

SWOT analysis for sustainable management: diagnosis of the integrated management of urban solid waste in Granada, Nicaragua

Análisis foda para una gestión sostenible: diagnóstico de la gestión integral de residuos sólidos urbanos en Granada, Nicaragua

José Antonio Rodríguez Gaitán

Universidad Internacional Iberoamericana, Mexico (tristanjose82@yahoo.com) (<https://orcid.org/00090003-2419-7194>)

Erick César López Vidaña

Centro de Investigación en Materiales Avanzados, Nicaragua (erick.lopez@cimav.edu.mx) (<https://orcid.org/0000-0002-9200-6578>)

Información del manuscrito:

Recibido/Received: 03/03/26

Revisado/Reviewed: 02/07/26

Aceptado/Accepted: 07/09/26

ABSTRACT

Keywords:

SWOT analysis; sustainable development; urban solid waste management; strategic planning; non-hazardous solid waste.

The management of municipal solid waste is one of the main environmental and socio-economic challenges in contemporary urban contexts. Although this sector presents a number of opportunities linked to sustainable development, technological innovation, and the circular economy, it also faces multiple structural, institutional, and environmental threats that limit its effectiveness. In Granada, the management of municipal solid waste is governed by the Nicaraguan Mandatory Technical Standard 05 014-02, Environmental Technical Standard for the Management, Treatment and Final Disposal of Non-Hazardous Solid Waste, since hazardous solid waste is not managed in the city. The main objective of this research was to conduct a strengths, opportunities, weaknesses, and threats analysis of the integrated management of urban solid waste in the city of Granada during June 2025, in order to understand the current management of urban solid waste and thus determine possible sustainable strategies to improve waste management. Qualitative data collection instruments were used, with a cross-sectional design and descriptive scope, such as document analysis, interviews, and observation. The analysis reveals that waste management in Granada presents a marked asymmetry between numerous weaknesses (14) and few strengths (3), highlighting the lack of political will, insufficient economic budget, and a funding and infrastructure crisis as the core of the problem. In conclusion, this diagnosis guides sustainable strategies to strengthen local management.

RESUMEN

Palabras clave:

Análisis FODA; desarrollo sostenible; gestión de residuos sólidos urbanos; planeación estratégica; residuos sólidos no peligrosos.

La gestión de residuos sólidos urbanos constituye uno de los principales desafíos ambientales y socioeconómicos en contextos urbanos contemporáneos. Aunque, este sector presenta una serie de oportunidades vinculadas al desarrollo sostenible, la innovación tecnológica y la economía circular, también enfrenta múltiples amenazas estructurales, institucionales y ambientales que limitan su efectividad. En Granada, la gestión de los residuos sólidos urbanos, se rige a través de la Norma Técnica Obligatoria Nicaragüense 05 014-02, Norma Técnica Ambiental para el Manejo, Tratamiento y Disposición Final de los Residuos Sólidos No Peligrosos, puesto que, en la ciudad no se gestionan desechos sólidos peligrosos. El objetivo principal de esta investigación fue realizar un análisis de las fortalezas, oportunidades, debilidades y amenazas, de la gestión integral de residuos sólidos urbanos, que se realizó en la ciudad de Granada, durante el mes de junio, 2025, para conocer cómo es el manejo actual de los residuos sólidos urbanos y así determinar las posibles estrategias sostenibles que mejoren el manejo de los residuos. Se emplean instrumentos de recolección de datos cualitativos, con diseño transversal y alcance descriptivo tales como, análisis documental, entrevista y la observación. El análisis revela que en Granada la gestión de los residuos presenta una marcada asimetría entre numerosas debilidades (14) y escasas fortalezas (3), destacando la falta de voluntad política, presupuesto económico insuficiente y crisis de financiamiento e infraestructura como núcleo del problema. En conclusión, este diagnóstico orienta estrategias sostenibles para fortalecer la gestión local.

Introduction

In the complex global context of integrated urban solid waste management (IUSWM), Nicaragua—following the guidelines of the United Nations (UN) 2030 Agenda for Sustainable Development (SD)—is implementing a series of measures within its policies to mitigate climate and environmental impacts, which must be fully complied with by the country's municipalities.

There are numerous international and regional organizations that promote sustainable development (SD) and environmental protection (EP), most notably the United Nations Environment Program (UNEP), along with the International Solid Waste Association (ISWA), (2024), which state that global municipal solid waste (MSW) production is projected to grow by 56% by 2050, rising from 2.1 trillion (10^9) metric tons in 2020 to 3.8 trillion.

Solid waste (SW) refers to materials in a solid state that result from human activities, excluding those that are in liquid or gaseous form. Within this category, municipal solid waste (MSW) refers to waste generated in urban areas and their surrounding regions. Sustainable management of this waste involves shifting from the traditional linear consumption model to a circular one, which prioritizes reduction, reuse, separation, and recycling, limiting final disposal to non-recoverable materials only. (Inter-American Association of Sanitary and Environmental Engineering [AIDIS], 2018)

A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of a situation or project is a methodology used to identify both internal and external evaluation criteria in order to make strategic decisions (Betancur et al., 2023)

Rapid population growth, urban expansion, industrial development, and increased consumption of disposable products have significantly increased the generation of municipal solid waste in Granada. (Economic Commission for Latin America and the Caribbean [ECLAC], 2016)

Currently, the city of Granada does not have an adequate system for the collection, transportation, and treatment of waste, which has led to the creation of a landfill that is operating beyond its capacity (in terms of both space and time). The lack of control over waste inflow, combined with a shortage of resources for treatment and final disposal, has led to the accumulation of waste, creating public health problems that affect the population's quality of life. In this context, it is essential to conduct an assessment of GIRSU, as is being done by the Granada City Government, in order to move from poor management to a comprehensive, efficient, and sustainable approach.

However, despite this background, no comprehensive study has been conducted in the city that includes a SWOT analysis of GIRSU to inform strategic and sustainable decision-making. This study aims to fill that knowledge gap and help address the lack of information at GIRSU, transforming it from a burden into a driver of sustainable development, which would benefit the local economy, the environment, and the health of Granada's population.

Consequently, the overall objective of this article is to conduct a SWOT analysis of GIRSU, carried out by the city government of Granada, Nicaragua, during the month of June 2025, which will serve as a guide for establishing strategies to address environmental problems in the short, medium, and long term.

The research questions posed are: How can GIRSU in Granada be optimized through a SWOT analysis to turn weaknesses into strengths and capitalize on

opportunities in the face of threats? How is municipal solid waste currently managed in the city of Granada?

To this end, first, various scientific articles are collected and analyzed, such as the one published by Romero and Martínez (2024), who use SWOT analysis to analyze the GIRSU in the Naranjito Canton, Guayas Province, Ecuador. They conclude that the population has a per capita waste generation rate of 0.5 kg per person per day. Demonstrating the feasibility of establishing a municipal solid waste sorting plant in the Naranjito canton, using technological expertise that enables both the design of machinery and the selection of the necessary equipment to recover as much material as possible for use in the creation of new products or for reuse, the creation of jobs, and the reduction of environmental impact.

In contrast, Hernández et al. (2025) present a methodology for analyzing the potential of collaborative governance to strengthen the public management of municipal solid waste in the municipalities of Veracruz, Mexico, and conclude that multisectoral participation is the cornerstone of collaborative governance, public-private partnerships optimize resources, introduce technological innovation, and improve operational management indicators; finally, they note that sustainable MSW management requires recognizing the interdependence among stakeholders, resources, and capabilities.

Similarly, Cardona (2025) analyzes community-based environmental management (CEM) in a rural community in Acapulco, Mexico, using the SWOT analysis tool. He highlights that the study succeeded in identifying a set of challenges and opportunities for reaching the pre-operational phase of CEM, and concludes that citizen participation is essential for designing a socio-environmental program within the framework of strategic management (SM) and CEM, with an emphasis on local knowledge and community leadership.

Along the same lines, Lozano and Morocho (2025) explain the circular economy (CE) approach to waste management at the comprehensive sustainable waste management center in Loja, Ecuador—a study in which they use SWOT analysis as one of the tools to demonstrate the obsolescence of the comprehensive waste management center. The causes identified included inadequate leachate management, population growth, low recycling and sorting rates, and administrative shortcomings. Causing negative effects that include risks to workers' health and safety and environmental pollution.

Vasquez (2025) examines the challenges of managing municipal solid waste in the context of Mexico's emerging economy in the 21st century; Although he did not use SWOT analysis, he explains the interrelationship between population growth, urban development, waste generation, impacts on the environment, and quality of life, and argues that, through the circular economy, even in a market economy scenario, it is possible to generate added value or convert waste into valuable materials.

With regard to the history of GIRSU in Nicaragua, there are many studies and projects focused on this topic; however, these academic works lack depth and address the subject conceptually, offering only limited insights.

No studies were found that addressed a SWOT analysis of GIRSU in Granada. In this regard, Palma and Sánchez (2017) use SWOT analysis to propose a comprehensive environmental management plan for municipal solid waste in the municipality of Yalagüina (2017–2037). They determine that the shortcomings of the municipal solid waste management system (GIRSU) are the result of a combination of a series of institutional, environmental, social, cultural, and economic factors, among which the following stand out: weak managerial, financial, and legal planning; low qualifications and

training among the personnel involved; collection fees not aligned with the actual costs of the service or the socioeconomic conditions of the population; and a culture of nonpayment.

In Cambio, Zelaya (2025) argues that energy recovery from municipal solid waste (MSW) is a viable alternative for improving integrated waste management in Managua and Ciudad Sandino, as it significantly reduces the amount of waste sent to landfills and creates jobs. In addition, this strategy contributes to the circular economy and the energy transition by treating waste as a resource. However, its implementation requires updating national regulations, promoting incentives for clean technologies, strengthening the institutional capacities of local governments, and fostering collaboration with the private sector and international organizations to improve energy efficiency and reduce pollutant emissions.

For his part, Aguilar (2017) analyzes the socioeconomic impact of the EMTRIDES plant (Municipal Company for Comprehensive Solid Waste Treatment, Managua) from 2008 to 2016, concluding that the plant's operation has enabled effective waste management, brought about positive changes in social, economic, environmental, and health areas, provided direct employment to 500 people, and improved the quality of life for the population of Managua.

On the other hand, Vega (2020) conducts an environmental audit of municipal solid waste management in Granada and concludes that the municipality of Granada has been improving its waste management practices; however, it lacks studies and action plans to revitalize and promote the development of comprehensive waste management, and there is a need for better coordination between local government and civil society. Furthermore, it is necessary to raise environmental awareness through environmental education for the management of solid waste.

In this regard, González (2025), in his study "Approaches to Environmental Education in Nicaragua," concludes that environmental education is essential for fostering environmental awareness and contributing to the solution of global ecological problems. Its purpose is to develop knowledge, values, skills, and attitudes that enable students to understand the complexity of the relationships between society and the natural world. The study concurs with the findings of Ayala and Gómez (2025) regarding environmental education (EE), stating that it is one of the main strategies for addressing current environmental challenges. In their study, "Strategies for Improving Environmental Education in Peru," they concluded that comprehensive projects and cross-curricular integration proved to be effective strategies for strengthening environmental awareness, improving the relationship between schools and the community, and reducing waste. In this context, Mora (2025) emphasizes that environmental education (EE) is a fundamental strategy that helps reduce environmental impact and make better use of resources, enabling anyone to contribute to the care of the natural environment, regardless of age or social status.

In this regard, EA should be understood as an ongoing, dynamic process in the medium and long term that links theory with practice; this will help bring about cultural changes in society and environmental transformations (González et al., 2021).

Method

This is a qualitative study with a cross-sectional design, as the data were collected at a single point in time (June 2025). This approach allows for the analysis of data on waste

generation, collection, transportation, and final disposal, as well as treatment capacities, technical sizing, and infrastructure (Hernández et al., 2017).

In terms of its scope, this study is descriptive; this aids in understanding the context surrounding social and normative perceptions as well as relevant case studies, and provides insight into GIRSU in Granada. (Hernández et al., 2010)

This analysis was conducted in five phases, using techniques and tools for data collection and analysis with the aim of gaining a comprehensive understanding of GIRSU in Granada.

Population and Sample

The study population consisted of stakeholders directly involved with GIRSU, including municipal officials responsible for municipal solid waste management and informal waste pickers who recover reusable materials.

Due to access limitations, the lack of participation by certain stakeholders, and the small number of officials directly involved in waste management, non-probability convenience sampling was used. This type of sampling made it possible to select participants based on their availability, accessibility, and experience related to the subject of the study.

The exhibition consisted of:

- Three (3) municipal officials, including the director of the municipal public services department, the supervisor of city beautification and sanitation, and the supervisor of waste disposal.
- Ten (10) informal recyclers who collect and sell recyclable materials at various locations throughout the municipality and at the landfill.

Phase I. Literature Review

This phase focused on the collection, review, and analysis of secondary information related to GIRSU and included the following activities:

- Search and selection of source materials: A comprehensive review was conducted of scientific literature, technical documents, regulations, management plans, institutional reports, and publications related to GIRSU, both internationally and nationally.
- Document validation: The selected documents were evaluated based on criteria of quality, relevance, timeliness, reliability, and thematic relevance, ensuring that the information used was consistent with the research objectives.
- Information collection and systematization: The most relevant data were extracted from the documentary sources using literature review forms and analysis matrices.
- Document analysis and interpretation: The information gathered was organized and analyzed to identify concepts, approaches, experiences, regulations, and challenges related to GIRSU, thereby enabling the construction of the conceptual and contextual framework for the research.

Phase II. Semi-structured interviews

Semi-structured interviews were conducted with key stakeholders associated with GIRSU in the municipality. First, an interview was conducted with the director of the municipal public services department—the agency responsible for operating the public sanitation service—in order to gather information on the technical, administrative,

operational, and regulatory aspects of the GIRSU implemented by the Granada mayor's office. In addition, a supervisor in the landscaping and cleaning department was interviewed to learn about operational planning, field supervision, resource management, and workplace safety. Finally, the supervisor in charge of waste disposal at the landfill was interviewed to learn about the infrastructure, daily operating procedures, sorting, treatment, and final disposal of waste.

In addition, interviews were conducted with informal waste pickers who engage in waste recovery and reuse activities in the municipality, with the aim of identifying their perceptions, experiences, level of knowledge about the GIRSU, participation in the waste management chain, challenges they face, and potential contributions to the municipal management system.

The interviews were recorded, transcribed, and subsequently subjected to qualitative analysis.

Phase III. Direct observation

Direct observation was conducted at various stages of municipal solid waste management, including collection and transportation activities carried out by the municipality. In addition, an on-site visit was conducted to the La Joya open-air landfill to observe the operational, environmental, and safety conditions related to the treatment and final disposal of solid waste.

The observations were recorded using field notes and observation checklists, which made it possible to document aspects relevant to the GIRSU analysis.

Phase IV. Processing and Analysis of Qualitative Data

The information obtained through interviews and observation underwent a qualitative analysis process that included:

- Transcription of interviews and organization of observation records.
- A thorough review of the collected data.
- Open coding to identify categories, themes, and emerging patterns.
- Grouping codes into analytical categories related to the research objectives.
- Interpretation of results through thematic analysis, providing insight into the relationships among the various stakeholders and components of GIRSU.

Phase V. Analysis of the Information and Development of the SWOT Matrix

In order to strengthen the validity and reliability of the results, a methodological triangulation process was applied, cross-checking the information obtained from three main sources:

- Literature review.
- Interviews with municipal officials and informal waste pickers.
- Direct field observation.

Triangulation made it possible to identify similarities, differences, and complementary aspects among the various sources of information, thereby fostering a more comprehensive and objective understanding of GIRSU in the municipality of Granada.

Based on the information obtained through literature review, interviews, and observation, a SWOT analysis was conducted to identify the internal and external factors that influence GIRSU in the municipality of Granada.

As a result, three strengths, eight opportunities, 14 weaknesses, and 13 threats were identified, which made it possible to assess GIRSU's current situation and generate

input for the development of strategies aimed at improving municipal management and mitigating the environmental impacts associated with waste management.

Subsequently, all the information was organized and systematized using Microsoft Office tools—specifically Word and Excel—to facilitate the processing, analysis, and presentation of the research results.

Results

The following presents the results of the qualitative analysis of municipal solid waste management carried out by the City of Granada across the various stages of the waste life cycle, providing insight into the dynamics, interactions, and tensions present in the system. In this regard, the themes that emerge from the analysis form the basis for the structure of the results sections presented here.

GIRSU Assessment Conducted by the City of Granada

Study Area and Population

Santiago de Granada, or simply Granada, is a municipality and city in the Republic of Nicaragua. This department is divided into four municipalities: Granada, Nandaime, Diriá, and Diriomo. The municipality's main economic activities are divided into three sectors: a) primary sector: agriculture and livestock, extraction of non-metallic resources, and fishing; b) secondary sector: industry and construction; c) tertiary sector: commerce, services, transportation, and finance (Regional Program for the Reduction of Vulnerability and Environmental Degradation [PREVDA], 2014).

Granada covers an area of 592.1 km² and has a current population of 134,114. Of this population, 49.4% are men and 50.6% are women, with 78.8% living in urban areas (J. Ruiz, personal communication, Granada Civil Registry, 2023, March 13).

Current Status of GIRSU in Granada

In an interview with the director of the municipal public services department, he stated that the municipality of Granada does not have a comprehensive urban solid waste management plan (PGIRSU); it only has a plan for regular and special or extraordinary urban solid waste collection.

The management of these wastes is governed by the provisions of the Nicaraguan Mandatory Technical Standard (NTON) 05 014-02, Environmental Technical Standard for the Management, Treatment, and Final Disposal of Non-Hazardous Solid Waste (RSNP). Since the municipality does not manage hazardous solid waste (RSP), this standard establishes guidelines for the management, treatment, and final disposal of non-hazardous solid waste in Nicaragua, with the aim of protecting the environment and public health. This applies to all individuals and businesses that manage this waste in the country. Among the key points outlined in the document are: a) waste classification: household, commercial, institutional, market, and street sweepings; b) management and disposal: storage, collection, transportation, and final disposal; and c) best practices: source separation, recycling, reuse, and composting.

Currently, waste is disposed of at an open-air landfill called “La Joya,” located in the district of the same name, 5 km from the city center. The landfill has been in operation for more than 40 years, exceeding its projected useful life of 25–30 years. Covering an

area of 20,966.88 m², this site receives approximately 110 metric tons of trash daily without precise monitoring, due to the lack of a functional scale; it only allows non-recyclable solid waste (RSNP) from households, industries, markets, shopping centers, hotels, restaurants, and hospitals to be brought in.

Previous studies report that the accumulation of waste has exceeded the level of the natural topography, forming a sort of dome that facilitates the accumulation and drainage of leachate, which threatens to seep into the aquifer. (Guatemala, 2007)

Waste Generation and Separation at the Source

At present, the per capita waste generation (PPC) of the population of the municipality of Granada is unknown; however, according to an interview with the head of municipal services, he stated that the average amount of waste generated per resident is estimated to be 0.90 kg/resident/day, since in the year 2000, the figure used was 0.70 kg/person/day, and since then, the increase in municipal solid waste has been estimated at 1% per year. This figure is consistent with estimates for countries with lower-middle income, which range from 0.6 to 1.2 kg per person per day (United Nations Environment Programme [UNEP], 2018).

This information is similar to that presented in the article “Environmental Audit of Solid Waste Management in the City of Granada, Nicaragua,” by Vega (2020). Similarly, comparable values (0.9 kg/person/day) are reported in the article “Analysis of Integrated Solid Waste Management in the Naranjito Canton, Guayas Province,” presented by Romero and Martínez (2024).

The handling and storage of waste comply with the general provisions set forth in NTON 05 014-02, since users of the collection service store only non-hazardous solid waste in plastic bags, nylon sacks, and cardboard boxes. In various industries, markets, and businesses, containers such as barrels, half-barrels, and other containers are used. However, source separation is not promoted in any way, which reduces the efficiency of recycling; waste is mixed, causing cross-contamination, which makes subsequent treatment more difficult and costly, and results in a greater amount of trash ending up in landfills, thereby exacerbating the problem of inefficient waste management.

Collection and Transportation of Municipal Solid Waste

According to information gathered through interviews with the head of municipal services and the supervisor of beautification and sanitation, the municipal solid waste management service is organized into two categories: routine or regular sanitation and extraordinary or special sanitation. However, the municipality currently operates primarily under a basic framework focused on waste collection, street sweeping, and the cleaning of drainage channels and storm drains, without comprehensive programs aimed at the recovery, treatment, or reuse of waste.

According to the officials interviewed, the urban area is divided into twelve macro-routing zones, with micro-routing routes operating Monday through Sunday. Collection is carried out using the curbside system, in which crews of workers collect waste at predetermined locations according to set schedules and frequencies. However, both informants agreed that the system has operational and financial limitations that restrict its capacity to respond, since its management focuses primarily on waste collection and final disposal, without incorporating source separation, recycling, composting, or other treatment alternatives.

The interviews revealed that one of the main challenges to the service's sustainability is its funding. The current municipal fee is 50 córdobas per month

(approximately US\$1.35), collected annually along with the Property Tax (IBI), for a total of 600 córdobas per year (approximately US\$16.20). According to municipal authorities, this revenue is insufficient to cover the actual costs of operating, maintaining, and administering the service. In addition, there are reports of low payment compliance among the population, a situation that forces the city government to subsidize a significant portion of the costs associated with waste management.

In terms of operational capacity, the public sanitation department has seven subcontracted trucks, fifty handcarts, and a workforce of 117 garbage collectors. Both the head of municipal services and the supervisor of public appearance and sanitation noted that the vehicles used were not originally designed to transport solid waste. These are flatbed trucks with a capacity of approximately eight metric tons, equipped with side rails to prevent waste from spilling during collection and transport to the final disposal site. However, these vehicles lack compaction systems, covers, and adequate containment mechanisms, which leads to waste spilling out, the generation of unpleasant odors, and a negative impact on the city's image.

Figure 1 shows the results, which depict a truck and its crew hired by the City of Granada for the collection of municipal solid waste. It is clear that the truck is not suitable for this operation, and the crew can be seen working without any personal protective equipment.

Figure. 1
Collection of RSNP



Note: Figure 1 shows a truck used for curbside collection of RSNP in Granada. Source: Photo by the author, June 13, 2025.

This situation also constitutes a violation of the provisions of NTON 05 014-02, which stipulates that vehicles or equipment that are unsuitable for the handling and transport of waste, or that pose a risk to workers' health or to the environment, must not be used.

The interviews also helped identify deficiencies related to occupational safety. Waste collection workers do not always have the personal protective equipment required to perform their duties safely, exposing them to physical, chemical, and biological hazards resulting from direct contact with waste. This condition increases the likelihood of workplace accidents, infectious diseases, and occupational health problems.

From an operational perspective, the use of non-specialized trucks results in additional negative impacts, including: reduced efficiency on collection routes, an increase in the frequency of trips to the final disposal site, higher fuel and maintenance costs, longer operating times, and the potential loss of recyclable materials. It also contributes to air pollution by emitting unpleasant odors and to the deterioration of the city's environmental and sanitary conditions.

Waste from the municipal market and the surrounding streets is transported to a transfer station known locally as "El Plantelito," located on the southeast side of the market. This site receives the waste collected by the market's cleaning staff and street-sweeping crews, which is then transported to the municipal landfill.

In the healthcare sector, particularly at the municipal hospital, waste is classified as hazardous or biohazardous waste and non-hazardous or general waste, under the supervision of the staff responsible for epidemiology. Common waste generated by users, employees, and food service areas includes paper, plastic containers, bags, and organic waste. Internal collection takes place twice a day, and the waste is temporarily stored in containers until it is picked up by the municipal service.

According to information provided by the officials interviewed, the municipal waste collection service also collects non-hazardous solid waste generated by health centers, private clinics, hotels, restaurants, retail establishments, and supermarkets such as La Colonia, La Unión, Pali, and Maxi Palí. Similarly, companies such as Molinos de Nicaragua S.A. (MONISA), E. Chamorro Industrial, and Laboratorios CEGUEL directly manage the transport of their non-hazardous solid waste to the final disposal site.

In general terms, the analysis shows that the current solid waste management system provides basic operational coverage that allows for the regular collection of waste generated in the municipality; however, it faces significant institutional, financial, technical, and environmental constraints that hinder compliance with the principles of integrated solid waste management (GIRSU). Among the main gaps identified are insufficient financial resources, the use of inadequate transportation equipment, deficiencies in occupational safety, the absence of waste recovery programs, and an exclusive reliance on final disposal as a management strategy.

Final Disposition of Municipal Solid Waste

During the field visit to the final disposal site in the municipality of Granada, it was observed that, upon entering the landfill, the garbage trucks deposit the waste in the areas previously designated by the municipal supervisor in charge of the operation. Subsequently, a backhoe operator distributes and spreads the waste across different areas of the site without following the technical criteria for compaction, coverage, or containment typical of a solid waste landfill.

Figure 2 shows various trucks contracted by the Granada City Council dumping RSNP at the city's open-air landfill.

Figure 2
Final Provision of the RSNP



Note: Figure 2 shows trucks unloading RSNP at the La Joya landfill. Source: Excerpt from the article “La Joya,” the dark side of La Gran Sultana: this is what life is like at the Granada landfill. Primer Orden Online Newspaper, 2024, March 15.

Based on the observations made and the information provided by the final disposal supervisor, the site has significant operational and infrastructure deficiencies. First, it lacks a functioning scale, which makes it impossible to keep a reliable and accurate record of the quantities of waste received daily, as well as to perform a quantitative and qualitative characterization of the waste. Current monitoring is limited to manually recording the number of vehicles entering the site; the daily intake is estimated to be between 17 and 20 trucks, each with a capacity of approximately eight metric tons. According to the supervisor, only RSNP materials—primarily paper, cardboard, plastic, glass, and organic waste—are permitted.

In addition, it was found that the site lacked basic infrastructure necessary for its operation and security, including perimeter walls, protective fences, controlled-access gates, and surveillance systems. Similarly, essential services such as electricity, drinking water, and sanitation facilities are not available to the staff working there.

It was observed that the waste deposited does not undergo any type of treatment or processing prior to final disposal, in violation of the provisions of NTON 05 014-02, which stipulates that non-hazardous solid waste must undergo physical, chemical, or biological processes aimed at reducing its volume, minimizing health and environmental risks, and promoting the recovery of recyclable materials. The treatments covered by the regulations include shredding, compaction, composting, vermicomposting, incineration, pyrolysis, and disposal in technically designed municipal solid waste landfills. These processes also enable the production of value-added byproducts such as biogas, compost, humus, and energy.

Similarly, the conditions observed indicate noncompliance with NTON 05 013-01, the Technical Standard for Environmental Control of Municipal Solid Waste Landfills, because the municipality does not have a municipal solid waste landfill that ensures environmentally sound waste management.

During the visit, it was determined that there were approximately 40 informal recyclers, or “pepenadores,” who were engaged in the recovery of recyclable materials such as paper, cardboard, plastic, glass, and metals. Both the supervisor and the waste pickers interviewed agreed that this activity is an important source of income for their families. However, the conditions under which they perform their work are extremely precarious.

Figure 3 shows informal recyclers, or waste pickers, of both genders working at the La Joya landfill without any protective gear, exposing themselves to all kinds of diseases.

Figure 3
Collection of RSNP



Note: Figure 3 shows people of different genders working without any personal protective equipment at the “La Joya” open-air landfill, collecting plastic, glass, and/or paper. Source: Photo taken by the author, June 25, 2025.

Interviews with five informal waste pickers in the city and five waste pickers who work directly at the landfill revealed that none of them have a full set of personal protective equipment, such as heavy-duty gloves, safety boots, face masks, protective goggles, or appropriate clothing. The interviewees stated that they frequently suffer cuts, injuries to their hands and feet, constant exposure to foul odors, smoke from occasional fires, and direct contact with decomposing waste.

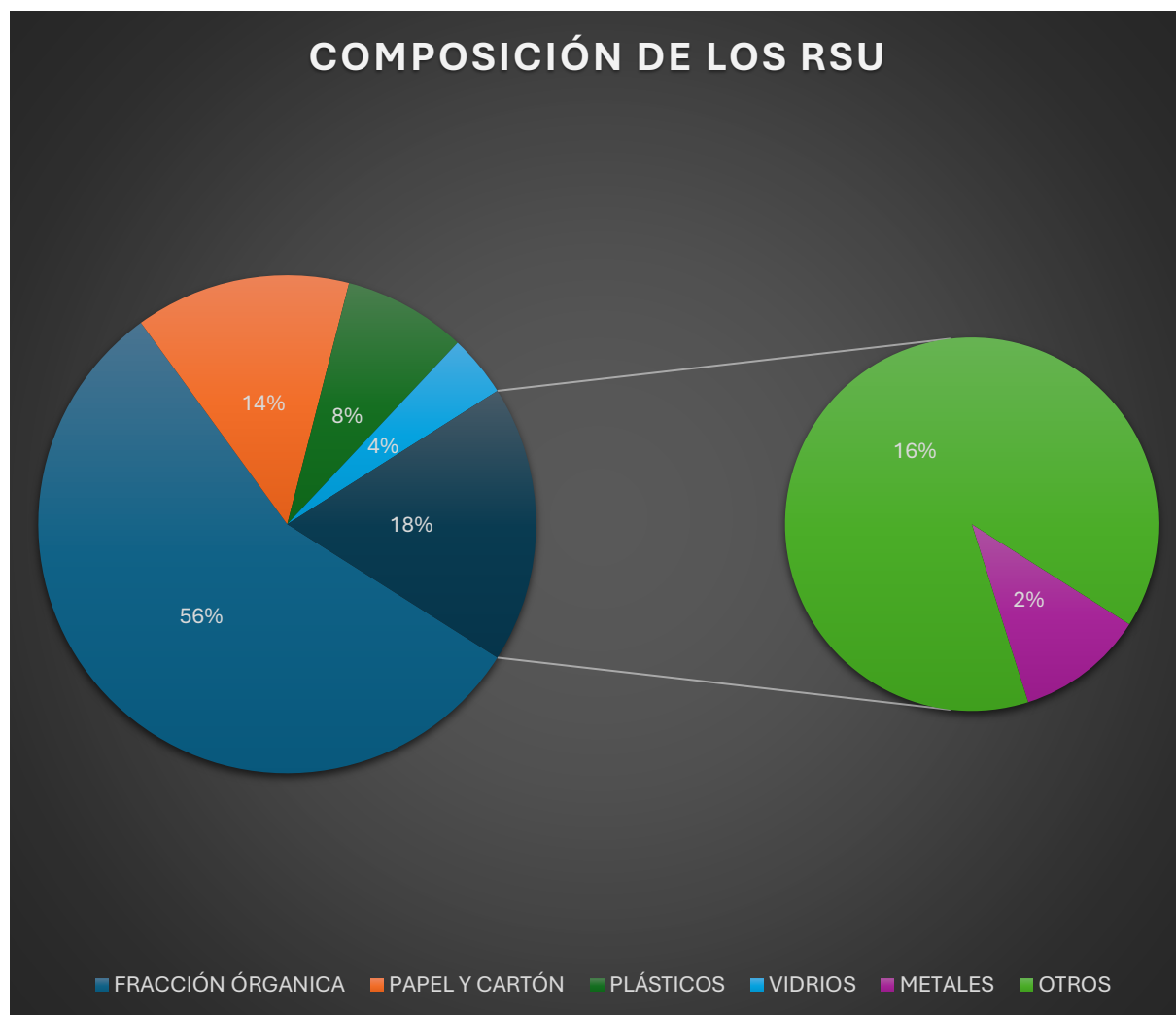
The conditions observed and the testimonies collected indicate ongoing exposure to various occupational hazards, including:

- **Biological hazards:** contact with pathogenic microorganisms, contaminated waste, vectors, and disease-carrying animals.
- **Chemical hazards:** exposure to gases generated by the decomposition of waste, particularly methane, as well as smoke and potentially toxic substances resulting from fires.
- **Mechanical hazards:** injuries from sharp objects, accidents involving heavy machinery, and the risk of being run over during unloading operations.
- **Ergonomic risks:** repetitive physical exertion, manual handling of loads, and maintaining improper postures during long workdays.
- **Psychosocial risks:** social stigmatization, economic exclusion, and a lack of formal recognition of their work.

The waste pickers interviewed also noted that the amount of recoverable materials at the site is considerably greater than what they are able to collect, due to limitations in time, resources, and operational capacity. This situation was confirmed during the tour, as large quantities of plastic bags, paper, cardboard, containers, and bottles were observed scattered throughout various areas of the landfill, indicating a significant waste of potentially recyclable resources.

Based on the average composition of municipal solid waste in countries with low-to-middle per capita income, as shown in Figure 4:

Figure 4
Composition of Municipal Solid Waste



Note: Figure 4 shows the composition of municipal solid waste for countries with low-to-middle per capita income. Source: Adapted from the report *An Overview of Waste Management in Latin America and the Caribbean*. (UNEP, 2018)

These data were extrapolated to Nicaragua, where organic waste accounts for approximately 56 percent, followed by paper and cardboard (14 percent), plastics (8 percent), glass (4 percent), metals (2 percent), and other waste (16 percent). It can be inferred that a significant proportion of materials with recovery potential is being disposed of without being utilized in any way. This situation represents not only a loss of financial resources for the municipality and waste pickers, but also a missed opportunity to strengthen recycling, composting, and EC programs that help reduce the volume of waste sent to landfills.

Legislation and Policies on GIRSU in Nicaragua

In Nicaragua, the management of municipal solid waste is not regulated by a specific law but is governed by the NTONs, issued by the Ministry of the Environment and Natural Resources (MARENA), the agency responsible for coordinating and directing the government's environmental policy.

These regulations establish guidelines for the management, treatment, and final disposal of municipal solid waste, with the goal of minimizing its environmental impact and promoting sustainable practices.

Table 1 details the legal framework governing GIRSU in Granada.

Table 1

Legal Framework Governing GIRSU in Nicaragua

Law/Decree /Regulation	Purpose	Key Provisions	Date of Issuance
Law No. 217, General Law on the Environment and Natural Resources	Establish standards for the conservation, protection, improvement, and restoration of the environment and natural resources.	Environmental impact assessment, natural resource management, wildlife area protection, environmental education, violations, and penalties.	1996 (Amended in 2023)
Law No. 40, Nicaraguan Municipalities Act	Establish the legal framework for municipalities.	It regulates the establishment of municipalities, their autonomy, organization, powers, and administrative operations, ensuring participatory democracy and the comprehensive socioeconomic development of each locality.	1988 (Amended in 2021)
Nicaraguan Mandatory Technical Standard (NTON) No 05-013-01	Environmental regulations for landfills for non-hazardous solid waste.	Criteria for the siting, design, and operation of landfills. Leachate and gas control. Requirements for year-end closing and post-closing procedures.	2001
Nicaraguan Mandatory	Guidelines for the Management, Treatment, and	Regulations for collection, transportation, disposal at landfills.	2002

Technical Standard (NTON) N° 05-014-02	and Final Disposal of Nonhazardous Solid Waste.	Promoting recycling and source separation. It establishes guidelines for the management of residential and commercial waste.	
Nicaraguan Mandatory Technical Standard (NTON) N° 05-015-02	Regulations for the Management and Disposal of Hazardous Solid Waste.	Definition and Classification of Hazardous Requirements for proper storage, transportation, and handling. Guidelines for Safe Disposal.	2002
Executive Decree No. 47-2005	National Policy on Integrated Solid Waste Management	Principles and guidelines that include definitions, plans, actions, and strategies for implementation throughout the country.	2005
Executive Decree N° 91-2005	National Policy for the Comprehensive Management of Hazardous Substances and Waste	A framework, principles, and guidelines that will guide the plans, programs, strategies, and actions of the public administration, civil society, and the Nicaraguan population in general regarding the management of RSPs.	2005 (Amended in 2023)
Nicaraguan Mandatory Technical Standard (NTON) N° 05002	To establish provisions and technical specifications aimed at protecting the environment by preventing and reducing environmental impacts associated with the generation and management of Waste Electrical and Electronic Equipment (WEEE).	This regulation governs the comprehensive management of this waste, classifies it as hazardous or non-hazardous, and establishes the responsibilities for generators, importers, and distributors to protect the environment. It defines WEEE and requires MARENA to submit annual reports.	2024

Note: Source: Produced in-house.

The Mandatory Technical Standards, the General Law on the Environment and Natural Resources (Law N°. 217), Nicaragua's Environmental Policy, and the Municipalities Act (Law N°. 40) establish the legal and institutional framework designed to ensure proper solid waste management in Nicaragua. These provisions recognize the importance of preventing pollution, promoting the environmentally sound management of waste, strengthening municipal responsibility, and encouraging practices aimed at the reduction, reuse, and proper final disposal of solid waste. However, in practice, significant institutional, technical, and economic constraints remain that hinder the achievement of these objectives.

From an institutional perspective, there is a clear gap between regulatory design and the operational management carried out by municipalities. Although Law N°. 40 assigns responsibility for public sanitation and solid waste management to local governments, the mayor's office lacks a Solid Waste Management Plan (PGIRSU) and is limited to implementing basic waste collection programs. Consequently, waste management focuses primarily on waste collection and transportation, neglecting essential components such as source reduction, separation, recycling, and proper final disposal. This situation reflects insufficient institutional capacity and limited allocation of financial resources for environmental management.

Furthermore, there is significant noncompliance with the technical provisions related to the final disposal of waste. Although mandatory technical standards promote the use of solid waste management systems that meet environmental and public health criteria, in Granada, collected waste continues to be dumped in an open-air landfill. This site lacks systems for waterproofing, leachate management, gas control, and environmental monitoring, resulting in contamination of the soil, surface water, and groundwater, as well as health risks to nearby communities.

The problem is exacerbated by insufficient oversight and enforcement of mandatory technical standards. Although the legal framework establishes obligations for public institutions, businesses, and citizens, the oversight and enforcement mechanisms have weaknesses that limit their effectiveness. The lack of inspections, insufficient monitoring of municipal environmental plans, and a lack of interagency coordination contribute to many legal provisions remaining merely on paper.

Another key factor is limited EA and low public awareness. Although Law N°. 217 and Nicaragua's Environmental Policy recognize the importance of environmental education as a tool for promoting responsible behavior, awareness campaigns have been insufficient and sporadic. As a result, inappropriate practices—such as the lack of source separation—persist. This situation makes it difficult to recycle and recover materials, as organic, recyclable, and non-recyclable waste from households and commercial establishments gets mixed together.

Similarly, the infrastructure dedicated to comprehensive waste management is insufficient to meet the municipality's needs. In Granada, there is a shortage of technically adequate treatment plants, collection centers, and state-owned recycling companies. This limitation reduces the potential for waste recovery and contributes to the continued use of environmentally unsound final disposal systems. The lack of sustained investment in infrastructure is one of the main obstacles to the effective implementation of GIRSU.

From a regulatory perspective, there is also a fragmentation of the regulatory framework. Although there are various laws, policies, and mandatory technical standards that address specific aspects of waste management, Nicaragua still lacks comprehensive and specialized legislation on municipal solid waste that coherently articulates institutional responsibilities, financing mechanisms, planning tools, shared responsibility

systems, and incentives for environmental compliance. As MARENA (2022) points out, this situation limits the development of more effective public policies and hinders efforts to strengthen waste management at the national level.

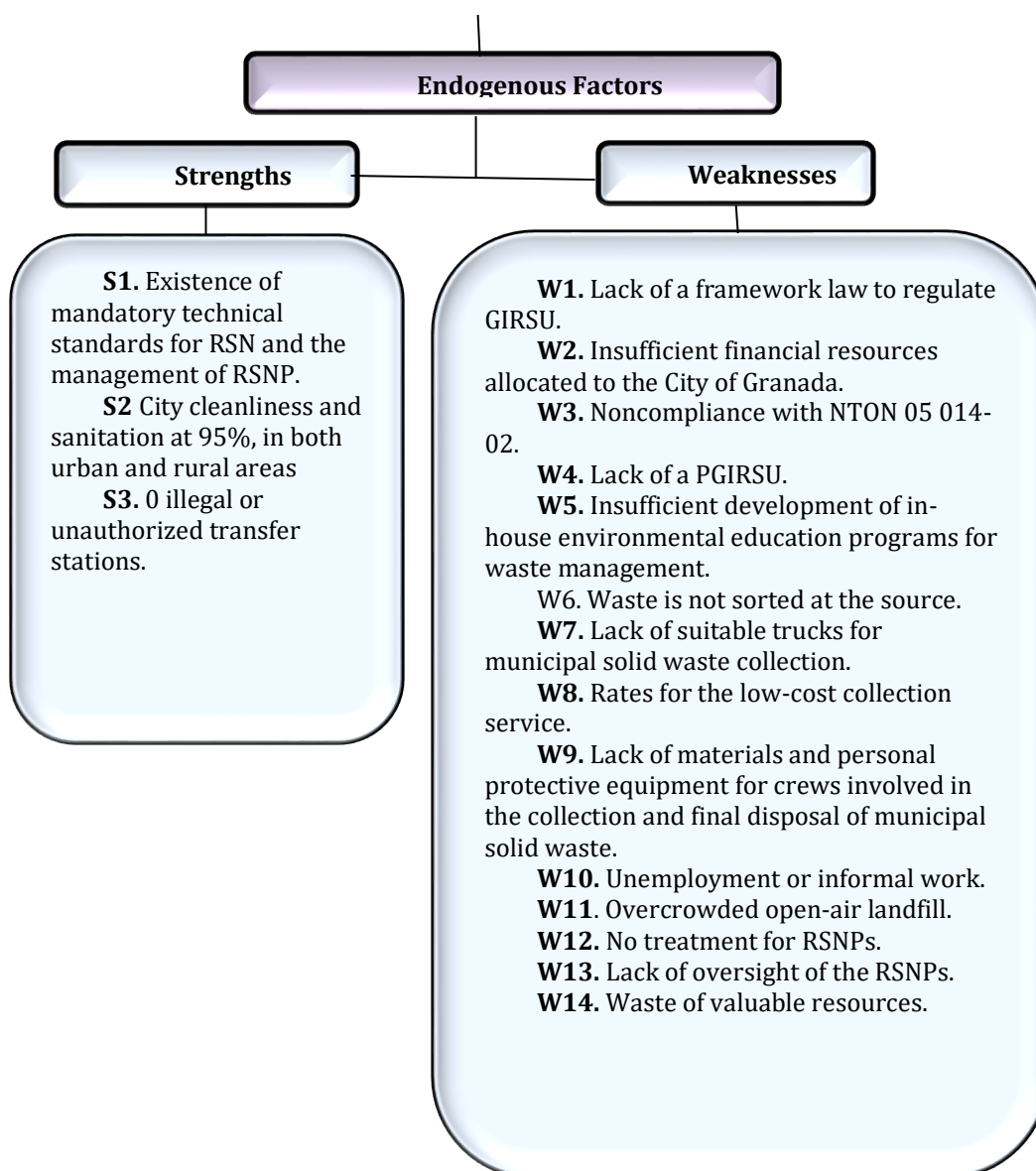
In conclusion, an analysis of Law N°. 217, Law N°. 40, Nicaragua's Environmental Policy, and the Mandatory Technical Standards related to GIRSU and RSN demonstrates that the main challenge does not lie in the total absence of regulation, but rather in the weaknesses in its implementation, oversight, and financing. The continued existence of open-air dumps, inadequate infrastructure, limited environmental impact assessments, and the lack of comprehensive, specialized legislation highlight the need to strengthen municipal capacities, improve oversight mechanisms, increase public investment, and promote greater citizen participation in order to move toward comprehensive and sustainable management of municipal solid waste in Granada.

SWOT Analysis Matrix

The development of the SWOT matrix as a methodological tool made it possible to identify the strengths, opportunities, weaknesses, and threats at GIRSU, as shown in the figures. 5 and 6. These findings highlight the importance of understanding both endogenous and exogenous factors in order to improve the integrated waste management system (GIRSU) operated by the City of Granada. Among these factors, the following stand out: political commitment to strengthening the legal framework; insufficient resources for effective waste management; and high investment costs for infrastructure and technology.

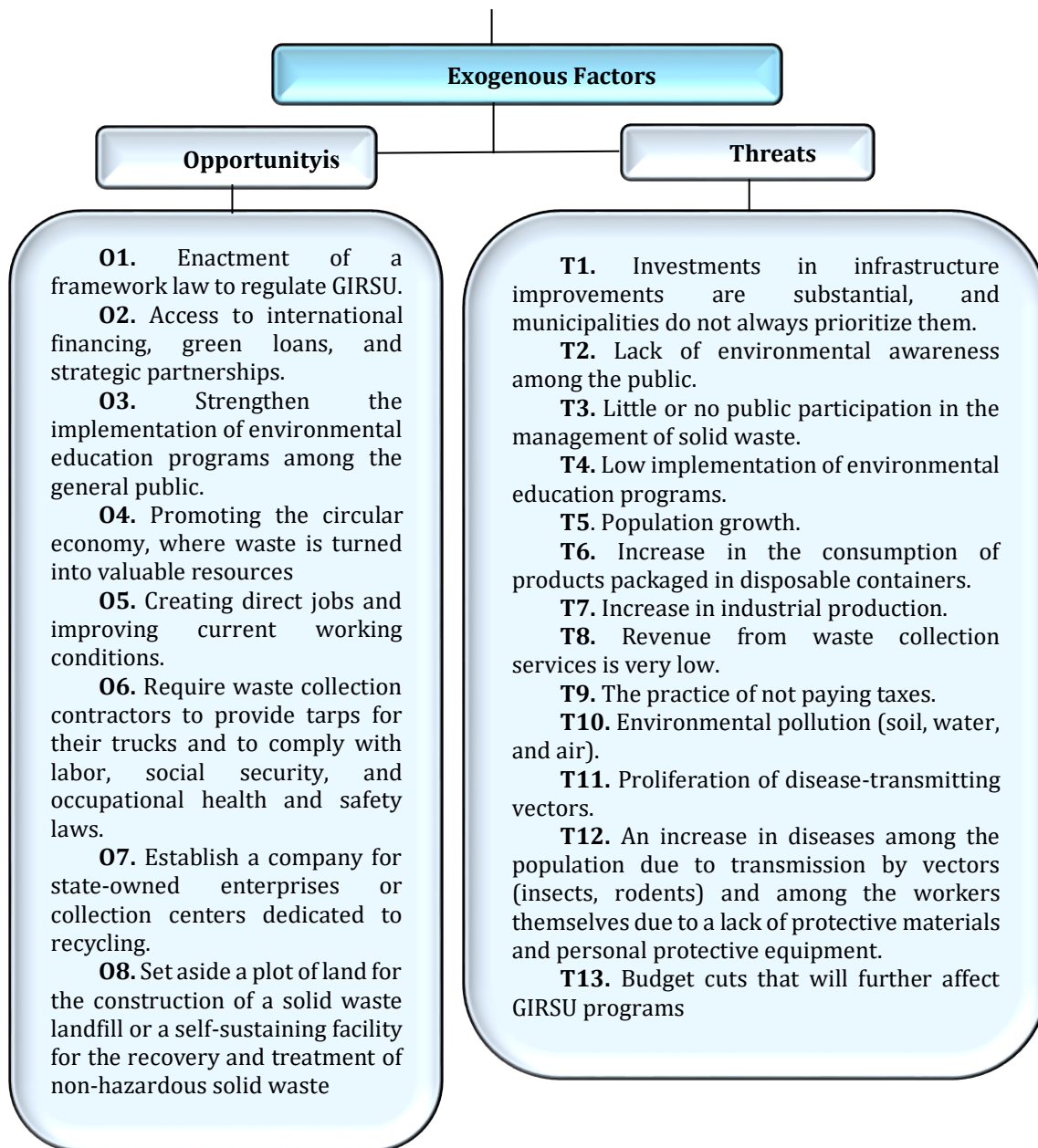
Figure 5
GIRSU's Strengths and Weaknesses Matrix in Granada

Analysis of Integrated Municipal Solid Waste Management



Note: Figure 5 illustrates the strengths and weaknesses of the GIRSU carried out by the Granada City Government during the month of June 2025. Source: Compiled by the author.

Figure 6
GIRSU's Opportunities and Threats Matrix in Granada



Note: Figure 6 illustrates the opportunities and threats identified in the GIRSU report prepared by the City of Granada in June 2025. Source: Compiled by the author.

Critical Analysis of the Endogenous Factors of the GIRSU in Granada: An analysis of the internal factors of the GIRSU in the municipality of Granada reveals a marked imbalance between the identified strengths (3) and the existing weaknesses (14), reflecting an institutional and operational structure with limited capacity to ensure comprehensive, efficient, and sustainable management of municipal solid waste.

Notable strengths include the existence of mandatory technical standards for municipal solid waste (MSW) and the management of non-municipal solid waste (NMSW), a level of cleanliness and collection service coverage that reaches approximately 95% of urban and rural areas, as well as the absence of illegal or unauthorized transfer stations. These elements are positive indicators of territorial control and a certain level of municipal operational capacity to maintain basic conditions of public health and environmental order.

However, a more in-depth analysis reveals that these strengths have limited scope because they focus primarily on formal operational and regulatory aspects, without necessarily translating into comprehensive waste management. The existence of mandatory technical standards, for example, loses its effectiveness when noncompliance with NTON 05 014-02 is acknowledged alongside the absence of institutional, financial, and technical mechanisms to ensure their enforcement. Similarly, keeping a city relatively clean does not mean that the system properly manages the waste once it has been collected, especially when it ends up in an overcrowded open dump.

The weaknesses identified reflect structural problems that affect all stages of the waste management cycle. In the regulatory and institutional sphere, the absence of a national framework law for GIRSU and the lack of a PGIRSU are particularly notable; this situation limits strategic planning, the definition of institutional responsibilities, and the coordination of public policies aimed at the sector's sustainability.

In the financial sphere, the insufficient funds allocated to the municipality, combined with low waste collection fees, create a significant gap between the actual needs of the service and the municipality's investment capacity. This situation is one of the root causes underlying other shortcomings, such as the lack of adequate trucks for waste collection, insufficient personal protective equipment for workers, and the inability to develop modern infrastructure for waste treatment and final disposal.

From a technical and environmental perspective, these weaknesses take on an even more critical dimension. The lack of waste separation at the source, the absence of municipal solid waste treatment, inadequate control over municipal solid waste, and the waste of recoverable materials demonstrate that the current model continues to be based on a "collection and final disposal" approach, moving away from the internationally promoted principles of circular economy, waste recovery, and resource efficiency. This situation not only increases environmental impacts but also represents a loss of economic and social opportunities associated with recycling, material recovery, and the creation of green jobs.

Furthermore, inadequate environmental assessment and low levels of citizen participation are systemic weaknesses that affect the performance of the entire system. The lack of ongoing awareness programs limits the public's shared responsibility for waste management, making it difficult to implement practices such as source separation, waste reduction, and community recycling.

Furthermore, the working conditions identified reflect a significant social problem. The lack of personal protective equipment and the presence of informal activities related to waste recovery suggest the existence of occupational hazards and situations of labor vulnerability that may affect the health and safety of workers in the sector.

The interplay between strengths and weaknesses leads to the conclusion that the former are primarily operational in nature and relate to basic compliance, while the latter stem from structural, financial, institutional, and technical limitations that affect the overall functioning of the system. Consequently, current strengths are insufficient to offset the weight and complexity of existing weaknesses.

From a strategic perspective, the main challenge for the municipality is not merely to improve the efficiency of waste collection, but to gradually transform a model focused on final disposal into a comprehensive system based on planning, financial sustainability, waste recovery, environmental management, and compliance with technical and environmental standards. Unless these structural limitations are addressed, the identified strengths could become temporary achievements that fail to ensure the long-term environmental, economic, and social sustainability of waste management.

A Critical Analysis of Exogenous Factors Affecting GIRSU in Granada: GIRSU's strategic analysis reveals a structural imbalance between the identified opportunities (8) and the existing threats (13). Although these opportunities hold great potential for transforming the waste management system, their realization is constrained by economic, institutional, social, and environmental factors that act as persistent barriers. Beyond the numerical difference between opportunities and threats, the most important aspect is the causal relationship that exists between the two. In practice, many opportunities can only be realized if certain structural threats are first reduced or controlled.

The creation of a Framework Law for GIRSU (O1) represents a strategic opportunity of the highest order, as it can serve as the guiding instrument for addressing multiple threats simultaneously. Strong legislation would make it possible to establish sustainable financing mechanisms, reduce political discretion in budget allocation, and strengthen institutional capacities to address threats such as budget cuts (A13), low revenue from waste collection services (A8), and the lack of municipal priority given to infrastructure investments (A1). However, a lack of political will or limited institutional capacity can delay or undermine their effective implementation.

Access to international financing, green loans, and strategic partnerships (O2) offers an alternative for overcoming the economic constraints affecting the sector. This opportunity is directly linked to threats such as high infrastructure costs (A1) and budget cuts (A13). However, experience shows that financial institutions typically require robust regulatory frameworks, institutional transparency, and technical management capacity. Therefore, if these aspects are not strengthened beforehand, the opportunity could go to waste.

EA (O3) stands out as one of the factors with the greatest transformative potential due to its multiplier effect on social behavior. Proper implementation would help reduce the lack of environmental awareness (A2), low citizen participation (A3), and the limited implementation of educational programs (A4). In addition, it could indirectly contribute to a reduction in the consumption of disposable products (A6) and to improved compliance with collection rates, thereby partially mitigating the decline in municipal revenue (A8). However, the results of EA typically become apparent in the medium and long term, which is why they require institutional continuity and sustained funding.

Promoting the circular economy (O4) presents an opportunity to transform waste from an environmental problem into an economic resource. This approach could help mitigate the effects of population growth (A5), increased consumption of disposable products (A6), and rising industrial production (A7) by promoting the reuse, recovery, and recycling of materials. However, its development depends on the existence of markets for recycled materials, economic incentives, and proper source separation—factors that are currently limited by low environmental awareness and low public participation.

The creation of direct jobs and the improvement of working conditions (O5) are of significant social importance, as they help formalize activities within the waste management chain that have traditionally been precarious. This opportunity can help

reduce the risks associated with occupational diseases and exposure to pollutants, partially mitigating threats such as the proliferation of vectors (A11) and the increase in diseases among workers and the general population (A12). However, its sustainability will depend on the availability of financial resources and institutional strengthening.

The requirement for better operational and working conditions for waste haulers (O6) is a corrective measure that can reduce health and environmental risks. The mandatory use of tarps on trucks, along with compliance with labor, social security, and occupational health and safety regulations, would help reduce the scattering of waste, environmental pollution (A10), the proliferation of vectors (A11), and the risk of disease (A12). However, this opportunity could face resistance from contractors due to rising operating costs.

The establishment of a state-owned enterprise or collection centers for recycling (O7) would strengthen the system's operational capacity and generate economic value from recoverable waste. This opportunity is directly related to EC (O4) and could help improve the system's revenue, partially offsetting the effects of low municipal tax collection (A8). However, it requires significant initial investments and efficient management to prevent it from becoming an additional financial burden for municipalities.

Finally, setting aside a plot of land for the construction of a RSN or a self-sustaining recovery and treatment plant (O8) is one of the opportunities with the greatest structural impact. Its implementation would significantly reduce soil, water, and air pollution (A10), curb the spread of disease vectors (A11), and lower the risk of diseases associated with improper waste management (A12). However, this opportunity is directly threatened by high investment costs (A1), as well as potential social conflicts related to the location of the facilities.

From a systemic perspective, the identified threats do not act in isolation but rather reinforce one another. The lack of EA (A4) contributes to low public awareness (A2), which in turn reduces social participation (A3). This situation encourages improper waste disposal practices, leading to increased environmental pollution (A10), the proliferation of vectors (A11), and associated diseases (A12). At the same time, low municipal tax revenue (A8) and a culture of tax evasion (A9) limit the availability of resources for investment and infrastructure, further exacerbating budgetary constraints (A13).

Therefore, GIRSU's main challenge lies not only in taking advantage of existing opportunities, but also in breaking the causal cycles that perpetuate these threats. The analysis shows that the opportunities with the greatest transformative potential are the creation of a robust legal framework (O1), access to sustainable financing (O2), and the strengthening of environmental agencies (O3), because they address the structural causes of multiple threats. These opportunities serve as enabling factors that can enhance the success of other initiatives.

In summary, the fact that threats outweigh opportunities reflects a situation of institutional, financial, and social vulnerability that limits the sustainability of GIRSU. Despite this, the opportunities identified have significant strategic potential to reverse this situation if they are implemented in a coordinated and prioritized manner. The key lies not only in implementing isolated projects, but also in building a governance model capable of strengthening the regulatory framework, securing financial resources, promoting cultural change, and developing adequate infrastructure. Only through this comprehensive approach will it be possible to gradually transform threats into

manageable factors and turn current weaknesses into strengths for the sustainable management of municipal solid waste.

Discussion and Conclusions

Discussion

This study shows that the challenges facing GIRSU in Granada cannot be interpreted solely as technical or financial constraints, but rather as the result of a complex interplay of institutional, economic, social, and governance factors. The SWOT analysis revealed that the system's main shortcoming lies in the coexistence of national regulatory instruments and technical guidelines with limited capacity for implementation at the municipal level.

Institutional interdependence (political will, institutional capacity, funding) and the central problem: The identified opportunity to develop a framework law for GIRSU takes on strategic importance, as it could help address one of the main weaknesses identified: the lack of financial resources to meet the growing demands for infrastructure, equipment, and technologies necessary for proper waste management. However, the results suggest that the existence of rules or regulations alone does not guarantee substantial improvements in management. The experience gained from the limited implementation of NTON 05 014-02 shows that the effectiveness of regulatory instruments depends on the simultaneous existence of political will, institutional capacity, and sustainable financing mechanisms.

This finding is partially consistent with Palma and Sánchez (2017), who found in Yalagüina that deficiencies in waste management stem from a combination of institutional, social, cultural, and economic factors. However, while problems in Yalagüina were primarily related to management planning, a culture of nonpayment, and limited staff training, the situation in Granada is more complex, stemming from growing demand for services driven by tourism and urban expansion, without an institutional framework capable of responding to these environmental pressures.

When comparing these results with the study by Romero and Martínez (2024) in the canton of Naranjito, Ecuador, a significant difference emerges. The authors conclude that the per capita waste generation (0.5 kg per person per day) and the composition of the waste provide a technical justification for the construction of a waste sorting facility, highlighting the technological and economic feasibility of waste recovery.

From this perspective, the problem is viewed primarily as an opportunity to make use of materials. In contrast, the results obtained in Granada suggest that technological feasibility alone does not guarantee the implementation of sustainable solutions. Local experience shows that even when technically feasible alternatives exist, the lack of funding, strategic planning, and effective regulatory frameworks can prevent them from being implemented.

This difference highlights a common limitation in studies that focus exclusively on technological aspects: they tend to assume that the availability of technology automatically leads to improvements in management, thereby underestimating the importance of institutional and political factors.

This interpretation is supported by Hernández et al. (2025), who argue that the sustainability of waste management depends fundamentally on collaborative governance and the ability to coordinate public, private, and community stakeholders. The findings from Granada confirm this premise by showing that the lack of coordination between local government, citizens, and the business sector is as significant a barrier as financial

constraints. In fact, the weakness identified in the area of financing can be interpreted not only as an economic shortfall, but also as a sign of insufficient governance to mobilize resources, build partnerships, and attract investment.

Similarly, Cardona (2025) emphasizes that citizen participation and community leadership are essential elements of community-based environmental management. However, the findings from Granada reveal a significant contradiction: although citizen participation is widely recognized as a critical factor in GIRSU's success, municipal strategies continue to focus primarily on the provision of waste collection and disposal services. This suggests the persistence of a traditional management approach based on service operations, to the detriment of more participatory models in which citizens take an active role in reducing, sorting, and recycling waste.

Another important point emerges when comparing the results with the studies by Lozano and Morocho (2025), Vásquez (2025), and Zelaya (2025); these studies argue that the EC represents a viable alternative for transforming waste into resources and reducing the pressure on final disposal systems. However, the situation in Granada shows that the transition to circular models faces significant structural obstacles.

The lack of infrastructure for sorting and recycling, limited source separation, and low private-sector participation create a significant gap between the principles of circular economy promoted in the literature and the actual conditions of implementation in municipal contexts with financial constraints. Consequently, the results suggest that EC should not be viewed solely as a technical solution, but rather as a process of institutional and social transformation that requires administrative capacity, economic incentives, and cultural changes sustained over time.

Furthermore, the findings related to EA allow us to expand upon the conclusions of Ayala and Gómez (2025), Mora (2025), and González et al. (2021), who highlight the role of environmental education as a tool for changing behavior and strengthening environmental awareness. Although there is a consensus regarding its importance, the results from Granada indicate that EA, on its own, is insufficient to resolve GIRSU's structural problems. Local experience suggests that educational programs have limited impact when they are not accompanied by adequate infrastructure, economic incentives, and effective oversight mechanisms. Consequently, EA should be viewed as a complementary component of a comprehensive strategy, rather than as a standalone solution.

The national context also helps put the results into perspective. Aguilar (2017) documented the socioeconomic, environmental, and health benefits generated by the EMTRIDES plant in Managua, demonstrating that investments in treatment infrastructure can have significant positive impacts. However, a comparison with Granada reveals marked regional disparities in waste management. While Managua has managed to develop specialized infrastructure backed by greater financial and institutional capacity, Granada continues to rely on an open-air dump. This situation demonstrates that the adoption of treatment technologies does not depend solely on their technical feasibility, but also on political, budgetary, and institutional factors that influence their implementation.

In this context, one of the most significant findings of this study is the apparent contradiction between the existence of NTON 05 014-02 and the continued use of an open-air dump as the primary method of final disposal in Granada. From a strictly regulatory perspective, this situation could be interpreted as a regulatory violation. Despite this, a more in-depth analysis suggests that the problem lies in the gap between the formulation of public policies and the actual capacity to implement them. The

regulations establish desirable technical standards, but do not automatically guarantee the availability of financial resources, suitable land, technical capabilities, or the monitoring mechanisms necessary for compliance.

This situation reflects a recurring problem in many Latin American municipalities: the existence of relatively advanced regulatory frameworks that coexist with limited institutional capacity for their effective implementation. Consequently, the continued existence of the open-air landfill in Granada should not be interpreted solely as a technical or administrative failure, but rather as a visible manifestation of a structural weakness in the environmental governance system. The regulations are in place, but the economic, political, and institutional conditions necessary to implement them remain insufficient.

Therefore, the results suggest that the main challenge facing GIRSU in Granada is not solely to build infrastructure or adopt new technologies, but rather to strengthen the governance capacities needed to coordinate stakeholders, secure sustainable financing, promote social shared responsibility, and ensure the effective enforcement of current regulations. From this perspective, the creation of a national framework law for GIRSU could serve as a strategic tool, provided that it incorporates specific financing mechanisms, incentives for waste recovery, extended producer responsibility schemes, and effective avenues for citizen participation. Otherwise, there is a risk of repeating the situation observed with NTON 05 014-02: a technically sound regulatory framework, but one with limited capacity for practical implementation.

Limitations: Among the study's main limitations was the restricted access to official information provided by some government agencies, which made it difficult to obtain up-to-date and complete data for the analysis. Furthermore, during the literature review, no previous studies were found that had been conducted in the municipality of Granada and that addressed GIRSU using the SWOT analysis methodology, which limited the ability to make comparisons and contrast the results obtained at the local level, implying that:

Implication 1: Although interviews were conducted with three officials from the Granada mayor's office involved in the management of RS, the information gathered comes exclusively from institutional actors. Consequently, the perspectives of other stakeholders, such as citizens and the private sector, were not included in the analysis, which could introduce a bias toward the institutional view of the waste management system.

Implication 2: Furthermore, the limited availability of specific quantitative data for the municipality—such as the waste generation rate and up-to-date studies on the physical composition of municipal solid waste—made it necessary to supplement the assessment with estimates and secondary sources at the regional level. This situation may affect the accuracy of some results and the level of detail achieved in the characterization of GIRSU in Granada.

Recommendations and Future Research Directions: Based on the findings, the first step would be to define a regulatory framework that prioritizes sustainable financing and shared responsibility, which involves: a) clearly establishing roles and responsibilities that include not only municipal authorities but also citizens and producers, as noted by Cardona (2025) and Hernández et al. (2025), thereby preventing the entire burden of waste management from falling on a single actor; b) conduct a proper assessment of collection service fees, which would allow the budget to be used for investments in infrastructure and technology; c) prioritize low-cost, high-impact strategies such as promoting EC, as demonstrated by Lozano and Morocho (2025); Vásquez (2025) and Zelaya (2025), and as established in NTON 05 014-02, d) create legal

conditions to attract both public and private investment (subsidies, incentives, legal certainty), thereby mitigating the risk of high initial costs; e) acquire a plot of land for the construction of a municipal solid waste (MSW) landfill or a facility for the separation and treatment of non-biodegradable solid waste (NBSW), since it has been demonstrated that valuable materials are lost at landfills. Previous studies (Aguilar, 2017; Romero and Martínez, 2024) have determined that the construction of a facility for the separation and treatment of non-food solid waste is feasible and that it enables effective waste management, thereby improving the social, economic, environmental, and health conditions of the population.

Future research should focus on designing a PGIRSU for the municipality of Granada, involving municipal authorities, the private sector, merchants, recyclers, and the general public. This plan should include a comprehensive physical characterization (both qualitative and quantitative) of solid waste and a detailed economic and financial feasibility analysis for the construction of a solid waste landfill or a facility for the separation and treatment of non-hazardous solid waste, analyze the impact of economic incentives and the creation of resource recovery infrastructure, in order to convert waste into resources, thereby closing the management cycle in a sustainable manner.

Conclusions

In Granada, GIRSU faces significant structural, financial, and operational challenges; however, it also has strengths and opportunities that can transform the waste problem into a driver of environmental, social, and economic development. The objective of the research is achieved by demonstrating, through a SWOT analysis, that the municipality lacks a comprehensive and efficient system for the storage, collection, transportation, treatment, and final disposal of solid waste—a situation reflected in noncompliance with current regulations, the absence of a Solid Waste Management Plan (PGIRSU), the lack of source separation, and the existence of an oversaturated open-air dump.

The study also identifies significant strengths, such as the existence of mandatory technical standards for the management of non-hazardous solid waste, the city's high level of cleanliness (95%), and the absence of illegal transfer stations, all of which provide a solid foundation for driving improvements in municipal waste management.

In the short term, the top priority is to develop and implement the PGIRSU, accompanied by an ongoing municipal environmental education program targeting schools, households, businesses, and waste collectors, with the aim of promoting waste separation at the source and increasing public participation. It is also necessary to strengthen oversight and compliance with NTON 05 014-02, provide operational staff with appropriate personal protective equipment, and require contracted carriers to comply with occupational safety and waste transport regulations.

Similarly, it is essential to review and update waste collection service rates to improve the system's financial sustainability, implement mechanisms to strengthen municipal revenue collection, and prioritize investment in appropriate waste collection trucks. At the same time, temporary collection centers should be set up to recover recyclable materials, programs for waste recovery should be promoted based on the principles of the circular economy, and efforts should be made to organize waste pickers and informal workers in order to create formal jobs and improve their working conditions.

In the medium term, the municipality must secure a plot of land for the construction of adequate infrastructure for the final disposal of non-hazardous solid

waste, thereby reducing the environmental and health impacts associated with the current open-air landfill. These measures will help reduce soil, water, and air pollution, control the spread of disease vectors, and reduce risks to public health.

Finally, it is concluded that the SWOT analysis constitutes the main contribution of this research, as it provides an objective basis for formulating strategies that capitalize on existing strengths and identified opportunities, thereby enabling the organization to overcome its weaknesses and mitigate threats. The coordinated implementation of measures related to planning, financing, environmental assessment, oversight, infrastructure, and waste management will enable progress toward a more efficient, sustainable, and inclusive solid waste management model, aligned with the principles of sustainable development and aimed at improving the quality of life for the people of Granada.

Acknowledgments

I would like to thank Dr. Erick López Vidaña for his guidance in writing this article.

Conflict of Interest

The author declares that he has no conflict of interest.

References

- Aguilar, D. (2017). *Impactos socioeconómicos de la planta EMTRIDES en el barrio Acahualinca, Managua 2008-2016*. [Undergraduate thesis, National Autonomous University of Nicaragua]. https://scholar.google.com/scholar?q=valoracion+economica+planta+EMTRIDE+S+NICARAGUA,+2017&hl=es&as_sdt=0.5
- Asamblea Nacional de la Republica de Nicaragua. (November 26, 2020). *Ley N°. 40: Ley de Municipios con Reformas Incorporadas*. La Gaceta, Diario Oficial N°. 189, October 13, 2021. <http://legislacion.asamblea.gob.ni/normaweb.nsf/3133c0d121ea3897062568a1005e0f89/67cc56a8b80761da0625886f006dcdcb?OpenDocument>
- Asamblea Nacional de la República de Nicaragua. (September 27, 2023). *Ley N°. 217: Ley General del Medio Ambiente y los Recursos Naturales, as amended*. La Gaceta, Diario Oficial N°. 217, November 29, 2023. <http://legislacion.asamblea.gob.ni/normaweb.nsf/9e314815a08d4a6206257265005d21f9/10cf7b394a7719c006258ac10057df30?OpenDocument>
- Ayala, X., and Gómez, K. (2025). Estrategias de mejora en la Educación Ambiental Escolar: Una revisión sistemática. *Aula Virtual*, 6(13). <https://doi.org/10.5281/zenodo.17298893>
- Betancur, S., Ortega-Avila, N., and López-Vidana, E. (2023). Strengths, Weaknesses, Opportunities, and Threats Analysis for the Strengthening of Solar Thermal Energy in Colombia. *Resources*, 13(1), 3. <https://doi.org/10.3390/resources13010003>
- Cardona, J. (2025). Gestión ambiental comunitaria: desafíos y oportunidades para una comunidad rural de Acapulco, México. *Revista Kawsaypacha: Sociedad y Medio Ambiente*, (16). <https://doi.org/10.18800/kawsaypacha.202502.A008>
- González, A. (2026). Enfoques de la Educación Ambiental en Nicaragua. *Revista Torreón Universitario*, 14(41), 26–41. <https://doi.org/10.5377/rtu.v14i41.22019>

- González, O., Areas, F., and López, F. (2021). La educación ambiental como herramienta para conectar a las personas con su entorno inmediato. *Ciencia Latina Revista Científica Multidisciplinar*, 5(3), 3603-3612. https://doi.org/10.37811/cl_rcm.v5i3.553
- Guatemala, J. (2007). *Caracterización de la estela de contaminación del basurero La Joya en Granada, Nicaragua* [Master's thesis, National Autonomous University of Nicaragua]. Repositorio Institucional UNAN-Managua. <https://repositorio.unan.edu.ni/id/eprint/2393>
- Hernández, R., Fernández, C., and Baptista, M. (2010). *Metodología de la investigación* (5th ed.). McGraw Hill
- Hernández, R., Fernández, C., and Baptista, M. (2017). *Metodología de la investigación* (6th ed.). McGraw Hill
- Hernández, F., Sánchez, L., Alba, E., Lovato, M., and Sandoval, F. (2025). Gobernanza Colaborativa; Estrategia para la Gestión Pública de los Residuos Sólidos Urbanos (RSU). *Ciencia Latina: Revista Multidisciplinar*, 9(4), 3418-3440. https://doi.org/10.37811/cl_rcm.v9i4.18997
- “La Joya”, el lado gris de La Gran Sultana: así es la vida en el vertedero de Granada (2024, marzo 15). *PRIMER ORDEN NICARAGUA*. <https://www.primerorden.com/2024/03/15/nacionales/basurero-granada-nicaragua/>
- Lozano and Morocho, R. (2025). Enfoque de economía circular en la gestión de residuos sólidos en el Centro de Gestión Integral Sostenible de Loja. *Revista Impulso*, 5(9), 51-67. <http://doi.org/10.59659/impulso.v.5i9.69>
- Ministerio del Ambiente y los Recursos Naturales (January 29, 2022). MARENA lanza novedosa estrategia para el manejo integral de los residuos en Nicaragua [News]. <https://www.marena.gob.ni/2022/01/29/marena-lanza-novedosa-estrategia-para-el-manejo-integral-de-los-residuos-en-nicaragua/>
- Ministerio del Ambiente y los Recursos Naturales. (February 11, 2002). *Norma Técnica NTON 05 013-01: Norma Técnica para el Control Ambiental de los Rellenos Sanitarios para Desechos Sólidos No Peligrosos*. La Gaceta, Diario Oficial, No. 73, April 22, 2002. <http://legislacion.asamblea.gob.ni/normaweb.nsf/b92aaea87dac762406257265005d21f7/68722115e0e27f50062573610072a1ab?OpenDocument>
- Ministerio del Ambiente y Recursos Naturales. (November 11, 2002). *Norma Técnica No. NTON 05 014-02: Norma Técnica Ambiental para el Manejo, Tratamiento y Disposición Final de los Desechos Sólidos No-Peligrosos*. La Gaceta, Diario Oficial No. 96, May 24, 2002. <http://legislacion.asamblea.gob.ni/normaweb.nsf/9e314815a08d4a6206257265005d21f9/3d7b0c9bf4c186790625764e005d16f4?OpenDocument>
- Ministerio del Ambiente y los Recursos Naturales. (August 8, 2002). *Norma Técnica NTON No. 05-015-02: Norma Técnica para el Manejo y Eliminación de Residuos Sólidos Peligrosos*. La Gaceta, Diario Oficial, No. 210, November 5, 2002. <http://legislacion.asamblea.gob.ni/normaweb.nsf/bbe90a5bb646d50906257265005d21f8/f124ab4e19e485950625728a005c2c3f?OpenDocument>
- Ministerio del Ambiente y Recursos Naturales. (November 14, 2023). *Norma Técnica NTON No. 05002: Gestión Ambiental. Residuos de Aparatos Eléctricos y Electrónicos. Generadores y Gestores de Residuos*. La Gaceta, Diario Oficial No. 63, April 11, 2024. [http://legislacion.asamblea.gob.ni/Normaweb.nsf/\(All\)/525394A99E8D36F706258AFD006C1FD9?OpenDocument](http://legislacion.asamblea.gob.ni/Normaweb.nsf/(All)/525394A99E8D36F706258AFD006C1FD9?OpenDocument)

- Mora, D. (2025). Educación ambiental, consumo responsable y tres R: revisión para fomentar prácticas sostenibles del manejo de residuos urbanos. *MLS Environmental Sciences and Practices*, 3(1). <https://www.mlsjournals.com/Environmental-SciencePractices/article/view/4059>
- Palma, C., and Sánchez, C. (2017). *Diseño del Plan Integral de Gestión Ambiental de los Residuos Sólidos Urbanos del Municipio de Yalagüina. PIGARS (2017–2037)* (Doctoral dissertation, National University of Engineering). <https://ribuni.uni.edu.ni/2501/1/92508.pdf>
- Presidente de la Republica de Nicaragua. (July 21, 2005). *Decreto Ejecutivo No. 47-2005: Política Nacional sobre Gestión de Residuos Sólidos*. La Gaceta, Diario Oficial, No. 163, August 23, 2005. <http://legislacion.asamblea.gob.ni/normaweb.nsf/b34f77cd9d23625e06257265005d21fa/d132318726051846062570ab0064017d?OpenDocument>
- Presidente de la República de Nicaragua. (September 27, 2023). *Decreto Ejecutivo No. 91-2005: Política Nacional sobre Gestión Integral de Sustancias y Residuos peligrosos*. La Gaceta, Diario Oficial No. 217, November 29, 2023. [http://legislacion.asamblea.gob.ni/Normaweb.nsf/\(\\$All\)/3337D11E0DAFE09B06258AC1005DC635?OpenDocument](http://legislacion.asamblea.gob.ni/Normaweb.nsf/($All)/3337D11E0DAFE09B06258AC1005DC635?OpenDocument)
- Programa Regional de Reducción de la Vulnerabilidad y Degradación Ambiental [PREVDA], (2014.) *Caracterización Municipio de Granada, Nicaragua. Énfasis, Planificación y Gestión Territorial de los Riesgos, del Agua y del Medio Ambiente, con Enfoque de Multiculturalidad y Género*. Publication ME-144. <https://bvssan.incap.int/local/M/ME-144.pdf>
- United Nations Environment Programme. (2018). *The State of Waste Management in Latin America and the Caribbean*. <https://wedocs.unep.org/handle/20.500.11822/26448>
- Romero, S., and Martínez, E. (2024). Análisis de la gestión Integral de Residuos Sólidos en el Cantón Naranjito, Provincia del Guayas. *Ciencia Latina Revista Científica Multidisciplinar*, 8(5), 10652-10667. https://doi.org/10.37811/cl_rcm.v8i5.14442
- Rondón, E., Szanto, M., Pacheco, J., Contreras, E., and Gálvez, A. (2016). Guía General para la Gestión de Residuos Sólidos Domiciliarios. Manuales de la CEPAL 2. <https://repositorio.cepal.org/server/api/core/bitstreams/a5f80abc-8063-4e19-b871-e954f1db5bf6/content>
- Tello, P., Campani, D., and Sarafian, D. (Eds.). (2018). *Gestión Integral de Residuos Sólidos Urbanos*. AIDIS. <https://aidisnet.org/wp-content/uploads/2019/08/GESTION-INTEGRAL-DE-RESIDUOS-SOLIDOS-URBANOS-LIBRO-AIDIS.pdf>
- United Nations Environment Programme. (2024). *Global Waste Management Outlook 2024*. <https://www.unep.org/resources/global-waste-management-outlook-2024>
- Vasquez, O. (2025). Retos y desafíos del manejo de residuos sólidos urbanos: El caso de una economía emergente en México durante el siglo XXI. *Observatorio de las Ciencias Sociales en Iberoamérica*, 6(3), 40-61. <https://doi.org/10.51896/ocsi.v6i3.919>
- Vega, I. (2020). Auditoría ambiental del manejo de residuos de la ciudad de Granada, Nicaragua. *Revista Torreón Universitario*, 9(24), 84-101. <https://doi.org/10.5377/torreon.v9i24.9726>

Zelaya, J. (2025). Valorización Energética de Residuos Sólidos Urbanos - Estudio Comparativo entre Managua y Ciudad Sandino Nicaragua bajo un Enfoque de Economía Circular. *Revista Latinoamericana De Calidad Educativa*, 2(3), 224-230. <https://doi.org/10.70625/rlce/226>