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Sustainable Development and Integrated Municipal Solid Waste Management in Abancay, Peru

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Abstract The objective of this research is to determine the relationship between the integrated management of municipal solid waste and sustainable development in Abancay, Peru. The methodology corresponded to a quantitative investigation of correlational study level, with a population of 72,277, from which a statistical sample of 383 inhabitants was obtained. Through the investigative process, it was possible to specify the existence of weaknesses in the integral management of solid waste carried out by the municipality, highlighting a conclusion of a statistically significant association between both variables. This was verified through a hypothesis contrast, which allowed Kendall's tau_b correlation coefficient, to obtain a p of 0.000, evidently lower than the 0.05 significance level, with which the null hypothesis was rejected and the alternate hypothesis was accepted, with a degree of moderate relationship between these variables (Tau_b = 0,638). Finally, it was considered that the need to, in the future, apply an action proposal oriented towards a management model for the integrated management of solid waste, aligned with the Sustainable Development Goals (SDGs), according to Agenda 2030, and framed in the National Plan for Integrated Solid Waste Management 2016-2024 of the Peruvian Ministry of Environment (2016).

Keywords Integrated Management, Solid Waste, Municipality, Sustainable Development

1. Introduction

Currently, there are enormous difficulties related to global sustainability, which makes it necessary to adopt environmentally friendly practices through adequate integrated waste management, which, according to Limache [1], includes government, financial, and planning measures for waste management at all stages of its generation. Concerning the waste treatment procedures, it is important to consider the tools and processes used for effective control [2]. It should be noted that the procedures are different for addressing each type of solid waste; therefore, they should be treated responsibly, using systems and protocols that reduce and apply mitigation measures [3].

Likewise, according to Carvajal et al. [4], solid waste can be diverse, domestic, commercial, sanitary, and industrial. It should be noted that according to Mumtaz et al. [5], various methods are currently used to manage these materials, such as converting plastic waste into high-energy fuels, which are the most advantageous in the long term. On the other hand, Carvajal et al. [4] suggest that, if leftovers or residuals cannot be reused or reprocessed, they should be disposed of in the least environmentally damaging way.

At this point, it should be noted that waste management represents a challenge for the local government as the main responsible party, and includes the different actors of the communities. According to their roles, the population must

stimulate healthy behaviors to maintain their environment, while municipalities must guarantee the collection of household waste [6]. In turn, policies should be generated to encourage participation. About this point, Ariza et al. [7] consider it important to integrate technical information-gathering activities with the active participation of the community, while Mondal et al. [8] highlight the role of companies, which should work to create sustainable management solutions.

Concerning integrated solid waste management, the activities mainly involve sweeping, transportation, collection, and final disposal. Regarding sweeping, Trujillo and Aroca [9] mention that this activity allows the streets to be free of any solid material, such as paper, cardboard, and plastic, among others. Likewise, for the municipality, the proper application of the procedure depends on the frequency of the procedure, the type of paving and topography, the length of the streets, pedestrian traffic, location of garbage containers, equipment and personnel necessary for the service; this action can be performed manually or mechanically [10].

Within the functions of integral solid waste management, there is also the collection of compact waste, which represents a typical municipal responsibility that is carried out through the provision of public services [11]. This collection encompasses various aspects, such as the condition of the trucks, and the uniforms and institutional identifications of the personnel dedicated to this activity [12]. Likewise, Huamaní et al. [13] emphasize that to recycle this waste, a facility to classify, package, and supply it as inputs to the recycling market.

On the other hand, regarding the transportation of solid waste, Jiménez [14] points out that it consists of transporting the collected materials to the treatment plant for recovery or final disposal. In an ideal situation, transportation is distributed by categories that help organize the materials for recycling or disposal [15].

Another fundamental aspect is the final disposal in which the choice of a place for the complete waste disposal is crucial. In this regard, it is important to highlight that municipalities are primarily responsible [1], and in ideal conditions, they should have waste treatment plants [16]. However, it should be noted that for a large amount of solid sediments, treatment plants cannot do an adequate job [17]. The final disposal of these wastes is the key to avoiding environmental contamination of nearby soils and water supplies [18].

As the state of the art, it is necessary to consider everything related to solid waste management as essential to achieve sustainable development, which implies the vision that social and environmental systems have the same relevance as economic systems [19]. Precisely, its importance lies in the elaboration of strategies based on the interests of developed and developing countries [20]. To this end, companies must be responsible for self-regulating production and addressing social, environmental, and economic growth issues [21]. In this sense, Martínez et al. [22] found that the organic coexistence of different actors, both governmental and non-governmental, is necessary for the projection of plans and initiatives already accepted by the community, taking into account the cultural perspective.

For his part, Manero [23] detected that the expansion of sustainable development policy continues to spread through free trade agreements signed with various nations in America, Asia, and Europe, to achieve the objective of extending such policies through the European Union. In this context, Manzanares [24] affirms that the functionality of sustainable development in public management implies the articulation of multiple dimensions (economic, social, ecological, etc.) at different levels (international, national, and local), with the influence of different actors, such as the State, companies, NGOs, among others.

According to research by Almeida and Diaz [25], there are currently many models to address the problems caused by a linear system of production and consumption. Among these models is the circular economy, which aims to achieve financial success and the viability of the paradigm shift towards the environmental topic. Molina and Zaldumbide [26] found that this model works as a continuous cycle of positive development that manages reserves and renewable flows, to protect and enhance natural capital, and maximize the return on resources.

Similarly, according to the findings of Merino [27], models such as the green economy have been developed, which have proved efficient since they focus on the collaboration between economic, environmental, and social issues. In this context, Domínguez et al. [28] emphasize that, for such an objective, it is necessary to have a financial contribution that allows a balance between the use and effects of the environment, as well as the resources needed to reduce those effects.

According to Bom [29], by achieving sustainable management in economic, social, and ecological terms, companies adopt social responsibility as a strategy, so it is considered that sustainable development is closely related to the social dimension. Barrera [30] complements that, in this way, a balance is sought that allows social justice and sustainability, both for organizations and for the planet's ecology.

It is necessary to recognize that the achievement of sustainable development depends on many factors and, therefore, only the articulation of the main actors would facilitate the orientation of actions in search of solutions with greater effectiveness; therefore, this study is of great value because it offers the result of updated bibliographic information to support any action of municipal management, adapted to reality. For this study, the general objective is to determine the relationship between the integrated management of municipal solid waste and sustainable development and to clarify the situations related to solid waste management. Consequently, a statistical contrast is considered for the study to answer the research, starting from the null hypothesis H_o: There is no

relationship between sustainable development and the integrated management of municipal solid waste. The alternative hypothesis H_1: There is a relationship between sustainable development and the integrated management of municipal solid waste.

2. Materials and Methods

This study is a quantitative research whose purpose is to examine numerically the phenomenon under study [31]. Regarding the level of study, it was placed in the non-experimental design of correlational scope [32], to understand how one variable may behave concerning the other [33]. The population consisted of 72,277 people from the city of Abancay, from which a sample with an estimation error of 5% (383 inhabitants) was obtained. [34]. The survey was used as a technique and as an instrument [34], which was validated by expert judgment. For reliability, Cronbach's alpha was applied, selecting a group of 22 participants from the community, from which a value of 0.806 was obtained. About the data processing technique, the descriptive information was first collected, ordered, and tabulated, which subsequently made it possible to contrast the hypothesis through the test chosen with Kendall's Tau_b correlation coefficient. Finally, we proceeded with the analysis of the data, which allowed us to establish discussions, conclusions, and recommendations.

3. Results and Discussion

3.1. Integrated Solid Waste Management

The application of instruments made it possible to identify the performance of municipal government policies about integrated solid waste management. In the present study, weaknesses of the local government in the integral management of solid waste were observed; in this sense, 68.66% of the respondents indicated that the local government never carries out an integral management of solid waste. This can be seen in Table 1.

Table 1. Results of the integral management of solid waste by the local government

Option	Frequency	Percentage
Never	263	68,66 %
Sometimes	70	18,34 %
Always	50	13.00 %
Total	383	100.00 %

Based on their research, Lakhouit et al. [35] argued that in recent decades, solid waste generation has received greater attention. This contemplates the categories of integrated solid waste management, sweeping, collection, transportation, transfer, and final disposal. However, despite the efforts of state policies, in developing countries, unmanaged solid waste continues to be a problem [36]. For Eshete et al. [37], based on their findings, the greatest sources of environmental pollution and public health concerns are generated by inadequate solid waste management in urban and semi-urban cities in developing countries. Considering also that urban waste materials generate a high cost to the municipal budget, it represents logistical and technical problems in both handling and processing process [35]. With no short-term response in rural areas, non-reusable waste materials continue to increase as a result of population growth [36].

3.2. Sweeping of Public Areas

The results obtained through the participation of the people surveyed make it possible to determine their perception of street sweeping. Table 2 shows that 72.20% of the sample indicates that street sweeping and other public places are sometimes carried out by the municipality.

Table 2. Sweeping

Option	Frequency	Percentage
Never	38	9.80 %
Sometimes	276	72.20 %
Always	69	18.00 %
Total	383	100.0 %

According to Ramírez and Santiago [38], the collection is a responsibility that concerns all cities and can lead to higher costs and health problems when it is not carried out properly. Currently, waste management is a problem that involves major challenges, regardless of whether it is a developed or developing country.

According to the study by Arcgis et al. [39], another issue to consider is the absence of garbage cans and the overflow of existing ones, which creates constant management problems. Trash containers in the community are filling up faster and faster and end up overflowing long before they are recycled, causing negative effects on health and the environment [40]. For Eshete et al. [41], even though some populations have a predisposition for solid waste management, inexperience in the classification, disposal, and reduction of solid waste, as well as the lack of landfills and collection services, produce conditions that generate bad practices.

On the other hand, it is necessary to highlight the existence of alternatives such as smart collection, a method through which it is intended to speed up the collection of garbage accumulation, using a cell phone that distinguishes scope and lengths. It reduces the points of travel [40], which shows a panorama of solutions that a few decades

ago were unthinkable, but that today are close to reality.

3.3. Transportation of Solid Waste

The results obtained show that 59.30% of the respondents agree that the municipality sometimes carries out this activity, as shown in Table 3.

Table 3. Transportation of solid waste

Option	Frequency	Percentage
Never	106	27.60 %
Sometimes	227	59.30 %
Always	50	13.00 %
Total	383	100.00 %

According to Li et al. [42], the transportation of solid waste generates such high costs that it affects the capacity to collect a greater amount of solid waste. This represents a disadvantage; however, at the transportation level, the development of technology has made new alternatives available. For Saad et al. [43], the successful implementation of location software to monitor in real-time, identify garbage containers and control collection has been achieved, opening the possibility to the application of intelligent systems for the management of routes and transport fleets. Machine learning, due to its effectiveness, is playing an important role in the modernization of compacted waste management [44].

3.4. Final Disposal of Solid Waste

Concerning the transportation of solid waste, the response of the personnel surveyed (Table 4) is in the majority, with 65.40% indicating that it is sometimes carried out, which infers that the municipality does not have a structured and supervised plan for transporting waste with a safe classification.

Table 4. Final disposal of solid wastes

Option	Frequency	Percentage
Never	133	34.60 %
Sometimes	250	65.40 %
Always	0	0.00 %
Total	383	100.00 %

In the work of Quispe [45], it was found that, instead of sanitary landfills, there is an alarming amount of landfills, so organic waste is often greater than inorganic waste. Moreover, these remaining materials continue to be a problem for the development of local communities [46]. On the other hand, pathogenic microbes with antibiotic resistance can thrive in compacted municipal waste materials as nutrients, and be aerosolized and transported nearby during waste disposal processes [44].

In many places, water contamination by leachate has been widely reported [47]. Therefore, one of the major challenges in integrated municipal solid waste management systems is the sustainable and green treatment of landfill water [48]. In turn, Ratnawati et al. [46] point out that the aim is to apply the most cost-effective methods to decrease percolation fluids to achieve a longer landfill life and store a larger amount of waste.

In landfills, soil contamination by heavy metals is a widespread and complex problem [49]. However, there are innovative techniques, such as landfill mining, which seeks to recover valuable objects or minerals in the waste [50]. This would decrease the interaction of heavy metals with other compounds.

3.5. Sustainable Development

In the context of sustainable development, it was found that 69.80% of the respondents (n = 267) indicated that no actions have ever been implemented to promote the fulfillment of its objectives, as shown in Figure 1.

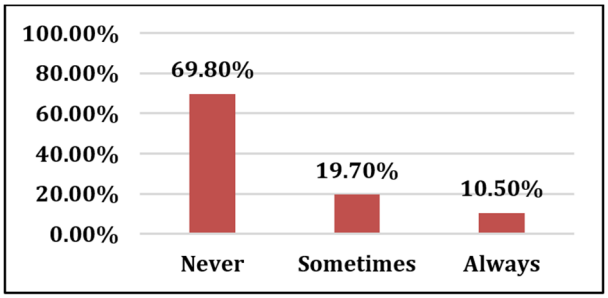

Figure 1. Fulfillment of the Sustainable Development Goals

In the same vein, Annamalaisamy and Vepur Jayaraman [51] argue that climate change has generated significant adverse effects on the environment and that achieving greater economic growth without compromising environmental quality is a difficult challenge for countries. This is why urban planners and governments must understand local and cultural contexts to identify the real needs of cities, and thus achieve sustainable development goals [52].

In the current context, governments need to identify the main dimensions of the Sustainable Development Goals (SDGs), which are key to measuring the extent to which these goals are being met [53]. It is also worth highlighting the performance of companies, which, in globalization, has accelerated competition among themselves and is seeking to adapt to new sustainable development policies [54], which is part of change initiatives that allow new adaptations to take place.

3.6. Sustainable Development: Social Dimension

This study found that in terms of the social dimension of sustainable development, in general, and for most

respondents, No. = 284, representing 74.30% of people who maintain that prevention campaigns that include inter-institutional agreements and communication about the importance of waste management are never applied. This result shows that the population is exposed to risks and dangers of a biological nature and, therefore, the current conditions do not allow the cultivation of values and do not benefit health, education, and integral well-being, as shown in Figure 2.

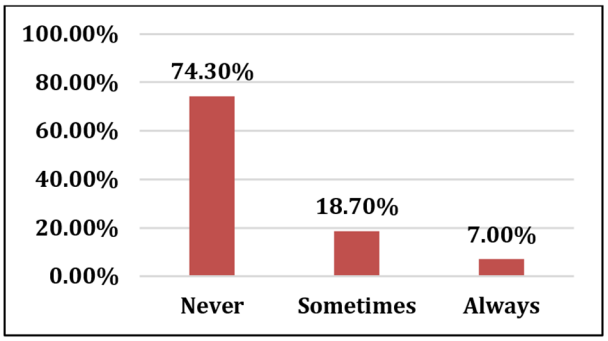

Figure 2. Policy development in the social dimension

Based on a study by Omodero and Alege [55], the issue of social development has gained attention on a global scale, due to the implications in the lives of people. For Das [56], it includes all social sectors that contribute to sustained integral progress in areas such as gender equality, infrastructure, family planning, health, and education, among others.

3.7. Sustainable Development: Economy

The results show that 80.90%, corresponding to 310 respondents, indicate that there are never adequate activities for people to generate an economic income from the management of solid waste. Based on this, there is an opportunity to establish policies to promote the creation of companies that provide solid waste services or companies that commercialize solid waste, which would lay the foundations for the generation of conditions that would allow people to obtain some benefit from the situation, as shown in Figure 3 below.

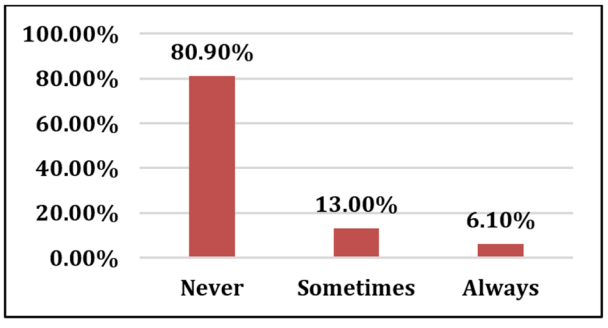

Figure 3. Policy development in the economic dimension

Based on the findings of Largo [57], rapid population expansion and lack of resources aggravate the situation of waste and misuse of resources, leading to an unprecedented ecological catastrophe with already visible effects. On the other hand, according to Wang et al. [58], the growth of calls to reduce emissions, save energy, increase corporate social responsibility, and mitigate the negative effects of economic growth on the environment and society is evident. Companies have to rethink their plans and modify their supply chains [59], so there is a need to adjust even further the industrial structure [58], which is being regulated through the Sustainable Development Goals (SDGs) that were proposed in 2015 to promote global improvements in human well-being [59].

3.8. Sustainable Development: Environment

Regarding the results, most people (239), representing 62.30 %, consider that the current waste management never contributes to avoiding water, soil, and air pollution. This result indicates the need for active participation by the population in environmental campaigns, as well as the maintenance and preservation of green areas (Figure 4).

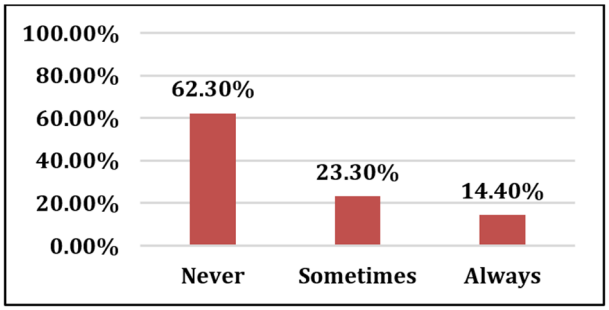

Figure 4. Policy development in the environmental dimension

In the review by Normalina et al. [60], they found that the main responsibility is on the State, which has capabilities through its institutional policies, therefore, harmonious development with the environment is the long-term construction of conditions to ensure the benefit of available natural and human resources. In the 21st century, the most critical global agenda is environmental sustainability [61]; this is probably due to the complexity of immersed economic interests that hinder its fulfillment. The environment is an elemental factor in sustainable development.

3.9. Correlation between Integrated Municipal Solid Waste Management and Sustainable Development

The correlation study starts with the formulation of the research hypotheses, as follows:

Ho: There is no relationship between sustainable development and integrated municipal solid waste management.

H_1: There is a relationship between sustainable development and integrated management of municipal solid waste.

The result of the contrast reached a p-value equal to 0.000 and was less than the significance level (0.05), so the null hypothesis is rejected and the alternative hypothesis is accepted. Consequently, it is affirmed that there is a highly significant relationship between integrated municipal solid waste management and sustainable development, with a moderate degree of association between these variables, with a correlation coefficient, of Tau_b = 0,673. This is shown in Table 5.

Table 5. Correlation between integrated municipal solid waste management and sustainable development

Tau_b of Kendall	Integrated management of municipal solid waste	Correlation coefficient	1,000	0,673
		Sig. (bilateral)	.	0,0
		N	383	2
	Sustainable development	Correlation coefficient	0,673**	1,0
		Sig. (bilateral)	0,000	
		N	383	2

Note. **Correlation is significant at the 0.01 level (bilateral).

In mentioning their findings, Villalba et al. [62] point out that the absence of municipal government policies generates that production and consumption waste is stored in certain places, whose organization and content in most cases do not comply with regulatory requirements. For Bhatt and Mohapatra [63], large amounts of waste require sustainable waste management strategies; in addition, they demand comprehensive knowledge about different waste management strategies.

3.10. Reflections

According to Wang et al. [58], the municipal government is essential to improve efficiency and meet the sustainability requirements of the urban environment through integrated solid waste management. Also, for Bespalyy [64], with the cooperation of the government, NGOs, and media programs, many problems for sustainable development would be solved. Molayzahedi and Abdoli [65] argue that some municipalities invest in more complex types of solid waste management cooperation and achieve improved waste management in comprehensive performance.

For Largo [57], rapid population expansion and lack of resources aggravate the situation of waste and misuse of resources, leading to ecological catastrophe. In the face of this, it is worth mentioning the proposed initiatives, such as the Sustainable Development Goals (SDGs), which were proposed in 2015 to incentivize global improvements in human well-being [59].

Regarding the economic dimension, it is highlighted that adequate activities are never carried out so that people, from solid waste management, can generate an economic income. In addition, from an environmental perspective, it was found that, for those surveyed, the waste management carried out by the municipality does not contribute to preventing water, soil, and air pollution.

Likewise, the absence of actions for the development of prevention campaigns and inter-institutional agreements that contribute to achieving better socio-environmental conditions was also highlighted. For Cobos et al. [66], negative socio-environmental conditions are derived from urban solid waste, due to its excessive generation, lack of governance, and financial resources, which demand sustainable and integrated solutions.

Finally, there are currently many technological resources that generate opportunities in solid waste management processes. In this regard, Lakhouit et al. [35] point out that the design of an intelligent waste management engineering system presents the opportunity to reduce the environmental, economic, and social impacts of waste.

Based on the above, it is proposed to apply a proposal for action oriented towards a management model for integrated solid waste management aligned with the Sustainable Development Goals (SDGs), according to the 2030 Agenda, considering the National Plan for Integrated Solid Waste Management 2016-2024, of the Ministry of Environment of Peru [67]. The aspects to be considered are directly related to SDG 3: Health and Well-being, SDG 6: Clean Water and Sanitation, and SDG 11: Sustainable Cities and Communities.

This model is based on three specific strategic axes:

1- Capacity building

The objective of this axis is to improve the capacity of the main actors in the general management of solid waste. This axis is based on the need found in the analysis of the sector, where there is a lack of technical knowledge and waste management, values, attitudes, and good practices at all levels of the companies that make possible the expected results.

2- Institutional development

This axis is aimed at strengthening the activities of the Solid Waste Environmental Management Authority and various competent sectors to promote adequate solid waste management at the national level. It also seeks to improve solid waste management teams at all levels at the local level.

3- Investment promotion

This third axis promotes the increase of public and private investment in solid waste management and maintenance at the national level. Monetary investment should be the product of a needs assessment to cover the current deficit. These investments must be sustainable,

which is achieved by strengthening and implementing technical, economic, financial, and legal instruments.

The structuring of the axes leads to three expected results in the medium term, which should be considered from the outset as specific objectives of this model. These objectives are:

1. Promote and achieve universal coverage of public cleaning services based on comprehensive and sustainable management systems, to prevent environmental contamination and protect the health of the population.
2. Promote the expansion and implementation of solid waste minimization, reuse, and recycling systems, adopting aspects of social inclusion and environmental responsibility towards the sustainable management of solid waste.
3. Strengthen integrated management by articulating the actions of the competent institutions and corporate responsibility, citizen participation, and free access to information.

For the application of the suggested model, it is indispensable to carry out an institutional campaign that pursues the following elements:

a. Updating of the General Law on Solid Waste and its regulations.
b. Promote and stimulate private investment in waste management. Application of the Extended Producer Responsibility Principle (EPR) for waste prioritized at the local level.
c. Review restrictions on mass consumption products with a high incidence of waste generation, such as packaging or plastic bags, *technopor*, etc.
d. Review and update the land-use plan for the selection of areas for solid waste infrastructure within the municipality's reach.
e. Facilitate and encourage the formalization of recyclers, with effective training and their incorporation into integrated solid waste management at the local level.
f. Establish a safe procedure for the management and handling of hazardous solid waste generated as part of municipal solid waste.
g. Promote the creation of solid waste management units at the municipal level.
h. Manage internally, and in collaboration with other entities, the approval of infrastructure for the treatment or final disposal of solid waste.
i. To establish environmental surveillance in the matter of solid waste.
j. Ensure the collection, tariff structures, and collection models for public cleaning services.
k. To implement in a sustained manner the environmental control in the matter of waste at the municipal level.
l. Incorporate the aspects of integrated solid waste management in the event of disasters, as part of the Solid Waste Management Plans (SWMP) and the Integrated Solid Waste Environmental Management Plans (ISWAP).
m. Design and apply procedures to reevaluate solid waste for energy purposes.
n. Apply methodologies to distinguish ferrous and non-ferrous mining waste.
o. Apply guidelines or directives to implement occupational health and safety considerations in municipal solid waste management activities.

4. Conclusions

Based on the opinions of the inhabitants of the community of Abancay who participated in this study, it was possible to conclude that the integrated solid waste management carried out by the municipality under study does not meet the expectations of the citizens. From this perspective, there are major weaknesses related to the continuous growth of the population and the increase in solid waste. In this sense, if rapid and effective changes are not made, the situation will have an exponentially negative trend.

Considering the evidence gathered, a significant relationship was found to exist between integrated municipal solid waste management and sustainable development. This is reasonable if we consider that government policies are regulatory references for activities related to such management. It is also important to note that it is possible to contribute to sustainable development through the implementation of municipal government strategies and programs in the area of solid waste management, led by people with experience and knowledge in this area. At the same time, it is essential to establish alliances with NGOs, private companies, public institutions, and social representatives to guide actions towards the achievement of the objectives implicit in the governmental policies, and thus manage the solid waste problem in the municipalities safely and reliably. Therefore, we propose the future application of an action proposal oriented toward a management model for the integrated management of solid waste, aligned with the Sustainable Development Goals (SDGs), according to the 2030 Agenda.

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