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Solid Waste Management in the Generation of Economic Income for Informal Recyclers

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Abstract

This study established the relationship between solid waste management and the generation of economic income for informal recyclers in Chiclayo, Peru. Based on a quantitative, basic, non-experimental and descriptive-correlational approach, with the application of two structured instruments with five ratings on the ordinal Likert scale, duly validated by experts, data were collected from a sample of 300 recyclers through a non-probabilistic sampling by quotas. These data were analyzed using ordinal logistic regression (OLR) and indicated the significant relationship between waste management efficiency and economic income of informal recyclers; acceptable management practices correlated with average income levels, suggesting that improved management could raise the income of these workers; environmental and socioeconomic challenges were also significantly associated with income generation, although health problems arising from poor waste management did not show a direct correlation, their impact on average income levels highlights the importance of addressing these risks. In conclusion, it highlights the need to implement integrated policies that improve waste management, address environmental and socioeconomic concerns, and promote sustainability for informal recyclers.

Keywords: *Environmental management, community development, solid waste, waste recycling.*

Introduction

In this context, citizen participation and community partnerships have been essential to promote independent and sustainable waste management (Oh & Hettiarachchi, 2020). Whose efforts have also been used by productive enterprises to provide economic income to the population, since this value is inherent to waste and has significant potential to promote the Sustainable Development Goals (Sumardjo et al., 2022), and contribute to poverty alleviation through the generation of economic income. However, local officials have often failed to support these initiatives, despite their potential to improve environmental reputation by supporting programs that encourage recycling with the strategic involvement of citizens, as current administrations have lacked the capacity to manage the enormous quantities of waste produced in cities, resulting in large quantities still being discarded alongside regular municipal collection efforts.

World Bank analysis has found that the COVID-19 pandemic has significantly impacted millions of people by increasing the rate of extreme poverty, fundamentally in scenarios where inequality levels have decreased, as observed in the Shared Socioeconomic Pathways (SSP) (Soergel et al., 2021), anticipating that 190 million people will be affected by extreme poverty, living on $1.90 per day. Similarly, an ECLAC report in Latin America has indicated a similar trend, with poverty and extreme poverty increasing from 27.8% to 30.5% and from 7.8% to 11.3%, respectively, between 2014 and 2019 (CEPAL, 2022). Consequently, household income generation has decreased in 2019, with between 467 and 491 million people living with incomes up to three times below the poverty line, encouraging the creation of initiatives that support income generation and social integration of waste pickers (Nolasco et al., 2021).

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On the other hand, Latin American countries continue to face complex and inefficient waste management problems, exacerbated by rapid population growth and construction booms (Davids et al., 2022). easing to worsening environmental problems in urban areas, with estimates suggesting that there are between 100,000 and 200,000 informal recyclers throughout Peru, according to data from the National Environmental Information System of the Ministry of Environment. In 2020, informal recyclers throughout Peru, according to data from the Ministry of Environment's National Environmental Information System, in 2020, 7,905,118.13 tons of solid waste was generated, or 0.57 kilograms of waste per person per day, while Lambayeque generated only 330,570 tons of solid waste, highlighting a persistent socio-environmental problem (SINIA, 2022).

In addition, it has become clear that socioeconomic characteristics such as gender, age, education, income, marital status, ethnicity, religion, nationality, and place of origin have significantly impacted participation in waste management (Alwan & Bachai, 2023); which remains a major challenge, as Brazil, Mexico, and Colombia lead research on organic waste management due to their large populations of informal recyclers working in hazardous conditions and without adequate resources (Hemidat et al., 2022; Ulloa-Murillo et al., 2022). This situation underscores the urgent need for positive socioeconomic models to serve as a basis for the creation of new laws and regulations for the industry (Davids et al., 2022).

In Peru, a study by the National Institute of Statistics and Informatics (INEI) has indicated that the poverty rate reached 30.1% in 2020, which represents an increase of 9.9% in the cost of a basic food basket with respect to 2019, therefore, extreme poverty was defined with monthly expenses that do not exceed the cost of the basic food basket, calculated at USD 53.06 per capita per month in 2020. This classification makes it possible to distinguish between those living in extreme poverty and those whose expenses remain above the average cost of basic consumption (INEI, 2022).

In this context, the importance of informal recyclers engaged in solid waste recycling cannot be underestimated (Yalçıntaş et al., 2023); given that these recyclers have played a crucial role in waste management, processing and recycling 30% of the country's waste, thus reducing the burden on municipal services by recovering and reselling essential materials for reuse. However, their limited scope and early development make it clear that they cannot cover all jurisdictions within Peruvian municipalities, and that, to improve the efficiency of the recycling process, greater collaboration between public and governmental efforts has been required (Guibrunet, 2019). Local authorities must create legal frameworks, provide formalization possibilities, extend financial support and integrate informal recyclers into the production chain (Ben Amor & Hammami, 2022).

In that sense, based on general information, it has become evident that municipal solid waste management remains inadequate and that there are insufficient incentives for the growth of waste pickers who see recycling as an additional source of income for their families (Ferronato & Torretta, 2019), despite the importance of the sector, research on the exact number of informal recyclers and their unique contributions to waste management has been limited. Consequently, creating effective public policies to support and regulate this group of workers remains a challenge.

To address this research gap, this study has closely examined the role of informal recyclers in Peru, their contributions to municipal waste management services and the characteristics of the market in which they operate, determining that this research provides information for the development of legislation to improve working conditions and integrate informal recyclers into the formal waste management system, therefore, the objective was to examine the impact of solid waste management on income generation from the perspective of informal recyclers, focusing on the economic, environmental and health implications, due to the fact that this is an area of scarce study and interest of the municipal administration in addressing the relevant solutions to this problem. Therefore, having identified this gap in public management, the results of this research are intended to achieve theoretical and empirical approaches for its adequate treatment.

Similarly, best practices in solid waste management have been essential to improve the living conditions and income of informal recyclers (Tong et al., 2021), with the adoption of optimal measures to support

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solid waste management (Ulloa-Murillo et al., 2022) that have been crucial to formalize the process and work of informal recyclers (da Silva et al., 2019), generating basic knowledge for this purpose.

In the same vein, the results obtained will clarify policies that facilitate the creation of more green jobs (Vesere et al., 2021) and progress towards a circular and sustainable economy (Hemidat et al., 2022), with guidance to public managers on the implementation of best practices in solid waste management, potentially extending to the Latin American context. This could lead to strategies that improve economic income generation (Ariani et al., 2022), improve municipal solid waste management, decrease negative environmental impacts, and align with the sustainable ideal described in technical documents and regulations (Prenovitz et al., 2023).

Ultimately, the hypothesis postulates that solid waste management significantly influences the economic income of informal recyclers and those effective municipal policies that address management challenges, environmental concerns, and socioeconomic issues can improve income generation from waste recycling activities.

Theoretical Approach

Solid waste management in South America involves informal recyclers who, despite not being formally recognized by municipal authorities, have carried out essential recycling operations (Moreira Gomes & Aragão Neto, 2018), and have contributed significantly to both the circular economy and solid waste management in metropolitan areas (Guarnieri et al., 2020; Rutkowski & Rutkowski, 2015; Valencia, 2019). such is the case of Brazil, which has been considered one of the nations with the most effective waste management systems, despite this substantial contribution, there is a gap between PET packaging capacity and consumption due to lack of funds, public awareness and incentives for informal recyclers, which negatively affects the efficiency of solid waste management initiatives (25, 26).

In Lima, where 40% of all waste pickers in Peru live, the formal system has collected solid waste and transported it to the outskirts of the city. However, informal recyclers have collected and purchased recyclable waste, selling it for a minimal profit and, at times, modifying the waste to increase their profits (Aparcana, 2017).

On the other hand, management theories have been fundamental to understand and optimize the relationship between production, profits and results in organizations (Skačkauskienė, 2022), based on Frederic W. Taylor's scientific management principles, which have introduced techniques to increase process efficiency (Maccoby, 1984), while Henri Fayol's management theory, with its 14 fundamental principles and functions of the administrative process, has provided a framework for resource allocation and management (Hatchuel & Segrestin, 2019); likewise, Douglas McGregor's Theory X and Theory Y (Head, 2011), has considered various relevant mindsets and management styles when discussing solid waste management as a source of revenue, as well as Ludwig Von Bertalanffy's systems theory (ĆWIK, s. f.) which has examined the connections between systemic components, providing a framework for understanding the complexity of waste management systems, furthermore, Max Weber's bureaucratic theory (Dash & Padhi, 2020) has emphasized the hierarchical structure for effective organization, and Elton Mayo's (Hassard, 2012) human relations theory has stressed the importance of individuals in management, directly relevant to multi-stakeholder solid waste management.

On the other hand, Naess' deep ecology has suggested comprehensive methods for sustainable waste management, requiring recyclers to convert waste materials into economic resources (Anderson, 2020), in the face of this, the regulatory approach hypothesis has suggested that society can adopt sustainable waste management techniques by applying the necessary regulations (Bergquist et al., 2021), it is important to consider the origin of the term "management" which is derived from "gestio" and "gestionis", denoting an integral activity (Anders, 2022), just as Forrester's decision making theory has been useful to analyze how waste management data are transformed into economic actions, promoting effective waste management and income generation (Shornikov & Popov, 2019).

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In addition, waste management influences the physical and mental health of communities and the environment (Ferrandiz, 2022), whose research has emphasized the regulation of concepts such as global health and sustainable development when analyzing environmental risks (Carducci et al., 2021), considering Margaret A. Newman's proposals have focused on health as a catalyst to broaden awareness, aligning with the World Health Organization's definition of "health", which encompasses physical, mental and social well-being (OMS, 2022). Consequently, Nightingale's environmental theory has emphasized practices such as environmental and hand hygiene, supporting the environmental dimension that includes elements that coexist with human activity (42, 43). These guidelines underline the importance of efficient solid waste management for environmental preservation and economic benefit.

In this context, socioeconomic dimensions include microeconomics, macroeconomics and social theory, which examines human social phenomena through associations, groups and institutions (44, 45). Therefore, the implementation of cooperative strategies, such as organizations and collectives, is recommended to optimize the earnings of informal recyclers with sustainable waste collection management, in communion with the municipality.

The generation of economic income from recyclers, through the recognition of the value of recycled materials, has shifted their focus from public health concerns to environmental preservation, which has been a relevant factor for our study, which examines how solid waste management could increase economic income (Tong et al., 2021), because recyclable solid resources can be used directly or sold for processing, which facilitates income generation (Valencia, 2019).

On the other hand, in many Chinese cities, the public has not been aware of solid waste sorting, especially household waste sorting (Wang et al., 2021), which often falls to low-income households or informal sector workers (Ogwueleka & Naveen, 2021) who sell recyclable materials to supplement their income (Hemidat et al., 2022). This highlights the importance of understanding solid waste management and implementing new ideas to maximize financial rewards and environmental preservation.

Such is the case, in Mexican cities, where municipal solid waste is collected along designated routes and transported to transfer stations and disposal facilities, that informal recyclers often work in groups earning up to USD 520.00 per day obtaining recyclable waste (Gutierrez Galicia et al., 2021), consequently, this example emphasizes the important role of informal actors in waste management and the clear connection between waste management and economic income. However, public understanding of solid waste management has been hampered by a lack of awareness of segregation processes, making it imperative to inform the public about proper waste management procedures and to consider waste collection as a means of providing income to households.

In this sense, Adam Smith's perspective in "The Wealth of Nations" has distinguished between use value and commercial value, emphasizing labor productivity as the main source of national income (Brooks, 2018; Retuerto et al., 2021; Robinson & Subrick, 2021). because inclusive models have promoted entrepreneurial sustainability in developing countries (Ghosh & Rajan, 2019) by empowering people at the bottom of the socioeconomic pyramid to start businesses and achieve self-sufficiency (53).

In this context, government policies, as an external factor, significantly influence the income sources dimension of informal recyclers (Prenovitz et al., 2023), so recycling has been seen as a source of income rather than a mere waste, helping recyclers to diversify their income (van der Velden et al., 2021) and in parallel protect the environment (Ezeudu et al., 2021), with this perspective aligning with the theories of the informal economy (Charmes, 2019), empowerment and sustainable development.

However, the second dimension on physical wear and tear incorporates occupational safety and health theories (Rodrigues et al., 2020), recognizing that working with waste causes the most common physical wear and tear (Sapkota et al., 2020), which makes it necessary to improve safety measures and working conditions (Zolnikov et al., 2018) for informal recyclers.

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Likewise, the theories of well-being (Tong et al., 2021) and occupational mental health consider the dimension of mental burnout (Moreno Fortes et al., 2020), examining how the mental health of waste pickers is affected by stress, instability and uncertain working conditions. In addition, economic marginalization (Sasman et al., 2021) and informal work theories (Sapkota et al., 2020) are relevant to understanding the psychological problems arising from unstable employment and lack of adequate working conditions.

Methodology

This research is in line with the positivist paradigm (Catalán-Vázquez & Jarillo-Soto, 2010) and focuses on objectively determining the origins and correlations of particular social phenomena. The main objective is to examine the relationship between solid waste management and the income generated by informal recyclers in Chiclayo, Peru. To achieve this, a quantitative and systematic evaluation of the variables involved was possible by using a descriptive correlational approach (Bernardo et al., 2019).

A representative sample of 300 people was selected from among the 1,370 informal recyclers working in Chiclayo who make up the target group of the study, in order to provide an equitable and representative distribution of the research population, this selection was made by non-probabilistic quota sampling, which ensures the representativeness of certain subgroups according to age, sex and educational level (Arias Gonzáles & Covinos Gallardo, 2021).

Structured surveys were used in the data collection process, and two separate questionnaires were created and distributed, each with a five-point Likert scale setting (Arias Gonzáles & Covinos Gallardo, 2021) and prior validation by experts in the field. In the first of these surveys, 18 items were divided into four dimensions to assess solid waste management: management, health, environmental effect, and socioeconomics. The second questionnaire, which examined income creation, had sixteen items organized into three dimensions: sources of money, wear and tear on the body and wear and tear on the mind.

Five experts in the fields of waste management and the informal economy certified the content validity of the instruments: the solid waste management and income production questionnaires received Aiken V coefficients of 0.960 and 0.970, respectively. In addition, Cronbach's alpha coefficient was used to evaluate the reliability of the instruments (Martinez & Juárez, 2020), reaching results with values of 0.888 and 0.810, respectively, indicating strong internal consistency in both situations.

Ordinal logistic regression (OLR) procedures were applied to data analysis and hypothesis testing. By using this approach, it was possible to take into account any confounding variables and to evaluate the connection between the independent and dependent variables, establishing a significance threshold of 0.05 for each statistical test performed.

Results

The responses of the 300 participants indicated different trends among the variables analyzed. For solid waste management (independent variable: IV), the "optimal" level had the lowest frequency, with a predominance of "acceptable" levels (more than half of the responses) moving towards "deficient" levels. For the dependent variable (DV), generation of economic income, medium level responses predominated, representing almost half of the participants, with a clear trend towards higher levels of income, as shown in the following figure.

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Figure 1: Frequencies of responses of the variables analyzed

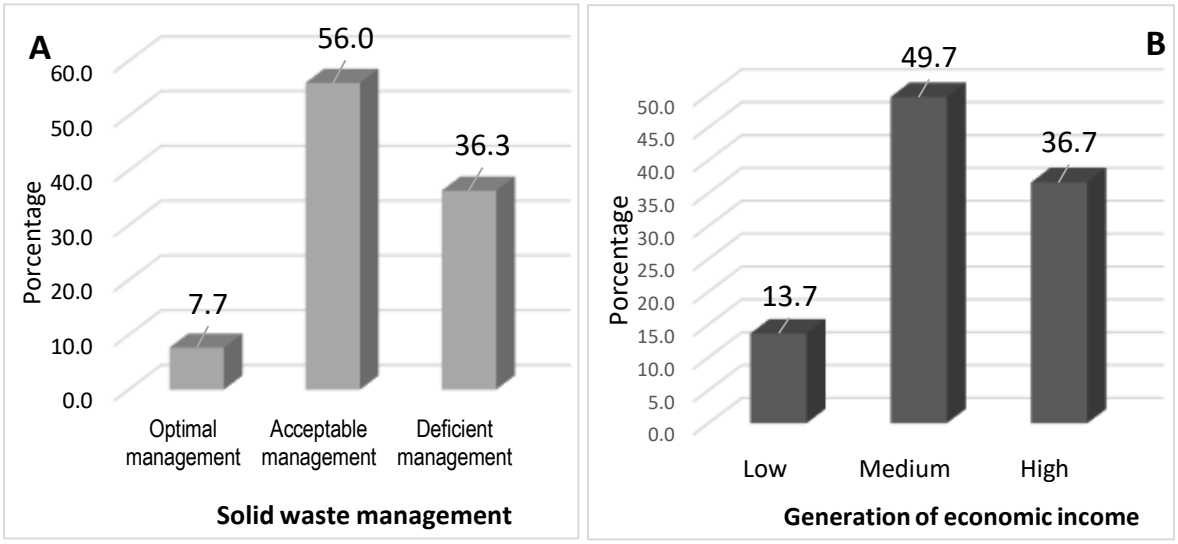

Figure 1 Section A presents the frequencies of responses on solid waste management. It is noteworthy that the "Acceptable" level of solid waste management is the most prevalent (56%), followed by the "Poor" level (36.3%), indicating a notable discrepancy in the perception of waste management in the study area. The "Optimal" level is the least prevalent (7.66%), underscoring the urgent need to improve management practices through more rigorous policies, investments in infrastructure, and greater citizen participation. Section B of the graph reveals that the "Medium" level of economic income generation is the predominant category (49.7%), while the "Low" level also stands out (13.66%). These findings indicate that a portion of the population is not taking full advantage of the economic opportunities associated with solid waste management. The "High" level represents 36.66% of the responses, indicating the existence of economic opportunities that could be enhanced. The prevalence of "Medium" and "Low" levels of economic income generation underscores the need to implement effective strategies to increase income. Such strategies may include formalizing the informal recycling sector, providing economic incentives, and establishing training and skills development programs for waste pickers.

For informal recyclers, these results underscore the urgent need for strategies to increase their incomes and improve their working conditions. Formalization of the informal recycling sector, coupled with the provision of economic incentives and training programs, can significantly transform their lives. These measures will not only benefit informal recyclers, but will also contribute to more efficient and sustainable solid waste management, with positive impacts on public health and the environment. In conclusion, these results are a call to action to implement comprehensive and sustainable policies that recognize and strengthen the crucial role of informal recyclers in the solid waste management system.

When crossing the responses of the dimensions with the independent variable (IV) and the dependent variable (DV), it was observed:

Management Problems (D1)

In this dimension, it is observed that optimal management is more prevalent in the low- and middle-income levels, with 8.7% and 8.3% respectively, while no optimal management is recorded in high income. Acceptable management is more prevalent in the middle-income level with 29%, followed by high income with 10.7%. However, it is worrying to note that poor management is significantly high in the high (26%) and middle (12.3%) income brackets, suggesting a lack of effectiveness in the implementation of management policies in these economic groups.

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Health Problems (D2)

Optimal management in this dimension shows 10% in middle income, 7.3% in high income and barely 2% in low income. Acceptable management is predominant at the middle level with 14%, followed by high income with 10.3%. Poor management is alarmingly high in the middle (25.7%) and high (19%) incomes, indicating a substantial negative impact on public health due to inadequate waste management in these groups.

Environmental Problems (D3)

Here, optimal management reaches 10.3% in middle income, 6.7% in high income and 6.3% in low income. Acceptable management is notably high in middle-income (23.7%) and high-income (14.7%), while poor management affects 15.7% of middle-income and 15.3% of high-income. This pattern indicates a direct relationship between lack of efficient management and environmental degradation, particularly in higher income groups.

Socioeconomic Problems (D4)

Regarding this dimension, optimal management is highest in middle income (7%), followed by low (4.3%) and high income (3.7%). Acceptable management is predominant at the middle level with 23%, followed by high income with 13%. Poor management shows alarming figures in the high (20%) and middle (19.7%) income brackets, reflecting inequities and structural challenges in the implementation of waste management policies (detailed **table 1**).

Table 2: Frequencies obtained from crossing the levels of the economic income generation variable (DV) and the dimensions of the solid waste management variable (IV)

Dimensions of the variable Solid waste management		Generation of economic income					
		Low		Medium		High	
		n	%	n	%	n	%
D1: Management problems	Optimal management	26	8.7	25	8.3	0	0.0
	Acceptable management	12	4.0	87	29.0	32	10.7
	Deficient management	3	1.0	37	12.3	78	26.0
D2: Health problems	Optimal management	6	2.0	30	10.0	22	7.3
	Acceptable management	16	5.3	42	14.0	31	10.3
	Deficient management	19	6.3	77	25.7	57	19.0
D3: Environmental problems	Optimal management	19	6.3	31	10.3	20	6.7
	Acceptable management	16	5.3	71	23.7	44	14.7
	Deficient management	6	2.0	47	15.7	46	15.3
D4: Socioeconomic problems	Optimal management	13	4.3	21	7.0	11	3.7
	Acceptable management	19	6.3	69	23.0	39	13.0
	Deficient management	9	3.0	59	19.7	60	20.0

As indicated, the Ordinal Logistic Regression Analysis (OLR) between the variables:

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First, it is observed that the DV=Low parameter has an estimated coefficient (β) of -2.726 with a statistical significance of 0.000, indicating a strong negative influence on low income generation when waste management is poor. This suggests that inadequate management significantly reduces income generation opportunities, disproportionately affecting the most vulnerable sectors.

On the other hand, the DV=Medium parameter shows an estimated coefficient of -0.088, with a significance of 0.642, indicating that waste management has a less pronounced and statistically non-significant impact on average income generation. This finding implies that other factors may be playing a more determinant role in this income range, underscoring the need for comprehensive policies that consider multiple dimensions of economic and environmental management.

In terms of the independent variable (IV), it is noted that optimal management (IV=Optimal) presents an estimated coefficient of -2.548, with a significance of 0.000, reinforcing the importance of efficient waste management to improve economic conditions. The wide difference in the confidence interval (from -3.466 to -1.631) and the high Exp ratio (β) of 7.82 corroborate that optimal management is associated with a significant reduction in the odds of low income, benefiting informal recyclers by providing them with a more stable and productive environment.

Acceptable management (IV=Acceptable) also shows a significant impact with a coefficient of -0.928 and a significance of 0.000, suggesting that although not as effective as optimal management, it is still preferable to poor management. The Exp (β) of 39.53 indicates that even a moderate improvement in management can have significantly positive effects on the economics of informal recyclers.

Finally, the parameter for poor management (IV=Deficient) is used as a benchmark (0a), highlighting its predominant negative role in the model. The absence of a coefficient estimate for this category reinforces the urgent need to improve waste management practices to avoid perpetuating cycles of poverty and environmental degradation (Detail **Table 2**).

Table 3: Estimations of the OLR to measure the influence of Solid waste management on Economic income generation

Parameters	Estimate (β)	Dev. Error	Wald	gl	sig.	95% confidence interval		Exp (β) (%)
						Lower limit	Upper limit	
a) DV = Low [1]	-2.726	0.258	112.051	1	0.000	-3.231	-2.222	6.55
b) DV = Medium [2]	-0.088	0.188	0.216	1	0.642	-0.457	0.282	---
c) IV = Optimal [1]	-2.548	0.468	29.631	1	0.000	-3.466	-1.631	7.82
d) IV = Acceptable [2]	-0.928	0.243	14.539	1	0.000	-1.405	-0.451	39.53
e) IV = Deficient [3]	0[a]			0				

Note 1. Link function: Logit.

Note 2. a. This parameter is set to zero because it is redundant.

The results show that, in general, solid waste management has a significant impact on income generation. The DV=Low parameter presents an estimated coefficient (β) of -5.148 with a significance of 0.000,

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indicating a strong negative relationship with low income. This implies that poor waste management is closely associated with lower income, severely affecting the most vulnerable sectors of the population.

In the management problems dimension (D1), it is observed that optimal management has a coefficient of -4.152 and a significance of 0.000, indicating a strong positive influence on income generation. The Exp (β) of 1.57 suggests that optimal management significantly reduces the probability of low income. Acceptable management, with a coefficient of -1.966, also shows a notable positive impact, although less pronounced than optimal management. This underscores the importance of implementing efficient management policies to improve the economic conditions of informal recyclers.

The health problems dimension (D2) presents fewer convincing results. Optimal management shows a positive coefficient of 0.447, although it is not statistically significant (sig. 0.211), indicating that, in terms of health problems, waste management does not have such a clear impact on economic income. Acceptable management, with a coefficient of 0.177, also lacks statistical significance (sig. 0.559), suggesting that other factors may be influencing this dimension more strongly.

In the environmental problems dimension (D3), the data are more revealing. Optimal management has a coefficient of -1.357 and a significance of 0.000, indicating a significant positive impact on income generation. The Exp (β) of 25.74 highlights the importance of adequate environmental management in improving economic conditions. Acceptable management, with a coefficient of -0.796 and significance of 0.009, also shows positive effects, although less pronounced.

Finally, in the socioeconomic problems dimension (D4), optimal management presents a coefficient of -0.872 and a significance of 0.023, suggesting a significant positive impact on the economy. The Exp (β) of 41.80 reinforces the importance of addressing socioeconomic problems through efficient management. Acceptable management, however, does not show a clear statistical significance (sig. 0.139), indicating that economic benefits depend more strongly on optimal management (Detailed **Table 3**).

Table 4: ***OLR estimations to measure the influence of the dimensions of Solid waste management on Economic income generation***

Parameters	Estimate (β)	Dev. Error	Wald	gl	Sig.	95% confidence interval		Exp (β) (%)
						Lower limit	Upper limit	
DV = Low [1]	-5.148	0.465	122.316	1	0.000	-6.060	-4.236	0.58
DV = Medium [2]	-1.480	0.311	22.639	1	0.000	-2.090	-0.870	22.76
D1_IV = Optimal [1]	-4.152	0.445	87.075	1	0.000	-5.024	-3.280	1.57
D1_IV = Acceptable [2]	-1.966	0.292	45.300	1	0.000	-2.538	-1.393	14.01
D1_IV = Deficient [3]	0[a]			0				
D2_IV =Optimal [1]	0.447	0.358	1.564	1	0.211	-0.254	1.149	---
D2_IV = Acceptable [2]	0.177	0.303	0.341	1	0.559	-0.417	0.772	---
D2_IV =Deficient [3]	0[a]			0				
D3_IV =Optimal [1]	-1.357	0.379	12.836	1	0.000	-2.099	-0.615	25.74
D3_IV = Acceptable [2]	-0.796	0.305	6.803	1	0.009	-1.394	-0.198	45.11

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D3_IV =Deficient [3]	0[a]			0				
D4_IV =Optimal [1]	-0.872	0.383	5.179	1	0.023	-1.623	-0.121	41.80
D4_IV = Acceptable [2]	-0.414	0.280	2.184	1	0.139	-0.962	0.135	---
D4_IV =Deficient [3]	0[a]			0				

Note 1. Link function: Logit.

Note 2. a. This parameter is set to zero because it is redundant.

Discussion

The findings of this study provide valuable insights into the intricate dynamics between solid waste management and economic income generation for informal recyclers in northern Peru. The analysis reveals significant implications for municipal policies, which must address management challenges, environmental concerns, and socioeconomic issues to improve both environmental sustainability and economic outcomes for waste pickers. (Foy Valencia & Instituto de Estudios Ambientales, 1998).

The results underscore the importance of raising solid waste management practices to at least an acceptable level, as this has been shown to have a significant impact on the economic returns of informal recyclers. The data indicate that middle income levels are predominantly associated with acceptable management practices, suggesting that improvements in management efficiency could lead to better economic returns for waste pickers (Oh & Hettiarachchi, 2020). Conversely, the presence of high-income levels despite poor management practices points to the existence of other compensatory mechanisms or external influences that may require further investigation.

Environmental challenges are also closely related to income generation (Hemidat et al., 2022). Findings reveal that best management practices are correlated with average income levels, emphasizing the need to address environmental impacts to improve economic performance. This connection underscores the need for policies that not only focus on waste management, but also actively work to reduce environmental degradation (Moreira Gomes & Aragão Neto, 2018).

Socioeconomic factors play a crucial role in determining the economic viability of waste management activities (Max-Neef, 2006). Data show that acceptable levels of management are associated with average income levels, indicating that socioeconomic improvements can directly enhance economic benefits (Buch et al., 2021). This finding argues for integrated approaches that consider the economic and social dimensions of waste management (Wilson et al., 2022).

Interestingly, health problems (Carducci et al., 2021) did not show a direct correlation with income generation in ordinal logistic regression (OLR) analysis. However, the significant impact of poor management on average income levels suggests that health risks remain an important factor to consider (Filho et al., 2020). Addressing health problems through better management practices could potentially improve economic benefits for informal recyclers (Gaur et al., 2022; van der Velden et al., 2021).

Given this knowledge, the study highlights the urgent need for comprehensive municipal policies that integrate solid waste management with economic development objectives (Pongrácz, 2002). Local authorities should recognize and formalize the contributions of informal recyclers by providing them with the resources, training and infrastructure necessary to improve their efficiency and economic performance.

In order to address these issues effectively, the following policy recommendations are proposed: i) In Formalization and Training: create a national registry of informal recyclers to formalize their activities and

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implement training programs focused on recycling techniques, waste management and occupational health and safety; ii) In Regulation and Standards: Establish clear regulations for waste segregation, collection and recycling, ensuring uniform application of legislation at all municipal levels and imposing sanctions for non-compliance; iii) In Economic Incentives and Financing: Provide economic incentives for the purchase of equipment and technology to facilitate waste collection and processing. In addition, facilitate access to micro-credits and subsidies to recyclers and recycling cooperatives; iv) In Improving recycling infrastructure: Invest in infrastructure for selective collection and recycling centers equipped with the necessary technology. Establish accessible recycling points in communities to encourage citizen participation; v) In Public Health and Safety: Implement specific occupational health policies for waste pickers, including vaccination, periodic medical exams and provision of personal protective equipment. Promote awareness campaigns on the health risks associated with poor waste management; vi) In Intersectoral Cooperation: Encourage cooperation between ministries, local governments, non-governmental organizations (NGOs) and the private sector to address waste management challenges in a collaborative manner. Establish platforms for dialogue and coordination to integrate diverse initiatives and resources.

In addition, future research should expand the scope of this study to cover other regions and investigate additional variables that impact the relationship between solid waste management and economic income generation. Longitudinal studies could provide deeper insights into the long-term effects of improved waste management practices on the livelihoods of informal recyclers.

In conclusion, this research provides essential information on the critical role of solid waste management in improving the economic sustainability of informal recyclers. The findings underscore the need for comprehensive and integrated policies that promote both environmental and economic benefits, contributing to the broader goals of sustainable development and social equity. The public policy proposal for the sustainable management of solid waste and the empowerment of informal recyclers in Peru aims to develop and implement a comprehensive framework that promotes efficient and sustainable waste management, optimizes the economic income of informal recyclers, improves public health conditions and protects the environment.

The implementation of this public policy consists of three phases: In Phase 1: Diagnosis and planning (year 1): Conduct a national diagnosis to identify the specific needs and existing capacities of informal recyclers. Develop a strategic plan based on the results of the diagnosis, including clear and measurable goals. Phase 2: Implementation and follow-up (years 2 to 4): Implement formalization, training and infrastructure improvement programs. Continuously monitor progress and make necessary adjustments. Phase 3: Evaluation and Adjustments (year 5): Evaluate the impact of the policy on waste pickers' income, waste management and public health. Make adjustments based on the evaluation to improve the effectiveness of the policy. And funding for this policy will come from government sources, international loans (such as the World Bank and IDB) and possible collaborations with the private sector. This public policy seeks to transform the waste management landscape in Peru, improving the quality of life for informal recyclers and promoting a cleaner, more sustainable environment for all communities.

By addressing management challenges, environmental concerns and socioeconomic issues through integrated and comprehensive policies, local authorities can significantly improve economic and environmental outcomes for informal recyclers. This approach will contribute to the broader goals of sustainable development and social equity and ultimately create a more inclusive and sustainable society.

In the framework of urban management, the implementation of Pigouvian fiscal measures appears as an essential tactic to address deficiencies in waste management by assigning a financial burden to waste producers that incentivizes sustainable behaviors and, with the revenues obtained from these measures, advance waste management programs that could be financed contributions that significantly contribute to the reduction of environmental pollution and effectively address the socio-environmental challenges derived from waste accumulation (Martins & Cró, 2021).

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Conclusions

This study has illuminated the critical role of solid waste management in shaping the economic well-being of informal recyclers in a provincial municipality in northern Peru, as the findings indicate that improvements in solid waste management practices can significantly influence the income-generating capacities of these recyclers, thus underscoring the importance of integrating these practices into municipal policies.

The application of Ordinal Logistic Regression (OLR) revealed that the "acceptable" level of solid waste management exerts a substantial influence on average and low levels of income generation among informal recyclers, because the findings indicated that effective management, defined as the proper handling of environmental, health and socioeconomic concerns, is a crucial factor in improving the economic performance of these workers.

This analysis identified four key dimensions (management challenges, health issues, environmental concerns, and socioeconomic issues) that need to be addressed to optimize the income potential of informal recyclers, with the implementation of specific municipal policies that address these dimensions can facilitate the development of more sustainable and economically viable waste management systems.

The study highlights the imperative for local authorities to recognize and formalize the contributions of informal recyclers, for the formulation of supportive legal frameworks, the provision of financial and logistical assistance, and the incorporation of these workers into the formal waste management infrastructure. These measures are crucial for the advancement of a circular economy and the promotion of sustainable development.

Further research should focus on expanding the scope of this study to cover other regions and investigate additional variables that may affect the relationship between solid waste management and economic income generation. In addition, longitudinal studies could provide deeper insights into the long-term consequences of improved waste management techniques on the livelihoods of informal recyclers.

In conclusion, this research provides a fundamental understanding of the important role solid waste management plays in the economic sustainability of informal recyclers. The findings provide valuable information for policy makers and stakeholders seeking to develop effective waste management strategies that protect the environment while improving the socioeconomic conditions of marginalized communities.

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