



GUIDELINES FOR THE PRE-ISSUANCE OF GREEN BONDS TO PROMOTE SOLID WASTE MANAGEMENT IN BRAZIL

Luciana Vilardo de Freitas Figueras¹

Antonio Pasqualetto²

ABSTRACT: The objective was to present a set of guidelines for the pre-issuance of Green Bonds aimed at financing projects related to municipal solid waste (MSW) management and recycling in Brazil, focusing on strengthening the circular economy and promoting environmental sustainability. The study is based on a literature review regarding green financial instruments—such as Green Bonds—and public policies concerning waste management and recycling. The proposal includes developing a methodology to identify, select, and showcase eligible MSW management and recycling projects to investors. This methodology is grounded in technical and regulatory criteria that assess the environmental and social impact of projects, ensuring alignment with global best practices. Furthermore, strategies to attract domestic and international investors are detailed, highlighting the importance of transparency and guarantees regarding the use of raised funds. The results suggest that issuing Green Bonds has the potential to finance waste management and recycling projects, contributing to the mitigation of environmental impacts associated with improper waste handling and fostering economic benefits, such as job creation in the MSW management and recycling sector. However, the study highlights that achieving this requires aligning the indicative allocation of funds from the Sustainable Sovereign Bond issuance with the sector's structural needs and the regulatory mandates of the National Solid Waste Policy.

Keywords: Sustainability; Recycling; Environment; Payment for Environmental Services.

DIRETRIZES PARA PRÉ-EMIÇÃO DE GREEN BONDS DE FOMENTO À GESTÃO DE RESÍDUOS SÓLIDOS NO BRASIL

RESUMO: Objetivou-se apresentar um conjunto de diretrizes para a pré-emissão de *Green Bonds* direcionados a financiar projetos relacionado à gestão de resíduos sólidos urbanos (RSU) e reciclagem no Brasil, com foco no fortalecimento da economia circular e na promoção da sustentabilidade ambiental. O estudo baseia-se em revisão da literatura sobre instrumentos financeiros verdes, como Green Bonds, e políticas públicas voltadas à gestão de resíduos e reciclagem. A proposta inclui o desenvolvimento de metodologia para identificar, selecionar e evidenciar para investidores projetos de gestão de resíduos sólidos urbanos (RSU) e reciclagem considerados elegíveis. Essa metodologia é fundamentada em critérios técnicos e normativos que avaliam o impacto ambiental e social dos projetos, assegurando que estejam alinhados as melhores práticas globais. Além disso, são detalhadas estratégias para atrair investidores nacionais e internacionais, destacando a importância de oferecer transparência e garantias em relação ao uso dos recursos captados. Os resultados sugerem que a emissão de *Green Bonds* apresenta potencial para financiar projetos de gestão de resíduos e reciclagem, contribuindo para a mitigação dos impactos ambientais associados ao manejo inadequado de resíduos e promovendo benefícios econômicos, como a geração de empregos no setor da gestão de resíduos sólidos urbanos (RSU) e reciclagem, porém evidencia que para tanto precisa alinhar a alocação indicativa de recursos oriundos da emissão do Título Soberano Sustentável com as carências estruturantes do setor, bem como aos comandos regulatórios da Política Nacional de Resíduos Sólidos.

Palavras-chave: Sustentabilidade; Reciclagem. Meio Ambiente; Pagamento por Serviços Ambientais.

1 Introduction

¹ Master's degree in Development and Territorial Planning. Pontifical Catholic University of Goiás – PUC Goiás. Goiânia, GO, Brazil. ORCID: <https://orcid.org/0009-0009-9527-7814>. Lattes: <http://lattes.cnpq.br/2740607101436506>. E-mail: figuerasadv@gmail.com.

² Postdoctoral studies in Environmental Sciences – UFG. Professor in the Graduate Program in Regional Development and the Right to the City at the Pontifical Catholic University of Goiás – PUC Goiás, and professor at the Federal Institute of Education, Science and Technology – IFG. ORCID: <http://orcid.org/0000-0002-8639-6725>. Lattes: <http://lattes.cnpq.br/4691515540448143>. E-mail: profpasqualetto@gmail.com.



The growing generation of municipal solid waste is one of the main environmental challenges faced by contemporary society. Globally, inadequate waste management contributes to problems such as soil pollution, contamination of water bodies, and greenhouse gas emissions, requiring innovative solutions that combine sustainability with economic viability.

In Brazil, this situation is aggravated by structural barriers, such as insufficient collection and recycling infrastructure, limited implementation of effective public policies, and low public awareness of the importance of proper disposal and recycling.

One of the greatest challenges in urban solid waste management is ensuring environmentally appropriate final disposal. In most Brazilian states, the target of eliminating open dumps by 2024 was far from being achieved (Lenzi; Massi; Santana, 2024).

In this context, Green Bonds (green bonds) have emerged as an innovative and strategic alternative for mobilizing financial resources for projects that promote recycling and sustainable waste management.

These financial instruments, aligned with global sustainable-finance practices, offer an opportunity to engage investors concerned with environmental responsibility while fostering initiatives aligned with the Sustainable Development Goals (SDGs), particularly those concerning responsible consumption and production.

Thus, this study aims to present specific guidelines for the pre-issuance of Green Bonds for the municipal solid waste (MSW) management and recycling sector in Brazil.

By proposing these guidelines, the study seeks to demonstrate how Green Bonds can play a fundamental role in improving urban waste management and recycling in cities and in promoting the circular economy in Brazil, transforming waste-management challenges into opportunities for positive environmental, social, and economic impacts.

2 Literature Review

2.1 Assessing the Effectiveness of the National Solid Waste Policy

The National Solid Waste Policy (Política Nacional de Resíduos Sólidos — PNRS), established by Law No. 12,305/2010, was hailed as a regulatory milestone in Brazil, setting clear guidelines for integrated management and environmentally sound handling of solid waste (Brasil, 2010). However, more than a decade after its enactment, the PNRS continues to face challenges that undermine its full implementation and effectiveness (Table 1).



Table 1 – Challenges of the National Solid Waste Policy in Brazil

Challenges	Description
Structural and Operational Challenges	• 36.6% of Brazilian cities still had open dumps (IBGE, 2023), in violation of the PNRS; • Deficient Selective Collection: Just over half of Brazilian cities had selective waste collection, representing 60.5% (IBGE, 2023).
Deficiencies in Municipal Planning	• Fewer than 50% of Brazilian cities had a Municipal Solid Waste Policy: 46.5% had one, 10.7% were preparing one, and 42.7% had none (IBGE, 2023); • Just over half of Brazilian cities had a Municipal Plan for Integrated Solid Waste Management: 55.8% had one, 14.1% were preparing one, and 30.0% had none (IBGE, 2023).
Lack of Financial Resources	• Limited Economic Incentives: Fewer than 50% of Brazilian cities charged for or had financing mechanisms for urban cleaning and solid waste management services; the figure was 42.3% (IBGE, 2023).
Institutional Fragmentation	• Lack of Environmental Education: Fewer than 50% of Brazilian cities had environmental education initiatives, at 44.6% (IBGE, 2023); • Undervaluation of Waste-Picker Cooperatives: Lack of technical and financial support.

Source: Municipal Basic Information Survey (MUNIC), which forms part of the Brazilian Institute of Geography and Statistics (IBGE) Basic Sanitation Supplement (2023).

The lack of basic infrastructure for solid waste management remains one of the main obstacles to the effectiveness of the PNRS. According to data from the Municipal Basic Information Survey (MUNIC), 36.6% of Brazilian cities still had open dumps (IBGE, 2023), to which they illegally sent their urban waste.

Although the PNRS requires selective waste collection in cities, only slightly more than half of Brazilian cities had such a system. Its implementation depends on partnerships among governments, companies, and consumers, but a lack of coordination and oversight prevents it from operating properly.

Articles 18 and 55 of the PNRS established that preparing a Municipal Plan for Integrated Solid Waste Management is a condition for the Federal District and municipalities to access federal funds for projects and services related to urban cleaning and solid waste management, or to benefit from incentives offered by federal credit or development agencies for this purpose (Brasil, 2010).

Many municipal difficulties in accessing federal or state funds stem from the lack of municipal policies and plans for integrated solid waste management. IBGE data (2023) show that fewer than 46.5% of Brazilian cities had a Municipal Solid Waste Policy, while 55.8% had a Municipal Plan for Integrated Solid Waste Management.

The purpose of thematic public policies is to plan executive actions in Brazilian cities; the absence of such planning prevents the implementation, operation, and expansion of urban waste-management and recycling infrastructure.



In addition to the omission of sector-specific municipal policies, implementation of the PNRS is hindered by weak coordination among levels of government, undermining the effectiveness of actions in Brazilian cities. States and municipalities often struggle to harmonize their plans with federal guidelines, resulting in overlapping responsibilities or gaps in accountability.

Another challenge is environmental education. Although it is essential for raising awareness among the public and technical personnel in Brazil's public sector, campaigns and training on proper urban waste management and recycling are scarce, poorly structured, or nonexistent, since fewer than 50% of Brazilian cities had environmental education initiatives (IBGE, 2023). Selective collection, for example, depends on public participation, but a lack of knowledge about how to separate and dispose of waste correctly compromises its effectiveness.

Waste-picker cooperatives, recognized as essential partners under the PNRS, face difficulties obtaining technical and financial support. Many waste pickers still work in precarious conditions, without access to basic equipment or training programs.

2.2 Green Bonds as Tools for Mobilizing Financial Resources

Green Bonds are defined as debt instruments that earmark the proceeds raised for sustainable projects, including renewable energy, energy efficiency, clean transportation, sustainable water management, climate-change adaptation, reforestation, and waste management (CBI, 2023). These projects must be properly specified and monitored to ensure that their environmental benefits can be measured and reported.

Green Bonds are one possible way to improve urban waste management and increase recycling rates in Brazilian cities. Growing demand for sustainable practices can mobilize financial resources and help overcome these barriers, integrating different policies and generating environmental and social impacts (Table 2).



Table 2 – Main Characteristics and Classification of Green Bonds

Aspect	Description
CHARACTERISTICS	• Specific use of proceeds: The funds raised must be used exclusively for projects that generate clear and measurable environmental benefits. • Transparent reporting: Issuers must regularly disclose how the funds are being used and the environmental impacts achieved. • External certification and verification: Green Bonds are often certified by independent organizations, such as the Climate Bonds Standard, which validates compliance with rigorous environmental criteria.
CLASSIFICATION	• Governmental: Issued by national or local governments to finance environmental public policies. • Corporate: Issued by companies to finance sustainable projects within their businesses. • Multilateral: Issued by development banks, such as the World Bank, to support sustainable projects in developing countries.

Source: Prepared by the author based on CBI data (2019).

Green Bonds offer several economic and environmental benefits, including the promotion of sustainable investment, which is vital for directing capital flows toward initiatives that contribute to the Sustainable Development Goals (SDGs). Projects financed by Green Bonds may include clean energy, resilient infrastructure, and sustainable cities.

Closely aligned with global climate needs, Green Bonds support the transition to a low-carbon economy by financing projects that reduce greenhouse gas emissions and promote energy efficiency (Flammer, 2020). They also encourage the development of sustainable markets by motivating companies and governments to adopt more responsible practices, helping consolidate innovative and sustainable markets (CBI, 2023).

Green Bonds are governed by international standards and guidelines, such as the Green Bond Principles (GBP), developed by the International Capital Market Association (ICMA), which provide a set of voluntary guidelines for their issuance. Their core components include a clear definition of the use of proceeds; a process for project evaluation and selection; transparent management of the funds raised; and regular reporting on the use of proceeds and the impacts achieved.

They also follow the parameters of the Climate Bonds Standard (CBS), managed by the Climate Bonds Initiative (CBI). This certification framework assesses project eligibility on the basis of specific criteria, such as emissions reductions and climate adaptation.

A master's dissertation from the Graduate Program in Agribusiness at the Federal University of Rio Grande do Sul mapped companies in Brazil's pulp and paper sector. Suzano stored the largest amount of carbon dioxide equivalent (tCO₂e), followed by Fibria, Klabin, and Celulose Irani. The four companies analyzed published reports in accordance with the Green Bond Principles (Oliveira; Poyer, 2021).



China has emerged as one of the largest issuers of Green Bonds, leveraging its domestic market to finance clean-energy projects and mitigate urban pollution. In 2021, the country issued more than US\$60 billion in green bonds (CBI, 2021).

2.3 Challenges and Opportunities in Brazil

In Brazil, Green Bonds represent a strategic opportunity to finance projects addressing critical environmental challenges, such as deforestation, waste management, and the energy transition. Brazil issued a total of US\$2 billion in green sovereign bonds in 2023 and 2024 (CFSS, 2024).

However, obstacles still need to be overcome to expand this market in the country, including the misalignment between the eligibility criteria set out in the indicative allocation of proceeds from Sustainable Sovereign Bonds, market realities, and national public policies. Clear guidelines aligned with the National Solid Waste Policy could attract green investment to Brazil, generating positive impacts on both national urban infrastructure and the economy.

The international landscape shows that Green Bonds offer an issuance model that can be implemented on a large scale and allow investment diversification, while delivering shared socioeconomic and environmental benefits to society.

3 Methodology

The methodology combines a qualitative approach to develop robust guidelines for the pre-issuance of Green Bonds aimed at supporting urban solid waste management and increasing the scale of solid waste management and recycling in Brazilian cities.

The research corpus was organized into three groups of sources: scientific publications on green bonds and solid waste management; regulatory documents and institutional guidelines related to sustainable financing; and international experiences in structuring and applying these instruments.



3.1 Bibliographic Research

The bibliographic search was conducted in the CAPES Periodicals Portal in 2024 and assessed articles published up to that year. Portuguese- and English-language search terms included “Green Bonds,” “títulos verdes,” “gestão de resíduos sólidos,” “solid waste management,” “recycling,” and “circular economy,” combined using the Boolean operators AND/OR.

The inclusion criteria were scientific articles related to financing through green bonds, solid waste management, recycling, the circular economy, and sustainable-finance policies, with contributions relevant to the research objectives. Duplicate publications, studies not directly related to the topic, and works that did not provide information relevant to the proposed analysis were excluded.

Selection was based on the relevance of each work’s title, abstract, and content to the subject of the study. Ultimately, nine articles were selected for analysis. These publications supported the identification of concepts, criteria, and practices used to develop the guidelines for the pre-issuance of Green Bonds for solid waste management in Brazil.

This material was supplemented by analyses of a recent article by the authors themselves and a dissertation related to the topic.

3.2 Document Analysis

The document analysis was conducted in 2024 and covered documents published before that year, located in government repositories and organizations representing the field, using the same search terms. Studies related to sustainable financing, green-bond issuance, solid waste policies, and the identification of environmentally eligible projects were included. Documents not directly related to the research objectives, duplicate records, and materials containing insufficient information for analysis were excluded.

The document analysis aims to understand the concept and purpose of Green Bonds and how they can support urban solid waste management and recycling in Brazil. This stage comprises three distinct steps (Table 3).



Table 3 – Stages of the Document Analysis of the Concept and Purpose of Green Bonds and Their Potential to Support Urban Solid Waste Management and Recycling in Brazil

Stages	Analysis
Guides and market analyses	Review of publications by financial institutions, such as the Climate Bonds Initiative and the International Capital Market Association (ICMA), and reports by development banks (e.g., the World Bank and BNDES), to identify global trends in Green Bond issuance and their applications in the environmental sector.
Review of public policies	Analysis of Brazilian legislation, such as the National Solid Waste Policy (PNRS), and programs promoting recycling and green finance, in order to identify gaps and opportunities in the Green Bond market.
Academic studies	Review of scientific articles, books, and dissertations exploring the economic, social, and environmental impacts of Green Bonds and their feasibility as a means of financing recycling projects.

Source: Authors (2025).

The twelve institutional and regulatory documents are associated with the following organizations (Table 4) :

Table 4 – Institutions and Documents on Green Bonds and Their Potential to Support Urban Solid Waste Management and Recycling in Brazil

Institution or organization	Document or material
Bangladesh Bank	Green Bond financing policy for banks and financial institutions
Brazil — federal legislation	Law No. 12,305/2010, National Solid Waste Policy
Caixa Econômica Federal	News item on green-bond issuance
Climate Bonds Initiative (CBI)	Waste criteria, institutional information, and report on the Chinese market
Sovereign Sustainable Finance Committee / Ministry of Finance / National Treasury	Brazilian Framework for Sustainable Sovereign Bonds
China Green Bond Standards Committee (CGBSC)	Chinese Green Bond Principles
Council of the European Union	Regulation (EU) 2023/2631
CEBDS and FEBRABAN	Guide to Green Bond Issuance in Brazil
CSRC, NDRC, and PBOC — China	Catalogue of projects eligible for green bonds
European Commission	NGEU Green Bonds Allocation and Impact Report
Brazilian Institute of Geography and Statistics (IBGE)	Municipal Basic Information Survey — Basic Sanitation Supplement

Source: Authors (2024).

The topics were classified into five categories: (i) project eligibility criteria; (ii) governance and transparency in the use of proceeds; (iii) environmental and climate impacts; (iv) social and economic benefits; and (v) monitoring and evaluation of results. These categories guided comparisons among sources and the identification of requirements relevant to structuring solid waste management projects that can be financed by Green Bonds.

3.3 Case Studies

The case-study research, intended to develop evidence to support Green Bond issuance, covered Brazil, Bangladesh, China, and the European Union. These cases were selected because they allow comparison of different regulatory approaches, eligibility criteria, and environmental financing mechanisms.

The approach was designed to collect primary data to enable a practical and detailed understanding of the barriers and opportunities for using Green Bonds to finance projects supporting urban solid waste management and recycling in Brazilian cities. It prioritizes the study of real experiences, both domestic and international, to underpin the proposed guidelines. Table 5 presents the stages.

Table 5 – Barriers and Opportunities for Using Green Bonds to Finance Projects Supporting Urban Solid Waste Management and Recycling in Brazilian Cities

Stages	Analysis
Selection of Case Studies	• Identification of solid waste management and recycling criteria and projects that have already been financed through green bonds in Brazil and other countries;
Data Collection on the Cases	• Review of Green Bond guides and market analyses to obtain information about selection criteria, impact metrics, and challenges encountered;
Case Analysis	• Identification of eligibility and impact criteria used in different contexts; • Extraction of lessons learned and good practices that may be adapted to the Brazilian context.
Development of Recommendations Based on Real Cases	• Synthesis of the information obtained, highlighting successful strategies and potential adaptations for projects of different scales in Brazil; • Development of practical guidelines for Green Bond pre-issuance, based on evidence from concrete cases.

Source: Authors (2025).

By prioritizing the analysis of real cases, this approach seeks to ensure that the guidelines are pragmatic, applicable, and aligned with market realities and public policies. Drawing on concrete experiences provides a solid basis for validating the recommendations and maximizing the likelihood of successful implementation of Green Bonds to support urban solid waste management and recycling in Brazilian cities.

3.4 Eligibility Criteria

To establish a basis for comparison with criteria applied in other countries, the following general eligibility criteria are proposed for projects related to municipal solid waste (MSW) management and recycling:



- Generate clear environmental benefits, such as pollution reduction, mitigation of greenhouse gas (GHG) emissions, promotion of the circular economy, and recovery of recyclable materials;
- Comply with the Green Bond Principles (GBP), ensuring that the use of proceeds is transparent and sustainable;
- Align with national and international solid waste management policies, such as the National Solid Waste Policy (PNRS);
- Undergo independent verification and certification in accordance with recognized standards, such as those of the Climate Bonds Initiative (CBI).

According to the Handbook for Financial Institutions in Latin America and the Caribbean, Brazil has the region's largest capital market and the highest number of financial institutions (FIs) that have issued green bonds. The market's main players include Itaú, Bradesco, and BTG (FEBRABAN; CEBDS, 2016).

It is worth noting that most of these issuances do not finance projects related to municipal solid waste (MSW) management and recycling. The handbook itself provides no examples of eligibility criteria applied by FIs to green bonds for the topic examined in this study, highlighting an existing gap in Latin America and the Caribbean.

Finally, by combining document analysis, case studies, and eligibility criteria, this methodology seeks to ensure that the proposed guidelines are both scientifically grounded and practically applicable.

4 Results and Discussion

4.1 Guides, Market Analyses, Principles, and Public Policies

The review of guides, market analyses, principles, and public policies on Green Bonds sought to identify the criteria used for selection, impact metrics, and challenges encountered in other countries. These findings were compared with the Brazilian context to propose improvements that would increase allocations to Brazil's Sustainable Sovereign Bonds for waste management and recycling. Table 6 systematizes this information.



Table 6 – Green Bond Guides and Market Analyses Relevant to Waste Management and Recycling

Country	Guides, market analyses, principles, and public policies	Author	Relevance to the study
BRAZIL	• Sustainable Sovereign Bonds (Pre-Issuance Report 2024)	• National Treasury Secretariat, Ministry of Finance.	• Lists as an eligible expenditure the circular-economy criterion for industrial plants that process waste to produce new products or restore materials to a condition that enables further processing.
BANGLADESH	• Policy on Green Bond Financing for Banks and FIs	• Bangladesh Bank	• The Bangladesh Bank provided policies on Green Bond financing for banks and financial institutions, covering waste collection, transport, and sorting; the establishment of material recovery and recycling plants; manufacturing using recycled materials; investment in, modernization of, or operation of manufacturing plants using recycled materials as primary feedstock; landfills with gas capture; and the construction, operation, and/or installation of facilities dedicated to hazardous waste, medical waste, electronic waste, radioactive waste, composting, and anaerobic digestion of sewage sludge.
EUROPEAN UNION	• Regulation (EU) 2023/2631 — European Green Bond Standard (EUGBS) • NGEU Green Bonds Allocation and Impact report (2024)	• Council of the European Union • Publications Office of the European Union, 2024	• Regulation establishing clear criteria for issuing green bonds, aligned with the EU taxonomy, to ensure that proceeds are directed to sustainable activities and to prevent “greenwashing.” The EUGBS is voluntary and seeks to promote transparency and credibility in the European green-bond market. • Household waste management measures, including prevention, minimization, sorting, reuse, and recycling, are reflected in the climate impacts of investments eligible for expenditure under European Union green bonds.
CHINA	• China Green Bond Principles (CGBP) • Green Bond Endorsed Projects Catalogue (2021)	• China Green Bond Standard Committee • People's Bank of China (PBOC), the National Development and Reform Commission (NDRC) and the China Securities Regulatory Commission (CSRC)	• These principles seek to harmonize domestic standards with international practices. Aligned with the International Capital Market Association’s (ICMA) Green Bond Principles, they establish that 100% of the proceeds raised through green bonds must be allocated to environmental projects. Their adoption seeks to unify these criteria and promote transparency in China’s green-bond market. • Among the projects listed in the Endorsed Projects Catalogue under China’s Green Bond regulations is a broad range of options for constructing and operating facilities for recycling, sorting, and processing residual resources from industrial and urban processes.

Source: Authors (2025).



The analysis of the indicative allocation of proceeds from Brazil's Sustainable Sovereign Bonds for waste management and recycling showed that it is limited compared with approaches in other countries, including global leaders in green-bond issuance such as China and the European Union, as well as Bangladesh, whose eligibility criteria are notably detailed.

In addition to its China Green Bond Principles, which seek to harmonize domestic standards with international practices (CGBSC, 2022), China created a catalogue of rules for green-bond issuance that endorses waste management and recycling projects, clearly identifying the industries eligible to raise capital through this instrument (CSRC; NDRC; PBOC, 2021).

Like China, the European Union has taken substantial steps in this area. It has adopted the European Green Bond Standard (EUGBS) under Regulation 2023/2631 (CUE, 2023) and has also analyzed investments already allocated and their climate impacts. That report presented projects in waste management and recycling, along with supporting evidence and impacts, demonstrating the benefits of green investment in the sectors examined (European Commission, 2024).

In Bangladesh, the country's central bank issued policies on green-bond financing for financial institutions, identifying a broad range of eligible actions and projects involving waste management and recycling (Bangladesh Bank, 2022).

Brazil, by contrast, appears out of step with market realities and national public policies, as only one solid waste management and recycling project financed through green securities was identified. Adami S.A. Madeiras used funds from green debentures issued through Caixa Econômica Federal to expand its operations by installing a new plant capable of producing 125,000 metric tons of paper annually from 100% recycled material. The project created 150 direct and 350 indirect jobs and promoted responsible resource management and waste recovery (CAIXA, 2024).

The indicative allocation of proceeds from the Sustainable Sovereign Bond, prepared by the Brazilian National Treasury's Sovereign Sustainable Finance Committee (CFSS), addresses waste management and recycling only superficially. It does not detail allocation criteria in a way that reflects the sector's needs and structural deficiencies or the regulatory requirements of the National Solid Waste Policy (CFSS, 2024).

Investors are attracted by clear rules and transparency. China has made its criteria explicit through a catalogue, the European Union has measured the climate impacts and results of its investments, and Bangladesh has provided a comprehensive and detailed set of criteria for waste management and recycling activities that can be financed through Green Bonds.

As discussed in this section, Brazil still needs to close open dumps in many cities; implement selective collection and reverse logistics; promote the socioeconomic inclusion of



recyclable-material waste pickers; expand environmental education; and expand and modernize solid waste management infrastructure, including mechanized sorting plants, biodigesters, and composting facilities. The climate impacts of these action areas should be demonstrated, and the areas should be identified as eligible under the allocation of proceeds from national sovereign bonds.

A more detailed indicative allocation of proceeds from the Sustainable Sovereign Bond, including specific eligibility criteria for projects related to municipal solid waste (MSW) management and recycling, would make this investment instrument more visible to investors seeking, among other sustainable measures, to direct capital flows toward initiatives that contribute to the Sustainable Development Goals (SDGs).

The path toward more climate-resilient cities lies in climate financing for urban solid waste management and expanded recycling. Green Bonds are growing in emerging countries, supported by increasing investor awareness of climate issues (Banga, 2018).

4.2 Analysis of the Selected Articles

The analysis of the articles (Table 7) identified Brazil's capacity, as an economy in transition, to establish a green-bond market and make it attractive to domestic and international investors (Lin; Hong, 2022).

The analysis also revealed a trend of continued growth in and increasing investor interest in the green-bond market, with Europe accounting for the largest share of the Green Bond market (Niyazbekova et al., 2021).



Table 7 – Categorization of Selected Articles on Green Bonds for Solid Waste Management

Title	Author(s)	Study objective	Methodology identified	Journal or publication outlet
Assessment of the Effectiveness of Public Policies Addressing Solid Waste Management: A Brazilian Overview	Andréa Ryba Lenzi, Edson Henrique Gaspar Massi & Raniel Marcelo de Santana.	Assess the effectiveness of the National Solid Waste Policy (PNRS) with regard to waste prevention/reduction and final disposal, comparing data from the National Sanitation Information System (SNIS) with the targets established in the National Solid Waste Plan for sustainable development.	Document analysis and comparison of secondary SNIS data with the targets of the National Solid Waste Plan.	Cuadernos de Educación y Desarrollo
Developing a Green Bonds Market: Lessons from China.	Lin Lin & Yanrong Hong.	Analyze how an economy in transition can develop a growing green-bond market in a short period, using China as a case study.	Case study of China, including a legal-institutional and regulatory analysis of green-bond market development.	European Business Organization Law Review.
Green Bond Issuance and Corporate's Environmental Performance: Evidence from China	Xia Chen & Md. Atikur Rahaman.	Investigate the relationship between green-bond issuance and the environmental performance of listed non-financial companies in China by comparing green and conventional bond issuances and examining post-issuance effects.	Quantitative empirical study of listed non-financial companies in China; comparison of green-bond and conventional-bond issuers using PSM-DID models.	Frontiers in Business, Economics and Management.
Green bonds – a tool for financing "green" projects in countries	Shakizada Niyazbekova, Luiza Moldashbayeva, Seyit Kerimkhulle, Nurdin Dzholdoshev, Tamara Dzholdosheva, and Madina Serikova.	Discuss whether green bonds are relevant and attractive to investors today.	Analytical-descriptive approach involving logical generalization, conceptual analysis, and secondary data on the green-bond market.	EDP Sciences.
Green Bonds: Effectiveness and Implications for Public Policy.	Caroline Flammer	Examine green bonds as a relatively new instrument in sustainable finance.	Quantitative empirical study using company data; analysis of market reactions and financial and environmental performance, including an event study and difference-in-differences.	Environmental and Energy Policy and the Economy.



Title	Author(s)	Study objective	Methodology identified	Journal or publication outlet
National Solid Waste Policy: Perspectives a Decade after Its Enactment.	Cristine Diniz Santiago, Ana Cristina Bagatini Marotti, Erica Pugliesi & Juliano Costa Gonçalves.	Analyze the implementation of the National Solid Waste Policy.	Document analysis of the implementation of the National Solid Waste Policy.	Desenvolvimento e Meio Ambiente.
Reimagining urban waste management: Addressing social, climate, and resource challenges in modern cities.	Jutta Gutberlet & Torleif Bramryd.	Offer a new, integrated perspective on waste management in relation to poverty reduction, climate change, and resource conservation.	Brief analytical-critical communication based on a conceptual discussion of the social, climate, and resource impacts of urban waste management.	Cities: The International Journal of Urban Policy and Planning.
The green advantage: Exploring the convenience of issuing green bonds	Gianfranco Gianfrate & Mattia Peri.	Analyze whether green bonds can mobilize resources to finance the transition to a low-carbon economy and help achieve the Paris Agreement target.	Quantitative empirical study using propensity score matching, applied to European green bonds and comparable conventional bonds.	Journal of Cleaner Production.
The green bond market: a potential source of climate finance for developing countries.	Josué Banga	Examine the potential of green bonds to mobilize adaptation and mitigation financing for developing countries.	Theoretical-conceptual analysis of the green-bond market, identifying drivers of expansion and barriers to climate finance in developing countries.	Journal of Sustainable Finance & Investment.

Source: Authors (2025).

The articles showed that green bonds can help implement the National Solid Waste Policy by financing Brazil's waste-management and recycling infrastructure (Santiago et al., 2023). Green Bond investment will be effective only when financing criteria for the waste-management and recycling agenda are aligned with cities' demands and needs.

The studies also highlighted the potential of waste management to reduce poverty, influence climate change, and conserve natural resources (Gutberlet; Bramryd, 2025).

If financed through green bonds, the closure of open dumps, implementation of selective collection and reverse logistics, improvements to urban waste-management infrastructure, and increases in recycling rates would have measurable climate impacts and could help Brazil transition to a low-carbon economy, in line with the Paris Agreement target (Gianfrate; Peri, 2019).

Another point of concern was the need to reduce the cost to companies of financing green commitments (Chen; Rahaman, 2022). Better access to Green Bonds could increase the allocation



of resources to projects in this area. It is also important to emphasize the capacity of green bonds to mobilize resources for adaptation and mitigation in developing countries such as Brazil (Banga, 2018).

In this regard, the socioeconomic inclusion of waste pickers helps move them out of socially vulnerable conditions and promotes climate adaptation. In addition, the emissions avoided through recycling contribute to climate mitigation because tons of waste are diverted from landfills and open dumps and returned to the production chain as raw materials (Figueras; Pasqualetto, 2024).

Finally, an important international trend is the inclusion of green climate-adaptation projects among eligible investments in the portfolios of multilateral development banks and municipalities that include climate-adaptation components in their green bonds (FEBRABAN; CEBDS, 2016).

4.3 Specific Eligibility Criteria for Projects Related to Municipal Solid Waste (MSW) Management and Recycling

Based on the good practices identified and lessons that can be adapted to the Brazilian context, a synthesis of guidelines was developed for the pre-issuance of Green Bonds intended to finance projects related to municipal solid waste (MSW) management and recycling, grounded in evidence from concrete cases (Table 8).

Table 8 – Summary of Guidelines for the Pre-Issuance of Green Bonds to Finance Municipal Solid Waste Management and Recycling Projects

Areas	Guidelines
Project infrastructure and operations should include:	• Expansion and modernization of solid waste management infrastructure, such as mechanized sorting plants, biodigesters, and composting facilities; • Investment in waste-tracking and monitoring technologies, such as smart systems for collection and reverse logistics; • Structured selective-collection projects, including partnerships with waste-picker cooperatives; • Support for circular-economy models, such as the production of refuse-derived fuel (RDF), packaging recycling, and energy recovery from waste; and • Closure and environmental remediation of open dumps and illegal landfills, promoting environmentally appropriate alternatives.
Projects should demonstrate positive environmental impacts, such as:	• Reducing methane (CH₄) and carbon dioxide (CO₂) emissions by improving landfill management; • Recovering energy from organic waste through biodigestion or waste-to-energy processes; and • Using low-carbon technologies, such as electric waste-collection fleets.
Green Bonds should also generate social and economic impacts and encourage:	• The inclusion and strengthening of waste-picker cooperatives, ensuring fair remuneration and better working conditions; • Promotion of the circular economy through the creation of markets for recycled materials; and • Environmental education programs and public awareness of the importance of waste separation and recycling.

Source: Authors (2025).

The lessons learned make clear that the eligibility criteria established in a country's regulations, standards, and principles governing Green Bonds must be robust and comprehensive, so that investors can clearly identify the areas within the waste-management and recycling sector that are eligible for financing.

In this regard, Bangladesh provides a clear example: it has an extensive and detailed list of waste-management and recycling activities that may be financed through green bonds. China is also particularly important; in addition to its Green Bond Principles, it developed an Endorsed Projects Catalogue for investors, offering a wide range of investment options in waste management and recycling. Finally, the European Union has published an investment-impact report demonstrating to investors the importance and relevance of investment in this sector.

4.4 Critical Analysis

Issuing Green Bonds to finance projects related to municipal solid waste (MSW) management and recycling in Brazil has considerable potential to promote environmental sustainability and the circular economy. Measuring their climate impacts can support integrated



climate-adaptation and mitigation actions and contribute to Brazil's transition to a low-carbon economy, in line with the Paris Agreement target.

Adopting clear, transparent, comprehensive guidelines aligned with the needs of Brazilian cities and the National Solid Waste Policy is crucial to ensuring the credibility and success of these bonds, as well as attracting investors in the financial market.

In this regard, the indicative list of projects related to municipal solid waste (MSW) management and recycling should be accompanied by detailed provisions on the allocation of proceeds from the issuance of Brazil's Sustainable Sovereign Bond. These endorsed requirements would help make this type of investment more visible and direct capital flows toward the sector.

Eligible activities and criteria apply to projects and assets focused on: Collection: infrastructure, containers, and systems for waste collection; Sorting: facilities for separating recyclable materials; Reuse and Recycling: processing waste into secondary raw materials or repairing products; Composting and Anaerobic Digestion: treatment of green, garden, and food waste; Thermal Treatment with Energy Recovery: processing residual waste (outside the EU only); and Landfill Gas Recovery: installation of systems to capture gas from decommissioned landfills.

The National Treasury Secretariat of the Ministry of Finance is encouraged to consider the proposed synthesis of pre-issuance guidelines for Green Bonds, which could help complete the list of eligible expenditures in the allocation of proceeds from Brazil's Sustainable Sovereign Bond, specifically for projects related to municipal solid waste (MSW) management and recycling.

Given the recent regulation of Green Bonds in Brazil, it is essential to expand academic studies and research on their application to waste-management and recycling projects. The lack of technical and academic support in this area undermines the full use of this sustainable-financing mechanism, which could play a fundamental role in promoting the circular economy and mitigating environmental impacts.

Despite the limitations in publications and legislation on this subject, further research is recommended to help develop more effective guidelines, adapt international best practices to the Brazilian context, and expand access to sustainable investment. This would help ensure that Green Bonds become an effective tool for advancing sustainability in the country and delivering the long-awaited effectiveness of the National Solid Waste Policy.



5 Final Considerations

The objective was to analyze the integration of recycling into urban adaptation actions and greenhouse gas (GHG) mitigation. This integration was found to be an indispensable strategy for building more sustainable and climate-resilient cities. The analysis showed that recycling contributes to proper solid waste management and plays a fundamental role in reducing GHG emissions, especially when incorporated into integrated and effective urban management.

The findings indicate that recycling provides an environmental service with significant ecosystem impacts in Brazilian cities, promoting climate resilience through the socioeconomic inclusion of recyclable-material waste pickers, the conservation of natural resources, and the recovery of waste that would otherwise be sent to landfills and open dumps throughout Brazil.

However, implementing these practices on a large scale is closely linked to climate finance, which is one of the main drivers of sustainable policies and projects. The flow of resources toward initiatives that align climate adaptation with emissions mitigation is vital to ensuring that cities and nations, especially in more vulnerable regions, can move toward a low-carbon development model.

Although challenges remain, including a lack of alignment between local and global policies, the absence of robust climate governance in some regions, and unequal access to financial resources, the opportunities offered by climate finance are promising.

It is concluded that combining recycling with appropriate urban solid waste management, within urban adaptation and climate-mitigation actions supported by climate finance—especially Green Bonds—offers a robust, integrated solution for mitigating environmental impacts and promoting an effective transition toward greener, more sustainable cities.

For this transition to succeed, the list of eligible expenditures in the allocation of proceeds from Brazil's Sustainable Sovereign Bond must be described in greater detail, particularly with respect to projects related to municipal solid waste (MSW) management and recycling. Eligible expenditures should be aligned with the needs of Brazilian cities, national public policies, and international best practices.

The proposed initiatives, combined with coordinated efforts by governments, companies, communities, and international organizations, will give investors a clearer view of national sovereign bonds intended to support solid waste management and recycling in Brazil.

It is also essential to expand academic studies and research on this subject. The lack of scientific support impedes the development of technical foundations needed to attract resources



for financing sustainability in Brazil and to deliver the long-awaited effectiveness of the National Solid Waste Policy.

Referências

BANGA, Josué. The green bond market: a potential source of climate finance for developing countries. **Journal of Sustainable Finance & Investment**, v. 9, n. 1, p. 17-32, 13 jul. 2018. Disponível em: <https://doi.org/10.1080/20430795.2018.1498617>. Acesso em: 12 fev. 2025.

BANGLADESH BANK. **Policy on Green Bond Financing for Banks and FIs**. Bangladesh: Sustainable Finance Department, 2022. Disponível em: <https://www.bb.org.bd/mediaroom/circulars/gbcrd/sep202022sfd05e.pdf>. Acesso em: 12 fev. 2025.

BRASIL. Lei nº 12.305, de 2 de agosto de 2010. **Dispõe sobre a Política Nacional de Resíduos Sólidos**. Disponível em: <https://www.lexml.gov.br/urn/urn:lex:br:federal:lei:2010-08-02;12305>. Acesso em: 12 jul. 2024.

CAIXA. **Caixa coordena oferta pública e emite títulos verdes de R\$ 300 milhões**. Disponível em: <https://agenciagov.ebc.com.br/noticias/202404/caixa-coordena-oferta-publica-e-emite-titulos-verdes-de-r-300-milhoes>. Acesso em: 12 fev. 2025.

CBI – CLIMATE BONDS INITIATIVE. **About Climate Bonds Initiative**. 2023. Disponível em: <https://www.climatebonds.net/>. Acesso em: 7 jul. 2024a.

CBI – CLIMATE BONDS INITIATIVE. **Climate Bonds launches Green Criteria for Waste Management Investment**. 2019. Disponível em: <https://www.climatebonds.net/resources/press-releases/2019/12/climate-bonds-launches-green-criteria-waste-management-investment>. Acesso em: 18 jul. 2024

CBI -CLIMATE BONDS INITIATIVE. China central depository & clearing co. Ltd. Research centre. **China Green Bond Market Report 2021**. 2022.

CBI – CLIMATE BONDS INITIATIVE. **Waste Management**. Disponível em: <https://www.climatebonds.net/standard/waste>. 2026. Acesso em: 18 jul. 2026.

CFSS – COMITÊ DE FINANÇAS SUSTENTÁVEIS SOBERANAS. **Arcabouço Brasileiro para Títulos Soberanos Sustentáveis**. Brasil: Secretaria do Tesouro Nacional do Ministério da Fazenda, 2024. Disponível em: https://sisweb.tesouro.gov.br/apex/f?p=2501:9::::9:P9_ID_PUBLICACAO_ANEXO:21059. Acesso em: 12 fev. 2025.

CGBSC – CHINA GREEN BOND STANDARDS COMMITTEE. **China Green Bond Principles (CGBP)**. China: CGBSC, 2022. Disponível em: <https://www.nafmii.org.cn/ggtz/gg/202207/P020220801631427094313.pdf>. Acesso em: 9 fev. 2025.

CHEN, X.; RAHAMAN, M. A. Green Bond Issuance and Corporate's Environmental Performance: Evidence from China. **Frontiers in Business, Economics and Management**, v. 6, n. 3, p. 1-6, 2 dez. 2022. Disponível em: <https://doi.org/10.54097/fbem.v6i3.3108>. Acesso em: 13 jan. 2025.

CONSELHO DA UNIÃO EUROPEIA. **Regulamento (UE) 2023/2631: relativo às obrigações verdes europeias e à divulgação opcional de informação relativamente a obrigações comercializadas como sustentáveis do ponto de vista ambiental e a obrigações ligadas à sustentabilidade**. União Europeia: CUE, 2023. Disponível em: https://pessoas2030.gov.pt/wp-content/uploads/sites/19/2023/12/Regulamento-UE_2023.2631_22.11.2023.pdf. Acesso em: 9 fev. 2025.

CONSELHO EMPRESARIAL BRASILEIRO PARA O DESENVOLVIMENTO SUSTENTÁVEL; FEDERAÇÃO BRASILEIRA DE BANCOS. **Guia para emissão de títulos verdes no Brasil**. São Paulo: CEBDS; FEBRABAN, 2016. Disponível em: https://cmsarquivos.febraban.org.br/Arquivos/documentos/PDF/Guia_emissa%CC%83o_ti%CC%81tulos_verdes_PORT.pdf. Acesso em: 9 fev. 2025.

CSRC – CHINA SECURITIES REGULATORY COMMISSION; NDRC – DEVELOPMENT AND REFORM COMMISSION; PBOC – PEOPLE'S BANK OF CHINA. **Green Bond Endorsed Projects Catalogue**. China: CSRC; NDRC; PBOC, 2021. Disponível em: <http://www.pbc.gov.cn/goutongjiaoliu/113456/113469/4342400/2021091617180089879.pdf>. Acesso em: 12 fev. 2025.



EUROPEAN COMMISSION. **NGEU Green Bonds Allocation and Impact Report**. Luxembourg: Publications Office of the European Union, 2024. Disponível em: <https://data.europa.eu/doi/10.2761/5785036>. Acesso em: 9 fev. 2025.

FIGUERAS, L. V. de F.; PASQUALETTO, A. Recycling in Integrated Urban Adaptation Actions and Greenhouse Gas Mitigation: A Sustainable Approach for Climate Resilient Cities. **International Journal of Business Administration**, v. 15, n. 2, p. 66, 24 maio 2024. Disponível em: <https://doi.org/10.5430/ijba.v15n2p66>. Acesso em: 7 jul. 2024.

FLAMMER, C. Green Bonds: Effectiveness and Implications for Public Policy. **Environmental and Energy Policy and the Economy**, v. 1, p. 95-128, jan. 2020. Disponível em: <https://doi.org/10.1086/706794>. Acesso em: 13 jan. 2025.

GIANFRATE, G.; PERI, M. The green advantage: Exploring the convenience of issuing green bonds. **Journal of Cleaner Production**, v. 219, p. 127-135, maio 2019. Disponível em: <https://doi.org/10.1016/j.jclepro.2019.02.022>. Acesso em: 13 jan. 2025.

GUTBERLET, J.; BRAMRYD, T. Reimagining urban waste management: Addressing social, climate, and resource challenges in modern cities. **Cities**, v. 156, p. 105553, jan. 2025. Disponível em: <https://doi.org/10.1016/j.cities.2024.105553>. Acesso em: 13 jan. 2025.

IBGE. **Pesquisa de Informações Básicas Municipais: Suplemento de Saneamento Básico**. Brasil: IBGE, 2023. Disponível em: https://agenciadenoticias.ibge.gov.br/media/com_mediaibge/arquivos/7ef9ceedcb004663fecf5a38ff6b43a8.pdf. Acesso em: 12 fev. 2025.

LENZI, A. R.; MASSI, E. H. G.; SANTANA, R. M. Avaliação da efetividade das políticas públicas que abordam a gestão de resíduos sólidos: um panorama brasileiro. **Cuadernos de Educación y Desarrollo**, v. 16, n. 3, p. e3557, 20 mar. 2024. Disponível em: <https://doi.org/10.55905/cuadv16n3-090>. Acesso em: 13 jan. 2025.

LIN, L.; HONG, Y. Developing a Green Bonds Market: Lessons from China. **European Business Organization Law Review**, v. 23, n. 1, p. 143-185, 21 fev. 2022. Disponível em: <https://doi.org/10.1007/s40804-021-00231-1>. Acesso em: 13 jan. 2025.

NIYAZBEKOVA, S. et al. “Green” Bonds - A Tool for Financing “Green” Projects in Countries. **E3S Web of Conferences**, v. 244, p. 10060, 2021. Disponível em: <https://doi.org/10.1051/e3sconf/202124410060>. Acesso em: 13 jan. 2025.

OLIVEIRA, L.; POYER, F. R. **A Transparência na Adoção dos Green Bonds no Setor de Papel e Celulose no Brasil**. 2021. Dissertação — Universidade Federal do Rio Grande do Sul.

SANTIAGO, Cristine Diniz et al. Política Nacional de Resíduos Sólidos: perspectivas após um decênio de sua promulgação. **Desenvolvimento e Meio Ambiente**, v. 62, p. 152-177, jul./dez. 2023. Disponível em: <https://doi.org/10.5380/dma.v62i0.81833>. Acesso em: 8 jul. 2024.