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MUNICIPAL SOLID WASTE MANAGEMENT: ANALYSIS OF SUSTAINABILITY INDICATORS IN THE METROPOLITAN AREA OF FORTALEZA, CEARÁ

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ABSTRACT

Public managers, increasingly, due to concern about the sustainability of urban centers, are adopting public policies focused on improving the environment and quality of life. In this context, the study aims to analyze the level of sustainability of urban solid waste management in the metropolitan region of Fortaleza. Therefore, an exploratory study was conducted, with descriptive approach, whose data collection was performed through the application of questionnaires and semi-structured interviews, based on the Matrix of Sustainability Indicators proposed by Santiago and Dias (2012). The results of the research show that the municipalities of the metropolitan region of Fortaleza present, in their highest representativeness, medium-low levels of sustainability. Thus, it is concluded that, in fact, municipalities present incipient practices regarding the search for sustainability of the management of municipal solid waste, from the frequent context of excessive generation and inadequate disposal of solid waste.

Keywords: Public management, Solid waste, Sustainability indicators, Metropolitan area.

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RESUMO

Gestores públicos, cada vez mais, em razão da preocupação com a sustentabilidade dos centros urbanos, estão adotando políticas públicas centradas na melhoria do meio ambiente e na qualidade de vida. Diante desse contexto, o estudo tem por objetivo analisar o nível de sustentabilidade da gestão de resíduos sólidos urbanos da região metropolitana de Fortaleza. Para tanto, foi realizado um estudo exploratório, com abordagem descritiva, cuja coleta de dados foi realizada através da aplicação de questionários e de entrevistas semiestruturadas, baseadas na Matriz de Indicadores de Sustentabilidade proposta por Santiago e Dias (2012). Os resultados da pesquisa demonstram que os municípios da região metropolitana de Fortaleza apresentam, em sua maior representatividade, níveis médio-baixos de sustentabilidade. Desse modo, conclui-se que, de fato, os municípios apresentam práticas incipientes quanto à busca por sustentabilidade da gestão de resíduos sólidos urbanos, a partir do contexto frequente da geração excessiva e da destinação inadequada dos resíduos sólidos.

Palavras-chave: *Gestão pública. Resíduos sólidos. Indicadores de sustentabilidade. Região metropolitana.*

1 INTRODUCTION

The search for sustainable development, regardless of the targeted approach, is present as an inherent objective of government policies. The society, in current times, faces major environmental problems related to the excessive generation of solid waste and its inadequate final destination. For Martins and Cândido (2012) and Santiago and Dias (2012) the management of municipal solid waste has been at the heart of the concern of researchers in several areas of study.

In this context, a way to minimize the effects caused by excessive generation and improper disposal of solid waste refers to the use of instruments that make it possible to manage them properly, however several studies have pointed out a certain complexity in the management of such waste (AGAMUTHU; KHIDZIR; FAUSIAH, 2009; GOMES et al., 2014; POLAZ; TEIXEIRA, 2009; DIAS et al., 2012; SANTIAGO; DAYS, 2012; SANTOS; TEIXEIRA; KNIESS, 2014). O'Leary et al. (1999) state that good management of solid waste has positive consequences for the preservation of natural resources, the reduction of landfill areas, job creation and income, reduction of energy consumption, as well as in the awareness of society under a change in the social and cultural aspects.

The management of municipal solid waste (GRSU) emerges as a strategy, which goes through technical, political and administrative levels, whose objective is to manage solid waste, aiming at the protection, conservation and improvement of urban quality of life (VICTOR; AGAMUTHU, 2013). Silva and Torre (2008) argue that GRSU minimizes the effects of these problems, needing to reconsider discard patterns, instigating conscious consumption and improving living and working conditions.

The application of integrated management of municipal solid waste should be considered by public agencies and should be concerned with the creation and adoption of a set of methodologies with the aim of reducing the production and inadequate disposal of waste, following its entire production cycle (PIRES; MARTINHO; CHANG, 2011). It is noteworthy that the integrated and sustainable management of solid waste should consider the production of sustainable generating sources, selective collection with inclusion of waste pickers and the reuse of waste.

Legal instruments were created in order to minimize the impact of solid waste on society and the environment. The National Basic Sanitation Policy, created by Law No. 11,445/2007, establishes guidelines on basic sanitation, referring to the management and handling of solid waste in Brazil, and the National Solid Waste Policy, created by Law No. 12,305/2010 that assigns a set of objectives, in order to seek the strengthening of integrated management and sustainability of solid waste.

A relevant factor to be considered by municipalities refers to the construction and use of sustainability indicators, as well as the development of strategies that take into account local specific characteristics through environmental management (FERREIRA, 2011; BORGES, 2012). The sustainability indicators can be used as a source of information on the environment, allowing to summarize and ensure the comparability of information in different regions and, consequently, assist in the development of public policies (MILANEZ; TEIXEIRA, 2003). In this sense, the sustainability of urban solid waste management should be specifically treated by municipal environmental management as a way to seek sustainable development in urban areas, reducing the impact caused to the environment, seeking to add quality of life to society.

Several researches have sought to examine the level of sustainability of a given region due to the management of municipal solid waste in municipalities, using indicators created specifically for each reality (BRIASSOULIS, 2001; BRAGA et al., 2004; CARVALHO; BARCELLOS, 2009; ROY, 2009; TANGUAY et al., 2010; SANTIAGO; DAYS, 2012). It is noteworthy that studies conducted on the subject have been commonly addressed in the construction of indicators not worrying about its application, as proposed by this research when describing the level of sustainability in the municipalities (BRAGA et al., 2004; CARVALHO; BARCELLOS, 2009; SANTIAGO; DAYS, 2012). In view of the above, the study seeks to answer the following question: what is the level of sustainability of the management of municipal solid waste in the municipalities belonging to the Metropolitan Region of Fortaleza (MRF)?

In order to answer the proposed question, the objective is, under the premises of environmental management, to analyze the level of sustainability of the management of municipal solid waste in the RMF. The following specific objectives are therefore: (i) to trace the profile of municipalities belonging to the RMF, regarding economic, social and environmental aspects; and (ii) present descriptively the main practices adopted in the management of municipal solid waste from the different dimensions of the sustainability of urban solid waste management: political, technological, economic – financial ecological-environmental, knowledge, social inclusion.

Conducted through an exploratory study with descriptive approach, the study verifies the level of sustainability of the management of municipal solid waste in 12 of the 15 municipalities belonging to the RMF. Data collection was performed with the application of questionnaires and semi-structured interviews, based on the Matrix of Sustainability Indicators proposed by Santiago and Dias (2012), which were answered by the managers responsible for the environmental public policies of each municipality visited. To meet the overall objective of the study, the ArcGIS ArcMap version 10.1 software was used to organize and systematize the cartographic basis for exploratory analysis of the level of sustainability.

Considering that solid waste management is seen as a strategy inherent to large urban centers (BORGES, 2012), knowing the level of sustainability can allow the public manager greater speed and punctuality in the decision making process, in order to ensure, through environmental policy, the protection, maintenance and improvement of the environment and, consequently, the quality of life (VICTOR; AGAMUTHU, 2013).

The work is structured in five sections, including this introduction; followed by the theoretical foundation of the study, considering the themes sustainable development, sustainability and management of municipal solid waste in section two; methodological aspects in section three; the results and discussions of the research in section four; and, finally, section five with the final considerations.

2 LITERATURE REVIEW

2.1 Sustainable Development and Sustainability

Economic, environmental and social disparities have been perceived in the current development model. In recent times, a broad set of development models based on production and consumption relations has increased the level of degradation of natural resources, as well as the growth of social inequalities and wealth concentration (MARTINS; CÂNDIDO, 2012).

It is emphasized the need to evaluate development as a fundamental requirement for achieving sustainability, constituting an essential factor for the formulation of public policies and decision-making. In order to minimize these impacts, based on the perception of the fragility of the current model and the need for a new perception about the environment, the concepts of sustainable development and sustainability arise.

The term sustainable development became internationally known from the preparation of the Brundtland Report, built by the World Commission on Environment and Development, also called as Our Common Future. The concept of sustainable development described in the report is defined as meeting the needs required by generations present without compromising the possibility for future generations to meet their own needs (BRUNDTLAND et al., 1991), this concept has often been used in the literature (FLORÊS, 1995; CASTRO; ARAÚJO, 2004; DELAI; TAKAHASHI, 2008; ARAS; CROWTHER, 2008; STRIEDER; DELUQUE, SCADECK, 2012).

To conquer sustainable development, Strieder, Deluque and Schadeck (2012) say that natural resources must be recognized as limited. Thus, in order to legitimize sustainable development, it is necessary that a set of decisions needs to be taken so that changes can be established in the contexts of sustainability in cities, sustainable infrastructure, reduction of inequalities and science and technology. The themes involving sustainable development and sustainability have a comprehensive scope of interdisciplinarity, present in discussions in various fields of science, in the public or private spheres, in non-governmental organizations, as well as throughout society (MARTINS; CÂNDIDO, 2012).

The different perceptions of the concept of sustainability caused different types of sustainability dimensions to be constructed. The most widespread dimensions indicate that sustainability must meet the concepts of triple bottom line (ELKINGTON, 1997), which includes responsible performance with the environment and society, without disregarding its main objectives. In addition, other studies have pointed out different dimensions of sustainability, such as cultural, ecological, knowledge, among others (SACHS, 2007; CONSALTER, 2008; SANTIAGO; DAYS, 2012). Barreto (2004) argues that the dimensions of sustainability should also indicate the character of sustainable, durable and conservable continuity, and should provide fundamental properties for sustainable development, not limited only to the protection of the environment, but also incorporating social needs in the current context (BAQUERO; CREMONENSE, 2006).

For the operationalization of the concept of sustainability, its measurement is essential. The adoption of policies and actions aimed at sustainable development will only be effective if the concept of sustainability is measured and if there is a support to evaluate advances towards the objectives outlined (SIENA, 2002). The measurement of sustainability has, as a basic goal, the provision of concrete elements to support the decision, being a resource to support the planning of future actions (MARTINS; CÂNDIDO, 2012).

In this context, Polaz and Teixeira (2009) argue that sustainable development is challenging the creation of measurement instruments that enable the provision of information, allowing the evaluation of the degree of sustainability of society by the monitoring of improvement goals. Shen et al. (2011) affirm that the indicators have the function of measuring performance, highlighting the relevance of the process of evaluating urban sustainability.

The sustainability indicators, in addition to enabling knowledge about their level in a given reality, improve the basis of information on the environment, assist in the development of public policies, as well as ensure comparability between regions (MILANEZ; TEIXEIRA, 2003). Several researches seek to document the level of sustainability of a given region, using indicators created specifically for each reality (BRIASSOULIS, 2001; ROY, 2009; TANGUAY et al., 2010).

In this context, Ferreira (2011) argues that municipalities should build their sustainability indicators and develop their strategies according to local characteristics, which should be a continuous and permanent process of development. Thus, the sustainable development process requires the creation of systems that adapt to the needs and current dynamics of urban centers, seeking to equalize economic, environmental and social priorities, as well as the expansion of participatory management and investments in training of personnel with focus on sustainability management.

2.2 Urban Solid Waste Management

The process of urbanization coupled with economic development, generated during the twentieth century, allowed a growth in the level of consumption and, consequently, an increase in solid waste generation (DIAS et al., 2012), consequently causing environmental problems, aggravated by the continuous urban density not accompanied by investments in infrastructure (POLAZ; TEIXEIRA, 2009).

Additionally, Mazzer and Cavalcanti (2004) and Jacobi and Besen (2006) argue that waste returns to the environment inappropriately causing economic, social and environmental damages. It should be noted that urban solid waste refers to materials disposed of in urban areas, including, in addition to domestic waste, commercial waste collected and disposed of by the municipalities (VICTOR; AGAMUTHU, 2013). Silva, Fugii and Santoyo (2017) strengthen the participation of municipalities in the proper management of waste generated by society, as well as strengthen the idea of environmental education as a subsidy for the success of sustainable urban solid waste management practices.

The uncontrolled generation of solid waste is currently one of the biggest environmental problems faced by humanity, due to the complexity of waste management (AGAMUTHU; KHIDZIR; FAUSIAH, 2009; POLAZ; TEIXEIRA, 2009; DIAS et al., 2012; SANTIAGO; Dias, 2012). Urban solid waste management (GRSU) emerges as a way to minimize the effects of these generated problems, requiring reconsideration of disposal patterns, instigating conscious consumption and improving society's living conditions (SILVA; TORRE, 2008). GRSU can be defined as a set of strategies from the technical to the political levels until the administrative ones, systematically seeking solid waste management, and consequently the protection, conservation and improvement of the quality of urban life.

As a way to address the gaps in solid waste management, the concept of socially integrated management is added to this by adding the quantitative aspect to the waste system. The core of integrated urban solid waste management is to reduce waste at its source before entering its disposal cycle so that it is recovered through reuse and recycling. To this end, Piaz and Ferreira (2011) argue that integrated solid waste management should be added to the essential participation of all social actors involved in this process, taking into account the reality of each local environment. In addition, integrated and sustainable management of solid waste must include the generation of generating sources, selective collection with the inclusion of recyclable waste pickers, energy recovery and waste reuse (ADEDIPE et al., 2005).

Based on the arguments about the problems related to the increase of solid waste generation, the absence of public policies, the population growth and the impacts of these events on the environment, it is emphasized the existence of an ecological imbalance, thus indicating a production (more) waste than the environment could handle and greater than the needs of individuals.

From this perspective, legal instruments have been developed in order to minimize the impacts arising from the problem that solid waste causes to society and to the environment. The legal frameworks, the first related to urban sanitation, regarding the management and handling of solid waste in Brazil, Law No. 11,445, of August 5, 2007, called the National Basic Sanitation Policy (PNSB), and the second related to the National Policy of Solid Waste (PNRS), Law No. 12,305, of August 2, 2010.

Through PNRS, the Federal Government seeks to strengthen integrated management and sustainable generation of solid waste by: (a) protecting the environment and public health; creation and development of processes that change production patterns; and reduction, reuse, recycling and treatment of solid waste. The Federal Government, through PNRS, also proposes the formation of interrelationships for regionalized management, with the objective of increasing the administration capacity, increasing scale gains and reducing costs. The standard proposes shared responsibility for the product life cycle and reverse logistics and builds mechanisms for inserting waste pickers into municipal selective collection systems (BRASIL, 2010).

In this sense, impacts on sustainability must be made by municipal environmental management, as a way of seeking sustainable development in urban areas, providing quality of life for society and protection for the environment. Brazilian municipal administrations face technical and administrative difficulties to properly and efficiently manage urban solid waste (BESEN; RIBEIRO, 2008). The GRSU, when not articulated efficiently, can generate social, environmental and economic parables.

3 RESEARCH DESIGN

The study is descriptive in nature as it seeks to identify and describe the level of sustainability of urban solid waste management in the Metropolitan Region of Fortaleza (RMF). In the data collection and treatment procedures, qualitative methods were adopted, while for data analysis quantitative procedures were used. Primary data collection was performed through the application of questionnaires and semi-structured interviews.

The State of Ceará, the research population, is composed of 184 municipalities, of which 15 municipalities make up the Fortaleza Metropolitan Region - sample study universe - representing 8.2% of the total municipalities in the state (IBGE, 2010). Although some significant changes in the state action in solid waste management can be noticed - such as the construction of sanitary landfills and the elaboration of solid waste master plans (ARAÚJO, 2011), some researchers have evidenced the evolution of the potential impacts on the environment due to the final disposal of municipal solid waste in the RMF (SANTOS; RIGOTTO, 2008).

The list of those responsible for Urban Solid Waste Management (GRSU) of the 15 municipalities of the population was provided by the Sustainable Development Coordination of the Environmental Policy and Management Council (CONPAM). From this population, it was only possible to contact 12 municipalities, being excluded from the sample the municipalities of Maracanaú, Pindoretama and São Gonçalo do Amarante. In these, the contact, via telephone, was made in order to schedule a visit to the municipality to apply the questionnaires to the manager responsible for the municipality's environment secretary, or equivalent secretary.

To obtain the data, questionnaires were used as a collection instrument applied "in loco" with the presence of the researcher, as well as a semi-structured interview. The application of the questionnaire proved to be the most appropriate way to this field research by allowing direct contact with the respondent, besides facilitating the completion of the research instrument completely (MALHOTRA, 1996; MCDANIEL; GATES, 1996), mitigating possible biases in the answers.

In this sense, a questionnaire was constructed, with a score based on the matrix of sustainability indicators proposed in the study by Santiago and Dias (2012). The questionnaire consists of 43 closed and multiple-choice questions, with three variable scoring options in each question, grouped into six dimensions: political, technological, economic-financial, environmental-ecological, knowledge and social inclusion. Chart 1 presents the main characteristics about each dimension of urban solid waste sustainability.

Chart 1 – Sustainability Dimensions of Urban Solid Waste Management Description

GRSU Sustainability Dimensions	**Dimension Description**
Political	It relates to the adoption of normative actions in solid waste management policies, given that they direct and define institutional guidelines according to national and international guidance, in order to highlight if the municipal policies are involved with Federal Basic Sanitation Policy and the National Solid Waste Policy.
Technological	It refers to the use of clean and appropriate solid waste processing technologies taking into account the social-economic and cultural context and also the local environmental context verifying if the cities utilize technological, economic and political development strategies, which practice technological choice as a way of using that technology in favor of society.
Economic-Financial	It is a preventive action focused on avoiding the possibility of environmental risks and damages in relation to the proper destination and management of the financial resources available for the maintenance of GRSU, verifying the ability of society to afford resources for waste management. solid and if it self-finances.
Environmental-Ecological	It refers to the limitation of the use of non-renewable natural resources, in the preservation and evaluation of ecosystems, in the disposal and reduction of tailings, in increasing the reuse, recycling and treatment of waste before their final disposal, verifying the environmental impact caused in the municipality by the final disposal of solid waste, as well as the existence of selective collection in the municipality.
Knowledge	It is based on environmental education and social mobilization, by involving characteristics related to the issue of solid waste, as well as the participation of society in the National Solid Waste Policy, aiming to verify the consonance of these practices with the National Environmental Education Policy and the National Environmental Education Program.
Social inclusion	Allows the inclusion of social agents (waste pickers of recyclable materials, artisans and others) verifying the insertion of these, at the level of organization and management of Municipal Solid Waste.

Source: Elaborated by the authors based on a study by Santiago and Dias (2012).

In this sense, the construction of Santiago and Dias (2012) is adopted to evaluate the sustainability of the management of municipal solid waste, adopting all dimensions: political, technological, economic-financial, environmental-ecological, knowledge and social inclusion.

The questionnaire elaborated was submitted to pre-tests with specialists in the respective areas of the work, in order to adapt it to the objective of the research. The application of pre-tests in small samples makes it possible to identify and exclude possible problems and, from the identification of these problems, proceed to proper corrections, subjecting them to other pre-tests until the final instrument is obtained (MALHOTRA, 1996). In addition to the application of the questionnaire, a semi-structured interview was conducted, consisting of a methodological approach, making it possible to discuss the main aspects related to the sustainability of each municipality. The application and collection of information occurred during the period between August and October 2013.

Based on the methodology proposed by Santiago and Dias (2012), it was possible to calculate the level of sustainability of solid waste of each municipality. Thus, the measure was calculated using the ratio between the score obtained in the questionnaire and the maximum possible score (215 points, that is, 5.0 points multiplied by 43 questions). The scale used to meas-

ure the level of sustainability was classified in an interval between 0.0 and 10.0. Classifying the municipality as unsustainable (result equal to 0.0), low sustainability (above 0.0 to 4.0), average sustainability (above 4.0 to 9.0) and high sustainability (above 9.0). The calculation of the level of sustainability of municipal solid waste was calculated by dimension and considering all dimensions, as a general level of sustainability, using the same parameters as Santiago and Dias (2012).

With the score of the level of sustainability measured for each dimension in the municipalities studied, the level of sustainability was spatially presented in the municipalities of the RMF, using the ArcGIS ArcMap version 10.1 software to add, organize and systematize the cartographic basis for the analysis of the study. Strong effort was concentrated in trying to ensure that sustainability indicators were applied correctly, since existing practices can faithfully reflect the real state of sustainability in solid waste management. Also seeking to verify from the indicators, the main practices and management mechanisms in decision making and their effects on urban sustainability.

4 RESULTS

4.1 Characterization of the Metropolitan Region of Fortaleza (MRF)

Located in the northeastern region of the State of Ceará, the Metropolitan Region of Fortaleza (RMF) is composed of 15 municipalities, namely: Aquiraz, Cascavel, Caucaia, Chorozinho, Euzébio, Fortaleza, Guaiúba, Horizonte, Itaitinga, Maracanaú, Maranguape, Pacajus, Pacatuba, Pindoretama and São Gonçalo do Amarante. The RMF comprises an area of 5,790.71 km2, distributed among the municipalities, with the municipality of Caucaia the largest area, of 1,228.51 km2. The region is considered the seventh largest metropolitan region in Brazil in population terms, with an estimate of 3,615,767 inhabitants (IBGE, 2010).

Table 1 presents economic, social and environmental characteristics of the municipalities of the RMF, such as: demographic density, PIB per capita and the volume of solid waste generated by each inhabitant.

Table 1 – Economic, social and environmental profile of the Metropolitan Region of Fortaleza

Cities	PIB per capita at current prices(R$)	Population density (hab/km²)	Solid waste per capita (t)	Generated waste (t)
Aquiraz	9.395,20	150,50	0,271	19.671
Cascavel	6.762,09	78,99	0,284	18.793
Caucaia	7.998,82	264,91	0,274	89.175
Chorozinho	4.773,93	67,94	0,289	5.459
Eusébio	27.616,33	582,66	0,276	12.711
Fortaleza	15.161,47	7.786,44	0,290	710.063
Guaiúba	4.177,73	90,19	0,266	6.398
Horizonte	18.052,72	344,96	0,284	15.676
Itaitinga	5.106,64	236,51	0,260	9.297
Maracanaú	19.548,87	1.960,25	0,277	57.890
Maranguape	6.670,50	192,19	0,255	28.984
Pacajus	8319,43	243,00	0,284	17.587
Pacatuba	7.680,07	547,74	0,259	18.713
Pindoretama	4.827,83	256,06	0,286	5.341
São Gonçalo do Amarante	25.430,88	52,60	0,274	12.011
Mean	**11.434,83**	**856,99**	**0,275**	**19.671**

Fonte: Elaborated by the authors based on IBGE data (2010).

It is noted that the region has an average GDP per capita of R$ 11,434.83, with high levels of disparities, with the municipality of Guaiúba with the lowest GDP per capita, of R$ 4,177.73, and the municipality of Euzébio at the other end, with R$ 27,616.33. As for population density, the municipality of Fortaleza (State Capital) stands out with a population density of 7,784.44 inhabitants per km2, followed by the municipality of Maracanaú, with 1,960.25 inhabitants per km2. On average, the MFR produces about 280 kg per capture of solid waste per year, highlighting approximate values in each municipality. It is noteworthy that the municipality of Fortaleza has the highest volume of garbage generated, presenting itself in isolation in relation to the other municipalities. The municipalities of Pindoretama and Chorozinho, on the other hand, have the smallest volumes of garbage generated.

4.2 Descriptive analysis of the Political Dimension

It was found that seven of the municipalities that make up the sample have at least two departments that act in line with the National Basic Sanitation Policy (PNSB). This result may be related to the search for speed in the application of federal policies. In a representative portion of these municipalities, the departments involved in solid waste management are the departments of infrastructure and the environment.

Another aspect dealt with in this dimension concerns the degree of access by households to basic sanitation. In this, half of the municipalities of the RMF have less than 30% of households with access to basic sanitation. The opposite result was found in the municipality of Chorozinho, which has more than 75% of households with access to basic sanitation. This indicator of sustainability (integrality) is extremely important for maintaining the balance of the environment and indispensable to human life, according to Oliveira and Carvalho (2004), as well as defines the level of evolution of a given region, according to Days (2004).

The integrated basic sanitation services available to the population in half of the municipalities have water and waste services. Only the municipalities of Fortaleza, Caucaia and Guaiúba presented the water, sewage, solid waste and drainage services integrated in a representative extension.

With regard to the National Solid Waste Policy (PNRS), six of the 12 municipalities have an Integrated Solid Waste Management Plan (PGIRS), among these the municipality of Fortaleza. On the other hand, four municipalities claim not to have PGIRS and the municipalities of Guaiúba and Maranguape have their PGIRS in the process of elaboration.

Finally, it was verified, with regard to public cleaning surveillance services, that ten of the municipalities carry out the supervision of public cleaning services, whether carried out by the municipalities themselves or through companies contracted in bidding process. The municipality of Pacatuba hires outsourced companies to conduct inspection of municipalities, while the municipality of Guaiúba does not carry out the supervision of this municipality.

4.3 Descriptive analysis of the Technological Dimension

Nine municipalities, that is, 75% of the sample use local labor in all phases of solid waste management. One of the municipalities, Cascavel, uses local labor only in the collection process. The use and maintenance of equipment in this process of solid waste management are carried out in all phases of management in four municipalities (Cascavel, Pacatuba, Caucaia and Fortaleza).

Among the municipalities studied, it was found that Itaitinga and Fortaleza use clean technologies in the reuse of waste with reduced energy consumption. The other municipalities present the non-use of any clean technological resource.

The representative part of the municipalities has specific collector vehicles, including the use of compactors, specifically intended for the collection of solid waste. Through the interview, it was noticed that the number of vehicles in the municipalities is reduced, including in the capital. The other municipalities – Pacajus, Guaiúba, Itaitinga and Maranguape – do not have collecting vehicles, being in charge of the companies contracted to perform these services.

4.4 Descriptive analysis of the Economic and Financial Dimension

The resources allocated to the management of municipal solid waste come from several sources, such as annual budget of the municipality, collection of specific population rate, among others. With the exception of the municipality of Aquiraz, all municipalities of the study do not carry out any collection of fees for the management of solid waste. Aquiraz, in turn, collects this fee together with the Urban Land and Territorial Tax (IPTU). The respondents say that they have projects for the preparation of this collection, seeking to provide the improvement of the quality of life of the population, since this additional resource would be reinvested in the management of municipal solid waste. Additionally, Jacobi and Besen (2011, p. 152) state that "the collection of a rate proportional to the quantities generated is also an important factor of awareness and education of citizens to reduce the quantities produced and waste."

It was found that eight of the municipalities allocate less than 5% of the municipal public budget for public cleaning services. In this sense, God, Luca and Clarke (2004) argue that the lower the allocation of municipal budget resources to public cleaning services, the greater the exposure of the population to the risk of contamination. On the other hand, the municipalities of Chorozinho, Itaitinga, Caucaia and Fortaleza allocate values greater than 5% of budgets for public cleaning services, presenting an average allocation of 12%.

It was also found that the municipalities of the sample do not have control over the resources derived from selective collection. The results found, based on the instruments used, allow us to infer that the selection of waste collected by these municipalities is made, for the most part, by waste pickers not associated or not organized in cooperatives.

4.5 Descriptive analysis of the Environmental-Ecological Dimension

Regarding the environmental-ecological dimension it was identified that municipalities have relatively high waste collection efficiency, considering that eight of the municipalities said that more than 90% of the waste generated by their municipalities, are from rural and urban area as well.

Another aspect analyzed refers to the distribution of public dumps in the municipality, where it was found that all municipalities have dumps located in urban areas, distributed in places of movement of people. However, eight municipalities do not use selective waste collection. In addition, less than 5% of the recyclables are recovered.

Another important factor is that half of the municipalities do not have landfills, and solid waste destined for dumps distributed in the RMF. From this perspective, Mucelin and Bellini (2007) argue that these dumps can cause soil contamination, rivers, as well as the transmission of diseases. Being this method considered the most primitive method of destination, because it does not consider the environmental impacts caused (SANTOS; RIGOTTO, 2008). About the others, five have controlled or licensed landfills, while the municipality of Horizonte is in the process of licensing the landfill.

Based on the research instruments, it was found that all municipalities have clandestine waste points, which are located farthest from the capital (Fortaleza). The other municipalities have irregular points of waste, however, as far as their extension is small and incipient. It is

pointed out that irregular sites of solid waste deposition are recovered, in whole or in part, by municipalities. It was also found that the recovery of these areas has a high cost for municipalities corroborating the arguments of Aberte, Carneiro and Kan (2005), in which the recovery of degraded areas due to inadequate disposal of garbage has high costs, as it involves the processes of total removal of deposited waste, as well as transport to landfills and then the deposition of natural soil of the region in the area.

4.6 Descriptive analysis of the Knowledge Dimension

In this dimension, it was found that the investment or attention paid to environmental education is low when compared to the other dimensions. Aspects such as the low allocation of resources for environmental education, the lack of projects focusing on environmental education and the lack of mobilization of the population on the theme of environmental education.

On the other hand, events with the environmental theme was frequent in the municipalities studied, as well as the existence of specific advice to treat the solid waste policy and education of the population on environmental protection. These results allow us to affirm that the participation of the community in environmental issues becomes relevant, not only with regard to environmental education, but also as a way of supervising accountability of actions carried out by the municipality. The issue of environmental education, specifically related to solid waste, should include, in addition to the participation of social actors directly involved with the management of solid waste and the community as a participatory actor in the construction of solutions (LOGAREZZI, 2006).

4.7 Descriptive analysis of Social Inclusion Dimension

Half of the studied cities do not have collectors' associations or cooperatives, however the cities of Itaitinga, Pacatuba, Caucaia and Fortaleza have several collectors' groups, mostly of them organized in associations or cooperatives. Despite the existence of these social, organized actors in the treatment of urban solid waste, they have an income lower than a basic salary, with the exception of Fortaleza and Horizonte cities, where the agents' income is a basic salary. It was reported that neither training courses are offered for environmental education nor the professionalization of these social actors. However, the cities of Itaitinga and Pacatuba affirmed that about 50% of the collectors of their respective cities are involved in training and environmental education courses.

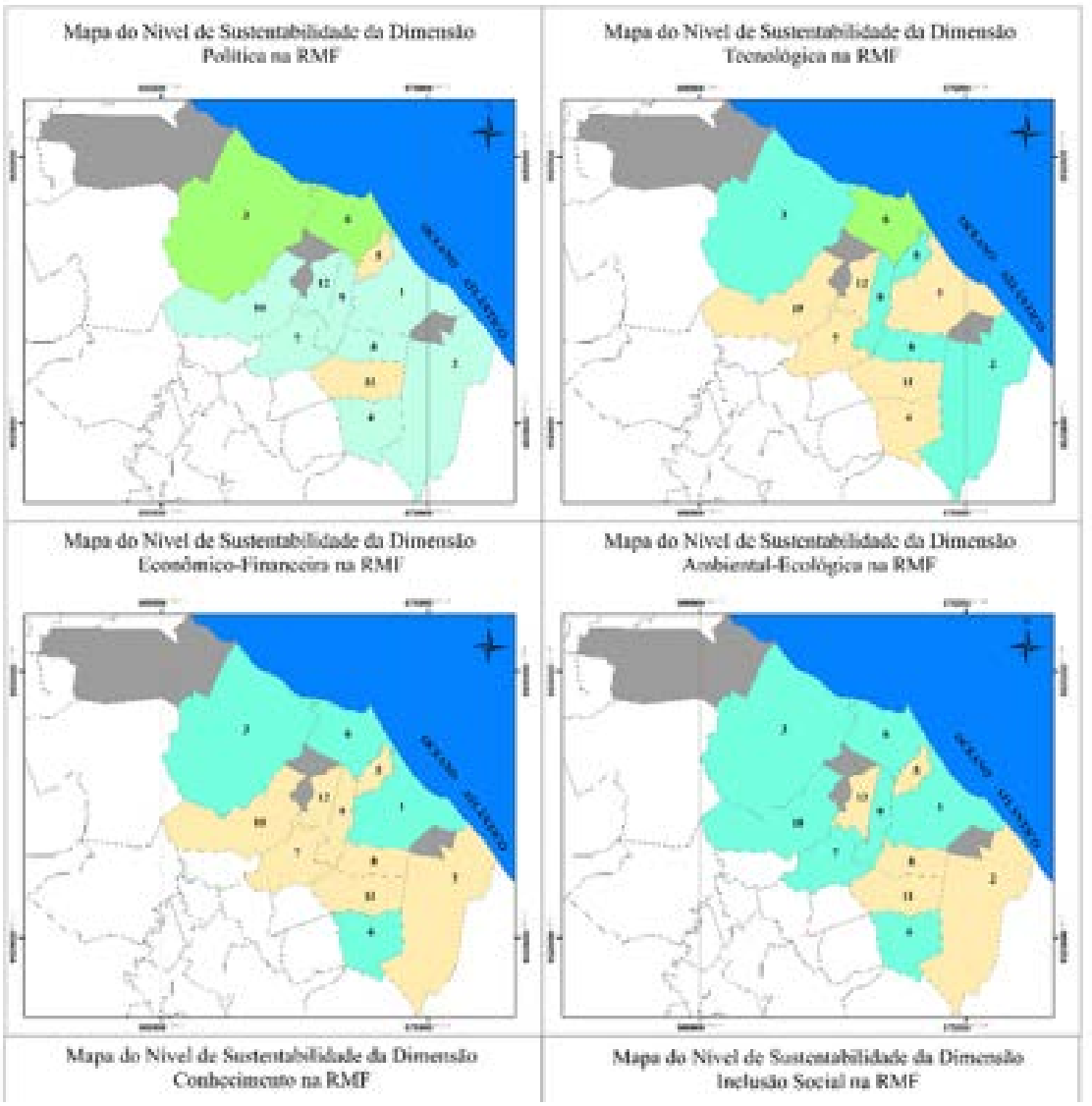
Another analyzed aspect refers to collectors working conditions and the use of solid waste post-consumption by artisans as a source of income. In the former it was found that the working conditions of the collectors are low, because they do not have an adequate work structure, as well as the non-use of adequate equipment to execute these services. Confronting this result, Ribeiro *et al.* (2009) stated that the collectors, individual or organized in cooperatives, should be considered as central actors in the shared solid waste management. Regarding the latter, it was evidenced that the cities of Fortaleza and Caucaia are the only ones which have artisans' cooperatives with fixed remuneration not based on productivity.

The last aspect worked in this dimension is the existence of support to these social actors by the cities, identifying the absence of any kind of support program for waste pickers. However, Fortaleza city has a formal agreement with the collectors, and the cities of Chorozinho, Horizonte and Maranguape affirmed to support the development of these social actors.

4.8 Sustainability of Urban Solid Waste Management (GRSU)

In order to explain the level of sustainability of the different dimensions of sustainability in the Metropolitan Region of Fortaleza (RMF) Figure 1 is presented, in which it is highlighted spatially the level of service to the sustainability of urban solid waste management.

Figure 1 – Level of sustainability, by size of Urban Solid Waste Management



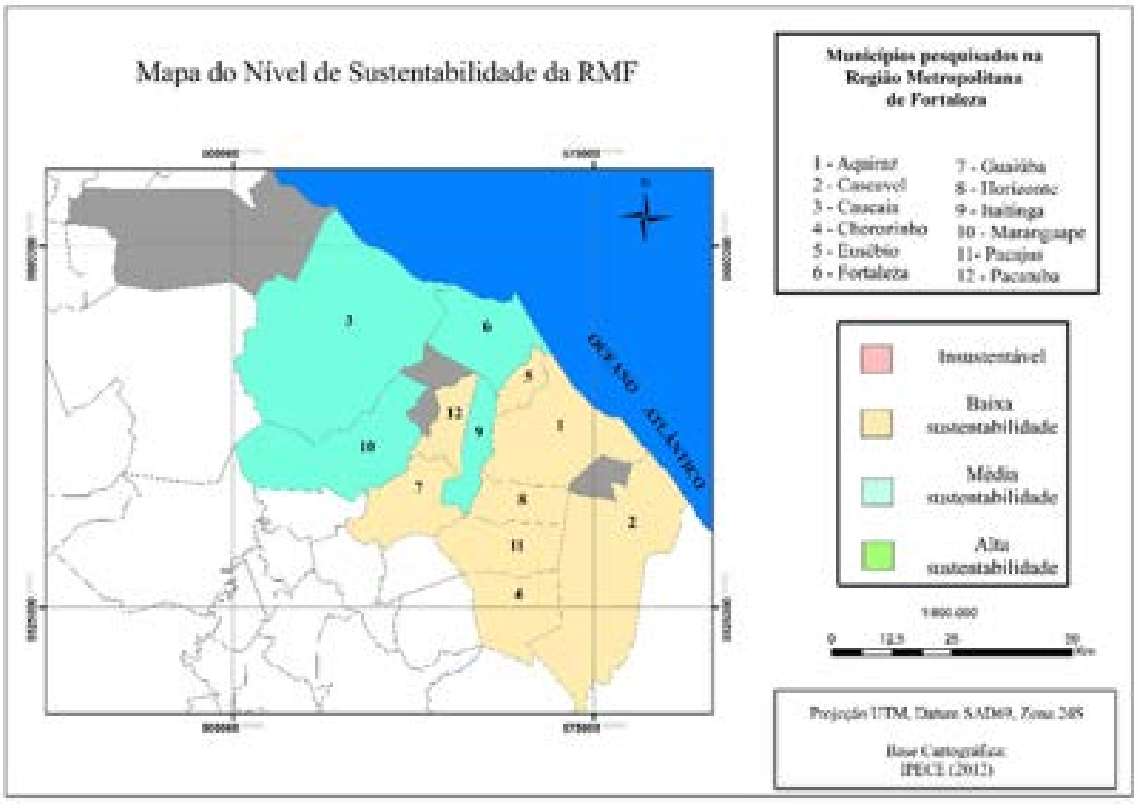
Source: Research data.

It is noted that the municipalities of Fortaleza and Caucaia have a high level of sustainability in the political dimension, thus evidencing their consonance with government policies and strong adherence of the municipality's environmental management to the practices of sustainability. It should be emphasized that in the technological dimension, only the municipality of Fortaleza presented high levels of use of processes and clean technologies for the management of solid waste.

It is also observed that in the economic-financial, environmental-ecological dimensions, knowledge and social inclusion there are no high levels of sustainability, focusing on low and medium levels of sustainability. This result points to the asymmetric concern of managers or organs in the different contexts of the sustainability of solid waste, seeking to adopt sustainable practices by legal requirements or by the use of mechanisms that reduce costs, than those aspects related to the volume of resources allocated in the potential reduction of the effects of solid waste, population awareness and the support of social agents in the implementation of sustainable policies of municipalities.

The level of sustainability of solid waste management is presented in Figure 2, in which all dimensions related to the management of solid waste proposed by Santiago and Dias (2012) were considered.

Figure 2 – General level of sustainability of Urban Solid Waste Management



Source: Research data.

It is inferred, through the interpretation of the data of Figure 2, which shows the sustainability level of the RMF, the effectiveness of low sustainability in most municipalities. More than 60% of the assessed cities do not have management policies for solid waste management. However, 33% of these municipalities had an average level of sustainability. In these municipalities, Caucaia, Itaitinga, Fortaleza and Maranguape, 5% of their municipal revenue is allocated to the public cleaning service, which increases the economic and financial dimension of these cities compared to the others that make up the RMF.

Although there were high rates in the municipality of Fortaleza regarding to political and technological dimensions, it is observed that, within the general analysis of urban solid waste management, none of the municipalities had high levels of sustainability. Table 2 shows the numerical results of the RMF GRSU sustainability level.

Table 2 – GRSU sustainability level (by dimension and general)

Cities	GRSU Sustainability Dimensions						
	Political	Technological	Economic--Financial	Environmental-Ecological	Knowledge	Social inclusion	GRSU
Aquiraz	6,00	3,50	4,50	5,23	2,00	0,67	3,58
Cascavel	4,80	6,50	3,50	3,08	4,20	1,67	3,63
Eusébio	4,00	5,50	3,50	3,23	1,60	0,67	2,74
Chorozinho	7,60	4,00	4,50	4,62	1,60	1,67	3,67
Horizonte	6,80	5,50	3,50	3,69	2,00	3,33	3,67
Pacajus	3,20	3,00	3,50	2,92	0,40	0,67	2,05
Guaiúba	4,80	3,50	3,50	4,46	1,60	0,67	3,02
Itaitinga	4,80	5,00	2,50	5,38	4,00	3,33	4,28
Maranguape	6,80	3,00	3,50	6,00	2,00	2,67	4,05
Pacatuba	5,60	7,50	3,50	3,85	3,00	3,33	4,00
Caucaia	9,20	7,50	4,50	6,00	5,20	4,00	5,77
Fortaleza	9,20	9,00	4,50	5,54	7,40	6,33	6,60
Mean	6,07	5,29	3,75	4,50	2,92	2,42	3,92
SD	1,92	1,99	0,62	1,13	1,96	1,75	1,24

Source: Research data.

The results show that, in a general analysis, the municipality of Fortaleza, and capital of the state of Ceará, has the highest level of sustainability in urban solid waste management, followed by the municipality of Caucaia. The difference between the highest and lowest levels of sustainability is 4.55 (Fortaleza-Pacajus). This result indicates the disparity in the level of sustainability in urban solid waste management, converging with the study by Polaz and Teixeira (2009).

It is observed that the political dimension presents the highest level by the municipalities, followed by the technological and environmental-ecological dimension. It is also worth noting that there is a great disparity between the municipalities, regarding the dimensions of technological sustainability, knowledge and politics, presenting an average dispersion of 1.96.

4 CONCLUSIONS

Based on one of the pillars of sustainable development - environmental management - this study aimed to verify the level of sustainability of urban solid waste management in the Metropolitan Region of Fortaleza (RMF). To this end, an exploratory study with descriptive characteristics was conducted using a sample of 12 of the 15 municipalities belonging to the RMF. Thus, the treatment of the collected data made it possible to infer some considerations about solid waste management practices, as well as to know the level of sustainability in these municipalities.

In general, it is clear from the descriptive analysis that solid waste management differs greatly between municipalities, since, through the application of questionnaires and interviews, solid waste treatment practices are specific to each municipality. Regarding the characteristics of solid waste management, distributed in the dimensions proposed by Santiago and Dias (2012), it was observed that: (i) in the political dimension, there was a preponderant participation in the supervision of public cleaning services; (ii) in the technological dimension, it was noticed that the use of local labor during all phases of management is frequent; (iii) in the economic-financial dimension, there was a high percentage of self-financing of the cost of collection, treatment and final disposal of waste, common in practically all municipalities; (iv) regarding the environmental-ecological dimension, we resort to collection efficiency, population satisfaction and the existence of clandestine waste in the municipalities; (v) in the knowledge dimension, the predominant feature refers to the holding of annual events on environmental education; and (vi) in the social inclusion dimension, it was noted the existence of independently organized waste pickers or associations in a representative part of the municipalities.

Regarding the level of sustainability of urban solid waste management, it can be seen that in the political dimension the municipalities of Caucaia and Fortaleza presented a high level of sustainability; in the technological dimension, only the municipality of Fortaleza stands out with a high level of sustainability; in the other dimensions of sustainability, no municipality presented a high level of sustainability, evenly distributed in the medium and low levels. It is noteworthy that no municipality presented the sustainability of solid waste management as unsustainable. In general, and considering all the dimensions mentioned in the study, no municipality presented a high level of sustainability.

It should be noted that previous studies have highlighted the low level of sustainability of regions due to the lack of effective urban solid waste management (AGAMUTHU; KHIDZIR; FAUSIAH, 2009; GOMES et al., 2014; POLAZ; TEIXEIRA, 2009; SANTOS; TEIXEIRA; KNIESS, 2014). It should be noted that great progress in solid waste management came only after the enactment of Law No. 11,445 / 2007 and Law No. 12,305 / 2010. In this sense, it is hoped that future studies can identify the potential effects of solid waste management policy in urban centers, aiming to identify improvements in the environment and quality of life. This is because improvements in the management of municipal solid waste, due to legal compliance with Law No. 12,305 / 2010, have not yet been sufficient to create integrated and sustainable management (NASCIMENTO et al., 2015).

The results of this research provide empirical indications of solid waste management practices and the current context of sustainability in the municipalities of the RMF, being part of the research group that seeks to examine the sustainability level of Brazilian municipalities. It is also noteworthy that this study differs from the others, as it seeks to examine the sustainability level of a group of municipalities, not only refraining from analyzing the sustainability level of a municipality or in the construction of indicators to measure them.

The result obtained allowed us to understand the practices adopted regarding the management of urban solid waste, as well as the level of sustainability of the Metropolitan Region of Fortaleza. Given the rapid process of urbanization linked to economic growth, the generation of

solid waste has increased considerably in recent times, but its correct treatment has not gained prominence. In this sense, assessing the sustainability of a region provides managers of municipalities with knowledge of their local needs, enabling this information to assist them in making political decisions to manage this waste, seeking sustainable development.

Finally, considering that the study presented some limitations regarding the sample and the specific analysis given, it is proposed for future research to carry out the application of questionnaires in different metropolitan regions in order to compare the main similarities and differences between the municipalities of the metropolitan regions of Fortaleza, seeking to examine their possible effects.

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Contribution of authors

Contribution	[Author 1]	[Author 2]
1. Definition of research problem	√	
2. Development of hypotheses or research questions (empirical studies)	√	√
3. Development of theoretical propositions (theoretical work)	√	√
4. Theoretical foundation / Literature review	√	√
5. Definition of methodological procedures	√	√
6. Data collection		√
7. Statistical analysis		√
8. Analysis and interpretation of data	√	√
9. Critical revision of the manuscript	√	√
10. Manuscript writing	√	√
11. Other (please specify)		