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Perspectives on sociodemographic factors and solid waste management in the district of Chachapoyas

Jose-Walter Coronel-Chugden[1*], Yersi-Luis Huaman-Romani[2], Guido Ayay-Arista[3], Marcos-Marcelo Flores-Castillo[4], Rocio Cahuana-Lipa[5], Julio-Cesar Machaca-Mamani[6]

[1]*National University Toribio Rodriguez de Mendoza of Amazonas, Peru.*
[2]*National Amazonian University Madre de Dios, Puerto Maldonado, Peru.*
[3]*Fabiola Salazar Leguia National Intercultural University of Bagua, Bagua, Peru.*
[4]*National Frontier University, Sullana, Peru.*
[5]*Technological University of the Andes, Andahuaylas, Peru.*
[6]*National University Jose Maria Arguedas, Andahuaylas, Peru.*

Corresponding author: Jose-Walter Coronel-Chugden (*Email: jose.coronel.epg@untrm.edu.pe*)

Abstract

The accelerated production of solid waste in the urban-rural context requires studies to optimize the environmental pollution gap. The objective of the study is to know the perspectives of sociodemographic factors and solid waste management in the district of Chachapoyas. The research is of a causal descriptive type at an explanatory level. The sample is composed of 382 families obtained through probabilistic sampling. The survey technique was used, and the questionnaire was a valid and reliable instrument (Cronbach's alpha = 0.777). The results indicate that the sociodemographic profile has a significant effect ($p<0.05$) on solid waste management, including economic status, age, occupation, education level, monthly income, area of residence, and number of persons per household. In addition, it was found that solid waste management in the city has a regular level of performance. However, there are gaps that need to be addressed in the following order of priority: storage, final disposal, generation, treatment, and recycling. In conclusion, solid waste management in the city of Chachapoyas is average, indicating the need to address these gaps in the formulation of new public policies.

Keywords: Chachapoyas, Domestic waste, Environment, Environmental conservation, Environmental pollution, Public management, Urban waste.

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1. Introduction

The increase in population, urbanization, and economic development generates a drastic increase in waste, causing serious pollution problems [1]. Furthermore, multiculturalism, eating habits, and lifestyles contribute to the persistence of unresolved issues in Municipal Solid Waste Management (MSWM). This situation not only poses economic and environmental problems but also social challenges; however, only a few studies have examined the socio-demographic factors associated with solid waste management [2]. This scenario is becoming increasingly critical, both in developed and underdeveloped countries. Meanwhile, scientists aim to understand the key factors in management strategies to support sustainable development, address climate change, and promote citizenship [3].

In addition to this dilemma, the rising production costs and problems associated with landfills for industrial waste and consumer goods pose challenges to the logistical approach to municipal solid waste management difficult (MSW) [4]. Consequently, the cost of collection constitutes a significant portion of the allocated funds for waste management [5]. Furthermore, management deficiencies persist in cities and municipalities [6], [7], particularly in third-world countries due to logistical constraints [8]. In addition to this, a certain model is often applied in the management of MSW, wherein traditional methods of disposal, such as landfill and incineration, are practiced [9]. However, this model lacks the inclusion of the moral obligation of the individual to care for the environment in its plans [10]. Therefore, managers must make planning decisions in the short, medium and long term, the interconnected supply chain involving multiple levels of waste generation, treatment, and disposal [11] to avoid adverse effects on human health and the economy [12].

It is known that the world generates about 2,010 million tons of urban waste per year, approximately 0.74 kg per person per day. By 2050, an average of 3,4000 million tons is expected. In addition, it is estimated that 33% is not managed safely [13]. In the case of Peru, seven million tons are generated per year, with a collection coverage of 93.74% in urban areas. Only 14% of the waste is reinserted in the recycling stages [14], a situation that is detrimental to the municipal service delivery system [15]. Therefore, ineffective practices such as burning [16] or burying [17] are chosen. Although it is known that lately, the treatment rate in the country has increased, it still has low performance due to inefficient guidance, inspection, and supervision [18]. This situation is reflected in the Amazonas region of Peru, according to Espejo [19]. The current landfill of Rondón in the city of Chachapoyas has a deficit of more than 50% of the optimal location criteria for the landfill. This scenario has an impact on environmental health [20], so there is an urgent need for efficient, sustainable, and socially supported integrated systems [21], considering economic and technical aspects [22].

In this context, different solutions and alternatives have been proposed. Hosseinalizadeh, et al. [23] propose a solid waste management model that can improve recycling and composting by incorporating promising technologies. They argue that using anaerobic digestion as an alternative to composting results in an expensive environmental cost. Tsai, et al. [24] found that technical integration and social acceptability are common in all cities and that MSW control and economic sufficiency are among the most common causes in city systems. Meyer, et al. [25] developed a waste management model and discovered that it is a complex issue involving multiple components that pose challenges to conventional management methods and lead to sustainability problems [26].

As evident, there is limited number of studies that have evaluated the sociodemographic factors in solid waste management. In response to this situation, the UN has proposed goals that aim to address the environmental, social, and economic aspects worldwide [27]. These goals directly relate to solid waste management [28], particularly goal number 11, which focuses on "sustainable cities and communities". The goal aims to tackle the gaps in inadequate and overloaded services such as waste collection, with the objective of achieving inclusive, safe, resilient, and sustainable cities [29].

Effective planning of solid waste management policy and treatment capacities requires precision and knowledge of the behavioral, socioeconomic, and demographic factors that influence household waste recycling behavior [30]. The research is relevant because it conducts statistical data analysis on variables that will enable local government administrators to take planning actions based on identified gaps [31]. The evaluation of socio-demographic factors and solid waste management will provide results that enable local authorities to improve the design of recycling systems with the sole purpose of developing strategies for solid waste reduction, reducing disease transmission, and controlling climatic factors [32]. The results will serve as motivation for formulating new policies and implementing different strategies to achieve the intended goals and improve the environment, as well as the quality of life [33].

Statistical data from these types of studies will enable decision-makers to address the problem by involving public and private companies and applying modern engineering to accelerate the transition towards the development of integrated systems for solid waste in the city [34]. Additionally, Amoah, et al. [35] emphasize the importance of evaluating the sociodemographic factors that impact solid waste management in order to develop sustainable policies. This, in turn, will help reduce costs including household bills [36], and optimize the logistic network within the solid waste treatment system [37]. Such optimization requires the coordination of mechanical and human efforts, taking into account various demographic factors that are directly linked to solid waste management [38].

In order for public organizations in different regions to undertake effective actions that can implement a circular economy, it is important to evaluate the various factors that influence solid waste generation at the regional, micro-regional and municipal levels [39]. The scientific information provided by these types of studies contributes specially to undertake actions from the perspective of citizen awareness [40]. It also assists planners in formulating strategies to improve the environmental context [41]. Furthermore, it establishes the foundation for increasing participation, and education, enhancing people's knowledge, providing adequate facilities and equipment, and implementing recycling programs in coordination with the governmental and private sectors [42].

1.1. Justification and Objectives of the Research

The city of Chachapoyas, located in the northern highlands of Peru, serves as both a district and a province within the Amazonas department. It is classified as an intermediate city, housing a population of 63,118 families and experiencing an intercensal growth rate of 3.3%. Situated at an altitude of 2,483 meters above sea level, it covers a total area of 12.3 km² with an average altitude matching its elevation. While the garbage truck passes through the city every day, the management and treatment of solid waste generated due to population growth remain unknown. Currently, the waste is taken to a location called Rondón, approximately 5 km from the city of Chachapoyas, for dumping and/or incineration. Unfortunately, this practice leads to environmental contamination of the air, soil, and water, especially considering its proximity to two water sources. The untreated scenario is particularly alarming, with a pollution rate of 45.1% [43].

For this reason, the objective of this study is to determine the perspectives of sociodemographic factors and solid waste management in the district of Chachapoyas. The aim is to identify the factors that have the most impact on solid waste management. By doing so, the study intends to provide accurate data to the municipality's administrative sector, enabling them to take short-, medium- and long-term actions. The specific objective of the research is to analyze and describe the perspectives related to waste generation, storage, collection and transportation, treatment and recycling, and final disposal of municipal solid waste management in the city of Chachapoyas.

2. Methodology

2.1. Population, Sample and Sampling

The population under study consisted of 63,188 families residing in the sixteen (16) neighborhoods of the city of Chachapoyas as of 2021. From this population, a representative and definitive sample was estimated, consisting of 382 families. The sample had a participation rate of 31% male and 79% female. This high female participation can be attributed to surveys being conducted during working hours, indicating that women were more likely at home and were available to respond to the surveys.

The participants were distributed across various aged groups as follows: 20-31 years (24%), 32-41 years (47%), 42-51 years (23%), 52-61 years (6%), and 62-65 years (0.1%). The survey included individuals with diverse occupations, such as housewives (32%), administrators (16%), teachers (13%), independent workers (7%), nurses, secretaries and tradesmen (3%), computer technicians, security, masons, accountants, salesmen, drivers (2%), and others (14%).

2.2. Methods, Techniques and Instruments

Methods: The study employed a quantitative approach, utilizing hypothetico-deductive methods to test predetermined hypotheses [44]. Additionally, an explanatory causal descriptive design was applied [45] to provide an explanation of the causal relationships between variables.

Techniques: The fieldwork technique was used, which allowed observation and data collection from individuals, cultures and natural environments [46]. In our study, this technique was used during home visits to families in the city, where the questionnaire was administered.

Instrument: A questionnaire was administered through home visits to evaluate the sociodemographic factors. The questionnaire included the following items: sex, age, employment status, educational level, monthly income, area or sector and the number of persons per household.

For the variable of solid waste management, the questionnaire was structured with 33 items divided into five dimensions, presented in the following order: generation of solid waste G (12 items), storage of solid waste AML (6 items), collection and transportation of solid waste RT (6 items), treatment and recycling of solid waste TR (4 items), and final disposal of solid waste DF (5 items).

The questions consisted of dimensions that focus on different aspects solid of waste generation. The first-dimension deals with the generation of solid waste and has the following items: G1: Attempts to reduce the production of solid waste (used paper, glass plastic bottles, cardboard containers, others). G2: Avoid littering in any public place. G3: Mostly generates organic solid waste (fruit or vegetable peels, food scraps, eggshells, bread, coffee filters, tea bags, animal waste, bones, seeds, flowers, etc.). G4: Mostly generates inorganic solid waste (metal, glass, cardboard, plastic, leather, fibers, ceramics, wood, clothing and textiles). G5: Daily generates solid waste of less than 2 kg (approximately). G6: Daily generates solid waste from 2 to 4 kg (approximately). G7: Daily generates solid waste between 5 to 8 kg (approximately). G8: Daily generates solid waste greater than 8 kg or more (approximately). G9: The municipality or other local institution has trained and involved you in the segregation or management (sorting, reuse, composting and others) of solid waste. G10: You have filed complaints with the municipality because of the storage of waste in unauthorized places. G11: Your waste is placed in plastic bags to be sent to the collection cart. G12: The containers in which the waste is placed are collected after being sent to the collection cart.

The second dimension refers to solid waste storage (ALM) and consists of the following elements: ALM1: Your neighborhood or block has containers for waste storage. ALM2: Neighbors leave their waste in bags or other containers at the storage points designated by the municipality. ALM3: The municipality has provided (delivered) containers for sorting waste. ALM4: If they had containers, they would be willing to sort their waste. ALM5: Residents comply with the schedules and timetable for waste storage. ALM6: The municipality sanctions those who do not comply with the waste storage schedule and calendar.

The third-dimension deals with the collection and transportation (RT) of solid waste, and has the following items, RT1: The waste collection calendar and schedule are adequate. RT2: The waste collection schedule should be increased. RT3: The payment you make for waste collection services allows this activity to be carried out efficiently (without difficulty). RT4:

You would be willing to pay an additional amount compared to the current one if the municipality proposes to improve the waste collection system. RT5: The waste in your neighborhood or block is removed in a timely manner by the municipal garbage truck. RT6: The garbage collection staff is fit and competent to collect solid waste.

The fourth dimension, which deals with the transport and recycling (TR) of solid waste, has the following items: TR1: The municipality reports on the treatment given to solid waste. TR2: The municipality informs about the purpose of solid waste recycling. TR3: Would like to participate in waste recycling if other policies are implemented in the municipality. TR4: Reuses some materials after use.

The fifth dimension, which deals with the final disposal (FD) of solid waste, has the following items, DF1: The incineration (burning) of waste in the open air in Rondón (an open area used to burn waste) can generate health problems for the population. DF2: The municipality implements and disseminates projects to recover the flora and fauna of the Rondón sector. DF3: The municipality has taken actions to reduce contamination of the Sonche River. DF4: The municipality has taken actions to prevent air pollution from incineration in the Rondón sector. DF5: The municipality is implementing a waste treatment project through sanitary landfills.

The time required to complete the instrument is approximately 20 minutes. The instrument utilizes Likert-type response scales from “definitely no” (1) to “definitely yes” (5), with scores ranging from 1 to 5. A score of 1 represents the lowest rating for solid waste management, while a score of 5 represents the highest/optimal rating. The scores obtained are categorized into three levels for each dimension. For the first dimension, solid waste generation (G), scores ranging from 12 to 27 indicate a bad level, scores from 28 to 43 indicate a regular level, and scores from 44 to 60 indicate a good level. For the second dimension, solid waste storage (ALM), and the third dimension, solid waste collection and transportation (RT), scores from 6 to 13 indicate a bad level, scores from14 to 21 indicate a fair level, and scores indicate 22 to 30 indicate a good level. In the fourth dimension, treatment and recycling of solid waste (TR), scores from 4 to 9 indicate a poor level, scores from 10 to 14 indicate a regular level, and scores from 15 to 20 indicate a good level. Lastly, in the fifth dimension, final disposal of solid waste (DF), scores from 5 to 11 indicate a poor level, scores from 12 to 18 indicate a regular level, and scores from 19 to 25 indicate a good level.

The statistical validity of the instrument is assessed using Cronbach's Alpha, which yielded a value of 0.777, indicating validity and acceptance within the scientific community. The validity by total items, with a value of 0.804, further demonstrates a high level of validity, ensuring the reliability of the research.

2.3. Data Analysis

First, data collection was carried out using probabilistic sampling based on the ease of conducting surveys. A letter requesting information was sent to the mayor of the municipality, who provided contact details of the presidents of each neighborhood or area of the city. Coordination was then carried out with the neighborhood presidents to schedule survey dates for each family according to the sample size and research objectives. A total of 400 surveys, containing the research questionnaire, were printed and distributed. Over a period of four months (July-October 2022), visits were made to each neighborhood to conduct the surveys with the assistance of four researchers responsible for data collection. After completing the surveys, a thorough review and debugging process was conducted. No incomplete surveys were found, and the data were organized and entered into Excel 2019 spreadsheets. Once all the data were downloaded, they were processed using statistical software such as Minitab v.19, and Python v.3.10.

Two types of statistical analysis were applied: descriptive statistics and inferential statistics. Descriptive statistics involved analyzing the data using tables and figures such as bars, histograms, radial graphs, and correlation graphs. These descriptive analyses provided information on the behavior and comparison of variables and dimensions studied, including measures such as mean, median, maximum and minimum values, standard deviation, variance, and coefficient of variation. Inferential statistics specifically correlation analysis, were used to determine whether there were significant correlations between the dimensions studied. This analysis aimed to test the statistical significance of the relationships observed.

3. Results

With the processed data obtained from the administered questionnaires, a statistical analysis was conducted, revealing the following findings.

Table 1 presents the sociodemographic characteristics of the sample. The data indicates that 79% of the sample consisted of females. The age distribution shows a higher proportion in the range of 32-51 years, and the most prevalent occupation was that of a housewife (32%), followed by administrators and teachers (29%). At the time of the study, 55% of the participants were employed, 27% were unemployed, and 18% were underemployed. In terms of education, 30% had non-university higher education, 29% had university higher education, and only 23% had completed high school. Regarding monthly income, 50% had a low income between S/ 500.00 and S/ 1000.00, while only 7% had an income of S/ 3000.00 or higher. Among the population under study, 35% of families live in peripheral areas of the city (AA. HH), while 65% live in the urban interior. The family structure was predominantly nuclear, with 60% of families consisting of 4 to 6 members, followed by 30% with 1 to 3 members. Furthermore, Table 1 shows that the Kruskall Walis test statistic, applied to the 9 evaluated characteristics, revealed a significant effect ($p<0.05$) on solid waste management for 7 of them. These significant factors include economic condition, age, occupation, education level, monthly income, area of residence, and number of persons per household. The analysis revealed that better solid waste management practices were observed in families with higher socioeconomic status, higher education levels, and residing in urban areas.

Table 1.
Distribution of socio-demographic characteristics in solid waste management according to families in the city of Chachapoyas.

Sociodemographic characteristics	Categories	Frequency distribution		Kruskal Wallis test		
		Fi	Percentage	Degrees of freedom	Statistic H	P-value
Gender	Female	302	79%	1	0.17	0.681
	Male	80	31%			
Age (Years)	20-31	92	24%	5	10.63	0.005*
	32-41	181	47%			
	42-51	86	23%			
	52-61	22	6%			
	62-65	1	0.10%			
Occupation	Housewife	121	32%	20	25.96	0.001*
	Administrator	60	16%			
	Teacher	49	13%			
	Self-employed	25	7%			
	Nurse	13	3%			
	Secretary	12	3%			
	Merchant	11	3%			
	Computer technician	7	2%			
	Security	7	2%			
	Mason	7	2%			
	Accountant	7	2%			
	Salesman	6	2%			
	Driver	6	2%			
	**Other	51	14%			
Employment status	Unemployed	103	27%	2	3.59	0.166
	Employed	212	55%			
	Underemployed	67	18%			
Level of education	Primary school complete	20	5%	6	17.06	0.002*
	Primary incomplete	7	2%			
	Secondary complete	88	23%			
	Secondary incomplete	30	8%			
	Higher non-university	116	30%			
	Higher university	111	29%			
	***Other	10	3%			
Monthly income	S/. 1000.00 a S/. 1500.00	74	19%	4	11.45	0.003*
	S/. 1500.00 a S/. 2000.00	67	18%			
	S/. 2000.00 a S/. 3000.00	24	6%			
	S/. 3000.00 a S/. 500.00	26	7%			
	S/. 500.00 a S/. 1000.00	191	50%			
Area of residence	AA. HH 16 de octubre	27	7.10%	15	30.72	0.001*
	AA. HH Pedro Castro Alva	27	7.10%			
	AA. HH Señor de los Milagros	27	7.10%			
	AA.HH. San Carlos de Murcia	25	6.50%			
	AA.HH. Santa Rosa de Lima	27	7.10%			
	El Prado	18	4.70%			
	Higos Urco	26	6.80%			
	La Laguna	28	7.30%			
	Los Rosales	18	4.70%			
	Luya Urco	25	6.50%			
	Pollapampa	18	4.70%			
	Santa Isabel	18	4.70%			
	Santo Domingo	25	6.50%			
	Santo Toribio de Mogrovejo	26	6.80%			
	Virgen de Asunta	19	5.00%			
	Yance	28	7.30%			
Number of family members	1-3 members/family	114	30%	4	16.91	0.004*
	4-6 members/family	231	60%			
	7-9 members/family	29	8%			
	10-12 members/family	6	2%			
	13-15 members/family	1	0%			
	16-18 members/family	1	0%			
Total		382	100%	-	-	-

Note: Fi: simple frequencies. Survey applied to families in the city of Chachapoyas.
*Indicate the significant effect according to the dimensions of the variable in solid waste management.
**Others. Include/Civil engineers, farmers, policemen, cosmetologists, social communicators, laboratory technicians, lawyers.
*** The respondent does not have any degree.

Table 2 illustrates the distribution of solid waste management levels within the study population. The results indicate that 8% of the sample achieved a good level of solid waste management, while 88% maintained a regular level, and 4% had a bad level. Regarding the specific dimensions of solid waste management, the generation dimension exhibited a good level in 13% of cases, a regular level in 82%, and a bad level in 5%. The storage dimension displayed a good level in 8% of cases, a regular level in 56%, and a bad level in 36%. In terms of collection and transportation, the level was good in 50% of cases, fair in 45%, and poor in 5%. The treatment and recycling dimension showed a good level in 28% of cases, a fair level in 58%, and a poor level in 14%. Finally, for the final disposal dimension, a good level was observed in 16% of cases, a fair level in 58%, and a poor level in 25%. In summary, the majority of cases demonstrated a fair level of solid waste management.

Table 2.
Level of solid waste management and according to dimensions of the city of Chachapoyas.

Variables and dimensions	Levels	Population	Percentage
Solid waste management	Bad	14	4%
	Fair	335	88%
	Good	33	8%
Solid waste generation	Bad	20	5%
	Fair	312	82%
	Good	50	13%
Solid waste storage	Bad	138	36%
	Fair	215	56%
	Good	39	8%
Solid waste collection and transportation	Bad	19	5%
	Fair	170	45%
	Good	193	50%
Solid waste treatment and recycling	Bad	53	14%
	Fair	222	58%
	Good	107	28%
Solid waste final disposal	Bad	96	25%
	Fair	223	58%
	Good	63	16%
Total		382	100.00%

Table 3 shows the descriptive statistics of the scores for each dimension: For the generation dimension, the mean score was 3.08, with a standard deviation (Sd) of 0.50, variance (S2) of 0.25, and coefficient of variation (Cv) of 16.21%. In the storage dimension, the mean score was 2.56, with an Sd of 0.68, S2 of 0.46, and Cv of 26.45%. The collection and transportation dimension had a mean score of 3.54, an Sd of 0.71, S2 of 0.51, and Cv of 20.20%. The treatment and recycling dimension had a mean score of 3.15, an Sd of 0.80, S2 of 0.63, and Cv of 25.22%. Lastly, the final disposal dimension had a mean score of 2.88, an Sd of 0.82, S2 of 0.67, and Cv of 28.30%.

In summary, the generation, collection and transportation, and treatment and recycling dimensions obtained the highest mean score on the 1-5 points scale, while the final disposal and storage dimensions had lower averages of 2.88 and 2.56, respectively.

Table 3.
Descriptive statistics of the dimensions and the variable: Solid waste management.

Dimensions	Statistics						
	N	Mean	Sd	S^2	Cv%	Min.	Max.
Solid waste management	382	3.08	0.50	0.25	16.21	1.00	5
Storage	382	2.56	0.68	0.46	26.45	1.00	5
Collection and transport	382	3.54	0.71	0.51	20.20	1.00	5
Solid waste generation	382	3.15	0.80	0.63	25.22	1.00	5
Final disposal	382	2.88	0.82	0.67	28.30	1.00	5

Note: Sd: Standard deviation, S2: Variance, Cv: Coefficient of variation.

Figure 1 presents the histogram depicting the distribution of the variable "Solid waste management." The histogram provides insights into the behavior of the distribution of the variable. Based on a score of 1-5, with a sample of 382 families, the average score for solid waste management is 3.05, with a standard deviation of 0.43. The minimum average value recorded is 1.88 points, while the maximum is 4.82 points. Furthermore, the data evaluated does not exhibit normality concerning the average, as indicated by a p-value greater than 0.05. Additionally, the 95% confidence intervals for the mean, median, and standard deviation are as follows: mean (3.0020-3.0892), median (2.9697-3.0606), and standard deviation (0.4054-0.4635). Within these ranges, all the mentioned indicators provide reliable population parameters with a 95% confidence level.

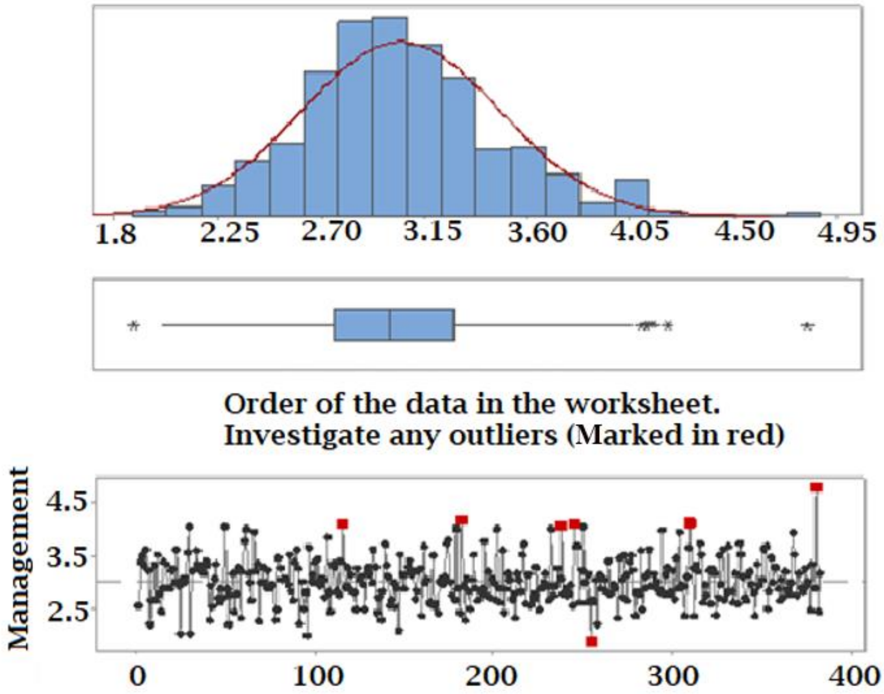

Figure 1.
Histogram of the solid waste management score in the city of Chachapoyas 2021.
Note: * This is the behavior and distribution of the variable. With a score of 1 to 5 points, with an evaluated sample of 382, the average score for solid waste management is 3.05 points, with a standard deviation of 0.43 points, with an average minimum value of 1.88 points and a maximum of 4.82 points.

Table 4 presents the prioritization of the 5 dimensions aimed at improving solid waste management. The priorities are as follows:

1. Storage: This dimension has an observed percentage of 51% and a gap percentage of 49%. The average score for storage is 2.56 points.
2. Final disposal: With an observed percentage of 58% and a gap percentage of 42%, the average score for final disposal is 2.88 points.
3. Generation: The observed percentage for this dimension is 62% with a gap percentage of 38%. The average score for generation is 3.08 points.
4. Treatment and recycling: This dimension has an observed percentage of 63% and a gap percentage of 37%. The average score for treatment and recycling is 3.15 points.
5. Collection and transportation: With an observed percentage of 71% and a gap percentage of 29%, the average score for collection and transportation is 3.54 points.
6. Overall solid waste management: The observed percentage for overall solid waste management is 61%, with a gap percentage of 39%. The average score is 3.04 points.

In summary, the prioritization of the 5 dimensions to improve solid waste management should be considered in the following order: storage, final disposal, generation, treatment and recycling, and collection and transportation.

Table 4.
Order of prioritization of solid waste management by dimensions according to % observed and % gap.

Dimension and variable	Observed mean score	Expected mean score	Gap score	% Observed	Gap % Gap	Prioritization for improvement
Solid waste management	2.56	5.00	2.45	51%	49%	1
Storage	2.88	5.00	2.12	58%	42%	2
Collection and transport	3.08	5.00	1.92	62%	38%	3
Solid waste generation	3.15	5.00	1.85	63%	37%	4
Final disposal	3.54	5.00	1.46	71%	29%	5
Solid waste management	3.04	5.00	1.96	61%	39%	*

Note: * Indicates the priority order of gaps according to the dimensions.

Figure 2 shows a heat map depicting the degree of correlation between solid waste management and its 5 dimensions. The correlation between solid waste management and the generation dimension is (R=0.70, p<0.05), with storage (R=0.65, p<0.05), with collection and transportation (R=0.63, p<0.05), treatment and recycling (R=0.61, p<0.05), and final disposal (R=0.70, p<0.05). It is statistically inferred that the dimensions of generation and final disposal have a higher degree of correlation with solid waste management; however, the dimensions storage, collection and transportation, treatment and recycling exhibit lower correlations with solid waste management.

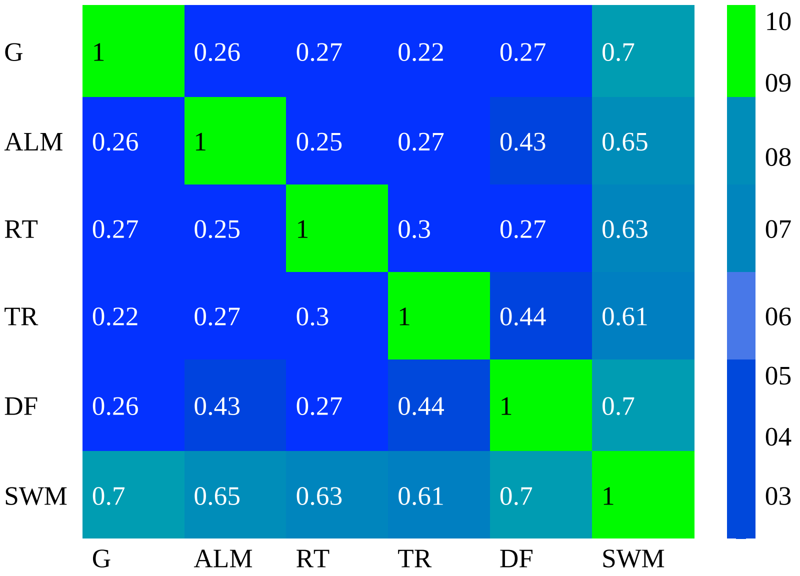

Figure 2.
Heat map of the degree of correlation of the solid waste management scores and by its 5 dimensions.

Note: G: Generation of solid waste, AML: Storage of solid waste, RT: Collection and transportation of solid waste, TR: Treatment and recycling of solid waste, DF: Final disposal of solid waste. SWM: Solid waste management.

Figure 3, presents the estimated general model based on the structural equations. The results show the following predictions and corresponding p-values: Final disposal (FD) and recycling treatment (TR) predict the value of the model at 0.432 (p-value: 0. 00), with collection and transportation (RT) at 0. 148 (p-value: 0.00), with storage (ALM) at 0. 296 (p-value: 000) and with generation (G) at 0.074 (p-value: 0.03) the value of the model; consequently, a positive prediction is evident with respect to the values of this field. Treatment and recycling with collection and transport predicts 0.201 (p-value: 0.00), with storage 0.064 (p-value: 0.15) and with generation 0.046 (p-val:0.17); consequently, the prediction between the first and the last dimension is positive except with the storage dimension no predictive value is found p-value: 0.15 (> 0.05). Additionally, collection and transportation and storage predict at 0.125 (p-value:0.01), with generation 0.108 (p-value:0.01). Both predictions show a positive relationship. In summary, the figure demonstrates positive predictions between different dimensions, except for the lack of significant predictive value between storage (ALM) and treatment and recycling (TR) with a p-value of 0.15 (> 0.05). Finally, storage (ALM) predicts generation (G) at 0.108 (p-value: 0.01).

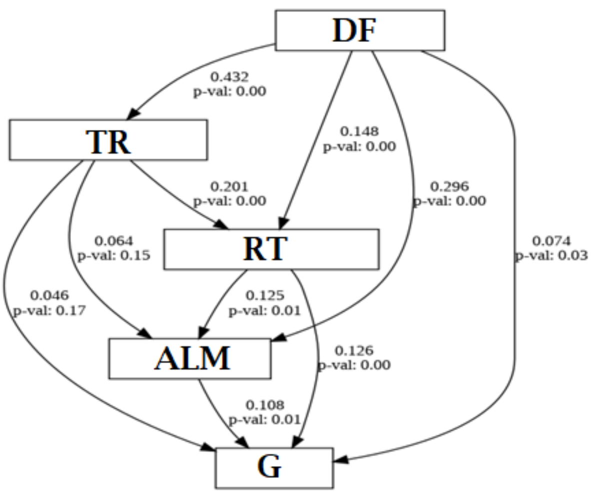

Figure 3.
General estimated structural equation model of solid waste management.

4. Discussion

The characterization of the urban solid waste management system is complex due to its dependence on various political, administrative, and behavioral factors within social groups. These factors are influenced by variables such as the level of environmental identity, and education, among others. Ramos and Rouboa [47] state that urban solid waste management is a challenging task in developing countries because it encompasses not only economic and environmental aspects but also social and demographic aspects. This multifaced nature of waste management poses difficulties for municipal managers. However, it is important to diagnose the management of SW in order to identify gaps that may have a negative influence on the management process and thus make timely decisions. By doing so, timely decisions can be made to address these gaps effectively. The study offers both theoretical and practical insights into solid waste management, focusing on five key dimensions: generation, storage, collection and transportation, treatment and recycling, and final disposal. This comprehensive approach contributes to the understanding and improvement of solid waste management practices.

Within this framework, when evaluating the sociodemographic profile of the families, it was found that 79% of them are predominantly female, with a higher proportion falling within age the range of 32-51 years. The most significant occupation among the respondents was that of housewife (32%), followed by administrators and teachers (29%). In terms of employment status, 55% of them had jobs as domestic workers, while the remaining 45% had jobs as employees. 55% percent were employed at the time of the study, 27% were unemployed and 18% were underemployed.

Regarding educational attainment, 30% had pursued non-university higher education, 29% had completed university-level education, and only 23% had completed high school. Moreover, 50% of the respondents reported having a low monthly income, ranging between S/ 500.00 and S/ 1000.00, while only 7% had an income of S/ 3000.00 or higher.

In terms of residential distribution, 35% of the families resided in the outskirt of the city (AA. HH) while the remaining 65% lived in the inner areas. Family structure was characterized by nuclear families, with 60% having between 4 to 6 members, followed by 30% with 1 to 3 members per family.

These data can be compared with the findings of Rybova [48], who found in their research that sociodemographic variables have a positive influence on solid waste management (SWM). The factors identified as influential include the average size of members per household, the proportion of individuals with higher education, and the purchasing power per person. Another study [49] indicates that the percentage of employed individuals and the gender composition also have a positive influence on SWM. Additionally, Lorenzoni, et al. [50], explain that age, and urban versus rural location are influential factors. Furthermore, [51] supports the conclusion that the percentage of individuals aged 25 years or older with a bachelor's degree or higher increases their level of participation in SWM. In our case, occupations such as housewives, administrators, teachers, self-employed, nurses, secretaries, and shopkeepers, are significantly associated with SWM. However, gender (male-female) and employment status (unemployed, employed, underemployed) are not significantly related to SWM. According to Balundė, et al. [52], people who possess biospheric values, environmental self-identity, social norms, personal norms, and habitus are strongly associated with SWM. However, there is limited knowledge about the specific behaviors associated with SWM [53].

Similarly, the data revealed that the level of solid waste management in urban areas of the city of Chachapoyas, as perceived by families, is classified as follows: 4% rated it as bad, 88% rated it as regular, and 8% rated it as good. These results can be compared with the findings of Mendes, et al. [54], who conducted periodic evaluations of SWM and reported ratings of 51.7 %, 66.1 % and 70.1 % for 2009, 2010 and 2011, respectively. These figures indicate an improvement in the overall performance of the service over time, with a higher level achieved in 2011. On the other hand, Oyedotun, et al. [55] affirm that the waste management system in Nigeria and Guyana is of poor quality, as it raises concerns of dissatisfaction among communities and households.

According to Alomari, et al. [56], solid waste management is considered favorable when it is timely and effective, as it plays a significant role in protecting the public from inadequate disposal practices and meeting the expectations of the user population. Other studies have also linked favorable waste management to timely initiatives that increase awareness and participation among all stakeholders. On the contrary, Yee, et al. [57] assert that low levels of SRM are often associated with a lack of planning and alignment of objectives, as well as inadequate implementation of local policies. Based on these statements, it can be extrapolated that various determinants that affect waste management are dependent on factors such as logistical approaches, budgetary considerations, administrative levels, as well as human attitudes [58].

The study also evaluated the level of solid waste management across different dimensions. In terms of waste generation, the findings revealed a poor level of management in 82% of cases, regular in 13%, and good in only 5%. These indicators could be attributed to various factors, such as the insufficient number of waste containers, inadequate training provided by municipalities, and the level of environmental awareness among residents. It appears that many residents lack interest in reducing solid waste production and exhibit indifference towards waste disposal schedules, resulting in improper waste disposal practices and a high generation of solid waste. According to Kofi, et al. [59], the level of waste management is significantly associated with factors such as awareness, attitude, practice, age, and education. These factors have a direct relationship with individuals' attitudes, knowledge, and environmental practices.

Similarly, when evaluating the collection and transportation dimension, it was found that out of the total surveyed families, 5% considered it to be at a bad level, 45% at a regular level, and 50% at a good level. These findings can be compared with the results obtained by Taşkın and Demir [60], who concluded that the collection and transportation of MSW is predominantly rated as regular to bad. This dimension has always posed challenges in the development of integrated MSW systems. Additionally, Hoornweg and Bhada-Tata [61] state that solid waste collection and transportation consume a significant portion, approximately 50-80%, of municipal waste management budgets, which often leads to inefficiencies in waste management.

In other parts of the world, urban planners have resorted to geographic information systems (GIS) for the selection and optimization of routes in the collection process [62]. These findings are indirectly related to our results, as the majority of the statistics indicate fair and poor waste management levels, which are associated with the capacity of municipal management. It appears that the available collection containers in the municipality are insufficient, and there is also a shortage of personnel to provide the service. Moreover, there is a lack of awareness-raising and community engagement initiatives regarding waste disposal. The proposal to optimize routes is being discussed, taking into consideration that there are areas in the city with limited access and challenging topographical features, which make it less feasible to utilize certain alternatives.

Additionally, when evaluating the treatment and recycling dimension, it was found that out of 100% of the families surveyed, 14% considered the level to be bad, 58% regular and 28% good. This finding is related to the data reported by Guo, et al. [63], who emphasize that the methods practiced by the municipality for the treatment and recycling of organic solid waste are of a conventional nature and suffer from inherent flaws, such as low efficiency, low precision, high cost, and potential environmental risks. Similarly, Muisa, et al. [64] found that at least 70% of the waste was not reused or recycled off-site. The higher proportions of bad and regular levels observed in our case for this dimension may be attributed to the lack of sufficient communication from the municipality to the residents regarding the treatment processes and the purpose of recycling practices. Therefore, these findings align with the aforementioned data, indicating that the municipality's treatment and recycling efforts are not significantly advanced in terms of technical or scientific methods, with processes often being carried out in a conventional manner.

Similarly, when evaluating the final disposal dimension, it was found that 25% of the families perceive it as bad, 58% as regular, and 16% as good. Safo-Adu and Owusu-Adzorah [65] reported that the methods used to dispose of solid waste in the Kumasi metropolis included disposal in municipal containers (58.8%), public dumping (15.6%), open burning (4.4%), burial (1.6%), and indiscriminate disposal (1.9%). In our case, the higher proportions of bad and regular levels observed in this dimension can be associated with the fact that the final disposal of MSW is carried out air open-air incineration and indiscriminate disposal, causing air, soil, and water contamination. This contamination flows into the Sonche River, thus affecting the local flora and fauna. However, the issue of waste disposal through burial, as mentioned in the aforementioned sources, is not relevant to our study as this activity is not practiced in the municipality of Chachapoyas. The percentage of good level is associated with the fact that in some way the municipality has not failed to fulfill its function of MSW collection, however, the final disposal of waste is still inadequate.

In identifying the gaps that need to be addressed in the municipal solid waste management system in the city of Chachapoyas, it can be concluded that the solid waste management variable has a gap of 39% to be closed. When considering the individual dimensions, the gaps are as follows: storage (49%), final disposal (42%), generation (38%), treatment and recycling (37%), and collection and transportation (29%). These findings can be compared to those of Cervantes, et al. [66], who reported gaps of 20.2% for collection, 16.4% for recovery and treatment, and 13.8% for disposal in their study. According to the waste hierarchy, collection should be prioritized as the highest priority. This prioritization is influenced by factors such as logistics, policy, planning [67], and budget management for timely decision making [68]. However, in our case, storage and final disposal have emerged as the top priorities with gaps of 49% and 42% respectively. These results highlight the need for further research to propose alternative solutions to address each of the identified gaps. By focusing on these dimensions and their respective priorities, new avenues of research can be explored, contributing to the development of innovative strategies tailored to the specific characteristics and needs of the municipality, region, or country.

On the other hand, it is worth noting that there is a lack of extensive research at the local, national, and international levels that specifically focuses on analyzing solid waste management in relation to sociodemographic characteristics. Conducting research in this area would provide accurate and timely information for implementing effective interventions. Ribeiro-Rodrigues, et al. [69] emphasize that conducting statistical analysis on sociodemographic data can offer a comprehensive understanding of individuals' engagement levels in various actions related to environmental conservation and waste prevention. Such research would enable a more detailed diagnosis of the sociodemographic factors influencing waste management practices.

Solid waste management is a complex subject that encompasses multiple variables, which collectively determine its effectiveness within municipal management. Factors such as political, administrative, geographic, and others play a crucial role in shaping the outcomes of municipal solid waste management. Therefore, identifying and understanding these factors is essential in order to take timely actions and promote efficient service delivery to achieve organizational objectives. Although the present did not evaluate these specific fields of knowledge, it is highly recommended to include them in future studies. In this context, [70] it is asserted that in order to improve SR management policies, more attention should be paid to performance management, collection and transportation management, sorting and grading management, product marketing management, professional qualification, occupational health, as well as quality and safety. By addressing these aspects, positive individual differences can be made in favor of the environment [71], and it can contribute to the growth of the tourism sector [72].

5. Conclusion

The socio-demographic profile was found to have a significant effect ($p<0.05$) on solid waste management, with several associated characteristics: economic condition, age, occupation, level of education, monthly income, area of residence and number of people per household.

Solid waste management in urban areas of the city of Chachapoyas, 2021, is characterized by a higher proportion of a regular level, as well as in the dimensions of generation, storage, and final disposal; however, the dimension of collection and transport was found to be of good level according to the data from the perception of families.

The order of prioritization of the dimensions of solid waste management, according to the perception of families in the urban areas of the city of Chachapoyas, 2021 is as follows: Storage (priority 1), Final disposal (priority 2), Generation (priority 3), Treatment and recycling (priority 4), and Collection and transport (priority 5).

Identified gaps to be closed in the solid waste management system, based on the perception of families in urban areas of the city of Chachapoyas, 2021, are as follows: Storage (49%), Final disposal (42%), Generation (38%), Treatment and recycling (37%) and Collection and transportation (29%).

Identified gaps in the solid waste management system underscore the need for targeted actions in specific dimensions. The high percentage of gaps in storage and final disposal indicates the urgency of addressing issues related to these areas. Additionally, efforts should be directed towards improving waste generation practices, treatment and recycling methods, and collection and transportation efficiency.

Overall, these findings provide valuable insights for policymakers, municipal authorities, and stakeholders involved in solid waste management in Chachapoyas. Addressing the identified gaps and considering the socio-demographic factors can contribute to the development of more effective strategies, policies, and interventions to enhance the overall management of solid waste in the city.

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