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Diagnosis of construction and demolition waste management (CDW) in the city of Caruaru, Pernambuco

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ABSTRACT

The management of construction and demolition waste (CDW) is the main tool for construction housing sustainably. This article presents a diagnosis of the management of CDW and their environmental impacts in the municipality of Caruaru, Pernambuco. The construction and demolition waste management Index (CDWMI) was calculated. This index uses the environmental sustainability indicators: management instruments, management programs, collection and screening, and treatment and disposition of the CDW. The results of this research were compared with the results of six municipalities in the metropolitan region of Recife (MRR). The evaluation of the management of the municipality of Caruaru regarding the CDW indicated the low performance of the municipality since, of the four groups of instruments used, three of them were low grades, and only in the indicators of instruments for policies obtained the average grade. With the diagnosis of a low degree of sustainability in relation to the management of CDW, it is evident that there must be a restructuring in the management of the municipality so that what is established and agreed upon in the Municipal Solid Waste Plan (MSWP) is commenced.

KEY-WORD: Waste management. Construction and demolition waste. CDWMI.

1. INTRODUCTION

The development of the construction sector is closely linked to the country's economic situation, as some economic factors directly interfere in this sector, such as interest rates, economic stability, and public investments. This sector accounts for thousands of jobs and income generation and moves a large production chain of sectors interconnected to this branch. In 2020 there were 112,000 new job openings generated, and 62 economic activities of the national industry moved by this sector (ABRAINC, 2020). Another factor that highlights the relevance of the construction sector is the demand for housing and infrastructure, which is increasing with population growth, especially in developing countries such as Brazil.

The construction sector extracts many natural resources as a source of raw material (gypsum, for manufacturing gypsum; limestone; rocky materials such as natural gravel). Part of these natural resources is discarded in the form of waste; this whole process contributes to environmental degradation (SANTOS, 2015; PASCHOALIN FILHO; DIAS; CORTES, 2014). These residues formed in each stage of the construction process, either by losses or by the waste of materials, mainly generated from renovations and demolitions, are nominated construction and demolition waste (CDW).

The fact that the Brazilian construction process is predominantly manual in its execution, with financial losses, more outstanding production of this by-product, and more significant degradation of the environment, corroborates the problem of CDW (NAGALLI, 2014). This significant amount of waste, for the most part, does not have adequate final disposal, which causes numerous problems in the localities where they are improperly deposited. Leite (2014) states that the direct consequences of inadequate disposal are public health problems and damage to CDW that are no longer recycled. Correct identification and evaluation of influence factors, together with a diagnosis of waste generation, can generate positive impacts on the environment as successful enterprises (VIEIRA; LAFAYETTE; SILVA, 2019).

It is essential to minimize the production of CDW to protect and preserve the environment (LIMA, 2016). This need stimulated an expansion of the concepts and principles of sustainable development regarding implementing an effective management policy of CDW. Laws and decrees are created, such as CONAMA Resolution No. 307/2002 and Law 12 305/10 of the National Solid Waste Policy (NSWP), for the implementation of such CDW management

policies throughout its production chain and, above all, at its final disposal or possible reuse (CRUZ JÚNIOR, 2011).

Other actions by the government are employed to regulate the management of CDW, sharing this responsibility with states and municipalities and attributing responsibility to generators. These initiatives generate the perspective of a new production chain that will lead waste management to a more appropriate level and be consistent with the new reality that is presented, in which both the public authorities and the private sector work together to seek viable alternatives for the mitigation of CDW and their use as raw material (PITOMBEIRA, 2013).

The construction sector advances to meet these objectives with the added benefit of reducing waste losses and costs and promoting this sector's sustainable development (RIBEIRO; NOBREGA, 2013). Due to the importance of the theme, Brazilian municipalities have established as a progressive goal the incentive to initiatives aimed at greater sustainability of development and management processes. Thus, the management of CDW is promoted to a level in which it is possible to reconcile the cost-benefit ratio in the search for viable alternatives and consequent sustainable growth of the construction industry. This should be the basic principle to be observed and followed in managing CDW at the municipal level to mitigate environmental, social, and economic impacts (ALBUQUERQUE, 2015).

Significant research has been carried out on the diagnosis of CDW management, like Silva (2017), Albuquerque (2015) and Lafayette (2018), Santos (2015), Falcão (2011), and Ximenes (2018), respectively in Cabo de Santo Agostinho, Recife, Jaboatão dos Guararapes, Olinda and Paulista. These cities are part of the Recife Metropolitan Region (RMR).

This article presents the diagnosis of the management of CDW and its environmental impacts in Caruaru city through the calculation of environmental sustainability indicators. The results presented here are part of the research conducted by Gomes Júnior (2022), in which 410 points of irregular CDW provisions were mapped through Software QGis 3.16 to identify the socio-environmental aspects involved and the factors that interfere in the dynamics of irregular disposal of CCRs in Caruaru.

MATERIALS AND METHODS

Characterization of the study area

The municipality of Caruaru is located in Agreste of Pernambuco and the Ipojuca Valley microregion, at 08º17'00" south latitude and 35º58'34" west longitude (Figure 1); headquarters altitude is 554 meters and is west of the state capital, Recife, and distant of it about 130 Km (WIKIPEDIA, 2020). The city's total area is 920.611 km^2, 80.56 km² is in an urban perimeter, and the remaining 840.05 km² is from the rural area (IBGE, 2010).

The population of the Caruaru is 314,912 inhabitants, of which 276,932 are located in the urban area and, according to estimates, in 2020, will be 365,278 inhabitants, which places it as the most populous city in the interior of Pernambuco and the third most populous in the northeast region (IBGE, 2010). The state database makes the same forecast for population growth. The city's population in 2021 is 369,343 inhabitants (BDE/PE, 2020).

Caruaru is a polo city having relevant importance for the region and a thriving economy, partly leveraged by the construction sector.

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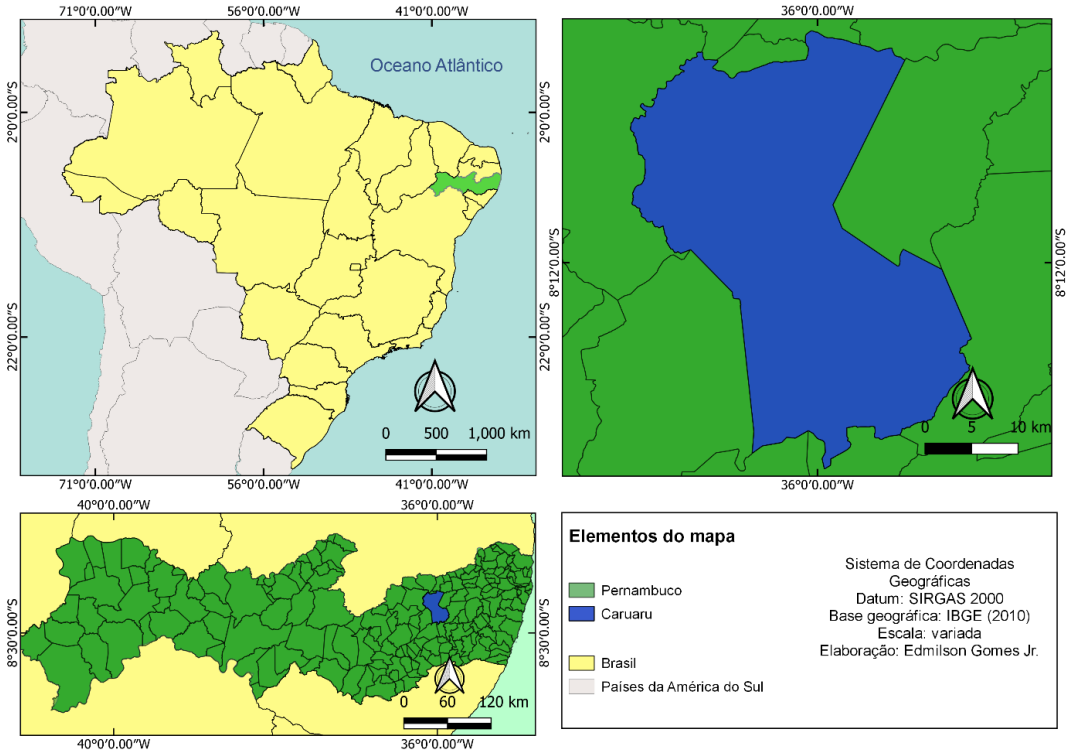
Figure 1: Location of the municipality of Caruaru / PE.



Source: The Authors (2022)

Methodology

For the analysis of municipal management regarding CDW, it was necessary: to collect data from public agencies; the questionnaire composed of four groups of indicators (HOLANDA *et. al*, 2016); determination of the construction and demolition waste management index (CDWMI); and comparison between the municipalities.

For data collection, meetings were held with the coordinator and with the secretary of public services of the municipality of Caruaru to clarify issues such as the regulation of activities necessary to deal with CDW and information on the collection and disposal of waste at the municipal level, with the objective of obtaining the diagnosis of the management of CDW.

Demographic and socioeconomic data, such as population, the Municipal Human Development Index (MHDI), and the municipality's Gross Domestic Product (GDP), were obtained from the 2010 Census of 2018 on the IBGE site estimated for the year 2020. Consultations were also made on technical reports on the subject on official institutional websites such as the Institute of Applied Economic Research (IPEA), the Institute of Technology of Pernambuco (ITEP), and the Brazilian Association of Public Cleaning Companies and Special Waste (ABRELPE) and others.

The Brazilian Association of Technical Standards (ABNT) was consulted regarding its specific standards. The standards consulted can be found in Gomes Júnior (2021).

Federal, state, and municipal laws were also the subject of consultation, such as the National Solid Waste Policy (No. 12,305/2010), the State Solid Waste Plan of Pernambuco

(PERNAMBUCO, 2012), the State Solid Waste Policy (Law No. 14,236, of December 13, 2010), Resolution No. 307/02 of CONAMA, and in books, journals, and other technical literature.

The questionnaire comprises the following groups: management tools, programs, collection and screening, and treatment and disposition. They are formed by 27 sustainability indicators specific to CDW management; these sub-items are formed by laws, management plans, educational actions, and others:

• 10 indicators are directed to management instruments: laws, decrees, and resolutions (Table 1). These instruments were elaborated based on environmentally correct procedures, including the generation, packaging, collection, transportation, treatment, and final disposal of solid waste. The municipality is classified as low grade (from 0 to 11 points), middle grade (from 12 to 16 points), and low grade (from 17 to 24 points).

Table 1: Analysis of CDW management tools

Item	Subitem	Evaluation	Score
CDW management tools	Municipal law for construction waste management	Specific	2
		Embedded in another law	1
		No	0
	Municipal Plan for Solid Waste Management of Civil Construction -MPSWM	Yes	5
		In preparation	3
		No	0
	Percentage of public expenditures related to public cleaning of the municipality	Over 15%	2
		7 to 15%	1
		0 to 7%	0
	Own or inline CDW collection fees/fees at another rate/tax/tariff	Yes	3
		No	0
	Analysis of Construction Waste Management Plans (CWMP)	Computerized system	3
		Physical	2
		No	0
	The specific budget target for solid waste management	Yes	1
		No	0
	Registration of large generators (over $1m^3$/day)	Yes	2
		No	0
	Register of waste carriers	Yes	2
		No	0
	Registration of cooperatives /Association of waste pickers	Yes	2
		No	0
	Registration of licensed areas for receipt of CDW	Yes	2
		No	0

Source: Adapted from Netherlands et al. (2018).

• 7 indicators are directed to municipal programs (Table 2). It is the educational actions aimed at raising awareness of the need to reduce and reuse the CDW, the periodic control of works for compliance with the relevant legislation, the promotion of incentives and selective collection and recycling programs, and the reverse logistics of these materials. The classification of the performance degree of the indicators of programs is a low degree (from 0 to 6 points), medium degree (from 7 to 10 points), and low degree (from 11 to 13 points).

• 5 indicators for the collection and sorting of waste (Table 3), whose attention is dedicated to the collection system, the scope of the regular collection in the occupied urban

area, the structure of the waste screening system in Small Volume Receiving Units (SVRU), such as buckets, stalls and compactors, and the existence of consortia with other municipalities.

• 4 indicators for the final disposal of waste (Table 4) in which a specific approach is given to how the municipality carries out the final disposal of waste and what type of treatment is used before the final disposal. The performance degree of the treatment indicators and the final disposition is classified as low grade (from 0 to 7 points), medium degree (from 8 to 11 points), and low grade (from 12 to 16 points).

Table 2: CDW analysis of management programs.

Item	Subitem	Evaluation	Score
CDW management programs	Educational actions aimed at preventing or reducing solid construction and demolition waste	Structured	2
		Sporadic	1
		No	0
	Training and training of agents or waste pickers	Yes	1
		No	0
	Periodic supervision of works	Structured	2
		Sporadic	1
		No	0
	Existence of incentives aimed at obtaining credit for the financing of projects and the market of recycled aggregates	Governmental	3
		Private	2
		No	0
	Programs or actions in selective collection and recycling by municipal initiative	Implanted	2
		In Deployment	1
		There is no	0
	Programs and actions in partnership with other actors (state, federal, private initiatives, associations, and other agencies)	Yes	2
		No	0
	The incentive to reverse logistics of particular waste (plaster, cement bags/mortar, and paint cans	Yes	2
		Partly	1
		No	0

Source: Adapted from Holanda et al. (2018).

Table 3: CDW collection and screening analysis.

Item	Subitem	Evaluation	Score
CDW collection and sorting	CDW collection system deployed (city hall or third parties)	CDW Specific	2
		Mixed with SUW	1
		No	0
	A regular collection of CDW serves % of the urban area occupied	81 to 100%	3
		61 to 80%	2
		0 to 60%	0
	Waste sorting in small volume receiving units - SVRU (buckets, bays, and compactors)	Enough	4
		Insufficient	3
		No	0
	Transshipment and Sorting Area - TSA (deployment and operation)	Public	3
		Private	1
		No	0
	Receipt of CDW from other municipalities (Consortium)	Yes	2
		No	0
	Disk Collection System Deployment	Yes	2
		No	0

Source: Adapted from Holanda et al. (2018).

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Table 4: CDW treatment analysis and final disposal.

Item	Subitem	Evaluation	Score
CDW Treatment and final disposal	CDW disposal in construction waste processing plant	Public	4
		Private	3
		No	0
	Screening shed for recyclable materials in agreement and/or with the participation of the city	Yes	3
		No	0
	CDW arrangement in an inert landfill	Public	3
		Private	2
		No	0
	Disposal of CDW in landfill	Yes	3
		No	0

Source: Adapted from Holanda et al. (2018).

All indicators have their respective gradations and scores, so the group score is a function of the sub-items that make up this group. The maximum score of the groups added totals 66 points, configuring the cities' sustainability index in relation to the management of construction and demolition waste index, the MCDWI (Equation 1).

$$\text{MCDWI} = \text{MQI} + P\text{QI} + C\text{QI} + QT\text{I} \quad (1)$$

Where: MQI = management quality index; PQI = program quality index; CQI = collection quality index; QTI = quality of treatment index.

The municipality that obtains a score equal to or less than 60% (less than or equal to 40 points) is classified as having inefficient management. If the percentage obtained is greater than 60% and less than or equal to 80% (from 41 to 53 points), management will be considered median, and para a score greater than 80% (from 54 to 66 points), management is characterized as efficient.

ANALYSIS AND DISCUSSION OF RESULTS

Among the indicators of the topic "Instruments for waste policy," it was verified, concerning waste policy, if Caruaru had its specific legislation for the management of solid waste, as well as the solid waste management plan (Table 5). In the sum of the indexes, Caruaru reached the minimal score of 12, necessary to be classified as having the management of CDW classified as the median. The size of the municipality and its natural growth make it a great generator, which makes the result unsatisfactory.

It is observed that the need to improve its management instruments and adopt measures that enable the optimization of services of this group to obtain management with higher rates, which reflects a better quality in the management of CDW.

According to the Secretariat of Public Services, together with the Secretariat of Environment, the municipality constantly implements improvements in waste management instruments. It seeks to conduct public-private partnerships for the improvement of services provided, in addition to raising funds for the execution of projects related to expanding the existing structure and implementing licensed areas for receiving CDW. In addition, through its

legislative power, the municipality seeks to expedite the drafting the law that will create the Municipal Plan for Solid Waste Management of Civil Construction - MPSWMCC.

Table 5: Results of the group "CDW management instruments" sustainability indicators."

Management tools		
Indicators	**Evaluation**	**Score**
Municipal law for construction waste management	Specific	2
Municipal Plan for Solid Waste Management of Civil Construction -MPSWMCC	In preparation	3
Percentage of public expenditures related to public cleaning of the municipality	0 to 7%	0
Own or built-in CDW collection fees/fees at another rate/tax/tariff	No	0
Analysis of Construction Waste Management Plans (CWMP)	Physical	2
The specific budget target for solid waste management	Yes	1
Registration of large generators (over 1m^3/day)	No	0
Register of waste carriers	Yes	2
Registration of cooperatives /Association of waste pickers	Yes	2
Registration of licensed areas for receiving CR	No	0
TOTAL =		12

Note: Low = 0 to 11 points, Medium = 12 to 16 points, Grade: High = 17 to 24 points.

Source: Adapted from Holanda et al. (2018).

In the second part of the questionnaire verified the programs aimed at the education of the population for reduce waste generation, as well as the interventions carried out by the town hall for educational, as a selective collection program in buildings in the region.

This group scored 6, corresponding to a low grade (Table 6). It is found that there are no educational actions aimed at the prevention or reduction of CDW. This implies the lack of engagement of the population and awareness of the importance that each citizen has in mitigating the CDW generation, its correct conditioning and use of the collection system offered for town hall. Without implementing these educational programs, there is a more significant generation of waste, irregular disposal in inappropriate places, exhaustion of the collection service, and increased operating costs.

Table 6: Results of the Sustainability Indicators of the Group "CDW Management Programs"

Municipal CDW management programs		
Indicators	**Evaluation**	**Score**
Educational actions aimed at preventing or reducing solid construction and demolition waste	No	0
Training and training of agents or waste pickers	No	0
Periodic supervision of works	Sporadic	1
Existence of incentives aimed at obtaining credit for the financing of projects and the market of recycled aggregates	Governmental	2
Programs or actions in selective collection and recycling by municipal initiative	Implanted	2
Programs and actions in partnership with other actors (state, federal, private initiatives, associations, and other agencies)	Yes	1
The incentive to reverse logistics of particular waste (plaster, cement bags/mortar, and paint cans	No	0
TOTAL =		6

Note: Low = 0 to 6 points, Medium = 7 to 10 points, Grade: High = 10 to 13 points.

Source: Adapted from Holland et al. (2018).

The most severe damage caused by the lack of educational campaigns developed by Caruaru is the degradation of the environment by contamination caused by the exposure of toxic materials (class D waste, according to CONAMA resolution 307/02) mixed with CDW that are released to the banks of rivers and streams of the locality and close to native vegetation. Of all the investments that should be made, the most important and the most return is the educational campaigns aimed at awakening the sense of collaboration of the citizen in favor of improving the environment conditions.

The town hall Caruaru does not encourage the generation and training of agents or waste pickers. Thus, the realization of sustainable business in solidarity networks, such as solidarity enterprises of waste pickers through cooperatives, is hampered by the non-conditions for this human/professional development. With due guidance and training, these professionals may have more significant opportunities to contract with the public authorities to provide services for collecting and screening recyclable materials. Thus, there will be a significant improvement in the local production chain through the industrialization of recyclables, adding more excellent value to the materials worked in the recycling process and the valorization of waste pickers. Once trained, there is the most outstanding possibility of forming contracts with industries to implement reverse logistics services.

This set of procedures for collecting and forwarding materials in the after-sales sector in the business sector for reuse or for the correct final destination of these wastes is called reverse logistics. This feature is an important management tool that has been increasingly implemented to optimize the return of material goods after their disposal. In the case of CDW, they can be transformed into recycled aggregates for application in mortars and non-structural concrete in recycling plants.

It was researched the coverage of the areas for collecting CDW in the municipal territory and the details about like the screening and destination of these materials are made (Table 7). For the collection and screening group, the municipality obtained a meager income for its indicators, with an score 3.

Table 7: Results of the Sustainability Indicators of the Group "Collection and screening of CDW."

Collection and sorting		
Indicators	**Evaluation**	**Score**
CDW collection system deployed (city hall or third parties)	No	0
A regular collection of RCD serves % of the urban area occupied	0 to 6%	0
Waste sorting in Small Volume Receiving Units - URPV (buckets, bays, and compactors)	No	0
Transshipment and Sorting Area - TSA	Deployment and private operation	1
Receipt of CDW from other municipalities (Consortium)	No	0
Disk Collection System Deployment	Yes	2
TOTAL =		3

Note: Low = 0 to 7 points, Medium = 8 to 11 points, Grade: High = 12 to 16 points. Source: Adapted from Holanda et al. (2018).

The collecting system has not yet been implemented in the municipality, corroborating for the increase in irregular disposal of these materials by the population. This small generator often does not know how to proceed with the disposal because there are no collection points in

the vicinity of his work, nor a public or private company to whom the citizen can trigger for the collection of CDW.

The coverage of the urban area served by regular collection is another aggravating factor. The improvement of this regular collection depends how it is offered in the urban space. For the expansion of the coverage area served by regular collection, it is essential that there is a survey with qualitative and quantitative data on this type of service - such as the expansion of the existing structure, greater collection, and transportation capacity - so that, based on this information, it could determine the activities and locations that require more significant investments.

It was verified that the existence and operationalization of the Integrated Management Program, in compliance with Municipal Law No. 930/13, and which educational programs or actions are being performed to reuse CDW. With these results, the municipality was diagnosed with its potential management of CDW (Table 8). In the latter, the municipality obtained an unsatisfactory result, reaching index 6, which corresponds to the low degree of sustainability regarding the treatment and disposition of CDW.

Table 8: Results of the sustainability indicators of the group "Treatment and final disposal of CDW".

Treatment and final disposition		
Indicators	**Evaluation**	**Score**
CDW disposal in construction waste processing plant	Private	3
Screening shed for recyclable materials in agreement and/or with the participation of the city	Yes	3
CDW layout in an inert landfill	No	0
Disposal of CDW in landfill	No	0
TOTAL =		6

Note: Grade: Low = 0 to 7, Medium = 8 to 10 points, High points = 10 to 13 points. Source: Adapted from Holanda et al. (2018).

According to the Municipal Department of Public Services, registered companies collect and final destination of CDW in a processing plant located in the city's rural area. However, there is still no inspection or even control by the city to ensure that all the waste collected is transported to the processing plant, where they are transformed into aggregates of varying diameters and reused in the preparation of non-structural concrete.

After the analysis of the four groups that make up the questionnaire to evaluate the management of the municipality of Caruaru regarding the CDW, poor performance of the municipality was observed, considering that, of the four groups of instruments, it obtained a low degree in three of them. Only in the indicators of instruments for policies obtained the average degree, still, with the minimum score necessary for this.

Figure 2 shows the individual score of the groups of management indicators of CDW. Among the main factors that contributed to the unsatisfactory result are: (a) the lack of the Municipal Solid Waste Management Program of Civil Construction - PMGRCC (since it is still in the elaboration phase); (b) low percentage of expenses related to urban cleaning of the municipality, covered by a specific budget; (c) absence of specific or inline CDW collection fees and fees; (d) non-computerization of the analysis system of The Construction Waste Management Plans (PGRCC); (e) not having a record of large generators and licensed areas for the receipt of CDW, in the group of instruments for solid waste policies; (f) lack of development

of educational actions aimed at the prevention or reduction of CDW and the training and training of agents or waste pickers; (g) sporadic supervision of works and lack of incentive to reverse logistics of particular waste in the group of programs; (h) the city does not have an implanted CDW collection system; (i) low percentage of urban area occupied served by regular collection of CDW, not being performed the screening of waste in small volume receiving plants - URPV, in the collection and sorting; (j) no CDW disposal in an inert landfill or landfill, in the treatment and disposal group.

The final value obtained for the MCDWI was 27 points (Management policy = 45%; Programs = 22%; Collection and screening = 11%; Treatment and final disposition = 22%). For the score obtained for each group, the Caruaru had its management classified as inefficient (Figure 3). Because of the above, the municipality must adopt the necessary measures to evolve its construction waste management and establish progressive guidelines and targets for the plans and programs established by the specific legislation.

Figure 2: Result of the evaluation of CDW management in Caruaru

Source: The authors (2022).

As for the comparison of the municipal management of Caruaru with cities of the RMR, regarding the group of Management Indicators, Caruaru obtained the third-best performance among the seven municipalities analyzed, behind only the city of Recife, the only municipality to obtain a degree considered high for this indicator and equating to the result of the Olinda city, both classified as middle-grade. This good capital performance can be explained by the growing investments made by its city hall - in a local partnership with the company responsible for providing maintenance and urban cleaning services - to improve waste management.

Recife was the first in the state to create its Municipal Program for Waste Management of Civil Construction (MPWMCC) to comply with the Construction Waste Management Plan (CWMP). The main requirements for this group of indicators are the creation of a register of duly licensed areas and, therefore, able to receive waste, the creation of the register of cooperatives, and the incentive to train their employees, whether waste pickers or collectors.

Although only slightly ahead of Caruaru in scoring on these instruments, Olinda has most evolved its policy of managing the CDW among the municipalities analyzed. Recife already has the PMGRCC implemented and has a registration of licensed areas for the receipt of solid waste, in addition to allocating a specific budget for the treatment and management of CDW.

The other municipalities did not reach the score necessary to obtain a minimally satisfactory classification. This performance may be related to the insufficiency of municipal policies that promote the creation of those instruments provided for in the PGRCC, whose proposed actions if carried out, would leverage the performance of these municipalities.

Caruaru remained among the best scores for the second group of sustainability indicators, "municipal programs," not signifying a satisfactory performance. Its low score for this group reflects its reality because the municipality has not yet fully developed a tight confirmation for the training and training of waste agents and the incentive to create recycling cooperatives. Moreover, the lack of educational actions aimed at preventing or reducing the production of solid waste from construction and demolition is one of the main aggravating factors regarding the instruments of management programs for keeping the population unrelated to the damage brought by the irregular provision of RCD.

Among all the municipalities analyzed, only Camaragibe obtained a score that allows evaluating its degree as being of medium sustainability performance relative to the index of this group (9 points). This result is the result of actions that promote the reduction of solid waste production through population awareness programs and the constant supervision of work. The implementation of cycling programs in partnership with other agents and agencies and the realization of selective collection allows more remarkable local socioeconomic development through these cooperatives, bringing benefits to the population and the urban environment.

The fact that the municipality of Paulista does not have municipal programs in force explains that he obtained the lowest value (2 points) among the seven research municipalities for these indexes. According to Ximenes (2018), some programs were in the study phase for implementation by its Environment Secretariat, programs aimed at training agents, supervision of works, and environmental education actions.

In the case of the other municipalities, because they obtain low scores, less than or equal to 6 (Cabo de Santo Augostinho = 3 points; Jaboatão dos Guararapes and Olinda = 4 points; Caruaru and Recife = 6 points), are classified as low degree of sustainability concerning the index of this group, for the same reasons exposed to Caruaru. There is an urgent need for a set of measures by these municipalities to mitigate the harms fostered by their inactions related to the management of this solid waste through practices and actions that significantly improve these parameters.

Regarding the third group of sustainability indexes evaluated for collecting and screening waste, Caruaru obtained the worst performance among all the municipalities that participated in the research (3 points). Of the six criteria analyzed for this group, the municipality met only two of them, with the implementation of a transshipment and screening area - but private operation - and the installation of a collection dial system – but without a CDW collection system implemented, which practically does not use the first one.

In general, only Recife and Jaboatão dos Guararapes achieved a degree index considered average sustainability (10 and 8 points, respectively), with the CDW collection and collection dial systems implemented and in operation.

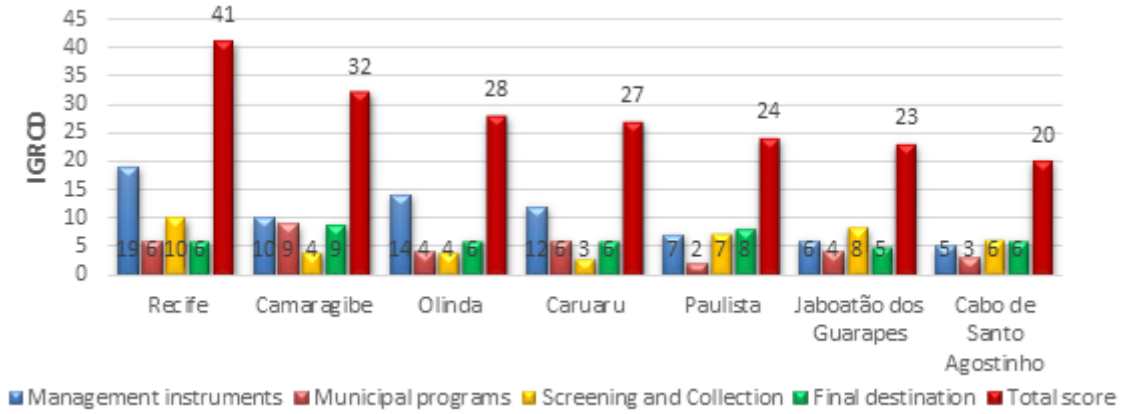
For the sustainability indexes of the destination of the CDW, Paulista and Camaragibe obtained scores that reached the minimum value necessary for a median degree classification (9 and 8, respectively). These municipalities already have a project for the final disposal and

processing of CDW, a shed for the screening of recyclable materials, and agreements with companies. The other municipalities, Recife, Olinda, Jaboatão dos Guararapes, Cabo de Santo Agostinho, and Caruaru, achieved a low sustainability index, according to their scores. According to the Secretariat of Public Services, Caruaru has a register of companies, without any connection with the municipality, that carries out the collection and transportation to the processing plant, also private, for treatment and final disposal of the CDW.

Of the four groups of sustainability indexes applied, the one with the highest financial cost and the highest demand for its implementation - depending, including, on the drafting and approval of laws at the municipal level - is the definitive treatment and disposition, as it is necessary to allocate public or private areas for their installation and specific physical structure, for example, the treatment, and processing of CDW. Most municipalities find meeting these indexes difficult, reflecting their unsatisfactory results. Camaragibe scored 9 points, Paulista 8 points, and Jaboatão dos Guararapes, 5 points. The other municipalities obtained 6 points for the sustainability indexes for the destination of the CDW.

Analyzing all groups of civil construction waste management indicators and adding the score of each of these groups determined IGRCD for all municipalities compared (Figure 3). It considers all the municipalities analyzed; only the capital Recife reached the lower minimum limit for its management of CDW to be considered median. As it is the state capital, it is expected to achieve better rates than other municipalities because of its political-administrative importance and its ability to collect taxes and consequent investments in public planning, infrastructure, and management as a way of returning these collected taxes.

Figure 3: Comparison of Caruaru IGRCD with RMR cities.



Source: Adapted from Ximenes (2018).

Given the results, there is a need for modernization of the management of CDW through government investment, as well as the formation of public-private agreements and partnerships so that it is possible to improve the guidelines and strategies already established in the National Solid Waste Policy - NSWP and the CWMP.

CONCLUSIONS

Through the application of sustainability indicators, it was possible to verify that the Management of CDW of Caruaru is below what is considered sustainable (24 points in the IGRCD), thus one inefficient management.

With the diagnosis of a low degree of sustainability in relation to the management of CDW, it is evident that it is essential that there is a restructuring in the management of Caruaru, so that what is established and agreed upon in the PMRS is commenced.

From the analysis of the groups that compose the questionnaire to evaluate the management of CDW in Caruaru it was possible observed, in general, a low performance of this manage. Of the four instruments groups, three of them presented a low degree. Only the indicators for policies presented the average degree, but with the minimum score necessary.

Its low performance highlights the need for an indispensable structuring of municipal management of CCR and the creation of its Municipal Program for Waste Management of Civil Construction - PMGRCC, obeying the guidelines of Law No. 12,305/10 deals with the National Solid Waste Policy - PNRS.

The municipality demonstrates a way towards an improvement in this situation with the implementation of its first Eco station (and still seeks to gather resources for the implementation of others). It also has a transshipment and sorting area of implementation and private operation destined for CDW, located in its rural area, besides having municipal law for the management of CDW and being already in the process of elaborating its MPWMCC, which assigns responsibilities to the waste generator.

Despite the efforts that the municipal power has shown in trying to achieve greater efficiency in the management and search for integration for the correct management of the CDW, it is evident the low efficiency and lack of proposals that act in order to prevent the problems arising from this lack of structuring and integration.

REFERENCES

ABRAINC - Associação Brasileira de Incorporadoras Imobiliárias (2020). Disponível em: https://www.abrainc.org.br/indicadores/2020/12/22/dezembro-2020/ Acesso em: 02 de nov. de 2019.

ALBUQUERQUE, D.M.S**. Situação socioambiental disposição irregular dos resíduos da construção e demolição na cidade do Recife** (Dissertação de Mestrado em Engenharia Civil). Escola Politécnica de Pernambuco, Universidade de Pernambuco, Recife, 2015.

BRASIL. Constituição da República Federativa do Brasil (1988). Brasília, DF: Senado Federal: Centro Gráfico. Lei n° 12.305, de 2 de agosto de 2010. Institui a Política Nacional de Resíduos Sólidos. Diário Oficial da República Federativa do Brasil.

CONSELHO NACIONAL DO MEIO AMBIENTE (CONAMA). Resolução nº 307, de 5 de julho de 2002. Brasília, 2002.

CARUARU. In: WIKIPÉDIA, a enciclopédia livre. Flórida: Wikimedia Foundation, 2022. Disponível em: <https://pt.wikipedia.org/w/index.php?title=Caruaru&oldid=63858078>. Acesso em: 24 jun. 2020.

CRUZ JUNIOR, J. B. **Análise da Gestão dos Resíduos Sólidos da Construção e da Demolição (RCC's) no Município de Angicos - RN**. Monografia (Graduação em Ciência e Tecnologia) Universidade Federal Rural do Semiárido, 2011.

FALCÃO, N.C. B. **Diagnóstico da situação atual dos resíduos da construção civil no município de Olinda.** (Dissertação de Mestrado em Engenharia Civil) - Escola Politécnica, Universidade de Pernambuco, Recife, 2011.

GOMES JÚNIOR, E. **Diagnóstico da gestão e impactos ambientais dos resíduos de Construção e demolição no município de Caruaru/PE.** (Dissertação de Mestrado em Engenharia Civil) - Programa de Pós-Graduação em Engenharia Civil e Ambiental da Universidade Federal de Pernambuco, Caruaru, 2021.

HOLANDA, M.J.O.; PAZ, D.H.F.; XIMENES, T.C.F.; LAFAYETTE, K.P.V. **Indicadores de sustentabilidade como ferramenta de gestão municipal de resíduos da construção civil**. In: Encontro Pernambucano de Resíduos Sólidos, Recife, 2016.

IBGE – Instituto Brasileiro de Geografia e Estatística. Censo 2010. Disponível em: <http://www.ibge.gov.br/home/estatistica/populacao/censo2010/caracteristicas_da_populacao/caracteristicas_da_populacao_tab_municipios_zip_xls.shtm>. Acesso em: 15 de dez.de 2020.

NAGALLI, A. **Gerenciamento de Resíduos Sólidos na Construção Civil**. Editora: Oficina de Textos, 2014. 176p.

PASCHOALIN FILHO, J. A.; DIAS, A. J. G.; CORTES, P. L. **Aspectos normativos a respeito de resíduos de construção civil: uma pesquisa exploratória da situação no Brasil e em 137 Portugal**. Desenvolvimento e Meio Ambiente, 2014, v. 29, p. 155-169.

PERNAMBUCO. Plano Estadual de Resíduos Sólidos. Governo do Estado de Pernambuco. Disponível em:<http://www.cidadessustentaveis.org.br/sites/default/files/arquivos/plano_estadual_residuos_solidos_pernambucp.pdf>. Acesso em julho de 2021.

PITOMBEIRA, S. C**. Aspectos relevantes da Política Nacional de Resíduos Sólidos**. São Paulo: Atlas, 2013. 280p

PREFEITURA DE CARUARU. Lei complementar nº 72.19-30.12.2019 Plano Diretor de Caruaru. Disponível em< https://caruaru.pe.gov.br/wp-content/uploads/2020/01/Plano-Diretor-de-Caruaru-Lei-Complementar-72.19-30.12.2019.pdf > Acesso em 25 de nov. de 2020.

SANTOS, D.S. (2015). **Diagnóstico da gestão dos Resíduos de Construção Civil e seus impactos ambientais no município de Jaboatão dos Guararapes/PE.** (Dissertação de Mestrado em Engenharia Civil). Escola Politécnica de Pernambuco, Universidade de Pernambuco, Recife.

SILVA, A.A. **Diagnóstico da gestão dos Resíduos de Construção Civil no município do Cabo de Santo Agostinho/PE** (Dissertação, de Mestrado). Universidade de Pernambuco, Escola Politécnica, Programa de Pós-Graduação em Engenharia Civil, Pernambuco, 2017.

VIEIRA, C. R., ROCHA, J. H. A., LAFAYETTE, K. P. V., & SILVA, D. M. **Análise dos fatores de influência e diagnóstico da gestão dos resíduos da construção civil (RCC) nos canteiros de obra da cidade do Recife-PE**. URBE. Revista Brasileira de Gestão Urbana, v.11, e20180176, 2019. https://doi.org/10.1590/2175-3369.011.e20180176

XIMENES, T. C. F**. Diagnóstico da Gestão Municipal dos Resíduos de Construção Civil e seus Impactos Ambientais no município de Paulista/PE** (Dissertação de Mestrado). Universidade de Pernambuco, Escola Politécnica, Programa de Pós-Graduação em Engenharia Civil, Pernambuco, 2018.