

Actions and policy tools for local governments to achieve integrated sustainable waste management

Ações e ferramentas políticas para governos locais alcançarem a gestão integrada sustentável de resíduos sólidos

Valdir Eduardo Olivo¹ , Pedro Domingos Marques Prietto¹ , Eduardo Pavan Korf² 

ABSTRACT

Integrated management of municipal solid waste seeks sustainability under the premises of environmental protection, health promotion, and economic development. In this context, this article proposes actions and policy tools for local governments to improve quality and governance in waste management. A set of 23 actions is proposed based on existing conceptual models and available legislation. The results are presented in three levels as follows: planning of the administrative and operational structure, waste management, and performance evaluation. The results showed that the proposed actions need to be implemented through policy tools, such as municipal legislation, social communication, normative instructions, and technical studies. The applicability of the proposed methodology, which might be replicated in any municipality to increase the efficiency of the waste management system, was positively evaluated in a medium-sized Brazilian city, which presented an overall attendance level of 52%.

Keywords: public management; sustainability; governance; municipal solid waste.

RESUMO

A gestão integrada de resíduos sólidos urbanos busca a sustentabilidade sob as premissas da proteção ambiental, promoção da saúde e desenvolvimento econômico. Nesse contexto, o presente artigo propõe ações e ferramentas políticas para os governos locais melhorarem a qualidade e a governança na gestão de resíduos. Um conjunto de 23 ações é proposto com base em modelos conceituais existentes e legislação disponível. Os resultados são apresentados em três níveis: planejamento da estrutura administrativa e operacional, gestão de resíduos e avaliação de desempenho. Os resultados mostraram que as ações propostas precisam ser implementadas por meio de ferramentas de política, como legislação municipal, comunicação social, instruções normativas e estudos técnicos. A aplicabilidade da metodologia proposta pode ser replicada em qualquer município para aumentar a eficiência do sistema de gestão de resíduos e foi avaliada positivamente em uma cidade brasileira de médio porte, que apresentou um índice geral de atendimento de 52%.

Palavras-chave: gestão pública; sustentabilidade; governança; resíduos sólidos urbanos.

¹Engineering Department, Universidade de Passo Fundo – São José (RS), Brazil.

²Engineering Department, Universidade Federal Fronteira Sul – Chapecó (SC), Brazil.

Correspondence address: Valdir Eduardo Olivo – Rua Equador, 313 D – CEP: 89805-211 – Chapecó (SC), Brazil. E-mail: eduardo@baseamb.com.br

Conflicts of interest: the authors declare that there are no conflicts of interest.

Funding: none.

Received on: 11/03/2020. Accepted on: 06/10/2021.

<https://doi.org/10.5327/Z21769478968>



This is an open access article distributed under the terms of the Creative Commons license.

Introduction

Waste management is one of the essential public services and is considered a “basic human right.” If not properly provided, it represents a threat to public health and the environment (UNEP, 2015). Most municipalities in underdeveloped and developing countries face significant challenges in waste management, mainly regarding the implementation of sustainable practices, due to the economic and technological limitations and the lack of trained staff, which causes fragility in the system’s operation, particularly in smaller cities (Marino et al., 2018; Deus et al., 2020).

Integrated management is being widely adopted by municipalities to properly handle local waste (Asefi and Lim, 2017). This system allows the municipalities to adapt to the existing norms, guaranteeing physical structure, economic sustainability, and social responsibility. It includes the physical elements of the system, the interested parties, encompassing the technical, environmental, financial, sociocultural, institutional, and political dimensions (Van De Klundert and Anschutz, 2001).

The Integrated Sustainable Waste Management (ISWM) conceptual model has four main objectives as follows: the promotion of health and well-being of the entire population, the protection of the environment and the guarantee of sustainability, the promotion of efficiency and productivity in the economy, and the generation of jobs and income (Schübeler, 1996). This model is widely discussed at a conceptual level (Schübeler, 1996; Van De Klundert, 1999; Mwangi and Thuo, 2014). However, there is a lack of studies that address practical actions to be taken by government officials to meet ISWM requirements (Marino et al., 2018).

The integrated urban solid waste management system is divided into three steps as follows: planning, management, and evaluation (Figure 1), with each stage having axes of actions for the integrated management (Schübeler, 1996; Van De Klundert and Anschutz, 2001; Mwangi and Thuo, 2014).

The purpose of this article is therefore to present a set of actions and tools for the local government to achieve integrated solid waste management. Thus, municipalities can implement an integrated management system through these actions. They are based on the principles of sustainability, current legislation, and the local capacity of the municipalities. The actions can be applied to all municipalities that

need technical guidance to implement this management system, enabling managers to increase local sustainability by reducing environmental impacts, minimizing operating expenses, and engaging society.

This study was conducted on the medium-sized municipalities with a population between 100,000 and 250,000 inhabitants, and Brazil has 172 cities with this population (Brazil, 2019). Due to the great relevance in the economic market and for becoming a regional pole for services and infrastructure, these municipalities have high growth potential, thus requiring the planning of actions aimed at sanitation.

Methodology

The research was conducted initially through a systematic review and performed in two steps as follows: the first one comprised three database searches using the key words relevant to the research and the analyses of selected articles and documents from the database search (Figure 2).

Initially, a search for national legislation regarding the management of solid waste was carried out. The research took place on the legislation portal of the Brazilian federal government and identified 24 legislations on the subject, in the period between 2001 and 2021. Eight federal laws were selected, which served as a legal basis for this work. After, a systematic literature review was realized to this article. ScienceDirect and Scopus databases were consulted using three search criteria as follows: all types of articles, time interval from 2011 to 2021, and the following key-word associations: “municipal solid waste” and “policy tools,” “guidelines” and “municipal solid waste” and “policy tools,” and “municipal solid waste” and “integrated management.”

A total of 448 articles were identified and selected by the abstract reading, and 29 were selected for the in-depth discussion for this study.

The guidelines were defined based on the analysis of the 29 articles. From these, actions and policy tools to ISWM were selected.

The municipality of Chapeco (SC), Brazil, was selected to assess the conditions of applicability of the study. The municipality presented an excellent performance in waste management in 2018 (Brazil, 2019).

Actions and policy tools to implement ISWM

The actions and tools were established for each of the axes and were based on the principles of sustainable management (Van De Klundert and Anschutz, 2001) and on the legislation available at the national level (Brazil, 2007, 2010).

Each ISWM area of activity generated a set of practical actions that the local government must adopt to achieve sustainable management. The vast majority of actions are based on structuring legal support through standardization and inspection, social mobilization, technical studies, increasing physical structure, and projects to minimize environmental impacts.

Several authors approached the ISWM as a methodological alternative to improve the municipal management system. These practices were observed in studies conducted by Dutra et al. (2018), Fuss et al. (2018), and Marino et al. (2018).

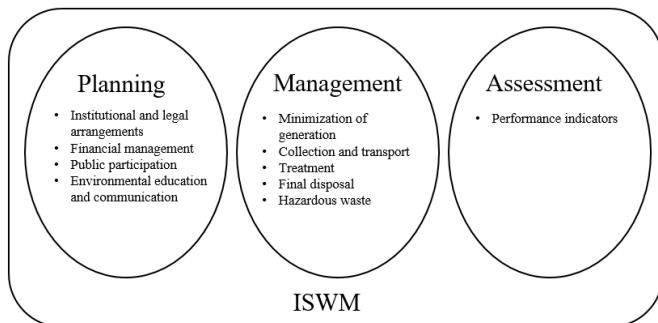


Figure 1 – The ISWM system.

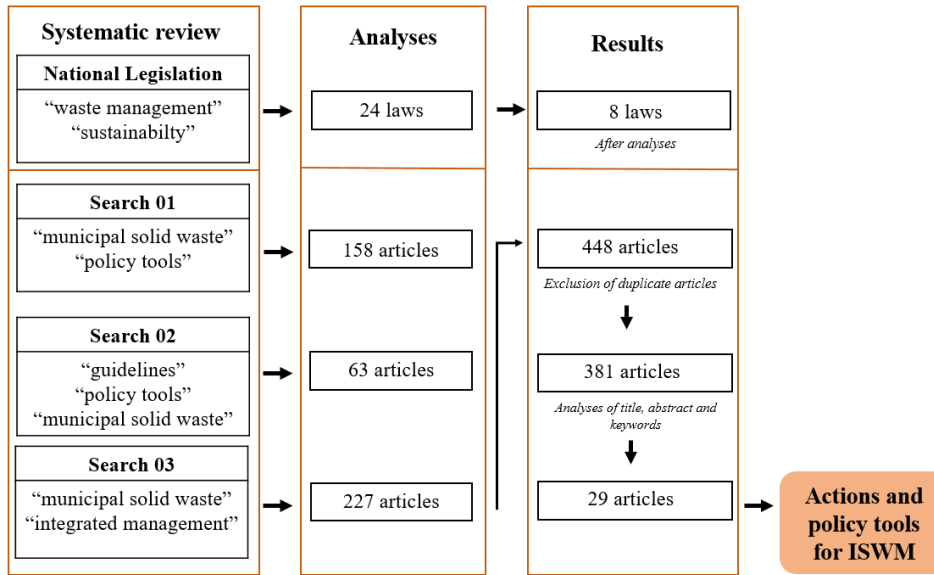


Figure 2 – Methodology.

Step 1: Planning

The first step in starting a municipal management system is to develop adequate planning based on the current situation of local governance. Planning must involve institutional, legal, financial, and social aspects. Table 1 shows the government actions proposed for this step. The letter "P" was assigned to establish a relationship between the action and the step it refers to. It is also presented the necessary tool for the action implementation.

In waste management planning, communication must involve all levels of government and stakeholders (Kaza et al., 2018). The basis of a management system occurs through the development of sound public policies that guarantee the availability and continuity of services. Government actions in the institutional and legal aspects emphasize the importance of drafting the Brazilian Policy on Solid Waste (BPSW). In Brazil, this policy is provided in federal laws. ISWM will contemplate all the actions present in this article. The plan will serve as a base document for government officials and should be implemented through municipal law (i.e., actions P.1 and P.2).

According to Marino et al. (2018), the biggest problems of planning public management in the area of solid waste are related to the technical and operational incapacity of local governments. Low- and middle-income countries find it difficult to achieve adequate management due to poor sector planning (Kaza et al., 2018). Therefore, the creation of a municipal public cleaning department with a qualified technical staff guarantees responsible execution of planned actions, monitoring and implementation of plans, contract management, technical studies, standardization, inspection, and social mobilization (i.e., actions P.3–P.5).

The local government team should prepare normative manuals and instructions that involve, for example, guidance for minimizing waste generation, segregation at source, encouraging home reduction and reuse of waste, the requirements for waste management plans, the licensing of potentially polluting activities, and the standardization of waste disposal facilities (i.e., action P.6). As provided in the Brazilian Policy on Basic Sanitation (BPBS), the local government should promote sectoral agreements to reach reverse logistics among the parties involved, guaranteeing participation at all levels (i.e., action P.7; Brazil, 2010).

The inclusion of waste pickers in integrated management (i.e., action P.8) is foreseen in the BPSW (Brazil, 2010). The municipality should encourage the establishment of cooperatives so that waste pickers can work in an organized and wholesome environment, yet provide subsidies and technical partnership to support the structuring of sorting spaces (Fidelis et al., 2020; Siman et al., 2020).

According to Schübeler (1996), ISWM provides priority assistance to the needy population and vulnerable areas at risk. A detailed study of these areas must be prepared and instituted in municipal legislation to guarantee the care of this population (i.e., action P.9).

The structure of a management system must contain legal support to guarantee the execution and continuity of actions. The single legislation can facilitate the understanding of users (e.g., municipal code for urban cleaning; action P.10). The code will provide guidance on the segregation of waste, the responsibilities of each user, the service charge, the inspection process, penalties, and tax incentives (Kaza et al., 2018). According to Fernando (2019), for the effectiveness of local regulations, the punishment process must be provided for cases of noncompliance with local guidelines.

To standardize and supervise the provision of basic sanitation services (Brazil, 2010), the BPSW determines the adhesion of municipalities to regulatory agencies (i.e., action P.11).

The financial area of management proposes to standardize and make the financial issues of the local government feasible. The government should implement a program of continuous assessment of the management system, allowing the assessment of available technologies and the necessary instruments to match financial availability and to achieve greater efficiency (Asian Development Bank, 2017). The preparation of a detailed economic feasibility study will assess the financial deficiencies and deficits in the operational area (i.e., collection, transportation, treatment, and disposal; action P.12).

Public services must be sustainable (Bartolacci et al., 2018); therefore, charging of the waste collection tariff (i.e., action P.13) is a determining factor for the functioning of the solid waste management system (Brazil, 2010). The charging can be carried out through a fixed tariff or as a function of the amount of waste generated (Welivita et al., 2015). However, the fixed tariff does not encourage the population to minimize the generation of waste (Chung and Yeung, 2019). It is recommended that the best alternative be evaluated and chosen according to the technologies available to the municipality.

According to Xu et al. (2018), there are two ways to engage the population in the waste segregation at source as follows: through intensive environmental education and through financial incentives. The local government can institute financial support legislation for users who

Table 1 – Actions and policy tools for ISWM planning.

Government actions	Policy tools
Planning – institutional and legal arrangements	
P.1) Implement the municipal policy of basic sanitation	Municipal law
P.2) Implement the municipal plan for integrated solid waste management	Municipal law
P.3) Create the municipal department responsible for waste management	Municipal law
P.4) Encourage employee participation in waste management training	Social communication
P.5) Network with municipalities with similar characteristics	Social communication
P.6) Establish operational procedures for the management plan, considering all types of waste	Normative instruction
P.7) Promote sectoral agreements between the parties involved and guarantee reverse logistics	Social communication
P.8) Include recyclable material collectors in the integrated management	Municipal law
P.9) Define priority areas and actions for social inclusion	Municipal law
P.10) Implement the municipal code of urban cleaning	Municipal law
P.11) Join a regulatory agency to monitor contracts and tariffs	Municipal law
Planning – financial management	
P.12) Prepare technical–economic feasibility study in all operational sectors	Technical study
P.13) Institute the collection of services	Municipal law
P.14) Stimulate the creation of management consortia and public–private partnerships	Social communication
P.15) Establish norms for participation in transparent bidding processes, guaranteeing publication in user access channels	Normative instruction
P.16) Create incentive programs for companies in the waste area	Municipal law
P.17) Seek external financing for new investments	Technical study
P.18) Institute a tax incentive and certification program for companies that adopt environmental responsibility regarding their waste	Municipal law
Planning – public participation and environmental education	
P.19) Create an environmental education program ensuring the minimization of waste generation	Technical study
P.20) Increase social communication through social media, newspapers, and television	Social communication
P.21) Develop training courses for users for proper waste management	Technical study
P.22) Promote local events and discussion forums focused on waste management	Social communication
P.23) Establish partnerships with universities for research, technological development, and innovation	Social communication

adopt good waste management practices and contribute to local management. Companies engaged in the proper management of waste must be recognized and encouraged. An environmental certification and tax incentive programs are recommended for companies that contribute to the proper management of waste (i.e., action P.18).

Public participation is an important aspect to be considered and must be guaranteed through an active environmental education program. In addition to adequate social communication to transmit information, guidance, and recommendations to users of the system (i.e., actions P.19 and P.20), environmental education should primarily target organized groups and schools, to which information will be disseminated. The user must be provided with training courses for the proper handling of waste (i.e., action P.21). Environmental education for solid waste must be included in the public education curriculum for all levels (Fernando, 2019).

The municipality must encourage and hold debates, discussion forums, and local events that allow the exchange of experiences, information, and knowledge for waste management (i.e., action P.22). Local universities can develop research projects to solve local problems with waste management (i.e., action P.23).

Step 2: Management

The management step addresses the operational aspects of the process. In this step, all operational tasks previously defined and institutionalized are carried out (Table 2).

Minimizing generation is the first axis of the waste management hierarchy (UNEP, 2005). This topic must be worked on with appropriate public policies and an intense process of environmental education. Decentralized composting is an example of minimizing waste for conventional collection. In addition to the economic benefits, the user will obtain a compound to be used at their residence. The government might encourage the provision of domestic composters (i.e., action M.1).

Municipalities that adopt voluntary delivery points have higher recycling rates than others (Brazil, 2019). The green points are structures for concentrating the reception of previously segregated waste, ensuring greater efficiency in the recycling of materials and less waste (action M.2).

For workers in the waste area (e.g., collectors and drivers), continuous training should be carried out according to the demand of each sector (Fernando, 2019; action M.3). Also, individual safety equipment (i.e., action M.4) and adequate physical structure (i.e., action M.5) suitable for the development of activities must be available.

Differentiated collection for dry and wet waste (i.e., action M.6) is decisive for the engagement of the population, guaranteeing the quality of the recyclable material and the health and safety of workers.

The recovery of waste (i.e., action M.7) is the highlight of the process, since almost all waste is liable to treatment and reuse, thereby reducing the impacts on the environment. The waste that was treated as an environmental liability can be transformed into an asset for the local government if appropriate technologies are used. The proposal for a waste recovery park must contain the feasibility study for the sorting unit, the centralized composting of organic waste, the composting of green waste, the energy use of composting or incineration systems, the use of civil construction aggregates, the recycling of unserviceable items (e.g., furniture, mattresses, and other waste), and the recycling of electronics.

As for the final disposal of waste, measures to reduce impacts must be taken (i.e., action M.8), for example, the control of the exclusive destination of tailings for landfills, adequate treatment of leachate, and periodic inspection of the units. Controlled landfills and dumps must be closed and recovered in accordance with the NSWP (Brazil, 2010).

According to NSWP, large generators are responsible for the proper destination of waste (i.e., hazardous or nonhazardous; Brazil, 2007). Therefore, it is up to the local government to guarantee the inspection regarding the disposal of waste. For small generators, voluntary deliv-

Table 2 – Actions and policy tools for ISWM management.

Government actions	Policy tools
Management – minimization of waste generation	
M.1) Make domestic or community composters available to the population	Bidding process
Management – collection and transport	
M.2) Implement voluntary delivery points and green points for proper waste disposal	Bidding process
M.3) Promote training for waste workers	Social communication
M.4) Provide safety equipment for workers	Bidding process
M.5) Provide adequate work structure and equipment for workers	Bidding process
M.6) Establish differentiated collection for recyclables, organic, and tailings	Technical study
Management – waste treatment	
M.7) Study and enable the installation of a solid waste recovery park containing waste sorting and transformation units	Technical study
Management – final provision	
M.8) Carry out mitigating measures for the environmental impacts	Bidding process
Management – hazardous waste	
M.9) Implement hazardous waste disposal points for small generators and ensure supervision of large generators	Bidding process

ery points (i.e., action M.9) must be made available for waste classified as hazardous, which is not suited to reverse logistics.

Step 3: Assessment

The planning and management steps should be evaluated and revised periodically. Performance indicators are an important tool for analyzing the performance of the local government waste management system (Table 3).

The local government must constantly evaluate its management system through the use of performance indicators (i.e., action A.1; Zurbrugg et al., 2014). It is recommended to use indicators validated by the literature to assess the efficiency of the management system through information previously stored in a database. The sustainability indicators presented by Silva et al. (2019) are specific to small- and medium-sized municipalities and cover all areas of action of integrated management. These indicators must be evaluated at least once a year and can be compared with other municipalities with similar characteristics. Revisions and improvements must be made in case of the inefficiency of the system.

Applying ISWM in a medium-sized Brazilian municipality

The governmental action proposal was tested in a medium-sized municipality located in the southern region of Brazil. The municipality of Chapeco has 220,000 inhabitants and is located in the state of Santa Catarina (IBGE, 2020). The city stands out among small- and medium-sized municipalities due to adequate solid waste management (Brazil, 2019). Therefore, the application of this model can make the municipality a reference for others with similar characteristics in the dissemination of environmentally appropriate practices.

The applicability of the model of sustainable integrated management of solid urban waste for the municipality was evaluated (Table 4). The data collection related to local management was obtained through a questionnaire sent to the responsible sector of the local government. To identify the status of the current situation of the local management, a color traffic code was used for each action. The green color represents full service (i.e., actions taken or in progress), the yellow color represents partial service (i.e., actions started and not finished or actions suspended), and the red color represents no service (i.e., actions not implemented).

Among the 33 actions proposed, the municipality of Chapeco serves 17 actions (52%) with full service, 8 actions (24%) with partial service, and 8 actions (24%) without service. The biggest

challenges are related to the planning aspects due to the lack of standardization, the lack of technical studies to evaluate the operating conditions of the system, and the lack of incentive to develop new businesses and to strengthen existing companies. It is recommended that the municipality restructures its management system, starting with the update of the BPSW so that all the items in Table 4 will be covered. The planning stage is fundamental for the involvement of the parties and to guarantee the engagement of the local government.

The municipality must implement the actions provided in the BPSW using the tools presented. The municipality needs to establish the responsibilities of reverse logistics through municipal legislation to inspect these activities. The municipality may adopt measures for the inclusion of recyclable material collectors in the selective collection, in an organized and remunerated manner. The municipality will be able to prepare a feasibility study for all operational sectors involved in waste management; thus, it will be possible to assess the demand for interventions in the management model.

In this sense, the municipality will be able to encourage the creation of a consortium to manage waste management in an inter-municipal manner. Economic development can be expanded through specific programs for companies that value waste in their process.

As for the treatment of waste, the municipality should implement a differentiated collection system for the fraction to be used in composting. The municipality will also be able to set up a waste recovery center, ensuring maximum efficiency in sorting and making use of recyclable material.

Finally, from this analysis, it was possible to assess the municipality's level of sustainability in relation to integrated waste management. The municipality is recommended to adopt an action plan defining priority actions and the resource planning to apply them.

Conclusions

Integrated waste management must be based on the principles of sustainability and depends on the commitment of the local government to carry out the actions proposed in this article. For this, an analysis must be carried out to identify which measures can be adopted by each municipality according to their demands and socioeconomic characteristics. Planning is the first step at which the municipality must structure itself. Through sound public policies, the local government will obtain support to define the responsibili-

Table 3 – Actions and policy tools for ISWM assessment.

Government actions	Policy tools
Assessment – performance indicators	
A.1) Establish quality indicators to assess the efficiency of the municipal management system	Normative instruction

Table 4 – Assessment conditions of application of ISWM in the municipality of Chapeco.

Government actions	Situation
Planning	
P.1) Implement the municipal policy of basic sanitation	Green
P.2) Implement the municipal plan for integrated solid waste management	Green
P.3) Create municipal department responsible for waste management	Green
P.4) Encourage employee participation in waste management courses and training	Green
P.5) Network with municipalities with similar characteristics	Yellow
P.6) Establish operational procedures for the management plan (considering all types of waste)	Yellow
P.7) Promote sectoral agreements between the parties involved and guarantee reverse logistics	Red
P.8) Include recyclable material collectors in the integrated management	Red
P.9) Define priority areas and actions for social inclusion	Yellow
P.10) Implement the municipal code of urban cleaning	Yellow
P.11) Join a regulatory agency to monitor contracts and tariffs	Green
P.12) Prepare technical-economic feasibility study in all operational sectors	Red
P.13) Implement the collection of services	Green
P.14) Stimulate the creation of management consortia and public-private partnerships	Red
P.15) Establish norms for participation in transparent bidding processes, guaranteeing publication in user access channels	Red
P.16) Create incentive programs for companies in the waste area	Red
P.17) Seek external financing for new investments	Yellow
P.18) Implement a tax incentive and certification program for companies that adopt environmental responsibility with their waste	Yellow
P.19) Create an environmental education program ensuring the minimization of waste generation	Green
P.20) Increase social communication through social media, newspapers, and television	Green
P.21) Develop training courses for users for proper waste management	Green
P.22) Promote local events and discussion forums focused on waste management	Green
P.23) Establish partnerships with universities for research development	Green
Management	
M.1) Make domestic or community composters available to the population	Red
M.2) Implement voluntary delivery points and green points for proper waste disposal	Green
M.3) Promote training for waste workers	Green
M.4) Provide safety equipment for workers	Green
M.5) Provide adequate work structure and equipment for workers	Yellow
M.6) Establish differentiated collection for recyclables, organic, and tailings	Green
M.7) Study and enable the installation of a solid waste recovery park containing waste sorting and transformation units	Red
M.8) Carry out mitigating measures for the environmental impacts caused in the process	Green
M.9) Implement hazardous waste disposal points for small generators and ensure supervision of large generators	Green
Assessment	
A.1) Establish quality indicators to assess the efficiency of the municipal management system	Yellow

ties of each party involved. The proposed actions consider environmental, social, and economic aspects, through environmental education programs that promote the minimization of waste generation and the reduction of impacts on the environment, the valorization, and social inclusion of recyclable material collectors and economic development through the standardization of service provision.

Following the management step, the municipalities will carry out actions related to the operational part of the management system, complying with the technical, environmental, and legal requirements regarding the collection, transportation, treatment, and final disposal of solid waste, guaranteeing the service to all users, economic sustainability, and appropriate technologies for each activity.

For the management stage, the municipality must establish differentiated waste collection and implement waste collection points not served by conventional collection, physical structure of machines and equipment suitable for the operation of activities and training of the team.

It is recommended to evaluate the implemented integrated management system through the use of selected reference indicators for small- and medium-sized municipalities. Municipalities can consult

government reports to identify the data related to waste management, thereby establishing a benchmarking.

Finally, the study evaluated the conditions of applicability of the proposed methodology in the Brazilian city of Chapeco. The municipality can implement the actions proposed presenting an initial attendance of 52% of the proposed actions. It is recommended that the municipality should carry out a planning so that the other actions are adequate.

Contribution of authors:

Olivo, V.E.: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, and Writing – original draft; Prietto P.D.M.: Conceptualization, Validation, Formal analysis, Investigation, Resources, Project administration, and Review & Editing; Korf E.P.: Conceptualization, Validation, Formal analysis, Investigation, Visualization, Supervision, and Review.

References

- Asefi, H.; Lim, S., 2017. A novel multi-dimensional modelling approach to integrated municipal solid waste management. *Journal of Cleaner Production*, v. 166, 1131-1143. <https://doi.org/10.1016/j.jclepro.2017.08.061>.
- Asian Development Bank. 2017. Integrated solid waste management for local governments: a practical guide. Asian Development Bank, Manila, Philippines. <https://doi.org/10.22617/tim178662-2>.
- Bartolacci, F.; Paolini, A.; Quaranta, A.G.; Soverchia, M., 2018. Assessing factors that influence waste management financial sustainability. *Waste and Management*, v. 79, 571-579. <https://doi.org/10.1016/j.wasman.2018.07.050>.
- Brazil. 2007. Federal Law No. 11,445. Establishes national guidelines for basic sanitation (Accessed September 2, 2020) at: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/11445.htm.
- Brazil. 2010. Federal Law No. 12,305. Institutes the National Solid Waste Policy (Accessed September 1, 2020) at: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/112305.htm.
- Brazil. 2019. Ministério do Desenvolvimento. Diagnosis of urban solid waste management in 2018 (Accessed June 27, 2019) at: <http://www.snis.gov.br/diagnostico-anual-residuos-solidos/diagnostico-do-manejo-de-residuos-solidos-urbanos-2018>.
- Chung, W.; Yeung, I.M.H., 2019. Analysis of residents' choice of waste charge methods and willingness to pay amount for solid waste management in Hong Kong. *Waste and Management*, v. 96, 136-148. <https://doi.org/10.1016/j.wasman.2019.07.020>.
- Deus, R.M.; Mele, F.D.; Bezerra, B.S.; Battistelle, R.A.G., 2020. A municipal solid waste indicator for environmental impact: Assessment and identification of best management practices. *Journal of Cleaner Production*, v. 242, 118433. <https://doi.org/10.1016/j.jclepro.2019.118433>.
- Dutra, R.M.S.; Yamane, L.H.; Siman, R.R., 2018. Influence of the expansion of the selective collection in the sorting infrastructure of waste pickers' organizations: A case study of 16 Brazilian cities. *Waste Management*, v. 77, 50-58. <https://doi.org/10.1016/j.wasman.2018.05.009>.
- Fernando, R.L.S., 2019. Solid waste management of local governments in the Western Province of Sri Lanka: An implementation analysis. *Waste and Management*, v. 84, 194-203. <https://doi.org/10.1016/j.wasman.2018.11.030>.
- Fidelis, R.; Marco-Ferreira, A.; Antunes, L.C.; Komatsu, A.K., 2020. Socio-productive inclusion of scavengers in municipal solid waste management in Brazil: Practices, paradigms and future prospects. *Resources, Conservation and Recycling*, v. 154, 104594. <https://doi.org/10.1016/j.resconrec.2019.104594>.
- Fuss, M.; Barros, R.T.V.; Pogonietz, W.R., 2018. Designing a framework for municipal solid waste management towards sustainability in emerging economy countries - An application to a case study in Belo Horizonte (Brazil). *Journal of Cleaner Production*, v. 178, 655-664. <https://doi.org/10.1016/j.jclepro.2018.01.051>.
- Instituto Brasileiro de Geografia e Estatística – IBGE. 2020. Projection of the population of Brazil and of the federation units (Accessed June 5, 2020) at: <http://www.ibge.gov.br/apps/populacao/projecao/index.html>.
- Kaza, S.; Yao, L.C.; Bhada-Tata, P.; Van Woerden, F., 2018. What a Waste 2.0: a global snapshot of solid waste management to 2050 (Accessed June 1, 2020) at: <https://openknowledge.worldbank.org/handle/10986/30317>.
- Marino, A.L.; Chaves, G.L.D.; Santos Junior, J.L., 2018. Do Brazilian municipalities have the technical capacity to implement solid waste management at the local level? *Journal of Cleaner Production*, v. 188, 378-386. <https://doi.org/10.1016/j.jclepro.2018.03.311>.
- Mwangi, M.; Thuo, A., 2014. Towards conceptual and theoretical foundation for identifying problems, challenges and mechanisms for municipal waste management in developing countries. *International Journal of Innovation and Science Research*, v. 2, (2), 230-251.
- Schübeler, P.; Wehrle, K.; Christen, J., 1996. Conceptual framework for municipal solid waste management in low-income countries. Working Paper No. 9. Switzerland.
- Silva, L.; Prietto, P.D.M.; Korf, E.P., 2019. Sustainability indicators for urban solid waste management in large and medium-sized worldwide cities. *Journal of Cleaner Production*, 237, 117802. <https://doi.org/10.1016/j.jclepro.2019.117802>.

Siman, R.R.; Yamane, L.H.; De Lima Baldam, R.; Pardino Tackla, J.; Assis Lessa, S.F.; Britto, P.M., 2020. Governance tools: improving the circular economy through the promotion of the economic sustainability of waste picker organizations. *Waste and Management*, v. 105, 148-169. <https://doi.org/10.1016/j.wasman.2020.01.040>.

United Nations Environment Program – UNEP. 2005. Integrated Waste Management Scoreboard: a tool to measure performance in municipal solid waste management. United Nations Environment Program (Accessed April 10, 2020) at: <http://wedocs.unep.org/handle/20.500.11822/8409>.

United Nations Environment Program – UNEP. 2015. Global Waste Management Outlook. United Nations Environment Program, Osaka (Accessed April 10, 2020) at: https://www.researchgate.net/publication/283085861_Global_Waste_Management_Outlook_United_Nations_Environment_Programme_UNEP_and_International_Solid_Waste_Association_ISWA.

Van De Klundert, A., 1999. Integrated sustainable waste management: the selection of appropriate technologies and the design of sustainable systems is

not (only) a technical issue. In: CEDARE/IETC Inter-Regional Workshop on Technologies for Sustainable Waste Management, 1999, Alexandria, Egypt.

Van De Klundert, A.; Anschutz, J., 2001. Integrated sustainable waste management - the concept: tools for decision-makers: Experiences from the Urban Waste Expertise Program.

Welivita, I.; Wattage, P.; Gunawardena, P., 2015. Review of household solid waste charges for developing countries - a focus on quantity-based charge methods. *Waste and Management*, v. 46, 637-645. <https://doi.org/10.1016/j.wasman.2015.08.018>.

Xu, L.; Ling, M.; Wu, Y., 2018. Economic incentive and social influence to overcome household waste separation dilemma: a field intervention study. *Waste and Management*, v. 77, 522-531. <https://doi.org/10.1016/j.wasman.2018.04.048>.

Zurbrügg, C.; Caniato, M.; Vaccari, M., 2014. How assessment methods can support solid waste management in developing countries-a critical review. *Sustainability*, v. 6, (2), 545-570. <https://doi.org/10.3390/su6020545>.