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Municipal management of urban solid waste in a municipality in the southeastern region of the state of Paraná: implications for sustainability

A gestão municipal dos resíduos sólidos urbanos em um município da região sudeste do estado do Paraná: implicações para a sustentabilidade

Gestión municipal de desechos sólidos urbanos en un municipio de la región sureste del estado de Paraná: implicaciones para la sostenibilidad

Flavia Massuga
State University of the Midwest (PPGDC/UNICENTRO)
R. Miguel Agulham Júnior, 180, Jardim Virgínia, Irati-PR, Brazil. CEP: 84507-208
https://orcid.org/0000-0003-2490-6678
e-mail: flavia.massuga@gmail.com

Simone Soares Mangoni
State University of the Midwest (PPGDC/UNICENTRO)
R. Abdalla Miguel Sarraf, 1010, Rebouças-PR, Brazil. CEP: 84550-000
https://orcid.org/0000-0002-0282-2599
e-mail: simonesmangoni@gmail.com

Sérgio Luis Dias Doliveira
State University of the Midwest (PPGDC/UNICENTRO)
R. Duque de Caxias, 596, ap. 303, Bloco 1, Irati-PR, Brazil. CEP: 84500-122
https://orcid.org/0000-0001-9957-225X
e-mail: sldd@uol.com.br

Mara Sandra Parlow
R. Palmira, 493/05, Serra, Belo Horizonte-MG, CEP: 30220-110
EST Colleges (São Leopoldo, RS)
https://orcid.org/0000-0002-1482-0777
e-mail: msparlow@hotmail.com

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KEYWORDS
Municipal solid waste; Sustainable development; Solid waste management.

Abstract: *The increase in the diversity and generation of solid waste and the resulting environmental, social and economic problems, place the sustainable management of waste as a critical issue to be considered in municipal realities. Based on this context, this study aimed to understand how solid waste management occurs in the municipality of Irati-PR, describing regulatory aspects, management practices in its various stages and the impacts of management on sustainability. Data were collected through field research, using interviews, observations and document analysis. The results show that there is a limitation of municipal laws and regulations, especially considering the lack of the Municipal Plan for Integrated Management of Solid Waste (PMGIRS). Waste generation corresponds to 0.853kg/per capita/day, with the selective collection of organic waste being outsourced and*

prioritizing the collection, segregation and destination of recyclable waste by organized collectives. The final destination of organic waste and rejects is still inadequately carried out in a controlled landfill. Among the positive points regarding environmental, social and economic sustainability, the separation of waste by the cooperative and association, awareness measures, concerns related to the health and safety of waste collectors and financial returns from the sale of recyclable materials are highlighted. On the other hand, weak legislation, disposal of waste in controlled landfills, inadequate public dumps, failure to carry out gravimetric control and failure to differentiate between small and large generators are some of the challenges to be overcome.

PALAVRAS-CHAVE
Resíduos sólidos municipais; Desenvolvimento sustentável; Gerenciamento de resíduos sólidos.

Resumo: O aumento na diversidade e geração de resíduos sólidos e os problemas de ordem ambiental, social e econômica decorrentes, colocam a gestão sustentável dos resíduos como uma questão crítica a ser considerada nas realidades municipais. Baseando nesse contexto, este estudo teve como objetivo compreender como ocorre o gerenciamento de resíduos sólidos no município de Irati-PR, descrevendo os aspectos regulamentares, as práticas de gerenciamento em suas diversas etapas e os impactos da gestão na sustentabilidade. Os dados foram coletados por meio de uma pesquisa de campo, utilizando-se de entrevistas, observações e análise documental. Os resultados demonstram que há uma limitação das leis e regulamentos municipais, especialmente considerando a inexistência do Plano Municipal de Gestão Integrada de Resíduos Sólidos (PMGIRS). A geração de resíduos corresponde a 0,853kg/per capita/dia, sendo que a coleta seletiva dos resíduos orgânicos é terceirizada e há a priorização da coleta, segregação e destinação dos resíduos recicláveis pelos coletivos organizados. A destinação final dos resíduos orgânicos e rejeitos é ainda efetuada de modo inadequado em aterro controlado. Dentre os pontos positivos considerando a sustentabilidade ambiental, social e econômica se evidenciam a separação dos resíduos pela cooperativa e associação, medidas de conscientização, preocupações vinculadas à saúde e segurança dos catadores de resíduos e retornos financeiros com a venda dos materiais recicláveis. Por outro lado, a legislação fraca, destinação final dos resíduos em aterro controlado, lixeiras públicas inadequadas, não realização de controle gravimétrico e não diferenciação de pequenos e grandes geradores são alguns dos desafios a serem superados.

PALABRAS CLAVE
Desechos sólidos municipales; Desenvolvimiento sustentable; Gestión de desechos sólidos.

Resumen: *El aumento de la diversidad y generación de residuos sólidos y los problemas ambientales, sociales y económicos que de ello se derivan, sitúan la gestión sostenible de los residuos como un tema crítico a considerar en las realidades municipales. Con base en este contexto, este estudio tuvo como objetivo comprender cómo ocurre la gestión de residuos sólidos en el municipio de Irati-PR, describiendo los aspectos normativos, las prácticas de gestión en sus diversas etapas y los impactos de la gestión en la sostenibilidad. Los datos fueron recolectados a través de investigación de campo, utilizando entrevistas, observaciones y análisis de documentos. Los resultados muestran que existe una limitación de las leyes y reglamentos municipales, especialmente considerando la falta del Plan Municipal de Gestión Integral de Residuos Sólidos (PMGIRS). La generación de residuos corresponde a 0,853 kg/per cápita/día, estando externalizada la recogida selectiva de residuos orgánicos y priorizando la recogida, segregación y destino de los residuos reciclables por parte de colectivos organizados. El destino final de los residuos y rechazos orgánicos aún se realiza de forma inadecuada en un vertedero controlado. Entre los puntos positivos en cuanto a la sostenibilidad ambiental, social y económica, se destacan la separación de residuos por parte de la cooperativa y la asociación, las medidas de*

sensibilización, las preocupaciones relacionadas con la salud y seguridad de los recolectores de residuos y la rentabilidad económica por la venta de materiales reciclables. Por otro lado, la débil legislación, la disposición de residuos en rellenos controlados, los botaderos públicos inadecuados, la falta de control gravimétrico y la falta de diferenciación entre pequeños y grandes generadores son algunos de los desafíos a superar.

Introduction

Modern challenges, like climate change, ozone layer destruction, pollution, water scarcity, the decimation of biodiversity, inequality, hunger, deprivation, and poverty, have pointed to sustainability as the appropriate paradigm of development in this era (Mensah & Casadevall, 2019). Sustainability implies transformation into actions, considering three pillars encompassing economic growth, environmental integrity, and social well-being, whose interconnection is crucial (Purvis, Mao & Robinson, 2018).

Solid waste management is one of the complex sustainability issues, as it is associated with many economic, environmental, and social factors (Ikhlayel, 2018). The issue has become urgent due to an increase in solid waste generation as a consequence of economic and population growth, rapid urbanization, and better living standards. Furthermore, the complexity of the composition of this waste brings about the need for developing new processes and systems to avoid the resulting liabilities (Rodrigues *et al*., 2018; Das *et al.*, 2019).

According to Kaza, Yao, Bhada-Tata and Van Woerden (2018), the world produces 2.01 billion tons of Municipal Solid Waste (MSW), with at least 33% not being managed in an environmentally sound manner. The coming years expect to see an increasing generation of global waste, reaching a production of 3.40 billion tons in 2050, corresponding to more than double the population growth for the same period. In Brazil, the data point to a generation of 81.8 million tons of solid waste in 2022, representing an increase of 30.5% in the last ten years. Of this total, 39.5% were dumped inappropriately by 2826 municipalities in controlled landfills or dumping grounds (Associação Brasileira de Limpeza Pública e Resíduos Especiais [ABRELPE], 2022).

Public waste management is generally the responsibility of the municipalities, which provide essential services to the population (Rodrigues *et al*., 2018; Abubakar *et al*., 2022). According to Fuss, Barros and Poganietz (2018), since Brazil is a rising economy, the Organization for Economic Cooperation and Development (OCDE) has required Brazilian municipalities to present more sustainable MSW management systems, balancing social, economic, and environmental aspects. The Legislative power also shows these concerns. One example is Federal Law No. 12.305/2010, which instituted the National Solid Waste Policy (PNRS) in Brazil, establishing integrated management. Municipalities are specifically required to elaborate a Municipal Plan of Integrated Solid Waste Management (PMGIRS) to implement proper forms of local management (Law No. 12.305, 2010).

However, despite the recommendations and institution of laws and regulations, the data reveal the neglect in the management and final destination of waste in most Brazilian cities. It is noticeable in the failure to develop a PMGIRS and in the disposal of solid waste in environmentally inappropriate ways, which reflects directly on the emission of Greenhouse Gases (GHG) (Sistema de Estimativa de Emissões de Gases Efeito Estufa [SEEG], 2021).

According to data from the National Information System on Solid Waste Management (SINIR, 2021), only 44.6% of the Brazilian municipalities investigated have municipal plans as determined by the PNRS. Moreover, only 49.8% of towns dispose of waste in adequately licensed landfills (ABRELPE, 2022).

In this context, solid waste management is fundamental for municipalities since it directly affects the three dimensions of sustainability (Rossit & Nesmachnow, 2022). Few studies have focused on assessing specific Brazilian realities (e.g., Liikanen, Havukainen, Viana & Horttanainen, 2018; Pereira & Fernandino, 2019). Understanding these management practices and their impacts on the environment and human health in cities of the Global South is therefore an important means to seek improvements in diverse urban realities (Abubakar *et al.*, 2022).

Based on this intent, this study aimed to understand how solid waste management occurs in the municipality of Irati, located in the southeast of the state of Paraná. To achieve that goal, we described the regulatory aspects found in the town, observed the existing practices of solid waste management in its various stages, and identified

the economic, environmental, and social impacts, positive and negative, resulting from solid waste management. To provide a better understanding, we initially present a brief history and conceptualization of sustainability, followed by issues relevant to solid waste management and the national regulations applied to the municipal context. Next, we show the methodology employed in the research, followed by the central results and discussions, leading to the conclusions of the study.

Sustainability

Sustainability and sustainable development, as concepts, have gained global receptivity and attention from government agencies, academics, professionals, and organizations (Olawumi & Chan, 2018). However, the definition of these terms took place over a long historical process, accompanied by the growing awareness of environmental problems, economic crises, and social inequalities (Sartori, Silva & Campos, 2014; Machado & Matos, 2020).

According to Purvis *et al*. (2018), the incipient environmental movements of the 1960s, with the criticism of strictly economic development, contributed to the rise of sustainable development in the 1980s. The authors highlight, among the milestones of criticisms of economic growth, the paper *Limits to Growth* of 1972, which raises the impossibility of unbridled growth on a planet with finite resources.

In 1987, already considering social concerns, another notable contribution emerged from the conceptual declarations of the Brundtland Report, which based the definition of sustainable development on the concept of development (economic growth limited by ecological constraints); the concept of needs (provision of scarce natural resources to all to ensure the quality of life); and on the concept of future generations (resource use from a long-term perspective) (Klarin, 2018). According to the report, sustainable development is "[...] one that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development [WCED], 1991, p.46).

After the publication of the Brundtland Report, sustainable development became a dominant paradigm, and the literature grew exponentially (Purvis *et al*., 2018). Moreover, since then, other events have been developed in the world to promote sustainability, such as the United Nations Conference on Environment and Development [UNCED] (1992); the United Nations General Assembly Special Session - Rio +5 (1997); the Kyoto Protocol on climate change (1997); the Millenium Summit - Millenium Declaration (2000); the World Summit on Sustainable Development, Rio +10 (2002); the International Conference, Rio +15 (2007); the United Nations Conference on Sustainable Development, Rio +20 (2012); the United Nations Summit on Sustainable Development (2015); and the United Nations Climate Change Conference, COP 21 (2015).

Due to the malleability of the first definition, the concept kept an open and dynamic idea, allowing numerous interpretations to emerge. However, a prevalent description usually employs three interrelated dimensions: environmental, economic, and social (Klarin, 2018; Olawumi & Chan, 2018).

The environmental pillar relates to the natural environment and its resilience capability to sustain life and human development. It involves, for instance, concerns about environmental impacts caused by the use of resources and emissions or pollutants. Thus, environmental sustainability can be driven by adequate planning of resource use and the conservation of ecology and biodiversity (Barbieri, Vasconcelos, Andreassi & Vasconcelos, 2010; Mensah & Casadevall, 2019).

The social aspect relates to the social impacts on communities, involving factors like unemployment, social exclusion, and poverty (Barbieri *et al.*, 2010). Social sustainability aims to guarantee human dignity and well-being

through better political, cultural, health, and educational systems. It also seeks peace opportunities and respect for human rights, honest work, gender equality, and the rule of law (Olawumi & Chan, 2018; Mensah & Casadevall, 2019).

In turn, the economic dimension relates to meeting the current production, distribution, and consumption needs without compromising future needs. Thus, it requires economic models that use financial and natural resources to obtain profits and benefits while valuing their sustainability (Mensah & Casadevall, 2019). Moreover, it involves employment opportunities that reflect the income and standard of living of the population (Claro, Claro & Amâncio, 2008). Table 1 summarizes the considerations on the dimensions of sustainability based on the issues covered in each pillar.

Table 1
Summary of the considerations on the pillars of sustainability

DIMENSION	ISSUES COVERED
Environmental	Preservation of the ecosystem, reduction of pollutant emission, rational use of resources, protection of air, water and soil, etc.
Social	Social well-being, quality of life, combating poverty, seeking social equity, preserving cultural identity, and promoting basic rights like healthcare and education, etc.
Economic	Increase in production and consumption efficiency based on the rational use of resources and other sustainable principles; creation of opportunities for income generation; and increase in the living standards of individuals, etc.

Source: Based on the literature consulted.

Thus, sustainability is a complex concept surrounded by numerous challenges that must be discussed and resolved from the integration and balance of the environmental, economic, and social pillars. Among these challenges, MSW management stands out and will be discussed in the following section.

Municipal solid waste management

Solid waste is unwanted, discarded remains or byproducts no longer necessary for the initial user (Amare, Al-Bhadly, Birhan, Hamid & Mohamad, 2022). According to Law No. 12.305/2010, in a more comprehensive way, it includes any material, substance, object, or good used in human activities and discarded due to its loss of instrumental value, whose final destination is in solid, semi-solid, gaseous or liquid states (Law No. 12.305, 2010).

Globally, more than half of the population resides in cities. By 2050, the population is expected to increase to 9.8 billion people, with about two-thirds living in urban areas (The World Bank, 2022). Due to industrialization, globalization, and the tendency of population growth, MSW generation is expected to increase over time, especially considering more populous low- and middle-income countries (Das *et al*., 2019; Amirdadi, Dehghanian & Kohneh, 2021; Bello, Al-Ghouti & Abu-Dieyeh, 2022; Takeda, Leme, Romeiro, Silva & Miguel, 2022).

Currently, Brazil generates 0.971 kg of solid waste per capita daily, or 354 kg per inhabitant annually (ABRELPE, 2022). The data presented by the World Bank (Kaza, 2018) estimate an increase of 19% in solid waste production in developed nations by 2050, while 40% is expected for low- and middle-income countries, which also have problems regarding waste collection and proper disposal.

Among the inadequate waste management practices in cities of the Global South, Abubakar *et al*. (2022) highlight mixed wastes, waste disposal in landfills and dumping grounds, and open waste burning. Other problems that stand out are linked to waste-storage spaces, such as public dumps, which interfere with the overall effectiveness of the entire system, especially given the recycling process (Aleluia & Ferrão, 2016; Rossit & Nesmachnow, 2022).

Specifically, in the context of small Brazilian municipalities, Pereira and Fernandino (2019) found low sustainability in MSW management due to the lack of a municipal solid waste plan, the absence of selective collection, and the lack of social control means, for example.

Although waste sorting and recycling are

effective methods for reducing household waste (Hoornweg & Bhata-Tata, 2012, Ibrahim & Mohamed, 2016), the rates are still low, which constitutes another problem identified (Fan, Yang & Shen, 2019). According to SINIR (2021), the National Waste Recovery Index in Brazil is only 1.67%. This figure indicates that, of the total waste generated, only this percentage is reused, recycled, or shows some form of energy recovery. According to Conke (2018), the lack of knowledge regarding what can or cannot be recycled and operational problems in transport cause errors in waste sorting and contamination. Thus, successful recycling programs depend on family behavior that prioritizes sorting at the source in addition to proper sorting, collection, treatment, and final disposal. Public awareness campaigns are also necessary to encourage the correct disposal of waste (Pistorello, Conto & Zaro, 2015; Abubakar *et al*., 2022; Amare *et al*., 2022, Bui Tseng, Tseng & Lim, 2022).

Similarly, the disposal of organic waste in landfills and the lack of alternative treatments, like composting, is also an undesirable problem from an environmental perspective (Hoornweg & Bhada-Tata, 2012).

Poor or even absent solid waste management leads to degrading effects on the environment in terms of sanitation levels, which affect the quality of life (Nwachukwu, Ronald & Feng, 2017; Das *et al*., 2019; Abubakar *et al*., 2022). Negative impacts include changes in ecosystems such as air, water, and soil pollution, emissions of methane and hazardous leachate, climate change, health and safety problems (especially for more vulnerable social groups), destruction of aesthetics, and the odor-related discomfort due to incorrect waste disposal (Ibrahim & Mohamed, 2016; Okwesili, Ndukwe & Nwuzor, 2016; Abdel-Shafy & Mansour, 2018; Purwani, Hisjam & Sutopo, 2020; Abubakar *et al*. 2022; Amare *et al*., 2022).

Besides social and environmental effects, the economic impacts stand out, considering that improper management results in higher downstream costs than the costs of proper waste management (Hoornweg & Bhada-Tata, 2012). Moreover, proper waste management can contribute to the economy by providing cost-effective secondary materials and helping to create new businesses, jobs, and investments (Das *et al*., 2019; Slomski, Lima, Slomski & Slavov, 2020).

The numbers and the resulting environmental, social, and economic problems reveal the need for establishing adequate and sustainable solid waste management, particularly in urban centers (Ibrahim & Mohamed, 2016; Bui *et al.*, 2022). This management involves a chain of connected steps that include waste generation, methods of collection, sorting, storage, transport, treatment, and final disposal (Das *et al*., 2019). Sustainable solid waste management, by definition, entails that the waste generated does not accumulate and can be recovered, reused, and recycled (Bello *et al.*, 2022). Menezes, Castro, Silva, Teixeira, and Silva (2019) and Das *et al*. (2019) also suggest the gravimetric analysis of solid waste to promote integrated management since it allows a better understanding of the quantity and quality of the waste generated. Moreover, it allows the definition of the appropriate treatment.

In this context, decision-makers must ensure that human actions are responsible and appropriate during all management stages (Mensah & Casadevall, 2019). Essentially, given that public waste management is usually the responsibility of municipal administration, public managers must create their strategies and processes for developing smart and sustainable cities (Rodrigues *et al*., 2018; Rossit & Nesmachnow, 2022).

The PNRS, waste management, and municipal government

Besides contributing to population well-being and better environmental conditions, a clean and sustainable city generates interest from investors who seek places to develop their operations with high living standards (Rodrigues *et al*., 2018). Thus, according to Hoornweg and Bhada-Tata

(2012, p. 1), public managers have an enormous task: "get the garbage out from under their feet and do it in the most economically, socially, and environmentally sound way possible."

In Brazil, Federal Law No. 12.305/2010 created the National Solid Waste Policy (PNRS), establishing general guidelines for the sustainable management of solid waste and determining the shared responsibility between the federal government, states, municipalities, and individuals, be they companies or consumers (Law No. 12.305, 2010). This shared management reflects the need to develop a management plan for each level.

The content in the PNRS determines that the municipalities are responsible for the integrated management of the solid waste generated in their territories, in addition to the elaboration of the municipal plan of integrated management. The PMGIRS should include specific actions toward the rational use of environmental resources, combating wastage, and minimizing solid waste generation. Moreover, the law also forbids the use of uncontrolled landfills (Law No. 12.305, 2010). Based on these guidelines, each municipality must create and execute its management plan according to the local reality and determining conditions.

Brazilian solid waste regulation prioritizes, in its policy, the participation of cooperatives and associations of waste pickers in the selective collection of reusable and recyclable materials (Law No. 12.305, 2010). Consequently, informal or organized waste pickers play a direct role in solid waste management, acting in MSW collection, sorting, and commercialization (Fidelis, Marco-Ferreira, Antunes & Komatsu, 2020). According to data from SINIR (2021), more than 31 thousand associations and cooperatives and about 1.5 thousand independent solid waste pickers are registered. This integration of the informal sector can bring benefits by generating jobs, improving work conditions, and reducing social vulnerability, for instance (Cano, Iacovidou & Rutkowski, 2022).

Considering the principle of shared responsibility, the development of the PNRS also allowed the distinction between small and large waste generators, freeing the public administration from transporting and disposing of solid waste produced by large generators (Bidinoto Júnior, Faria & Riveiro, 2022). Large generators are individuals or legal entities that generate more than 120 liters of waste per day in commercial establishments, whose composition is equivalent to household waste (Instituto Brasileiro de Administração Municipal [IBAM], 2001). It is up to each municipality to define this issue through laws and decrees, as done by the Federal District with Law No. 5.610, in 2016 (Bidinoto Júnior *et al*., 2022).

The PNRS also defined reverse logistics as a tool for implementing shared responsibility (ABRELPE, 2022). Its goal is to shape product flows in the opposite direction, minimizing their environmental impact and exploring their economic potential (Mesjasz-Lech, 2019). Thus, each company must manage its products and prioritize their return to a new cycle (Purwani *et al*., 2020). However, a large part of the Brazilian industry has not adhered to reverse logistics and, consequently, has not internalized waste treatment courses into production costs (Slomski *et al*., 2020). Among the barriers to these results, we can highlight, for example, the lack of awareness by consumers and companies, the absence of collection points, the absence of technology and infrastructure, the fact that some managers see reverse logistics as an economically unjustifiable investment, and the lack of municipal waste management plans (Bouzon, Govindana, Rodriguez & Campos, 2016; Castro *et al*., 2022).

Despite substantial improvements in solid waste management in recent decades, it is worth noting that its sustainable management is still a subject of great challenges for municipal authorities, especially in low-income nations that still rely on conventional landfill and burning techniques to dispose of their solid waste (Abdel-Shafy & Mansour, 2018; Gupta & Paranjape, 2020; Takeda *et al*., 2022). This is mainly due to reduced public budgets, which lead to low-cost and unsustainable policy solutions (Abdel-Shafy

& Mansour, 2018, Fuss *et al*., 2018; Bui *et al*., 2022). Moreover, weak legislation, like the absence of the PMGIRS, is one of the basic gaps in environmentally sound management solutions (Durgekar, 2016).

In this context, accompanied by the growth in waste generation, management-related costs also reveal themselves as a difficulty. According to ABRELPE (2022), municipalities spend about R$ 10.95 per inhabitant monthly to handle all urban cleaning services in Brazil. The data reveal that low-income countries dedicate, on average, 20% of municipal budgets to solid waste management, compared to 4% in high-income countries (Kaza et al., 2018).

Thus, given the increases in the generation and diversity of solid waste, which still tend to expand in the coming decades, we observe that its management is a theme that requires discussion and proposal of alternatives that minimize its effects. Sustainable solutions must appear to eliminate problems and generate environmental, social, and economic benefits. In this context, municipalities have an important role since they are the front line in managing the solid waste generated by them. Moreover, they are responsible for defining policies and implementing them based on current legislation, like the PNRS, and the common good of the population.

Methodological elements of research

This is a qualitative and descriptive study aimed at understanding the individual meaning and interpretation of the complexity of a situation without using statistical methods and techniques (Creswell, 2010). According to Collis and Hussey (2005), qualitative-descriptive research is useful for gaining information about the characteristics of a problem or issue. In this case, there is no interference by the researcher. Their role is to discover the frequency with which a phenomenon occurs, its nature, characteristics, causes, and connections to describe it (Barros & Lehfeld, 2007).

Regarding the technical procedures, the research is a field study. According to Gil (2008), field studies seek to deepen the knowledge of the proposed questions by studying a single group or community in terms of its social structure. They are somewhat flexible, allowing the reformulation of their goals during the research process.

To understand how solid waste management occurs in the municipality of Irati, the objective of this study, we opted for a methodological triangulation in data collection, employing three instruments: a) semi-structured interviews, b) non-participant observations, and c) documentary research.

Interviews are understood as a meeting between two people to understand the meaning attributed by the interviewees to a given question (Marconi & Lakatos, 2009). We conducted two interviews. The first approached the secretary of the taxation department of the town to gather information on the municipal legislation related to solid waste and collection fees. The second talked to two representatives of the Department of Environment and Ecology of Irati-PR (secretary and deputy secretary) to understand, in-depth, the management practices adopted in the town. We selected the format of semi-structured interviews because the interviewer can keep order to the points of interest while letting the interviewee speak freely about the topics under discussion (Gil, 2008). Among the initial topics selected for the interview with the taxation department employee, the waste collection fees and related legislation stand out. It is worth mentioning that no additional points of interest were raised during the conversation. In turn, the interview with the representatives of the Department of Environment and Ecology covered the municipal plan; municipal laws related to solid waste; the management process of recyclable waste including collection, sorting, storage, and transport; treatment and final disposal of waste; municipal expenses; and alternatives sought by the town for better management. During the interview, other topics relevant to understanding waste

management emerged, such as gravimetric control, reverse logistics, methods to raise awareness among the population, events held about solid waste, and work safety for waste pickers during the Covid-19 pandemic.

We also employed observation as a data collection technique. We observed the association and cooperative of waste pickers in town to understand the processes performed in waste sorting. This study employed the non-participant observation method, in which the researcher witnesses the fact but does not interfere or get involved with the situation (Barros & Lehfeld, 2007).

Finally, the documentary research covers the analysis of documents, regulations, and municipal laws on solid waste, including those indicated in the interviews. According to Gil (2008), documentary research corresponds to the use of materials that have not yet received an analytical treatment or that can be reworked depending on research objectives.

For data analysis in this study, we chose the content analysis method, in which, through systematic procedures, the objective is to describe the contents of messages and gain knowledge related to them (Bardin, 2011). We organized and codified the transcript of the interviews, records of the observations, and compilation of related legislation according to the interview topics, followed by the study objectives, including regulatory aspects and stages of solid waste management.

It is worth mentioning that we collected and analyzed the data between 2019 and 2020 and portrayed the reality in this time frame. Moreover, this study followed all proper procedures regarding the use of a third-party intellectual property. The interviews were requested and granted through protocol procedure. The observation and the images provided had their disclosure authorized through the signing of an Authorization for the Use of Image form by the president of the organized collective.

The results initially present the characterization of the municipality studied, followed by the description of the municipal regulations linked to solid waste. We also present the waste management practices in their stages of generation, collection, sorting, storage, transport, treatment, and final disposal. Moreover, we analyze the management from a sustainability perspective, considering economic, environmental, and social impacts according to the objectives established.

Presentation and discussion of results

Municipal characterization

Irati is a municipality located in the southeastern region of the state of Paraná, about 150 km from the capital Curitiba, as shown in Figure 1. It has an estimated population of 61,439 (Instituto Brasileiro de Geografia e Estatística [IBGE], 2022).

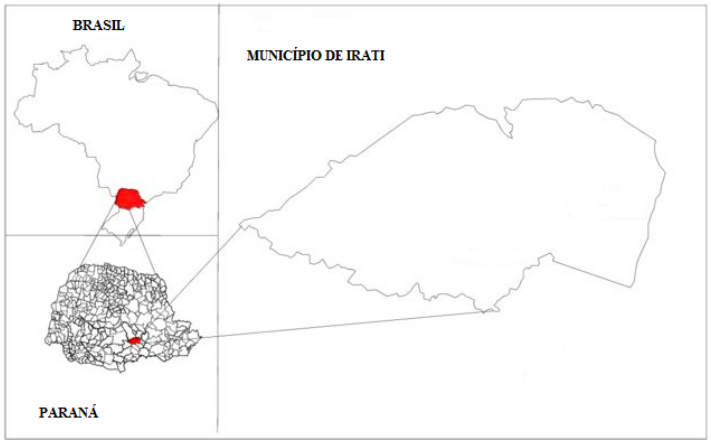

Figure 1 – Location of Irati-PR
Source: Adapted from Antoneli and Bednarz (2011).

Irati has borders with the municipalities of Prudentópolis, Imbituva, Fernandes Pinheiro, Rebouças, Rio Azul, Inácio Martins, and Guarapuava. Its economic activities are distributed in the trade and services sector (54.2%), agriculture (27.4%), and industry (18.4%) (Instituto Paranaense de Desenvolvimento Econômico e Social [IPARDES], 2023). Furthermore, Irati presented a GDP per capita of R$ 33,519.24 in 2020, ranking 213th among the

399 municipalities of the state. Moreover, it has a high Human Development Index (HDI) of 0.726 (IBGE, 2022).

Regulatory aspects related to municipal solid waste

Although its presentation is mandatory, as established in the PNRS, Irati has not created its PMGIRS yet. According to the Department of Environment and Ecology, in 2019, the town raised budgets for selecting and opening a contract with an external specialized company to construct the plan in dialogue with all parties involved. However, in addition to the large funds necessary, legislative issues were responsible for postponing the plan creation. On this issue, the town had two municipal laws (Law No. 2.436/2006 and Law No. 4.486/18) that referred to the Municipal Environment Council (Conselho Municipal de Meio Ambiente [CMM]), responsible for the decisions that involve, for example, approving budgets and, consequently, realizing the solid waste management plan. These laws had problems of jurisprudence, considering divergences and overlaps of one over the other. Thus, the town prioritized the creation of a new law that would repeal the previous ones and regulate the Council's actions. Law No. 4.735/2019 was passed on October 11, changing the CMM to the Municipal Council for Environmental Defense (Conselho Municipal de Defesa do Meio Ambiente [CONDEMA]), which is still in its construction process.

The situation found in Irati corroborates with data at the national level raised by the SINIR report (2021), which points out that less than half of the Brazilian cities investigated have a finalized municipal plan.

Due to the absence of the PMGIRS, Irati currently follows, besides the federal guidelines, the Municipal Policy of Basic Sanitation (PMSB) instituted by Law No. 3.608/2012 and other local laws that address questions pertinent to solid waste management. It is worth mentioning that although the PNRS determines the integration of the municipal plan to the basic sanitation plan (Law No. 12.305, 2010), the aforementioned municipal policy does not meet the minimum content required. Table 2 shows the legal instruments related to solid waste instituted in the town.

Table 2
Municipal legislation on solid waste

LEGAL INSTRUMENT / DOCKET	CONTENT RELATED TO SOLID WASTE
Municipal Organic Law/1990 - Establishes the Organic Law of Irati-PR.	The treatment and disposal of household waste and other waste of any nature are the town's obligation. It establishes that individuals or legal entities that perform polluting activities will have the responsibilities and measures adopted regarding their waste defined by State Law. They will also be obliged, under penalty of licensing suspension, to comply with the guidelines established by the competent body.
Law No. 3.608/2012 - About the Municipal Policy of Basic Sanitation.	The handling of solid waste is a part of municipal basic sanitation. Conducting it in a manner appropriate to public health and environmental protection is one of the basic principles of the policy. Moreover, the packaging, collection, transport, treatment, and final disposal of solid waste are factors of local interest.
Law No. 4.229/2016 - About the Code of Conduct of Irati-PR.	It determines the municipal government as responsible for performing street cleaning services, collecting, transporting, and treating household waste; it prohibits the sweeping of garbage or solid debris into streets or gutters of public locations; it establishes the packaging of household garbage into plastic bags for proper removal by the public cleaning service; it does not consider industrial, factory, and workshop waste as garbage for collection purposes, in addition to demolition and construction debris, soil, leaves, branches, and hospital waste; it prohibits the disposal of waste in inappropriate places, as well as its burning; it prohibits the installation of vertical ducts for garbage collection in residential or commercial buildings; and it determines that healthcare solid waste is the responsibility of the generator, and its handling and disposal should comply with specific technical standards.

Source: Research data (2020).

Moreover, as determined by the PMSB, the

municipality is not responsible for collecting, transporting, or treating waste produced by large generators (Plano Municipal de Saneamento Básico de Irati (PR), 2012). However, currently, due to the absence of a PMGIRS, there is no distinction between small, medium, and large generators adapted to the municipal reality, as defined by IBAM (2001) and Bidinoto Júnior *et al*. (2022). Because of that, commercial establishments are equated with households and pay the same collection fee, regardless of the amount of solid waste generated. Considering recyclable waste, to enable a social counterpart, the town created a term for signature at the time of renewing the operating permit. This document determines that recyclable materials should be forwarded to the cooperative or association rather than sold by commercial establishments for profit.

Considering the national legislation, we observe that the town meets the legal provisions by prioritizing the collection, sorting, and disposal of recyclable solid waste to organized collectives. Altogether, 22 families are connected to the cooperative and 25 to the association. Their incomes come from selling the collected material. Thus, informal waste pickers, the association, and the cooperative play a direct role in the management of municipal solid waste (Fidelis, Marco-Ferreira, Antunes & Komatsu, 2020).

Reverse logistics, on the other hand, despite the determination by the federal legislation, is an unregulated and unsupervised matter in the town. Materials like lamps, tires, and batteries are a major problem, unsolved by commercial companies. They take up large spaces in the sorting sheds used by the association and cooperative of waste pickers. This can be justified by the barriers that still exist in the implementation of reverse logistics, such as the lack of information, lack of technology and infrastructure, lack of collection points, and lack of interest by private managers in investing in this system (Bouzon, Govindana, Rodriguez & Campos, 2016; Castro et al., 2022). According to the research data, issues related to differentiating waste generators and reverse logistics should be regulated with the creation and implementation of the PMGIRS.

Thus, we observe that the existing regulations in the town are still superficial concerning solid waste, which can compromise its correct management and amplify the negative environmental, social, and economic consequences of poor management.

Solid waste management in Irati-PR

To assess how the management of MSW occurs in Irati, we report the practices in the stages of generation, collection, sorting, storage, transport, treatment, and final disposal of solid waste (Das *et al*., 2019).

According to the latest available data, provided via an interview with representatives of the Department of Environment and Ecology, the town generates approximately 46 tons of organic waste and 5.8 tons of recyclables daily, still subject to sorting. These numbers, translated into individual values, correspond to a generation of 853 grams of solid waste per capita daily, or approximately 311 kg per capita yearly, which is lower than the Brazilian average of 0.971 kg of waste per capita daily (ABRELPE, 2022).

The selective collection is the responsibility of the town government, which outsources the collection of organic waste and prioritizes the collection, sorting, and disposal of recyclable solid waste to organized collectives of workers in the form of cooperatives and associations, as determined by Federal Law No. 13.305/2010.

The outsourcing of the collection services of organic material is seen as advantageous for the town since it transfers the responsibility of allocating human and material resources for executing those activities, defined by a work plan created by the town government. The service provided is remunerated according to the weight and quantity collected and is paid for through the garbage fee, included in the water supply bill paid by the citizens. The town is responsible only for managing the resource collection. According to the municipal taxation department, the fee

corresponds to R$ 1.44 per truck pass during the month.

Regarding the collection of recyclables, the town government establishes a partnership with the association and the cooperative of waste pickers in the town, paying for the required logistical process without compensation from the population benefited. In this case, the town hall must make three trucks available for collection and transport, hire drivers for them, rent the sheds, and cover the costs of water and electricity used on the premises. The association and cooperative must assign the labor force to collect the solid waste in the trucks and sort them correctly. It should be noted that the prioritization policy established does not stop individuals from collecting recyclable waste. For that, the town government structured a collection map. Its schedule indicates the neighborhoods and assignment days of each one. In this agreement, the cooperative and association share the same route since there is a weekly intercalation of waste collection and sorting activities.

After an on-site visit to the sheds where the organized collectives work, we could understand the processes in the sorting of recyclable materials in the town (Figure 2). Initially, the trucks used in the selective collection deposit the waste at a specific place in the shed (1). The waste gradually goes onto the tables where the materials are effectively sorted into bags according to the established categories (2,3). In this process, we observe a large amount of organic waste and dirty materials that arrive for the sorting process, which frequently occurs in cities of the global South (Abubakar *et al*., 2022) and may result from the lack of knowledge and awareness of the population or operational problems in transport, for example (Conke, 2018; Amare et al., 2022; Bui et al., 2022). After sorting, the waste is pressed and ready for sale (4).

Figure 2 - Waste sorting process performed at the cooperative of recyclable waste pickers.
Source: Research data (2020).

In the town center, the collection occurs from 6 p.m. every day. This schedule was adapted at the end of 2019. Previously, waste collection took place in the morning. This proposal still faces resistance from businesses gradually adapting to the change. In this new scenario, there is a reduction in urban mobility problems, given that no solid waste is put on the streets during business hours. The absence of garbage trucks during this period also helps.

Regarding the districts and other rural areas of the municipality, the collection of recyclable waste follows a specific schedule, occurring on Fridays weekly or monthly, depending on the location. In this case, specific points are set for waste placement and collection. Regarding organic waste, there is the assumption that collecting it is unnecessary and, therefore, waste burning is one of the common problems in those locations. Moreover, in what we presume is a cultural issue, the same occurs with part of the recyclable materials, an unfortunately common practice of poor solid waste management (Abubakar et al., 2022).

Regarding the municipal expenses for collecting organic and recyclable waste, according to the numbers found by the Department of Environment and Ecology, an amount of R$ 2,988,311.52 was allocated for selective waste collection from August 2017 to July 2018. The

sum is equivalent to approximately R$ 4.00 per capita per month for urban cleaning services. Albeit expressive, the per capita value is significantly lower than the national average of R$ 10.95 per inhabitant per month (ABRELPE, 2022). These reduced values tend to result in low-cost policy solutions with little regard for sustainability issues (Abdel-Shafy & Mansour, 2018, Fuss *et al*., 2018; Bui *et al*., 2022). Table 3 breaks down the municipal expenditures related to solid waste management.

Table 3
Municipal spending on the collection of organic and recyclable waste from August 2017 to July 2018.

DESCRIPTION - COLLECTION	AMOUNT SPENT
Organic waste collection	R$ 2,114,266.12
Collection of recyclables[1]	R$ 874,045.40
Total	**R$ 2,988,311.52**

Source: Data provided by the Town Hall of Irati, Department of Environment and Ecology (2019).

Despite the available data, we note the limitation of available information, given the lack of gravimetric control in solid waste generation and disposal. According to the town's Department of Environment and Ecology, until September 2017, the association and cooperative were required to report the items and quantities collected. They only took up this practice again at the beginning of 2020. However, despite the monthly distribution of forms for recording the information, the involved parties did not provide the expected results. This case reveals the need to reintegrate and reinforce this practice. Regarding organic waste collection, the truck that performs the final disposal is not weighted due to the use of a controlled landfill. Thus, only an estimate of the amount generated and discarded can be obtained.

Given the limited practices of reverse logistics in the municipal reality, in addition to lamps, tires, and batteries, Styrofoam stands out as a difficult-to-treat material. Usually, it arrives at the sorting process and ends up rejected and forwarded to the landfill along with the organic waste since it cannot be used. The same occurs with glass shards and contaminated materials (wet, dirty), resulting in a large volume of rejects, about 40%, even after sorting.

The volume of reject waste forwarded to the landfill is also a consequence of the models of public garbage bins available in the town's public areas. These bins are unsuitable for sorting and, therefore, contain mixed waste, mostly recyclable (Figure 3), forwarded directly to the controlled landfill.

Figure 3 - Model of garbage bins available in public areas of Irati-PR
Source: Research data (2020).

Regarding the citizens' awareness issue, the town government has been developing a series of efforts to improve waste sorting and management. First, they adopted an educational and forceful corrective measure by not collecting household waste if a residence mixes organic and recyclable waste. They also employ social media to raise awareness through videos that reinforce the importance of recycling. In this case, despite the lack of gravimetric control, we observed an increase in recyclable materials available in the sheds of the association and cooperative. We assume that this increase is a result of these

1 These costs include the maintenance of the trucks employed in the collection of recyclables (parts and services), the rental of the property where the cooperative and association of recyclable waste pickers is located, investments towards a new place where the collectives will move to in the future, and the acquisition of a truck through the agreement with the Águas Paraná Institute.

measures.

Moreover, in 2019, the 1st Environment Conference was held. Its discussion and proposal of alternatives related to solid waste management stood out. Three actions were priorities in the action plan: the implementation of Voluntary Delivery Points (VDPs) for solid waste, especially considering districts and rural zone of the municipality; municipal decentralization aimed at environmental licensing and inspection; and the creation and execution of the PMGIRS, demanding that large waste generators present the Solid Waste Management Plan (PGRS).

Furthermore, the support in work safety for the cooperative and association that receive recyclable waste, with the provision of Personal Protective Equipment (PPE), was also a point of discussion. Due to the Covid-19 pandemic, this action was anticipated, especially given the recommendation of the Public Ministry that required all municipalities to provide adequate PPE for workers during this period. Given the continuation of waste collection services, recommended by the Department of Sustainable Development and Tourism (SEDEST), other precautions were adopted, such as training personnel for waste collection and quarantining the collected material for 48-72 hours before sorting.

Regarding the final destination of solid organic and/or reject waste, it should be noted that, according to the Plan for Integrated and Associated Management of Urban Solid Waste in the State of Paraná (PGIRSU/PR), Irati is part of the municipalities covered by the Regional Office of Irati (ERIRA) and the only one that still disposes of its waste inadequately in a controlled landfill. The other towns in the region, namely Imbituva, Guamiranga, Teixeira Soares, Fernandes Pinheiro, Inácio Martins, Rebouças, Rio Azul, and Mallet, already dispose of their solid waste in properly licensed landfill areas (Instituto Ambiental do Paraná [IAP], 2017).

The controlled landfill is located in Pinho de Cima, 25 km from the town, and does not develop any treatment process like incineration or composting. Due to the lack of space for expansion, the complaints from people who use nearby areas for agriculture, and the need to regularize the landfill to meet the PNRS, the municipal representative faced several judicial situations by the intervention of the Public Ministry to deactivate the landfill. In an agreement established, the town government committed to finding a solution for the waste's final destination. The alternative envisioned by the town consists of granting a site for the installation of a company that will reuse solid waste to produce biosynthetic wood. The factory agreed to recover the landfill area by using the material already decomposing. However, until the installation occurs, the landfill will continue to be the destination of reject waste.

Analysis of solid waste management from the sustainability perspective

The increase in the diversity and generation of solid waste contributes to expanding the concerns about its proper management through rigorous methods, taking into account aspects inherent to sustainability (Ibrahim & Mohamed, 2016; Bui *et al.*, 2022; Bello *et al*., 2022). This topic, therefore, focuses on assessing the identified municipal practices of solid waste management, considering the positive and negative aspects evidenced in the environmental, social, and economic pillars.

Regarding the environmental pillar of sustainability (Barbieri *et al*., 2010; Mensah & Casadevall, 2019), positive points stand out in the waste sorting performed by the association and cooperative of waste pickers, as well as in the collection of recyclable materials from districts and rural areas and the possible implementation of VDPs for that purpose. As stated by Hoornweg and Bhada-Tata (2012) and Ibrahim and Mohamed (2016), sorting and recycling waste are basic options for waste management that prove beneficial by minimizing the amount generated and reducing waste deposited in landfills or even inappropriate places. Moreover, educational and

corrective measures, like videos on social networks and not collecting mixed waste, are actions that reduce the volume of reject waste and its harmful impacts on the environment, ensuring sustainability (Pistorello, Conto & Zaro, 2015; Abubakar *et al*., 2022; Amare *et al*., 2022, Bui Tseng, Tseng & Lim, 2022).

Other positive points in evidence include the events to discuss the theme and propose alternatives, the intention to decentralize the municipality aiming to perform environmental licensing and inspections, allowing decisions to be made closer to harmful situations, and the possible implementation of the company that will transform solid waste into biosynthetic wood. Regarding the last point, it is worth highlighting social and economic benefits such as job creation and financial returns to the population and enterprise.

Among the negative impacts, considering the environmental dimension, we observe still limited legislation on solid waste management. It does not regulate reverse logistics or include the PMGIRS. Durkegar (2016) and Pereira and Fernandino (2019) point out that lack of legislation is one of the basic gaps in environmentally sound management solutions. Although the town has been seeking alternatives, the disposal of organic and reject waste in the controlled landfill and the lack of alternative treatments, like composting, are other problems observed. Environmentally speaking, they are undesirable strategies (Hoornweg & Bhada-Tata, 2012).

Moreover, despite recycling practices, cultural aspects related to burning solid waste in the open air in rural areas contribute to the increase of pollution and CO2 emission. This action is prohibited by the PNRS (Law No. 12305, 2010). In addition, there is a high percentage of reject waste forwarded to the controlled landfill by the cooperative and association, which has amplified negative aspects caused by the disposal of waste in this location, such as the release of large amounts of carbon dioxide and methane into the atmosphere, resulting in climate change and public health problems (Purwani, Hisjam & Sutopo, 2020; Abubakar *et al*. 2022; Amare *et al*., 2022). Another factor that increases waste disposal in landfills is using inappropriate garbage bins in public areas, directly affecting the sorting and recycling process (Rossit & Nesmachnow, 2022). According to Aleluia and Ferrão (2016), it is essential to create an adequate infrastructure to promote the correct sorting of waste, like providing garbage bins labeled for the disposal of various types of solid waste.

Finally, the lack of gravimetric control of the waste collected and forwarded to the final destination also stands out. On this issue, Menezes *et al*. (2019) and Das *et al*. (2019) point out that knowing the physical composition and quantum of generated solid waste, according to types, is essential to classifying and handling it properly.

Regarding the social pillar, which encompasses notions of human well-being (Olawumi & Chan, 2018; Mensah & Casadevall, 2019), the positive aspects observed include the prioritization of the association and cooperative in waste collection and recycling, which benefits 47 families that obtain income from this activity. Other benefits are job creation, improvement of work conditions, and better quality of life for those individuals (Cano et al., 2022). The proposition of a term to be signed by companies committing to allocate recyclables to the organized collectives also contributes to this matter. Moreover, the collection schedule aims to reduce urban mobility problems, translating into a collective benefit. In turn, albeit a recommendation from the Public Prosecutor's Office, the provision of PPE to workers and other actions related to precautions against the coronavirus highlight a social concern for the people who work in this sector.

Given the lack of associated regulations, equating commercial establishments to households is a clear negative point. As the service provided by the outsourced company is remunerated according to the weight and quantity collected, these values invested by the town government to meet the needs of large waste generators could be used to pay for other issues of social interest. This point is a negative economic aspect since the

equitable rate, in a way, burdens public coffers and benefits large generators by removing their responsibility for waste management and facilitating the final disposal of their waste. Thus, large waste generators are exempt from internalizing waste management costs into production costs (Bidinoto Júnior et al., 2022).

Another point to be considered is the lack of projects that include organic waste composting. Besides reducing the materials forwarded to the landfill, the organic compound resulting from composting could be applied in community gardens whose products would benefit several families. In that sense, waste could become valuable resources (Das *et al*., 2019; Slomski, Lima, Slomski & Slavov, 2020).

Finally, in the economic aspect of sustainability (Claro, Claro & Amâncio, 2008; Mensah & Casadevall, 2019), the financial return to the families that make up the association and cooperative of waste pickers is a positive aspect. On the other hand, high municipal expenses with solid waste management, including the lack of distinction and accountability of large waste generators in the disposal of their waste, are negative factors under an economic lens.

For a better understanding, Table 4 summarizes these considerations on the municipal solid waste management analyzed from a sustainability perspective.

Table 4
Positive and negative aspects of solid waste management in the municipality of Irati-PR, concerning sustainability

	POSITIVE ASPECTS	NEGATIVE ASPECTS
ENVIRONMENTAL	Waste sorting performed by the Association and Cooperative of waste pickers. Collection of recyclable materials from rural areas. Educational and corrective measures in waste collection. Awareness of the population through videos released on social media. Events held for discussing solid waste and proposing alternatives. Municipal decentralization with the goal of environmental licensing and inspection. Possible implementation of a company that will use solid waste in the production of biosynthetic wood to replace the controlled landfill.	Lack of a PMGIRS. Limited legislation on municipal solid waste management. No reverse logistics regulation. Disposal of organic and reject waste in a controlled landfill. Lack of alternative waste treatment methods, like composting. Cultural aspects related to the burning of solid waste in rural areas. Large amount of reject waste sent by the cooperative and association to the landfill (~40%). Inadequate garbage bins available on public spaces. Lack of gravimetric control of the waste collected and forwarded to the final destination.
SOCIAL	Companies signing a term to commit to forwarding their recyclable materials to the association/cooperative. Prioritization of the association/cooperative in waste collection and recycling, benefiting 47 families with the income gained. Collection schedule that reduces urban mobility problems. Provision of PPE to the association/cooperative and other actions related to precautions against the coronavirus.	Equating commercial establishments to households, burdening public coffers. Lack of community projects based on composting organic waste.
ECONOMIC	Financial returns to families that work in the association/cooperative with the sale of recyclable solid waste.	High municipal spending. Equating the fee charged from commercial establishments

		and households for waste collection.

Source: Research data (2020).

Final Considerations

This study had the central objective of understanding how solid waste management occurs in the town of Irati-PR. We conducted a field study, collecting data through interviews, observations, and documentary material.

Regarding regulatory aspects, we observed a limitation of municipal laws and regulations concerning solid waste. Even though the town meets the legal dispositions of the PNRS, considering the prioritization of collection, sorting, and disposal of recyclable waste for the organized collectives, the lack of a PMGIRS has essentially hindered determinations related mainly to reverse logistics and the distinction of waste generators according to the volume produced, which, in a way, burdens public budgets.

The management practices revealed that the waste generation, although lower than the national average, is still high, corresponding to 311 kg per capita per year. Given population growth and urbanization, it tends to increase over time. The selective collection of organic waste is outsourced and paid for through the garbage fee charged to citizens. In turn, the collection, sorting, and disposal of recyclable waste are conducted by the association and cooperative of waste pickers, and the logistics process is provided and funded by the town government. The collection downtown occurs at a time that contributes to urban mobility. In rural areas, collections take place on Fridays, according to the schedule, but only cover recyclable waste, which leads to problems related to the burning and incorrect disposal of solid waste in these locations. Municipal spending is still low when compared to the national average, which can result in unsustainable low-cost policy solutions. The town does not conduct a gravimetric control of waste, making it difficult to develop an effective management strategy. Large volumes of reject waste are still discarded mainly due to unregulated reverse logistics, unsuitable public waste bins, and large amounts of wet, dirty, or mixed materials that affect waste sorting practices. The town government works on raising the citizens' awareness, and events have been promoted to discuss alternatives and propose solutions regarding themes like municipal decentralization, implementation of VDPs, and development of the PMGIRS. There is also a concern with the organized collectives regarding safety, especially during the Covid-19 pandemic. The final disposal of organic waste still occurs inadequately in the controlled landfill without any treatment process. The proposed alternative is the installation of a company that would use the waste to produce biosynthetic wood, which has not materialized yet.

Finally, by assessing the adopted practices, we could establish the economic, environmental, and social impacts of solid waste management. Regarding the environmental pillar, positive aspects include waste sorting by the organized collectives, collection of recyclables in rural areas, educational and awareness measures, the realization of events, proposals of actions like municipal decentralization, and implementation of solutions to replace the controlled landfill. On the other hand, the lack of a PMGIRS, weak legislation, use of the controlled landfill as the final destination of organic and reject waste, waste burning in rural areas, inadequate public bins, and lack of gravimetric control are some deficiencies identified.

From the social point of view, the prioritization of organized collectives, the collection schedule aimed at improving urban mobility, and the precautions related to the health and safety of waste pickers are positive points. As negative aspects, we observed the lack of community projects based on composting and the non-distinction between small and large waste generators, which burdens public coffers and results in an economic problem. Finally, we observed the increased income of the families that work in the association and cooperative as a positive point of economic sustainability.

Despite the positive aspects, we found that the

town of Irati still has a long way to go to meet the dispositions of the PNRS, starting from the development of its PMGIRS. This document will define the current situation and the direction toward better environmental and human health conditions through proper solid waste management.

As a contribution to the literature, this study presented findings that corroborate the reality of many Brazilian municipalities and point to the complexity and major challenges related to solid waste management, especially considering local municipal realities. This analysis enables the proposal of actions and solutions that aim at sustainability aspects and a long-term perspective, adopting an approach of multiple environmental and socioeconomic criteria to eliminate or, at least, mitigate the harmful effects of poor solid waste management.

As limitations of this study, we point to the low number of interviews and the possible bias in the responses, considering that the interviewees work for the municipal public administration.

To expand knowledge on the subject, we suggest conducting studies in different realities, including quantitative analyses that can identify the relationship between solid waste management practices and sociodemographic characteristics like town size, development level, and economic activities, among other variables. We also suggest studies that present positive and innovative examples of municipal solid waste management for possible replication in different contexts. Finally, studies on implementing the PMGIRS and identifying facilitators and barriers could find alternatives and promote rapid compliance with the PNRS guidelines.

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