

Matrix Indicators for Assessing the Quality of Municipal Plans for Integrated Management of Urban Solid Waste

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Research Article

Keywords: solid waste, integrated management, indicators, index

Posted Date: May 10th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1630966/v1>

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Abstract

The correct management of solid waste is still considered an obstacle for Brazilian municipal realities. In this sense, the National Policy on Solid Waste (NPSW) brings the Integrated Municipal Solid Waste Management Plans (IMSWMP) as a fundamental instrument to guide decision-making. From this, this article sought to propose indicators to assess the quality of elaboration of these documents. The methodological steps were composed of 3 parts: literature review to build a matrix of 40 indicators and 7 dimensions; matrix validation with the attribution of grades to the descriptors and weights to the dimensions considered by the Delphi Method; and calculation of the Quality Index of Integrated Municipal Solid Waste Management Plans applied to the 16 municipalities in the State of Pará. The proposed matrix was able to identify the dimensions and indicators that need improvement, contributing to the elaboration of consistent IMSWMP and for the continuity regarding the advances of the IMSWMP considering the municipal limitations and government changes.

Introduction

Developing countries with intense urbanization process, such as Brazil, have obstacles to the implementation of an adequate management, due to factors such as: low financial and administrative capacity to ensure basic services infrastructure, among them, the services of collection and proper disposal of waste (Jacobi and Besen 2011). One of the greatest difficulties is to perform the proper management of municipal solid waste (MSW), considering its evaluation and monitoring to formulate strategies and ensure environmental sustainability, as well as improvements in the quality of life of the population, becoming a long-term challenge.

Inadequate waste management causes socio-environmental impacts, such as: soil degradation, pollution of water bodies, intensification of floods, air pollution, proliferation of vectors that cause diseases, in addition to providing an unhealthy environment for the activity of the collector (Besen et al. 2014; Maiello et al. 2018). Some authors have been conducting research of models that apply integrated management, in order to propose better solutions or alternatives for minimizing the socioeconomic, environmental and health impacts that are the result of the issue of solid waste, from its generation to the final disposal stage (Pinho, 2011; Agostinho et al. 2013; Pereira et al. 2018; Kneipp et al. 2014; Agovino et al. 2016; Aguilar et al. 2018).

Statistical information released in the report by the Brazilian Association of Public Cleaning and Special Waste Companies in 2017, indicated total annual generation of 78.4 million tons in Brazil, having a collection coverage index of 91.2%, resulting in approximately 6.9 million tons of MSW disposed of inappropriately. Of this amount only 59.1% of the waste was sent to landfills, and consequently more than 80,000 tons of waste per day were sent to inappropriate sites, such as dumps and controlled landfills, causing environmental and public health damage. Dealing more specifically with the North region, 15,634 tons/day of MSW were generated, and 81.3% of this amount was collected. Of the total collected, 65.3% were sent to dumpsites and controlled landfills, representing the two main destinations of the materials generated in the region (ABRELPE 2017).

The specific legal framework for the solid waste sector was given with the effectiveness of the Federal Law 12.305/2010, also known as the National Policy on Solid Waste (NPSW) (BRASIL 2010), encompassing the objectives, principles, instruments and guidelines applicable to the proper management of these materials, in addition to defining the responsibilities of each actor involved in these processes. In the context of management, the NPSW addresses the Integrated Municipal Solid Waste Management Plans (IMSWMP) as a tool of public administration, this being a condition for access to resources from the Union, as well as an aid tool for the management of activities related to urban cleaning and management of this waste (Costa and Pugliesi 2018).

The minimum content of these Plans is provided for in Article 19 of the current legislation, containing 19 items. Paragraph 1 of this article addresses the possibility of inserting the IMSWMP in the Basic Sanitation Plans (BSP), respecting the minimum content required in the NPSW. The § 2° deals with the simplified IMSWMP for municipalities with less than 20,000 inhabitants, not being valid for municipalities that are in areas of tourism interest, in areas of influence of enterprises or activities with significant regional or national environmental impact, or that are inserted totally or partially in Conservation Units, being the minimum content described in article 52 of Decree 10.936/2022, contemplating 14 items (BRASIL 2010).

Decree 10.936/2022 brings in its art. 52 conditions for the preparation of Simplified Plans for municipalities with less than 20,000 inhabitants, and the municipalities that participate in consortium solutions are exempt from the preparation of IMSWMP, provided that the intermunicipal plan meets the minimum items required in art.19 of NPSW (BRASIL 2022). It is noteworthy that it is necessary to perform constant evaluation of solid waste management, because the monitoring of municipal public policies ensures possibilities for

improvements in strategies to achieve the objectives, promoting environmental sustainability and ensuring more quality of life for the population (Santiago and Dias 2012; Chaves et al 2020).

Article 18, § 1, describes the priority conditions for access to federal resources, prioritizing municipalities that "opt for inter-municipal consortium solutions for the management of solid waste, including the elaboration and implementation of an inter-municipal plan, or that voluntarily enter the micro-regional solid waste plans referred to in § 1 of art. 16" or that "implement selective collection with the participation of cooperatives or other forms of association of collectors of reusable and recyclable materials formed by low-income individuals" (BRASIL 2010).

It is worth emphasizing the relevance of inter-municipal management and sanitation consortia or MSW management, because Brazilian municipalities find it difficult to plan, regulate and promote the operation of solid waste management services alone, so to overcome this structural deficiency, it is important to consider the regionalization of management through public consortia to ensure the sustainability of investments in this sector (Gouveia 2012).

Although the NPSW has established deadlines for the preparation of IMSWMP, it is evident the difficulty that small, medium and large municipalities face in ensuring the minimum legal compliance, mainly due to political/institutional, technical and financial limitations that make the preparation of IMSWMP unfeasible under the Law, such as aspects related to the lack of training of the technical team responsible, absence of a structured sector and limited material and budgetary resources (Polaz and Teixeira 2009; Chaves et al. 2020; Neves et al. 2021). According to the Brazilian Institute of Geography and Statistics (IBGE 2017), 54.8% of municipalities in Brazil have these plans, and of these, 82.1% cover only the municipality and not a set of municipalities, which is provided for in Law as inter-municipal plans, that is, union of municipalities with common interests to enable the implementation of legal instruments (BRASIL 2010).

Given this scenario, there is a need to propose a tool to assist municipal managers in the decision-making process, prioritizing the quality of preparation and constant monitoring and review of these documents, seeking to portray actions likely to be implemented considering the peculiarities and limitations at the local level (Pereira et. al. 2018; Chaves et al. 2020). Therefore, the objective of this article was to elaborate a tool to evaluate the IMSWMP of 16 municipalities in Pará, based on solid waste management indicators, as a way to circumvent the difficulties faced by municipal governments in the process of elaboration of IMSWMP.

Methodology

Construction of the Indicator Matrix

Initially a survey was conducted in the literature about the consolidated sustainability indicators, as well as the dimensions that represent them. It is noteworthy that after the construction of the initial matrix, 16 IMSWMP were evaluated in the State of Pará, provided by the Secretariat of Public Works and Urban Development of the State of Pará (SEDOP), in order to assist in the process of reducing indicators from the realities described in these documents.

The IMSWMP of the municipalities of Acará, Abaetetuba, Abel Figueiredo, Augusto Correa, Aurora do Pará, Barcarena, Bonito, Canaã dos Carajás, Capanema, Colares, Concórdia do Pará, Curuçá, Goianésia do Pará, Inhangapi, Juruti and Muaná were chosen. The choice of the study area considered the ease of access to IMSWMP provided by SEDOP, however, as they were not available on the websites of all municipalities; the convenience sampling technique was used, in which the most accessible members of the population are considered (Ramos et al. 2018; Souza and Broleze 2019), different from the conditions of the research developed by Chaves et al. (2020), in which there was an ease of access to IMSWMP, being possible to consider the population representativeness as a criterion for the selection of the study areas.

Considering population data, the State of Pará has approximately 8 million inhabitants, and the municipalities with IMSWMP finalized so far represent only 10.26% of the total population of the state. According to the classification established by IBGE (2017), 72.22% of the municipalities selected in this research fit into small-sized conditions (population of up to 50 thousand inhabitants), while 27.78% correspond to the percentage of medium-sized municipalities (population greater than 50 thousand to 200 thousand inhabitants), represented by Abaetetuba, Acará, Barcarena, Capanema, and Juruti.

The initial matrix was composed of 73 indicators and went through filtering stages to reduce the number of indicators (Fig. 1), in order to avoid the use of repeated information, to eliminate indicators not fully met by the municipalities, as well as to translate quantitative

information into qualitative indicators, due to the difficulty of municipal managers in providing this information due to the absence of a systematized database.

The matrix applied in this research was composed of 7 dimensions and 40 indicators, with a variation of 2 to 3 descriptors depending on the indicator analyzed. The sustainability dimensions selected to incorporate the solid waste management indicators were based on the research of Polaz and Teixeira (2009); Santiago and Dias (2012); Fehine and Moraes (2014); Pereira et al. (2018) and are described below in Table 1:

Table 1
Description of the research dimensions (Authors 2022)

Dimensions	Description
Policy/Institutional (PI)	Related to the adoption of public policies to guide and define guidelines, as well as institutional arrangements according to national and international guidelines, considering the local demands for the adequate management of solid waste.
Technological/operational (TO)	Linked to the use of clean technologies in waste processing, and should prioritize the non-manufacture of products unable to return to the economic chain, control over generation, minimization, reuse, and recycling, in addition to considering aspects of the operational conditions of the waste management system.
Economic/Financial (EF)	Includes to the origin, the application, and the adequate administration of the budgetary resources destined to the maintenance of the management of urban solid waste.
Environmental/Ecological (EE)	Involves directing waste to landfills, minimizing generation, reusing/recycling, and treating waste before it is sent for final disposal.
Knowledge/Environmental Education (KEE)	It is characterized by involving all issues related to the solid waste problem and is the basis for achieving the objectives of the principles set out in the NPSW.
Social Inclusion (SI)	It ensures the insertion of social actors, such as collectors of recyclable materials in the process of solid waste management, through improvements in working conditions and education, contributing to citizenship, poverty reduction, and employment development.
Cultural (C)	Aspects of contextualization and local appreciation are considered, as well as the changes in habits that can vary between generations.

Delphi Method

The matrix of 40 indicators was applied to municipal managers and validated using the Delphi Method, also known as the method of experts, represented by those who use as a source of information a group of people previously selected for their high knowledge on the subject matter (Rozados 2015). It is characterized as a qualitative technique that gathers information to obtain a similarity in the opinion of a group of experts through repeated rounds, and its use is recommended when there is not enough information for decision-making, and there is the need to seek consensus among the experts (Mercedes and Mercedes 2016).

The consensus after the application of the method is still subjective, being defined by several authors, in different scales in the literature (Osborne et al. 2003; Santos et al. 2005; Grisham 2009; Santiago and Dias 2012), however, regardless of the level of consensus to be used, it must be pre-established before the application of the method Marques and Freitas (2018). In this research, the consensus established was equal to or greater than 50% for the attribution of scores for each descriptor (Santiago and Dias 2012), and the failure to reach this percentage contributed to the realization of a second round of the Delphi Method.

The questionnaire was prepared based on the matrix of 40 indicators, and was composed of two parts: subjective questions, which were the weights given to each dimension; and multiple-choice questions, with grades given to each descriptor of each indicator. Briefly, the researchers attributed grades on a scale of 1 to 5. To facilitate the filling out of the questionnaires according to local realities, the grades could be repeated for the descriptors of the same indicator, considering the following legend: Excellent (5), Great (4), Good (3), Fair (2), Poor (1).

Furthermore, weights were provided for each dimension of solid waste management totaling a sum equal to 100, which were distributed in the seven selected dimensions, in which the highest weights indicated the most important dimensions for the specialists. It is worth mentioning that the weights could also be repeated in some dimensions, being the final weight of each dimension calculated by the simple average of the weights provided by the total of panelists.

In this study, consultation was conducted via structured questionnaires sent via e-mail to scholars in the solid waste field, using the Google Forms platform, composed of dimensions, indicators and descriptors, of an objective and easy to understand nature, so as to obtain a convergence between replies at the first round. The first round was sent together with the Free and Informed Consent Form for voluntary participation in the research, and the total time of application of the Delphi Method was equal to 10 months, in which the first round took place in the period from 02/25/2020 to 07/25/2020 and the 2nd round occurred in the period from 08/09/2020 to 01/09/2021.

The panel of specialists was composed of 5 groups (Table 2), which were selected considering the knowledge of each group to obtain more precise answers. The fragmentation of the forms to specific groups was also based on the possibility of a higher adherence rate to the survey, due to the specialist having a smaller number of questions to be answered.

Table 2
Delphi Method expert groups by dimension (Authors 2022)

Dimensions	Target group	Criteria for target group selection
PI	State Secretariat of Environment and Sustainability (SEMAS) and Secretariat of Development and Public Works (SEDOP).	Elaboration of Studies and Plans in the area of Basic Sanitation, dealing with public policies for the solid waste sector.
TO/EF	Field professionals from the solid waste area of the Sanitation Secretariat (SESAN).	Carrying out operational activities, which directly depend on investments for their functioning.
EE	Teachers in the solid waste area.	High degree of knowledge in the aspects of this dimension, considering the completion of courses and specific studies in the area of solid waste.
KEE	Environmental sanitation academics	Access to disciplines focused on environmental issues and social mobilization.
IS	Representatives of the collectors' cooperatives	Group affected by the eradication of landfills and the creation of cooperatives or associations of recyclable material collectors.

Note that dimension C was not presented in Table 2 to avoid duplicate information, since all the groups involved responded to the indicators in this dimension, except for the members of the collectors' cooperatives, justified by the delay in returning the answers from this specific group.

Development of the Quality Index for Solid Waste Management Plans (QISWMP)

The development of the index was based on the methodology of Crispim (2015), who developed the water poverty index in the municipality of Pombal. This methodology was adapted to the conditions of this research, in which the proposed index was based on values of the dimensions and on scores assigned to the descriptors of each indicator (Delphi method). The first step of the QISWMP is given through the calculation of the dimension (Eq. 1):

$$D_i = \sum_{j=1}^n X_j / n \quad (1)$$

In which:

D_i is the value of the dimension;

n is the number of indicators that compose the dimension;

X_j is the score determined by the Delphi method for a given indicator j .

Finally, the QISWMP was calculated based on the weighted averages that consider the values of the dimensions referring to Eq. 1 and the weights of the dimensions assigned by the Delphi method (sum equal to 100) by the following mathematical formulation (Eq. 2)

$$QISWMP = \frac{(P1 \cdot D1) + (P2 \cdot D2) + (P3 \cdot D3) + (P4 \cdot D4) + (P5 \cdot D5) + (P6 \cdot D6) + (P7 \cdot D7)}{100} \quad (2)$$

In which:

QISWMP is the index value referring to the IMSWMP elaboration quality.

D1 to D7 are the values of the dimensions.

P1 to P7 are the weights established for these dimensions, obtained by the Delphi method.

It is noteworthy that higher QISWMP values indicate more consistent IMSWMP in terms of elaboration, with a greater amount of relevant information to enable the implementation of activities focused on solid waste management.

Results And Discussion

Validation of the indicator matrix with the Delphi Method

The indicator matrix and its respective descriptors are presented in Table 3, according to the dimensions considered in the research, as well as the scores and weights assigned by the specialists. The use of the Delphi Method presented an adhesion rate equal to 70.87%, it is believed that the return of more than half of the answers was due to the quality of the questionnaire preparation, resulting in quick and easy to fill out documents.

Table 3
Description of the matrix of indicators, descriptors and dimensions (Authors 2022)

PI Dimension	Symbols	Dimension Weight PI	17,06
Indicators		Descriptors	Notes
Degree of structuring of MSW management in the municipal public administration	PI1	Non-existence of the specific sector.	1
		Existence of the specific sector, but not structured.	3
		Existence of the structured specific sector	5
Degree of training of employees working in MSW management	PI2	No employee of the MSW sector has received specific training.	1
		Only part of the employees of the MSW sector received specific training.	3
		All MSW sector employees received specific training	5
Existence of specific legislation for MSW management in the municipality	PI3	Yes	5
		No	1
Existence of information on MSW management systematized and made available to the population	PI4	Information on MSW management is not systematized.	1
		The information about MSW management is systematized, but not accessible to the population.	3
		Information on MSW management is systematized and proactively disseminated to the population.	5
Society participation in MSW management	PI5	Yes	5
		No	1
Participation in consortiums	PI6	Yes	5
		It has feasibility studies for the realization of consortiums	3
		No	2
TO Dimension		Dimension Weight TO	13,44
Indicators		Descriptors	Notes
Introduces inspection of public cleaning services	T01	Throughout the municipality.	4
		Only in the city center.	4
		No inspection	2
Use of local labor	T02	In all phases of solid waste management.	5
		In collection and administration.	4
		Only in collection	3
Use of Personal Protective Equipment by MSW employees	T03	In all phases of solid waste management.	5
		In collection and administration.	4
		Only in the collection	2
The maintenance of the equipment is done locally	T04	In all phases of solid waste management.	5
		Transportation only.	4

PI Dimension	Symbols	Dimension Weight PI	17,06
		External maintenance	2
Existence of a system for evaluating the quality of service provided by managers?	T05	Yes	5
		No	2
EF Dimension		Dimension Weight EF	14,93
Indicators		Descriptors	Notes
Source of resources for solid waste	FE1	There is a specific fee for the public cleaning service.	5
		Collection of the tax along with urban property tax (IPTU).	4
		No charge for this service	2
% Of the municipal budget allocated to public cleaning services and MSW management	FE2	0–5%	3
		5,1–10%	4
		> 10%	5
Application of resources from selective collection	FE3	In the maintenance of selective collection itself.	4
		Socio-cultural and welfare activities	5
		Other	3
EE Dimension		Dimension Weight EE	16,52
Indicators		Descriptors	Notes
Satisfaction of the population in relation to public collection (periodicity/ frequency and time)	EE1	> 70%	5
		30 a 70%	3
		< 30%	2
Existence of public garbage cans	EE2	In all urban areas installed in places where people circulate.	4
		Only in the city center.	3
		It does not have a trash can	2
Existence of selective collection in the municipality	EE3	Yes	5
		Under implementation	4
		No	2
Scope of selective collection in the municipality	EE4	The whole municipality	5
		The entire urban area of the municipality.	4
		Exclusively in some neighborhoods in the urban area.	3
Existence of Voluntary Delivery Points for segregated waste	EE5	Serves more than 50% of the population	4
		Serves less than 50% of the population	3
		Does not have	2
Recovery of recyclable materials	EE6	Above 30%	4
		Between 5.1% and 30%.	3
		Up to 5%.	2

PI Dimension	Symbols	Dimension Weight PI	17,06
Recovery of organic waste	EE7	Above 30%	4
		Between 5.1% and 30%.	2
		Up to 5%.	1
Annual per capita generation of urban solid waste (kg/inhab.year)	EE8	< 307	4
		Between 307 and 376	3
		> 376	2
Existence of licensed sanitary landfill / controlled landfill	EE9	Yes	5
		In licensing process	5
		Unlicensed or dump	1
Existence of reclamation of areas degraded by waste	EE10	Totally	5
		Partially	5
		Absent	1
Degree of implementation of the measures foreseen in the licensing of MSW- related activities	EE11	Non-existence of environmental licensing.	1
		Environmental licensing carried out, but the measures have not been fully implemented.	3
		Environmental licensing carried out and measures fully implemented	5
Existence of sorting and composting centers	EE12	Yes	5
		No	2
KEE Dimension		Dimension Weight KEE	17,61
Indicators		Descriptors	Notes
Resources allocated for environmental education actions	KEE1	≥ 3%	5
		1 a 2,9%	4
		< 1%	1
Periodicity of environmental education actions	KEE2	Annual	5
		Sporadic	4
		There are no actions	1
Existence of environmental mobilization/awareness actions	KEE3	Participatory planning	5
		Informative meetings	4
		No	1
Existence of partnerships (associates, universities, private sector, social movements)	KEE4	Two or more	5
		Less than two	3
		It does not	1
Existence of councils (sanitation, health and environment)	KEE5	Sanitation Council	5
		Another	3
		It does not	2
IS Dimension		Dimension Weight IS	11,74

PI Dimension	Symbols	Dimension Weight PI	17,06
Indicators		Descriptors	Notes
Existence of organized waste pickers	IS1	All organized	4
		Part organized	3
		Presence of waste pickers in the final disposal area	2
Scope of the training courses provided to the waste pickers	IS2	> 90%	4
		50–90%	3
		< 50%	2
Salubrity of the waste pickers' workplace	IS3	Contemplates all items	4
		PPE and restroom only	2
		Absence	1
Partnership of the public power with the waste pickers in the separation of waste to support or guide municipal policies	IS4	Yes	5
		No	1
People with the ability to use post-consumer waste as a source of income (Collectors, craftsmen, etc.)	IS5	Organized in cooperatives or associations with fixed income.	4
		Organized in cooperatives or associations with no fixed income.	2
		Non-existent	1
People active in the waste chain who have access or orientation defined in municipal public policy	IS6	Existence of a municipal program to support the collectors with a formal agreement.	4
		Existence of a municipal program to support the collectors without a formal agreement.	2
		Non-existence of a municipal public policy to support the collectors.	1
Dimension C		Weight Of Dimension C	8,69
Indicators		Descriptors	Notes
Variation of MSW generation per capita	C1	Rate of change > 1	2
		Rate of change = 1	3
		Rate of change < 1	5
Effectiveness of ongoing educational programs focused on best practices in MSW management	C2	Non-existence of educational programs.	1
		Existence of continuous educational programs, but with low involvement of the population.	3
		Existence of continuous educational programs with high involvement of the population.	5
Effectiveness of activities to multiply good practices in relation to MSW	C3	Lack of dissemination of good management practices of MSW or their inexistence.	1
		Little effective dissemination of best MSW management practices.	3
		Effective dissemination of best practices in MSW management, including replication of the same	5

A total of 127 panelists were selected, considering that the EE, KEE and C dimensions needed 2 rounds to obtain consensus among the participants. The PI, TO/EF and IS dimensions obtained consensus in the first round, so it is assumed that the players involved in these dimensions were able to influence the answers through information exchange, clarification of doubts or because they work in the same environment. In total, there was a total loss equal to 29.13% of panelists between the two rounds, with the participation of 90 panelists.

Over this period of approximately 10 months, the IS dimension did not return any questionnaires. To get around this situation, it was necessary to contact an employee of the City Hall of Belém and an employee of the City Hall of the Campus of the Federal University of Pará, in order to mediate the obtaining of the answers by the representatives of some cooperatives located in the Metropolitan Region of Belém, since both employees knew the difficulties and obstacles for the participation of the representatives of cooperatives in academic research. Thus, 12 cooperatives were contacted, but only 8 cooperatives volunteered to participate in the research, by e-mail, during the period from February 10th to February 21st, 2021, to send and return the answers.

By ordering the degree of importance of the dimensions, it was found that the KEE dimension was considered by panelists as being the most relevant, given the conditions represented by its indicators, which are directly linked to planning issues, which justifies the PI dimension being considered the second most important, since it is characterized as the guiding basis in the management process. Next are the dimensions EE, EF and TO, focused more on the feasibility of implementing planning activities, with regard to the transfer of financial resources, properly qualified technical staff, practices and monitoring of environmental education activities.

Finally, dimensions IS and C were those that obtained the lowest weights among the others. This does not imply that they are unimportant in the waste management process, but rather that the priorities portrayed by the panelists are focused more on issues of planning and operation of activities. It is worth noting that the insertion of waste pickers in waste management is relatively recent, established by the NPSW (BRASIL 2010) and consequently, still needs many efforts by society and the government to ensure due recognition.

QISWMP mathematical results

After the matrix validation and analysis of the IMSWMP, it was possible to assign scores to each indicator (Table 4), and the number of notes assigned is related to the number of indicators in each dimension, being separated by "/". For example, in the PI dimension there are 6 indicators, so for the municipality of Abaetetuba, indicators PI1, PI2, PI3 and PI5 received a score of 5; indicator PI4 received a score of 1 and indicator PI6 received a score of 2.

Table 4
Grades established for the indicators by dimension for each municipality (Authors 2022)

Dimensions	Abaetetuba	Abel Figueiredo	Acará	Augusto Correa
PI	5/5/5/1/5/2	5/1/1/1/1/2	1/1/1/1/1/2	5/5/5/1/5/2
TO	2/3/2/5/2	4/3/2/2/2	2/3/2/2/2	2/3/5/2/2
EF	5/5/3	2/3/3	2/3/3	2/5/3
EE	2/4/2/3/2/2/1/2/1/1/1/5	2/4/2/2/3/2/2/4/1/1/1/2	2/2/2/3/2/2/1/2/1/1/1/2	2/4/2/2/3/2/2/4/2/1/1/1
KEE	1/1/1/5/2	1/1/1/1/2	1/1/1/1/2	5/1/1/5/5
IS	4/2/1/1/1/4	2/2/1/1/1/1	2/2/1/1/1/1	2/2/1/1/1/1
C	5/1/1	2/1/1	2/1/1	5/1/1
Dimensions	Aurora Do Pará	Barcarena	Bonito	Canaã Dos Carajás
PI	5/1/5/1/5/2	5/5/5/1/5/2	5/5/1/1/5/2	5/5/1/1/5/2
TO	2/3/2/2/2	2/3/5/2/2	4/5/2/2/5	2/5/2/2/2
EF	2/5/3	2/3/3	5/3/3	5/5/3
EE	2/2/2/3/2/1/2/1/1/1/2/1	2/2/2/3/2/2/1/4/1/1/1/2	2/4/2/3/2/2/1/4/1/1/1/2	2/4/2/3/2/4/4/4/1/1/1/2
KEE	1/1/1/2/2	1/1/1/5/5	1/1/5/5/5	1/5/1/1/2
IS	2/1/1/1/1/2	2/2/1/1/1/1	2/2/1/1/4/1	2/2/1/1/1/1
C	1/1/1	5/1/1	2/5/5	2/1/1
Dimensions	Capanema	Colares	Concordia Do Pará	Curuçá
PI	5/5/5/1/5/2	5/5/5/1/5/2	5/1/5/1/5/2	5/1/5/1/5/2
TO	4/5/2/2/2	4/3/5/2/2	4/3/5/2/2	2/3/2/2/2
EF	5/5/3	2/3/3	2/3/3	2/5/3
EE	2/4/2/3/2/4/4/4/1/5/1/5	2/4/2/3/2/2/1/4/1/1/1/2	2/4/5/3/2/2/1/4/1/1/1/2	2/2/5/3/2/4/4/4/1/1/1/2
KEE	1/5/5/5/4	1/5/5/1/2	1/1/1/5/2	1/1/1/1/5
IS	4/1/1/4/1/4	2/2/1/1/1/1	2/1/1/1/1/4	2/2/1/1/1/1
C	2/1/1	2/1/1	2/1/1	2/1/1
Dimensions	Goianesia Do Pará	Inhangapi	Juruti	Muaná
PI	5/5/5/1/5/2	5/5/1/1/5/2	5/5/5/1/5/2	5/1/5/1/5/2
TO	4/3/5/2/2	4/3/5/2/5	4/3/5/2/2	2/3/5/2/5
EF	2/5/5	2/5/3	2/5/3	2/5/3
EE	2/4/5/5/2/4/1/4/1/1/1/5	2/2/5/3/2/4/4/4/1/1/1/2	2/4/2/3/2/2/1/4/1/1/1/2	2/4/2/3/2/2/1/4/1/1/1/2
KEE	1/5/1/5/5	1/5/1/5/5	1/5/1/5/5	1/1/1/1/2
IS	2/2/1/1/1/4	5/2/2/1/1/1	2/2/2/1/1/4	2/2/2/1/1/1
C	2/1/1	2/1/1	5/1/1	2/1/1

With the indicator scores already established, it was possible to calculate the values of the dimensions and the QISWMP for each municipality through the product between the dimensions and the weights obtained by the Delphi Method, as presented in Table 5.

Table 5
Values of the dimensions and QISWMP based on the IMSWMP evaluation (Authors 2022)

Municipality	Dimensions Value							QISWMP
	PI	TO	EF	EE	KEE	IS	C	
Abaetetuba	3,83	2,80	4,33	2,17	2,00	2,17	2,33	2,84
Abel Figueiredo	1,83	2,60	2,67	2,17	1,20	1,33	1,33	1,90
Acará	1,17	2,20	2,67	1,75	1,20	1,33	1,33	1,67
Augusto Correa	3,83	2,80	3,33	2,17	3,40	1,33	2,33	2,84
Aurora do Pará	3,17	2,20	3,33	1,67	1,40	1,33	1,00	2,10
Barcarena	3,83	2,80	2,67	1,92	2,60	1,33	2,33	2,56
Bonito	3,17	3,60	3,67	2,08	3,40	1,83	4,00	3,08
Canaã dos Carajás	3,17	2,60	4,33	2,50	2,00	1,33	1,33	2,57
Capanema	3,83	3,00	4,33	3,08	4,00	2,50	1,33	3,33
Colares	3,83	3,20	2,67	2,08	2,80	1,33	1,33	2,59
Concórdia do Pará	3,17	3,20	2,67	2,33	2,00	1,67	1,33	2,42
Curuçá	3,17	2,20	3,33	2,58	1,80	1,33	1,33	2,35
Goianésia do Pará	3,83	3,20	4,00	2,92	3,40	1,83	1,33	3,09
Inhangapi	3,17	3,80	3,33	2,58	3,40	2,00	1,33	2,93
Juruti	3,83	3,20	3,33	2,08	3,40	2,00	2,33	2,96
Muaná	3,17	3,40	3,33	2,08	1,20	1,50	1,33	2,34

It is worth noting that the municipalities with higher values of the calculated index represented more consolidated IMSWMP or with greater prominence in terms of the presentation of information regarding the description of the reality of the local management of MSW; whereas the lowest values of the index indicated that the IMSWMP contain little or no information on local management, prevailing the presence of theoretical data, without explicitness of the real conditions of the municipality and difficulties in the systematization and monitoring of information on MSW Costa and Pugliesi (2018), being characterized as materials of little support for the implementation of activities focused on this sector.

The maximum value of the index to be reached if all the items of the matrix of 40 indicators were met would be equal to 4.8. In terms of quality in the elaboration of the IMSWMP, the areas that still need more investments to guarantee improvements regarding the presence of information in the body of their text are: Acará and Abel Figueiredo, represented by the lowest indexes in the graph, therefore these plans do not represent the realities of municipal management practices. The areas with the highest indices are: Goianésia do Pará and Abel Figueiredo: Goianésia do Pará and Capanema, which can be justified by the concern of the large lumber and mining companies installed in these areas to carry out the proper management of solid waste generated in the municipalities in partnership with the public authorities and the local population, as a mitigating measure of the impacts caused by the environmental degradation processes of their activities.

After the calculations presented in Table 5, it was possible to prepare the radar diagram to identify the dimensions that need improvement in the IMSWMP (Fig. 2), that is, the dimensions with the highest number of indicators with bad or regular scores. In addition, it was also possible to notice the dimensions with the highest number of indicators with good, excellent or excellent grades. It is noteworthy that the larger areas of the polygons generated indicate the dimensions with better conditions, while the smaller areas emphasize the dimensions that need adjustments to improve the quality of IMSWMP elaboration.

In Fig. 2, it was possible to identify that the Social Inclusion dimension needs improvements in IMSWMP, especially in relation to the development of public policies aimed at encouraging waste pickers, affirming the result obtained by Ramos (2013). There is still much to be done in the context of improvements in the work qualities of these individuals, since the NPSW brings this requirement; however,

the municipalities still have notorious difficulties to ensure support for the collectors and their relocation from dumps to associations or cooperatives. This fact does not depend only on the development of public policies, but demands high costs to ensure the necessary structure for the dignity of these workers.

The Economic/Financial dimension stood out in terms of the scores given to its indicators, very close to the Political/Institutional dimension. Some municipalities presented budgetary information well explained or present in their IMSWMP, while others showed more attention as to the presence of information focused on the institutional and legal framework of solid waste management. It is worth emphasizing that the quality of the elaboration of the IMSWMP considered the presence of information in the documents and not necessarily the fulfillment of the indicators in the management practice.

The results found for small municipalities resembled those described in the research of Chaves et al. (2020), related to problems in as much as the participation of the population in management processes is concerned, to monitoring and review mechanisms for IMSWMP, as well as to assistance in the development of waste picker cooperatives or associations. Furthermore, in this study's analysis of IMSWMP, a problem was perceived in the origin of resources applied to MSW management and the amount of the municipal budget allocated to management services, hindering the performance of basic tasks such as urban cleaning and the planning of the necessary good practice actions.

The results found for medium sized municipalities were also similar to those described in the research of Chaves et al. (2020), related to difficulties in the preparation of studies for consortium solutions and the presentation of mechanisms to monitor and evaluate the indicators of the services. This is due to the lack of interest or the population's greater resistance as to the insertion of new habits in their daily lives to improve the management of the waste generated, the lack of interest of the Public Authorities in carrying out activities focused on this sector due to the barriers to be faced in this process, the lack of professionals trained for this demand or the lack of financial resources/materials to make these activities feasible.

In this sense, Polaz and Teixeira (2009) state that although this is not an easy task, in small and medium sized municipalities there is an urgent need for the intervention of the Public Authorities in their several spheres, to ensure the implementation of programs and tools to improve solid waste management, in addition to the need to prepare public policies planned for the long term, so as to ensure the sustainability of the management of these materials. The translation of these results is able to assist managers in the decision-making process, identifying more clearly which aspects need to be improved and consequently which actions and activities should be carried out, considering the limitations of each municipality.

Conclusions

The IMSWMP are essential decision-making tools and help to understand the peculiarities of the municipalities and their limitations in terms of achieving the indicators of the proposed matrix. However, the change in the people responsible for MSW management caused by political elections is a serious problem for the continuation of proposals and activities consolidated in the previous administration, where priorities may be altered, making it difficult or postponing the implementation of necessary actions for improvements in environmental quality and the health of the population.

It is noteworthy the difficulty to obtain the IMSWMP in this research, which should be made available by the municipalities, in addition, only 12.5% of the municipalities of Pará have prepared and granted their plans to SEDOP; the municipalities that have plans and were not considered in this work, did not submit their documents to SEDOP and neither made available on the pages of the environmental secretariats or municipalities. It is important to note that the research matrix is subject to adaptations, but applicable to any municipality considering the reality described in the IMSWMP, which will reflect in a particular condition of the analyzed indicator.

The mentioned barriers make it difficult to comply with the indicators that are present in the matrix under study, given that municipal limitations are not taken into account when preparing federal public policies and there are divergences between what is required and what localities are capable of accomplishing. Therefore, it becomes necessary for municipal governments to consider the relevance of preparing their plans, not only because of legal requirements, but to ensure the beginning or advancement in terms of improvements in MSW management, ensuring quality of life and environmental balance through more responsible and interconnected governments.

Declarations

Statements and Declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Figures

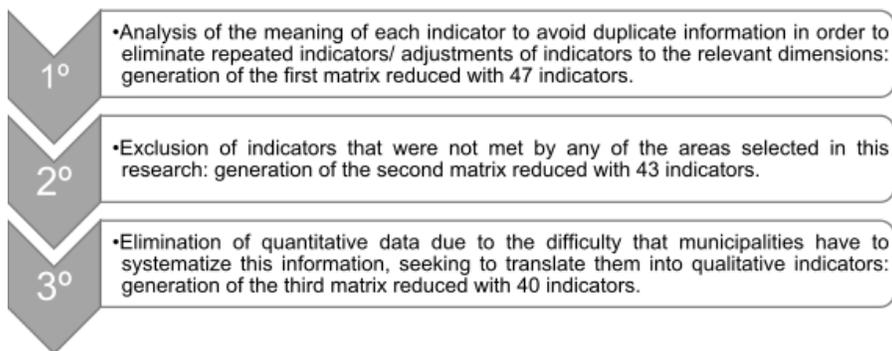


Figure 1

Steps for selecting the indicators to compose the Matrix (Authors 2022)

PI TO EF EE KEE IS C

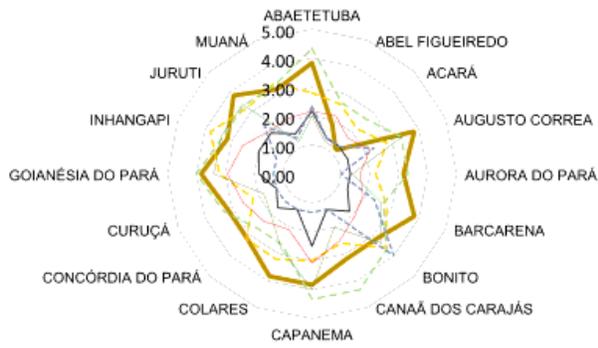


Figure 2

Radar diagram of the dimensions under study by municipality (Authors 2022).