

SOLID WASTE POLICIES AND CLIMATE CHANGE – THE CASES OF FEDERAL BRAZIL AND CANADA

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Article Info:

Received:

21 March 2024

Revised:

27 June 2024

Accepted:

26 August 2024

Available online:

8 October 2024

Keywords:

Solid waste policy

Climate change

Comparative study

Federalism

Brazil

Canada

ABSTRACT

The objective of our paper is to scrutinize the ongoing dynamics surrounding waste and climate policies within the federal democracies of Brazil and Canada. Our research design is guided by four primary inquiries. Firstly, we look at the integration of the circular economy concept within waste and climate policies. Secondly, we explore the extent to which concerns regarding solid waste are assimilated into climate mitigation and adaptation strategies. Thirdly, we assess the degree to which social inclusion is upheld as foundational principle within climate and waste policies. Lastly, we investigate the governance practices that have been put in place to promote effective intergovernmental and state-society cooperations. Initially, we illuminate the commonalities and disparities between Brazilian and Canadian federalism, emphasizing the challenges of policy coordination—a critical prerequisite for a smooth integration and successful execution of solid waste and climate policy initiatives. In the core section of our paper, we adopt a comparative lens to analyze both policy domains, focusing on (a) institutional frameworks, competencies, and the characteristics of the policy-making processes in each country; (b) legislative measures, programs, plans, and policy instruments to elucidate the policy fields and the linkages between them. We conclude our paper by juxtaposing the experiences of both countries and suggesting potential ways for mutual learning to improve federal democratic responses in tackling these complex and interlinked challenges.

1. INTRODUCTION

Establishing links between solid waste management (SWM) and climate policy does not seem obvious at first glance, yet they are intrinsically related. In the most recent IPCC reports, SWM is mentioned as important within urban services and connected to infrastructure. While recognized as a “short-term adaptation option” (IPCC, 2022, p. 46 (ch. 15)), waste management does not receive sufficient attention as a long-term structural requirement within climate policy. On local and regional scales, lacking waste collection, improper disposal practices, and unsuitable facility locations have negative effects both on the environment and the climate. Globally solid waste plays a significant role in exacerbating climate change, to a large extent linked to the greenhouse gas emissions from the organic fraction in waste dumps and landfills (Kaza et al., 2018) as well as from the plastic content in incineration.

According to Yang et al. (2023), the circular economy focuses mainly on conserving resources and optimizing

the energy and material cycles across various levels: at the micro-level, involving enterprises and consumers; at the meso level, where economic agents collaborate symbiotically; and at the macro-level, encompassing cities, regions, and governments. They consider that the increase in solid waste and the worsening of the climate crisis is due to global industrialization and excessive dependence on non-renewable energy sources. The authors assume that by promoting the circular economy, carbon emissions can be reduced by 45% by 2030 and carbon neutrality can be achieved by 2050. They analyzed circular economy strategies focusing on waste management, climate change, energy, air and water quality, land use, industry, food production, life cycle assessment and economic routes and noted that increasing the use of bio-based materials is a challenge in terms of land use and land cover. They pointed out that carbon removal technologies are still not economically viable and conclude that although circular economy strategies can be implemented in various sectors, such as industry, waste, energy, buildings and transport, life cycle

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assessments are necessary to optimize new systems. Other studies suggest that integrating waste management into future smart cities with complete product life cycles could be a potential step towards achieving “zero waste” (Lee et al., 2021) and to achieve this goal, three steps must be taken: waste prevention, accurate waste collection and recovery of the functional value of the collected waste (Yang et al., 2023). Fang et al., (2023) conclude that using Artificial Intelligence (AI) in waste logistics can reduce transportation distance by up to 36.8%, cost savings by up to 13.35%, and time savings by up to 28.22%. Furthermore, AI would also allow for identifying and sorting waste with high accuracy, ranging from 72.8 to 99.95% (Fang et al. 2023). The conditions for effective waste management are particularly precarious “in cities of the global South where the capacity to tax or charge for services is limited, waste is often an unmanaged and unregulated environmental blight, and its management is often a physical manifestation of political and social challenges of urban governance and urban service delivery” (Myers, 2014, p. 448).

In the global debate, policy initiatives such as the promotion of zero waste and circular economy through reverse logistics incentives, and the strengthening of the bioeconomy are some of the strategies which presumably could make an important contribution to the necessary transition to a sustainable and resource-efficient economy (Cosenza et al., 2020; UNEP/UN-Habitat, 2021). Yet, the Circularity Gap Report 2019 finds that just 9% of the 92.8 billion tonnes of minerals, fossil fuels, metals, and biomass that enter the economy are in fact re-used annually (Circle Economy, 2019).

Material use and climate change are closely linked. Waste accounts for 3-5% of global greenhouse gas emissions (GGE) and is the third source of methane emissions, after natural wetlands and agriculture. CO₂ is responsible for 74.4% of GGE while methane is the second most potent greenhouse gas, accounting for 17.6% of global emissions (IPCC, 2014). Yet, most of the global GGE (62%) are released during the extraction, processing and production phases (Circle Economy, 2019). Wilson, Filho and Ramola (2023) point out that calculations by the International Solid Waste Association (ISWA) suggest that better waste and resource management could mitigate 15% to 25% of global GGE and should therefore be included in the Nationally Determined Contributions (NDCs) of all countries.

Nevertheless, frequently, SWM is still confused with waste disposal and recycling at the local level, whereas Solid Waste Policies (SWP) should be considered part of an overall strategy of “transformational, systems-level change” (Anthony, 2022, p. 7), “building net zero, circular, resilient, inclusive and just cities” (UNEP/UN-Habitat, 2021, p. 39). We anticipate at least four approaches that go beyond technical strategies for improving systems and involve enforcement through climate and solid waste policies and their interfaces:

1. Divert materials from the waste stream into a circular system, engaging citizens and various production chains.
2. Integrate solid waste concerns into mitigation and ad-

aptation strategies within climate policy.

3. Foster fair and inclusive income opportunities in waste management, particularly for socially disadvantaged groups.
4. Ensure cooperation among different governmental levels, specifically related to environmental sanitation and climate change.

In our paper we examine ongoing experiences with waste and climate policies in the federal democracies of Brazil and Canada with focus on these four approaches. To achieve this goal, we conducted a literature search on relevant policy texts, analysing them for key categories and themes and comparing them across the two countries. Our paper is structured as follows. After introducing our methodology, we address the nexus between the management of solid waste and its contribution to global warming. Then we point out some commonalities and differences between Brazilian and Canadian federalism with a focus on the challenges of policy coordination, a crucial requirement for the integration of SWP and climate policy, and its successful implementation. In the main part of the paper, we look at both policy fields from a comparative perspective, highlighting (a) institutions, competencies, and the characteristics of the policy-making process in both countries; (b) legislation, programs, plans, and policy instruments, to elucidate the policy fields and the linkages between them. We conclude the paper comparing the experiences of both countries and highlighting possible mutual learning opportunities for federal democratic action to deal with such wicked problems.

2. RESEARCH METHOD

Data gathering for this research involved an online search for relevant legislation, programs, plans, and policy instruments as well as documents that describe the institutions, their competencies and the characteristics of the policy-making process in both countries. We consulted government websites, specialized policy databases and academic databases (Web of Science, Scopus). After sifting through the literature encountered, we applied thematic analysis: identifying, analyzing, and reporting relevant patterns or themes within our data that speak to our research question. We manually identified key categories revealing descriptive, interpretive and conceptual information of the data relevant to our research question. These categories were then organized into emerging themes across our set of texts to allow for comparison. Reading through the texts supported the review and refinement of these themes to ensure we accurately represent the identified codes and the overall data set. Our data analysis was an iterative process with constant comparison, whereby new data was compared to the existing categories. In this research phase we synthesized the findings in a spreadsheet, which helped visualize and organize the information (see Annex). We then explored the relationships, themes, and patterns that had emerged from the comparative analysis (Bauer & Gaskell, 2000).

3. THE NEXUS BETWEEN WASTE AND CLIMATE CHANGE

In many ways solid waste is one of the drivers for climate change; some aspects are already well known while others are less obvious or hidden and happen even before something is discarded. As with every material, before becoming a consumer object, resources have to be extracted and transported to industrial plants where they are transformed into the ingredients for manufacturing the final product, which then is transported to close and far retailers and consumers, generating emissions and waste with all its climate impacts along the chain (Pollans, 2021). These extraction and production processes involve the use of energy, affecting natural environments by contaminating soil, water, and air and generating GGE, leaving behind contaminated trails of what Lepawsky (2022) calls “discard-scapes”.

For example, oil is the primary ingredient necessary to produce the polymers required to make plastics and during its extraction waste is generated, environmental impacts occur and greenhouse gases are emitted. The extraction and processing/refining of oil and gas consumes large volumes of water, produces wastewater and contaminates surface and groundwater with benzene, methane, radiation and other chemicals, clearly affecting the environment and climate. Long-term pollution and habitat destruction affect wildlife, biodiversity and consequently also reduce ecosystem services, thereby avoiding their mitigating effects on climate change (Finer et al., 2008).

The case highlights possible hidden climate impacts not considered in the debate that links waste to climate change, generally limited to analysing different waste management options, including recycling, composting, landfilling, incineration (Kaza et al., 2018), or strategies less well reported such as open burning and waste export.

While recycling is presented as the basic solution to our waste problem, it is not exempt from GGE. The main source of greenhouse emissions linked to the recycling of materials like plastic and metal is the usage of energy (Astrup, Fruergaard, & Christensen, 2009a; Damgaard et al., 2009). Direct emissions refer to activities and processes that take place on-site at the Material Recovery Facility (MRF), whereas indirect emissions refer to the processes and activities that are affected by the operations at the MRF upstream and downstream (Damgaard et al., 2009).

Incineration as waste disposal strategy is portrayed as consistent with the circular economy idea based on energy recovery (Di Foggia & Beccarello, 2021; Kaza et al., 2018; Lausset et al., 2017; Malinauskaite et al., 2017). However, due to high contents of fossil energy in municipal solid waste (plastics, synthetic textiles, synthetic rubber, etc.) waste-to-energy is regarded as a mostly fossil energy source, thus a source of GGE (Zero Waste Europe, 2020).

Astrup, Møller & Fruergaard (2009) posit that incineration is characterized by the almost total oxidation of organic materials to CO₂ and that it is possible that some waste components are not going to be completely oxidized and may end up being released as CO₂ and other hydrocarbons. Furthermore, nitrous oxides (N₂O) may be

released, depending on the flue gas cleaning system of the incinerator (Chen & Lo, 2016). In comparison, Chen and Lo (2016) show that landfill sites generate fewer GGE than waste-to-energy facilities. According to Yifei Ma et al. (2024), incineration has become the largest source of GGE from the waste sector in China, with plastic representing the largest impact.

A particularly powerful greenhouse gas is methane (CH₄). Despite its brief atmospheric lifetime, methane has a global warming potential (GWP) of 72 over 20 years and 25 over 100 years, where a GWP of 72 means that 1 ton of methane released today is equivalent to 72 tons of CO₂ (O'Neill, 2019). GGE are measured throughout a product's manufacturing and use, but they are also connected to the techniques used to handle waste at the product's end of life (Braschel & Posch, 2013). Methane emissions from landfills have historically been the main source of GGE in the waste sector with a contribution rate ranging from 69% to 95% (Bogner et al., 2008).

Open burning of waste, which is common in low-income countries, is a low-temperature combustion method that emits large levels of contaminants, especially black carbon, a by-product of incomplete combustion, which also has an adverse effect on the environment (Reyna-Bensusan et al., 2018). Overall, we know that methane, carbon dioxide, nitrous oxide, and black carbon are some of the greenhouse gases connected to solid waste (UNEP/ISWA, 2015).

The waste-energy-climate nexus that becomes evident in waste policy, reveals, on the one hand, the associated technical and systemic complexity and, thus, the need for extending technical-scientific knowledge, but, at the same time, the strong economic vested interests that exert pressure on political decision-makers. Therefore, there is a need for strong governmental regulatory capacity to provide incentives and ensure a CO₂-reduced and climate-mitigating waste policy, and to establish clear responsibilities between the national, state, and municipal governments.

4. BRAZILIAN AND CANADIAN FEDERALISM: COMMONALITIES AND DIFFERENCES

It seems reasonable to assume that the state's capacity to act and to respond to challenges like environmental and climate crises is dependent on the effectiveness of the general political order. Particularly in federal states, it is the division of power between the constituent units, the rules and institutional arrangements that shape the federal dynamics (Benz & Broschek, 2003). In view of climate change, the degree of cooperative behaviour is considered crucial for the effectiveness of climate policies (Jordaan et al., 2019).

Brazil and Canada are both federal democracies with different historical traditions, sharing the common challenge of how to simultaneously “maintain and generate both unity and diversity” (Elazar, 1987, p. 64), which has been a common necessity of both federations due to their large territorial extension, their significant socioeconomic heterogeneity and cultural diversity (Abrucio, 2005; Lederman, 1975). Considering the institutional framework is

therefore crucial to understanding the different federal dynamics and governance patterns that manifest themselves in the waste and climate policies of the two countries and which are analysed comparatively in the next section.

In Brazil the country's democratic Constitution from 1988 aimed to reconcile the restoration of local autonomy – in order to guarantee diversity and favour citizen participation – with the promotion of greater territorial equity through federal authority – in order to maintain unity and ensure national governability (Abrucio, 2005; Souza, 2019; Watts, 2006). Municipalities even gained the status of federative entities. Since the 1990s, the federal government has increasingly taken the lead in shaping public policy within the framework of shared public responsibilities. National public policy systems were created, encouraging local authorities to adapt to the federal policies, particularly through financial incentives, which has contributed significantly to improving public policy indicators (Arretche, 2012). In their evaluation of Brazilian federalism, Souza and Fontanelli (2021, p. 139) conclude optimistically that “the design of Brazilian federalism contemplates institutional instruments capable of managing the tensions and dilemmas of the federation”.

However, it is important to recognize that under Jair Bolsonaro's right-wing government (2019-2022), intergovernmental relations have deteriorated sharply, leading to a general decline of democratic practices (Avritzer et al., 2021), and, specifically, the dismantling of environmental policy (Hochstetler, 2021a, 2021b). The first months of the government of Luiz Inácio Lula da Silva, though indicate important attempts to re-establish the former cooperative practice of governance, in the form of a kind of “executive federalism” with the president seeking to reassume direct dialogue with state governors and mayors in order to pacify the previous tense intergovernmental relations.

In Canada, the functioning of the institutional political order laid down in the 1982 Constitution has also been designated as “executive federalism”, defined as “the processes of intergovernmental negotiation that are dominated by the executives of the different governments within the federal system” (Watts 1989, quoted in Howlett & Migone (2019, pp. 64-65)).

It is the strong federal executive, sometimes even referred to as “an elected dictatorship” (Sayers & Banfield, 2013, p. 186), which should ensure the executive control of the political agenda. However, despite the institutionally strong position of the federal government, it has proved unable to unify the institutional-political practices and public policy-making. Different views on how a federation should work make it extremely difficult to come to a more consensual, consolidated decision-making and implementation process of public policies (Schertzer, 2020).

The “lack of jurisdictional clarity” (Schertzer, 2020, p. 165) in a country marked by extreme societal diversity contributes to what Howlett and Migone named “institutionalised ambivalence” – meaning a system in which political institutions in the country often make it difficult to clarify and achieve objectives, leading in turn to ‘ambivalent’ policies with often unclear impacts and effects” (Howlett & Migone, 2019, p. 142).

Hence, as highlighted by Cameron and Simeon (2002), Canadian federalism has undergone important variations concerning intergovernmental changes. In the last two decades, “oscillations between collaborative and conflictual relations in very short spans of time” (Schertzer, 2020, p. 175) has been observed, influenced by the specific political style of each Prime Minister, as well as by the general political configurations.

The following section analyses and discusses how these specific institutional conditions and governance practices have shaped waste and climate policies in the two federations.

5. SOLID WASTE AND CLIMATE-RELATED POLICIES AND LEGISLATION SPECIFIC TO BRAZIL AND CANADA

This section centres on the data found on the current policy and legal approaches to climate change and waste management in both countries. The focus will be primarily on federal and overarching jurisdictions. The following table (Table 1) provides a brief overview of the constitutional authorities and regulations related to solid waste in Brazil and Canada. A more detailed presentation with the description of these policies can be found in the attached Appendix.

5.1 Waste and Climate Policies and Plans in Brazil

In Brazil, the National Policy of Climate Change (PNMC), Federal Law 12.187 from 2009, and of Solid Waste (PNRS), Federal Law 12.305 from 2010 (Brasil, 2009; 2010a) and their respective regulatory decrees (Brasil, 2018; 2022a) and National Plans (Brasil, 2016; MMA, 2022) are in force.

In 2021 Brazil would rank fifth among the eight largest greenhouse gas emitters in the world (UNEP, 2022). It was estimated that from all land use sectors the Forestry represented 49%, Agriculture and Livestock 25%, Energy 18%, Industrial Processes and use of products 4% and Waste also 4% of the country's emissions (Observatório do Clima, 2023) Methane gas accounts for about 97% of emissions from the waste sector. Of the total, the main contribution is associated with the disposal of solid waste in controlled landfills, dumps and sanitary landfills (64.1%), followed by the treatment of domestic liquid effluents (28%), treatment of industrial liquid effluents (6.1%), incineration or open burning (1.7%) and, with a smaller contribution, biological treatment through composting (<1%). The impact of organic waste in dumpsites and landfills stands out for the emission of greenhouse gases, especially methane (O'Neill, 2019). In the country, about 45.3% of the waste collected is composed of food scraps and green waste (MMA, 2022).

Signatory of the United Nations Framework Convention on Climate Change (UNFCCC), Brazil has committed to regularly submit its National Communications every four years, including the National Inventories of GGE. Updates of the Nationally Determined Contribution (NDC) in 2022, confirm its commitment to reduce GGE in 2025 by 37%, and in 2030 by 50%, compared with 2005, and to achieve climate neutrality by 2050 (Brazil, 2022). Yet, the NDC does not give specific actions for the waste sector.

TABLE 1: Institutional arrangements and policies for solid waste management in Brazil and Canada (source: compiled by the authors from multiple official online sources).

Federal Level	Brazil	Canada
Constitution	Brazilian Constitution (1988)	Canadian Constitution Acts (1867 to 1982)
Policies	Federal Law on Solid Waste (Law N° 12.305/2010) Federal Law on Basic Sanitation (Law N° 11.445/2007) New Federal Law on Basic Sanitation (Law N° 14.026/2020)	Canadian Environmental Protection Act – CEPA National Parks Act (Garbage Regulations) Indian Act (Reserve Waste Disposal Regulations) Sanitary Landfilling Guidelines for Federal Agencies
Major agencies & institutions	Ministry of the Environment and Climate Change Ministry of Cities Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) National Environment Council (CONAMA)	Canadian Council of Ministers of the Environment (CCME) Environment and Climate Change Canada (ECCC)
Key instruments	National Solid Waste Plan (Decree N° 11,043/2022) National Program of Reverse Logistics (Decree N° 10,936/2021) National Solid Waste Management Information System National Sanitation Plan (PLANSAB) Sector Agreements	Canadian Environmental Protection Act (CEPA) National Packaging Protocol (1989) Single-Use Plastics Prohibition Regulations (2022)
State/Provincial	Brazil	Canada
Constitution	National Constitution (Art. N° 23), State constitutions Specific laws approved by the state legislative assemblies	Provincial amendments to the National Constitution
Key policies	State solid waste policy Solid Waste plans	Environmental statutes Provincial recycling regulations Provincial deposit refund systems
Major agencies & institutions	State agencies for environmental protection and control State environmental councils	Ministry or Department of Environment
Key instruments	State solid waste plans	Provincial solid waste management programs
Municipal	Brazil	Canada
Organic Law	As federative unities municipalities have their own organic laws (local constitutions)	Federation of Canadian Municipalities (FCM)
Key policies	Municipal basic sanitation law Municipal solid waste policies	Shared constitutional authority
Major agencies & Institutions	Municipal agencies for environmental policy / control Municipal Environment Council	Local departments or agencies overseen by ECCC
Key instruments	Municipal/Intermunicipal Solid Waste Plan Municipal Sanitation Plan Municipal Environmental Fund	Specific regulation, legislations and bylaws Extended Producer Responsibility Programs (EPR) Waste Diversion Programs

The PNMC created the Brazilian Forum on Climate Change and respective governance structure (Brasil, 2009). The Forum was initially very active, but lost space and relevance during Bolsonaro's term in office, which was accompanied by a general dismantling of the environmental and climate policy (Hochstetler, 2021a).

With regard to the national inventories, the IPCC (2019) found that these do not effectively reflect the contribution of the waste sector to GGE mitigation. If the recycling and energy recovery potential were included as a contribution of the waste sector, its potential contribution would reach up to 20% of total GGE (Brasil, 2021). At the interface between PNMC and PNRS, in 2011, the Action Plan for Sustainable Production and Consumption was developed by the Ministry of Environment, whose implementation could significantly contribute to reduce emissions from waste and leverage the circular economy, but was discontinued by the Bolsonaro government.

It is up to all spheres in Brazil, to establish public policies, norms and guidelines related to waste management. The state sphere is responsible, besides the formulation of policies and norms, for the inspection and monitoring of municipal and private treatment and final disposal systems. The attribution of the waste management system,

collection, treatment and final disposal of waste is municipal. Federal conflicts have arisen as in the case of the ban of the use of plastic bags in supermarkets, adopted in some cities of the country and contested in court, with the ruling that, in matters of concurrent legislation, the municipalities have broad power to regulate local systems on issues not regulated by federal or state law.

Unlike the PNMC, the PNRS does not have a governance system at the federal level (TCU, 2016) and relegates the development of state and local plans to the States and Municipalities. Yet, the PNRS establishes several principles to guide waste management in Brazil.

First, it defines a hierarchy from non-generation, reduction, reuse, recycling, waste treatment to environmentally appropriate final disposal for all types of waste.

Secondly, it stipulated that open dumping of waste must end by 2014 - a goal which is not yet achieved. Consequently, the Federal Law on Basic Sanitation No. 14.026/2020 had to establish a new deadline depending on the characteristics and size of the municipalities, between 2020 to 2024 (Brasil, 2020).

A third principle relates to the shared responsibility for the product life cycle of producers, importers, distributors and retailers, consumers, as well as providers of public

services for urban cleaning and solid waste management (Brasil, 2010). The tasks include the collection of products and residual waste after use and their subsequent environmentally sound final destination and the obligation to structure and implement reverse logistics systems through the return of products after use by the consumer. The aim is to reach sectoral agreements for different types of waste. However, the Federal Court of Accounts (TCU) warned in its report that shared responsibility fails to specify the parties accountable for the stages of the product life cycle related to environmentally appropriate disposal, without specifying the allocation of costs for each stage (TCU, 2016).

The fourth principle prioritizes contracting waste picker organizations for municipal recycling programs and facilitating reverse logistics for the private sector (Brasil, 2010). This involves a large number of waste pickers who work independently or organized as associations, cooperatives and networks (Gutberlet et al., 2020; Pisano et al., 2022). Brazil is a pioneer in the development of organized recycling and has inspired many other countries to provide opportunities for the generation of better working conditions for informal waste pickers (Besen & Fracalanza, 2016; Nogueira Zon et al., 2020).

A decree issued by President Bolsonaro's government (MMA, 2022), in 2022, integrates the PNRS into the National Environmental Policy, with the National Basic Sanitation Policy, however, without mentioning the National Climate Policy. The Decree launches the National Reverse Logistics Program, which is of great interest to the business sector and opens doors to regulating the incineration of municipal waste in the country. This action, however, contradicts the waste management model advocated by the civil society, which is based on participatory waste management and in which waste pickers play a pivotal role.

5.2 Waste and Climate Policies and Plans in Canada

In Canada, the provinces have constitutional authority to deal with most activities relating to solid waste. Federal authority extends primarily to federal lands, federal facilities, and 'Indian lands' (lands reserved for First Nations peoples under treaties, agreements, or other legal means). The Canadian Council of Ministers of the Environment (CCME) has produced guidelines on a variety of subjects related to municipal and hazardous wastes, including composting; waste incineration, alternative fuels for cement kilns; and lubricant recycling.

Climate change is already severely impacting Canada in many different and complex ways. The country has warmed up by around twice the rate of the rest of the world, and some communities have already suffered substantial harm from this phenomenon (Greaves, 2021).

While the oil and gas (26%) as well as the transportation sector (25%) continue to be Canada's largest sectoral GGE sources, the waste sector (4%) should not be overlooked as direct contributor (Government Canada, 2020). Several steps to combat climate change by addressing waste generation have been initiated, besides reducing GGE and assisting communities to adapt to their effects. (Guo et al., 2022).

In Canada, primarily municipalities handle solid waste generated by households, businesses and institutions.

Cities also manage landfill operations, waste collection, sorting and composting facilities. Local governments can lead environmental efforts by involving households and businesses in reducing waste and greenhouse gas emissions. They can also create low-emission energy sources and utilize resources from organic waste and biosolids to enhance sustainability. Landfills are the most widespread disposal form in Canada and regulations frequently call for landfill covers and landfill gas collection.

As a result of the relative municipal autonomy in policy implementation, the outcomes can be uneven and as a negative result, emissions have not decreased in most parts of the country for over a decade (Government Canada, 2020). Municipalities are bound to existing hierarchies in jurisdiction which can become a hurdle for progressive governments. For example, in 2018 the city of Victoria produced a bylaw to ban plastic bags. This bylaw was challenged by the Canadian Plastic Bag Association and the final ruling of the Supreme Court of Canada established that Victoria had exceeded its legal authority by implementing the ban without provincial approval.

Created in 1971, the Ministry of Environment and Climate Change Canada (ECCC) is responsible for coordinating environmental policies and programs, as well as preserving and enhancing Canada's natural environment and renewable resources. With the Canadian Environmental Protection Act (CEPA), from 1999, a consistent set of environmental protection standards have been set in place throughout the country.

The country's recent Climate Plan elaborated by ECCC (2022) points to: 1) Landfill methane regulations, 2) Food waste reduction and 3) Investments in waste and recycling infrastructure, as measures to reduce GGE. Landfill methane is generated as a result of decades of landfilling of biodegradable waste which still makes up more than 60% of the waste generated by households in Canada. It is most concerning that Canada wastes more than half of its food supply, most of which could be avoided, but instead releases large quantities of methane (ECCC, 2019). To address this challenge, the Government of Canada has launched in 2020, the first national plan to reduce food waste.

Canada's experiences with GGE reduction in the waste sector concentrate on capturing methane from landfills and directing food waste away from landfills. Nevertheless, a study by Williams et al. (2022) asserts that after Canada implemented its waste management rules through CEPA, GGE are being monitored in engineered and managed active landfill sites, but not in historic landfills, like those in Montreal and many other cities. These environmental passives are not part of current policies.

Plastic waste is also considered one of the key challenges for the country. Only 9% of the approximately three million tons of plastics discarded in Canada in 2016 was recycled (ECCC, 2019). In 2018, the federal, provincial, and territorial governments approved a Canada-wide Strategy on Zero Plastic Waste (Government Canada, 2020) and endorsed two aspirational waste reduction goals: to decrease waste by 30% by 2030, and up to 50% by 2040. Furthermore, the Single-use Plastics Prohibition Regulation (ECCC, 2023) in force prohibits the manufacture, import

and sale of specific single-use plastic items (e.g., check-out bags, cutlery, foodservice ware, ring carriers, stir sticks, straws). To achieve zero plastic waste, the Government has committed to innovation and investment, including in the design and construction of recycling facilities, the development of new recovery technologies, remanufacturing processes, and product delivery, reuse and repair systems, through Canada's Plastics Science Agenda.

Since 2021, the Government of Canada is preventing exports of plastic waste to countries that have established import restrictions (such as China) and taking steps to implement new controls under the Basel Convention. However, Canada continues to export plastic waste, shipping it illegally to the U.S. with unknown fate, but also to non-OECD countries in Asia, Central and South America (CBC, 2022; Basel Action Network, 2023; Stahl et al., 2023).

Canada is now developing a Federal Greenhouse Gas Offset System under the Greenhouse Gas Pollution Pricing Act (GGPPA), by adding a charge on fuels and by encouraging voluntary project activities to reduce GGE (e.g., capturing landfill methane) or to remove greenhouse gases from the atmosphere, translating them to "offset credits" (ECCC, 2022). In contrast, the provinces and territories in consultation with Indigenous peoples, developed a Pan-Canadian plan to act on climate change, primarily through technology development.

Canada's Clean Air and Climate Change Act gives no specific attention to waste-related air pollution, generated by solid waste incineration. The Regulatory Framework for Air Emissions even provides an extension of the 2020 existing tax incentive for waste-to-energy.

The 2030 Emissions Reduction Plan (ECCC, 2022) is an ambitious and achievable roadmap that outlines a sector-by-sector path for Canada to reach its emissions reduction target of 40% below 2005 levels by 2030 and net-zero emissions by 2050. Yet, a growing body of evidence is pointing to waste prevention, reuse, and recycling as key sources of untapped potential for GGE reductions. Countless local initiatives, found throughout the country, value discardable materials and products through community recycling centres, free stores, repair cafes, zero waste initiatives and projects that appreciate lifestyle and value change (Lee & Khan, 2020). In 2021, ECCC launched a public engagement process for the 2030 Emissions Reduction Plan (ERP) to seek submissions from interested persons, communities and organizations. The Canadian public's main concerns are about waste reduction, and proper waste management/disposal, specifically endorsing circular economy approaches to achieve net-zero, including generating less waste and changing consumption habits.

6. COMPETENCES, LEGISLATION, POLICIES, INSTRUMENTS AND EXPERIENCES IN WASTE AND CLIMATE POLICIES IN COMPARATIVE PERSPECTIVE

In the table in the Appendix the Canadian and Brazilian constitutional and legal competences and regulations, the main waste-related policies and competent governmental

institutions and agencies, as well as the main policy instruments applied at the different government levels to handle waste management are presented.

First, it is noticeable that in the Brazilian case the federal constitution provides a special chapter for the protection of the environment and obliges both government and community "to defend and preserve it for present and future generations", although there are no specific clues regarding solid waste or climate change issues. In contrast, in the case of Canada, there are no such provisions on environmental matters at the constitutional level. The Canadian Constitution is still based on the British North America Act from 1867, having the country achieved its full sovereignty only with the Constitution Act from 1982. While thus the constitution is not exactly up to date, having suffered since then only minor amendments, in Brazil the rupture with the authoritarian regime has provided the opportunity for a broad constitutional process with significant participation of civil society and social movements. As a result, far-reaching societal demands, e.g., environmental protection, were introduced in the Constitution. Although there have been no specific decisions by the Brazilian Supreme Court regarding waste management, it is worth noting that the Constitution has proven a significant tool during the government of Jair Bolsonaro, to slow down the degradation of environmental policies, obvious in the deforestation of the Amazon, the main source of CO₂ emissions in Brazil.

In Canada, CEPA is also the most important law for waste and climate-relevant policies. Several regulations refer to waste management and the definition of basic waste production related principles like the Extended Producer Responsibility and Product Stewardship and provide guidelines for municipal and hazardous waste management. We also find clues related to the importance and diffusion of best practices in reducing pollution and GGE from waste management.

In Brazil, in accordance with the attempts of providing nationally valid framework legislations for each policy field, "the principles, objectives, instruments, and guidelines related to the integrated management of solid waste" have been determined by the 2010 Federal Law on Solid Waste (N° 12.305/10), giving guidance to state and local governments of their responsibilities in the field.

A significant achievement lies in the recognition and prioritization of reverse logistics practices. This includes establishing shared responsibility among manufacturers, importers, distributors, and traders, and placing a central emphasis on nationally organized waste pickers associations. These efforts have been crucial in integrating social considerations into national policy legislation.

Solid waste concerns also entered the federal law on basic sanitation (N° 14.026/2020), amending the National Solid Waste Policy, setting time-limits for the environmentally adequate final disposal of waste and determining the collection of fees and rates for solid waste services.

This overlap of legislation finds its correspondence in the governmental and administrative division of responsibilities, which are shared between the Ministry of the Environment and Climate Change with the National Secretariat of the Urban Environment and Environmental Quality being

responsible for proposing policies, plans and strategies, as well as coordinating, monitoring and evaluating the implementation of the National Solid Waste Policy; and the Ministry of Cities with its National Secretariat of Environmental Sanitation providing for the elaboration of studies and projects related to solid waste.

As part of the framework legislation regarding the environment – the National Environmental System (SISNAMA) – the National Council of the Environment (CONAMA) is a consultative and deliberative body, gathering representatives from the government, the private sector and civil society, responsible for establishing criteria for environmental licensing and standards for the control and maintenance of environmental quality.

During the Bolsonaro Government this forum of participatory governance was 'dried out', reducing its composition from 96 to 23 members, concentrating the decision-making power in the government representatives and taking away votes from civil society, a decision contested by the Federal Supreme Court. In the current Lula government this Council was reconstituted with now 114 members, reestablishing the voice of civil society in environmental issues.

In Canada, the major institutional body is the Canadian Council of Ministers of the Environment (CCME) as an intergovernmental forum consisting of the 14 federal, provincial, and territorial ministers responsible in their states for environmental concerns. Waste management and climate change are part of the agenda, however due to lack of enforcement authority their recommendations are not binding for the provinces. This shows the difficulties the federal government has to unify public policymaking and it highlights the dependence on voluntary agreements to arrive at collective political strategies and practices. Some agreements have been negotiated within the Waste Management Committee of the CCME as for instance the preparation of a common packaging policy for Canada.

Despite ECCC – Environment and Climate Change Canada's broad mandate, there is a lack of enforcement capacity on the part of the federal government. ECCC works mainly with producing guidelines and recommendations. Ultimately, the treatment of environmental issues hinges on the decisions made by the Minister, who can subsequently be held accountable for those decisions.

In Brazil, there are national plans for waste and sanitation to complement and operationalize the corresponding federal laws, specific programs (reverse logistics) and information systems (National Solid Waste Management Information System – SINIR) to support, coordinate and conduct the waste policy in the federation. It is important to note the sectoral agreements, which are contractual acts, although their outcomes vary, as seen in the sectoral agreement on packaging. For instance, the packaging development paradigm prioritizes competitiveness over recyclability, which may impact the promised outcomes of the agreement (Demajorovic & Massote, 2017).

At the subnational level, the institutional structure follows the regulations provided in the constitution and the federal laws and policies, having their own environmental regulating laws and plans. Even though the federal government due to the local autonomy does not have the author-

ity to oblige municipalities to create their own Integrated Solid Waste Management Plan and their own Basic Sanitation Plan, the municipalities can only apply for federal resources in the case such plans already exist. Such kind of conditionality is a very popular tool used by the Brazilian government to make municipalities adopt the federal policy (Arretche, 2012). They also used to have their own Public Policy Council related to the environment allowing for the participation of civil society in environmental policy, dispose of a secretariat and – mostly – an environmental agency to implement the policies, and an environmental fund to support environmental initiatives and projects.

In Canada, by contrast, the subnational governments dispose of the constitutional authority to conceive or shape their own solid waste policies, favouring a greater plurality in initiatives and programs. At the provincial level there are Environmental Ministries and at provincial and municipal level agencies responsible for environmental control and climate change policies. It is also worth noting the role of the city council with specific committees created to tackle specific waste related issues and climate actions and of community councils which can be activated to collaborate with specific waste related issues and climate actions.

There are still other issues insufficiently addressed by waste policy like the consumer and citizen side of waste production and treatment. In view of the strong influence of business on waste policy, there is a need for environmentally aware citizens who increasingly base their consumption decisions on ecologically and socially relevant criteria. This strategy is insufficient to drive the necessary transformative change. Therefore, the political role of citizens and civil society needs to be strengthened by considering social mobilization and political participation as central. Politically conceived environmental education must therefore become an essential component of a comprehensive approach to waste and climate policy, which is still severely underexposed in the policy approaches examined.

It is the proximity between citizen and city hall that favours the role of local governments in environmental policy, especially waste policy. Whereas climate policy is mainly driven by global governance, assimilated and adapted to the national context by national governments, to be translated into regional and local strategies by subnational governments, in waste policy, the pressure to act rests primarily on local authorities, which must contend with the effects of the externalities produced by households and companies.

7. CONCLUSIONS

In this paper we worked out the commonalities and differences of Brazil and Canada, two federal democracies, in handling the challenge of integrated solid waste management in view of climate change. A true comparison of public policy in contexts as different as Brazil and Canada is a fundamental challenge given the different federal legal systems, the different legacies of bureaucratic and political action patterns in public policy making, the different stages of social, economic and democratic development, and the

different financial and technological resources available to these two governments. Initially, we identified four fundamental challenges that need to be addressed in order to achieve greater urban sustainability. Our assessment of the Brazilian and Canadian experiences with waste and climate policy speaks to these challenges.

1. We can say that in both countries the circular economy concept has been incorporated – not always explicitly – into the normative regulations of solid waste policy. However, several limitations have been identified, *inter alia*: (i) Implementation deficits in the municipal systems of selective collection. In both countries selective waste collection for recycling is the responsibility of local governments. In Brazil, the lack of policy capacities (Wu et al., 2018) – technological, financial and political –, poses a significant constraint, particularly for smaller municipalities, hindering effective delivery of environmental services (Frey et al., 2022); whereas in Canada insufficient enforcement capacity at the federal level results in varied performance across subnational waste management, by local governments; (ii) the inclusion of energy recovery from waste (waste-to-energy) in the circular economy concept, despite knowing of its climate impacts. The debate around waste incineration shows that highly influential business interests advocate for technical remedies like waste-to-energy, sidelining more socially and environmentally sustainable practices such as waste reduction and recycling, which include the work of waste pickers. Despite the existence of environmental movements in the global North, the economic-technological approach of ecological modernization or the “gospel of eco-efficiency” (Martinez-Alier, J., 2002) has always prevailed in environmental policy in highly developed countries like Canada, in Brazil the hegemony of this “Global North” approach has always been challenged by the “environmentalism of the poor” or environmental justice movement (*ibid.*; Guha, 2014). For its part, however, the latter has come under increasing pressure from the eco-efficiency approach fuelled by neoliberalism to the detriment of socially and ecologically compatible approaches. As a result, local authorities are increasingly resorting to supposedly more efficient technological solutions such as waste incineration, giving in to the pressure of powerful economic interests. (iii) the avoidance of getting to the root of the problem, namely curbing waste generation. This is a more fundamental challenge as it counters the basics of growth-oriented capitalism and our consolidated consumer practices. Thus, apart from some conceptual advances that have been incorporated into policies, we remain entrenched in a political landscape where the priorities and agendas of economic growth and competitiveness overshadow environmental and social considerations, hindering genuine structural change.
2. Both countries pay little attention to the problem of waste as a climate-related issue. The hidden effects of climate change resulting from the production pro-

cess and the corresponding supply chains tend to be ignored. Relying solely on seeing waste through the economic lens is inadequate and may even be counterproductive, as it tends to encourage more waste production rather than aiming to reduce it.

3. The Brazilian experience of explicitly including and promoting waste pickers as an essential component of waste policy is an important achievement in a policy field where technological and business concerns tend to take centre stage. The important role of social movements in the process of democratic transition, the new Citizen's Constitution of 1988, and the emergence of left-wing governments at local and later at federal level were fundamental contextual conditions for the creation of policies for the productive inclusion of waste pickers. Nevertheless, given the simultaneous expansion of waste incineration, the spreading of this experience seems difficult to achieve due to the powerful interests boosting this highly profitable business. Its continuity depends fundamentally on the political development in the country and municipalities, where, in view of the current political and ideological polarisation, such socially oriented policies have increasingly become the plaything of hostile opponents.
4. The different federal institutional arrangements make a difference in the design of waste policy in both countries. Due to the different historical legacies and the related differences in political and administrative structures, diverse strategies are being pursued to meet the challenge of “unity in diversity”. In Brazil, the constitutional process has favoured the strengthening of municipal autonomy and the principles of cooperative federalism, with the federal government increasingly taking the lead in public policy at the expense of the states, which have lost relative financial strength and governance capacity. This general condition has led to a national SWP where the federal government develops a general legal policy framework that establishes basic principles, institutional requirements and policy tools, and provides financial support for policy implementation by subnational governments, at least to the extent that they comply with the basic requirements stipulated by the federal government. In principle, participatory arrangements provide for the necessary democratic legitimacy of such policy measures. However, a lack of effective horizontal policy integration has been identified in the areas of waste, basic sanitation and climate policy and as has been seen with President Bolsonaro, federal governments that are not committed to environmental issues, can easily undermine such comprehensive approaches by omitting or obstructing them. In the case of the Canadian “executive federalism” the federal government's capacity to unify public policy-making is historically low and depends on the government's ability to negotiate joint agreements with the provincial ministers. In the event of differences of opinions or perceptions, the ECCC can only try to work with guidelines and recommendations lacking integration and enforcement capacities.

This is reflected in the waste and climate policy, where besides the general recommendations and guidelines there are only specific regulations that could be agreed upon and, in addition, quite different province-specific regulations, progressive in some provinces and more conservative and restraining in others. However, this results in a greater diversity of waste policy proposals and practices in the various sub-national governments. In summary, it has proven worthwhile to take the similarities and differences of federalism in both countries as a starting point for our analysis, in order to better understand the respective experiences themselves, as well as to draw lessons that may point beyond the individual cases. The complexities involved in our cases, especially if we look at solid waste and climate change as interdependent policy fields, reveal their character as wicked problems (Head, 2022). However, whereas such problems demand coordination, cooperation, innovation and policy integration, political-administrative systems in general tend to be siloed. We identified progress and obstacles in taking an integrative approach to the nexus waste-climate to address the related wicked problems in both countries.

Our research highlights the difficulties faced by both national governments in designing and enforcing national waste policies at the local level. In the case of waste policy, local administrations are in principle in better conditions to design locally adapted public policies through innovative contextual approaches that can only emerge from local experiences. At the same time, subnational governments must be supported in their waste policies and these must be integrated into federal climate policy. Effective multi-level and cross-policy governance is therefore critical to successfully coordinate these policies. Further empirical research is needed to better understand the potential and challenges for democratic federal systems in tackling such wicked problems. The climate contributions from specific waste management practices supported by public policies need to be further studied in order to learn about their impact and either expand their application or redesign these policies more effectively.

ACKNOWLEDGEMENTS

The research was supported in part by funding from the Social Sciences and Humanities Research Council (SSHRC) in Canada; and by the CAPES (Coordination for higher Education Staff Development), Internationalization Program (CAPES-Print, Process: 88887.310317/2018-00) and the National Council for Scientific and Technological Development (CNPq) (Process: 310314/2022-4), in Brazil.

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