issuers of international GSSS bonds in LAC over the ten-year period.

Renewable energy share in primary energy consumption. Between 2014 and 2024, Mexico maintained the highest share of renewables in total primary energy consumption, starting at about 64% in 2014 and reaching nearly 83% by 2024, with a peak above 90% in 2021–2022. Brazil followed, with renewables accounting for just under 40% in 2014 and rising to almost 50% by 2024. Peru and Colombia displayed relatively stagnant patterns, remaining near 25% throughout the decade. Chile, by contrast, began with the lowest share (about 20%) but steadily increased to over 30% by 2024 (figure 8).

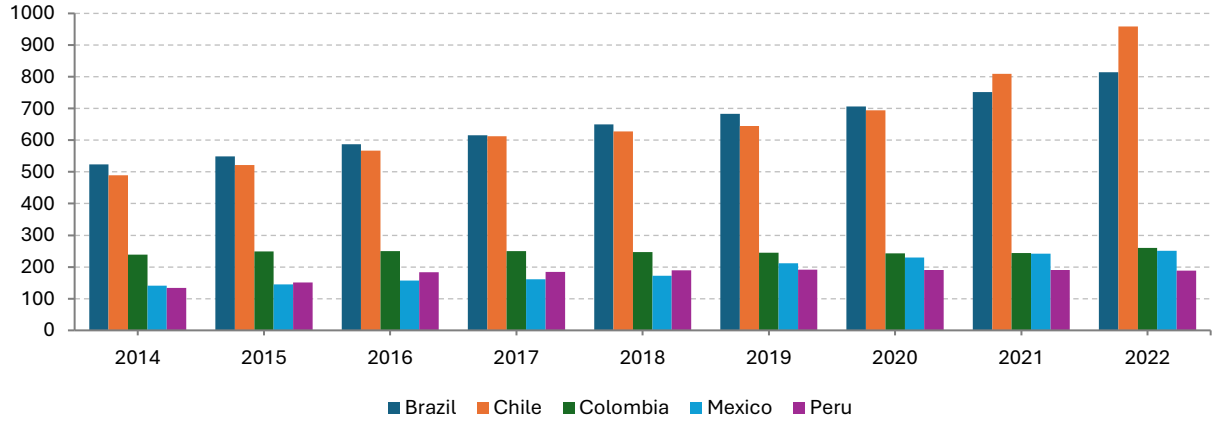
Figure 8
Renewable energy share in primary energy consumption, 2014–2024
(Percentage)



Source: ECLAC, based on data from the International Renewable Energy Agency (IRENA) and the United Nations.

Installed renewable capacity per capita. Renewable electricity-generating capacity per capita, measured in watts per person, shows more dynamic trends between 2014 and 2022. Chile and Brazil both started at around 500 watts in 2014, but by 2022 Chile had reached nearly 1,000 watts per person while Brazil climbed to 800 watts. Colombia remained flat at around 200 watts, while Mexico and Peru recorded only modest gains, finishing at approximately 300 and 200 watts per person, respectively (figure 9).

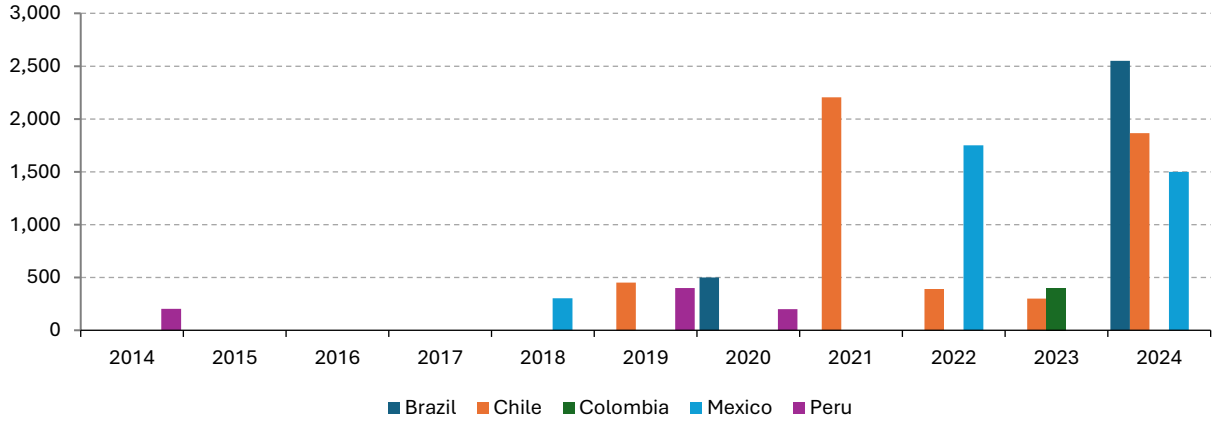
Figure 9
Renewable energy installed capacity per capita, 2014–2022
(Watts)



Source: ECLAC, based on data from the International Renewable Energy Agency (IRENA) and the United Nations.

Energy-sector issuance of international GSSS bonds. Energy-sector issuance volumes varied considerably across years and countries. Peaks of issuance were often followed by sharp declines, underscoring the volatility of this financing channel compared to the more gradual evolution of renewable energy indicators (figure 10).

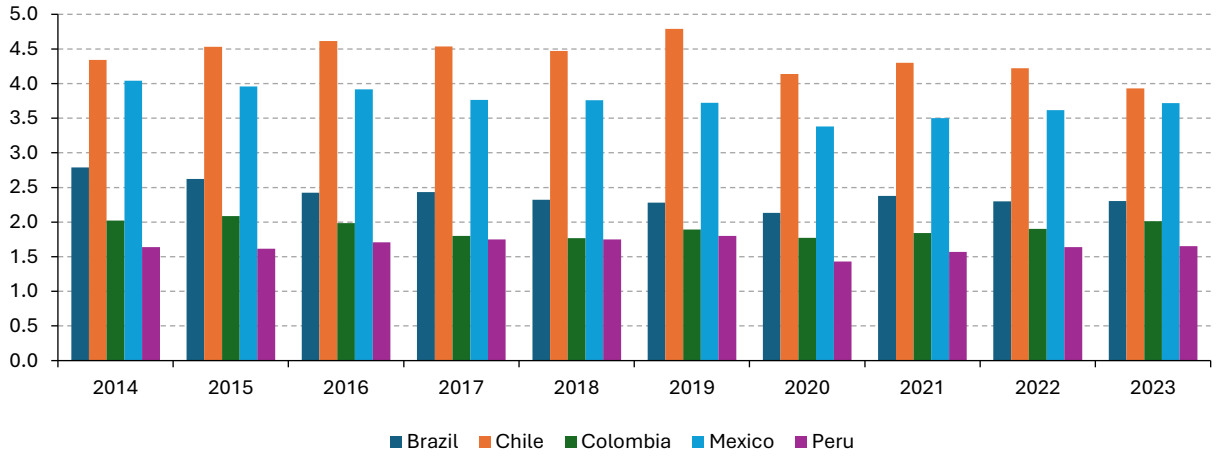
Figure 10
GSSS issuance in energy, 2014–2024
(Millions of U.S. dollars)



Source: ECLAC, based on data compiled by the ECLAC office in Washington, D.C.

CO_2 emissions per capita. Emissions levels, expressed in metric tons per person, highlight contrasting country profiles. Chile exhibited the highest levels at the beginning of the period (above 4 tons per capita) but managed a gradual decline below that threshold by 2023. Mexico hovered around 4 tons, Brazil declined from 3 tons to 2.5 tons, and Colombia and Peru remained relatively stable at about 2 and 1.5 tons, respectively (figure 11).

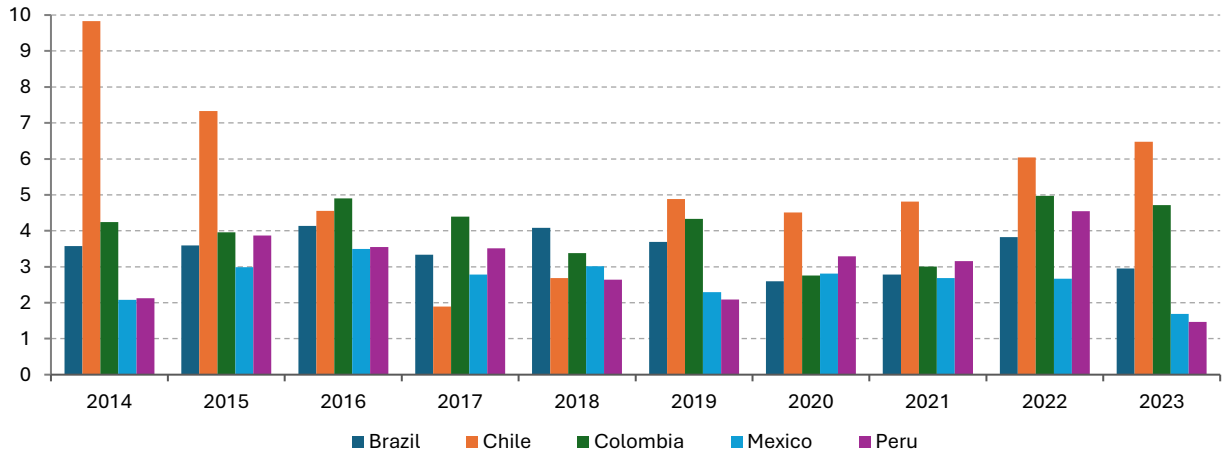
Figure 11
CO2 emissions per capita, 2014–2023
(Tons)



Source: ECLAC, based on data from the Global Carbon Budget.

Foreign direct investment (FDI). Net FDI inflows as a share of GDP fluctuated over the decade. Chile reached 10% of GDP in 2014 before declining and stabilizing above 6% in 2023. Colombia ended the period close to 5%. Brazil oscillated around 3–4%, while Peru and Mexico remained below 2% by the end of the sample (Figure 12).

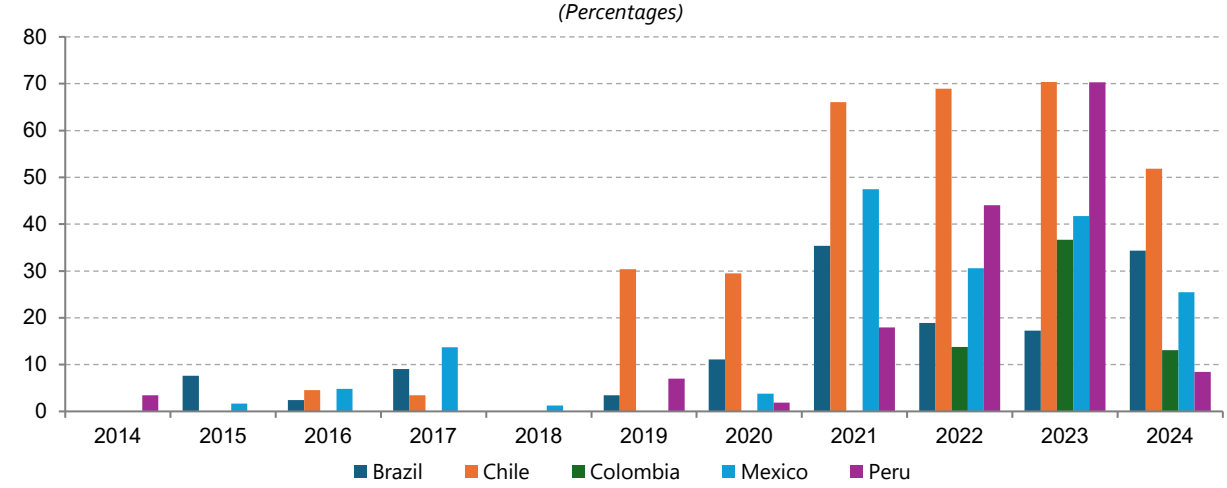
Figure 12
FDI net inflows, 2014–2023
(Percentage share of GDP)



Source: ECLAC, based on data from the International Monetary Fund, the OECD, and the World Bank.

Share of GSSS issuance in total international debt issuance. The role of GSSS instruments in overall debt markets expanded significantly but unevenly across the five countries. Chile led the region, rising from none in 2014 to about 70% in 2023 before moderating to 50% in 2024. Peru peaked at 70% in 2023 but dropped sharply thereafter. Mexico reached almost 50% in 2021 and ended with about 25% in 2024, while Colombia and Brazil displayed more gradual or delayed increases (figure 13).

Figure 13
GSSS in total international debt issuance, 2014–2024
(Percentages)



Source: ECLAC, based on data compiled by the ECLAC office in Washington D.C.

Taken together, these descriptive patterns underscore three important points: (i) renewable energy development in the region is uneven, with Chile and Brazil driving capacity expansion while Mexico maintains a structurally high renewable share; (ii) energy-sector international GSSS bond issuance is volatile and episodic; and (iii) control variables such as CO_2 emissions and FDI display heterogeneous dynamics.

D. Models and estimations

The empirical strategy relies on two specifications of the PARFEM, each targeting a distinct dimension of the energy transition.

Model 1: Installed renewable capacity per capita.

The first specification uses renewable electricity-generating capacity per capita as the dependent variable. Since data on installed renewable capacity per capita are available only until 2022, the estimation period spans 2014–2022. This model assesses whether energy-sector international issuance of GSSS bonds has contributed to expanding renewable energy capacity in the region.

The model is specified as:

$$Capacity_{it} = \alpha_i + \beta_1 \cdot IssuanceEnergy_{it} + \beta_2 \cdot CO2_{it} + \beta_3 \cdot FDI_{it} + u_{it}$$

Where:

$Capacity_{it}$: Renewable electricity-generating capacity installed per capita in country i at time t. The unit of measure is watts per person. Data are drawn from the International Renewable Energy Agency (IRENA) and the United Nations World Population Prospects.

α_i: Country fixed effect, capturing unobserved, time-invariant characteristics of each country (e.g., geography, infrastructure, institutional frameworks).

$IssuanceEnergy_{it}$: Total energy sector GSSS bond issuance in the five countries, measured in millions of USD. The ECLAC Washington, D.C. office compiles data.

$CO2_{it}$: Annual CO_2 emissions per capita, measured in metric tons, included as a control for environmental pressure. Data from the Global Carbon Budget.

FDI_{it}: Net foreign direct investment inflows as a share of GDP, included as a control for investment climate. Data from the International Monetary Fund, the OECD, and the World Bank.

u_{it}: Error term.

Model 2: Share of renewables in primary energy consumption.

The second specification applies the same logic but shifts the dependent variable to the share of renewable energy in total primary energy consumption. This model uses annual data from 2014 to 2023, consistent with the availability of the CO_2 and FDI series.

The model is defined as:

$$RenewablePercent_{it} = \alpha_i + \beta_1 \cdot IssuanceEnergy_{it} + \beta_2 \cdot CO2_{it} + \beta_3 \cdot FDI_{it} + u_{it}$$

Where:

$RenewablePercent_{it}$: Share of renewable energy in total primary energy consumption, based on the substitution method. This approach estimates how much fossil fuel would be required to generate the same amount of electricity produced by renewables or nuclear sources, thereby accounting for the energy losses inherent in fossil fuel generation. In practice, this measure reflects the contribution of renewables to overall energy use in a way that allows for comparability across energy sources. Data are from the Energy Institute's Statistical Review of World Energy (2014–2024).

Other variables: As defined in Model 1.

This second specification allows testing whether the region's international GSSS bond issuance is not only associated with capacity expansion, but also with a more profound structural transformation of the energy mix.

The results of the estimations are presented in Table 1. The first PARFEM specification produced statistically significant results. The coefficient for energy-sector issuance was positive (0.0584) and significant at the 5% level (p=0.0148), indicating that additional GSSS financing is associated with higher installed renewable capacity per person among the top five issuers in LAC. In contrast, both control variables showed negative and significant coefficients: CO_2 emissions per capita were negatively associated with renewable capacity (−220.16, $p < 0.01$), underscoring the inertia of carbon-intensive systems, while FDI inflows as a share of GDP also exhibited a negative relationship (−11.88, $p < 0.05$), suggesting that foreign investment flows in the region may not be systematically channelled toward renewable energy projects. Overall, the results from this model suggest that international GSSS bonds are indeed contributing to capacity expansion, even though other structural and financial factors continue to act as constraints.

In the second specification, which assessed the relationship between GSSS debt issuance in international markets and the share of renewable energy in total primary energy consumption, none of the explanatory variables were statistically significant. The coefficient for GSSS issuance was positive (0.0051) but non-significant ($p = 0.1621$), and both CO_2 emissions and FDI inflows showed similarly weak and statistically indistinguishable effects. This could indicate that, despite the expansion of renewable capacity, there has been no clear impact on the overall composition of the primary energy mix in the five countries.

Taken together, the results of the two models highlight an important distinction. On the one hand, international GSSS bonds appear to play a measurable role in supporting the deployment of renewable infrastructure, contributing to the growth of installed capacity across the region. On the other hand, these capacity gains have not yet translated into a structural shift in the energy matrix, where the relative share of renewables has mainly remained stable. This contrast suggests that while sustainable finance instruments are helping expand the supply of renewable energy, deeper policy, regulatory, and market reforms are required to impact the share of fossil fuels in primary energy consumption and accelerate the region's energy transition

Table 1
Estimation results

Variable	Model 1: Capacity per capita	Std. Error (Model 1)	P-value (Model 1)	Model 2 Renewable Share)	Std. Error (Model 2)	P-value (Model 2)
Energy Issuance	0.058	0.023	0.015**	0.005	0.004	0.162
CO_2	-220.16	55.91	0.00***	0.005	53.67	0.557
FDI	-11.88	4.93	0.021**	0.743	1.39	0.596

Source: authors' estimations.
*Note: Standard errors in parentheses. ***, *, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively

E. Key messages and policy reflections

The empirical evidence presented in this section highlights some of the contributions and limitations of GSSS bonds as a financing instrument for the energy transition in LAC. The estimations showed that energy-sector debt issuance is positively and significantly associated with increases in renewable capacity per capita among the top five regional issuers. This suggests that sustainable finance is indeed helping expand the stock of renewable infrastructure. However, the second specification revealed no significant relationship between international GSSS issuance and the share of renewables in total primary energy consumption, indicating that capacity additions have not yet translated into a structural reconfiguration of the regional energy mix.

These findings echo the mixed results in international literature. Studies such as Kartal et al. (2025) and Alamgir and Cheng (2023) find positive associations between green bond issuance and renewable generation or lower CO_2 emissions, while others, such as Chen (2025), detect no significant effects in specific contexts. The emerging picture is that the impact of sustainable bonds depends heavily on country-specific conditions, policy frameworks, and the maturity of energy markets. In this sense, the results for LAC align with a broader

pattern: GSSS instruments can contribute to renewable deployment, but their ability to drive deeper energy transitions is far from guaranteed.

It should also be emphasized that the analysis presented here constitutes an initial step in the empirical study of the role of GSSS bonds in the LAC region. The results are indicative rather than definitive, and future research should explore more sophisticated models capable of addressing potential issues of endogeneity and reverse causality. Expanding the scope to include additional countries, longer time horizons, and complementary financial indicators would also provide a richer understanding of how sustainable finance can shape the trajectory of the energy transition.

The evidence shows that GSSS bonds have contributed to expanding renewable capacity in LAC but have not yet driven a broader transformation of the energy mix. This suggests that, beyond financing, mechanisms such as priority dispatch of renewables,[7] storage expansion, and grid integration are essential to ensure that new capacity translates into a larger share of renewables in actual energy consumption. Closing this gap will require public policies that align sustainable finance with market design, productive strategies, and accountability mechanisms. The region has laid the foundations for sustainable finance; the next step is to embed these instruments within comprehensive strategies that connect financial mobilization to systemic transformation. Achieving this will demand coherence across financial markets, public policy, and development objectives.

It is important to emphasize that international experience offers a wide range of policy instruments that LAC countries can adapt to their specific contexts. Table 2 presents illustrative measures that could complement GSSS financing and strengthen its role in the energy transition. These measures address both supply and demand in electricity markets, improve storage and grid flexibility, and foster consumer engagement while reinforcing market incentives.

Table 2
Illustrative Public Policy Options to Complement GSSS Bond Financing

Policy Type	Description	Example
Support for Renewable Producers	Obligation to purchase renewable electricity at fixed prices, ensuring access and revenue.	France – EDF (Électricité de France) is obligated to buy renewable electricity at a fixed tariff.
Consumer Choice for Green Energy	Consumers may choose 100% renewable electricity; suppliers certify renewable origin.	France – *Garanties d'origine,* managed and auctioned by the French climate authority (DGEC); Germany – *Ökostrom* contracts.
Grid Flexibility & Dynamic Pricing	Electricity prices adjust to renewable availability, incentivizing consumption at peak production.	UK – Lower electricity prices during high wind/solar generation.
Complementary Renewable Sources	Combining solar, wind, and other renewables to balance intermittency.	General recommendation – solar at midday, wind in winter (Denmark, Uruguay, Germany, Spain, and China).
Green Hydrogen from Surplus	Utilizing excess renewable production to generate hydrogen enables storage and expanded uses.	Morocco – Solar-based green hydrogen plant; Brazil – high-potential sector.
Green Labelling & Certifications	Labels and disclosures indicate the renewable content of electricity.	EU – Energy origin disclosure on electricity bills.
Public-Private Partnerships	Governments co-finance innovation in storage and grid stability to de-risk private capital.	Australian government + Tesla built Hornsdale Power Reserve (150 MW).
Priority Dispatch of Renewables	Ensuring renewables have first access to the grid before fossil fuels.	Germany – *Erneuerbare-Energien-Gesetz* (EEG).

Source: Authors' compilation based on international experience.

[7] Priority dispatch of renewables is a regulatory principle in electricity market design that obliges system operators to schedule renewable generation with preferential access to the grid ahead of conventional sources, subject only to technical and system security constraints.

IV. Conclusion

Over the past decade, Latin America and the Caribbean (LAC) has increasingly turned to green, social, sustainable, and sustainability-linked (GSSS) bonds as a source of external financing. The market has expanded rapidly, involving sovereign, corporate, and supranational issuers, and consolidating its presence in strategic sectors such as energy, finance, and forestry. This growth mirrors global trends in sustainable finance and highlights the region's integration into broader transformations in capital markets.

The evidence in this report confirms that GSSS bonds are contributing to measurable outcomes. At the descriptive level, more than US$ 160 billion were issued in international markets between 2014 and 2024, with sovereigns dominating and productive sectors—particularly energy—playing a central role. At the econometric level, results suggest that among the region's top five issuers (Brazil, Chile, Colombia, Mexico, and Peru), greater energy-sector international GSSS issuance was significantly associated with higher installed renewable capacity per capita in the ten-year period analysed. This indicates that GSSS bonds are supporting the expansion of infrastructure linked to the energy transition.

At the same time, no significant effect was found on the share of renewables in total primary energy consumption. While GSSS financing helps add renewable projects to the system, it has not yet lessened reliance on fossil fuels. The energy mix remains persistent, revealing a dual outcome: resources have been mobilized and infrastructure expanded, but the transformative effect on energy use remains limited.

From a policy perspective, this gap underscores several priorities. Energy market design is critical: without mechanisms such as priority dispatch of renewables, adequate storage, and grid integration, new renewable capacity may coexist with fossil generation rather than increase its share in the overall mix. Linking GSSS-financed projects to domestic value chains can increase their impact by fostering industry, services, and technological innovation. Transparency and accountability are also essential, as the credibility of these instruments depends on reporting not only financial allocations but also concrete environmental outcomes.

Development banks have a strategic role to play. Their capacity to provide guarantees, blended finance, and local currency instruments positions them as key actors to reduce risks, crowd in private capital, and expand the reach of GSSS bond markets. By targeting underfinanced but high-impact sectors, these institutions can amplify the contribution of sustainable bonds to development goals.

Green Productive Development Policies (GPDPs) can complement this agenda by embedding environmental goals into productive strategies, strengthening coordination between public and private actors, and fostering innovation (Martínez et al., 2025). Applied to the energy sector, they can help channel financing from instruments such as GSSS bonds into renewable value chains, support technological upgrading, and generate quality jobs, ensuring that investments deliver environmental, social, and economic benefits.

The region has laid important foundations for sustainable finance. The next step is to align these instruments with systemic reforms that ensure renewable investments increase their share in the region's energy consumption and generate wider development benefits. International experience offers useful models that LAC countries can adapt, including priority dispatch of renewables, dynamic pricing schemes, investments in storage and grid flexibility, the development of green hydrogen, and stronger public-private partnerships. Together, these measures can enhance the contribution of GSSS bonds to the energy transition and sustainable development.

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Annex

A series of diagnostic checks was conducted to assess the robustness of both specifications. For Model 1, the F-test for individual fixed effects strongly rejected the null hypothesis that pooled OLS is sufficient (p = 2.2e-16), confirming that fixed effects are required to account for unobserved country-specific heterogeneity, similarly to the Model 2 result (p = 0.0547). Regarding cross-sectional dependence, the Pesaran CD test showed no evidence of correlated residuals in either model: Model 1 (p = 0.6479) and Model 2 (p = 0.0618).

The Breusch–Pagan test for heteroskedasticity indicated homoscedastic residuals in both cases, with high p-values (0.8364 for Model 1 and 0.9899 for Model 2), suggesting that the error variance is stable across observations. Finally, the Variance Inflation Factor (VIF) analysis revealed no multicollinearity issues, with values close to 1 for all explanatory variables in both models (Model 1: 1.067, 1.133, 1.065; Model 2: 1.059, 1.129, 1.069), far below the conventional threshold of 10.

Taken together, these diagnostic results confirm that both models are statistically well-behaved.

Table A1
Diagnostic test results

Test	Null hypothesis	Model 1	Model 2
F-test for fixed effects	Pooled OLS is sufficient	2.2e-16	0.0547
Pesaran CD (cross-dependence)	No cross-sectional dependence	0.6479	0.0618
Breusch–Pagan (heterosk.)	Homoskedasticity	0.8364	0.9899
VIF (multicollinearity)	VIF < 10 → no multicollinearity	1.067 / 1.133 / 1.065	1.059 / 1.129 / 1.069

Source: authors' estimations.
Notes: Reported values correspond to p-values for the F-test, Pesaran CD test, and Breusch–Pagan test. VIF values are shown for each explanatory variable (IssuanceEnergy, CO_2, and FDI). The conventional thresholds are p < 0.10 for statistical significance and VIF > 10 for multicollinearity concerns.

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