



Governance tools: Improving the circular economy through the promotion of the economic sustainability of waste picker organizations



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ABSTRACT

Waste Picker Organizations are the fundamental link in the integrated management of urban solid waste, and they play a key social, economic, and environmental role. The main activity performed by Waste Picker Organizations is to insert materials in the productive cycle, thereby promoting a circular economy. However, due to the financial dependence on the public sector as the main economic source, and difficulties in self-management, Brazilian organizations do not achieve a competitive position in the recycling market. In this study we aimed to strengthen the Brazilian Waste Picker Organizations as solidarity economy companies throughout the application of corporate governance tools as to provide conditions to make them efficient in the recycling market and in the management of solid urban waste. The methodology was developed in three stages: identification of the Operating Activities of Waste Picker Organizations (Stage 1); hierarchization of the Operating Activities according to criteria that influence market efficiency (Stage 2); and creation of applicable reference models (Stage 3). According to the main results, the development of reference models, the hierarchical order of the Operating Activities, and the modeled processes indicated that the main activities that influence the market efficiency are selective collection, reception of the dry solid recyclable waste, sorting, pressing, baling, and the commercialization of selected waste.

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1. Introduction

The collection of urban solid waste performed by waste pickers, according to Sasaki et al. (2014), is largely observed in developing countries and is done by informal or formal waste pickers. Informal waste pickers usually work at open air dumpsites. In Brazil, after the establishment of the policy on the closure of irregular dumpsites, these informal workers were legally integrated to municipal waste management and formalized by the National Policy on Solid Waste (NPSW) of Brazil, thus being professionally recognized by the Brazilian Ministry of Labor and Employment.

The NPSW cover topics such as prioritization of solid waste management actions, promotion of social inclusion, intensification of environmental education actions, reverse logistics, and shared responsibility for the product life cycle, and it also determines

the implementation of selective collection with the participation of Waste Picker Organizations (WPOs) formed by low-income individuals (Dutra et al., 2018).

Whereas in theory the legislation supports WPOs and promotes the reuse and recycling as a sustainable solution for solid waste, in practice there are still many challenges to be overcome (Gutberlet, 2015a). Overall, cities face technical and administrative difficulties to perform selective waste collection in a universal and efficient manner (Besen and Fracalanza, 2016).

Selective collection in Brazil has been performed by the local government, city contractors, waste picker organizations, and scrap dealers through door-to-door schedule or by adopting Small Volume Delivery Stations (PEVs) that are combined for garbage collection (Ferri et al., 2015). According to Cempre (2019), Brazilian cities (about 22%) develop selective collection programs by combining models: door-to-door (80%), PEVs (45%), and WPOs (61%).

Cities may have more than one selective collection agent. Selective collection is responsibility of the City Hall in 39% of cities; of private companies in 36%; and 50% cities support or maintain WPO as the executing agents (Cempre, 2019).

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Waste Picker Organizations play a key role in the circular economy and promote the integrated management of the city's solid waste (Dutra et al., 2018). According to Botello-Álvarez et al. (2018), the association with WPOs improves the working conditions of formal waste pickers by allowing them to demand their rights, improve the collection/sorting, negotiate a better sales price, and provide training to handle hazardous waste.

However, institutional, financial, political, and social issues still hinder the development of such activities, and also the effective inclusion of WPOs in the city's solid waste management, since waste picker activities have been widely disregarded, rarely supported and acknowledged, and highly exploited (Velis et al., 2012). This unfavourable situation has been coped by the Brazilian WPOs, which operate mostly in scenarios of very low economic efficiency.

The WPOs participation in the integrated management of solid waste has been promoted through subsidies and assistance programs, and depends on the public sector as the main financial source (Ferri et al., 2015), which grants WPOs machinery, sorting sheds, water and electricity allowances, trucks (including fuel), and training and investment in outreach and environmental education (Cempre, 2019).

WPOs also operate in places run by the government, and the scale depends on many factors (population size, types of implemented municipal selective collection, agreements with companies, number of associated waste pickers, structure capacity, among others) (Dutra et al., 2018).

Due to the financial dependence and difficulties in self-management, WPOs are currently unable to compete in the recycling market. The WPOs income during the trade of materials is lower than the profit achieved by middlemen and recycling industries (Tirado-Soto and Zamberlan, 2013; Velis et al., 2012).

The assessment of the internal situation of the organizations, as well as their dysfunctions and implications on business proposals, requires specific interventions. WPOs' activities have been the subject of academic researches whose authors aim to indicate methods to broaden the economic performance of WPOs and improve their position in the market (Fidelis, Ferreira & Colmenero, 2015; Hartmann, 2018). The broad recommendations to improve the WPOs' efficiency and achieve gains in scale and quality are: inclusion of WPOs in integrated solid waste management and reverse logistics; training for self-management of business; standardization of production; analysis of the recycling market; use of accumulation sites for waste with recyclable potential; and the establishment of commercial networks (Raghupathy & Chaturvedi, 2013; Tirado-Soto & Zamberlan, 2013; Damásio, 2014; Ferri et al., 2015; Fidelis et al., 2015; Dutra et al., 2018; Ibáñez-Forés et al., 2019).

In this sense, Damásio (2014) stated that the concept of market efficiency for WPOs, which deals with the capacity to obtain the best market price for the same quantities of Urban Solid Waste with Recyclable Potential (USWRP), is the ratio between economic efficiency and physical efficiency: average gross return (price in BRL/month/waste picker) divided by the average productivity (collected materials in kg/month/waste picker). Therefore, any criterion that interferes with physical or economic efficiency will also alter the market efficiency, i.e., the capacity of WPO's to insert their products in the most advantageous situation within the market (Damásio, 2014).

The application of corporate governance tools – such as Operational Activities Structure (OAS), Multiple Criteria Decision-Making (MCDM), Priority Matrix, and reference models of operating activities – favors the development of actions to strengthen WPOs as solidarity economy enterprises and improve the networks for commercialization of recyclables for joint development. Authors of previous researches have found that the Operating Activities of WPOs

are non-standardized, chaotic, have rudimentary practices, and lack knowledge of the relationship between these organizations and their respective importance (Dutra et al., 2018; Tackla et al., 2017). These factors create an unfavorable environment for WPOs within the industry (Fidelis et al., 2015; Tackla et al., 2017).

Thus, we must identify and standardize Operating Activities performed by WPOs according to the operational activities structure, in such a way that these activities may provide conditions to improve the self-management and economic efficiency of businesses, eliminate or reduce dysfunctions, and facilitate the work in network configurations (Tackla et al., 2017). Among the benefits of adopting the operational activities structure for WPO are the standardization and organization of initiatives, achievement of advances in the marketing structure, increase of competitiveness in the recycling market, and the broad knowledge of all the former (Baldam, Valle & Rozenfeld, 2014).

WPOs can adapt the operational activities structure to their reality, taking advantage of best practices, as a useful tool to standardize the developed activities and establish commercial networks, promoting communication between different WPOs with a standard language. According to Dijkman, La Rosa & Reijers (2012), the use of an operational activities structure allows understanding and managing how processes are interconnected and how this generates value within organizations. Therefore, the business organization becomes a tool for the WPOs to improve the value proposition to the client, in such a way WPOs become more efficient and have a more economically valued position in the recycling market (Damásio, 2014).

Analyzing processes of WPO allows the people involved to understand the business in which they are inserted and where they fit in such business. In addition, identifying aspects that can be improved enables the creation of optimized models of processes that can be applied as reference models.

Taking this into consideration, in our research paper we aimed to identify the activities and dysfunctions of the WPOs with the help of waste pickers, and then use that acquired knowledge to apply governance tools to propose improvements for these processes, ultimately solving the WPO's dysfunctions. Thus, this paper is innovative by establishing reference models that can be applied to WPOs that face common problems, and at the same time, proposing a methodology that can be used to discover different dysfunctions in other organizations.

2. Material and methods

2.1. Characterization of the study location

The study was conducted in the state of Espírito Santo (ES), Brazil, which has 65 WPOs in operation, distributed in 59 out of 78 cities. Fig. 1 shows the operational WPOs distributed throughout the six microregions, and those selected for the research paper were classified as “in operation,” whether or not they participated in the application of the focus group methodology.

A total of 41.6% of Brazilian waste pickers are concentrated in the Southeastern region, according to survey presented by the Institute for Applied Economic Research (Silva, Goes & Alvarez, 2013).

The number of waste pickers per WPO in ES has accounts for an average of 10 ± 5 waste pickers/WPO (maximum 28 and minimum 3), and 60.5% are women (Guimarães, 2017) with an average sorting productivity of 109 kg/waste picker/day (Dutra et al., 2018). The WPO's criterion for distributing earnings is based on collective work and division among workers, regardless of the function they perform. Thus, regarding the workers' self-reported income, 57.7% earn from more than half to 1 minimum wage (R\$ 441–R\$ 880),

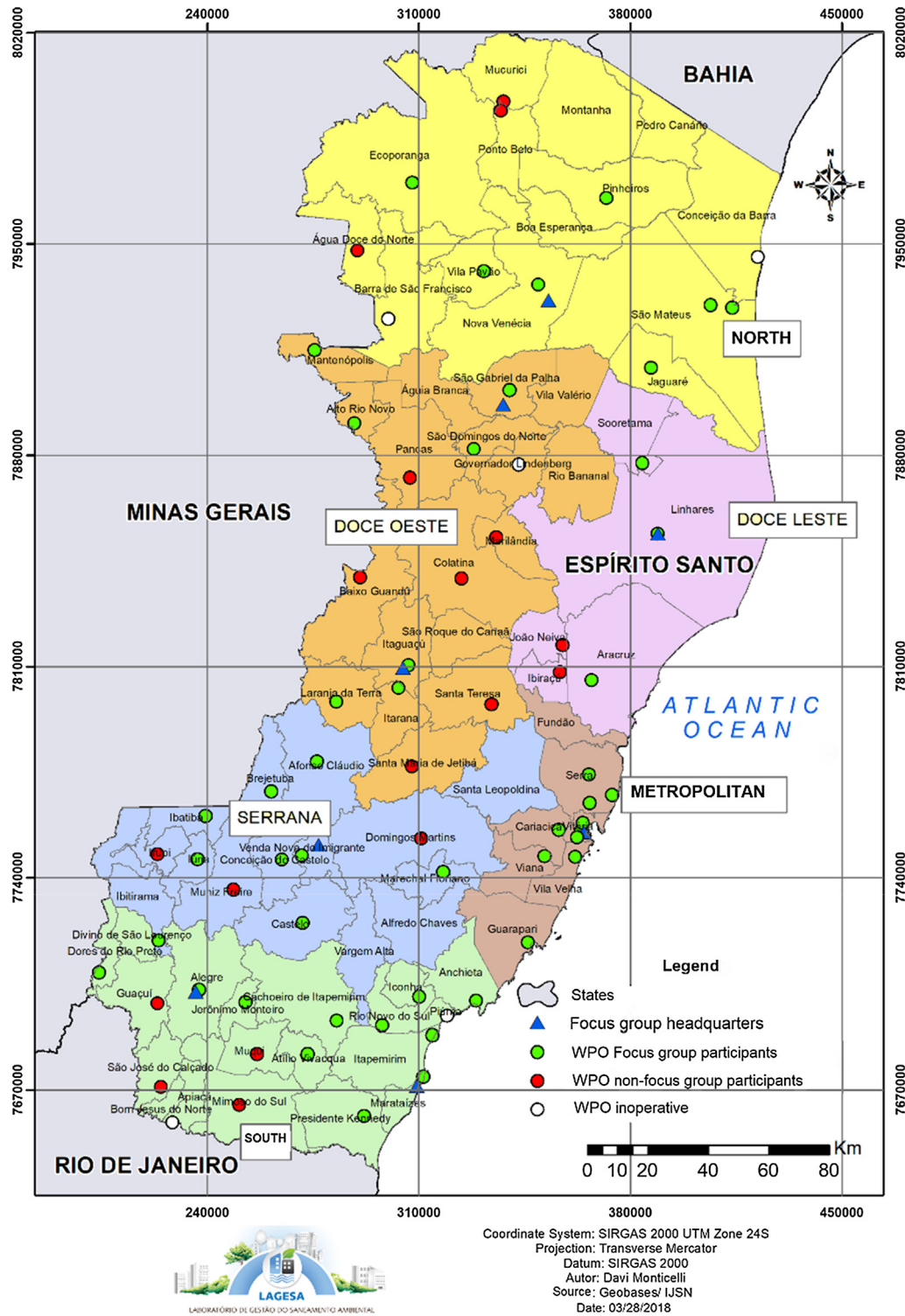


Fig. 1. Waste Picker Organizations location in the state of Espirito Santo, Brazil. Legend: WPO – Waste Picker Organization.

whereas only 24.2% earn from more than 1 to 2 minimum wages (R \$ 881–R\$ 1760). It is noteworthy that the compensation varies depending on the production each month (Guimarães, 2017).

Regarding the contract or agreement for municipal public support, 36 out of 65 WPOs maintain this type of relationship, which in fact has been necessary for them to remain in the market. The government generally participates by sending Urban Solid Waste with Recyclable Potential (USWRP) to the WPOs, in addition to

paying for water, electricity, or rent, and granting space or equipment to carry out the activities (Dutra et al., 2018; Tirado-Soto and Zamberlan, 2013).

As for the USWRP collection activity, only 6% of the contracts established for this service in ES are performed by WPOs. For other cases, the USWRP is delivered at the WPO sorting shed by the city. The main sources of USWRP are the city's selective collection, local markets, and companies. In the case of the conventional collection,

Table 1
Criteria that Influence Market Efficiency (CIME).

Criteria that Influence Market Efficiency (CIME)	Description
CIME 1 – Quality of life	Related to the health and safety at WPO's work environment
CIME 2 – WPO representation and inclusion in the region	Refers to the inclusion of WPOs in city's activities such as their representation in city meetings pertinent to the business
CIME 3 – Compliance with legal requirements	Refers to the WPO's compliance with legal aspects such as environmental licensing, contracts, and agreements
CIME 4 – Assistance	Refers to the dependence of WPOs on the government, partners, and intermediaries
CIME 5 – Support from the Government and Development Agencies	Unlike the assistance criteria (CIME 4), the support on the part of the government and development agencies refer to the development of actions that enable WPO to have better conditions to execute their activities. Example: Remuneration for the services rendered to the city
CIME 6 – Being self-managed and organized	Refers to the structure of the organization (association or cooperative) to perform activities, especially regarding the close participation of waste pickers for WPOs to develop
CIME 7 – Ability to compete in the market	Defined as the ability to obtain and maintain new clients, develop niche business, identify market demand, and acquire financial resources and incentives
CIME 8 – Ability to add value to the product	Refers to the way in which the production stages of segregating, sorting, baling, storing, and shipping are carried out in order to meet the market requirements in terms of quantity, quality, and frequency
CIME 9 – Easiness in executing the production steps	Making production easier to execute, including tasks such as planning and organizing production steps, having appropriate equipment, and redesigning layout with site utilization
CIME 10 – Clients' satisfaction	Refers to the return of clients and meeting requests and complaints
CIME 11 – Ability to receive and process USWRP	Refers to the infrastructure (shed), number of waste pickers, and working hours to process the USWRP, and to the expectation to increase the amount of material

Caption: WPO – Waste Picker Organization; USWRP – Urban Solid Waste with Recyclable Potential.

it is noteworthy that three WPOs receive mixed (or contaminated) solid waste that generates a high percentage of tailings. Tailings are considered the leftover materials after the process of sorting the recyclable materials; they are usually contaminated by organic or hazardous waste due to improper disposal.

The predominant form of commercialization in ES is bales, but there are also WPOs that sell the product in bags (6%), and others that manually make bales, although without a pressing machine. WPOs have a monthly sales cycle, being directly sent to intermediaries. According to the sales history, WPOs have sales forecasts, but there is no control or even goals to be achieved.

According to the characterization of the study location, we demonstrated that WPOs located in ES require an operational activities structure and applicable reference models in order to improve the competitiveness in the Brazilian recycling industry.

2.2. Experimental procedure

2.2.1. Stage 1 – Identification of the Operating activities of waste Picker organizations

We identified the Operating Activities of Waste Picker Organizations by literature review (in order to create a questionnaire presented at the Appendix A section) and survey (in order to apply the questionnaire).

Aiming to collect data about the performance of Operating Activities at Waste Picker Organizations, we applied a survey to nine representative WPOs, in the form of a semi-structured questionnaire, containing open and closed questions, prepared with Google Forms application (see Appendix A). We chose the survey respondents according to their function, degree of involvement in creating the organization, and time as an associate member. Then, respondents were selected among presidents, general coordinators, or production supervisors. The WPOs are located in the metropolitan region, which gathers almost half of the state population (46%) and 57% of the urban state population, namely:

- ABRASOL – Solidarity Regional Environmental Bank Association of Planalto Serrano;
- ASCAMARE – Waste Picker Organization of Vitória;
- ACAMARP – Waste Picker Organization of Nova Rosa da Penha II;

- AMARIV – Waste Picker Organization of Ilha de Vitória;
- ASCAMARG – Waste Picker Organization of Guarapari;
- ASCAMAVI – Waste Picker Organization of Viana;
- FLEX VIDA – Waste Picker Organization of Flexal;
- RECUPERLIXO – Waste Picker Organization of Serra;
- REVIVE – Vila Velhense Waste Picker Organization.

Surveys were applied *in loco* during technical visits carried out in July 2015 using the questionnaire, which consisted of 45 questions based on the Process Classification Framework reference model according to the American Productivity & Quality Center. The length of interviews varied from 1 to 2 h.

Questions about general information were used to identify the respondent, followed by questions distributed in five topics, as presented in Table 1, which represents the summary of the survey that was answered with a single option, between “always”; “most of the time”; “sometimes”; “rarely”; and “never.” In the end, an open-ended question enabled the respondents to discuss difficulties that hinder the business of the association to which they belong, thus allowing us to analyze this answer for the purposes of our investigation.

For this open question (“What difficulties hinder or may hinder the business of Waste Picker Organizations in the Brazilian recycling market?”), the qualitative evaluation of the answers enabled to identify dysfunctions that were internally present in the organizations, and which did not necessarily emerged in the closed questions.

The analysis of the frequency of answers given to the closed questions was performed aiming to identify practices shared by the surveyed organizations, assist in the identification of Operating Activities and in the elaboration of WPO's Operational Activities Structure.

The survey provided new information and complemented the information acquired in the literature review, since the information raised in the survey allowed identifying the level of the management and the activities performed in organizations. These activities, however, are unremarkable, since they are not directly linked to activities of delivery of products and services, thus allowing to establish the Operational Activities Structure (see Appendix B). Stage 1 was finalized in May 2016. In Stage 2, we defined a total of 21 Operating Activities (Stage 2) divided into five blocks, as we can observe in the following section.

2.2.2. Stage 2 – Hierarchization of the Operating activities according to Criteria that Influence Market Efficiency (CIME)

In Stage 2 we aimed to rank the Operating Activities of WPOs located in ES, according to Criteria that Influence Market Efficiency (CIME) by using the Priority Matrix software, in order to propose initiatives related to the standardization and organization of Operating Activities. The Priority Matrix can help the prioritization of internal issues and situations of the company and organizations.

For the hierarchization of Operating Activities, we carried out the following steps:

- (a) Relevance criteria were identified based on dysfunctions pinpointed in Stage 1 and in the literature review, considering 11 CIME;
- (b) Then, following the recommendation of the Analytic Hierarchy Process methodology, the six most relevant CIME were selected through virtual survey on 80 Brazilian specialists and used to create the CIME judgment matrices;
- (c) With the CIME judgment matrices we evaluated the Operating Activities by Focus Group (FG) meetings in six regions of the state comprising 124 WPOs and government representatives.

Based on the dysfunctions identified in Stage 1 and in the literature review (Tackla et al., 2017), we pinpointed 11 CIME, which are presented in Table 1.

Based on the 11 CIME (Table 1), the six most relevant CIME were selected by Multiple Criteria Decision-Making (MCDM). Different MCDM have been used such as AHP (Analytic Hierarchy Process), ELECTRE (Elimination and Choice Expressing Reality), PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations), and MACBETH (Measuring Attractiveness by a Categorical-Based Evaluation Technique).

AHP allows structuring a problem into hierarchies and evaluating components by peer comparison (Saaty, 2005, 1980). ELECTRE is widely studied and it has evolved into ELECTRE I, II, III, IV and TRI; this technique also uses peer comparison according to agreement and disagreement indices (Roy, 1990, 1968). PROMETHEE, which has evolved into PROMETHEE I and II, is a complete ranking of actions based on multicriteria net flow, and includes preordered preferences and indifferences (Brans, 1982). MACBETH is an interactive approach that requires only qualitative judgements about differences to help a decision maker or a decision-advising group in quantifying the relative attractiveness of options (Bana e Costa and Vansnick, 1993).

MCDM methods, such as ELECTRE, PROMETHE and MACBETH (more focused on the European School), assume that priorities are created with facilitators, and the main objective is to generate knowledge, which consists in useful and valid assumptions. Among other features, AHP (more focused on the American School) assumes that priorities are drawn from experts and the main goal is to find the optimal solution.

While recognizing some of the limitations of MCDM, we adopted AHP because it seems more appropriate to the type of research and audience attending the meetings, and we have optimized a simple method for everyone to participate in the decision-making process, based on spreadsheets easy to be used in FG meetings.

Following the recommendation of Russo & Camanho (2015) for the AHP application, the six most relevant criteria were selected concerning the improvement of market efficiency for the surveyed WPO.

We conducted the survey by applying a virtual questionnaire using the Google Forms online virtual tool. A weighting scale was used for the analyzed criteria, with values ranging from 5 to 1, where 5 referred to high influence and 1 to low influence. The survey was applied between August and November 2017 and, in order to obtain more answers, we resent new e-mails with the questionnaire each week. In total, we sent 370 e-mails and had 80 responses, and we analyzed all of them.

Experts from Instituto Sindimicro – ES, from the Technical Chamber of Solid Waste of the Brazilian Association of Sanitary and Environmental Engineering (ABES), from the Micro and Small Business Development and Entrepreneurship Agency (ADERES), from the Association of Cities of Espírito Santo (AMUNES), and other researchers working in Brazil participated in the survey. Thus, we ensured the application of the questionnaire at a national level, comprising representatives of the following states: Bahia, Federal District, Goiás, Espírito Santo, Minas Gerais, Paraíba, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Santa Catarina, and São Paulo. The survey participants' group was stratified into the following groups: 42% researchers, 27% government representatives, 23% WPO representatives, and 8% companies and consultants that perform or have performed any activity in the WPO.

After defining the most relevant CIME, we used judgment matrices to evaluate the Operating Activities by Focus Group (FG) meetings. FG meetings were held in eight cities of ES as described in Table 2, and were conducted by researchers from the Laboratory of Environmental Sanitation Management (LAGESA) of the Federal

Table 2
Description of Focus Group meetings.

Region	Place	Date and time	Involved cities
Doce River East	Linhares	October 17th, 2017 2 p.m.–5 p.m.	Aracruz, Ibirajuba, João Neiva, Linhares, and Sooretama.
Doce River West	São Gabriel da Palha	October 18th, 2017 2 p.m.–5 p.m.	Alto Rio Novo, Mantemópolis, Pancas, São Domingos do Norte, and São Gabriel da Palha.
	Itaguaçu	October 19th, 2017 9 a.m.–12 p.m.	Baixo Guandu, Colatina, Itaguaçu, Itarana, Laranja da Terra, Marilândia, Santa Maria de Jetibá, and Santa Teresita.
North	Nova Venécia	October 18th, 2017 9 –12 p.m.	Água Doce do Norte, Ecoporanga, Jaguaré, Mucurici, Nova Venécia, Pinheiros, Ponto Belo, São Mateus, and Vila Pavão.
South	Marataízes	October 24th, 2017 9 –12 p.m.	Anchieta, Cachoeiro de Itapemirim, Iconha, Itapemirim, Marataízes, Presidente Kennedy, and Rio Novo do Sul.
	Alegre	October 24th, 2017 2 p.m.–5 p.m.	Alegre, Atílio Vivacqua, Dores do Rio Preto, Guaçuí, Jerônimo Monteiro, Mimoso do Sul, Muqui, and São José do Calçado.
Mountain region	Venda Nova do Imigrante	October 25th, 2017 9 –12 p.m.	Afonso Cláudio, Brejetuba, Castelo, Conceição do Castelo, Domingos Martins, Ibatiba, Irupí, Iuna, Marechal Floriano, Muniz Freire, Venda Nova do Imigrante, and Ibitirama.
Metropolitan	Vitória	October 26th, 2017 9 –12 p.m.	Vitória, Guarapari, Serra, Cariacica, and Viana.

University of Espírito Santo, Brazil, with support of Instituto Sindimicro – ES (moderator).

FG meetings were carried out in about 71% of the existing WPOs in the ES. Regarding the number of waste pickers and government representatives, there was a total of 124 participants, being 78% waste pickers.

For the rating, a scale with numbers ranging from 1 to 9 was used, according to which 1 referred to lower importance; 5, equal importance; and 9, higher importance. We used the mathematical equation $n(n-1)/2$ to identify the total number of judgments. For the hierarchy of Operating Activities according to the CIME, of the 21 Operating Activities divided into 5 blocks, we obtained 30 combinations (Table 3).

It is noteworthy that combinations presented in Table 3 were performed within each activity block instead of being implemented in all Operating Activities. Thus, in total, there were 180 combinations compared with each 6 CIME. Rating was conducted as follows: how important is “left” versus “right” activity to influence the WPO’s ability to add value to the USWRP (criterion: ability to add value) for each CIME? The Stage 2 was finalized on August 2018.

2.2.3. Stage 3 – Creation of applicable reference models

The modeling and optimization of the main processes performed in WPOs allows highlighting unnecessary activities, limitations of the existing layout, and good practices carried out in

processes related to the activities of Collecting dry solid recyclable waste (DSRW), Receiving DSRW, Sorting solid waste, Pressing and baling DSRW, and Commercializing DSRW.

In order to create a reference model, we had to search for the best practices found in the WPOs. Therefore, we selected the 10 best-structured waste picker organizations through documentary research and information provided by technicians of Instituto Sindimicro – ES.

Documentary research was carried out in reports prepared by Instituto Sindimicro – ES in 2017 such as Gravity Composition Report, Productive Layout Analysis Report, Risk Map Report, and Economical Feasibility Analysis Report.

In addition, we established a dialogue with technicians of this institute, professionals who have been monthly visiting the WPO of Espírito Santo for 3 years (2015–2017) and who know the skills, challenges, and issues of each organization, in such a way they can inform which organizations in each region outstood regarding their business management model.

We created a reference model by focus groups using Business Processes Model and Notation during field visits carried out in January 2018 and based on the Operational Activities Structure that was determined in the previous step, according to which the best WPO practices were selected in a way we could model the prioritized processes.

Field visits were performed to evaluate the current conditions of: location, selective collection, conventional waste collection,

Table 3
Peer-to-peer comparisons of Operating Activities by Criteria that Influence Market Efficiency (CIME).

Block 1: Develops vision and strategy	
1.1 Defines business concept and long-term vision	1.2 Develops business strategy
1.1 Defines business concept and long-term vision	1.3 Manages strategic initiatives
1.2 Develops business strategy	1.3 Manages strategic initiatives
Block 2: Designs and develops products and services	
2.1 Manages product and service portfolio	2.2 Develops products and services
Block 3: Sells products and services	
3.1 Understands markets, customers, and capabilities	3.2 Develops marketing strategy
3.1 Understands markets, customers, and capabilities	3.3 Develops sales strategy
3.1 Understands markets, customers, and capabilities	3.4 Develops and manage marketing plans
3.1 Understands markets, customers, and capabilities	3.5 Develops and manage sales plans
3.2 Develops marketing strategy	3.3 Develops sales strategy
3.2 Develops marketing Strategy	3.4 Develops and manages marketing plans
3.2 Develops marketing strategy	3.5 Develops and manages sales plans
3.3 Develops sales strategy	3.4 Develops and manages marketing plans
3.3 Develops sales strategy	3.5 Develops and manages sales plans
3.4 Develops and manage marketing plans	3.5 Develops and manages sales plans
Block 4: Delivers products and services	
Products	
4.1 Plans and aligns supply chain resources	4.2 Purchases materials
4.1 Plans and aligns supply chain resources	4.3 Produces/manufactures
4.1 Plans and aligns supply chain resources	4.4 Delivers product to costumer
4.1 Plans and aligns supply chain resources	4.5 Manages logistics
4.2 Purchases materials	4.3 Produces/manufactures
4.2 Purchases materials	4.4 Delivers product to costumer
4.2 Purchases materials	4.5 Manages logistics
4.3 Produces/manufactures	4.4 Delivers product to costumer
4.3 Produces/manufactures	4.5 Manages logistics
4.4 Delivers product to costumer	4.5 Manages logistics
Services	
4.1 Plans and aligns services	4.2 Develops strategy services
4.1 Plans and aligns services	4.4 Delivers service to costumer
4.2 Develops strategy services	4.4 Delivers service to costumer
Block 5: Manages customer services	
5.1 Develops customer service and attention strategy	5.2 Plans and manages customer service-related operations
5.1 Develops customer service and attention strategy	5.3 Measures customer's satisfaction
5.2 Plans and manages customer service-related operations	5.3 Measures customer's satisfaction

contract with the municipal government, wet waste sorting, and different amounts of solid waste monthly sorted, in a way we could develop a reference model to cover different contexts.

Prioritized processes were modeled on the WPO with the aid of people involved in these processes. For each procedure, at least two people were invited, who could describe and comment on the operations under study in successive meetings, with a total duration of eight hours of work in each WPO.

At the end of each field visit, we prepared a model of the current condition. In addition, we systematized the collected data to create the models using the Microsoft Visio[®] software.

The 10 elaborated models represented different realities, in a way we could diagnose differences and similarities between conditions of the organizations and highlight the best practices. We compared the models to elucidate the main similarities and differences. When analyzing the elaborated models, we noticed a recurring similarity between the processes, and we decided to compare these processes with a single model that covered all the peculiarities found in the different WPOs. Hence, we generated comparative models.

Based on the comparative models, we analyzed the processes, which were redesigned and modified according to specific adjustments required to make them more efficient. After these adjustments, the optimized model became the reference model of the process. The last stage was finalized in February 2019.

3. Results and discussion

3.1. Stage 1 – Identification of operating activities in waste picker organizations

By applying the survey methodology, we identified the main Operating Activities performed in WPO, namely: Collecting DSRW; Receiving DSRW; Sorting solid waste; Pressing and baling DSRW; and Commercializing DSRW.

Operating Activities comprise the most common practices identified in the surveyed WPOs, although they do not convey all the possibilities of activities within a WPO. For example, in this study we showed the absence of practices for the processing of materials, such as milling and flocking, which is in line with findings from researches conducted by [Tirado-Soto and Zamberlan \(2013\)](#) regarding the situation of Brazilian WPO. It negatively impacts the value achieved during the sale of materials, since the organizations do not meet certain specifications required by recycling industries. Therefore, the organizations end up or are forced to only negotiate with intermediary traders, which, in turn, have a superior capacity than theirs for material processing.

Ultimately, only marketers are able to add value to the materials, directly selling them to recycling industries, which consist in the final consumer. [Damásio \(2008\)](#) corroborates this situation with data on the recycling chain and its economic impacts as well as [Freitas & Fonseca \(2012\)](#) in their waste pickers report.

[Tirado-Soto & Zamberlan \(2013\)](#) highlighted difficulties that the organizations have in meeting the quality of materials demanded by industries, which corroborates our investigation when emphasizing the predominance of a single basic activity for material improvement: sorting. In addition, the authors identified baling as the only strategy for disposing materials for delivery. The financial difficulty in purchasing specific equipment (crushers, extruders, and flocculators), which can be internally used by organizations to add value to recyclable materials, was mentioned as a possible explanation for this limitation ([Tirado-Soto and Zamberlan, 2013](#)).

As for “Collecting DSRW” and “Commercializing DSRW” activities, only one of the nine surveyed organizations outstood for hav-

ing the technical capacity and infrastructure to operate such activities. This was possibly due to these organizations possessing a trunk truck and being close to their suppliers/generators (private entities) of recyclable materials.

Conversely, the other organizations do not operate activities involving transportation, since they do not have the financial condition to purchase and maintain their own transportation or to outsource it. Thus, selective collection is carried out in a smaller degree by human traction transport (carts), which are pulled by the waste pickers themselves, as evidenced by [Tirado-Soto & Zamberlan \(2013\)](#), or by the public cleaning company hired by the City Hall, which delivers the recyclable in the WPO.

As described by [Velis et al. \(2012\)](#), this is a common practice that is described as an interventionist activity required to fulfill the legal right of WPOs to access recyclable materials, and is frequently experienced in regions where WPOs are located.

In addition, in the Operational Activities Structure of WPO (Appendix B), we can identify the level of management and the activities carried out in WPOs, but these activities are unremarkable, since those related to delivering products and services are not directly linked.

3.2. Stage 2 – Hierarchization of operating activities according to Criteria that Influence Market Efficiency (CIME)

We obtained the following weights from the evaluation of criteria that influence market efficiency:

- CIME 1 – Quality of life: weight 3.81
- CIME 2 – WPO representation and inclusion in the region: weight 4.40
- CIME 3 – Compliance with legal requirements: weight 3.83
- CIME 4 – Assistance: weight 3.56
- CIME 5 – Support from the Government and Development Agencies: weight 4.53
- CIME 6 – Being self-managed and organized: weight 4.49
- CIME 7 – Ability to compete in the market: weight 4.48
- CIME 8 – Ability to add value to the product: weight 4.60
- CIME 9 – Easiness to execute the production steps: weight 4.43
- CIME 10 – Clients’ satisfaction: weight 4.35
- CIME 11 – Ability to receive and process USWRP: weight 4.41

Although we selected the first six CIME for the hierarchization of Operating Activities, we evaluated such criteria considering a high level of importance, evidencing the need for initiatives in all areas.

Based on the CIME classification of the national scenario, we evaluated WPO by peer combination to obtain the priority eigenvector for ES. In [Fig. 2](#) we show the order of priority of the CIME concerning the state:

We observed that the CIME related to infrastructure and equipment are in first and third place in the hierarchy given in [Fig. 2](#). This demonstrates the importance WPOs give to this factor, and corroborates the Brazilian scenario regarding the need for having the minimum equipment and adequate infrastructure for the performance of Operating Activities. [Tirado-Soto & Zamberlan \(2013\)](#) and [Tackla et al. \(2017\)](#) state that the WPO dysfunction regarding these issues directly affects the development of Operating Activities. According to these authors, such dysfunctions are related, for example, to difficulties in packaging the USWRP, less power to add value to the recyclable material, lack of transport vehicles for collection and delivery of recyclable material, and low storage capacity for commercialization.

In ES, the WPO scenario does not differ from the Brazilian one. The studied WPOs do not meet the minimum requirements established by the 2010 National Policy on Solid Waste, despite invest-

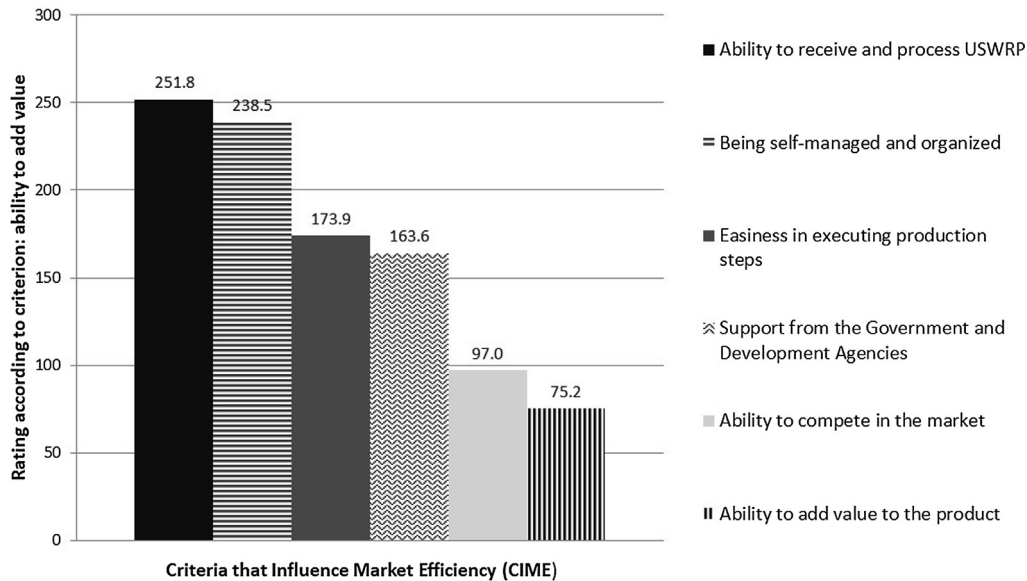


Fig. 2. Top 6 Criteria that Influence Market Efficiency (CIME) of Waste Picker Organizations (WPOs) from the state of Espírito Santo, Brazil.

ments of public authorities and development institutions. As described in the study area characterization, only 29% of the 65 WPO have a pressing machine, scale, and sorting table, and 43% still carry out sorting on the floor. WPOs are poor in terms of equipment and workplace organization, in a way the productivity and execution of Operating Activities are affected by the following failures: rework; daily reorganizations; lack of definition and identification of sectors (reception, sorting, pressing, storage, etc.); inefficient disposal of equipment; lack of logical sequence of production processes, which increases unnecessary work in storage and sorting sheds; poor distribution of types of activity by physical competence (example: older people performing physically-demanding activities); and structural aspects that potentiate accidents (floor differences, narrow doors, etc.).

Regarding sorting and storage sheds, they are mostly classified as small- (up to 300 m²) and medium-sized (up to 600 m²). In addition, it is noteworthy that when sheds are not owned by the City Hall, the rental costs are incurred by the WPO (Dutra et al., 2018).

Therefore, the importance given to the criteria “Ability to receive and process USWRP” and “Easiness in executing production steps” emphasizes the recurrent dysfunction in WPOs, the lack of compliance with legal or technical and infrastructure-related requirements, as well as it evidences that waste pickers perceive the need for adequate infrastructure and equipment essential for performing the Operating Activities (Campos, 2014).

Regarding “Being self-managed and organized,” the second most important CIME category in this investigation, we noticed that waste pickers identify the need for being organized in a way that WPOs are supported by the government. Corroborating this information, Guimarães (2017), in a survey on WPOs located in the state of Espírito Santo, pointed out that 90.5% of the 215 waste pickers from the 34 WPOs located in the state highlighted advantages in the organized labor. The author mentions the following advantages: better conditions for the activity; income regularity; having a work routine; and liking the environment and workgroup.

Also, regarding the self-management issue, Silva et al. (2013), Gutberlet (2015a,b) and Ghisolfi et al. (2017) also noted that the formalization of work in WPOs, opportunities to make investments in infrastructure in the production processes, and greater bargaining power in relation to individual marketing outstand as benefits.

Alves, Ferreira, & Araújo (2017) identified some difficulties in the work within informal organizations of waste pickers: difficulty in understanding and applying management principles; difficulty in understanding there is no employment relationship in WPO, and therefore, revenues are obtained by mutual work, and income comes from the division of profits; lack of skill and knowledge of how to manage a WPO; lack of capacity to execute Operating Activities; and difficulty in the formalization and regularization of the enterprise.

As for the CIME categories “Support from the Government and Development agencies” and “Being organized with self-management,” understanding the perspective of the participating waste pickers is important. We verified the recognition of WPOs that one criterion cannot be developed without the other, and these joint ventures could not survive without the support from the government or public development agencies for the WPO structuring. When comparing the criterion “Support from the Government and Development Agencies” with the other CIME, there was an intense discussion about the presence of the government for supporting the work structure, equipment, and miscellaneous expenses. These results corroborate those found by Guimarães (2017), in which waste pickers are somewhat aware of the need and benefits of the government support for the organization.

Regarding the CIME category “Ability to compete in the market,” we observed that WPOs generally trade with the same buyers. This is due to the lack of market conditions in ES, the lack of conditions to transport the recyclable material, and the lack of working capital to support a longer period for the accumulation of recyclable material (Dutra et al., 2018; Tackla et al., 2017).

Regarding the current CIME category “Ability to add value to the product,” WPO must predominantly add value to the sorting, pressing, and baling activities. Lima et al. (2015) and Silva et al. (2013) highlighted that the sorting is the activity that adds more value, because of the diversity of products that can be generated. Sorting diversification is sought in order to generate specific types of product with greater added value in the commercialization process. It is noteworthy that WPOs discard solid waste with recyclable potential due to the low market value and difficulty in commercializing solid waste, either because there are no buyers or because they are located far away. Hence, the percentage of tail-

Table 4
Hierarchization of the 21 Operating Activities according to Criteria that Influence Market Efficiency (CIME).

Operating Activities	Priority*
4.1 Plans and aligns supply chain resources and services	68.40
5.1 Develops customer service and attention strategy	67.19
3.1 Understands markets, customers, and capabilities	62.65
4.2 Purchases materials	60.47
5.2 Plans and manages customer service-related operations	58.13
1.2 Develops business strategy	55.32
5.1 Develops customer service and attention strategy	53.35
2.2 Develops products and services	48.68
1.3 Manages strategic initiatives	47.89
5.2 Plans and manages customer service-related operations	47.44
4.3 Produces/manufactures product	46.67
2.1 Manages product and service portfolio	46.56
3.5 Develops and manages sales plans	46.34
3.3 Develops sales strategy	45.07
3.4 Develops and manages marketing plans	42.97
3.2 Develops marketing strategy	41.07
1.1 Defines business concept and long-term vision	39.65
4.5 Manages logistics	33.32
5.3 Measures customer's satisfaction	31.38
4.4 Delivers product to customer	29.23
4.4 Delivers service to customer	28.23
Sum	1000

* Priority = final grade obtained to each Operating Activity applying judgment matrices in focus group meeting.

ings in the WPO can be high (Dutra et al., 2018; Fidelis and Colmenero, 2018; Hartmann, 2018).

Moreover, another way to add value is the installation of a plastic processing center for grinding, as highlighted by Fidelis et al. (2015). According to the authors, the grinding of plastic would enable adding from 60% to 75% of the market value of the material. However, the authors point out that WPOs are unable to implement such an undertaking alone because of their lack of adequate infrastructure, high implementation costs, minimal daily plastic flow (which is insufficient for operation), and lack of skilled labor.

Finally, as we detailed in the Experimental Procedure section, after defining the 6 most relevant CIME, we used the judgment matrices for the hierarchization of Operating Activities by Focus Group (FG) meetings. In Table 4 we present the hierarchization of the 21 Operating Activities, according to Criteria that Influence Market Efficiency (CIME):

As observed in Table 4, the hierarchical order of WPO's Operating Activities from ES also reflects the Brazilian reality, since the lack of infrastructure, equipment, and management skills are characteristics of WPO in developing countries. Hierarchization can be used to direct actions within the WPO, in such a way WPO activities become organized and standardized, and thus have the potential to acquire greater volume of raw materials, to add value to the product and service, and ultimately to boost the recycling value chain.

Overall, Fidelis and Colmenero (2018) describe that WPOs maintain a "standard" for executing and managing Operating Activities, without significant changes in the production flow. According to the authors, internal production activities and marketing practices are similar. The authors point out that even in the case of efficient WPOs, when receiving large amounts of USWRP, these organizations would not be able to perform their core activities, since they could not perform the Operating Activities in an organized manner.

WPOs tend to mainly market items with the highest volume and commercial value, which can represent up to 60% of the volume sold (paper, cardboard, HDPE, PET, and LDPE) (Fidelis and Colmenero, 2018; Ibáñez-Forés et al., 2019). These recyclable materials have greater ability to compete in the market when com-

pared with other recyclable waste. Dutra et al. (2018) and Steuer et al. (2017) mention that the decrease in market values has had one of the most significant impacts for WPO. When market values reduce in order to maintain income levels, WPOs must market a larger amount of recyclable material (Steuer et al., 2017).

Fidelis & Colmenero (2018) point out that the amount of recyclable materials sold positively impacts the performance of WPOs, but the amount of collected solid waste and the number of people working in production has a negative impact. This means that WPOs have underutilized inputs when generating marketable products. That is to say, WPOs can produce more with the same used inputs. This negative relationship can be attributed to the lack of equipment, infrastructure, turnover, and qualification of waste pickers for performing the Operating Activities.

We used the hierarchical order of Operating Activities to prepare reference models, aiming to collect the best practices of Operating Activities in order to disseminate and adapt them to other WPO.

3.3. Stage 3 – Creation of applicable reference models

Based on the best practices found in waste picker organizations, we created reference models for the following operating activities: "Collecting DSRW," "Receiving DSRW," "Sorting solid waste," "Pressing and baling DSRW," and "Commercializing DSRW," as detailed next.

3.3.1. Collecting DSRW

Collecting DSRW is an activity that can be carried out by the City Hall or WPO, which can be contracted with a waiver, as explained in the National Policy on Solid Waste, Article 36, Paragraph 2. In this policy, we find the good practices performed by the studied WPO for "Collecting DSRW" as follows:

- (a) Use a smaller vehicle to reach inaccessible neighborhoods by truck;
- (b) Promptly meet the calls for DSRW collection;
- (c) Record and monitor the mileage, collected volume, and time spent in each route;
- (d) Collect the waste before the conventional collection;
- (e) Increase the list of new partners and collect daily waste from the trade during strategic hours;
- (f) Monitor the quality of collected waste in voluntary delivery locations (VDL) to report possible change of position to the City Hall;
- (g) After evaluating productivity by modality, attempt to combine different modalities of selective collection in the city to increase its efficiency;
- (h) Invest in social mobilization (continuous awareness and training programs) to publicize the collection schedules and to improve the segregation of waste in the generating source;
- (i) Record the number of bags per source (VDL, partners, and others).

Based on these good practices, we propose the reference model presented in Fig. 3 for the "Collecting DSRW" Operating Activity:

In this reference model (Fig. 3), we chose to keep the activities carried out by the WPO minority, such as "Record mileage and arrival time for each route" and "Pre-sorting: only collect dry solid recyclable waste with market value", followed by activities common to all WPO. However, it is worth highlighting that driver training is required when the driver is not a member of the WPO, as to ensure that these two activities are well executed. We understand these two activities can optimize WPO sorting by minimizing the

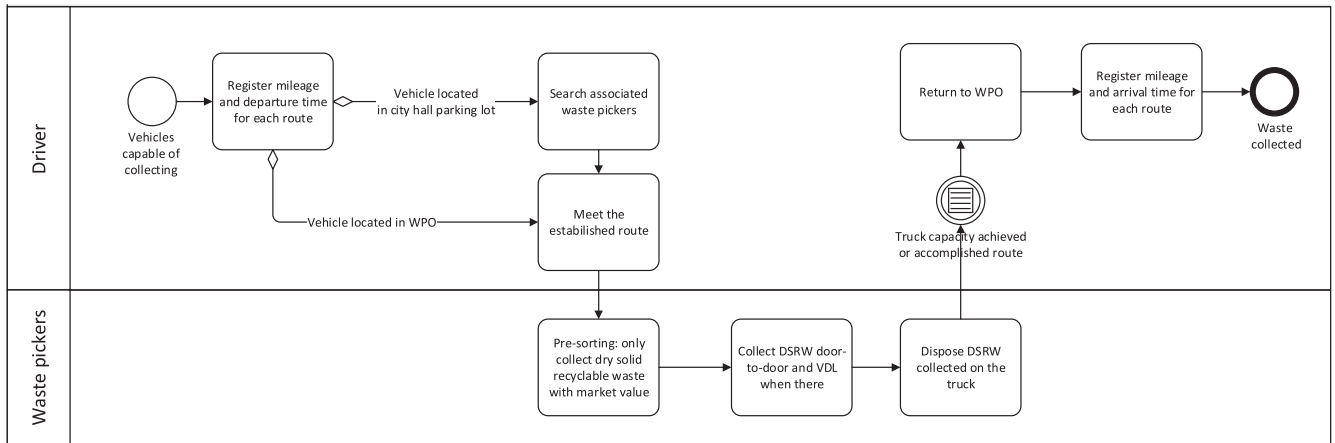


Fig. 3. Reference model for “Collecting DSRW.” Caption: DSRW – Dry Solid Recyclable Waste; WPO – Waste Picker Organizations.

amount of waste and by enabling to create collection productivity indicators.

3.3.2. Receiving DSRW

Receiving DSRW consists in a WPO routine activity in which the organization removes the waste from the collecting vehicle and temporarily stores it while awaiting sorting or removal from the vehicle, then directly placing the waste at the sorting site. The best practices performed by the WPO for the “Receiving DSRW” activity are:

(a) Weigh and register all waste that arrives at the WPO, for control purposes;

- (b) Identify the route through which the waste arrived, allowing its traceability, and record this information for control purposes;
- (c) Pre-sort bulky waste;
- (d) Organize temporary storage of waste in a place that does not hinder the transportation of cargo and that is strategic for movement.

Considering that the lifting of bags in the waste pile is a particular activity hardly found in WPOs, we decided to suppress this activity from the reference model. We present the suggested reference model in Fig. 4. It is noteworthy that such model covers all the

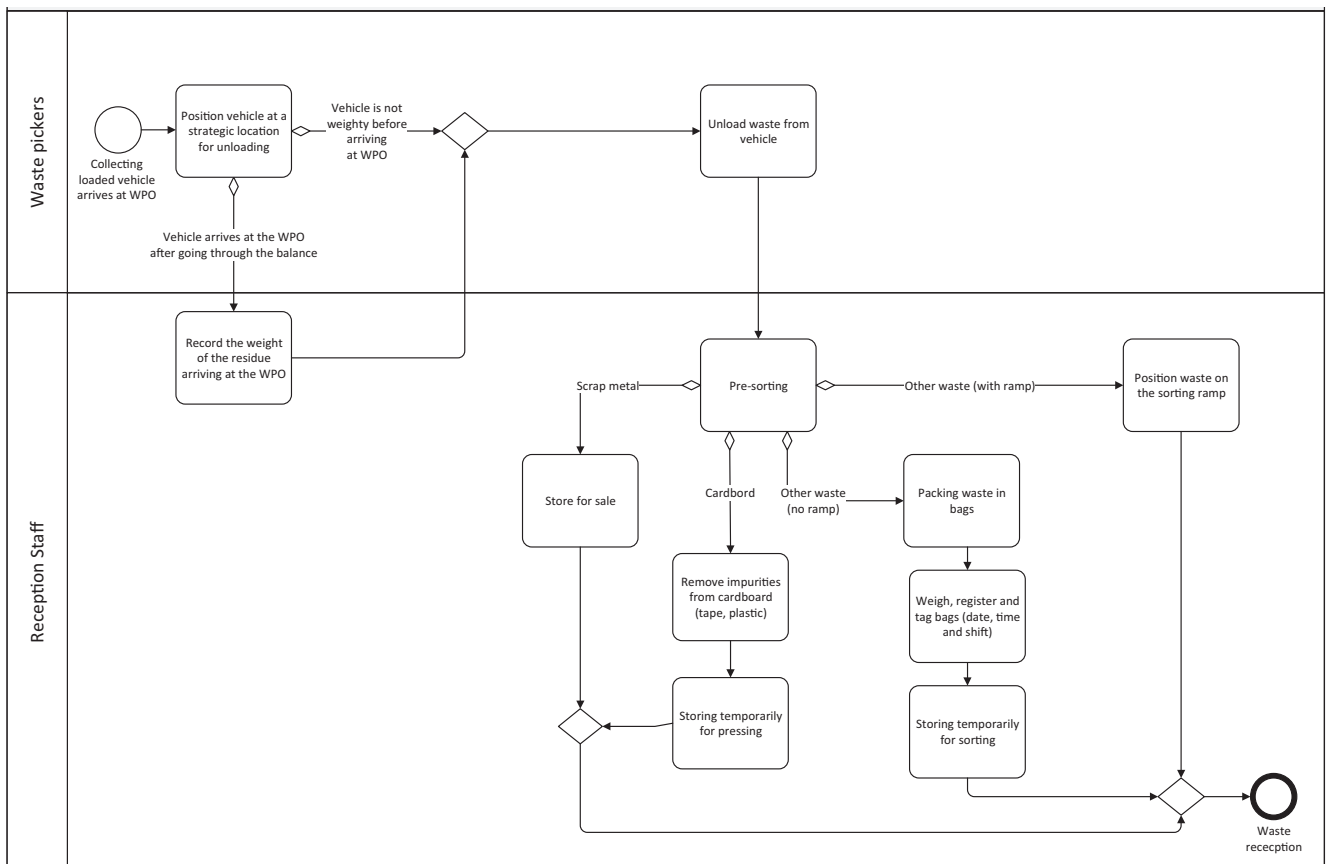


Fig. 4. Reference model for “Receiving DSRW.” Caption: WPO – Waste Picker Organizations.

possibilities found in the studied WPO, which are deemed as good practices:

3.3.3. *Sorting solid waste*

Sorting solid waste is the main WPO’s activity, since the value of waste is added to it (Lobato and Lima, 2010). Sorting can be done in different ways depending on the degree of residue separation, WPO’s physical structure, frequency with which the WPO receives the collected residues, and quality of the residues.

The best practices for “Sorting solid waste” performed by the investigated WPO were as follows:

- (a) Pre-sort cardboard;
- (b) Separate plastic for secondary sorting;
- (c) Perform control and registration of sorting in a way that productivity can be measured by origin, material, and worker;
- (d) Exposure of the physical, biological, chemical, accident-related and ergonomic risks, verifying their intention in

receiving several types of waste and the appropriate equipment for sorting the residues.

Since the comparison model comprised all the particularities of the studied WPO, as well as the good practices described for this activity, involving the number of activities required to track the sorted residue and to monitor the productivity of waste pickers, we decided to suppress the condition of residue on the ground, since this is not deemed a good practice. Therefore, we present the model to be used as a reference in Fig. 5:

3.3.4. *Pressing and baling DSRW*

The commercialization of dry solid recyclable waste in bale shapes allows optimizing the space in the buyers’ trucks and adding more waste in a smaller volume. According to Fonseca et al. (2017), the reason for pressing the solid waste is that it has a higher value when marketed in the form of bales.

The good practices performed by the studied WPO for “Pressing and baling DSRW” are as follows:

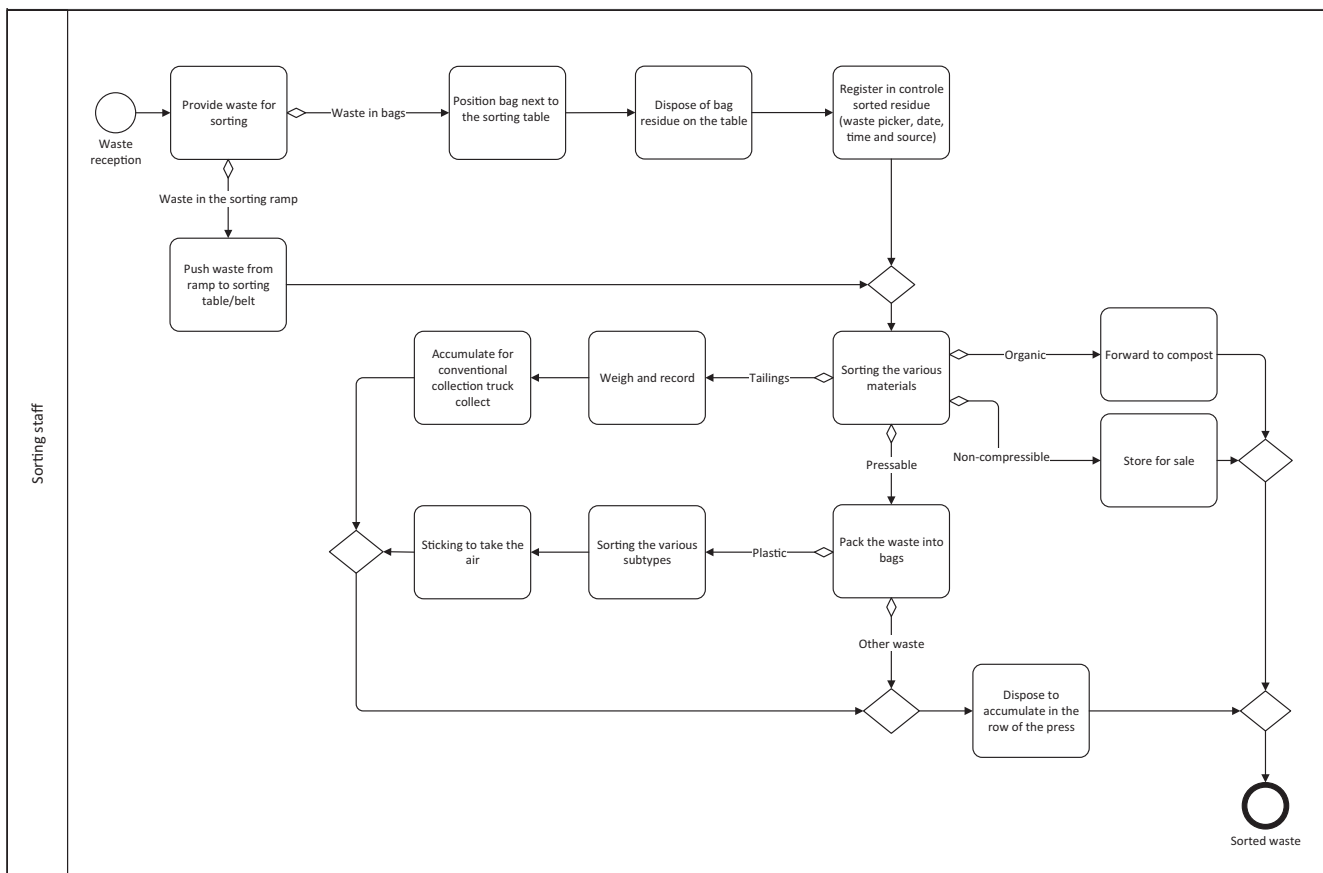


Fig. 5. Reference model for “Sorting solid waste.”

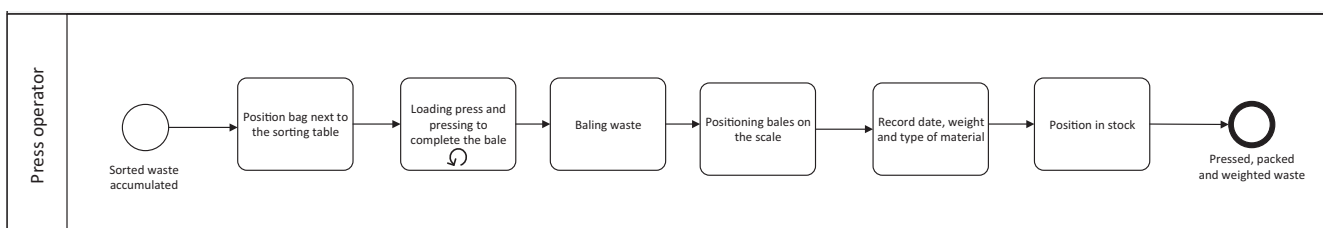


Fig. 6. Reference model for “Pressing and baling DSRW.”

- (a) Conduct recurrent training for pressing operators;
- (b) Attempt to use individual protection equipment (IPE) to mitigate accidents;
- (c) Adapt the WPO's layout to minimize the time spent with movements of unnecessary loads;
- (d) Purchase/Acquire vehicles to transport the bales to preserve the physical integrity of WPO members;
- (e) Ensure the frequent maintenance of all equipment used in this activity;
- (f) Attend to the maintenance of bale size standards required by customers;
- (g) Weigh the burden as soon as you leave the pressing machine to obtain an accurate picture of the amount of accumulated material to be marketed;
- (h) Keep internal records and the actual burden (such as weight and information of the person who processed it) to track any future problems;
- (i) Store the bale in an appropriate place sheltered from the elements.

We show the reference model in Fig. 6:

3.3.5. Commercializing DSRW

WPOs are responsible for sending almost all of the DSRW that are marketed in the recycling market to the industry through the middlemen. According to Tirado-Soto & Zamberlan (2013), the recycling market consists of a small number of buyers who need economies of scale to negotiate with the industry.

A good practice conducted by one WPO is to hold meetings with all members to decide which customer will negotiate, and ensure that everyone agrees with the marketed price. Holding periodic meetings contributes to the transparency of the sale and to the

group's integration. The following aspects are highlighted for the commercialization process:

- (a) Prospect new clients;
- (b) Use appropriate machinery for loading;
- (c) Describe and observe the standards required by the client;
- (d) Openly talk to all WPO members about the customer and the combined values;
- (e) Perform the control and registration of the material sold;
- (f) Search for prices among other WPOs and multiple customers to find the best value.

Some activities do not contribute to making the marketing process more agile, transparent, and advantageous for WPOs. Hence, we highlight the activities that lead to the dependence on the City Hall concerning the use of machinery of the city and the selection of the buyer. In addition, weighing bales prior to the time of shipment of the product proved to be important to make the sale more agile. Then, in Fig. 7, we suggest the reference model for “Commercializing DSRW,” from which these activities were suppressed:

By selecting the operating activities to be modeled, we identified those that influence the market efficiency reach of the organizations regarding selective collection, reception, sorting, pressing, baling, and the commercialization of DSRW. The selected processes are directly related to the end-of-business activity, and their improvement contributes to achieving the economic, environmental, and social sustainability of these joint ventures.

Selecting WPOs for our study allowed covering different regions of Espírito Santo, with different characteristics such as physical structure, productivity, and existence of contract, among others. These different contexts enabled us to verify good practices carried out in the organizations, which can be considered as references for other organizations.

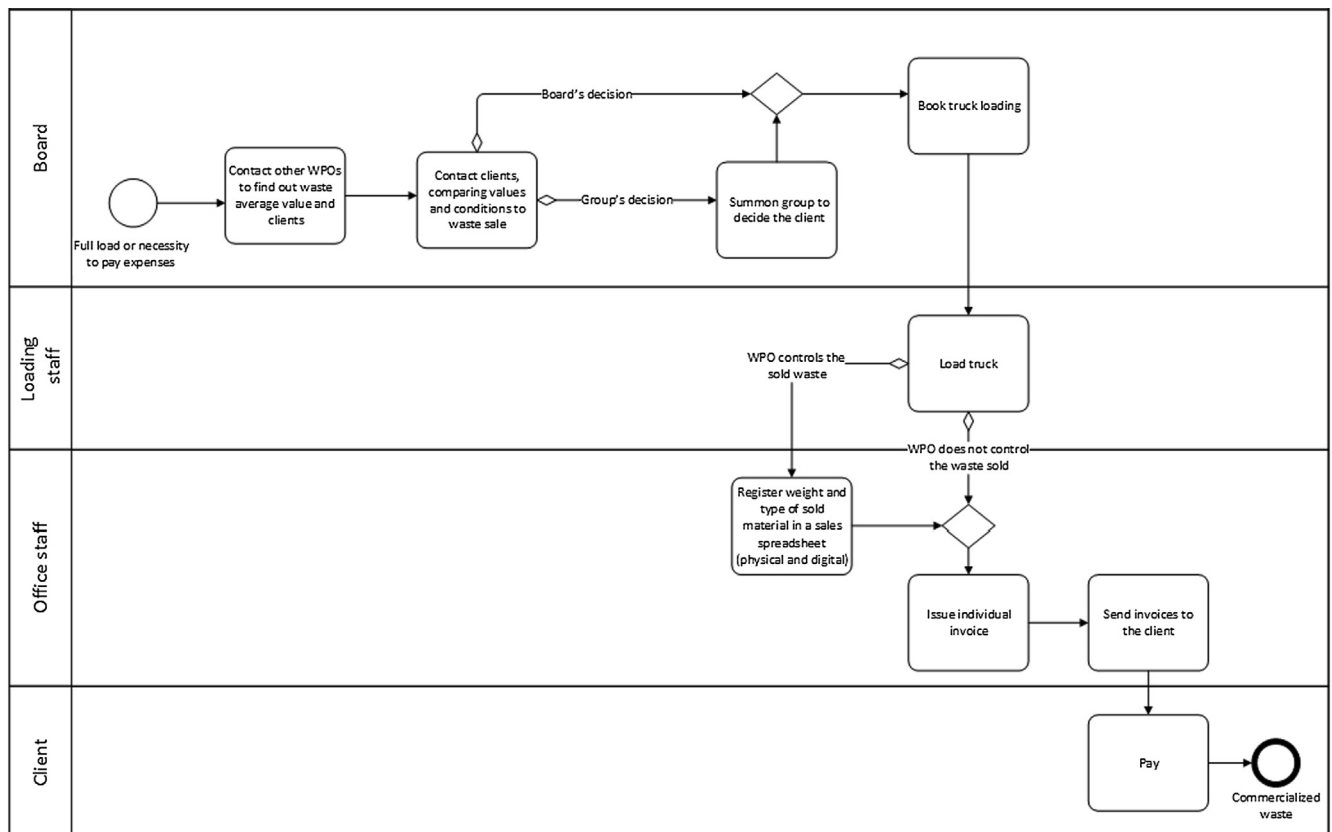


Fig. 7. Reference model for “Commercializing dry solid recyclable waste.” Caption: WPO – Waste Picker Organization.

We observed the need for increasing the selective collection in the cities, aiming to guarantee the social aspect in which WPOs are inserted: to divert the largest amount of waste from landfills and reduce the waste from the conventional collection for these enterprises. Waste management stages are greatly disarticulated in the cities, and the lack of understanding about carrying out selective collection should be overcome together with a broad and continuous work of environmental education.

DSRW sorting is the process that mostly differentiates among organizations. Firstly, regarding the structure for sorting, we observed the existence of tables, mats, ramps, and even the worst scenario, in which the sorting was performed on the floor. These organizations also differ in performing the second sorting for specific waste, such as plastic and electronics, and in the variety of typologies and subtypes in which the waste is sorted. This is because there are different markets for some materials, which vary among regions, in a way waste that is deemed tailings to some markets, is marketable waste to others.

Moreover, we observed the price discrepancy adopted by the same buyer and the same product for different WPOs. This highlights the importance of communication between WPOs and how the establishment of marketing networks can more fairly equate them.

The physical or virtual controls for the pressing and marketing activities were unanimous. For the other stages, these controls varied according to the controlling degree of the organization regarding work. It is noteworthy that monitoring the stage of selective collection and sorting, which is rarely conducted, allows tracing the residue as well as verifying the productivity of WPO members. This monitoring assists in improving environmental education activities by indicating the source of the waste that is poorly segregated in the WPO, in addition to verifying the WPO income and improving the earnings of members of these organizations.

Finally, in addition to the expansion of selective waste collection and environmental education in cities, there must be incentives for the recycling market economy, such as tax exemption from the sale of recyclable waste, in order to stimulate the creation of new industries and markets directed at waste that is currently unabsorbed. By developing these aspects and the possible establishment of marketing networks, WPOs are more likely to expand their businesses and fulfill the purpose for which they were created: ensuring adequate disposal of recycled dry solid waste through income generation and social integration.

4. Conclusions

Finally, the use of corporate governance tools provides conditions to improve the business self-management and the economic efficiency of WPOs, facilitate the work organized as commercial networks as well as eliminate or reduce dysfunctions.

Regarding the identification of the Operating Activities, we perceived the difficulty of WPOs in adding value to the materials as the main reason for the low economic efficiency of such organizations. Moreover, we emphasize that the hierarchization of Operating Activities is a necessary tool for the development of reference models, with which we can gather the best practices to disseminate and adapt them to other WPOs, but also to demonstrate that WPOs can produce more with the same used inputs.

The CIME “Ability to receive recyclable material,” “Ability to process recyclable material,” and “Being organized with self-management” outstood as the most important ones. The Operating Activities related to self-management, planning, and long-term vision are those WPOs have difficulty in achieving, since they outstood with the largest number of affirmations for partially or unachieved activities, resulting from dysfunctions regarding training and culture-related activities.

The dysfunctions identification resulted in a better understanding of the business, the problems that cause the low efficiency, but also the opportunities that can be used to invert this trend. WPOs might encounter some issues during changes implementation, such as low capacitation and governmental support, which causes poor working conditions, wages, collection rates, ultimately decreasing their performance (Navarrete-Hernandez and Navarrete-Hernandez, 2018).

The lack of efficiency also includes policy and legal arrangements, economical instruments, institutional/organizational arrangements, among others (Aparcana, 2017). According to Tirado-Soto and Zamberlan (2013), because of the way the recycling market works, the entire MSW stream has to be scrutinized in a whole, and not only the source-separated collection, because the WPOs intervene in the process, as well as the recycling companies, government, educational institutions and the population.

To Dentchev et al. (2016), even though these non-profit organizations are oriented to social and environmental issues, they can have a sustainable business model. This can be attained by using established technologies, innovative activity structures and institutional arrangements, adequate planning, and the involvement of concerned parties. Murakami et al. (2015) propose different ways to improve governmental support by changing policies to promote the pickers' actions, while simultaneously saving money from governments.

Finally, although some studies already applied process modeling to WPOs, regarding reverse logistics and WPO activities themselves (Fonseca et al., 2017; Lobato and Lima, 2010), a complete Business Process Model and Notation (BPMN) has not been used to the current date to create reference models for these organizations.

Reference models indicated that the main activities that influence the market efficiency are the selective collection, reception, sorting, pressing, baling, and the commercialization of dry solid recyclable waste. The analysis of the WPO's operating activities based on the models allows people involved in these organizations to understand the business in which they are inserted and where they fit in such business. This analysis also identified aspects to be improved to create optimized reference models. Moreover, we highlight the high feasibility of reference models, since the Operating Activities were modeled *in loco* for portraying the waste pickers' reality.

The perspective of WPOs as a business, and not as a welfare policy, allows proposing management solutions which aim to optimize the operating activities, and consequently the competitive positioning of the market. Improving the WPO's economic efficiency means reducing the current assistance policy of the government and contributing to achieve financial independence. Furthermore, it also promotes the effective inclusion of waste pickers into the municipal solid waste system provided for in the NPSW.

Therefore, this work is an important contribution for the scientific community, public decision makers, trainers and WPO managers, by providing models for the main WPO's processes, thereby assisting the effective management of these organizations.

The methodology described in this paper can be applied to any WPO group, especially in developing countries, to identify and understand possible dysfunctions that may affect the Operating Activities, but there are currently no reference models that can be applied to WPO management.

Finally, in the state of Espírito Santo, the WPO scenario does not differ from the Brazilian one, in a way the reference models can be generalizable to WPOs from other locations in Brazil and abroad, considering that the low market efficiency is not a reality exclusive to Brazil. Literature evidence highlighted the low market efficiency of the WPO in Brazil and also in developing countries (Dias, 2016; Dutra et al., 2018; Fidelis and Colmenero, 2018; Gutberlet, 2015b).

In addition to low market efficiency, Fidelis et al. (2020) and Botello-Álvarez et al. (2018) point out that in developing countries the productive chain of recycling depends on the work performance of waste pickers (informal and formal) at the base of the production system, collecting, processing and commercializing the recyclable materials. They also contribute to the diversion of recyclables from the landfills, increasing their lifespan, while providing materials to the recycling market that are converted into profits, and therefore are an integral part of the circular economy in developing countries (Velis, 2017).

4.1. Study limitations

The study investigated Waste Picker Organizations formally associated to Instituto Sindimicro (total sample size = 65 WPOs), but it did not address independent waste pickers or informal organizations.

The study adopted qualitative methods for data collection performed from July 2015 to January 2018. Survey conducted in Stage 1 was performed with 9 (nine) representative WPOs to identify the

Operating Activities, while in the survey from Stage 2 a virtual questionnaire was applied to a total of 80 respondents. Focus group meetings were carried out in about 71% of the WPOs, and the reference models were elaborated based on the 10 best-structured waste picker organizations.

The obtained data allowed us to identify diverse dysfunctions from which to draw the conclusions, but the results are limited by the WPOs from Espírito Santo State. It is possible that additional dysfunctions have not been identified in this investigation and the reference models cannot be applied to all WPOs, but they can be adapted.

The study includes in its scope technical reports which were exclusively accessed by an agreement with Instituto Sindimicro but cannot be accessed overseas.

Declaration of Competing Interest

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.

Appendix A

Survey
Waste Picker Organizations
Processes, Governance, and Operating Activities

1. Identification of Waste Picker Organization

2. Name and job function of people interviewed at the organization

3. In addition to members, are there other maintainers of the organization?

Yes No

4. Is there an established partnership?

Covenant Agreement

5. Is the search for new suppliers performed?

Always Most of the time Occasionally Rarely Never

6. Can the organization demand the quality of the material to be provided?

Always Most of the time Occasionally Rarely Never

7. Are new customers captured?

Always Most of the time Occasionally Rarely Never

8. Are operating activities divided?

Yes No

9. Is the production performed according to the market need?

Always Most of the time Occasionally Rarely Never

10. Is there communication between stakeholders (members, administrators, employees, and society)?

Always Most of the time Occasionally Rarely Never

11. Are there specific job functions?

Always Most of the time Occasionally Rarely Never

12. Is there a diagram of the organizational structure (organization chart)?

Yes No

13. Is the production line organized?

Always Most of the time Occasionally Rarely Never

14. Do products/services meet market needs?

Always Most of the time Occasionally Rarely Never

15. Are product quality and goal planning complied with?

Always Most of the time Occasionally Rarely Never

16. Is it possible to eliminate problems with product quality and reliability?

Always Most of the time Occasionally Rarely Never

17. Can you get the materials and equipment you need for production and services?

Always Most of the time Occasionally Rarely Never

18. Can you monitor the production?

Always Most of the time Occasionally Rarely Never

19. Do you analyze market trends (Competitor organizations, competitive products or substitutes)?

Always Most of the time Occasionally Rarely Never

20. Is there a specific target segment?

Yes No

21. Do you reach the best sales negotiations?

Always Most of the time Occasionally Rarely Never

22. Is there customer loyalty?

Yes No

23. Do you develop sales forecast?

Always Most of the time Occasionally Rarely Never

24. Do you establish relationships with sales partners and alliances?

Always Most of the time Occasionally Rarely Never

25. Do you establish general sales budget (revenue, costs, profit, budget)?

Always Most of the time Occasionally Rarely Never

26. Do you adopt any packaging strategy?

Always Most of the time Occasionally Rarely Never

27. Is there a definition of production goals?

Always Most of the time Occasionally Rarely Never

28. Is there a definition of the production process?

Yes No

29. Is there a definition of the production workplace infrastructure?

Yes No

30. Is the layout of the production workplace infrastructure defined?

Yes No

31. Can you certify your suppliers? Especially if in Question 4 you checked the 'Agreement' option".

Always Most of the time Occasionally Rarely Never

32. Do you have a work schedule?

Always Most of the time Occasionally Rarely Never

33. Is there a schedule for preventive maintenance on the production line?

Always Most of the time Occasionally Rarely Never

34. Is the management of raw material inventory performed?

Always Most of the time Occasionally Rarely Never

35. Is there rework of defective items?

Always Most of the time Occasionally Rarely Never

36. Is the inventory management of products for delivery performed?

Always Most of the time Occasionally Rarely Never

37. Do you confirm specific requirements of products for each customer?

Always Most of the time Occasionally Rarely Never

38. Do you receive customer's feedback on the delivered product?

Always Most of the time Occasionally Rarely Never

39. Do you provide transportation service for product delivery?

Always Most of the time Occasionally Rarely Never

40. Do you note the need for outsourcing of product shipping service?

Yes No

41. Do you plan to receive materials from your suppliers?

Always Most of the time Occasionally Rarely Never

42. Do you have a defined storage capacity?

Yes No

43. Do you provide any guarantee of your products/services?

Always Most of the time Occasionally Rarely Never

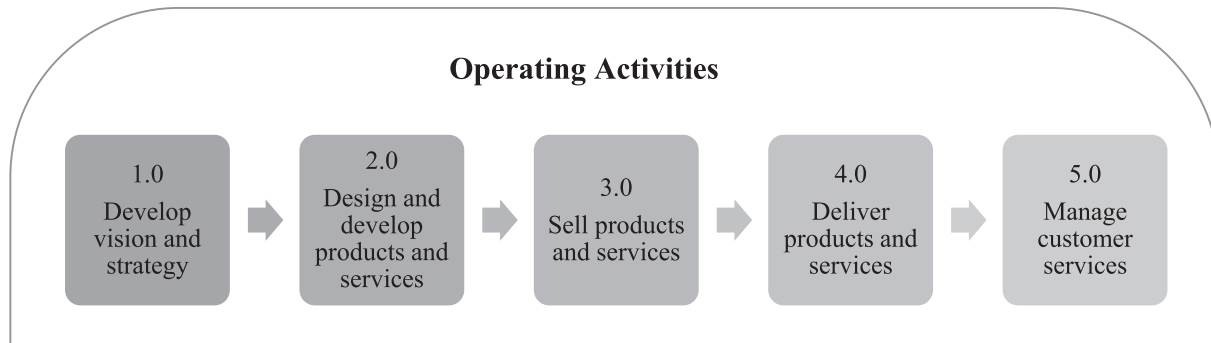
44. Do you stimulate any after sales activities for customers?

Always Most of the time Occasionally Rarely Never

45. What difficulties hinder or may hinder the business of waste picker organizations in the Brazilian recycling market (from procurement of materials to commercialization)?

Appendix B

Operational Activities Structure of Waste Picker Organizations

**1.0 Develops vision and strategy**

- 1.1 Defines business concept and long-term vision
 - 1.1.1 evaluates the external environment
 - 1.1.2 Searches market and determines the customer's needs and desires
 - 1.1.3 Performs internal analysis
 - 1.1.4 Establishes strategic vision
 - 1.1.5 Provides opportunities for restructuring the organization
- 1.2 Develops business strategy
 - 1.2.1 Develops global mission
 - 1.2.2 Evaluates strategic options for achieving objectives
 - 1.2.3 Selects long-term business strategy
 - 1.2.4 Coordinates and aligns functional and process-related strategies
 - 1.2.5 Creates organizational design (structure, governance, reporting, etc.)
- 1.3 Manages Strategic Initiatives
 - 1.3.1 Develops strategic initiative
 - 1.3.2 Evaluates Strategic Initiatives
 - 1.3.3 Selects Strategic Initiatives

2.0 Designs and develops products and services

- 2.1 Manages product and service portfolio
 - 2.1.1 Defines product/service development requirements
 - 2.1.2 Performs discovery search
 - 2.1.3 Confirms product/service concept alignment with business strategy
 - 2.1.4 Manages product/service life cycle
- 2.2 Develops products and services
 - 2.2.1 Designs, creates, and evaluates products and services
 - 2.2.2 Market testing for new or revised products and services
 - 2.2.3 Prepares for production

4.0 Deliver products and services

- 4.1 Plan and align supply chain resources and services
 - 4.1.1 Develop production and materials strategies
 - 4.1.1.1 Define capacities
 - 4.1.1.2 Define production network and supply restrictions
 - 4.1.1.3 Define production process
 - 4.1.1.4 Define layout of production workplace and infrastructure
 - 4.1.2 Manage demand for products and services
 - 4.1.2.1 Develop sales forecast base
 - 4.1.2.2 Collaborate with customers
 - 4.1.2.3 Determine availability for promise
 - 4.1.3 Create material plan
 - 4.1.3.1 Create unrestricted plan
 - 4.1.3.2 Collaborate with supplier and contract manufacturers
 - 4.1.3.3 Identify critical materials and supplier capacity
 - 4.1.3.4 Monitor material specifications
 - 4.1.3.5 Generate constrained plan
 - 4.1.3.6 Define production balance and control
 - 4.1.4 Create and manage production master schedule
 - 4.1.4.1 Create production plan and schedule at local level
 - 4.1.4.2 Manage inventory in production (work-in-progress)
 - 4.1.4.3 Collaborate with suppliers
 - 4.1.5 Plans distribution requirements
 - 4.1.5.1 Maintains master data
 - 4.1.5.2 Determines requirements for inventory of destination of the finished product
 - 4.1.5.3 Manages shipment plan achievement
 - 4.1.5.4 Manages capacity utilization
 - 4.1.6 Establishes distribution planning constraints
 - 4.1.6.1 Establishes distribution center layout constraints
 - 4.1.6.2 Establishes inventory management restrictions
 - 4.1.7 Reviews distribution planning policies
 - 4.1.7.1 Reviews distribution network
 - 4.1.7.2 Establishes supply relationships
 - 4.1.8 Develops quality standards and procedures
 - 4.1.8.1 Establishes quality goals
 - 4.1.8.2 Develops standard test procedures
 - 4.1.8.3 Reports quality specifications
- 4.2 Purchasing materials and develop strategy services
 - 4.2.1 Develops sourcing strategies
 - 4.2.1.1 Develops procurement plan
 - 4.2.1.2 Clarifies purchasing needs
 - 4.2.1.3 Develops inventory strategy
 - 4.2.1.4 Matches need for supply capabilities
 - 4.2.1.5 Analyze the spending profile of the organization
 - 4.2.1.6 Seeks opportunities to improve efficiency and value
 - 4.2.1.7 Collaborates with suppliers to identify sourcing opportunities

Continuation

4.0 Delivers products and services

- 4.2.2 Selects suppliers and develops/maintains contracts
 - 4.2.2.1 Selects suppliers
 - 4.2.2.2 Certifies and validates suppliers
 - 4.2.2.3 Negotiates and enters into contracts
 - 4.2.2.4 Manages contracts
- 4.2.3 Orders materials and services
 - 4.2.3.1 Posting goods receipt
 - 4.2.3.2 Searches/troubleshoots exceptions
- 4.2.4 Manages suppliers
 - 4.2.4.1 Monitors/manages supplier information
 - 4.2.4.3 Supporting inventory and production processes
 - 4.2.4.4 Monitors quality of delivered products
- 4.3 Produces/manufactures/delivers product
 - 4.3.1 Collecting urban solid waste
 - 4.3.1.1 Collects recyclable urban solid waste
 - 4.3.1.2 Transports to the warehouse of the organization
 - 4.3.1.3 Delivers recyclable urban solid waste
 - 4.3.2 Receiving waste
 - 4.3.2.1 Receives collected recyclable solid urban waste
 - 4.3.2.2 Receives recyclable solid urban waste voluntarily delivered to the shed
 - 4.3.2.3 Deposits inside the shed
 - 4.3.3 Sorting urban solid waste
 - 4.3.3.1 Transports waste to sorting area
 - 4.3.3.2 Separates waste according to material classification/typology
 - 4.3.4 Inspects and stores
 - 4.3.4.1 Takes separate stock into storage bay
 - 4.3.4.2 Performs equipment maintenance
 - 4.3.4.3 Takes material for post-sorting storage
 - 4.3.5 Pressing, baling, weighing, and storing the sorted material
 - 4.3.5.1 Pressing and baling
 - 4.3.5.2 Performs weighing and identification
 - 4.3.5.2 Stores
 - 4.3.6 Operates Storage
 - 4.3.6.1 Tracks product availability
 - 4.3.6.2 Packs and ship product for delivery
 - 4.3.6.7 Manages product inventory

Continuation

4.0 Delivers products and services

- 4.4 Delivers product/service to customer
 - 4.4.1 Confirms specific product/service requirements for each customer
 - 4.4.2 Identifies and schedule resources to meet product/service needs
 - 4.4.3 Provides the product/service to specific customers
 - 4.4.4 Ensures product/service quality
 - 4.4.4.1 Identifies completed orders
 - 4.4.4.2 Identifies incomplete orders and service failures
 - 4.4.4.3 Processes customer return on provided services
- 4.5 Manages logistics
 - 4.5.1 Defines logistics strategy
 - 4.5.1.1 Logistics network designing
 - 4.5.1.2 Communicates to outsourcing needs
 - 4.5.1.3 Develops and maintain delivery service policy
 - 4.5.1.4 Optimizes transport times and costs
 - 4.5.2 Operates dispatch/outbound shipping
 - 4.5.2.1 Plans and delivers outbound product
 - 4.5.2.2 Selects quantity and quality of products requested by customers
 - 4.5.2.3 Sets delivery date and time
 - 4.5.2.4 Shipping product
 - 4.5.2.5 Carries bales to the expedition truck

5.0 Manage customer services

- 5.1 Develops customer service and attention strategy
 - 5.1.1 Develops customer service segmentation/prioritization (e.g., levels)
 - 5.1.2 Defines customer service-related policies and procedures
 - 5.1.3 Establishes customer service levels
- 5.2 Plans and manages customer service operations
 - 5.2.1 Plans and manages customer service workforce
 - 5.2.2 Manages customer service requests/queries/complaints
- 5.3 Measures customer satisfaction with products and services and with handling questions/requests.

Appendix C. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.wasman.2020.01.040>.

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