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SOCIAL LIFE CYCLE ASSESSMENT IN WASTE PICKERS ASSOCIATIONS USING PRIMARY AND SECONDARY DATA

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Abstract

There is a growing interest in measuring and evaluating social aspects, such as the impact of actions, activities or decisions on society and the environment. To measure these impacts, a tool called Social Life Cycle Analysis (SLCA) can be used with different types of data or inventory sources. However, the conducted bibliographic review revealed that the quality of the data was not verified in previous SLCA studies of waste pickers associations. Therefore, this study compares the results of an SLCA using the same assessment method but with primary and secondary data, motivating the analysis of relationships between data types and assessment results. This analysis focused on the social impacts on Waste Pickers Organizations located in Vitória, the capital of Espírito Santo, Brazil. The results show better impact levels in the indicators and subcategories when using secondary data instead of primary data. This shows that using secondary data leads to more uncertainties for a study with a Type I SLCA with performance benchmarks. Regarding data quality, the trend remains the same, with primary data being of better quality than secondary data.

Keywords: Social Life Cycle Assessment, municipal solid waste, Waste Pickers Organizations, indicators, subcategories, primary/secondary data.

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Introduction

Social Life Cycle Assessment (SLCA) has been gaining momentum in case studies involving municipal solid waste management systems (MSWMS) that make use of recyclable material recovery and the utilization of waste pickers to verify social impacts (Aparcana and Salhofer, 2013a, 2013b; Yıldız-Geyhan *et al.*, 2017, 2019; Ibáñez-Forés *et al.*, 2019; Azimi *et al.*, 2020). This creates the need to collect inventory data to feed the characterization model and generate the results for assessing social impacts.

In developing countries, waste pickers play a prominent role in collecting recyclable and reusable materials and may or may not be part of the MSWMS (Ibáñez-Forés *et al.*, 2019; Wilson *et al.*, 2012). Particularly in Brazil, the Brazilian Classification of Occupations (Brazil, 2022) recognizes these professionals in category No. 5,192-05: *Catador de Material Reciclável* (Recyclable Waste Picker). These people collect, sort and sell reusable or recyclable materials as an income source (Siman *et al.*, 2020). These exhausting tasks have risks from handling and moving heavy loads containing sharp and biohazardous materials. Moreover, the search for materials in the dumps by informal, unassociated pickers is done under strong sunlight and without adequate personal protective equipment (PPE) to mitigate risks (Costa, 2019). In the search for better working conditions and social inclusion, waste pickers may be organized into associations or cooperatives, the Waste Pickers Organizations (WPO). These are supported by the Brazilian Solid Waste Policy (Brazil, 2010) which is in line with the United Nations Sustainable Development Goals (UN, 2015).

According to the United Nations Environment Programme (UNEP, 2020), the inventory of SLCA studies contains data classified as primary (or specific) and secondary (or generic) as to their origin. Primary data are obtained at the organization or company for the process under study. Conversely, secondary data are collected from other sources like articles, publications, audits, and for different studies and purposes (Ibáñez-Forés *et al.*, 2019; UNEP-SETAC, 2009). As for typology, data can be qualitative, semi-quantitative and quantitative. Examples of the quantitative data range from binary answers (1/0, yes/no) to numbers produced in statistical analyses. Regarding the data obtained in MSWMS that include waste pickers, the use of yes/no questions or coding data into performance reference points (PRP) on a scale of Excellent/Very good/Good/Mediocre/Poor can be used to express the opinion of the interviewees, the pickers (Aparcana and Salhofer, 2013a, 2013b).

The bibliographic review revealed that the characterization of previous social impact assessments in MSWMS with waste pickers did not verify the quality of the data (Mattos and Calmon, 2023). This is because primary data brings produces more accurate results than secondary data (Ibáñez-Forés *et al.*, 2019; Rafiaani *et al.*, 2018; Siebert *et al.*, 2018; UNEP-SETAC, 2009). However, collecting primary data in organizations requires plenty of time and resources (Bonilla-Alicea and Fu, 2019; Hosseinijou *et al.*, 2014; Martínez-Blanco *et al.*, 2014;

Pollok *et al.*, 2021), which may be unfeasible, depending on the study. This may make the use of secondary data the only way to perform the study.

There are two main SLCA families, Type I and Type II. The first is based on models that use PRP for their "scoring" or performance indication (UNEP, 2020). These models can use numeric or color scales, where the results are obtained by checking the indicator's value in a certain range or class of the scale used (UNEP-SETAC, 2009; UNEP, 2020). Conversely, Type II is based on social impact paths for midpoint or endpoint, just like in Environmental LCA, in which characterization models are defined to convert inventory data into impact category results (Neugebauer *et al.*, 2014; UNEP, 2020; UNEP-SETAC, 2009). Therefore, this study aims to compare the results of primary and secondary data use in two Type I SLCA applied to survey social impacts in WPO with PRP. This produces more information on the relationship between different SLCA outcomes when using primary and secondary data.

Materials and methods

According to UNEP (2020), the Social Life Cycle Assessment (SLCA) methodology used to measure social impacts in WPO located in Vitória (Espírito Santo, Brazil) has four basic phases, Goal and Scope, Inventory, Impact Assessment, and Interpretation (SM Figure 1), as in Environmental LCA. This study was also based on the Product Social Impact Assessment methodology, or PSIA 2020 (Goedkoop *et al.*, 2020). Notably, adaptations were made to contextualize the updated Guidelines for SLCA of Products and Organizations (UNEP, 2020) to the scenarios proposed for this study.

Since this paper is focused on the inventory, primary data were collected at the WPO and secondary data (including generic data) from different sources. These WPO were grouped into one, overlapping their influence zone in the municipality's community. This is because they all work in practically the same way, they have contracts with the municipality, receive material from source-separated collection from various points in the city and do not allow sensitive data to be exposed.

First phase of the SLCA: Goal and Scope

The main *goal* was to identify negative and positive social impacts for WPO in their activities, using primary and secondary data. Waste pickers perform these activities, which include collecting, sorting, pressing, baling and marketing recyclable materials (Figure 1). According to the classification proposed in PSIA 2020 (Goedkoop *et al.*, 2020) a WPO are considered companies or organizations comprised of small entrepreneurs. They are linked to a service or process, as they divert recyclable waste from final disposal and forward those sorted materials back to the product cycle.

Thus, the *scope* can be seen as grave-to-grave (Wu *et al.*, 2014), as the social impacts are measured from the end-of-use of a product until before the final disposal of the recyclable components of that product. The SLCA focuses exclusively on the operation/use phase of the WPO in this study (**¡Error! No se encuentra el origen de la referencia.**). The pre-use and post-use phases are not linked to WPO, as they relate to construction, donations, government aid, etc. This means that the system's boundaries restrict to the activities within the WPO only.

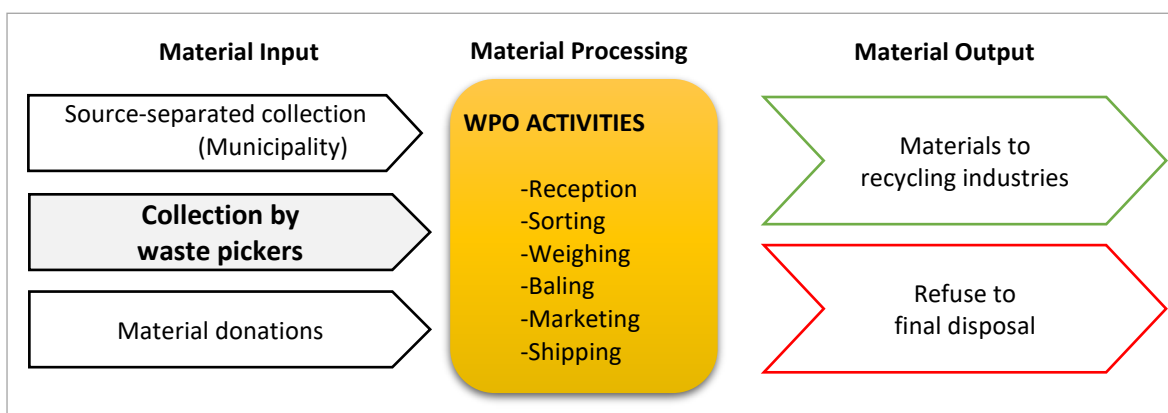


Figure 1. Activities of waste pickers organizations (WPO) considered in the system boundary

Social Hotspots

The social hotspots are social aspects of the stakeholders that are socially impacted by the product created or process performed by the organization and are used to define the stakeholder categories:

- Workers – the waste pickers who are associated with the WPOs;
- Local community – the residents of Vitória, who contact directly with waste pickers and WPOs that operate in that municipality;
- Society - population of ES and Brazil, which receives the indirect influence of WPOs.

These hotspots were based on literature that informs the minimum number of categories and subcategories for an SLCA study in MSWMS that include WPO (Aparcana and Salhofer, 2013b; Azimi *et al.*, 2020; Foolmaun and Ramjeeawon, 2013; Ibáñez-Forés *et al.*, 2019; Harijani *et al.*, 2017; Sousa-Zomer and Miguel, 2018; Umair *et al.*, 2015; Yıldız-Geyhan *et al.*, 2017). As for the primary and secondary data used for both SLCA, its source is indicated in Table 1 for the chosen indicators that comprise the subcategories and categories.

Table 1. Stakeholders, subcategories and indicators selected for evaluating social impacts with Social Life Cycle Assessment

Stakeholder categories	Subcategories	Indicators	Primary data source	Secondary data source	Secondary data year*
Worker	Child labor	Irregular work under 18	Interv., WPO info	IBGE, LL and MTP	2020; (-); 2022
	Collective Bargaining	Presence of collective bargaining	Interv., WPO info	LL, MTP and syndicates	(-); (-); 2022
	Fair Salary	Monthly salary	Interv., WPO info	IBGE, LL, MTP and syndicates	2021; (-); (-); 2022
		Payment regularity	Interv., WPO info	LL, MTP and syndicates	(-); (-); 2022
	Working Hours	Working hours/day	Interv., WPO info	LL and syndicates	(-); 2022
		Night work	Interv., WPO info	LL and syndicates	(-); 2022
	Equal opportunities/ Discrimination	Male/female workers ratio	Interv., WPO info	IBGE	2010, 2019, 2020 and 2021
		Male/female earnings ratio	Interv., WPO info	IBGE and MTP	2021; (-)
		Educational qualifications	Interv.	IBGE	2010, 2019, 2020 and 2021
		Social acceptability	Interv., WPO info	LL and syndicates	(-); 2022
	Health and Safety	Wearing personal protection equipment	Interv., WPO info	LL and MTP	(-); (-)
		Number of work accidents	Interv., WPO info	LL, SNIS and MTP	(-); 2020;(-)
		Has proper equipment for the job	Interv., WPO info	LL, SNIS and MTP	(-); 2020;(-)
		Health & Safety training	Interv., WPO info	LL and MTP	(-); (-)
		Has a suitable place to eat	Interv., WPO info	LL and MTP	(-); (-)
		Has suitable toilets	Interv., WPO info	LL and MTP	(-); (-)
		Job satisfaction	Interv.	IBGE, SEBRAE-DIEESE and syndicates	2021; 2018; 2022
	Social Benefits/ Social Security	Social benefits	Interv., WPO info	LL and MTP	(-); (-)
		Paid Time Off (sickness, accidents...)	Interv., WPO info	LL and MTP	(-); (-)
Local Community	Community engagement	Quantity of recycled material correctly disposed of	WPO info, Municipal data	SNIS	2020 and 2021
	Local employment	Creation of jobs or associations	WPO info	SNIS	2020 and 2021
	Access to material resources	Quantity of recycled materials returned to the raw material market	WPO info, Municipal data	SNIS	2020 and 2021
	Safe & healthy living conditions	Safe living conditions of the Local Community -Picker	Interv., WPO info	IBGE	2010, 2018 and 2021
Society	Sustainability	Public engagement sustainability issues	WPO info, Municipal data	LL, SNIS and IBGE	(-); 2020 and 2021; 2010, 2018 and 2021
	Contribution to economic development	Contribution to economic development	WPO info, Municipal data	SNIS	2020 and 2021

Note: interv. = interview with associated waste pickers; WPO info – collected information at the waste pickers associations; SNIS – Brazilian Sanitation Information System; IBGE – Brazilian Geography and Statistics Institute; MTP – Brazilian Ministry of Labor and Social Security; LL – Labor Laws; (-): current data or year of publication of the law not considered or does not apply.

Second SLCA phase: Inventory

Two different approaches were made to obtain the data needed to fill the inventory, depending on the data type. For the primary data, structured interviews with waste pickers were used to collect inventory data for the selected indicators, shown in Table 1, via questionnaires with yes/no answers or value scales (Juchen, 2019). As some waste pickers have reading difficulties, the interpretation of the questions may be compromised (Aparcana and Salhofer, 2013a, 2013b), needing an interviewer present to conduct the interview and fill in the questions. In the first visits to the WPO in Vitória (ES, Brazil), it was decided to interview all members who agreed to participate in the research, as the number of waste pickers was slightly less than 20 pickers per association. Conversely, the secondary data were found in bibliographic material related to WPO or similar organizations at a local, regional or national level, easily accessible for research. Examples of sources are surveys from state, national and international institutes, laws, trade unions, and companies similar to the WPO.

To assess the quality of those data, the PSIA 2020 data quality matrix (Goedkoop *et al.*, 2020) was used, with adaptations. These were necessary to understand better the texts based on the Pedigree matrix (Weidema and Wesnæs, 1996), as shown in SM Table 1. This was done by evaluating from 1 (best) to 5 (worst) each datum for the three criteria (Accuracy, completeness and validity; Temporal Correlation; Correlation and Representativeness). The final quality value is the average of those three criteria.

Third SLCA phase: Impact Assessment

The PSIA 2020 (Goedkoop *et al.*, 2020) already has data quality and characterization systems that can be adapted to meet UNEP (2020). Thus, it aligns with the SLCA articles on MSWMS obtained in the bibliography, meeting the SLCA requirements and adding data quality (SM Table 1). The PSIA 2020 uses a PRP system, assigning an importance value to inventory data through levels that indicate positive impacts (+1 and +2), negative impacts (-1 and -2) and an intermediate level (zero), which guarantees the minimum specification for the indicator not to be considered negative (Goedkoop *et al.*, 2020).

The assessment framework from PSIA 2020 evaluates the positive and negative social impacts of products and services, using four stakeholder groups: Workers, Local community, Small-scale entrepreneurs and users (Goedkoop *et al.*, 2018, 2020). Although the 2020 manual reports that this method does not aim to survey the social impacts of a company as a whole, it was used in this study as an evaluation method because the WPO's recyclable material sorting activity equates to a service. Additionally, the PSIA 2020 is equivalent to SLCA Type I and can be adapted to certain points of the SLCA methodology and stakeholders. The adaptations made in implementing the categories, subcategories and indicators of the UNEP (2020) were based on the item *Social*

Hotspots. In line with a Type I approach, reference performance scales based on the UNEP (2020) generic reference model (SM Table 2) were developed for each indicator used.

Regarding the indicators contained in the subcategories presented in Table 1, the reference scale has five performance levels (+2, +1, 0, -1 or -2) with their respective description based on the PSIA 2020 characterization framework (Goedkoop *et al.*, 2020). These descriptions are based on reference points set by national or international standards or government agencies. Thus, the reference scales used in this SLCA were designed for each indicator and can be consulted in Tables 3, 4 and 5 of the Supplementary Material. Then, the impact of the subcategories is calculated through the average value of the indicators that make up that subcategory (WBCSD, 2016), and the same is performed for the categories. Ultimately, the result comprises two values, the impact result and the data quality.

Results and discussion

The fourth phase of the SLCA, Interpretation, is when the results of the SLCA are analyzed and developed based on previous studies. Therefore, the SLCA results of all indicators are presented in SM Tables 6, 7 and 8 for the stakeholder categories *Worker*, *Local Community*, and *Society*, respectively. Since these categories are comprised of subcategories, their average results are presented in Table 2, whereas Figure 2 presents the social performance of each subcategory comprising the stakeholder categories for the SLCA with primary and secondary data.

Table 2. Impact levels of the subcategories with primary and secondary data.

Categories	Subcategories	Primary Data Results		Secondary Data Results	
		Result	Data Quality	Result	Data Quality
Worker	Child labor	1	1	2	2.7
	Collective bargaining	1	1	2	1.7
	Fair salary	0.5	1	1.5	2.0
	Working hours	0.5	1	0	2.7
	Equal opportunities/Discrimination	0.5	1	-0.5	3.2
	Health and Safety	-0.4	1	1.4	3.1
	Social benefits/Social security	2	1	2	2.7
Local community	Community engagement	0	2	0	3.3
	Local employment	0	1	1	3.3
	Access to material resources	-1	2	0	3.3
	Safe & Healthy living conditions (picker)	2	1	0	4.0
Society	Sustainability	1	1	0	3.3
	Contribution to economic development	0	1	1	3.3

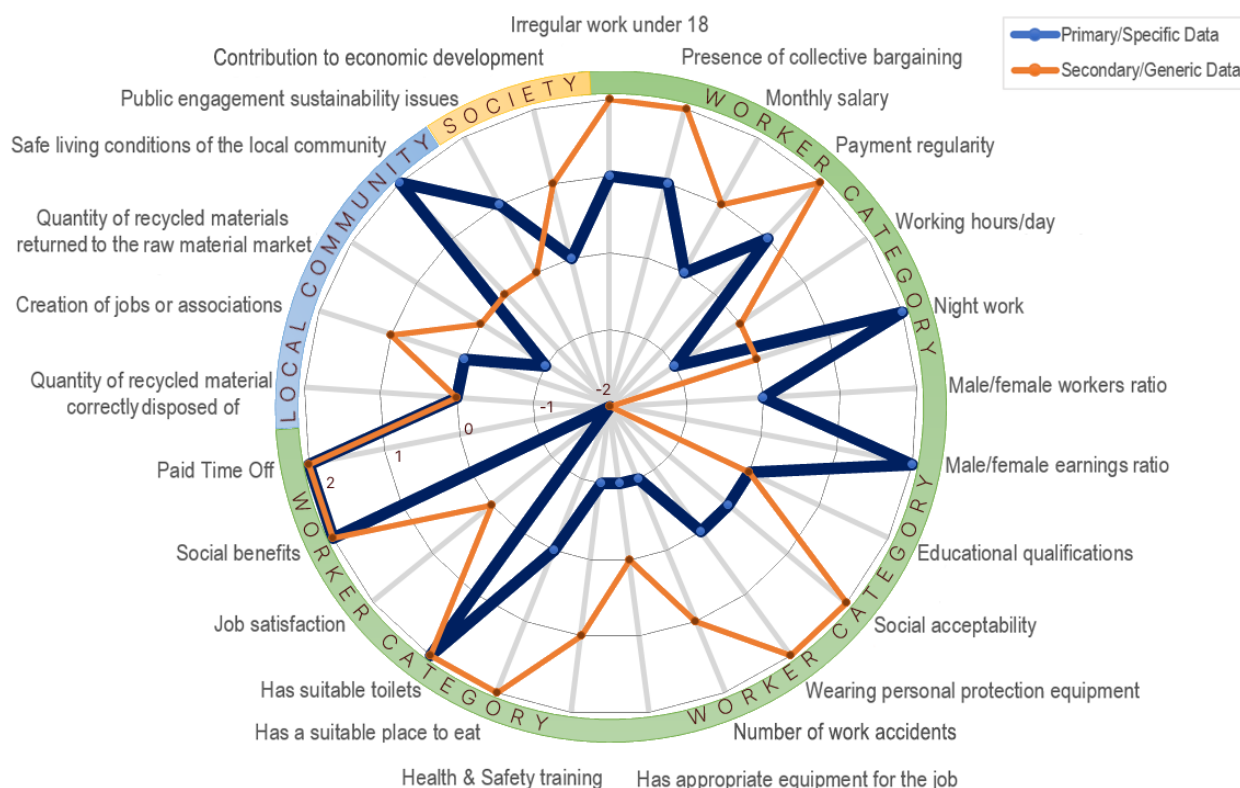


Figure 2. Social impact Levels in waste pickers organizations measured with primary and secondary data. *Source: own source.*

Worker

Starting the discussion by the subcategories, *Fair salary* and *Health and Safety*, the secondary data show better results because it is based on current laws or the companies that must follow such laws, conditioning more favorable results from the perspective of compliance, as well as the great dissatisfaction of the waste pickers of the interviewed WPO. On the other hand, *Working hours* and *Equal opportunities/Discrimination* had more favorable impact levels in the primary data than in the secondary data due to the large participation of women in this industry and equal earnings regardless of gender. The subcategory *Social benefits/Social security* has the same explanation as the equality of impact levels of the indicators that compose it.

As for *Child labor* and *Collective bargaining*, as well as *Local community* and *Society*, the average value is the same as the indicator since these subcategories have one indicator only. Therefore, these indicators will be further analyzed below with the rest of the indicators.

Comparing the 16 indicators of the *Worker* category shown in Figure 2, primary data had a better result than secondary data in three indicators only: *Night work*, *Male/female workers ratio* and *Male/female earnings ratio*. This result shows that this type of organization has particularities that are not captured by secondary data at the national level. This means that although waste pickers are looking for formal, regulated jobs (Aparcana and Salhofer, 2013b; Ibáñez-Forés *et al.*, 2019), this does not guarantee an improvement in the conditions represented by these indicators.

Contrarily, the remaining 12 indicators show more beneficial impact levels for secondary data (SM Table 5). Regarding the positive social impacts, the secondary data overshadowed the primary data in the indicators *Irregular work under 18*, *Presence of collective bargaining*, *Monthly salary*, *Payment regularity*, *Working hours/day* and *Social acceptability* because they are based directly influenced by the current legislation. The study conducted by Aparcana and Salhofer (2013b) proved that the formalization of waste pickers resulted in more favorable social impacts for waste pickers, largely because the pickers' earnings were influenced by the value of recyclable materials or the quantity sorted and sold.

About *Health and Safety*, the indicators *Wearing personal protection equipment*, *Number of work accidents* and *Health & Safety training* had a less favorable level of social impact with the primary data than with the secondary data. This is because the secondary data is based on laws that the company was supposed to obey, and there are discrepancies between the pickers' reports and the managers of the WPO (who are also waste pickers). Additionally, despite the brief explanation of accidents and safety during the interviews recommended by Ibáñez-Forés *et al.* (2019), it was difficult for waste pickers to report facts on this issue accurately. The indicator *Has proper equipment for the job* had a negative impact when primary data was used, particularly because of manual heavy loads handling. These results highlight inconsistencies between what is mandated by the laws and regulations and the reality in these organizations, which point to opportunities for improvement in work conditions.

These improvements are directly connected with *Job satisfaction*, in which the secondary data came from studies of companies that provide job vacancies. Since these data are not necessarily linked to public cleaning companies or equivalent, this explains why the primary data had worse but more accurate results, consistent with the pickers' reported dissatisfaction. This agrees with which analyzed the work conditions of the formal sector, which are better than in the informal sector (Aparcana and Salhofer, 2013b; Yıldız-Geyhan *et al.*, 2017). Conversely, the *Social benefits* and *Paid Time Off* indicators had the same level of social impact outcome because both companies and organizations use the same social security system offered by the Brazilian Federal government despite some differences in forms of contribution and benefits to be received.

Local Community

Regarding the four indicators of the *Local Community* category, only one had a better level with primary data than with secondary data in the *Safe living conditions of the Local Community-Picker*. This is because the actual housing conditions of waste pickers in Vitória, where the WPO are located, is better than the estimated situation of the entire State and country.

The *Quantity of recycled material correctly disposed of*, indicator had the same level of impact on both data types, because the secondary data is from a national report that includes WPO. The other indicators performed better with secondary data, as they represent national-level data that is closer to the performance levels established in the PRP of this study.

Regarding the case of the indicator *Quantity of recycled materials returned to the raw material market*, it was the only one with a negative level only with primary data. This can be explained by the need for improvements in the processes (activities) of the WPO (Dutra *et al.*, 2018) to increase the amount of recyclable material that returns to the raw material market. Another explanation is that the effectiveness of source-separated collection depends on cultural factors, the society's structure, economy, among others (Yıldız-Geyhan *et al.*, 2019), which cannot be accurately represented by the average of secondary data from several sources.

Society

In the *Society* category, the level of impact with primary data was higher than with secondary data in the indicator *Public engagement sustainability issues*. This is because the secondary data adopted the collection of the material by the WPO themselves or with the help of the local community, whereas in reality, the WPO also has contracts with the local government to be included in the MSWMS.

On the other hand, secondary data ranked higher than primary data regarding *Contribution to economic development*. Such a difference in level is explained by the performance reference point of this indicator being based on national data, bringing it closer to the secondary data.

Conclusion

This study was carried out to determine the social impacts of the WPO operating in Vitória (ES – Brazil), using SLCA. Performance Reference Points were used with the indicators' social impact levels (positive, negative or baseline) to determine the impact levels of the subcategories subsequently. Therefore, this enabled the comparison and interpretation of the results.

Regarding the application of primary/specific data, the highest levels of positive impact were verified in the indicators *Night work*, *Male/female earnings ratio*, *Has suitable toilets*, *Social*

benefits, Paid time off and Safe living conditions of the Local Community. Conversely, the *Job satisfaction* indicator achieved the worst level of negative impact. On the other hand, the SLCA with secondary/generic data had better impact levels than its primary data counterpart in 15 out of 25 indicators. Other five indicators had the same impact level value on both data types, and only in five indicators did the SLCA with primary data have better impact levels than the results with secondary data. Of the 25 indicators used in the indicator comparison, the results of 15 indicators with secondary data had better impact levels compared to those with specific data. Five indicators had the same impact level value, and in five indicators, primary data had better levels than the results of indicators using secondary data. This shows that the SLCA results using secondary data tend to outperform the ones measured with primary data.

This conclusion remains subcategory-wise, with the secondary data still achieving better impact levels in seven out of 13 subcategories, while primary data only scored better in four. In the remaining two subcategories impact level was the same. This shows that a study with non-local data does not guarantee an accurate representation of the real social impacts of the WPO operation. Regarding data quality, the trend for the indicators is kept for the subcategories, with primary data having better quality than secondary data. This demonstrates the importance of using primary data to represent the situation more closely. And the need for greater attention in the analysis of SLCA results in WPO when using secondary data.

The strengths of this study are in highlighting the importance of primary data by comparing it with results from the same method using secondary data. Additionally, the quality of the used data was tested while performing a social assessment of a WPO.

The limitations lie in adapting the characterization model for an SLCA with WPO, with the evaluation concentrated in three categories and 13 subcategories. Nevertheless, the adaptation of this model successfully demonstrated the difference between the use of the two types of data and their quality.

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