

## **National Solid Waste Policy (NSWP): Challenges and Advances after 10 Years of Implementation**

**Helder Araujo de Carvalho**

Doctoral candidate, UFPI, Brazil.  
heldercmaad@cmaad.br

**João Batista Lopes**

Professor, UFPI, Brazil.  
lopesjb@ufpi.edu.br

**José Natanael Fontenele de Carvalho**

Professor, UFDF, Brazil.  
natanaelfontenele@ufpi.edu.br

## Abstract

A decade after the implementation of the National Solid Waste Policy (NSWP), municipalities continue to face challenges in implementation. This study aimed to assess the influence of the Municipal Integrated Solid Waste Management Plan (MISWMP) and proper waste disposal in the main cities of the country, in light of the National System of Information on Solid Waste Management (NSISWM). The analyzed data indicate slight advances related to what the National Solid Waste Policy (NSWP) proposes, stemming from difficulties in implementing the policy itself and/or making its instruments viable, especially in cities in the North and Northeast regions of Brazil. Practices such as improper waste disposal in open dumps or controlled landfills and incineration characterize the reality of Brazil, even a decade after the publication of the NSWP. Among the adopted strategies, waste recycling emerges as significant, with emphasis on composting and energy generation from biogas. There is a need for the integration of municipalities, states, and the Union to provide support for them to better exploit the potential in the generated waste, based on dominant technologies. It is also noteworthy the absence of updated data and cities' non-compliance with individual declarations in the NSISWM, regarding the provision of public solid waste management services, contradicting the policy itself and hindering the transparency of each municipality's data, making it difficult or even preventing monitoring by interested parties, civil society, and public and private entities.

**Keywords:** Cities. Sanitary landfills. Municipal plan.

## 1 INTRODUCTION

Over a decade ago, Brazil took a significant step towards regulating the National Solid Waste Policy (NSWP), especially concerning issues related to Urban Solid Waste (USW), assigning responsibilities to its federated entities.

As a result, various instruments related to USW emerged from the NSWP, such as the National Solid Waste Plan (PLANARES), Municipal Integrated Solid Waste Management Plan (MISWMP), Zero Landfill National Program, and National Solid Waste Management System (NSISWM), among others, with the aim of monitoring and addressing waste management in each region of the country.

In addition to the established regulations, programs, and plans, discussions surrounding waste became a central theme in studies employing various theoretical approaches to comprehend and address the issue, involving USW, Hospital Waste, and Construction Waste. Furthermore, in recent years, due to the widespread dissemination of waste valorization strategies, movements focused on analyzing fractions of solid waste, including plant-origin waste, have grown, exploring their potential contribution to reducing environmental impacts (Carvalho; Carvalho; Lopes, 2022; Klein; Gonçalves-Dias; Jayo, 2018; Lima; Salum; Cruz, 2021).

Both legislation and the scientific community share a central concern about the exponential increase in waste. In this perspective, Martins and Stein (2014) highlighted two worrisome factors: population growth and gross domestic product (GDP) increase. This observation is reinforced by Norberto *et al.* (2021), who noted the correlation between these two factors in three of the four regions of the country regarding waste production growth.

Therefore, these factors lead to a broad discussion about everyone's responsibility regarding waste generation, disposal, and management, as actions to minimize environmental

pressures are still isolated or insufficient (Carvalho; Carvalho; Lopes, 2022; Silveira; Clementino, 2017). On a micro level, the MISWMP proved to be an important ally to the NSWP and PLANARES in mobilizing society for environmental education actions, discussing the municipality's waste reduction goals, and presenting indicators of environmental performance in urban cleaning and waste management, as advocated by Article 20 of the NSWP.

On the other hand, in contrast to the various innovations enacted in the NSWP, the reality of municipalities deviates from the ideal. In this scenario, municipalities face operational difficulties in implementing an MISWMP suitable for the NSWP. According to Oliveira and Galvão Junior (2016), the major difficulty encountered by municipalities relates to selective collection and recycling.

It is noteworthy, among the challenges, that the realization of the MISWMP and improper waste disposal do not align with the NSWP and Decree No. 10,936/22. Thus, although there is a willingness for change, this inclination is not a general reflection, as some cities in the metropolitan region of João Pessoa, in the state of Paraíba, lack local plans and do not participate in municipal consortia (Brasil, 2022a; Fernandes; Santos; Pereira, 2022; Oliveira; Galvão Junior, 2016).

Similarly, these problems point to the need for a general mobilization, beyond the creation of programs and/or the improvement of the NSWP, translating into actions aimed at the environmental sustainability of federated entities. Recent findings indicate that, out of the 27 federation entities, only five are at an acceptable level of environmental sustainability. On the opposite end of this spectrum, some municipalities in the North and Northeast of the country are at a critical or alert level (ABRELPE, 2020; Oliveira; Sousa, 2020).

It is emphasized that, despite the challenges, Brazil is not at ground zero. However, after more than a decade of the NSWP, there are significant indications in the current literature that the progress expected from post-NSWP Brazil may not have materialized. Thus, the objective was to identify the influence of the MISWMP and proper waste disposal in the main cities of the country, in light of the NSISWM.

## **2 THEORETICAL FRAMEWORK**

The NSWP represents the starting point for any discussion on solid waste management in Brazil, not only as the legal framework for addressing this issue but also for what it represents and proposes in terms of innovation, solutions, and integrated management involving the federal government, states, and municipalities.

With this perception, numerous authors have dedicated themselves to studying it from both a theoretical and empirical approach, contextualizing the theme with the reality of different parts of the country. Moreover, it is a policy of broad scope that allows for the discussion of waste management by engaging with various fields of knowledge, including Administration, Economics, Public Policies, Biology, Engineering, and Law.

It is noteworthy that the concern in studies on the management of different types of waste is not limited to national literature or developing countries. In addition to scientific

literature, institutions committed to the issue, such as the UN, monitor electronic waste worldwide and recently presented the report "The Global E-waste Monitor 2020". In 2021, they also called for reflection on fruit and vegetable waste in the report "Fruit and vegetables – Your dietary Essentials," in what they termed the International Year of Fruits and Vegetables (FAO, 2020; Forti *et al*, 2020; Carvalho; Carvalho; Lopes, 2022; Silveira; Clementino, 2017).

In the Brazilian context, PLANARES provides guidance on how to implement the NSWP in states and municipalities and, among other things, presents programs that outline how the Federal Government intends to combat the effects of waste on the national soil. This includes the National Program for the Recovery of Contaminated Areas, National Program for Combating Marine Litter, National Program Rivers + Clean, Implementation and Expansion Program for Reverse Logistics, and National Program Zero Dump (Brasil, 2022b).

States and municipalities, consequently, follow the national policy to develop waste management in the federative units. At the micro level, municipalities face the greatest difficulty in combating waste management. The Municipal Integrated Solid Waste Management Plan (MISWMP), usually updated every four years, is responsible for defining proper disposal in sanitary landfills or participating in consortia for this purpose, implementing environmental education and managing environmental liabilities, creating strategies for selective collection, and mobilizing waste pickers for cooperative formalization, among other obligations.

What is observed in official documents, such as NSISWM and/or current literature, is the manifestation of the fragility of municipalities, not only regarding full compliance with the NSWP but also in isolated points required by it. According to the 2022 PLANARES, there is still concern about the final disposal of waste. In essence, this concern contradicts the idealization of the NSWP to eliminate open dumps and controlled landfills within four years of its publication, as stipulated in Article 54 (Brasil, 2010; Brasil, 2022b).

One possible strategy to overcome the precariousness of MISWMPs in municipalities, which includes proper waste disposal, would be to establish that capital cities/metropolitan regions and/or major cities would be the first to fully implement integrated management to serve as a model for other municipalities. Thus, each state would be responsible for administrative and financial support, as well as mobilizing universities and research institutions to materialize the MISWMPs. This synergy of forces would maximize the quality of plans, as observed by Chaves, Siman, and Sena (2020b) in the cities of Águia Branca and Colatina, both located in Espírito Santo.

In contrast, municipalities remain oblivious to what the NSWP prescribes, either because they do not have MISWMPs or because they do not keep them updated. This national weakness concerning the effectiveness of MISWMPs falls into the "old obstacles," attributed by Silveira and Clementino (2017), referring to the obstacles that undermine the implementation of the NSWP. When evaluating the MISWMP of Porto Alegre - RS, and five other cities, for example, the authors found that the capital not only had an outdated MISWMP, contrary to Article 19 of the NSWP but also scored the lowest in quality and complexity indices.

Despite the willingness to change, this inclination does not reflect the reality of large urban centers, as some cities in the metropolitan region of the state of Paraíba do not have a

local plan and do not participate in municipal consortia. This fragility may occur not only due to a lack of interest in adapting but also due to low administrative and financial capacity to meet the requirements needed to implement the NSWP. Thus, Henrichs (2023) points out that this known problem gains more weight due to the fragility of Brazil's political-administrative organization, where the Union concentrates the greatest power in all aspects, outsourcing autonomy and responsibility for implementing public policies to municipalities, many of which are, in fact, dependent on Union support.

One way to overcome the deficiency of municipalities in implementing sanitary landfills is through public consortia. However, municipalities encounter other problems that hinder their operation, whether due to financial issues, lack of technical support, and, mainly, the absence of participation and integration with higher federative entities (Henrichs, 2023; Maiello *et al.*, 2018).

In this context, it is worth noting that in the metropolitan region of Rio de Janeiro, there is low integration of the consortium with the National Sanitation Information System (SNIS), a low rate of reuse/recycling and energy utilization, and the selective collection is insignificant for the region (Maiello *et al.*, 2018). Findings in the Brazilian northeast signal similarities to those observed in Rio de Janeiro, revealing a still initial/nascent situation regarding waste reuse and recycling (Pinheiro; Lima, 2020). In the current scenario, there is a precarious and incipient state in city management, resulting in a discrepancy between municipal reality and the objectives/goals of the NSWP.

With this, findings from the current literature, despite requiring further exploration of this hypothesis, indicate an exacerbated transfer of burden/responsibility to the smaller agent, who actually executes, represented in the NSWP by municipalities (Maiello *et al.*, 2018; Silveira; Clementino, 2017). Municipalities, in turn, are filled with their characteristics, such as cultural aspects, habits, geographic dimensions, and limited administrative, technical, and financial capacity that require monitoring and support from other powers. This implies greater integration of agents to implement what is regulated in the norm. On the other hand, as Maiello and coauthors warn, it is not possible to institutionalize a law without first understanding local peculiarities and/or offering an integrated structure with the state and Union.

Given this scenario, a decade after the implementation of the NSWP, there are still significant obstacles to be overcome by different cities/regions in the country. Despite many studies anchoring themselves in the law itself, its specific, regional, or national application, and/or waste typologies separately, as well as the tools necessary for policy implementation, little is known about local/regional challenges and impediments to complying with the NSWP.

### 3 METHODOLOGY

This study is characterized as descriptive and exploratory. To address the proposed objective, it is grounded in a quantitative approach. The analyzed data were collected from the National System of Information on Solid Waste Management (NSISWM), regarding the municipalities in each state of the federation.

The data extracted from NSISWM pertain to the year 2020 (the latest available data) and were collected between December 2022 and the first two months of 2023. Therefore, the data collection encompassed the following information: declarations made in NSISWM regarding the provision of public solid waste management services; existence of sanitary landfill (appropriate final disposal); selective collection (cooperative); recycling; composting; energy recovery; incineration; availability of Municipal Integrated Solid Waste Management Plan (MISWMP).

To broaden the scope of the research nationwide, three municipalities were selected per state. The number of cities was determined, taking into account that some states have smaller urban populations, especially those located in the North region, which have fewer cities. Thus, this sample definition method aimed to avoid disproportionate errors in comparisons and analysis between regions.

The selection of cities followed certain criteria and metrics: (a) inclusion of capitals, as they represent the state; (b) inclusion of the two most populous cities in each state, with the exception of Brasília, which only meets the first criterion. G1 news websites and/or specific websites for each state reporting preliminary results of the 2022 demographic census by IBGE were used as sources.

In this way, data from 79 Brazilian cities were obtained, including 27 capitals and 52 municipalities. To standardize and analyze the information collectively, the data were transformed into dichotomous responses (Yes/No). Thus, NO was defined as "0" for situations lacking information, while for YES, corresponding to the presence of information in the survey, "1" was assigned. After transformation, the data were analyzed using SPSS software, version 21. Due to the nature of dichotomous variables, the study's objective was addressed by assessing the relationships between variables using the Chi-square test ( $\chi^2$ ) and Odds Ratio (OR).

#### **4 RESULTS E DISCUSSION**

In Table 1, the cities are presented by state and region in Brazil, selected for the current study, along with the update status on solid waste management in 2020 in the National System of Information on Waste Management. Except for Brasília, in each state, the capital and two of the largest cities in terms of population were chosen, according to the IBGE Census initiated in 2022. Cities marked with an asterisk are those that did not report to the NSISWM regarding the provision of public services on solid waste management in 2020. The data reveal the deficiency of local management in providing information about waste management.



Table 1 – Evaluation of Cities in Light of NSISWM by Region

State	Capital	Selected Cities	Updated in NSISWM		Total by Region	
			Yes	No	Yes (%)	No (%)
North Region						
Acre	Rio Branco	Cruzeiro do Sul*; Tarauacá*	1	2		
Amapá	Macapá	Santana*; Laranjal do Jari*	1	2		
Amazonas	Manaus	Parintins; Itacoatiara	3	-		
Pará	Belém	Ananindeua*; Santarém	2	1	14 (67%)	7 (33%)
Rondônia	Porto Velho	Ji-Paraná; Ariquemes	3	-		
Roraima	Boa Vista	Rorainópolis*; Caracará*	1	2		
Tocantins	Palmas	Araguaína; Porto Nacional	3	-		
Northeast Region						
Maranhão	São Luís	Imperatriz; São José de Ribamar	3	-		
Piauí	Teresina*	Parnaíba*; Picos	1	2		
Ceará	Fortaleza	Caucaia; Juazeiro do Norte	3	-		
Rio G. Norte	Natal	Mossoró*; Parnamirim*	1	2		
Paraíba	João Pessoa	Campina Grande*; Santa Rita*	1	2	16 (59%)	11 (41%)
Pernambuco	Recife	Jaboatão dos Guararapes*; Olinda*	1	2		
Alagoas	Maceió	Arapiraca; Rio Largo	3	-		
Sergipe	Aracaju	Nossa Senhora do Socorro*; Itabaiana*	1	2		
Bahia	Salvador	Feira de Santana*; Vitória da Conquista	2	1		
Central-West Region						
Goiás	Goiânia	Aparecida Goiânia*; Anápolis	2	1		
Mato Grosso	Cuiabá	Rondonópolis*; Várzea Grande*	1	2	6 (60%)	4 (40%)
Mato Grosso do Sul	Campo Grande	Dourados*; Três Lagoas	2	1		
Distrito Federal	Brasília		1	-		
Southeast Region						
Minas Gerais	B. Horizonte	Uberlândia; Contagem*	2	1		
Espírito Santo	Vitória	Serra; Vila Velha	3	-		
Rio de Janeiro	Rio de Janeiro	São Gonçalo*; Duque Caxias*	1	2	8 (67%)	4 (33%)
São Paulo	São Paulo	Guarulhos; Campinas*	2	1		
South Region						
Rio Grande Sul	Porto Alegre	Caxias do Sul*; Canoas	2	1		
Paraná	Curitiba	Londrina*; Maringá	2	1	7 (78%)	2 (22%)
Santa Catarina	Florianópolis	Joinville; Blumenau	3	-		
Total Yes/No			51 (65%)	28 (35%)		

Source: Prepared by the authors, 2023.

In general, it is worth highlighting that the gathered data signal a fundamental non-compliance regarding the annual provision of information to the National System of Information on Solid Waste Management (NSISWM) concerning solid waste within its jurisdiction, as stipulated by articles 78 and 79 of decree no. 10,936/22. Simultaneously, this finding reinforces that NSISWM, an entity coordinated by the Ministry of the Environment (MMA) and intended to compile information about waste, not only has been outdated since 2020, contrary to current legislation but also deserves heightened attention from the MMA to take action in updating data for subsequent exercises.

Furthermore, the outdated status reveals that Brazil continues to move in the opposite direction concerning solid waste, as NSISWM essentially serves as a tool for social control over waste in the national territory. Such revelations underscore the challenges inherent to municipalities and the lack of more assertive strategies for implementing the National Solid Waste Policy (NSWP), meeting deadlines established in the aforementioned decree, and adhering to PLANARES (Brasil, 2022a; Henrichs, 2023; Maiello *et al.*, 2018; Silveira; Clementino, 2017).

The implications of NSISWM's outdated status generate negative effects on meeting the deadlines set by the new legal framework for sanitation (BRAZIL, 2020), as evidenced by the fact that, among the 79 studied cities, considered the most populous in their states, 17 (21.5%) do not have an established sanitary landfill. In this regard, adhering to the general deadline (by December 31, 2020) in the legal framework, Table 2 illustrates the cities that contradict the established norm two years after the specified date.

Table 2 – List of Evaluated Cities without Sanitary Landfills

Region	Cities
North	Cruzeiro do Sul (AC); Tarauacá (AC); Laranjal do Jari (AP); Parintins (AM); Ananindeua (PA); Rorainópolis (RR); Caracará (RR); Porto Nacional (TO); Belém (PA); Porto Velho (RO)
Northeast	Parnaíba (PI); Picos (PI); São José de Ribamar (MA); Olinda (PE); Arapiraca (AL); Rio Largo (AL); Mossoró (RN)

Source: Prepared by the authors, 2023.

In this way, the non-compliance with the regulatory framework not only reveals the difficulty/inadequacy of cities and capitals in implementing sanitary landfills but also highlights another aspect discussed in the literature, characterized by the absence of the Municipal Integrated Solid Waste Management Plan (MISWMP) (Table 3). In this regard, 25 of the evaluated cities, representing 31.6%, do not have MISWMP. Considering that the records in the National System of Information on Solid Waste Management (NSISWM) reflect the reality up to the data collection date, it is noteworthy that the capitals of the North and Northeast regions of the country, such as Macapá, Porto Velho, Belém, and Salvador, show inadequacy in this aspect, aligning with the findings observed by Neves *et al.* (2021).



Table 3 – List of Evaluated Cities without MISWMP

Ananindeua	Porto Nacional*	Nossa Senhora do Socorro
Arapiraca	Porto Velho	Olinda
Belém	Rio Largo	Parintins
Caracaráí	Rorainópolis	Parnaíba*
Contagem	Salvador	Picos
Cruzeiro do Sul	Santa Rita	Vila Velha
Laranjal do Jarí	Santana	Vitória da Conquista
Macapá	São José de Ribamar	
Mossoró	Tarauacá*	

Source: Prepared by the authors, 2023.

According to information highlighted in the literature, the Municipal Integrated Solid Waste Management Plan (MISWMP), in addition to encompassing proper waste disposal, is an important instrument that defines strategies for waste treatment, integration with private sector agents and their respective responsibilities, environmental education strategies, reuse (recycling/composting), and energy recovery from waste (Chaves; Siman; Sena, 2020a, 2020b; Fernandes; Santos; Pereira, 2022; Neves *et al.*, 2021).

Beyond the integration proposed by the National Solid Waste Policy (NSWP), waste treatment and management strategies focused on reduction, reuse, and recycling of waste aim to address environmental, social, economic, and health issues. In this regard, these strategies have been grouped by region to facilitate understanding of how they are employed in the country (Table 4).

The data indicate that selective collection and recycling are common and significant in all five regions. The Northeast region stands out by using selective waste collection, accounting for 66.7% of the total cases of this strategy, while the Southern, Southeastern, and Midwest regions primarily adopt recycling, accounting for proportions of 100%, 100%, and 90%, respectively. On the other hand, energy recovery shows no records, and composting is used to a lesser extent. Incineration is exclusively carried out in cities in the Northeast region, with an estimated value of 11.1%, and other regions do not employ this strategy. The Northern and Northeastern regions stand out quantitatively in these waste treatment strategies due to the total number of evaluated cities.

Table 4 – Waste Treatment Strategies by Region in Brazil

Strategies	Northeast		North		Central-west		Southeast		South		Σ
	<i>f</i> % <sup>1</sup>	% <sup>2</sup>	<i>f</i> % <sup>1</sup>	% <sup>2</sup>	<i>f</i> % <sup>1</sup>	% <sup>2</sup>	<i>F</i> % <sup>1</sup>	% <sup>2</sup>	<i>f</i> % <sup>1</sup>	% <sup>2</sup>	
Selective collection (cooperative)	18 67%	66,7%	10 48%	47,6%	5 50%	55,6%	7 58%	58,3%	4 44%	44,4%	44
Recycling	21 100%	77,8%	13 62%	61,9%	9 90%	100,0%	11 92%	91,7%	9 100%	100,0%	63
Composting	0	0,0%	0	0,0%	1 10%	11,1%	2 17%	16,7%	1 11%	11,1%	4
Energy recovery	0	0,0%	0	0,0%	0	0,0%	0	0,0%	0	0,0%	0
Incineration	3 11%	11,1%	0	0,0%	0	0,0%	0	0,0%	0	0,0%	3

%<sup>1</sup> - Among cities in the same region.

%<sup>2</sup> - Among the total (Σ) of cases for each strategy

Source: Prepared by the authors, 2023.

Reverse logistics fits among the strategies as a means to direct waste to the manufacturing industry or reintroduce it into the production process. These strategies, according to Brasil (2010; 2022a; 2022b), not only relieve landfills but also contribute to minimizing environmental impacts and generating income for cooperative members. Additionally, reverse logistics can promote social and economic inclusion of waste pickers, especially when combined with environmental education programs and community involvement, enabling greater citizenship and sustainable local development (Oliveira; Galvão Junior, 2016; Klein; Gonçalves-Dias; Jayo, 2018).

While Brazil shows a lack of progress in employing other strategies a decade after the National Solid Waste Policy (NSWP), incineration, a practice contrary to the national policy, is

still used in the Northeast, contributing to environmental pollution and the perpetuation of open dumps/controlled landfills. Similarly, there are few initiatives focused on composting and none on energy recovery.

According to Klein, Gonçalves-Dias, and Jayo (2018), composting in the country is low, around 271 thousand tons per year in 2016. In recent years, there have been growing concerns about studying and expanding discussions on composting, as well as exploring the energy potential that this strategy offers for the development of cities and the effectiveness of the NSWP (Carvalho; Carvalho; Lopes, 2022; Galvão; Ruiz; Costa, 2019).

Table 5 presents the association between cities adopting the Municipal Integrated Solid Waste Management Plan (MISWMP) and properly disposing of waste in sanitary landfills ( $X^2 = 14.41$ ,  $p < 0.01$ ). Cities with MISWMP showed a high prevalence (78%) for the proper treatment of urban solid waste.

Table 5 – Relationship between (MISWMP) and Sanitary Landfill in Evaluated Cities

	SANITARY LANDFILL (appropriate final disposal)		Total	$X^2$
	NO	YES		
<b>MISWMP</b>	NO	17 (68%)	25	15,41
	YES	12 (22%)	54	
<b>Total</b>		29	79	

Source: Prepared by the authors, 2023.

Similarly, cities with the Municipal Integrated Solid Waste Management Plan (MISWMP) (Table 6) also had a significant relationship with waste recycling efforts ( $X^2 = 17.43$ ,  $p < 0.01$ ), indicating that cities with MISWMP are more likely to engage in recycling activities with the collected waste.

Table 6 – Relationship between MISWMP and Waste Recycling in Evaluated Cities

	RECYCLING		Total	$X^2$
	NO	YES		
<b>MISWMP</b>	NO	12 (48%)	25	17,43
	YES	4 (7,4%)	54	
<b>Total</b>		16	79	

Source: Prepared by the authors, 2023.

Additionally, it was found that there was an association between proper disposal of urban solid waste (USW) (Table 7) and waste recycling ( $X^2 = 17.13$ ,  $p < 0.01$ ). This finding partly reaffirms the result observed in Table 6. According to Oliveira and Galvão Junior (2016), it is

relevant to highlight that there is a high probability (94%) of cities engaging in recycling when they have a sanitary landfill. This relationship with recycling in major cities may occur due to the tendency of municipal managers to develop such strategies, also influenced by the existence of the Municipal Integrated Solid Waste Management Plan (MISWMP).

Table 7 – Relationship between Sanitary Landfill and Waste Recycling in Evaluated Cities

		RECYCLING		Total	X <sup>2</sup>
		NO	YES		
<b>SANITARY LANDFILL</b> (appropriate final disposal)	NO	13 (45%)	16 (55%)	29	17,13
	YES	3 (6%)	47 (94%)	50	
Total		16	63	79	

Source: Prepared by the authors, 2023.

In order to identify possible associations between the Municipal Integrated Solid Waste Management Plan (MISWMP) and proper disposal in the five regions of the country, cities were classified into two types per region. Those belonging to their respective region were labeled as "Yes," and the others were labeled as "No."

Considering the challenges in the Northern region of Brazil in having the MISWMP, a relationship was established between the evaluated cities in this region and those in the other regions combined (Table 8). An inverse relationship was observed between cities in the other regions having the MISWMP and those located in the Northern region ( $X^2 = 8.6$ ;  $p < 0.01$ ).

Table 8 – Association between cities with MISWMP in the Northern region and those in the other evaluated regions

		NORTH		Total	X <sup>2</sup>
		NO	YES		
<b>MISWMP</b>	NO	13 (52%)	12 (48%)	25	8,6
	YES	45 (83%)	9 (17%)	54	
Total		58	21	79	
			Value	95% Confidence interval	
				Lower	Upper
Odds Ratio for MISWMP (NO / YES)			0,217	0,075	0,627
For Northern region – NO			0,624	0,420	0,926
For Northern region – YES			2,880	1,398	5,932
Number of Valid Cases				79	

Source: Prepared by the authors, 2023.

Thus, it was observed that the studied cities outside the Northern region of the country had a higher probability and odds (83%; 0.217) of having the Municipal Integrated Solid Waste Management Plan (MISWMP). This finding is in line with the ABRELBE report (2020) indicating that the Northern region faces greater challenges in implementing the National Solid Waste Policy (PNRS). However, the data from this research did not confirm this difficulty for cities in

the Northeast, South, and Southeast, as suggested by the report and other studies (Fernandes; Santos; Pereira, 2022; Klein; Gonçalves-Dias; Jayo, 2018).

When the cities in the Northern region with Sanitary Landfill were related to the others evaluated (Table 9), an inverse association was observed in the proper waste disposal between cities in the Northern region and those in the other regions, consistent with the findings in Table 5 where the association between MISWMP and sanitary landfill was observed. Thus, there is low probability of proper waste disposal happening in cities in the Northern region, with proper disposal demonstrating a higher probability (86%) in cities outside this region ( $X^2=11.04$ ;  $p<0.01$ ). Additionally, the odds ( $OR=0.17$ ) of a city outside the region having a sanitary landfill are higher, at 83% ( $1-0.17=0.83 \times 100 = 83\%$ ).

Table 9 – Association between cities with Sanitary Landfill in the Northern region and those in the other evaluated regions

		NORTH		Total	$X^2$
		NO	YES		
<b>SANITARY LANDFILL</b>	NO	15 (52%)	14 (48%)	29	11,04
	YES	43 (86%)	7 (14%)	50	
Total		58	58	21	
		Value		95% Confidence interval	
				Lower	Upper
Odds Ratio for MISWMP (NO / YES)		0,174		0,059	0,514
For Northern region – NO		0,601		0,416	0,870
For Northern region – YES		3,448		1,575	7,549
Number of Valid Cases				79	

Source: Prepared by the authors, 2023.

## 5 FINAL CONSIDERATIONS

The analyzed data indicate small advancements related to what the National Solid Waste Policy (NSWP) proposes, aligning with recent discussions in the scientific community. This observation is consistent with recent reports on the challenges of implementing the policy and making its instruments viable, particularly in specific cases, such as those in the North and Northeast regions of Brazil. There are indications that the federal government continues to focus on planning and expanding the scope of the NSWP through decrees and its alignment with other policies, such as the legal framework for sanitation, while leaving cities as the weak link in this integrated circuit. Cities, often lacking human/technical and financial resources, have been making efforts in their capacity to advance proper waste management. This includes developing Municipal Integrated Solid Waste Management Plans (MISWMP), ensuring proper disposal, promoting selective collection through cooperatives, and encouraging waste recycling.

However, there is still much to be done to facilitate the use of composting and energy recovery, effective strategies in waste reduction/reuse and in alleviating environmental pressure caused by waste deposition in open dumps or sanitary landfills. In this regard, practices

such as improper disposal (open dumps or controlled landfills) and incineration remain prevalent in Brazil, even a decade after the publication of the NSWP.

The absence of MISWMP proves to be a hindrance for many cities in the North/Northeast region, directly impacting municipal waste management and, consequently, proper waste disposal, whether within the municipality itself or through municipal consortia. Among the adopted strategies, waste recycling stands out as significant. However, it is crucial to disseminate composting and biogas energy generation strategies throughout the country. Both practices can be initially implemented in large cities of each state, serving as a model to be adopted.

The association observed in this study between MISWMP, sanitary landfill, and waste recycling suggests that there may be associations with other strategies once data on their applicability in municipalities become available. There is a felt need for the federal government to engage with states and their respective municipalities to provide support for better exploring the potential in the waste produced, based on dominant technologies.

It is noteworthy to emphasize the lack of updated data in the National System of Information on Solid Waste Management (NSISWM) and the non-compliance of cities with individual declarations made in NSISWM regarding the provision of public services for solid waste management. This not only signals a contradiction with the policy itself but also hinders transparency in the data of each municipality, as well as obstructs monitoring by interested parties, civil society, and public and private entities.

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