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Waste as an Opportunity: Circular Economy and the Implementation of a Waste Sorting and Utilization Station in Bosconia, Cesar*

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Abstract: The research examined the relationship between the circular economy and the implementation of a Waste Sorting and Utilization Station (WSUS) in Bosconia, employing a mixed-methods approach that combined quantitative and qualitative techniques. Surveys conducted with 400 residents, alongside data analysis from CORPOCESAR and BIOGER S.A. E.S.P., revealed that the current waste management system is inadequate, marked by illegal dumping sites and a low culture of recycling. Interviews with key stakeholders emphasized the need for sustainable strategies and the integration of waste pickers, in line with circular economy principles that promote waste reduction, reuse, and recycling. The proposed WSUS seeks to decrease the amount of waste sent to landfills, generate employment opportunities, and encourage source separation, drawing on successful experiences in Medellín and Bucaramanga. The project is projected to achieve a 35% reduction in pollution from leachates and greenhouse gas emissions, while creating both direct and indirect jobs, demonstrating its economic and social feasibility. Effective implementation will depend on supportive public policies, rigorous oversight of the operating company, and heightened citizen awareness. In conclusion, the transition to a circular economy in Bosconia is urgent and requires coordinated efforts among public and private sectors, as well as community participation, to enhance waste management and promote long-term sustainability.

* Research article
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Los residuos como oportunidad: Economía circular y la implementación de una estación de clasificación y aprovechamiento de residuos en Bosconia, Cesar

Resumen: La investigación examinó la relación entre la economía circular y la implementación de una Estación de Clasificación y Aprovechamiento de Residuos (SCA) en Bosconia, empleando un enfoque de métodos mixtos que combina técnicas cuantitativas y cualitativas. Las encuestas realizadas a 400 residentes, junto con el análisis de datos de CORPOCESAR y BIOGER S.A. E.S.P., revelaron que el sistema actual de gestión de residuos es inadecuado, caracterizado por vertederos ilegales y una baja cultura del reciclaje. Las entrevistas con actores clave enfatizaron la necesidad de estrategias sostenibles y la integración de los recicladores, en consonancia con los principios de la economía circular que promueven la reducción, la reutilización y el reciclaje de residuos. El WSUS propuesto busca reducir la cantidad de residuos que se envían a vertederos, generar oportunidades de empleo y fomentar la separación en origen, aprovechando las experiencias exitosas de Medellín y Bucaramanga. Se proyecta que el proyecto logre una reducción del 35% en la contaminación por lixiviados y las emisiones de gases de efecto invernadero, a la vez que crea empleos directos e indirectos, lo que demuestra su viabilidad económica y social. Su implementación efectiva dependerá de políticas públicas favorables, una rigurosa supervisión de la empresa operadora y una mayor concienciación ciudadana. En conclusión, la transición a una economía circular en Bosconia es urgente y requiere esfuerzos coordinados entre los sectores público y privado, así como la participación comunitaria, para mejorar la gestión de residuos y promover la sostenibilidad a largo plazo.

Palabras clave: economía circular; gestión de residuos; sostenibilidad; reciclaje; política ambiental

Os resíduos como oportunidade: economia circular e a implementação de uma estação de classificação e aproveitamento de resíduos em Bosconia, Cesar

Resumo: A pesquisa examinou a relação entre a economia circular e a implementação de uma Estação de Classificação e Aproveitamento de Resíduos (SCA) em Bosconia, utilizando uma abordagem de métodos mistos que combina técnicas quantitativas e qualitativas. As entrevistas aplicadas a 400 residentes, juntamente com a análise de dados da CORPOCESAR e da BIOGER S.A. E.S.P., revelaram que o sistema atual de gestão de resíduos é inadequado, caracterizado por lixões ilegais e uma baixa cultura de reciclagem. As entrevistas com atores-chave destacaram a necessidade de estratégias sustentáveis e da integração dos recicladores, em consonância com os princípios da economia circular, que promovem a redução, a reutilização e a reciclagem de resíduos. O WSUS proposto busca reduzir a quantidade de resíduos enviados a aterros, gerar oportunidades de emprego e fomentar a separação na origem, aproveitando as experiências exitosas de Medellín e Bucaramanga. Projeta-se que o projeto alcance uma redução de 35% na contaminação por lixiviados e nas emissões de gases

de efeito estufa, ao mesmo tempo em que cria empregos diretos e indiretos, demonstrando sua viabilidade econômica e social. Sua implementação efetiva dependerá de políticas públicas favoráveis, de uma supervisão rigorosa da empresa operadora e de uma maior conscientização cidadã. Em conclusão, a transição para uma economia circular em Bosconia é urgente e requer esforços coordenados entre os setores público e privado, assim como a participação comunitária, para melhorar a gestão de resíduos e promover a sustentabilidade a longo prazo.

Palavras-chave: economia circular; gestão de resíduos; sustentabilidade; reciclagem; política ambiental

Introduction

The management of urban solid waste is a challenge at global, national, and regional levels. In cities across the country, it has become a priority, and Bosconia, in the department of Cesar, is no exception. This situation is exacerbated by the fact that the regional landfill receives solid waste from the municipalities of Astrea, Bosconia, Curumaní, La Jagua de Ibirico, El Copey, El Paso, and Chimichagua in Cesar; Mompox in Bolívar; and Santa Ana, El Difícil, and El Banco in Magdalena.

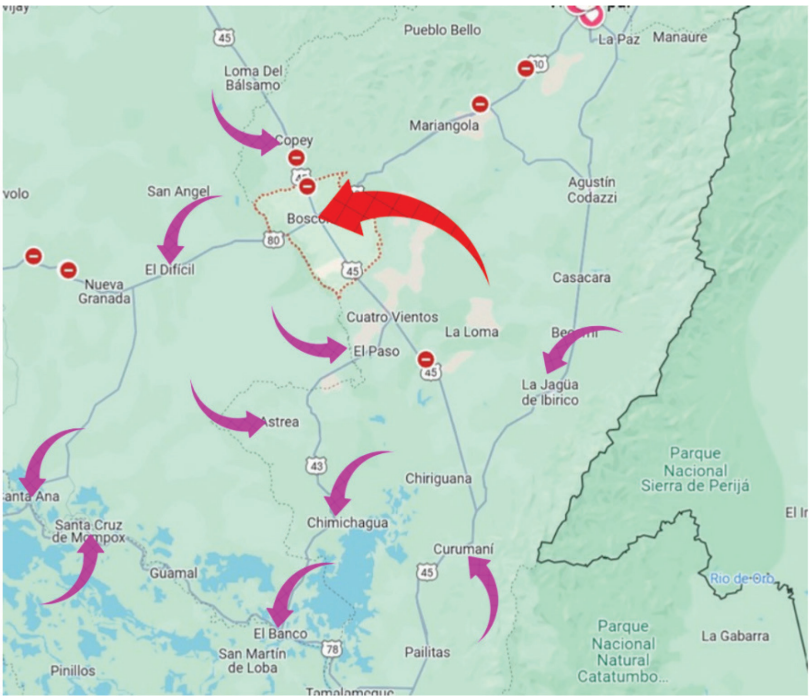
Currently, waste disposal is carried out at an open-air regional landfill called "Don Bosco," which lacks an efficient classification and treatment policy to minimize environmental impact and optimize the utilization of recyclable materials. In Bosconia, waste collection services are managed by the company BIOGER S.A. E.S.P., which faces challenges such as insufficient waste utilization, the proliferation of illegal dumping sites, and a weak recycling culture within the community.

The geographical location of Bosconia and the surrounding municipalities where waste is deposited is illustrated in Figure 1.

Only collecting vehicles and authorized dump trucks are allowed to enter the landfill. As a result, waste is frequently dumped illegally by individuals using motorcycle rickshaws, cycle taxis, and carts on the outskirts of the urban area, along roads leading to Bucaramanga, Pueblo Nuevo, Valledupar, and even on the road to Barranquilla, just before reaching the landfill. This problem also occurs within Bosconia, where there is no control over waste disposal in vacant lots neglected by their owners, creating a new source of environmental pollution.

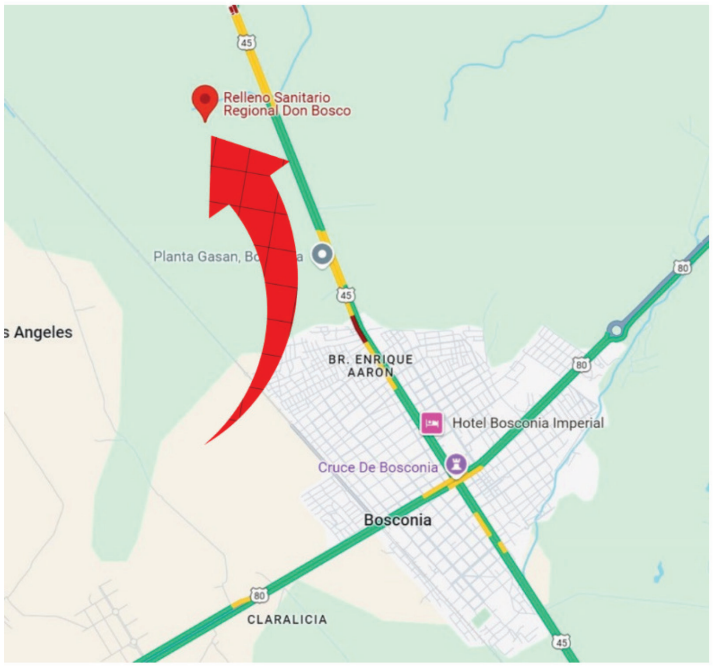
According to the Regional Autonomous Corporation of Cesar (CORPOCESAR), the solid waste generated in the department is managed in a technically controlled manner at the publicly owned "Don Bosco" landfill and at the privately owned "Las Bateas" landfill in southern Cesar. The location of the "Don Bosco" sanitary landfill is illustrated in Figure 2.

Figure 1. Location of Bosconia and waste-depositing municipalities



Source: Own elaboration.

Figure 2. Location of "Don Bosco" sanitary landfill



Source: Own elaboration.

To make matters worse, watchdog Jhon Garrido stated: "Don Bosco is currently an open-air dumpsite with no proper operational management techniques, failing to comply with the environmental management plan, as CORPOCESAR pointed out during the session held by the Departmental Assembly on April 5 in Bosconia. This indicates that BIOGER has failed to meet more than 75% of its mandatory commitments for landfill management, proving that the company lacks the capacity to handle the landfill, despite the department having invested a significant amount of money to ensure that a specialized operator would be in charge." [3]

At the global level, the generation of municipal solid waste has increased significantly in recent decades. In 2016, approximately 2.01 billion tons were produced, and this figure is projected to rise to 3.40 billion tons by 2050, driven by rapid urbanization and population growth. In Latin America and the Caribbean, the situation is equally concerning. In 2017, the region generated around 540,000 tons of municipal solid waste per day, with projections indicating an increase to 671,000 tons per day by 2050.

Colombia contributes substantially to these regional figures, producing approximately 39,000 tons of waste daily, according to data from the Ministry of Environment and Sustainable Development. This amount is expected to grow by about 6% annually, posing a considerable challenge for effective waste management in the country.

According to Resolution 050 of 2024 issued by CORPOCESAR, the quantities of waste received and projected for the municipality of Bosconia through 2043 are presented in Table 1.

Table 1. Projected Waste Disposal by the Year 2043

No	Year	Tons	Total	No	Years	Tons	Total
1	2014	6.000,12	6.000,12	16	2029	96.830,08	974.141,42
2	2015	33.773,55	39.773,67	17	2030	101.187,44	1.075.328,85
3	2016	36.184,05	75.957,72	18	2031	105.740,87	1.181.069,73
4	2017	39.639,43	115.597,15	19	2032	110.499,21	1.291.568,94
5	2018	39.694,60	155.291,75	20	2032	115.471,67	1.407.040,61
6	2019	44.034,77	199.326,52	21	2033	120.667,90	1.527.708,51
7	2020	39.650,53	238.977,05	22	2034	126.097,96	1.653.806,46
8	2021	67.743,57	306.720,62	23	2035	131.772,36	1.785.578,83
9	2022	71.153,50	377.874,12	24	2036	137.702,12	1.923.280,95
10	2023	74.355,41	452.229,53	25	2037	143.898,71	2.067.179,66
11	2024	77.701,40	529.930,93	26	2038	150.374,16	2.217.553,82
12	2025	81.197,96	611.128,89	27	2040	157.140,99	2.374.694,81
13	2026	84.851,87	695.980,76	28	2041	164.212,34	2.538.907,15
14	2027	88.670,21	784.650,97	29	2042	171.601,89	2.710.509,04
15	2028	92.660,37	877.311,34	30	2043	179.323,98	2.889.833,02

Source: Own elaboration.

As established by the 1998 National Policy for Integrated Solid Waste Management in Colombia, solid waste management has historically been treated as a component of sanitation services, primarily motivated by hygienic and sanitary concerns. In urban areas, waste issues were addressed only when communities disposed of refuse in public spaces, prompting the creation of collection services—without consideration for final disposal sites. Consequently, practices such as open dumping or disposal into water bodies were adopted without accounting for environmental externalities, reinforcing a culture of uncontrolled waste disposal. Recent assessments underscore how these historical sanitation-focused frameworks have perpetuated systemic neglect of environmental impacts and hindered the transition toward integrated or circular waste management models [4].

In this context, the circular economy emerges as a viable alternative to transform waste management in Bosconia, aligning with the "Zero Waste" program proposed in the National Development Plan. This economic model promotes the reduction, reuse, and recycling of materials to minimize waste and foster a sustainable system. Implementing a Waste Sorting and Recovery Station (WSRS) in the municipality could represent a turning point in solid waste management by encouraging source separation, recovering recyclable materials, and generating employment for recyclers and other stakeholders in the sector.

The circular economy model proposes a paradigm shift from the traditional linear 'take-make-dispose' system by prioritizing the reduction, reuse, and recycling of materials to minimize waste and optimize resource utilization [5]. In areas with limited waste management infrastructure, such as Bosconia, the absence of effective strategies for processing and reintegrating materials into the production chain has led to high dependence on landfills and restricted the development of sustainable waste recovery models [6]. This highlights the need to adopt circular systems that create value from waste while mitigating the negative environmental impacts associated with waste accumulation.

The proliferation of illegal dumping sites and poor waste disposal practices at the 'Don Bosco' landfill reflects systemic deficiencies in solid waste management, resulting in contamination of soil, air, and water, with dire consequences for biodiversity and human health. For example, a recent review concluded that open dumping leads to significant groundwater and soil contamination and poses serious environmental and health risks [7]. Transitioning to a circular economy in this region requires investment in infrastructure for differentiated collection, waste processing, and community awareness regarding sustainable practices [2]. Additionally, implementing economic incentives and regulations for efficient waste management could drive a more sustainable production and consumption model, reducing pressure on local ecosystems and promoting integrated resource management.

The purpose of this research is to analyze the relationship between the circular economy and the implementation of a Waste Sorting and Recovery Station in Bosconia, evaluating its feasibility as well as its economic, social, and environmental benefits. This involves reviewing the current regulatory framework, assessing community perceptions of waste management, and identifying strategies necessary to ensure the sustainability of this model.

The study will also examine experiences from other regions that have implemented waste recovery stations, identifying best practices and lessons learned that could be applied in Bosconia's context. Moreover, the economic impact of implementing this system will be considered, including the creation of direct and indirect jobs and the reduction of operational costs in waste disposal.

It is expected that the findings of this study will contribute to strengthening local policies that implement circular economic principles and improve the quality of life of Bosconia's inhabitants. Furthermore, the research aims to raise awareness among the population about the importance of source separation and recycling, fostering a culture of environmental responsibility and sustainable urban solid waste management.

General Objective

Examine the relationship between the circular economy and the implementation of a Waste Sorting and Recovery Station in Bosconia, assessing its feasibility and the potential economic, social, and environmental benefits.

Specific Objectives

1. Assess the current waste management system in Bosconia, including the condition of the Don Bosco landfill, the spread of illegal dumping sites, and the community's perceptions of waste disposal practices.
2. Assess successful circular economic initiatives in other regions, identifying strategies that could be applied in Bosconia to promote waste reduction, reuse, and recycling.
3. Propose a model for implementing a Waste Sorting and Recovery Station in Bosconia, considering its technical, economic, and social feasibility.

Background and Related Work

Solid waste management and the circular economy have been studied in various contexts, with the aim of finding sustainable solutions to reduce environmental impact and improve waste management efficiency. Globally, the Ellen MacArthur Foundation has developed conceptual frameworks emphasizing the importance of transitioning from a linear economic model to a circular system, promoting reduction, reuse, and recycling as key sustainability strategies [5]. In Europe, initiatives such as the European Union's Circular Economy Strategy have demonstrated that implementing waste sorting and recovery stations significantly reduces the volume of waste sent to landfills while generating employment in the recycling sector [8].

In Latin America, several countries have implemented circular economy strategies with positive outcomes in solid waste management. In Brazil, for instance, the National Solid Waste Policy (Política Nacional de Resíduos Sólidos, PNRS, Law 12.305/2010) has promoted the formalization of waste picker cooperatives and the establishment of

professionally managed sorting centers. As of 2024, over 3,000 cooperatives employ approximately 70,000 workers, substantially enhancing recycling efficiency. Through the Recicla Junto initiative, formalized sorting facilities increased the volume of recyclables processed from 111 to 173 tons between January and September, while contamination rates decreased from 12% to 9%, demonstrating how Brazil's circular economy framework strengthens both material recovery and social inclusion [9]. In Colombia, the "Zero Waste" policy has encouraged the adoption of circular economy practices in cities such as Bogotá and Medellín, where integrating recyclers and investing in infrastructure have proven effective in improving urban solid waste recovery rates [10].

At the regional level, CORPOCESAR has identified multiple deficiencies in waste management in the department of Cesar, including the lack of source separation, inefficient use of the "Don Bosco" landfill, and the proliferation of illegal dumpsites. Previous studies highlight that non-compliance with environmental regulations in waste management poses significant risks to public health and local ecosystems [11]. Research conducted at the Universidad Popular del Cesar indicates that limited infrastructure and environmental education programs have hindered the development of sustainable models in the region, reinforcing the need to implement circular economy-based alternatives.

Several studies have examined the implementation of waste sorting and recovery stations in intermediate Colombian cities. For example, in Bucaramanga, the local government has promoted a recovery model that integrates recycler associations into the operation of treatment plants, reducing landfill waste and improving working conditions for sector employees [12]. This model has been referenced in other regions of the country due to its positive economic and environmental impacts.

In Medellín, Empresas Varias de Medellín (EMVARIAS) has implemented a waste management system based on source separation and valorization of recyclable materials. A study by the Universidad de Antioquia [13] concluded that sorting station infrastructure and collaboration with recycler organizations improved waste recovery efficiency and fostered greater environmental awareness within the community.

Similarly, in Aguachica, Cesar, a study by the Universidad Nacional de Colombia [14] analyzed the feasibility of a circular economy-based waste recovery model. The results indicated that implementing a sorting station could reduce waste sent for final disposal by up to 40%, create employment opportunities for recyclers, and promote environmental education within the community. These experiences provide valuable references for formulating strategies applicable to Bosconia.

Overall, these studies underscore the importance of adopting circular economy models in solid waste management, particularly in regions with structurally deficient systems. Implementing a Waste Sorting and Recovery Station in Bosconia could offer a viable alternative to improve waste management efficiency, reduce pressure on the "Don Bosco" landfill, and generate economic, social, and environmental benefits for the community.

Materials and methods

In the preparation of this manuscript, the artificial intelligence tool ChatGPT by OpenAI was used for auxiliary purposes, specifically to support the preliminary literature review, provide writing suggestions, and enhance academic style. Its use was conducted under the continuous supervision of the authors, who validated, edited, and critically adjusted all generated content. The involvement of AI was strictly limited to supportive tasks and did not replace the analytical judgment or intellectual responsibility of the researchers. All content was carefully reviewed to ensure originality, scientific rigor, and compliance with ethical editorial standards.

This research was conducted under a mixed-methods paradigm, integrating both positivist and socio-critical approaches to analyze the relationship between the circular economy and the implementation of a Waste Sorting and Recovery Station in Bosconia.

From the positivist perspective, the study employed quantitative methods, including structured

surveys administered to 400 municipal residents and statistical data analysis based on official reports from CORPOCESAR and BIOGER S.A. E.S.P. This approach enabled an accurate description of the scale of the waste management problem and an objective assessment of the feasibility of applying a circular economy model.

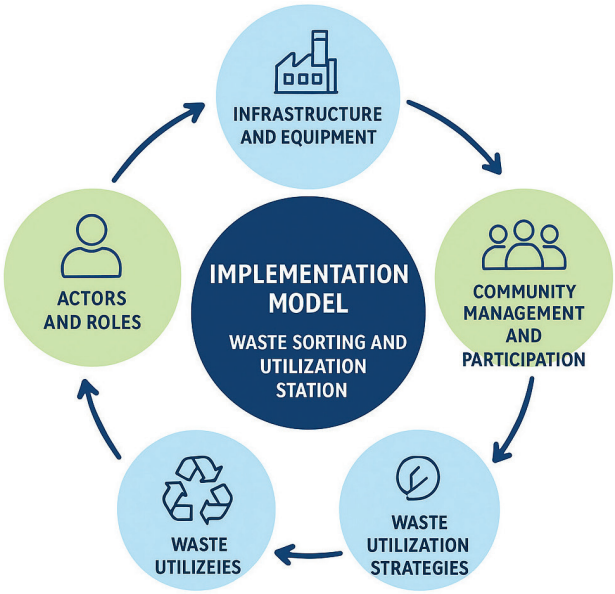
The socio-critical paradigm guided the qualitative component, which relied on semi-structured interviews with key stakeholders, including recyclers, environmental authorities, and representatives of relevant companies. This approach provided deeper insight into perceptions, barriers, and opportunities in transitioning toward a waste recovery system, fostering critical reflection on environmental management within the community.

The integration of these paradigms allowed for a scientifically rigorous characterization of the current waste management situation in Bosconia while facilitating the proposal of a sustainable circular economy-based alternative that encourages citizen participation and the development of more effective public policies.

The implementation model of the proposed Waste Sorting and Recovery Station is illustrated in Figure 3, offering a clear visual representation of its main components and processes. This visualization helps readers understand how circular economy principles will be applied in practice.

Additionally, a mixed-methods approach was employed, integrating both qualitative and quantitative elements to analyze the relationship between the circular economy and the implementation of a Waste Sorting and Recovery Station in Bosconia [1]. A descriptive and exploratory research design was adopted [15], allowing for a comprehensive characterization of the municipality's current waste management situation and an evaluation of the feasibility of implementing a sustainable circular economy-based model.

Figure 3. Implementation Model of the Waste Sorting and Recovery Station



Source: Own elaboration.

Figure 4. Research Methodology Own elaboration

Source: Own elaboration

Type of Research

For the qualitative component of this study, semi-structured interviews were conducted with key stakeholders in the environmental sector, including representatives from the waste management company BIOGER S.A. E.S.P., officials from CORPOCESAR, recyclers, and community members. This approach facilitated the identification of perceptions, barriers, and opportunities related to waste management and the transition toward a circular economy model [16].

From a quantitative perspective, surveys were administered to a representative sample of Bosconia's population to evaluate their knowledge of and participation in recycling practices. In addition, secondary data from CORPOCESAR and BIOGER S.A. E.S.P. reports were analyzed to assess waste generation and disposal patterns within the municipality and surrounding region [17].

Population and Sample

The study population comprised residents of Bosconia, environmental authorities, recyclers, and representatives from the waste management company. Survey participants were selected using stratified random sampling to ensure representation across different sectors of the municipality. For the interviews, a convenience sampling approach was employed, targeting key informants based on their experience and involvement in urban solid waste management [18].

Data Collection

Primary data were collected through structured surveys administered to 400 residents of Bosconia, semi-structured interviews with 15 key stakeholders in the waste sector, and direct observations at critical waste disposal points. The surveys included closed-ended questions and Likert-scale items to assess citizens' perceptions of waste management issues and potential solutions [19].

Secondary data were obtained from documentary sources, including official reports from CORPOCESAR and BIOGER S.A. E.S.P., previous academic studies, and current regulations on the circular economy and waste management in Colombia. Additionally, a comparative analysis was conducted with waste recovery models implemented in other regions of the country [20].

Data Analysis

Qualitative data were analyzed using content analysis techniques, identifying thematic patterns in interviews and observations. Quantitative data were analyzed using descriptive statistics and correlation tests to evaluate relationships between

variables, such as waste generation, citizen participation in recycling, and acceptance of a circular economy–based model [21].

Data processing was conducted using SPSS statistical software, enabling the results to be presented in comparative graphs and tables. Additionally, an economic and social feasibility analysis was performed based on cost–benefit studies for the implementation of a Waste Sorting and Recovery Station in the municipality [22].

Ethical Considerations

The research was conducted in accordance with ethical principles of confidentiality and informed consent. Participants in the interviews and surveys were fully informed about the purpose of the study, and measures were taken to protect their personal data, ensuring that the information collected was used exclusively for academic purposes [23].

Results

Result 1: Assess of the Current Waste Management in Bosconia

For the first specific objective, the study characterized the current waste management situation in Bosconia, highlighting critical issues such as illegal dumping, inadequate disposal practices at the "Don Bosco" landfill, and the absence of a source separation culture. Surveys and interviews with key stakeholders revealed that 78% of respondents perceive the collection and management system as insufficient. Furthermore, the landfill was found to be operating without full compliance with environmental regulations, contributing to soil and air pollution. The overall assessment of waste management in Bosconia is illustrated in Figure 5.

Figure 5. Waste Review. Own elaboration

Source: Own elaboration

Result 2: Identification of Successful Circular Economy Experiences Applicable to Bosconia

In relation to the second specific objective, case studies from Colombia and abroad were reviewed. Successful strategies were identified in Medellín and Bucaramanga, where the formalization of recyclers and the establishment of sorting stations significantly reduced the amount of waste sent to landfills. These cases demonstrate that investment in recycling infrastructure, combined with

economic incentives, enhances efficiency and promotes citizen engagement. Furthermore, institutional support and the integration of recycling cooperatives emerged as key factors for ensuring long-term sustainability.

Result 3: Proposal for an Implementation Model for a Waste Sorting and Utilization Station in Bosconia

Implementation Model Design: In line with the third specific objective, an implementation model was developed to align with the socioeconomic and environmental conditions of Bosconia. The model aims to establish a Waste Sorting and Utilization Station (ECA) capable of processing approximately 40% of the municipality's recyclable waste. It seeks to coordinate the participation of recycler associations, the public and private sectors, and implement an economic incentive system to encourage source separation. Key aspects, including infrastructure and equipment, community engagement strategies, waste utilization methods, and the project budget, have been carefully considered to ensure both effectiveness and sustainability. The overall design and components of the ECA implementation model are illustrated in Figure 6.

Infrastructure and Equipment: To ensure the optimal operation of the ECA, the following aspects have been considered:

- Architectural and Electrical Plans: Layout designs have been developed, incorporating designated areas for waste reception, sorting, storage, and processing.
- Scale Procurement: Industrial scales will be acquired to weigh the waste, enabling precise monitoring and control of the quantities processed.
- Technical and Legal Studies: All necessary legal and technical documentation has been prepared, including geotechnical studies, an assessment of the warehouse designated for the ECA, a structural stability certificate, and an updated Comprehensive Solid Waste Management Plan (PGIRS), ensuring full compliance with regulatory requirements for project implementation.

Community Management and Participation: The implementation model includes the formalization of the Association of Entrepreneurial Recyclers of Bosconia (AREB), promoting the social and labor inclusion of the municipality's recyclers. Planned training will cover waste management practices, environmental regulations, and the operational administration of the ECA.

Waste Utilization Strategies:

- Source separation and classification: Through environmental education campaigns and an economic incentive system, the proper disposal of recyclable waste will be encouraged.
- Organic waste management: A composting system will be implemented to process organic waste, reducing the volume sent to the landfill while generating valuable inputs for local agriculture.
- Revaluation of recyclable materials: Partnerships will be established with industrial companies for the commercialization and transformation of recyclable materials into new products, fostering the development of a circular economy in the region.

Budget and Economic Sustainability: The total project budget amounts to $408,000,372, encompassing expenses related to infrastructure, equipment acquisition, training programs, awareness campaigns, and the formalization of the recycler association. To ensure long-term sustainability, a mixed financing scheme is proposed, combining contributions from the public sector, private investments, and potential grants from environmental organizations.

Figure 6. ECA designs.

Source: Own elaboration

Result 4: Feasibility Assessment and Economic, Social, and Environmental Benefits

The feasibility analysis confirmed the strong potential of the proposed model across multiple dimensions:

- **Economic**: The project is expected to generate approximately 50 direct and indirect jobs during its initial phase, with potential for progressive growth as operations expand.
- **Environmental**: The model could achieve an estimated 35% reduction in landfill waste, along with significant decreases in leachate contamination and greenhouse gas emissions.
- **Social**: The inclusion and formalization of recycler groups, combined with environmental education initiatives, will foster community engagement, enhance public awareness, and promote long-term participation in sustainable waste management practices.

Discussion

The results obtained in Bosconia align with patterns previously identified in the literature regarding waste management challenges in small and medium-sized municipalities. Consistent with the findings of UNEP [4], the lack of adequate infrastructure and weak regulatory enforcement have led to a strong reliance on landfills and limited advancement in recycling initiatives.

The analysis of successful experiences in Medellín and Bucaramanga demonstrated that the formalization of recycler associations and

institutional support are critical determinants of success. In Bosconia, the proposed model seeks to replicate these principles; however, unlike larger urban centers, the municipality faces financial constraints and low public awareness, which may slow the adoption of circular economy practices.

The implementation model for the Waste Sorting and Utilization Station (ECA) represents an innovative adaptation to Bosconia's local context. By integrating technical, social, and economic dimensions, the model establishes a foundation for transitioning from a linear waste management system to a circular one. Nevertheless, the feasibility analysis highlights potential risks, including insufficient community engagement, market fluctuations in recyclable materials, and the need for consistent political and institutional support.

Therefore, the proposed model should be viewed not as a definitive solution but as a starting point for cultivating a culture of waste separation and resource recovery. Its long-term success will depend on the effective coordination among public institutions, private investors, and community organizations, alongside continuous monitoring, evaluation, and adaptation to local conditions.

Conclusions

In conclusion, the transition toward a circular economy model in Bosconia represents an environmental, economic, and social necessity. The implementation of a Waste Sorting and Recovery Station (ECAR) could become a turning point in the municipality's waste management, fostering a more efficient, sustainable, and inclusive system. Achieving this objective requires collaboration among the public sector, private entities, and the community, supported by clear environmental policies and comprehensive education programs. The project's feasibility and long-term success will depend on political commitment, investment in infrastructure, and increased public awareness of the importance of proper waste management.

The analysis of Bosconia's current situation—marked by the proliferation of illegal dumpsites and inadequate operation of the "Don Bosco" landfill—revealed significant deficiencies in infrastructure, regulation, and civic awareness regarding waste treatment.

The proposed Waste Sorting and Recovery Station offers a viable solution to reduce landfill dependence, create employment opportunities, and cultivate a recycling culture within the community. Evidence from other regions of Colombia and Latin America demonstrates that effective waste recovery not only mitigates environmental degradation but also stimulates economic growth and social inclusion

The results indicate that the lack of source separation and limited community participation in recycling initiatives are major barriers to adopting a circular economy framework. Consequently, it is vital to implement environmental education and awareness campaigns, alongside strengthened local regulations governing waste management practices

Another critical finding concerns the noncompliance of BIOGER S.A. E.S.P., the landfill operator, whose shortcomings have resulted in inefficient waste handling and negative environmental consequences. Enhanced monitoring and enforcement by relevant authorities, such as CORPOCESAR, are essential to ensure adherence to environmental standards and the execution of effective corrective measures.

From an economic standpoint, establishing the ECAR could not only reduce waste disposal costs but also generate revenue through the recycling and commercialization of recoverable materials. Moreover, the formalization of recyclers and the creation of new jobs would strengthen the local economy and improve living conditions for many residents of Bosconia.

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