MUNICIPAL SOLID WASTE GENERATION: AN EXPLORATORY ANALYSIS OF CONSUMPTION PATTERNS IN PERU

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ABSTRACT

Peru, a developing country, is experiencing an exponential increase in the municipal solid waste (MSW) generation due to population growth and disorderly territorial expansion in urban and rural areas. Most of these settlements do not have proper waste management, which causes contamination in various sectors: health, economy, environment (e.g., soil contamination, informal landfills), among others. Thus, this growth phenomenon can be explained through the consumption patterns of the population, especially those related to the household. To this end, this research seeks to contribute to the MSW management through an exploratory analysis using resources provided by public and non-governmental organizations. In this way, a national database was constructed that reflects consumption trends, characteristics, preferences and significant differences between rural and urban areas. It is expected that this information will contribute to the implementation of management tools that are better adjusted to reality in order to reduce the negative impacts generated by inadequate solid waste management.
Keywords: consumption patterns, households, national panel data, Peru, solid waste management.

1 INTRODUCTION

In a developing country such as Peru, a constant population growth resulting from seeking an improvement in life quality [1] brings with it a change in consumption preferences that causes an increase in the municipal solid waste (MSW) generation [2]. Such an increase is of concern since global solid waste generation levels reached approximately 1.3 billion metric tons in 2012 and an estimated total of 2.2 billion metric tons generated by 2025 [3]. Moreover, if we talk about the overall average composition of waste in the last 10 years, it consists mainly of organic waste (51%), followed by paper (14.1%), plastic (10.4%), glass (4.1%), metals (3.3%) and other materials accounting for 17% of the total volume [3]. However, Peru is no exception to these statistics, since in 2017 on average 58% of MSW was organic. This means that an important part of pollutant emissions can be directly linked to food loss and waste management, due to the fact that average temperature and rain decompose waste increasing pollution and carbon storage rates [4]. In addition, it is considered that the final disposal of MSW is the part of the process with the most shortcomings, since a large part of the MSW is disposed of improperly or is not part of the solid waste management system [5]. It should be noted that in order to address this problem, effective waste management practices must be in place, and for this it is important to be aware of their limitations. For example, the lack of data represents one of the most important restrictions to implement management actions [4], without neglecting other factors (i.e., social, economic and environmental) that can modify the waste generation trend [2].

In recent years, research has been conducted on the impacts generated by the increase in solid waste generation in Latin America [1]. The results of these investigations show an annual rate increase of 2–3% in MSW generation [6] mainly due to two factors that alter consumption patterns: population growth and increased purchasing power [5]. It should be noted that there will be variations in consumption trends if this population growth is greater [7] and even worse if there is no planning or management strategy [8]. This is due to the fact

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that, if the population increases in a disorderly manner, municipalities will not be able to cope due to the poor projection of resources to be used. For example, in marginal areas, where the most impoverished groups of the population live in precarious housing and with reduced spaces, they have low coverage of basic services, thus acquiring diseases associated with water contamination and/or accumulation of waste [8]. In this regard, Peru in the last 10 years, due to the 5% growth of urban population between 2010 and 2020 [9] experienced variations in consumption levels that resulted in a substantial increase in MSW, higher rate of environmental pollution and deterioration of surrounding natural resources [10].

During the last 10 years, the focus on solid waste management was only on cleaning to keep the city looking good; however, today the perspective is different, as an integrated management system that recognizes even more the potential value contained in waste is being contemplated [11]. On the other hand, although the management of MSW generation in other countries has proven to be efficient, the results on which they are based cannot be directly compared or applied at the national level, since there are fundamental differences at the economic, social and political levels [12] that are evidenced by changes in preferences and consumption trends [3]. Nevertheless, the information obtained can help us to project possible scenarios, allowing us to relate socioeconomic strata with consumption trends [2].

Therefore, in order to achieve sustainable management, it is necessary to incorporate national strategies for proper waste management. However, in order to design this action plan, it is essential to know the composition and limitations of the waste generated. For example, the availability of reliable and quality information is an influential factor in this type of analysis. Also, it is essential that the data found include the essential characteristics of the target population (e.g., consumption preferences, urban or rural household, etc.) [1]. Finally, although the information may exist, access to it is not as easy [13], [14]. Therefore, knowing the behavior at the level of preferences and consumption trends that allow understanding the MSW generation is fundamental, in order to contribute to an integrated management, providing strategies for its mitigation [2].

2 CONSUMPTION PATTERNS: CROSS-SECTIONAL ANALYSIS

In the last census of 2017, Peru had 31,237,385 inhabitants, which can be divided under location criteria: urban area (24,771,246 inhabitants) and rural area (6,466,139 inhabitants) [15]. According to INEI (2018) the average trend, both increase for urban and decrease for rural, is 0.19% [16]. On the other hand, the Ministry of Environment (MINAM) observed an average increase of 16.67% in the total annual trend of solid waste generation at the municipal level [17]. The increase in MSW evidenced in Fig. 1 can be explained through an understanding of variations in the inhabitants' consumption patterns [2]. To better understand this term, the Integral Plan for the Environmental Management of Solid Waste in the Province of Lima 2015–2025 defines consumption patterns as the acquisition of products per person in a given time [18]. It should be added that these patterns depend on demographic, social, economic and cultural factors [19]. An example for better understanding is that in places with high economic development, housing rent is a representative expenditure in households, which causes differences in solid waste generation between different regions, as it affects the real purchasing power of households [2].

This indicates that those who consume many resources produce a greater amount of waste as opposed to others who consume few resources. Therefore, these variations in consumption patterns produce changes in the amount and type of solid waste generated [20]. However, there is currently a lack of commitment in the participation of most people regarding MSW generation, so it is necessary to contribute to the sustainable development of waste [21] and

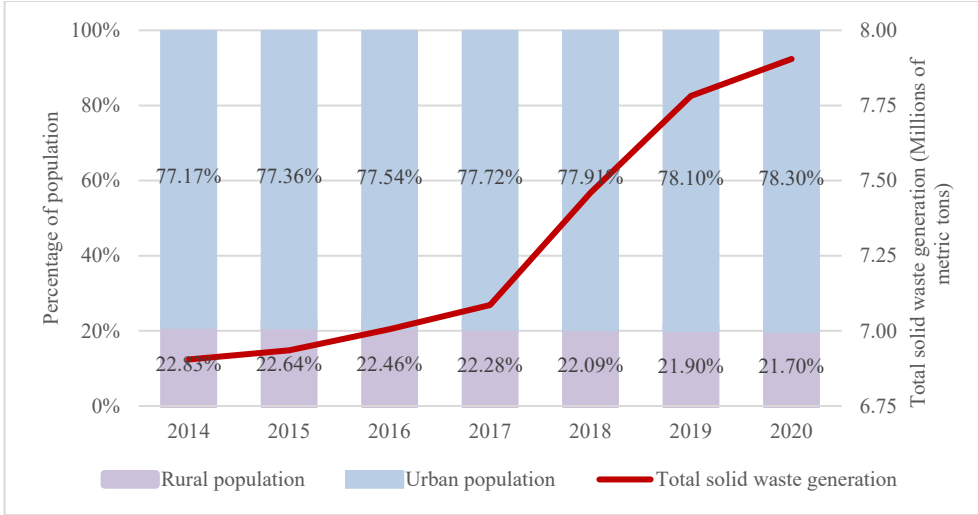

Figure 1: Percentage of urban and rural population and trend of MSW generation in Peru 2014–2020. *(Source: Adapted from INEI [16] and MINAM [17].)*

to adopt optimizations in the approach and development of management strategies [2]. These changes must be permanent and based on the adequate use of natural resources, so that new generations can have better opportunities to use these resources [21].

2.1 Household aspects

Regarding the household aspects, a clear distinction in the levels of expenditure between urban and rural households was evidenced; it is also considered useful to point out that between 2010 and 2020 there has been a 5% growth in the urban population [9]. This increase could be related to the variation in MSW generation rates. As a sample of the aforementioned, energy expenditure in rural households was significantly lower than in urban households, due to the lower purchasing power. On the other hand, there is also a clear distinction in the ownership of household appliances: while in urban households the use of appliances for activities not necessarily related to cooking is more frequent, such as air conditioning among others; in rural households the use of household appliances is specifically intended for this function [22]. Similarly, at the level of expenditures generated in urban vs rural households, it was found that households in urban areas have a higher average monthly expenditure compared to rural households; thus, during the year 2020, Lima, a department with a greater presence of urban households, had an average monthly expenditure of $210.00 in contrast to what was recorded in Puno with an average monthly expenditure of $110.00 [9]. Therefore, it is particularly necessary to analyze the most frequent activities in Peruvian households in order to understand the consumption patterns and which characteristics generate the greatest distinction in terms of municipal solid waste generation [23]. In this regard, Fig. 2 shows the percentage distribution of electricity use according to urban and rural population between 2019 and 2020 [22].

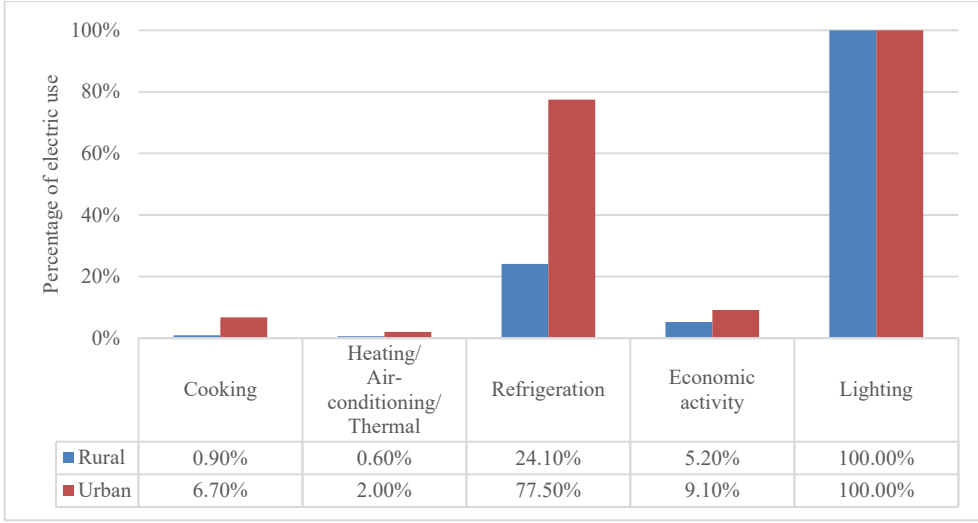

Figure 2: Percentage of electricity use distribution according to urban and rural population 2019–2020. *(Source: Adapted from OSINERGMIN [22].)*

2.2 Daily activities

According to the literature review, the activities carried out within the household do have an impact on the MSW generation, for example, in relation to fuel consumption, low-income households focus their electricity and energy consumption only on basic activities such as lighting and refrigeration, while non-poor households also have a more diverse range of consumption, for example, the use of other appliances such as dryers, heating, chargers, washing machines, among others [22]. Likewise, in relation to economic activities as a source of income in Peruvian households, the most frequent in Peru are tourism, livestock, agriculture, and fishing, among others, as well as families whose economic livelihood is based on the fact that household members pursue technical or professional careers [24]. This information is related to waste generation patterns since in the case of MSW generation in rural areas these have a greater participation of the inhabitants in relation to their economic activity while in urban areas they are more related to activities related to food consumption [25].

2.3 Urban and rural settlements

According to geographic location, the classification of households in Peru is divided into urban households belonging to a population center with 2,000 and more inhabitants and rural households belonging to a population center with 500 to 2,000 inhabitants [15]. Now when talking about the factors that affect waste generation rates, in addition to factors such as: lifestyles and economic activities, it is believed that one of the most important factors are food habits, culture, climate and occupation of the inhabitants [26]. In that sense, with respect to socioeconomic conditions, it is observed that there are differences in the level of expenditure related to the economic condition, since it was evidenced that the expenditure made in the household is proportional to its level of income [23]. On the other hand, the number of people in the household has decreased during the period 2007–2017, since the

average number of household members went from 4 to 3.5 in urban households and in rural households from 4 to 3.2 [15]. In that sense, Fig. 3 shows the differences between the monthly consumption (in thousands of sol (S/)) of the urban and rural population by department between 2019 and 2020 of electricity and fuels used for cooking (LPG) and vehicular and motorized use (NGV, gasoline, 90 and 84 octane gasohol) [23].

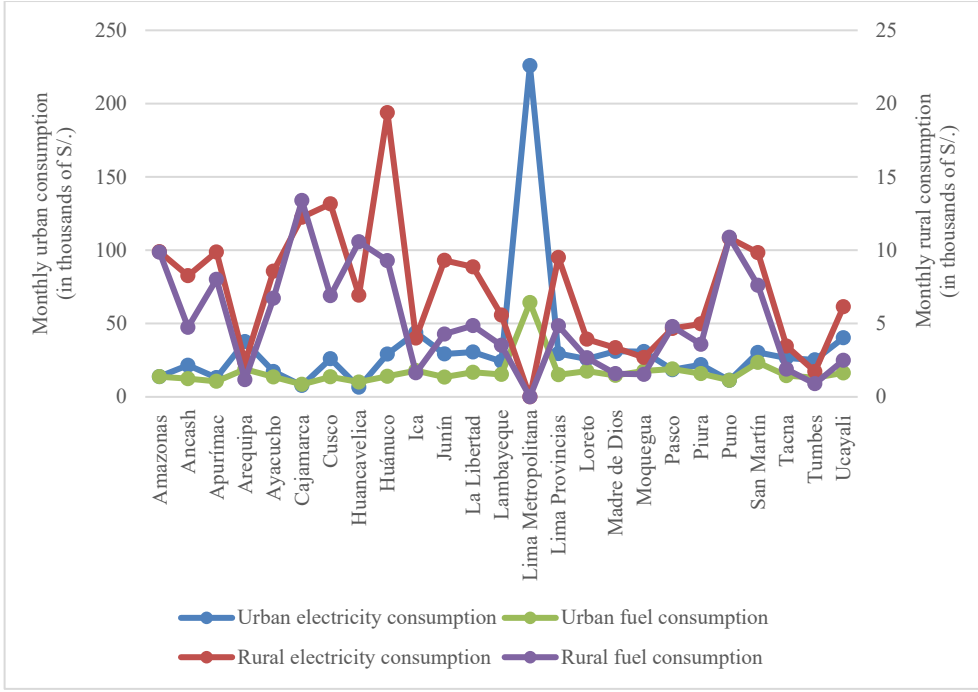

Figure 3: Monthly household fuel and electricity consumption by urban and rural population by department between 2019 and 2020. *(Source: Adapted from OSINERGMIN [23].)*

2.4 Fuels and energy

Research on the relationship between the use of fuel for cooking and the generation of solid waste is scarce. Consequently, for the analysis of fuel consumption trends, it is essential to know the differences in relation to their geographic location. In 2020, the monthly electricity expenditure of households in rural areas was S/ 13, and at the national level, S/ 58 [22]. Now if we talk about the main fuel used for cooking food in Peru in 2020, this was LPG, since it is used in approximately 74% of households. However, there was also evidence of a differentiation in the main use of fuel sources in relation to urban and rural households. For example, firewood represented a significant percentage of use in rural households 45%, while in urban households LPG registered a marked preference, with 81% [27]. In this regard, Fig. 4 shows the percentage of energy used for cooking in the home according to urban and rural population between 2019 and 2020 [22].

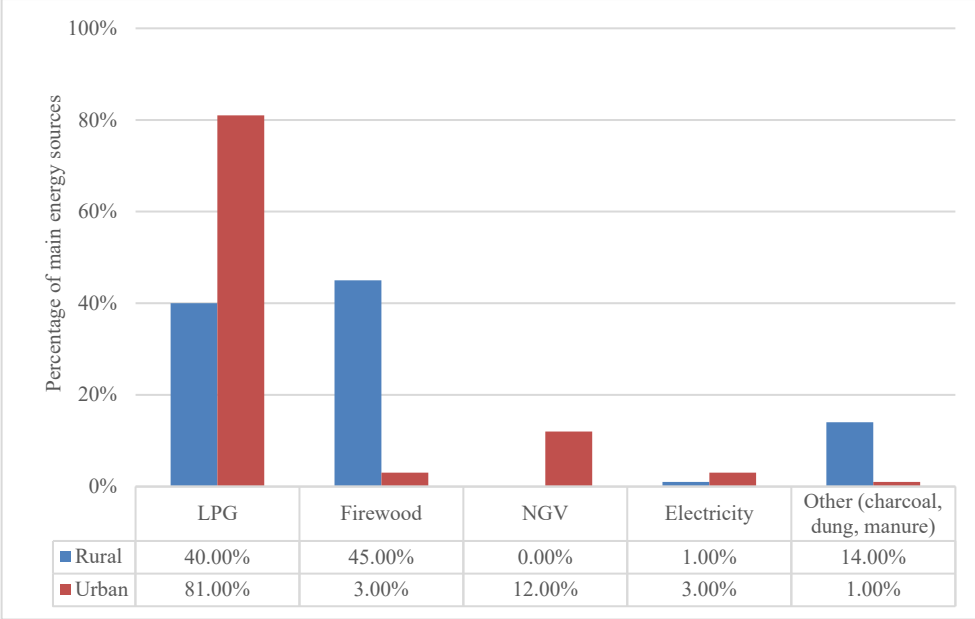

Figure 4: Percentage of energy sources used for household cooking according to urban and rural population 2019–2020. *(Source: Adapted from OSINERGMIN [22].)*

3 DISCUSSION AND MAIN FINDINGS

In relation to the results obtained in different countries with similar characteristics, it should be emphasized that the generation of MSW varies according to various factors, including economic, social and political level, and that these characteristics, together with the results obtained on the basis of preferences and consumption trends, represent valuable information [13]. Since from this information it is possible to estimate or predict possible changes in consumption trends and the incidence of MSW generation, from the present study it is believed that one of the main characteristics is the socioeconomic level [10]. There is evidence that the trend in waste generation varies according to purchasing power, due to the activities carried out within the home, as well as customs in relation to geographic location [10]. Also, in Latin American and Caribbean countries with similar socioeconomic conditions, the waste generated is mostly composed of food waste with energy recovery capacity [1], [28].

On the other hand, the aspects analyzed in this document aim to explain the MSW generation based on the characteristics of the community. These characteristics involve not only the demographic composition, but also the relational aspect between consumption patterns and the type of waste generated. Thus, each population settlement (i.e., urban and rural) will have different characteristics due to the different needs that arise. It is evident that urban population growth has been increasing in the last five years, which translates into an increase in the MSW generation. In addition, household aspects also differ according to geographic location. In urban and rural environments, the use of fuels or electrical resources varies according to the activity, which means that their characterization varies too.

Therefore, if the aim is to incorporate or improve MSW management policies, it is necessary to consider the criteria mentioned above in order to obtain functional results.

However, it is known that such integration with the objective of achieving sustainable development represents an important challenge, particularly in developing countries with a constantly increasing population, so that knowing and identifying the limitations is an important part to consider in future research.

4 FUTURE RESEARCH PROJECTIONS

For an efficient integration of measures that contribute to the mitigation of the damage caused by MSW generation, it is necessary to know what causes it; in this case, the relationship between consumption patterns and solid waste generation was analyzed. As it is known in Peru, not all municipalities have an integrated management system for the benefit of local development. In this sense, it is convenient to include in the current regulations all phases of generation, that is, not only the collection, transfer and final disposal, but also the identification of consumption patterns and their impact on MSW generation. In this way, it is possible to contribute to the implementation of more appropriate tools if characteristics such as geographic location, socioeconomic status, customs, preferences, among others, are considered, since these characteristics can explain in a more appropriate way the differentiation of MSW generation rates. For better data quality, it is also recommended to conduct interviews with more specific questions that contribute directly to the analysis of consumption patterns, since their role in the generation of solid waste is evident. In relation to the integration of policies involving MSW management between the public and private sectors, it is also necessary to include sustainable financing structures. Finally, it is intended that based on this analysis, future research will be initiated to work directly with the cause and not only with the consequences of MSW generation, in order to obtain sustainable results that contribute not only to the mitigation of the damage already generated at the environmental, social and economic level, since it is our responsibility to modify the production and consumption model to help create sustainable development and a better future for all.

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