# Brazilian Waste Sector Methane Analysis

November 2025

CLEAN AIR TASK FORCE

Instituto PNRS

THINKCITIES CONSULTIN

WASTEMAP

# About

## About Clean Air Task Force

Clean Air Task Force (CATF) is a nonprofit organization working to safeguard against the worst impacts of climate change by catalyzing the rapid global development and deployment of low-carbon energy and other climate-protecting technologies and practices. This is accomplished through research and analysis, public advocacy leadership, and partnership with the private sector. CATF is highly respected for its deep expertise on policy, technology and research that can radically shrink the impact the most polluting systems on the planet's atmosphere. Our team of experts and advocates (and global network of subject matter experts and civil society partners) put this research and knowledge into action by designing and enacting public policies that drive toward zero emissions. We also support policies and work directly with private industry to innovate in technology to make the path to zero emissions swift and affordable. CATF has offices in Boston, Washington D.C., and Brussels, with staff working virtually around the world. For more information, visit **www.catf.us**.

## About THINKCities Consulting

THINKCities Consulting provides advice and strategic guidance to governments, cities, towns and communities focused on sustainability, climate mitigation and resilience planning. Our technical expertise encompasses urban mobility, green space, water and air resources, waste management and energy. We work directly with municipal decision makers and municipal service departments as well as with the international donor community and other organizations and firms that support urban sustainability efforts globally, leading to more efficient municipal operations that maximize service while protecting the environment.

## About iPNRS

PNRS Institute – Brazilian Institute of Waste Management is a non-profit, technical institute whose mission is to preserve and protect the environment and promote sustainable development, having focus on the implementation of the National Solid Waste Policy in Brazil, aiming to achieve an integrated waste management system, based on the waste hierarchy principle, sustainable production and consumption patterns, mitigation of greenhouse gases emissions, and supporting the transition to a circular economy. For more information, visit **www.institutopnrs.com.br**.

## About the Waste Methane Assessment Platform

The Waste Methane Assessment Platform (WasteMAP), a joint initiative by RMI and Clean Air Task Force, is an open online platform that brings together waste methane emissions data with decision support tools for stakeholders in the waste sector. The platform is supported by country engagement that involves collaboration with national and subnational governments, waste management officials, and other key decision makers to provide capacity building and technical assistance – providing a pathway to reduce solid waste methane emissions. Please visit our website **https://wastemap.earth/** to learn more.

# Project Team

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# Abbreviations and Acronyms

| | |
|---|---|
| **ANP** | National Petroleum Agency |
| **CBios** | Decarbonization Certificates |
| **CDM** | Clean Development Mechanism |
| **CGOB** | Biomethane Guarantee of Origin Certificates |
| **GHG** | Greenhouse Gases |
| **MCid** | Ministry of Cities |
| **MMA** | Ministry of Environment and Climate Change |
| **MSW** | Municipal Solid Waste |
| **NDC** | Nationally Determined Contribution |
| **$Nm^3$** | Normal Cubic Meter |
| **PLANARES** | National Solid Waste Plan |
| **PLANARO** | National Plan for Reduction and Recycling of Organic Waste |
| **PNRS** | National Solid Waste Policy |

# Executive Summary

The waste sector is the third largest source of human-driven methane emissions, accounting for 20% of total global emissions. Reducing methane pollution from the Brazilian waste sector offers the nation a strategy to achieve Paris Agreement commitments and is already a key component of its most recent Nationally Determined Contribution (NDC) submission.

In the short term, methane is more than 80 times more potent than carbon dioxide as a driver of climate change. In Brazil, municipal solid waste (MSW) is a relevant source of methane emissions, primarily due to the anaerobic decomposition of organic waste, mostly in landfills and open dumpsites. In 2023, Brazil generated 78 million tons of MSW, of that approximately 35 million tons were organic waste. Methane contributed to 25% of total greenhouse gas emissions in 2022, with the waste sector representing 15% of the country's methane emissions. These emissions represent a critical challenge to achieving Brazil's climate targets, improving public health, and advancing sustainable development.

This report provides a comprehensive analysis of methane emissions from Brazil's waste sector, based on the current waste management system implemented in Brazil. It also highlights the policies already in place and includes regulations governing improvements in waste management and dumpsite closure. This report also considers instruments focusing on the development of the nascent biomethane market and the goal to incentivize recycling and diversion of organic waste to more productive use (Zero Methane Program and Fuel of the Future Law).

Challenges to the successful implementation of these policies remain. Notably, the Zero Dumpsites Program missed a 2024 deadline for closing open dumps. Infrastructure gaps identified are related to the 9% of the population that remains without collection services, the low source separation rate, the lack of separate collection services, and the limited organic waste treatment capacity. There are also data gaps and financial barriers that limit the understanding and proper allocation of funds for investments in composting, anaerobic digestion, and methane capture. Furthermore, enforcement and technical capacity are limited, especially at the municipal level in Brazil.

Despite those challenges, the Brazilian waste sector holds promise. The overarching goal of sector transformation is beginning to take shape as major investments are directed towards infrastructure for waste management disposal, recycling and organic waste treatment, methane capture and biomethane refining and transport. Expanding landfill gas capture and organic waste treatment can significantly cut methane emissions, enhance air quality, generate green jobs, and strengthen the circular economy. Brazil's active

role in international climate platforms also opens doors to funding, technology transfer, and capacity building. Meanwhile, local success stories – like the GNR Fortaleza project and composting efforts in Florianópolis – present scalable models that inspire broader adoption.

Ultimately, the path to successful waste methane management lies with the ability of Brazil's municipalities to convert policy into action to increase its current low rate of separate waste collection access of 36% and become a Global South leader on solid waste management.

For Brazil to achieve this goal, we present the following recommendations aimed at setting out action to cut methane emissions across the waste sector in coming years:

## Institutional recommendations

- **Composting and anaerobic digestion:** Support the development of small-scale and community-based composting and biogas plants for organic waste.
- **Improving waste disposal sites:** Create incentives for technologies to capture methane from landfills and convert it into energy, sell it to the gas grid, or flare it. Mandate methane recovery systems or biocovers and improved operational practices for landfills.
- **Integrated Waste Management Systems:** Support the development of integrated waste management systems aimed at minimizing waste generation, increase waste recovery, and enable organic diversion from landfills.
- **Promote international partnerships:** Leverage global climate funding and technology collaborations to scale solutions nationwide.

## Policy recommendations

- **Enforcing regulatory framework:** Enforce current legislation and the closure of all dumpsites. Develop new regulations on landfill operations, waste segregation at source, and methane usage as an energy source.
- **Incentives for sustainable practices:** Introduce subsidies or incentives for businesses investing in waste methane reduction.
- **Public-private partnerships:** Encourage partnerships between government and private sector to co-finance methane capture, resources recovery, and organic treatment facilities.
- **Capacity building programs:** Develop training programs with partners for local authorities and waste management professionals in advanced waste management techniques.

## Recommendations for future research and data collection

- **Improve emissions data:** Improve data systems to collect and monitor activity from disposal sites, including emissions.
- **Behavioral studies:** Study community attitudes and foster citizen's engagement towards waste segregation, recycling, and composting to design effective awareness campaigns.
- **Pilot projects and case studies:** Support pilot projects and document successful case studies.

SECTION 1

# Introduction

As the global community works toward achieving climate goals, reducing methane emissions has emerged as a crucial focus. Methane, a potent greenhouse gas (GHG), has a global warming potential over 80 times greater than carbon dioxide during a 20-year period. The waste sector is one of the major sources of methane emissions, particularly from municipal solid waste (MSW), mainly from anaerobic decomposition of organic matter in landfills and open dumps. Given its significant contribution to GHG emissions, curbing methane from the waste sector is vital to meeting climate targets, improving air quality, and enhancing public health.

In many places around the world, including Brazil, rapid urbanization has led to increased waste generation without parallel advancements in waste management infrastructure. As urbanization and population growth continue, it is expected that this situation will worsen, mainly in low-and-middle income cities.[1] Insufficient collection systems, limited waste segregation, and a heavy reliance on unmanaged landfills and open dumps mean that organic waste, which is highly biodegradable, often ends up in disposal sites where it generates methane that is released to the atmosphere. The environmental and health consequences are compounded by the lack of technical and financial resources to implement effective organic waste management practices and methane capture technologies.

In this context, reducing methane emissions from MSW becomes critical not only as a climate measure but also becomes key to promoting sustainable urban growth, improving public health, and creating economic opportunities, new jobs, and green technology investments. For Brazil and other developing countries in the Global South, addressing methane emissions from MSW presents unique challenges and significant opportunities.

[1] UN HABITAT. Waste Wise Cities Tool. Nairobi, 2021. Available at: https://unhabitat.org/wwc-tool. Accessed on Feb. 20th, 2025.

To provide a comprehensive analysis of methane emissions and management in the solid waste sector, this report is structured as follows:

- Section 2 establishes the foundation of the report, by analyzing Brazil's MSW management system, presenting key data on waste generation and composition — with particular emphasis on organic waste — alongside current disposal practices. Additionally, it examines the status of biogas recovery facilities across the country.
- Section 3 focuses on methane emissions in the Brazilian solid waste sector, assessing the current situation along with mitigation solutions, presenting the most updated data from the waste sector, and comparisons with other sectors, as well as historical trends.
- Section 4 explores the regulatory and institutional framework governing waste management and methane emissions in Brazil, detailing the main policies that shape this sector.
- Section 5 maps the network of stakeholders engaged in waste and methane management, ranging from federal regulators to local waste-pickers cooperatives. It outlines roles, responsibilities, and interactions in the implementation of methane reduction strategies.
- Finally, Section 6 evaluates the effectiveness of current policies and initiatives in mitigating methane emissions from waste, identifying best practices, challenges, and areas requiring improvement. This section also presents recommendations for strengthening regulatory frameworks, financial mechanisms, and stakeholder engagement to accelerate methane reduction efforts.

SECTION 2

# Setting the Scene: MSW Management Systems in Brazil

This chapter presents an assessment of the solid waste context in Brazil, which includes waste generated by domestic activities in urban settings, as well as waste collected from public spaces carried out by municipal services. It also includes non-hazardous waste from commercial establishments and service providers, which are legally classified as such by municipal authorities and are treated as equivalent to household waste.

## 2.1 MSW Generation

In 2023, MSW generation in Brazil reached a total of 78.2 million metric tons, equivalent to a national average of 380 kilograms (kg) per person per year, or 1.04 kg of waste per person per day. This amount varies within the country, according to regional conditions, urbanization rates and income level, from a low of 0.83 kg in the southern region to 1.14 kg per person per day in the northeast region.[2]

The accelerated expansion of Brazilian cities, combined with population growth and increasing consumption, has caused a significant rise in MSW generation over recent years. The upward trend is expected to continue in the coming decades, reaching around 100 million tons per year in 2040.[3] Economic growth has been identified as one of the main drivers of waste generation along with population growth, both having significant impact on the overall waste generation scenario.

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[2] BRASIL (2024). Ministério das Cidades. Secretaria Nacional de Saneamento Ambiental – SNSA. Relatório dos Serviços de Lompeza Urbana e Manejo de Resíduos Sólidos – SINISA 2024 ano de referência 2023. Brasília. Available at: https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/saneamento/sinisa/resultados-sinisa/RELATORIO_SINISA_RESIDUOS_SOLIDOS_2024.pdf. Accessed on May 9th, 2025.

[3] BRASIL (2022a). Plano Nacional de Resíduos Sólidos – Planares. Brasília: Ministerio do Meio Ambiente. Available at: https://portal-api.sinir.gov.br/wp-content/uploads/2022/07/Planares-B.pdf. Accessed on Nov. 6th, 2024.

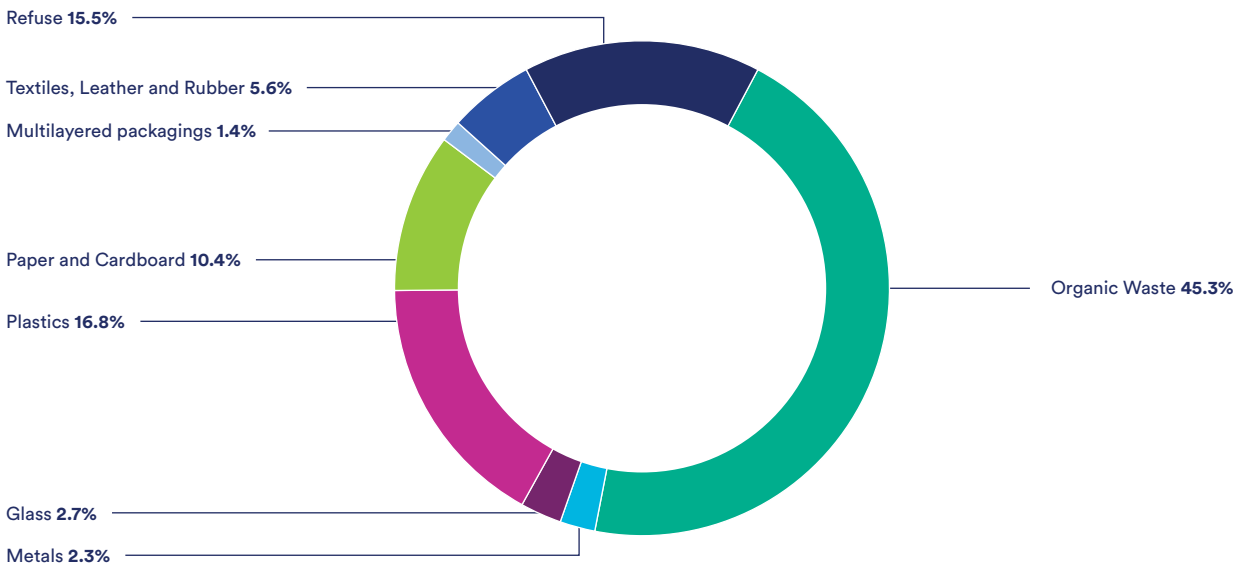
Other factors that influence the increase in urban solid waste generation in Brazil are:

- lack of a strategy to prevent food loss and waste, means that 45% of the MSW in Brazil corresponding to organic fraction from food and garden waste;[4]
- lack of user fees for waste management services in most Brazilian cities;
- low effectiveness of recycling systems and recycling rates for both dry and organic waste;
- insufficiency of economic instruments to promote material recovery, such as Extended Producer Responsibility; and
- increased consumption of single-use products.

## 2.2 MSW Composition

In Brazil, the largest fraction of municipal solid waste is the organic fraction — food scraps, pruning and garden waste — which accounts for around 45% of the total waste generated in the country,[4] as illustrated in the chart in **Figure 01**. The significance of organic waste is a key aspect of the climate agenda, as organics are the single most important factor impacting methane emissions from the waste sector.

**Figure 1: Average MSW composition in Brazil**




Source: BRASIL (2022a). Plano Nacional de Resíduos Sólidos – Planares. Brasília: Ministerio do Meio Ambiente. Available at: https://portal-api.sinir.gov.br/wp-content/uploads/2022/07/Planares-B.pdf. Accessed on Nov. 6th, 2024.

[4] BRASIL (2022a). Plano Nacional de Resíduos Sólidos – Planares. Brasília: Ministerio do Meio Ambiente. Available at: https://portal-api.sinir.gov.br/wp-content/uploads/2022/07/Planares-B.pdf. Accessed on Nov. 6th, 2024.

## 2.3 MSW Collection and Destination

More than 90% of the Brazilian population (187 million people) have access to MSW collection services throughout the country for unsorted waste, while only 36% of the Brazilian population counts with separated collection services (in two fractions). Considerable disparities exist between geographic regions: in the Southern region 69.3% of population have separated collection services meanwhile in the Northeastern region only 4.4% of the population has such service.[5]

Currently the majority of the MSW collected in Brazil is sent to disposal sites, with sanitary landfills being the predominant destination for 70% of collected MSW. However, around 26% of the collected waste still goes to inadequate disposal sites (open dumps and uncontrolled landfills). Notably, around 9% of the waste generated in Brazil is not collected, and it is illegally dumped, burned, or ends up in nature.[5]

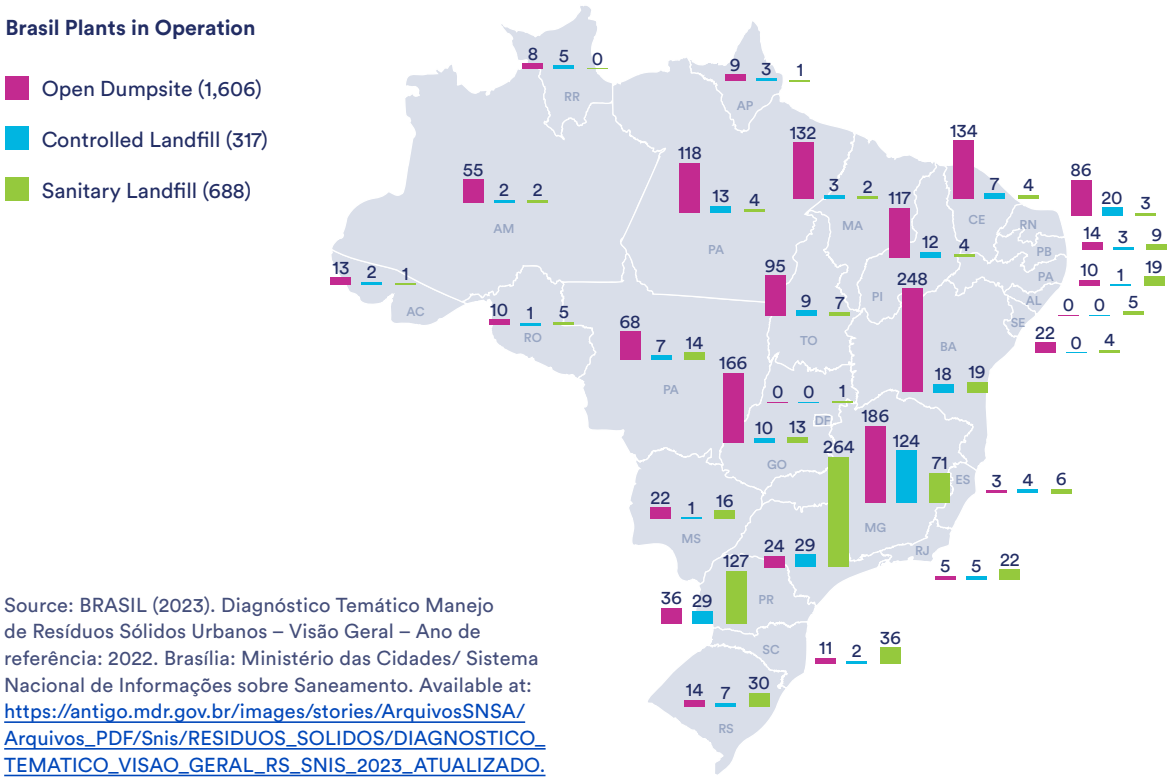
Waste treatment and disposal methods impact GHG emissions overall and especially methane emissions. Considering the volume of organics contained within Brazilian MSW, final disposal is the major methane emission source from the waste sector in Brazil, due to the anaerobic degradation of the organic fraction. The negative impacts of open dumpsites and uncontrolled landfills extend beyond purely climate considerations as associated emissions also contribute to air quality degradation, increased health risks, and harmful impacts to terrestrial and aquatic ecosystems; thus, immediate action towards their closure and remediation is needed.

The geographical distribution of waste disposal sites in the country gives perspective on the challenge to both close dumpsites while shifting disposal of waste away from uncontrolled landfills to sanitary ones. As shown in Figure 02, around 2,000 inadequate disposal sites remain operational (they are located in almost every Brazilian State) with only 688 operating sanitary landfills. These values show the potential for the development of additional biogas/biomethane plants within existing sanitary landfill operations, as well as highlighting the potential for recovery of valuable organic waste now being disposed of in disposal sites across Brazil.

The North and Northeast regions have the largest number of inadequate disposal sites in operation in the country (**Figure 02**). This situation highlights the opportunity to develop solutions to install adequate waste management infrastructure, by investing in sanitary landfills with gas capture in the region and, also, through the diversion of organic waste fraction from final disposal sites via composting and anaerobic digestion. In other regions, such as the South and Southeast, where most sanitary landfills sites are located, there is great potential to expand landfill gas capture and use systems, followed by new treatment solutions to address the organics recovery.

[5] BRASIL (2024). Ministério das Cidades. Secretaria Nacional de Saneamento Ambiental – SNSA. Relatório dos Serviços de Lompeza Urbana e Manejo de Resíduos Sólidos – SINISA 2024 ano de referência 2023. Brasília. Available at: https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/saneamento/sinisa/resultados-sinisa/RELATORIO_SINISA_RESIDUOS_SOLIDOS_2024.pdf. Accessed on May 9th, 2025.

**Figure 2: MSW Final Disposal site situation, by Brazilian State**




Source: BRASIL (2023). Diagnóstico Temático Manejo de Resíduos Sólidos Urbanos – Visão Geral – Ano de referência: 2022. Brasília: Ministério das Cidades/ Sistema Nacional de Informações sobre Saneamento. Available at: https://antigo.mdr.gov.br/images/stories/ArquivosSNSA/Arquivos_PDF/Snis/RESIDUOS_SOLIDOS/DIAGNOSTICO_TEMATICO_VISAO_GERAL_RS_SNIS_2023_ATUALIZADO.pdf. Accessed on Nov. 6th, 2024.

In Brazil, 4% of MSW is recovered for recycling and treatment, of which 3% corresponds to dry fraction and 1% to organic waste that is treated in composting plants.[6] As of 2023, Brazil had 1,587 biogas plants functioning in the country – 126 landfill gas capture plants, 1,268 anaerobic digestion plants, and 170 industrial plants – with a total installed capacity of 4.7 billion Nm3/year.[7] The waste and wastewater sector have registered together 149 biogas plants in the country, with an installed capacity of 2.85 billion Nm3/year, corresponding to around 64% of the total installed capacity in the country. This means that solid waste and wastewater biogas plants contribute to almost two thirds of the biogas capture in Brazil. The solid waste sector alone registers half (64) of such biogas plants installed at sanitary landfills, with 50 dedicated to electricity generation, and 14 to biomethane production. Currently, only 6 biomethane facilities are authorized by the National Petroleum Agency (ANP) for commercial production and thus, allowed to put biomethane in the Brazilian market.

6 BRASIL (2024). Ministério das Cidades. Secretaria Nacional de Saneamento Ambiental – SNSA. Relatório dos Serviços de Lompeza Urbana e Manejo de Resíduos Sólidos – SINISA 2024 ano de referência 2023. Brasília. Available at: https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/saneamento/sinisa/resultados-sinisa/RELATORIO_SINISA_RESIDUOS_SOLIDOS_2024.pdf. Accessed on May 9th, 2025.

7 CIBiogás - Centro Internacional de Energias Renováveis.Panorama do Biogás no Brasil 2024. Relatório Técnico nº 001/2024 – Foz do Iguaçu, CIBiogás, 2024.

SECTION 3

# Methane Emissions from the Brazilian Solid Waste Sector

According to the latest global data from World Resources Institute Climate Watch[8] for 2020, Brazil ranks as the sixth-largest emitter of GHGs, contributing 3% of global emissions. This places the country behind China, the United States, India, Russia, and Indonesia. Within Latin America and the Caribbean, Brazil stands out as the largest GHG emitter.

[8] WORLD RESOURCES INSTITUTE. Climate Watch – CAIT Country Greenhouse Gas Emissions Data. Available at: https://www.wri.org/data/climate-watch-cait-country-greenhouse-gas-emissions-data. Accessed on Nov. 14th, 2024.

### Box 1: Data sources for this chapter

Brazilian official GHG data is provided through the National Register System of GHG Emissions – SIRENE,[9] a digital monitoring platform maintained by the Ministry of Science, Technology, and Innovation. The 6th Annual Estimate of GHG Emissions is the latest emissions report, with estimates from 1900 until 2020.[10]

In order to provide the most recent waste data in Brazil, this report uses data from the "GHG Emissions and Removals Estimation System – SEEG"[11] managed by Observatório do Clima, a recognized network of Brazilian environmental organizations that provides emissions data up to 2022. SEEG estimates were conducted according to IPCC 2006 guidelines, incorporating both Brazilian government reports and additional data sources, including research institutes, sector entities, and non-governmental organizations.

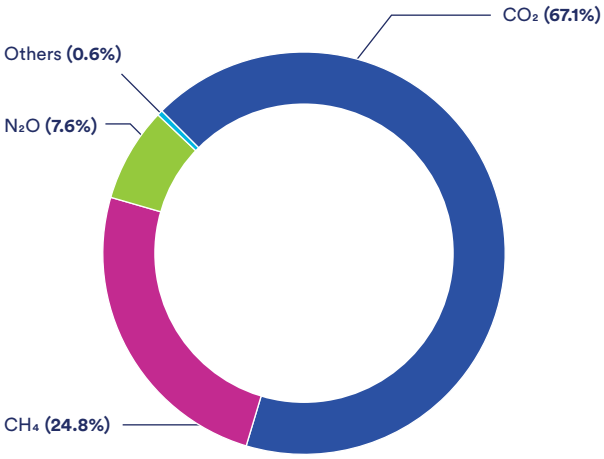
## 3.1 GHG emissions in Brazil

Brazilian GHG emissions reached a total of 2,318 million metric tons of $CO_{2\,eq}$ /year in 2022, with major contributions from land-use changes (48%) – primarily deforestation– and agriculture and livestock (27%), with the waste sector representing 4% of Brazilian GHG emissions. Although less representative than other GHG sources, the waste sector is important because it is the second largest source of methane emissions in Brazil (see next section) and also has mitigation technologies more readily available compared to other sources. Notably, Brazilian GHG emissions show an 8% decrease in 2022 compared to 2021, largely due to a reduction in Amazon Forest burning.[12]

## 3.2 Methane emissions in Brazil

In 2022, Brazil emitted 20.6 million metric tons of methane, representing 25% of the total Brazilian GHG emissions (**Figure 03**). Those emissions represent a

**Figure 3: Brazilian GHG emissions by gas, in 2022**




Source: OC - OBSERVATÓRIO DO CLIMA (2023). Análise das emissões de gases de efeito estufa e suas implicações para as metas climáticas do Brasil (1970-2022). https://oc.eco.br/wp-content/uploads/2023/11/Relatorio-SEEG_gases-estufa_2023FINAL.pdf. Accessed on Oct 14th, 2024.

9 BRASIL (2024). Sistema de Registro Nacional de Emissões – SINERE. Emissões. Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene. Accessed on Oct 14th, 2024.

10 BRASIL. Ministério de Ciência, Tecnologia e Inovação - MCTI (2022). Estimativas anuais de emissões de gases de efeito estufa no Brasil: 6ª edição – 2022. Brasília: MCTI. https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/estimativas-anuais-de-emissoes-gee

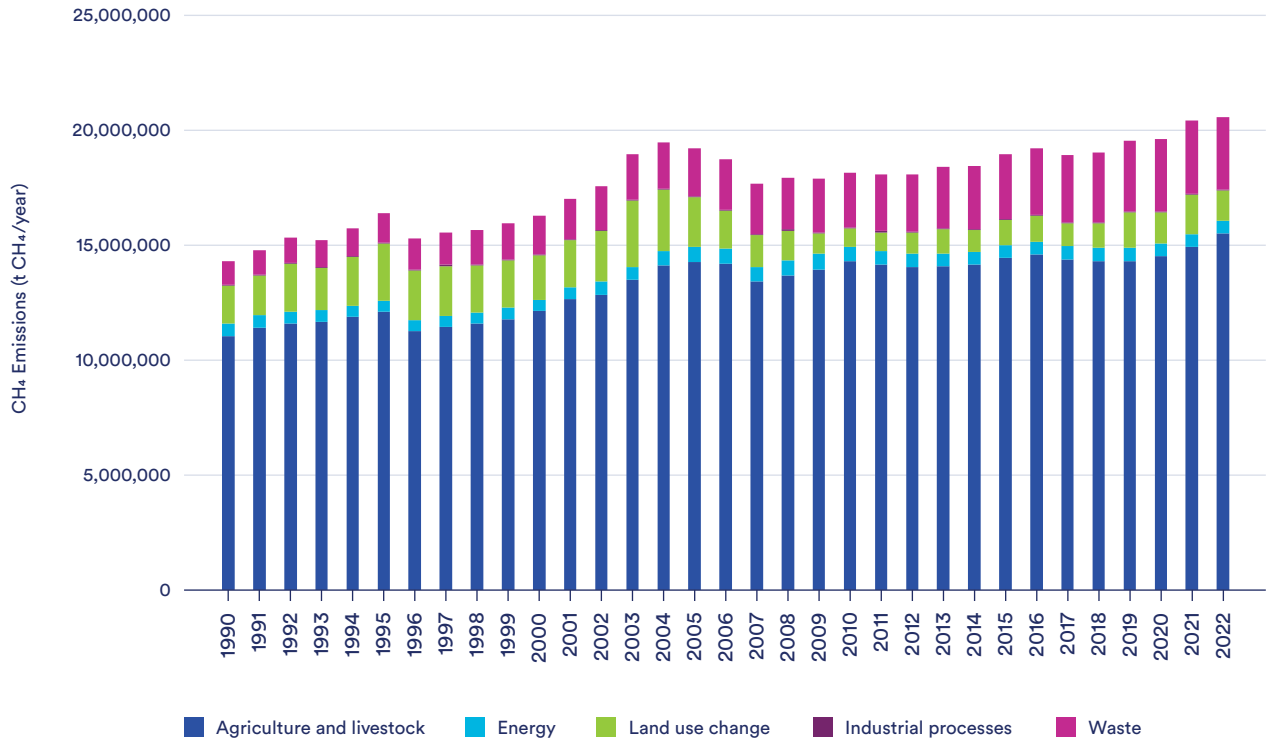
11 OC - OBSERVATÓRIO DO CLIMA (2023). Análise das emissões de gases de efeito estufa e suas implicações para as metas climáticas do Brasil (1970-2022). https://oc.eco.br/wp-content/uploads/2023/11/Relatorio-SEEG_gases-estufa_2023FINAL.pdf. Accessed on Oct 14th, 2024.

12 CIBiogás - Centro Internacional de Energias Renováveis. Panorama do Biogás no Brasil 2024. Relatório Técnico nº 001/2024 – Foz do Iguaçu, CIBiogás, 2024.

relevant target for mitigation actions, since most of those have opportunities to have high-impact interventions with technologies that are already proven and cost effective.[13]

According to SEEG,[14] methane emissions by sector are distributed among agriculture and livestock (75%), waste (15%), land-use change (6%), energy (3%) and industrial processes (0.3%).[15] **Figure 04** shows how total methane emissions in Brazil have evolved over time, revealing that after a decline from 2004 to 2008 (following the same trend in the total Brazilian GHG emissions, due to a decrease on Amazon region deforestation rates), they have gradually increased as a result mainly of population increase.

**Figure 4: Historical methane emissions in Brazil**




Source: OC - OBSERVATÓRIO DO CLIMA (2023). Análise das emissões de gases de efeito estufa e suas implicações para as metas climáticas do Brasil (1970-2022). https://oc.eco.br/wp-content/uploads/2023/11/Relatorio-SEEG_gases-estufa_2023FINAL.pdf. Accessed on Oct 14th, 2024.

[13] CIBiogás - Centro Internacional de Energias Renováveis. Panorama do Biogás no Brasil 2024. Relatório Técnico nº 001/2024 – Foz do Iguaçu, CIBiogás, 2024.

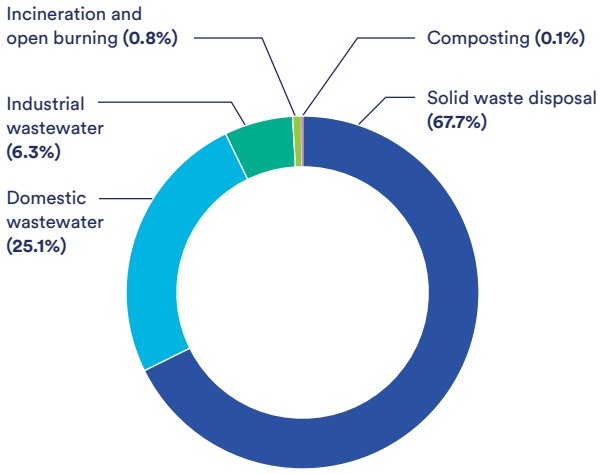
[14] OC - OBSERVATÓRIO DO CLIMA (2024). Greenhouse Gas Emissions and Removals Estimation System (SEEG) Platform. Available at: https://seeg.eco.br/en/home/. Accessed on Oct 14th, 2024.

[15] According to IPCC methodology, the most relevant methane emissions in "agriculture and livestock" in Brazil comes from "ruminant animals´ digestion process". In the case of "land-use change", methane emissions came basically from deforestation.

In the Brazilian waste sector, methane emissions dominate the landscape with 91 million metric tons of $CO_{2\,eq}$ in 2022,[16] which represent 97% of total GHG emissions from this sector. The prevalence of urban solid waste disposal[17] among the waste sector methane emissions, highlights the importance of waste sector methane abatement actions to reduce, separate, and treat the organic fraction, as its decomposition is the source of most of the methane emissions from the Brazilian waste sector.

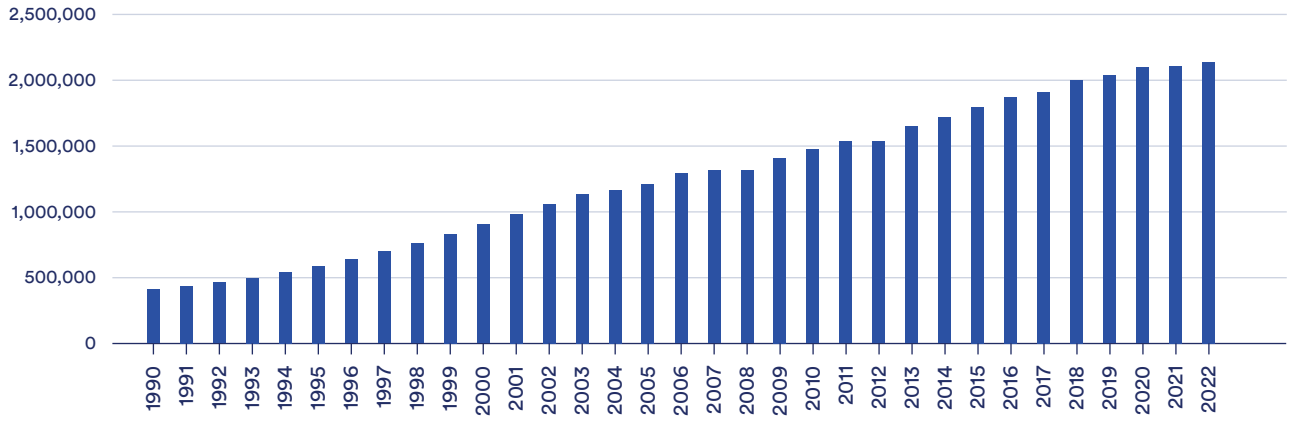
From 1990 to 2022, the subsector of solid waste disposal increased its methane emissions by a factor of five, reaching 2.14 million metric tons of $CO_{2\,eq}$/ year (**Figure 06**).[18] This increase is the combined effect of Brazilian population growth, high rates of urbanization, and rise of food waste due to higher family income rates, leading to the increase in generation of the organic waste fraction of municipal solid waste.

**Figure 5: Distribution of Brazilian waste sector methane emissions, in 2022**




Source: OC - OBSERVATÓRIO DO CLIMA (2023). Análise das emissões de gases de efeito estufa e suas implicações para as metas climáticas do Brasil (1970-2022). https://oc.eco.br/wp-content/uploads/2023/11/Relatorio-SEEG_gases-estufa_2023FINAL.pdf. Accessed on Oct 14th, 2024.

**Figure 6: Brazilian methane emissions from solid waste disposal**




Source: OC - OBSERVATÓRIO DO CLIMA (2024). Greenhouse Gas Emissions and Removals Estimation System (SEEG) Platform. Available at: https://seeg.eco.br/en/home/. Accessed on Oct 14th, 2024.

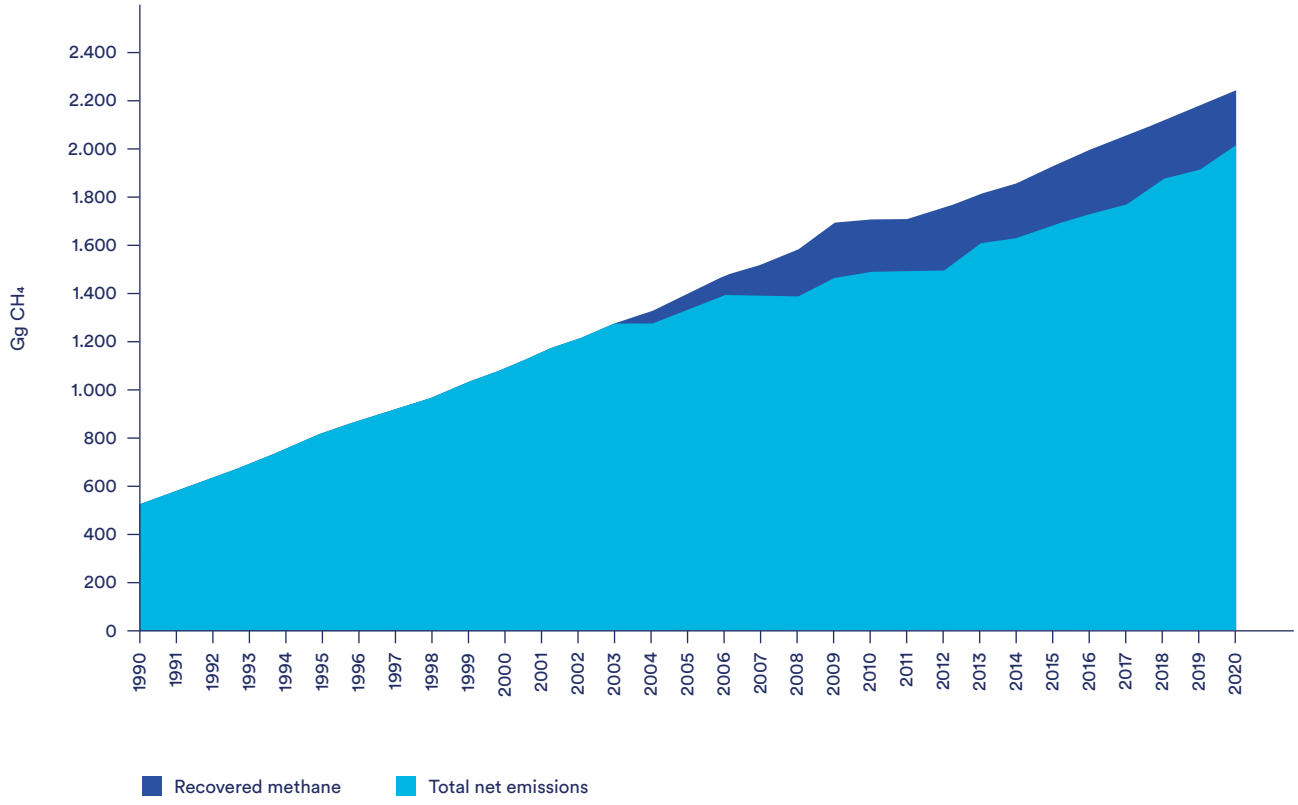
[16] OC - OBSERVATÓRIO DO CLIMA (2024). Infographics 2023. Available at: https://seeg.eco.br/en/seeg-infographics/. Accessed on Nov. 4th, 2024.

[17] According to IPCC 2006 methodology, waste sector GHG emissions encompass emissions from solid waste disposal (mainly landfills), biological treatment of solid waste, incineration and open burning of waste and wastewater treatment and discharge (divided into urban wastewater - sewage produced by people at cities, and industrial wastewater -produced by different industrial sectors at their plants).

[18] OC - OBSERVATÓRIO DO CLIMA (2024). Greenhouse Gas Emissions and Removals Estimation System (SEEG) Platform. Available at: https://seeg.eco.br/en/home/. Accessed on Oct 14th, 2024.

However, in the last 20 years Brazil has started to deploy measures to mitigate methane emissions in the waste sector, although still timidly. According to official government data[19] on Clean Development Mechanism projects registered from 2004 to 2019, Brazil had a significant emission reduction potential of 380 million metric tons of $CO_{2\,eq}$ for the first crediting period (period for which GHG reductions are verified and certified for issuance of a certified emission reductions). Among those, 52 landfill gas projects were registered, with a total estimated reduction in GHG emissions for the first crediting period of approximately 92 million metric tons of $CO_{2\,eq}$, or 24% of the total. **Figure 07** shows the evolution of avoided methane emissions in the waste sector by Clean Development Mechanism projects developed in the country and registered at the UNFCCC. These initiatives have expanded over time, and in 2020 it is estimated that they have reduced sector emissions from the estimated baseline by 10%.

**Figure 7: Historical evolution of methane emissions and methane recovery from MSW in Brazil**



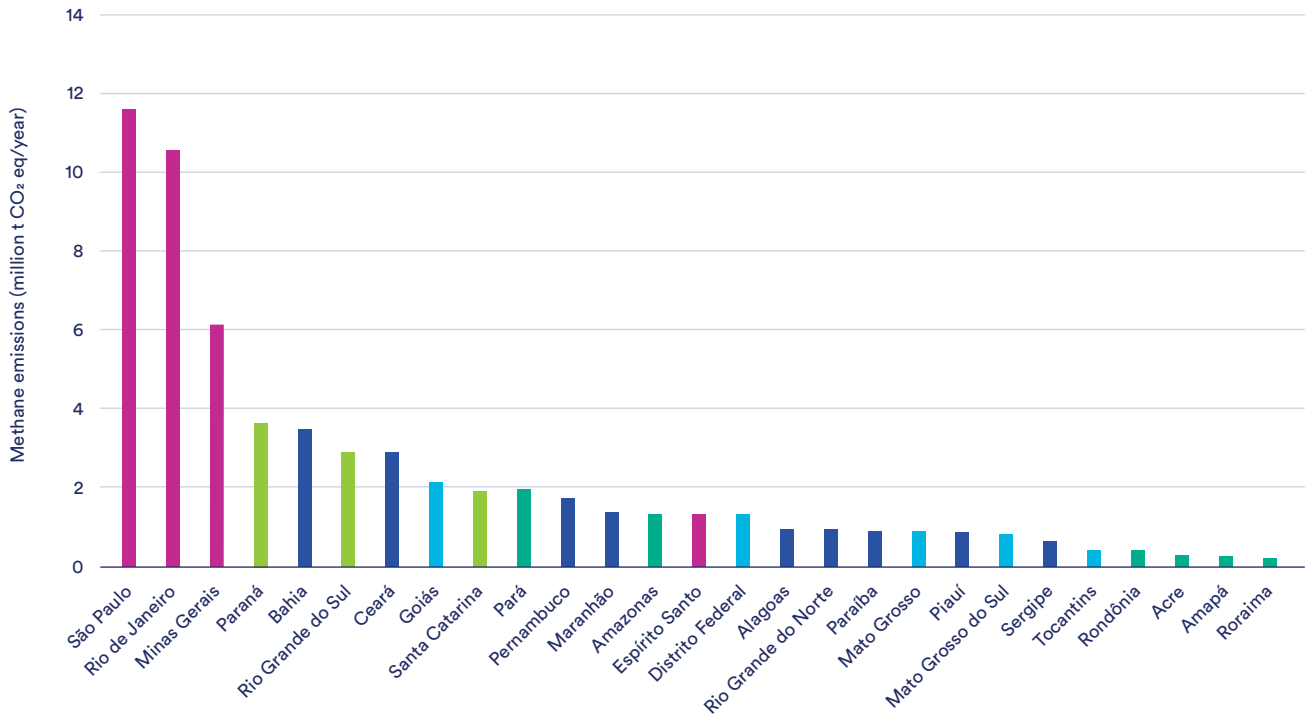

Source: BRASIL. Ministério de Ciência, Tecnologia e Inovação - MCTI (2020).

[19] BRASIL (2020). Ministério de Ciência, Tecnologia e Inovação - MCTI. Fourth Biennial update report of Brazil to the United Nations Framework Convention on Climate Change. Brasilia: MCTI, 2020. Available at: https://antigo.mctic.gov.br/mctic/export/sites/institucional/ciencia/SEPED/clima/arquivos/BUR/BUR4_Brazil_Ingl.pdf. Accessed on Feb. 14th, 2025.

Although GHG emissions from the waste sector have historically shown an upward trend, methane emissions declined by 1% in 2022 compared to 2021, due to increased biogas capture in landfills, which are estimated to reduce waste disposal emissions by 20% on average per project.[20] Biogas capture in landfills has been part of the MSW landscape in Brazil since 2003. In 2022, 526 thousand metric tons of methane were captured across 51 landfills, representing a 5% increase with respect to 2021. This is the first recorded decrease in solid waste emissions throughout the historical series, underscoring the importance of improving methane recovery from landfills.[20]

Brazil's size and diversity (e.g. weather, infrastructure, etc.) lead to significant regional variation in waste sector methane emissions. In 2022, São Paulo was the largest emitting state, with 11.58 million metric tons of $CO_{2\,eq}$/ year (18.7%), followed by Rio de Janeiro (10.56 million metric tons of $CO_{2\,eq}$/year, 17.0%) and Minas Gerais (6.15 million metric tons of $CO_{2\,eq}$/ year, 9.9%). **Figure 08** illustrates solid waste disposal methane emissions among Brazilian states.[21]

**Figure 8: Methane emissions from MSW disposal by Brazilian state, in 2022**




Source: OC - OBSERVATÓRIO DO CLIMA (2024)

[20] OC - OBSERVATÓRIO DO CLIMA (2023). Análise das emissões de gases de efeito estufa e suas implicações para as metas climáticas do Brasil (1970-2022). https://oc.eco.br/wp-content/uploads/2023/11/Relatorio-SEEG_gases-estufa_2023FINAL.pdf. Accessed on Oct 14th, 2024.

[21] OC - OBSERVATÓRIO DO CLIMA (2024). Greenhouse Gas Emissions and Removals Estimation System (SEEG) Platform. Available at: https://seeg.eco.br/en/home. Accessed on Oct 14th, 2024.

SECTION 4

# Regulatory and Institutional Framework for Waste Management and Methane

In Brazil, environmental regulatory authority is shared between the federal government, the states, the municipalities, and the Federal District, resulting in a vast and diverse body of local legislation. Due to this complexity and the significant number of regional regulations, this report will focus exclusively on presenting federal legislation and initiatives. This approach allows for a more focused and comprehensive analysis of national guidelines, which serve as the foundation for the regulation and implementation of environmental policies at other levels of government. However, please note that local governments are ultimately responsible for implementing solid waste management and some have enacted legislation that is stronger than that at the federal level. One example is Florianopolis, which has implemented progressive waste management initiatives that go beyond federal requirements, with more comprehensive selective collection programs and efforts to reduce the volume of waste sent to landfills, aligning with international best practices in urban waste management, as shown in Annex I.

## 4.1 National Policy Framework for Waste Management

### National Solid Waste Policy

The National Solid Waste Policy (PNRS, in Portuguese), established by Law No. 12.305/2010,[22] is a critical framework in waste management in Brazil, instituting shared responsibility for product life cycle between manufacturers, importers, distributors, retailers, consumers, and public authorities. The law imposes various obligations, including the drafting of waste management plans at regional, municipal, or inter-municipal levels, as well as the implementation of separate collection involving informal recyclers organized in cooperatives. In the management and handling of solid waste, the following priority order must be observed: non-generation, reduction, reuse, recycling, treatment of solid waste, and environmentally sound final disposal of waste residues. Selective collection systems are not yet fully disseminated in the country, but when available, they normally collect waste separated in two fractions: dry recyclables and wet organic waste. However, Federal Decree n.10.936/2022[23] determines that separated collection systems must be implemented by municipalities considering source segregation in three fractions: dry recyclables, organic waste, and non-recyclable rejects.

The PNRS allows municipalities to establish waste management tariff systems to fund proper waste collection, treatment, and disposal services, promoting financial sustainability of these essential services. One of its central objectives is the closure of open dumps in the country, with a deadline set for 2024. However, this target was not met, and according to recent data, 1,911 municipalities (34%) still rely on illegal and uncontrolled dumpsites.[24]

The PNRS promotes integration with take-back systems, called reverse logistics, aimed at returning post-consumer products and packaging into the production cycle, minimizing environmental impacts, and holding the entire life cycle chain accountable for waste generation. Its regulation, through Decree No. 10.936/2022, reinforces the guidelines for integrated and proper waste management.

The National Solid Waste Plan (PLANARES, in Portuguese),[24] the main instrument envisaged by the PNRS, sets out strategies, actions, and targets for achieving the law's objectives. The plan is periodically reviewed to ensure its alignment with evolving environmental, economic, and social challenges.

Currently, the Ministry of Environment and Climate Change (MMA, in Portuguese) is developing the National Organic Waste Plan (PLANARO, in Portuguese),[25] which is currently undergoing public consultation (mid 2025). This instrument will be crucial for promoting organic waste treatment, source separation, diversion, composting practices and anaerobic digestion across the country. It also promotes the use of biogas as a renewable energy source, directly contributing to methane emission reduction efforts. In summary, PLANARES serves as the overarching national plan for the management of all types of solid waste, including the definition of long-term strategies, goals, and scenarios for the next two decades, while PLANARO focuses specifically on the management of the organic fraction of municipal solid waste.

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22 Available at: https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/l12305.htm. Accessed on Nov. 14th, 2024.

23 Available at: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2022/decreto/d10936.htm. Accessed on May 6th, 2024.

24 BRASIL. Instituto Brasileiro de Geografia e Estatísticas (IBGE). Pesquisa de Informações Básicas Municipais – 2023. Brasília, 2024. Available at: https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/41994-munic-2023-31-9-dos-municipios-brasileiros-ainda-despejam-residuos-solidos-em-lixoes. Accessed on Nov. 28th, 2024.

25 BRASIL. Decreto nº 11.043, de 13 de abril de 2022. Aprova o Plano Nacional de Resíduos Sólidos. Available at: https://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2022/Decreto/D11043.htm. Accessed on Nov. 14th,2024.

26 Brasil. Ministério do Meio Ambiente e Mudança do Clima. Consulta Pública – Plano Nacional de Redução e Reciclagem de Resíduos Orgânicos Urbanos (Planaro). Brasília: MMA, 2025. Available at: https://www.gov.br/participamaisbrasil/consulta-plano-nacional-de-residuos-organicos-urbanos Acessed on Apr. 04,2025.

### BOX 2: A closer look into PLANARES

PLANARES is the main instrument emerging from the PNRS. It analyzes the current situation of MSW management in the country according to an initial assessment (the current baseline is 2020) and provides potential scenarios to define goals, strategies, and directives to improve waste management for the following 20 years. This first version of PLANARES was published via Decree n. 11.043 in 2022, and among other focus areas includes goals and strategies to reduce GHG emissions.

The country aims to improve MSW management by 2040, while simultaneously promoting energy generation through the recovery of biogas and biomethane, which has significant potential for emission reduction and renewable energy generation. The plan sets the following goals related to GHG and methane emissions:

- **Goal 7: Increase recycling of the organic fraction of MSW** - aims to increase recycling of the organic fraction from MSW, which accounts for approximately half of the total waste generated in Brazil. The target is to recover and treat 13.5% of this fraction by 2040, focusing on technological pathways such as composting and anaerobic digestion. The recovery of the organic fraction provides direct benefits, such as reducing transportation and disposal costs, as well as decreasing GHG emissions, especially methane. Additionally, these actions have great potential to generate carbon credits in national and international markets, encouraging the economic feasibility of the investments required to meet emission reduction targets.
- **Goal 8: Recovery and energy utilization of biogas from MSW** - aims to increase the recovery and energy utilization of biogas generated from the decomposition of organic matter in landfills and anaerobic digestion units. Biogas is recognized as an important renewable energy source, with great potential to mitigate methane emissions by converting it into electricity and heat. By 2040, Brazil aims to utilize more than 60% of the generated biogas, corresponding to an installed capacity of 257 MW from landfills, plus 69 MW from anaerobic digestion units. This energy recovery has the potential to supply approximately 9.5 million households with electricity by 2040, significantly contributing to the country's energy security and methane emission reduction goals.

## Basic Sanitation Legal Framework

The Basic Sanitation Legal Framework, established by Law No. 14.026/2020[27] restructured Brazil's sanitation sector and introduced significant innovations, with direct implications for MSW management and indirect effects on methane emissions. Its principal goal is the universalization of basic sanitation services by 2033, aiming to provide access to potable water for 99% of the population and to ensure sewage collection and treatment for 90% of Brazilians.

Although the primary focus of the law is on water supply and wastewater services, it also expressly includes solid waste management as an integral part of sanitation services. One of its core mechanisms is the creation of regional blocks of municipalities, designed to encourage the joint provision of services through resource sharing and cooperative governance. This regionalization strategy promotes economic viability and enhances service efficiency, thereby contributing to more effective waste handling and a reduction in methane emissions from unmanaged or poorly managed waste sites.

Furthermore, the law establishes that the financial and economic sustainability of sanitation services, including municipal waste management and urban cleaning, must be ensured through the implementation of user fee systems (either taxes or tariffs) that fully cover service costs. To support this requirement, the National Water and Basic Sanitation Agency issued a detailed regulation in 2021, outlining the criteria that municipalities must meet to comply with the law. This regulation also mandated the creation of a national information system to be updated annually by all 5,570 Brazilian municipalities.

[27] Available at: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2020/lei/L14026.htm. Accessed on Nov. 14th, 2024.

### Zero Dumpsites Program

Launched by the Ministry of Environment and Climate Change in 2019,[28] the Zero Dumpsites Program is a key initiative in the Brazilian government's efforts to eliminate open dumps and ensure the proper disposal of MSW nationwide. As mentioned earlier, Brazil did not meet the 2024 deadline to close open dumps. This program specifically targets the challenges faced by many municipalities in implementing effective waste disposal solutions, challenges that are further compounded by inadequate infrastructure and limited financial resources, particularly in more vulnerable regions of the country.

The primary goal of this Program is the total eradication of open dumps nationwide, replacing them with adequate infrastructure, thus minimizing environmental impacts, and preventing soil and water contamination. The program includes the regionalization of waste management, promoting the formation of inter-municipal consortia to share responsibility for waste treatment facilities, particularly for smaller municipalities lacking the financial capacity to maintain such facilities individually. Moreover, the Zero Dumpsites Program promotes environmental education, technical training, and support for recycling projects.

### BOX 3: Inclusive Recycling in Brazil

Brazil places significant emphasis on waste-pickers through formal recognition in its PNRS. The country aims to achieve multiple objectives through this focus, including social inclusion by integrating informal waste-pickers into the formal economy, creating economic opportunities for vulnerable populations, increasing recycling rates to reduce waste sent to landfills (directly contributing to methane emission reduction), improving resource recovery to promote circular economy principles, and strengthening waste-picker cooperatives to enhance their operational capacity and market position.

Brazilian MSW recycling schemes have long relied on informal recyclers (¨catadores¨ in Portuguese), an important workforce that has been partially formalized through the creation of cooperatives integrated into both municipal source-separated collection programs and extended producer responsibility systems. As of 2022, there were 2,941 formal cooperatives in the country, comprising 86,878 recyclers – representing approximately 10.9% of the estimated 800,000 recyclers nationwide. These cooperatives collectively sorted 1.77 million tonnes of recyclable material per year and generated more than €300 million in annual revenue.[29]

#### Pró-Catador Program

The Pró-Catador program, established by Federal Decree No. 11.414/2023,[30] is a Brazilian government initiative aimed at recognizing and formalizing the work of recyclers, ensuring better working conditions and social inclusion. The program provides technical and financial support for creating cooperatives and associations, facilitating access to resources and training. By promoting the organization of recyclers, Pró-Catador aims to improve their income while strengthening the recycling chain, contributing to waste reduction and environmental preservation.

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28 BRASIL. Ministério do Meio Ambiente. Programa Metano Zero. Disponível em: https://www.gov.br/mma/pt-br/assuntos/mudanca-do-clima/ozonio/ProgramaMetanoZero.pdf. Accessed on Feb 3rd, 2025.

29 BRASIL (2024). Ministério das Cidades. Secretaria Nacional de Saneamento Ambiental – SNSA. Relatório dos Serviços de Lompeza Urbana e Manejo de Resíduos Sólidos – SINISA 2024 ano de referência 2023. Brasília. Available at: h=ps://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-eprogramas/saneamento/sinisa/resultados-sinisa/RELATORIO_SINISA_RESIDUOS_SOLIDOS_2024.pdf. Accessed on May 9th, 2025.

30 Available at: https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2023/decreto/D11414.htm. Accessed on Nov. 20th, 2024.

### Incentives for Recycling

The Federal Law No. 14.260/2021[31] establishes tax incentives and benefits to be adopted by the Union for projects that stimulate the recycling production chain, in line with the guidelines of the PNRS. Measures include incentives for industries and entities dedicated to the reuse, treatment, and recycling of solid waste, allowing individuals and legal entities taxed on real income to deduct part of their income tax by directly supporting projects previously approved by the MMA. Additionally, the law authorizes the creation of Recycling Project Investment Funds, with resources earmarked for related projects, and its constitution, operation, and administration are regulated by the Brazilian Securities and Exchange Commission, in conjunction with the MMA.

## 4.2 Enabling National Policies

### Brazilian National Biofuels Policy

The Brazilian National Policy of Biofuels, known as RenovaBio, was established by Federal Law No. 13.576/2017[32] to define guidelines for the production, commercialization, and use of biofuels, fostering the integration between agriculture and the national energy matrix. The program is based on the premise that biofuels play a crucial role in mitigating climate change, reducing dependence on fossil fuels, and enhancing energy security. Additionally, RenovaBio prioritizes social inclusion and the strengthening of family farming.

A key mechanism of RenovaBio is the issuance of Decarbonization Certificates (CBios), which reward the efficient production of ethanol and other biofuels. CBios are different from CGOBs as they specifically apply to the RenovaBio framework for biofuels, while CGOBs are specific to biomethane under the Fuel of the Future law. CBios are traded on the Brazilian stock exchange. The number of CBios generated is directly linked to the Efficiency Score of production units, which is validated by the ANP. Higher efficiency results in the issuance of a greater number of certificates, which fuel distributors are mandated to acquire in proportion to their fossil fuel sales. Within this framework, biomethane derived from organic waste holds substantial potential as a complementary biofuel.

### "Fuel of the Future" Law

The "Fuel of the Future" law, enacted by the recently signed Federal Law No. 14.993/2024,[33] establishes national programs for the implementation of green diesel, sustainable aviation fuel, and biomethane, as well as setting mandatory targets for the blending of ethanol in gasoline, biodiesel in diesel and biomethane in natural gas. The objective is to foster a gradual substitution of fossil fuels in road, maritime, and air transport with sustainable alternatives. This law seeks to integrate various public policies related to the transport sector, promoting a cleaner and more efficient energy matrix for transportation.

Starting in 2026, the program will introduce a mandatory requirement for biomethane in the natural gas market, with the National Energy Policy Council setting annual GHG emissions reduction targets. These targets will be met through a gradual compulsory inclusion of biomethane into the natural gas pipeline, ranging from 1% to 10%, with exceptions for public interest or excessive costs.

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[31] BRASIL. Lei n. 14.260, de 8 de dezembro de 2021. Estabelece incen1vos à indústria da reciclagem; e cria o Fundo de Apoio para Ações Voltadas à Reciclagem (Favorecicle) e Fundos de Inves1mentos para Projetos de Reciclagem (ProRecicle). Diário Oficial da União: seção 1, Brasília, DF, 9 dez. 2021. Available at: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/l14260.htm. Accessed on 20 nov. 2024.

[32] BRASIL. Lei n. 13.576, de 26 de dezembro de 2017. Dispõe sobre a Polí1ca Nacional de Biocombusvveis (RenovaBio) e dá outras providências. Diário Oficial da União: seção 1, Brasília, DF, 27 dez. 2017. Available at: https://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/lei/l13576.htm. Accessed on Nov. 14th, 2024.

[33] BRASIL. Lei n. 14.993, de 8 de outubro de 2024. Dispõe sobre a promoção da mobilidade sustentável de baixo carbono e a captura e a estocagem geológica de dióxido de carbono. Diário Oficial da União: seção 1, Brasília, DF, 9 out. 2024. Available at: https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2024/lei/l14993.htm. Accessed on Nov. 14th, 2024.

The targets can be fulfilled by purchasing or using biomethane, or by acquiring and registering Biomethane Guarantee of Origin Certificates (CGOB). The CGOB will ensure traceability, and transparency, and prevent double counting of environmental attributes, functioning as both a certification and a tradable asset in the capital market. The National Petroleum Agency (ANP in Portuguese) will regulate CGOB issuance, monitor compliance, and define the obligated parties based on the volume of gas traded, with penalties for non-compliance.

### BOX 4: Federal Strategy for Incentivizing Sustainable Biogas and Biomethane Use

The Federal Strategy for Incentivizing Sustainable Biogas and Biomethane Use outlines comprehensive measures to support the growth of biogas and biomethane as sustainable energy sources. According to Article 4 of this strategy, the government provides support for the implementation of biogas digesters, biogas purification systems, and biomethane production and compression technologies. In addition, the strategy promotes the use of biomethane in transportation, encouraging initiatives to fuel light and heavy vehicles — such as buses, trucks, agricultural tractors, and even ships — using biomethane or hybrid technologies through the establishment of green corridors and fueling stations.

To further encourage investment, the strategy also supports the development of scientific and technological research, the dissemination of innovations, and the deployment of methane mitigation technologies. Measures and mechanisms are in place to stimulate methane emission reductions, with an emphasis on public-private partnerships. Moreover, the program fosters both national and international cooperation in financing, training, and technology transfer, facilitating the widespread adoption of methane capture technologies and creating opportunities for carbon markets.

### Resolution ANP No. 886/2022

ANP Resolution No. 886/2022[34] establishes guidelines for the regulation of biofuels in Brazil, aiming to promote sustainable use and expand production. This resolution specifically mentions biomethane as a renewable fuel and complements the previous policies by providing technical specifications and quality standards for biomethane production, distribution, and use. The regulation sets out criteria for the certification of biofuel producers and suppliers, as well as for the commercialization and quality control of the products offered in the market. Additionally, it defines mechanisms for monitoring and verifying GHG emissions, encouraging practices that promote efficiency and innovation in biofuel production.

## 4.3 Framework for Climate and Methane Mitigation from the Solid Waste

### Brazil's National Climate Change Policy

Brazil's National Climate Change Policy, established by Law No. 12.187/2009,[35] seeks to promote the mitigation of and adaptation to climate change in Brazil, aiming to reduce GHG emissions and promote sustainable development. This policy sets out guidelines and actions to integrate climate issues across federal, state, and municipal spheres, encouraging the participation of civil society, the private sector, and government bodies in implementing strategies that balance environmental

[34] BRASIL. Agência Nacional do Petróleo, Gás Natural e Biocombusvveis. Resolução ANP n. 886, de 27 de junho de 2022. Regulamenta o biometano e estabelece normas para sua produção e uso. Diário Oficial da União: seção 1, Brasília, DF, 28 jun. 2022. Available at: https://www.in.gov.br/en/web/dou/-/resolucao-anp-n-886-de-27-de-junho-de-2022-408203260. Accessed on Nov. 14th, 2024.

[35] BRASIL. Lei n. 12.187, de 29 de dezembro de 2009. Ins1tui a Polí1ca Nacional sobre Mudança do Clima e dá outras providências. Diário Oficial da União: seção 1, Brasília, DF, 30 dez. 2009. Available at: https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm. Accessed on Nov. 20th, 2024.

protection with economic development. The law also mandates the creation of a system for monitoring and verifying emissions and includes provisions for the development of carbon markets and other economic mechanisms to incentivize GHG emissions reductions.

### Zero Methane Program

Launched in 2022, the Zero Methane program is a federal initiative aimed at reducing methane emissions across various sectors of the economy, including MSW.[36,37] Key actions under this program include:

- Incentives for biogas capture at sanitary landfills and its use as an energy source. Methane capture technologies enable the conversion of methane into electricity or biofuel, promoting a circular economy and enhancing energy efficiency in the waste sector.
- Expansion of organic waste treatment through processes such as composting and anaerobic digestion, which allow for more efficient handling of organic waste, reducing the amount sent to landfills and consequently cutting methane emissions.
- Promotion of private and public investment in MSW management infrastructure, with an emphasis on methane capture and utilization technologies.
- Creation of opportunities for the private sector through carbon credit projects, where methane emission reductions can be converted into tradable assets in the carbon market, encouraging companies and industries to contribute to climate change mitigation. The Zero Methane program includes several specific incentives to promote investment in methane reduction technologies as the Federal Strategy for Incentivizing Sustainable Biogas and Biomethane.

### Brazil's Climate Change International Commitments: NDC Update, Global Methane Pledge and COP29 Commitment to Reducing Methane from Organic Waste

Brazil presented its updated Nationally Determined Contribution (NDC) at COP 29 in November 2024.[38] The country has committed to a significant reduction in its GHG emissions, with an economy-wide target of reducing net emissions by 59 to 67 % below 2005 levels, by 2035. This target sets an emission range of 1.05 to 0.85 gigatons of carbon dioxide equivalents each year for total emissions, based on the most recent inventory data. The updated NDC outlines specific sectoral actions and initiatives aimed at achieving these reductions across various areas, including land use, waste management, energy, agriculture, and industry.

It is also noteworthy that during COP26, held in Scotland in 2021, Brazil joined the Global Methane Pledge along with more than 100 other countries, committing to reduce global methane emissions by 30% by 2030 compared to 2020 levels.

Brazil's waste management strategy, PLANARES, which includes expanding technologies such as anaerobic digestion and aerobic treatment to reduce methane emissions from organic waste, directly supports the objectives outlined in the Global Methane Pledge and COP29 Declaration regarding prioritizing solutions that focus on avoidance, diversion, valorization, and infrastructure in the solid waste sector.

A key component of Brazil's strategy is the reduction of methane emissions, particularly from waste, which plays a central role in meeting the nation's overall GHG reduction targets. In the solid waste management sector, the overall goal is to expand waste management efforts through technologies aiming to support reducing methane emissions from organic waste (see initiatives in Annex I).

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[36] BRASIL. Ministério do Meio Ambiente. Programa Metano Zero. Disponível em: https://www.gov.br/mma/pt-br/assuntos/mudanca-do-clima/ozonio/ProgramaMetanoZero.pdf. Accessed on Feb 3rd, 2025.

[37] Further information about the program can be accessed at: h=ps://www.gov.br/mma/pt-br/assuntos/mudancado-clima/ozonio/ProgramaMetanoZero.pdf

[38] BRASIL. Second Nationally Determined Contribution (NDC): National determination to contribute and transform. Brasília, 2024. Available at: https://unfccc.int/sites/default/files/202411/Brazil_Second%20Nationally%20Determined%20Contribution%20(NDC)_November2024.pdf. Accessed on Nov. 20th, 2024.

### Table 1: Summary of the main National Regulations on Waste and Methane

| Regulation/Policy | Key Provisions | Impact on Waste Management & Methane Emissions |
|---|---|---|
| **National Policy Framework for Waste Management** | | |
| National Solid Waste Policy (PNRS) (Law No. 12,305/2010) | Mandates shared responsibility across product life cycles, promotes selective waste collection, and aims to eliminate open dumps. | Encourages integrated waste management, reduces landfill waste, and mitigates methane emissions through better organic diversion from landfills and other practices. |
| National Solid Waste Plan (PLANARES) (Decree No. 11.043/2022) | Main planning instrument of PNRS; provides long-term strategies and GHG-related goals (e.g., 13.5% organic recycling, biogas utilization). | Sets national goals for methane mitigation through organic waste treatment and energy recovery from MSW. |
| Basic Sanitation Legal Framework (Law No. 14.026/2020) | Aims for universal sanitation coverage by 2033, addressing waste management as part of basic sanitation services. | Promotes regional collaboration and investment in waste infrastructure, fostering methane capture. |
| "Zero Dumpsites" Program | Governmental initiative to eradicate open-air dumps and replace them with sanitary landfills. | Reduces methane emissions from decomposing waste through controlled landfill practices. |
| Incentives for Recycling (Law No. 14.260/2021) | Creates tax incentives and investment funds for recycling initiatives. | Encourages circular economy and reduces waste sent to landfills, lowering methane emissions indirectly. |
| Pró-Catador Program (Decree No. 11.414/2023) | Promotes the formalization and support of informal recyclers through cooperatives. | Strengthens recycling chain and diversion of recyclables from landfills, reducing methane generation. |
| **Enabling National Policies** | | |
| Brazilian National Biofuels Policy (Law No. 13.576/2017) | Incentivizes biofuel production and use, linking agriculture to renewable energy, including methane capture from waste. | Supports methane conversion to energy, enhancing the circular economy in the waste sector. |
| "Fuel of the Future law" (Law No. 14.993/2024) | Promotes green diesel, sustainable aviation fuel, and biogas/biomethane to replace fossil fuels. | Encourages methane in the transport sectors, reducing reliance on fossil fuels. |
| Federal Strategy for Sustainable Biogas and Biomethane Use | Supports biomethane infrastructure, research, and use in transportation; promotes public-private cooperation. | Enables methane conversion to clean energy; supports scaling of biomethane solutions nationwide. |
| ANP Resolution No. 886/2022 | Defines technical standards for biofuels and biomethane, including certification and GHG tracking. | Ensures biomethane quality, commercialization, and emission monitoring, fostering sustainable waste-to-fuel pathways. |
| **Framework for Climate and Methane Mitigation** | | |
| Brazil's National Climate Change Policy (Law No. 12.187/2009) | Framework for climate mitigation and adaptation; includes GHG monitoring and carbon markets. | Supports methane reduction goals and integration of waste management into climate strategies. |
| "Zero Methane" Program | Launched in 2022 to reduce methane emissions, focusing on capturing biogas from landfills and promoting waste treatment technologies | Targets methane reduction through landfill biogas capture and other initiatives, fostering energy recovery. |
| Brazil's NDC and Methane Commitments (COP26, COP29, Global Methane Pledge) | Commitment to reduce GHGs 59-67% below 2005 levels by 2035; includes organic waste treatment in methane strategy. | Aligns solid waste strategies (PLANARES, anaerobic digestion, etc.) with national and international methane reduction goals. |

SECTION 5

# Stakeholders Involved in Waste Methane

In Brazil, the key stakeholders in charge of improving waste management and mitigating methane emissions from waste include government agencies, private companies, industries, waste-picker cooperatives, local communities, and waste sector workers. The table below lists relevant stakeholders and explains their role in integrated solid waste management, climate change, and GHG mitigation.

**Table 2: Main Stakeholders and Roles on Methane emissions from the Brazilian Solid Waste Sector**

| Category | Stakeholder | Role | Methane-Specific Activities |
|---|---|---|---|
| **Federal Level** | | | |
| **Regulator** | **Ministry of Environment and Climate Change (MMA)** | Develops public policies for environmental management and climate change, coordinates the PNRS | Sets guidelines for methane reduction strategies and regulates GHG mitigation actions in waste sector |
| **Regulator** | **Ministry of Cities (Mcid)** | Oversee urban development policies, including infrastructure, sanitation, and land use for final disposal of municipal solid waste | Develops projects for sustainable landfill development to minimize methane emissions |
| **Regulator** | **National Water and Basic Sanitation Agency** | Regulates and ensures the provision of basic sanitation services, including the treatment of solid waste | Oversee the prevention of water contamination from waste disposal sites, contributing to methane mitigation efforts |

| Category | Stakeholder | Role | Methane-Specific Activities |
|---|---|---|---|
| **Federal Level** | | | |
| **Enabler** | **Ministry of Regional Development** | Promotes sustainable development initiatives in both urban and rural areas | Finances waste management infrastructure and sanitation projects targeting methane emission reduction |
| **Enabler** | **Brazilian Institute of Environment and Renewable Natural Resources** | Enforces compliance with environmental regulations | Monitors methane emissions from solid waste disposal sites and issues penalties for violations |
| **Funder** | **Brazilian Development Bank** | Provides financing and investment for infrastructure projects related to waste management | Supports biogas production, methane capture, and other initiatives aimed at reducing GHG emissions from the waste sector |
| **State Level** | | | |
| **Regulator** | **State Environmental Agencies** | Issue environmental permits for waste management activities at the state level | Ensure methane reduction measures are implemented in local jurisdictions |
| **Municipal Level** | | | |
| **Regulator and responsible for MSW servicies** | **Municipal Governments** | Responsible for management of household waste, including collection, transportation, treatment, and final disposal | Ensure adherence to methane emission regulations and implement waste collection fee systems to fund proper waste management |
| **Enabler** | **Municipal Environmental Councils** | Local entities that facilitate community participation in waste management decisions, policy formulation, and environmental education | Promote engagement in community-level methane reduction efforts |
| **All Levels** | | | |
| **Enabler** | **Waste-Picker Associations and Cooperatives** | Conduct solid waste management activities, facilitating the collection, sorting, and commercialization of recyclable materials | Divert waste from landfills, reducing methane generation potential while providing social inclusion and economic opportunities for marginalized populations |
| **Enabler** | **Private Sector and Industries** | Participate in corporate social responsibility programs and support reverse logistics initiatives | Collaborate on projects for anaerobic digestion, landfill gas capture and utilization to reduce methane emissions |
| **Enabler** | **Local Communities and Organizations** | Engage in recycling, composting, and other environmental awareness activities | Help reduce waste going to landfills and minimize methane emissions in local areas |
| **Supportive** | **Civil Society Organizations** | Act as advocates for the environment, raising awareness and providing local-level oversight | Participate in monitoring and advocacy for methane reduction practices |
| **Supportive** | **Academic Community** | Conduct research on waste management solutions and climate change mitigation strategies | Provide data and technological solutions for measuring and reducing methane emissions |

SECTION 6

# Challenges and Opportunities to Mitigate Waste Methane

Addressing methane emissions from waste requires a cross-cutting approach, involving prevention measures, improved waste collection, enhanced waste segregation, increased composting, increased gas capture and usage, both in anaerobic digestion and landfills, to reach the targets set by PLANARES.[39] Additionally, international support, knowledge transfer, innovative financing models, and robust policy frameworks are essential to transform current waste management practices and make meaningful strides in methane reduction.

Through targeted interventions and support, Brazil can turn the challenge of waste methane into an opportunity for sustainable development, reinforcing climate resilience, enhancing public health, and contributing significantly to global climate mitigation efforts. These targeted interventions are highly relevant in the context of Brazil being the host country of COP30 in 2025. All of them should be included in the agenda as one of the main topics of the Conference.

This section identifies the main challenges and opportunities for methane emissions reduction in waste management in the country based on the content presented in the previous chapters and also presents the synthesis of a Waste Clinic held in June 2024 (Box 5), where CATF convened 19 stakeholders, including municipalities, state and national government representatives in Brasilia/DF to discuss waste management and methane mitigation.

[39] Target for 2040 is to recover 257 MW from landfills and 69 MW from anaerobic digestion units.

## BOX 5: Identifying Challenges and solutions in Brazil's Waste Management Sector with Key Stakeholders – Synthesis of the main results of the Waste Clinic conducted in Brasilia in June 2024.

### What Is a Waste Clinic?

A Waste Clinic is an expert and peer assisted group session that focuses on discussing and identifying solutions to municipal solid waste challenges faced by local governments (the patients) by drawing on perspectives and knowledge of peers and experts (the doctors) who help diagnose problems and identify solutions.

Challenges and solutions identified by the participants of the Waste Clinic focused on the following four topics:

1. **Waste Sector Data**
   - **Data fragmentation:** lack of a unified and integrated system for collecting, storing, and analyzing data on waste generation, collection, and disposal.
   - **Incomplete or missing data:** data on large generators and municipal solid waste management plans is incomplete or nonexistent in many cases.
   - **Difficulty tracking data:** difficulty in tracking the flow of waste from generation to final disposal, especially in the case of organic waste.
   - **Lack of standardization:** absence of common standards and methodologies for data collection and analysis, making it difficult to compare different regions and identify trends.
   - **Shortage of qualified personnel:** lack of qualified professionals to collect, analyze, and interpret data.
2. **Source Separation, Collection, and Organic Waste Treatment**
   - **Low public participation:** difficulty in engaging citizens in source separation, especially for organic waste.
   - **Lack of infrastructure:** lack of adequate infrastructure for separate collection and treatment of organic waste.
   - **Challenges in environmental education:** difficulty in raising public awareness about the importance of waste separation and the need to change habits.
   - **Lack of composting scale:** difficulty in implementing large-scale composting systems.
3. **Final Disposal**
   - **Closure of dumpsites:** thousands of dumpsites are still in operation but there is an increased movement to close open dumpsites and seek for more sustainable alternatives for waste disposal.
   - **Bottlenecks in waste disposal:** difficulty in properly disposing of waste due to the absence of proper solutions in many regions, especially organic waste and waste from large generators.
   - **Illegal or irregular disposal:** presence of illegal disposal of waste in various locations.
4. **Financing for Waste Management**
   - **Lack of resources:** lack of financial resources to implement public waste management policies, considered as an obstacle to implementing effective public policies.
   - **Difficulty in obtaining data:** difficulty in obtaining data on the costs and benefits of different waste management alternatives.

Proposed solutions to address the challenges mentioned above:

- **Creation of a unified data system:** development of a single, integrated system for collecting, storing, and analyzing waste data.
- **Standardization of methodologies:** establishment of common standards and methodologies for data collection and analysis.
- **Strengthening enforcement:** increased enforcement of environmental laws and regulations.
- **Investment in environmental education:** intensification of environmental education efforts to raise public awareness about the importance of proper waste management, encouraging source separation and reduction of waste generation.
- **Implementation of composting systems:** implementation of large-scale composting systems for the treatment of organic waste.
- **Search for innovative solutions:** investment in innovative technologies and business models for better waste management, prioritizing anaerobic digestion technologies for the treatment of organic waste.
- **Financing:** structure adequate user fees systems and identify funding sources to enable the implementation of the proposed actions.

## 6.1 Challenges in reducing waste methane emissions

### Waste management infrastructure deficiencies

As presented on Section 2, Brazil still fails to provide collection services to 7% of users, while 26% of all collected MSW is sent to inadequate disposal sites, and only 4% of MSW recycled, including 1% of organic fraction recovered through composting initiatives.

Compared to other countries in the region, the MSW recovery rate in Brazil is slightly lower than the regional average of 6%.[40] This is a major challenge to the country's ambition to transition towards a circular economy but also presents a major opportunity to adopt a resourceful approach and reduce emissions, tackling methane from waste, with innovative solutions and technologies for gas capture and usage, both in landfills and treatment facilities. The afore mentioned challenges are primarily due to the following reasons:

- Limited waste segregation, collection, and inadequate disposal practices, with heavy reliance on landfills and open dumps.
- Reduced adoption of organic waste treatment systems, such as composting or anaerobic digestion.
- Lack of efficient landfill gas recovery systems and infrastructure challenges regarding landfill connection to the electricity grid or to natural gas pipelines.

### Lack of enforcement

The legal and regulatory framework dedicated to waste management in Brazil is quite comprehensive, ambitious, and modern, but the figures show that it's far from being implemented by the different stakeholders with direct responsibilities, as many targets set by the current legislation are not met. In this case it is important to highlight the lack of implementation of the national frameworks by municipalities, who are the primary responsible to deliver municipal waste management services and solutions, but lack of knowledge, human resources and funds for this agenda. For example, the determination to close all dumpsites in the country by August 2024 was not accomplished and the PLANARES target set in 2022 to divert MSW from final disposal sites (48% by 2040) is still pending to be implemented. Thus, poorly enforced regulations around waste collection, segregation, disposal, and methane emissions are one of the key challenges for waste methane mitigation in the country.

[40] UNEP and ISWA. Global Waste Management Outlook 2024 – GWMO2024. Nairobi, 2024.

### Financial constraints

Waste management costs in Brazil are mostly covered through resources from municipal budgets, with very few cities having user fees systems in place. In fact, several local governments have not been able to structure and approve a waste fee system (despite it being mandatory under Federal Law) due to local political conditions and social opposition.

According to the most recent information available in the system, only 437 municipalities (7.8% of total municipalities) have submitted the necessary information about the existing user fee system to cover waste management costs, and only 67 municipalities (1.2% of total municipalities) were able to demonstrate the economic sustainability of the user fees system.[41]

This situation makes financial constraints a considerable barrier to the overall advancement of the country's waste management system and therefore to methane mitigation, mostly for the following:

- Lack of waste fees systems to recover running costs of waste management in most cities in the country.
- Limited funding for advanced waste processing technologies and infrastructure development.

### Capacity and expertise gaps

Waste management has been following a business-as-usual approach in the country for many decades, with very little development, inhibiting the incorporation of new practices, new technologies, and innovative approaches. Therefore, the following challenges still inhibit methane mitigation:

- Lack of trained personnel and technical knowledge to expand methane capture or reduction technologies.
- Scarcity of local providers of methane recovery and treatment equipment and technology.

## 6.2 Opportunities for methane mitigation in MSW

### Economic opportunities

Methane mitigation represents not only a major opportunity to reduce global warming, but also an important source of revenue to the waste industry in the country, supporting the development of new initiatives.

- Implementing methane capture and biogas production could generate revenue to both waste operators and governments, while reducing fossil fuel reliance for the different industrial and economic sectors – contributing to their own scope 2 mitigation targets.
- Revenues from connection to the natural gas grid or selling compressed gas to industries.

### International support and funding

As Brazil is leading on many international policy topics (e.g., G20, BRICS, COP) there is a unique opportunity to bring more attention to this topic, with the attraction of more funds, awareness, technologies and capacity building both for public and private sectors.

- Attracting more visibility, additional support and opportunities from programs like the Global Methane Pledge, Green Climate Fund, LOW-M Initiative and others that provide technical and financial support.
- Use COP 30 visibility to attract international funding and investment.

### Job creation in the waste sector

The waste management industry can leverage its role and add-value to current practices, with more and better qualified job opportunities at the local level, aiming to improve waste collection coverage, waste diversion and treatment of organics, taking the opportunity that there is a growing market for by products from waste management. Therefore, we have identified the following specific opportunities to be explored in the country:

- Developing infrastructure and implementing technologies that create green jobs in waste collection, segregation, treatment and recycling.
- Enhance professional training with traditional institutions to promote capacity building.

[41] BRASIL (2024). Ministério das Cidades. Secretaria Nacional de Saneamento Ambiental – SNSA. Relatório dos Serviços de Lompeza Urbana e Manejo de Resíduos Sólidos – SINISA 2024 ano de referência 2023. Brasília. Available at: https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/saneamento/sinisa/resultados-sinisa/RELATORIO_SINISA_RESIDUOS_SOLIDOS_2024.pdf. Accessed on May 9th, 2025.

## 6.3 Priority recommendations to mitigate waste methane in Brazil

| Subject | Stakeholder(s) | Action |
|---|---|---|
| **Institutional recommendations** | | |
| Waste diversion and reduction | MMA together with National and State Environment Agencies | Enforce current legislation and ensure proper separate collection schemes, waste recovery and adequate disposal. |
| | MMA | Foster policies to promote waste reduction, reuse, and recycling, as well as composting, mechanical-biological treatment, and anaerobic digestion to reduce organic waste sent to landfills and open dumpsites.<br>Policies to promote waste reduction include: stimulating food banks and food donation, redefining products expiration dates, establishing waste fees and "pay as you throw" schemes, as well as developing public awareness campaigns and education programs. |
| Composting and anaerobic digestion | MMA, MCid and Brazilian Agricultural Research Corporation | Support the development of small-scale and community-based composting and biogas plants for organic waste to divert organic waste from disposal sites and tackle methane emissions. |
| | MCid, Ministry of Regional Development, Ministry of Agriculture together with the National and Regional Development Banks | Support the development of municipal composting and biogas plants for presorted organic waste, mainly green waste from public and private gardening and food supply-chain retailers. |
| Improving waste disposal sites | Ministry of Science, Technology and Innovation and Ministry of Development, Industry, Commerce and Services | Disseminate information, knowledge, and create incentives for technologies to capture methane from landfills and convert it into energy, sell it to the gas grid or flare it to reduce its atmospheric release. |
| | MMA and Brazilian National Environmental Council | Consider methane recovery systems as mandatory for landfills where technologically and economically viable and to have improved operational practices and biocovers where gas capture systems are not viable or are not working effectively. |
| Integrated waste management systems | MMA | Support the development of integrated waste management systems that combine various strategies and technologies to minimize waste generation, recover most of waste, enable organic diversion from landfills and thus, reducing methane emissions. |
| Promote international partnerships | MMA | Leverage global climate funding and technology collaborations to scale solutions nationwide. |
| **Policy recommendations** | | |
| Enforcing regulatory framework | MMA | Develop new regulations on landfill operations, waste segregation at source, and methane usage as energy source. |
| | MMA, MCid, Ministry of Regional Development, together with National and State Environment Agencies, Public Prosecution Sector and State Courts of Audits | Enforce the closure of all Brazilian dumpsites, to accomplish the National mandatory targets. |
| | National Water and Sanitation Agency, together with State Courts of Audits and Regional Regulation Agencies | Provide guidance and training in developing waste-fees systems for municipalities, to enable the recovery of running costs and finance of new infrastructure required to reach the targets set by PLANARES. |

| Subject | Stakeholder(s) | Action |
|---|---|---|
| **Policy recommendations** | | |
| Incentives for sustainable practices | Federal Government, State Governments, National Congress and State Parliaments | Introduce subsidies or incentives for businesses investing in waste methane reduction |
| | National Congress and State Parliaments | Consider developing new legislation on including biomethane as a target at public sustainable purchase policies (as a fuel for public services vehicles, for example). |
| Public-Private Partnerships | Federal Government, through the PPI Program and Federal banks | Encourage partnerships between government and private sector to co-finance methane capture, resources recovery, and organic treatment facilities. |
| | MCid | Foster municipalities and consortia to incorporate organic waste treatment, methane mitigation and, when technically feasible, landfill gas recovery and use in their waste strategies. |
| Capacity building programs | MMA and MCid | Develop training programs for local authorities and waste management professionals in advanced waste management techniques. |
| | MMA and MCid | Develop professional training programs with local partners (SENAI, FNP, CNM etc.) to create skills in methane prevention and recovery. |
| **Recommendations for future research and data collection** | | |
| Improve emissions data | MMA | Establish protocols for accurate and up-to-date measurement of methane emissions across different waste management practices. |
| | MMA and MCid | Improve data systems to collect and monitor activity from disposal sites, including emissions. |
| | Brazilian National Environmental Council and Brazilian Agency of Technical Norms | Develop standards to set guidance for methane measurement from landfills. |
| Behavioral studies | Municipalities | Study community attitudes and foster citizen's engagement towards waste segregation, recycling, and composting to design effective awareness campaigns. |
| Pilot projects and case studies | Federal Government, through the different Agencies (ABDI, FINEP, IPEA, etc.) | Support pilot projects addressing the challenges mentioned above and document case studies on successful methane reduction interventions, including costs, emissions impact, and replicability. |

SECTION 7

# Conclusions

Despite a comprehensive and ambitious regulatory framework that has been developed in the country during recent years, Brazil still faces several challenges to improve its current waste management system, where the linear approach (collection, transportation, and final disposal) is still the common practice. The transition towards a more resourceful system, with source separation and selective collection, closure of open dumpsites and other inadequate disposal sites, and installation of waste recovery and treatment facilities, requires joint actions to be implemented by the different level of governments and institutions, including the private sector and individuals. This transition will lead not only to a better waste management system but will also result in waste methane mitigation.

**The key takeaways emerging from this report can be summarized as follows:**

## The urgency of methane reduction

Methane is a potent short-lived GHG, and its reduction can slow global warming in the short term. The waste sector is a relevant source of methane emissions, largely due to organic waste decomposing. By reducing these emissions, Brazil can contribute meaningfully to climate targets while also improving air quality and public health, at a low cost in comparison to other mitigation alternatives.

## Main challenges

Brazil is experiencing increased waste generation, but many regions lack the infrastructure for effective waste management. Limited financial resources, technical expertise, and enforcement of waste management policies exacerbate methane emissions from MSW. These constraints require targeted strategies that account for both resource limitations and local contexts.

## Mitigation opportunities

Despite these challenges, there are numerous pathways to mitigate methane emissions from waste. These include waste minimization (mainly of food waste), enhanced waste collection, waste diversion, waste treatment (through composting, and anaerobic digestion initiatives), and methane capture and usage in landfills. Implementing such measures not only effectively reduces emissions but also creates opportunities for economic growth, such as job creation in waste management, revenues from biomethane sales to the grid, deploying the potential of innovative projects, and investment in green infrastructure.

## Strengthening and enforcing policy frameworks

Enforcement of existing regulatory frameworks is critical for achieving long-term reductions in methane emissions and developing new strategies such as PLANARO, National Circular Economy Roadmap, Climate Plan are positive instruments to support the implementation of legal instruments.

## Global support and collaboration as catalysts for change

Achieving methane reduction from MSW requires strong global support, emphasizing technology transfer, international funding, and capacity building. International partnerships can provide access to advanced waste management technologies, support capacity-building programs, and bridge financial gaps that often hinder progress in developing countries. Technology transfer is particularly important to enable the adoption of proven methods and technologies for methane capture, waste processing, and sustainable disposal.

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The climate agenda is now well perceived in the country and could serve as a key driver for strengthening the overall waste management system, given its cross-cutting mitigation potential across industries. Improved waste management can provide secondary resources to replace virgin raw materials and generate renewable fuels and energy sources such as biogas and biomethane. By adopting methane reductions as a guiding force, Brazil can turn today's constraints into tomorrow's opportunities by transforming waste into a resource and thus advancing its climate agenda while also fueling innovation, resilience, and a more sustainable future for long-term prosperity.

ANNEX

# Case Studies

This annex includes case studies showcasing successful methane mitigation projects and initiatives in Brazil.

## GNR Fortaleza

The GNR Fortaleza plant is an exemplary case of biogas-to-biomethane conversion in Brazil. It was inaugurated in 2018 in the municipality of Caucaia, inside the metropolitan region of Fortaleza, Ceará, in the Northeast of the country. The plant captures and treats biogas produced at the ASMOC Landfill, where MSW from the greater Fortaleza area is deposited.

The GNR Fortaleza operates an advanced natural gas treatment system with a production capacity of 100,000 $m^3$/day of biomethane, equivalent to approximately 20% of Ceará's natural gas consumption.[41] It is the first plant in the region to inject biomethane into the local gas pipeline network and was certified under Brazil's RenovaBio program. The facility is also certified by the United Nations to issue carbon credits and is part of the Clean Development Mechanism.

With a strong commitment to sustainability, the plant prevents the release of around 500,000 tons of $CO_{2eq}$/year, significantly reducing the region's GHG emissions. The GNR Fortaleza also participates in the Verified Carbon Standard program through Project 4209, certifying reductions and removals of emissions that contribute to Verified Carbon Units. This initiative represents a major step forward in mitigating climate change impacts, ensuring a positive environmental legacy for future generations.

## Orizon's Biogas Project in Paulínia

Orizon, a leading company in MSW management, has invested R$ 240 million (US$ 40 million) in an innovative project located in Paulínia, São Paulo, focused on converting waste into valuable biomethane. This initiative is part of a broader effort to contribute to sustainable energy production and improve waste management practices in the region.

The project is designed to process up to 200,000 tons/year of waste, primarily MSW.[42] Once processed, the biogas produced is purified and upgraded to biomethane, which can be used in place of natural gas, contributing to a significant reduction in methane emissions.

The project plays a key role in the local economy, by providing an efficient waste management solution and generating renewable energy. It also supports the regional agricultural industry by reducing the environmental impact of waste disposal, turning it into a resource that can power local industries and homes. Orizon's biogas project in Paulínia is not only a model of sustainable waste management but also an important step towards reducing the carbon footprint of the region.

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41 GNR FORTALEZA. Usina de Gás Natural Renovável Fortaleza: produção e valorização de biogás a partir de resíduos sólidos. Fortaleza, 2024. Available at: https://gnrfortaleza.com.br/. Accessed on Nov. 18th, 2024.

42 ORIZON. Relatório de Sustentabilidade 2023. Rio de Janeiro, 2023. Available at: https://orizonvr.com.br/novo_site/wp-content/uploads/2024/06/grupoOrizon_RelatorioSust2023.pdf. Accessed on Nov. 18th, 2024.

## Biogas and Biometano Production at the Sabará Landfill in Belo Horizonte

Minas Gerais will receive a new biomethane production and energy generation plant at the Sabará landfill, located in the metropolitan area of Belo Horizonte, with an investment of R$ 152 million (US$ 25.3 million). The plant is expected to produce 80,000 $m^3$/day of renewable natural gas, utilizing biogas generated from the decomposition of organic waste in the landfill.[43]

The biomethane plant will employ advanced technology to purify and enhance the calorific value of the biogas, making it nearly identical to conventional natural gas. In addition, the facility will include two energy generators with a combined capacity of 2.8 MW for self-consumption, further increasing its energy independence. This process will also prevent the release of 415 tons of $CO_{2\ eq}$/year, reducing the environmental impact of methane emissions from the landfill.

The investment aims to foster sustainable energy development while generating 24 permanent jobs and contributing to the diversification of Brazil's energy matrix. By utilizing waste to produce energy, the project is aligned with Minas Gerais commitment to environmental sustainability.

## Florianópolis Organic Waste Collection Initiative

Florianópolis, through the Capital Improvement Authority, has implemented an innovative organic waste collection program, aiming at significantly improving waste management and promoting sustainability. The initiative, launched in 2020, focuses on collecting organic waste from households, with an estimated monthly collection of 22 tons of food waste for composting. This groundbreaking program is the first of its kind in Brazil, introducing a third waste fraction: organic waste, alongside the already established separate collection of recyclables and residual waste.

The organic waste collected is processed for composting and used in urban agriculture, contributing to environmental sustainability by diverting significant amounts of waste from landfills. Approximately 35% of the material sent to landfills in the city consists of organic waste, with food waste accounting for 24% and green waste (such as garden refuse) making up 11%. By effectively separating and collecting organic waste, the initiative supports both composting and urban agriculture, aligning with the city's broader sustainability goals.

Florianópolis has set ambitious waste management goals for 2030, aiming to recycle 60% of dry recyclables and 90% of organic waste.[44] This initiative is expected to lead to significant cost savings, with an estimated R$ 50 million saved annually through reduced landfill and transportation costs, as well as gains in recycling. The project also aims to reduce the amount of organic waste currently sent to landfills as residual waste, contributing to the city's overall waste management efficiency and sustainability.

## Composting in São Paulo City

São Paulo, Brazil's largest city, has implemented a significant composting initiative that contributes to waste management, the reduction of methane emissions, and the creation of organic fertilizer. The project, known as "Feiras e Jardins Sustentáveis" (Sustainable Markets and Gardens), was introduced in December 2015 as part of the city's broader efforts to promote environmental sustainability and reduce the amount of organic waste sent to landfills.

The city operates five composting patios that together process organic waste collected from local open-air markets. These patios collectively have the capacity to receive a maximum of 15,600 tons/year of fruit, vegetable, and legume waste. In turn, they produce up to 3,120 tons/year of organic compost, which is distributed for use in public spaces such as parks and gardens.[45]

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[43] ASJA. Planta de Biometano em Sabará: unidade de produção de biometano a partir de resíduos orgânicos. Sabará, 2024. Available at: https://www.asja.energy/map-location/sabara/?mpfy-pin=2840. Accessed on Nov. 20th, 2024.

[44] FLORIANÓPOLIS. Secretaria Municipal do Meio Ambiente e Desenvolvimento Sustentável. Gestão de Resíduos Orgânicos. Portal da Prefeitura de Florianópolis. Available at: https://www.pmf.sc.gov.br/entidades/residuos/index_php?cms=organicos&menu=4&submenuid=150. Accessed on Nov. 14th, 2024.

[45] SÃO PAULO. Prefeitura da Cidade de São Paulo. Resíduos Orgânicos: Compostagem em São Paulo. São Paulo, 2024. Available at: https://capital.sp.gov.br/web/spregula/w/residuos_solidos/283430. Accessed on Nov. 18th, 2024.

The process begins at local open-air markets, where environmental education teams work with vendors to encourage the separation of organic waste from other types of waste. After the market ends, the cleaning crews collect the separated materials and transport them to the composting patios.

Upon arrival at the patios, the organic waste is mixed with tree pruning residues and straw, creating a mixture that is laid out in rows, composting beds. The composting process takes approximately 120 days to complete, during which microbial activity breaks down the organic materials into nutrient-rich compost.

## Composting in São José do Rio Preto

São José do Rio Preto, a municipality in the countryside of São Paulo, has been efficiently managing its waste for over 20 years. With a commitment to sustainable waste management, the city ensures that only non-recyclable materials are sent to the landfill, while the rest of the waste, particularly organic waste, is sent for composting.

The municipality's waste management process starts with the collection of approximately 400 tons/day of MSW. Once collected, the waste is first sorted on a conveyor belt, where workers separate recyclable materials that can be sold to recycling companies. However, the most notable aspect of São José do Rio Preto's waste management system is its efficient use of organic waste, such as food scraps, which is transformed into high-quality compost. This composting process takes place in a designated warehouse, where organic waste is stored for approximately 90 days. At the end of the 90-day period, the decomposed material is shifted to remove any remaining plastic or packaging, resulting in high-quality compost, which is then sold to local farmers for use as fertilizer. This facility produces 60 tons/month of compost through this system.[46]

## Composting in Brasília

In Brasília, the capital of Brazil, a successful initiative has turned organic waste into valuable resources for local farmers. The city, home to 2.9 million residents, processes a significant portion of the organic waste generated by the population, transforming it into organic compost for use in agriculture. This initiative has been instrumental in supporting the region's agricultural sector, particularly in areas with nutrient-poor soils.

The Municipality collects around 70,000 tons/month of MSW. Approximately 40% of this waste, including food scraps, fruit and vegetable peels, is sent to the composting facility in Ceilândia, where it undergoes a natural decomposition process. In 2022, almost 20,000 tons of organic waste were transformed into compost.[47]

The process of turning organic waste into compost is based on natural fermentation, where microorganisms break down plant and animal materials in the presence of air, moisture, and heat. The decomposition process takes approximately 90 to 100 days. Once the composting process is complete, the material is sifted to remove any non-compostable material, such as plastic. What remains is nutrient-rich compost ready for use.

In 2023, the program benefited 511 farmers, each receiving an amount of compost based on the size of their farm. Furthermore, a law passed in 2020 (Law No. 6.518/2020) has made the treatment of organic waste mandatory for public and private entities, as well as residential and commercial condominiums in the District. This has created a broader framework for managing organic waste across the region, with the composting program playing a critical role in meeting these legal requirements.

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[46] SÃO JOSÉ DO RIO PRETO. Prefeitura Municipal de São José do Rio Preto. Compostagem: programa de gestão de resíduos orgânicos em São José do Rio Preto. São José do Rio Preto, 2024. Available at: https://www.riopreto.sp.gov.br/secretarias/meio-ambiente. Accessed on Nov. 18th, 2024.

[47] BRASÍLIA. Serviço de Limpeza Urbana do Distrito Federal. Compostagem: gestão de resíduos orgânicos no Distrito Federal. Brasília, 2024. Available at: https://www.slu.df.gov.br/compostagem/. Accessed on Nov. 18th, 2024.

## Anaerobic Digestion in Rio de Janeiro

Located in the northern zone of Rio de Janeiro city, the *Caju Eco-park*[48] is an initiative that has transformed an old landfill into a sustainable waste treatment facility. Since its launch, it has become a crucial part of the city's efforts to improve waste management, reduce methane emissions, and generate renewable energy.

The Rio de Janeiro collaborative pilot-initiative, called "Biomethanisation Unit", treats the organic fraction through a solid-state batch anaerobic digestion with a leachate recirculation process. The facility has a processing capacity of approximately 3,000 tons/year of waste, and produces more than 300 tons/year of organic compost, offering essential support to Rio de Janeiro City's urban agriculture and reforestation programs. The focus is primarily on organic waste, which comes from various sources, such as local markets and residential areas.

Additionally, this process operates with a biogas yield of approximately 70 $Nm^3$ per ton of organic waste, reaching around 4,500 $m^3$/day of biogas, which is then converted into electrical energy to ensure the self-sufficiency of the treatment process. This provides about 150 kW of energy, making the facility partially self-sufficient.[49]

The Caju Eco-park solution has been developed through a partnership between Methanum Company, the Federal University of Minas Gerais and the Municipal Urban Cleaning Company of Rio de Janeiro and, by diverting 3,000 tons of organic waste from landfills, it effectively mitigates the approximately 3.4 Mt $CO_{2\,eq}$/year.

[48] The eco-park is a space formed by a cluster of plants with applied technology that enables the treatment and valorization of solid waste. In other words, an eco-park is a Waste Valorization and Processing Complex.

[49] RIO DE JANEIRO. Prefeitura da Cidade do Rio de Janeiro. Ecoparque do Caju: iniciativa de valorização de resíduos no município do Rio de Janeiro. Rio de Janeiro, 2024. Available at: https://prefeitura.rio/tag/ecoparque-do-caju/. Accessed on Nov. 18th, 2024.