

**DISASTER RISK GOVERNANCE: Institutional vulnerability assessment with
emphasis on non-structural measures in the municipality of Jaboatão dos
Guararapes, Pernambuco (PE), Brazil**

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Abstract

Climate change has had serious consequences at global and local levels and has required more effective scientific studies and management measures for disaster risk reduction strategies. In this sense, public managers should consider strategies that involve the integration of stakeholders, in relation to understanding the disaster risks to be faced. The aim of this paper is to analyze and discuss the degree of institutional vulnerability in terms of disaster risk governance, with emphasis on non-structural measures taken in the municipality of Jaboatão dos Guararapes, Pernambuco, Brazil. Five (5) indicators were analyzed, consisting of Planning and Management Instrument, Management Structure, Taking Preventive Actions, Multidisciplinary Work and Emergency Funds. The importance of non-structural measures that strengthen this governance is highlighted, namely community protection and civil defense groups and the warning system. From this study it was concluded that the management of the municipality of Jaboatão dos Guararapes was characterized as having a medium degree of institutional vulnerability and had taken actions to develop integrated planning, acting within the principles recommended in the Sendai framework (2015-2030). In this sense, recommendations are suggested for the improvement of the entire governance system according to the analyzed indicators and document.

1. INTRODUCTION

Environmental problems related to climate change have had significant local and global impacts. These problems have grown in size and repercussions that will affect present and future populations and generations.

The construction and promotion of strategic plans for governance are important perspectives in guaranteeing decision-making processes for disaster risk reduction (DRR). The new concepts revolve around management based on the integrating principle and combination of convergent forces and comprehensive decision-making processes with the participation of governmental and non-governmental stakeholders. This article addresses the priorities of the Sendai Framework (2015-2030) that focuses on the importance of understanding risk, strengthening governance, investing in disaster risk reduction for resilience, and enhancing disaster preparedness for effective response.

In Brazil, despite decisive steps with the institutionalization of Law 12,608 / 2012 establishing the National Policy on Protection and Civil Defense (NPPCD) and creating mechanisms for disaster risk management at the national, state and municipal levels, as well as creating disaster information system and monitoring, it is found that there is still a need to consolidate priorities when implementing public disaster risk management policies at the local level.

These priorities appear transversally in the analyzed indicators in this article, and governance is understood as a "system of institutions, mechanisms, regulatory and legal frameworks and other provisions aimed at guiding, coordinating and accompanying disaster risk reduction and related policy areas", (Unisdr, 2016).

In order for disaster risk governance to really happen, it is necessary to set up guidelines both in regard to the role of public agents in the process and of all stakeholders who may be involved in risk management and their coping capacity, the social subjects who are potentially exposed to situations of risks, vulnerabilities and hazards.

“Disaster risk depends not only on the possibility of intense events or natural phenomena but also on the vulnerability conditions that favor or facilitate the onset of disasters when such phenomena occur. The vulnerability is closely linked to the social processes developed in risk-prone areas and is often related to the vulnerability, susceptibility or lack of resilience of the population to different types of threats”, (Cardona, 2004).

In this context, aspects related to institutional vulnerabilities with a view to non-structural measures are addressed, verifying interfaces for prevention and mitigation, evolving towards a more holistic approach to risk in

the interdisciplinary and multidisciplinary fields. Debortoli et al. (2018) emphasize the importance of working from the perspective of the community interface, with cultural understanding, trust, integration of disparate worldviews and consideration of the realistic, feasible and desired involvement by these groups.

Considering the process of disasters and their effects, this study is based on a local analysis according to the principles of the Sendai Framework (2015-2030), in order to analyze the degree of institutional vulnerability in terms of disaster risk governance Geological hazard – landslides with emphasis on non-structural measures adopted in the municipality of Jaboatão dos Guararapes, Pernambuco, Brazil.

2. DISASTER GROWTH AND DRR CHALLENGES

In the globalized scenario, such as in Brazil, disasters have caused significant human, material and environmental damages. (Keim, 2008), (Debortoli, et al, 2017), (Viana and Johnsson, 2017) and (Mendonça and Gullo, 2017), stress the importance of conceptually discussing principles related to the problem of disaster risk, and their impacts on people's lives, and how institutions have worked on the approach to mitigation, which is fundamental when confirming that the risks are becoming more and more frequent and disasters affecting regions and populations are more widespread. Thus, it is evident that "climate change happens at a global level and will increase the probability of extreme weather events, including heatwaves, drought, wildfire, cyclones and heavy rainfall that could cause floods and landslides," (Keim, 2008), which represents a major challenge at all government levels.

In this context, damage to the surviving population after landslide-related disasters is considerable, involving economic losses, loss of housing, social and psychological damage that could last for several years, evidence of the low social resilience (Mendonça & Gullo, 2017).

According to the United Nations, there is a dramatic rise in natural disasters and driving 24 million people into poverty. Therefore, addressing the threat of disasters needs to be in the public arena, showing that extreme phenomena displace around 14 million people per year (Unisdr, 2017). With regard to Brazil, it is imperative to define strategies at the national, regional and local levels in order to consolidate more tangible actions to address the institutional vulnerability of agencies working with disaster risk management, and to meet the population's requirements.

In the disaster risk reduction context, non-structural measures translate institutional, economic and management actions that involve plans, programs, projects and laws that must be implemented in the local scenario to achieve risk control and protect the people from disasters.

In this view, non-structural measures involve "knowledge, practices or regulations to reduce disaster risks and their effects, through policies and laws, public awareness, training and education" (Unisdr, 2016). They are therefore important tools and actions that strengthen local governments in disaster risk reduction (DRR), by means of instruments such as a control plan to contain the advance of disordered occupations, actions to integrate the population for empowerment on risk prevention by implementing commissions that directly involve people living in vulnerable areas and precarious settlements.

2.1 Disasters associated with mass movements and flooding in Brazil

Concerning disaster risks in Brazil and their specificities, the Brazilian Institute of Geography and Statistics (IBGE, 2018) attributes these differences to the physical characteristics that provide different forms of occupation. It emphasizes that "the differences in municipal territorial fragmentation between the major regions of the country determined different patterns of spatial distribution of the population in risk areas".

On the other hand, the Brazilian Atlas of Natural Disasters (developed by CEPED/SC, 2013), highlights the increasing number of natural disasters occurring in the country. The document reports that "there was an increase in the occurrence of disasters in the 1990s and 2000s, following in the years 2010, 2011 and 2013, where 8,515 (22%) of the total 38,996 records, occurred in the 1990s; 21,741 (56%) in the 2000s; and in the years 2010, 2011 and 2012 alone this number increased by another 8,740 (22%)".

Surveys carried out by the São Paulo State Technological Research Institute (Macedo and Martins, 2015) reveal that in the period from 1988 to April 2015 Brazil recorded 773 cataloged disaster events, comprising a total of 3,396 fatalities. Deaths in landslides per State are also recorded. In decreasing order, the first eight: Rio de Janeiro (1,819), São Paulo (422), Minas Gerais (332), Bahia (209), Santa Catarina (206), Pernambuco (189), Alagoas (76) and Espírito Santo (66).

Other data to be considered are in the study developed by the Brazilian Institute of Geography and Statistics (IBGE, 2018), which presents an analysis on the higher rate of populations exposed to disaster risks on geological hazard – landslides and highlights the characterization of these vulnerable populations.

According to the study, 8,270,127 people live in disaster-prone areas in Brazil. Of this universe, the Southeast Region ranks first with a greater area and population in a situation of vulnerability. In the four (4) states in this region 308 municipalities were diagnosed as having 17,175 risk areas with a population of 4,266,301 inhabitants exposed to disaster risks, representing 9.8% of the total population in the monitored municipalities of the region.

Another worrying region is the Northeast, consisting of nine (9) states, where 294 municipalities were monitored. A total of 5,471 risk areas were identified, with 2,952,628 people living in vulnerable situations, representing 11.4% of the total population of the 294 municipalities that participated in the region analysis.

(Debortoli, et al, 2017) points out that studying the vulnerabilities to climate change in a continental country the size of Brazil is complex, considering several specificities to be verified. The author emphasizes the difficulty in obtaining a database related to disaster risks, levels of damage and others that reflect a weakness in the public authorities to be able to act on the causes and whys of those events.

One example of the importance of creating strategies for disaster risk governance was the Rio de Janeiro Mountain Region disaster in 2011, which according to (IBGE, 2018) "approximately 900 people died and more than 300,000 were affected. In addition to severe economic losses of USD 1.2 billion, according to the (World Bank, 2012), this was considered "the worst natural disaster of this century".

This catastrophe resulted in irreparable human losses and demonstrated a major weakness in the management structure for tackling the disaster, whether in the early warning system, relief and aid to the population, or in reconstruction where the resources were often not properly applied, causing significant disruption to the structure of the city and people's lives. In this sense, "it is necessary to foresee the risk of overlapping and duplicating alerts, reducing the political, economic and institutional weaknesses throughout the disaster risk management (Marchezini, 2015)".

3. CHARACTERIZATION OF THE STUDY AREA

The municipality of Jaboatão dos Guararapes is located 18 km from Recife, in the coastal area of the Recife Metropolitan Region-RMR (Figure 1). It has a territorial area of 258,694 Km² (IBGE, 2016) with a population of 644,620 inhabitants in the latest 2010 census, and an estimated projection of 691,125 inhabitants (IBGE, 2016). It covers a total area of 97.75% urban area and only 2.25% of the rural area. The population density is 2,491.82 inhabitants per

km², divided into 27 neighborhoods and its Administrative Policy Division comprises seven (7) Regionals, namely Jaboatão Center Regional, Cavaleiro Regional, Curado Regional, Murizeca Regional, Prazeres Regional, Beaches Regional, and Guararapes Regional. It is limited to the cities of Recife to the North, Cabo de Santo Agostinho to the South, São Lourenço da Mata, and Moreno to the West.



Figure 1. Location map of the municipality of Jaboatão dos Guararapes.

With regard to the administrative structure, the municipal management is defined by eight (8) municipal secretariats that develop integrated public policies, and five (5) special secretariats designed to take strategic actions linking projects intended for the population, according to the organization chart below (figure 2).

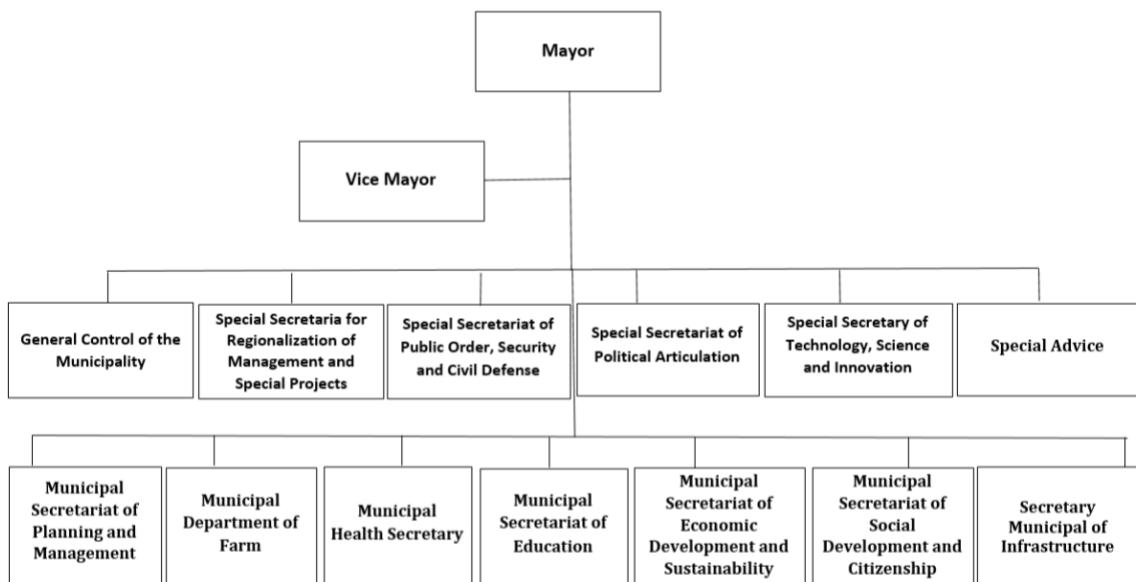


Figure 2. Organization chart of the Jaboatão dos Guararapes municipal government

Regarding the disaster risks on geological hazards - landslides, the municipality is the second largest in the State of Pernambuco, located in the Northeast Region, with 188,026 inhabitants living in risk areas; that is, 29.1% of the total population of the municipality occupying the sixth place in the national territory.

The concentrated rainy season stretches from March to August, with monthly rainfall average of more than 150 mm. This period is considered an alert for the civil defenses of Recife metropolitan area. The maximum monthly rainfall is recorded in the months of May, June, and July, with a monthly average of close to 250 mm of rainfall. The period from September to February has a low monthly rainfall average. (Figure 3) and always above 1,500 mm per year.

The average temperature is around 26°C, with a minimum of 18°C and maximum of 32°C. The lithology comprises lithotypes of the Pernambuco-Alagoas Massif (Brito Neves, 1975), lithotypes of the Pernambuco Group (Amaral and Menor, 1979) and Tertiary and Quaternary cover sediments distributed along the coastal strip.

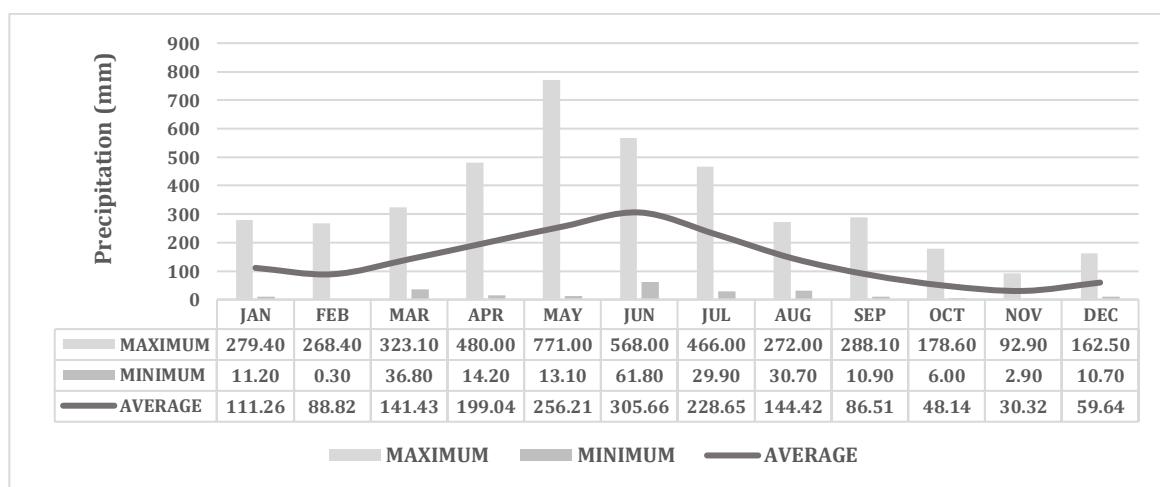


Figure 3. Annual distribution of the mean, maximum and minimum rainfall of the city of Jaboatão dos Guararapes, for the monthly historical series from 1994 to 2017.

With respect to its geomorphology, the municipality presents basically three landforms: hills, terraces and plain, expressed by well-defined topographical features. The features within these landforms resulted from a series of geological events related to tectonic activities and to the differential behavior of the rocks.

4. METHODOLOGY

4.1 Indicators for Governance Analysis

This study was initially part of the research project subsidized by the Ministry of National Integration, through the National Secretariat of Civil Defense (in Portuguese SEDEC/MI), based on an agreement signed with the Federal University of Pernambuco (in Portuguese UFPE) through the Geotechnical Engineering of Slopes, Plains, and Disasters Group (in Portuguese GEGEP), in the municipality of Jaboatão dos Guararapes-PE, Brazil. Interviews were carried out with government actors involving technicians from strategic areas, from both the risk management and monitoring actions, also highlighting specialists from areas of Geological hazard – landslides, considering quantitative and qualitative analyses at the level of institutional vulnerability based on management indicators.

The research developed cover all disaster risk management cycle, including the stages of response, recovery and reconstruction. However, for this article, were chosen five (5) indicators where are included the stages of prevention, mitigation and preparation for emergencies. Emphasis was to verify aspects of non-structural measure within the Disaster Risk Reduction.

From the proposed study, five (5) indicators were constructed and analyzed (table 1). Each indicator has a set of subindicators, considering the plans, programs, and projects related to the culture of disaster risk prevention. In addition to the data collected from the applied forms, it was also found that the extent answers obtained were consistent, supporting documents and projects in progress, assessing the effectiveness. In order to emphasize the non-structural measures taken by municipal management, the implementation of the Center for Protection and Civil Defense (Nupdec) project was analyzed, and one of the guidelines of the National Civil Protection and Protection System (Law 12,608 / 2012) is addressed in the study of Bandeira and Coutinho (2015) that provides parameters for analysis of critical rainfall, which can be used to improve the early warning system of the municipality of Jaboatão dos Guararapes, Pernambuco, Brazil.

It is worth mentioning that this methodology can be replicated to other Brazilian or international realities, considering that the institutions that work with the disaster risk problem have a similar profile. Thus, the indicators can be used to check the degree of institutional vulnerability, and it is possible to draw regional panoramas, considering the pertinent specificities to the institutional processes and scenarios. In this sense, Debortoli et al (2018) comment that indicators for vulnerability assessment "are an important tool for adaptive planning. And add that the variables should be easily applicable, measurable, accessible, transferable and non-redundant".

In this work, the idea was to develop an easy-to-apply methodology for analyzing institutional vulnerability in order to verify, measure and evaluate data identifying advances and difficulties in the process of disaster risk governance at the local level.

Table 1 - Indicators and their objectives for this study

INDICATOR	OBJECTIVES
Planning and Management Instrument	To analyze the level of use and availability of subsidies to consolidate planning in relation to disaster risk management, also considering, early warning system with technical parameters of critical rainfall suggested for the States Alert.
Management Structure	To assess organization of municipal management in relation to projects, fundraising for structural works, a logistics structure for action in prevention and preparation phases, register of population at risk and shelter registration in emergencies.
Preventive Actions Promotion	To check the performance of non-structural measures considering the formation of Nupdecs in schools, capacity building with health agents, a resilient city program, community rain gauge project and structural measures highlighting implementation of works in landslide risk areas, considering the actions of prevention, mitigation and preparation.
Multidisciplinary work	To examine the management of proximity, checking how municipal management is integrating with the population in relation to prevention practices and the intersectionality between public policies. To also consider integrating preventive actions between municipal institutions.
Emergency Funds	To analyze the tools for funding and support in emergencies, focusing on response as well as intersectoral actions to act with the disaster-affected population.

The study was based on the premise of Sendai Framework (2015-2030), Law 12,608 dated 2012, in addition to the municipal contingency plan, prevention plan, municipal risk reduction plan; master plan and other supporting instruments for analysis of disaster risk governance.

For the analysis of the five (5) indicators, parameters were used where the municipal management data were collected considering the degree of vulnerability and performance levels based on analysis of easy-to-apply forms according to (Debortoli, et al, 2018). Data were also collected from technicians and specialists, as well as documents, plans, programs and projects of municipal management and practical experiences and compared, using as counterpoint the answers obtained in the form, according to table 2.

Table 2 - Indicators and sub-indicators adopted to determine the degree of institutional vulnerability of

Jabotão dos Guararapes:

Indicator	Planning and Management Instrument	Management Structure	Taking Preventive Actions	Multidisciplinary work	Emergency Funds
Sub-indicator	<ul style="list-style-type: none"> - Municipal Risk Reduction Plan - Contingency plan - Georeferencing - Multiyear plan focusing on risk management 	<ul style="list-style-type: none"> - Design and procurement for structural works - Logistic structure for action in prevention and preparation phases 	<ul style="list-style-type: none"> - Formation of Nupdecs in schools - Training work with health workers - Resilient City Program - Project community rain gauges 	<ul style="list-style-type: none"> - Proximity management - Intersectoral action between public policies - Integration in preventive actions among municipal institutions 	<ul style="list-style-type: none"> - Civil Defense adhesion - Provisions for action in emergency - Intersectoral actions with the population

		<ul style="list-style-type: none"> - Population at risk - Register of shelters in emergencies 	<ul style="list-style-type: none"> - Execution of structural works 		
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Each indicator's degree of vulnerability was analyzed based on the interaction between the intervals identified in the items "use of tools" and usage effectiveness. The final degree of vulnerability was determined by the average of the results of each indicator. Table 3 shows an example of the analytical structure of indicators.

Table 3 - Example of the composition of an indicator and its respective subindicators, determining at the end the degree of vulnerability of each indicator.

4.2 Determining the degree of vulnerability

Indicator	Subindicator	Use of tools	Usage effectiveness range	Vulnerability degree	
Planning and management	Municipal Risk Reduction Plan	Always	Very efficient	1	
		Sometimes	Efficient	2	
		Rarely	Poorly efficient	3	
		Never	Inefficient	4	
	Contingency plan	Always	Very efficient	1	
		Sometimes	Efficient	2	
		Rarely	Poorly efficient	3	
		Never	Inefficient	4	
	Georeferencing	Always	Very efficient	1	
		Sometimes	Efficient	2	
		Rarely	Poorly efficient	3	
		Never	Inefficient	4	
	Multiyear plan focusing on risk management	Always	Very efficient	1	
		Sometimes	Efficient	2	
		Rarely	Poorly efficient	3	
		Never	Inefficient	4	
Final Degree of Vulnerability				1	
				2	
				3	
				4	

Each indicator is analyzed based on the identification of the degree of vulnerability of each sub-indicator, which will be calculated by the weighted average of its intervals. Factors are rated 1 (low), 2 (medium), 3 (high) or 4 (very high).

Equation 1 provides the mathematical model for analyzing the degree of vulnerability of each subindicator:

$$GV_{Sub} = G_{intSub} \times P_{Sub} \quad (1)$$

GV_{Sub} = The degree of vulnerability of the subindicator;

G_{intSub} = The degree of vulnerability related to the subindicator range.

P_{Sub} = Subindicator weight

The indicator's degree of vulnerability is obtained by the sum of each subindicator, which was obtained in Equation 1, according to Equation 2:

$$GV_{ind} = \sum GV_{sub} \quad (2)$$

GV_{ind} = The degree of vulnerability of the indicator;

GV_{Sub} = The degree of vulnerability of the subindicator.

Finally, the final degree of vulnerability is determined by the average of the result obtained for each indicator, according to equation 3.

$$GV_f = (GV_{ind} * Pi) \quad (3)$$

GV_f = The Final vulnerability degree;

GV_{ind} = The degree of vulnerability of the indicator;

Pi = Weight assigned to each indicator

The degree of vulnerability was classified into four bands presented in table 4.

Table 4: Representation of the ranges to classify the final degree of vulnerability

Degree of Vulnerability	Range
1 (low)	≤ 1.75

2 (medium)	> 1.75 to ≤ 2.5
3 (high)	> 2.5 to ≤ 3.25
4 (very high)	> 3.5 to ≤ 4.00

4.3 Correlation critical rainfall x mass movements

In order to enhance the management of risk areas in the municipality of Jaboatão dos Guararapes (Bandeira and Coutinho, 2015), a working methodology was presented to obtain rainfall parameters capable of triggering mass movements. The main steps of the authors' work will be described below.

Daily records of rainfall and occurrence of mass movements were collected during 2009 in five (5) areas of the territory, evidencing which regions were characterized by the most frequent recurrences of disasters in the municipality. The Jaboatão Centro, Cavaleiro, Curado, Muribeca and Prazeres regionals were chosen. The information about the landslides was obtained initially from the Municipal Civil Defense database of records of occurrences. News coverage in the press was also used. Landslides were recorded considering the location, date of occurrence, type of process and geological-geotechnical characteristics.

An example of the analysis of a sliding process and geotechnical-geological characteristics are presented in (Coutinho, et al, 2019).

From the studies, rainfall parameters were proposed for civil defense actions, observing the accumulation of rains for an early warning system. The critical rainfall accumulated in 72 h ($I_{72\text{h}}$), long-term (P_{ac}) and the values R_{crit} were proposed for each area. The R_{crit} is obtained using the products of $I_{72\text{h}}$ per P_{ac} .

5 ANALYSIS AND DISCUSSION OF RESULTS

Based on the analysis of the data collected during the research, the indicators were related to the theoretical aspects, in order to understand how municipal management has acted in the direction of the Sendai Framework guidelines (2015-2030) and the law 12,608 dated 2012. In this sense, five indicators were listed, considering the planning tools and management tools, management structure, adoption of preventive actions,

multidisciplinary work and the emergency fund of the municipality, and checking the management profile from the legal perspective.

Within the indicator tools of planning and management tools, is the analysis of critical rainfall, which assists in the management of risks and disasters in the municipality. For this study, (Bandeira and Coutinho, 2015), developed critical rainfall parameters capable of triggering mass movements. The results presented can be used as a reference for issuing disaster early warnings to the population of the risk areas of the municipality of Jaboatão dos Guararapes.

5.1 Planning and Management Tools

In this item, it was verified that the municipal management related to the indicator planning and management instruments, works with the municipal risk reduction plan, uses contingency plan and alert system, works with georeferencing of risk areas and its Multi-year Plan (PPA) focuses on risk management. In this sense, the average degree of vulnerability was obtained, since even though it was pointed out that it disposes and uses these instruments, it was observed that there is a need for updating and that even though resources are available in the PPA for RDR, these resources are still not very significant considering the reality of the Municipality and within the Sendai framework, according to table 5. This means that it is necessary to give greater importance to actions related to the updating of plans and projects and the implementation of technologies aimed at an alert system as defended by (Bandeira and Coutinho, 2015). At the same time, you can see the implementation of resources for the management of risks and disasters, working with strategies aimed at prevention, mitigation, and preparation.

In this context, Cardona and Cerreño(2013, p. 05) shows that "the reduction of risk seeks to intervene in major risk factors before the occurrence of the event". Thus, structural and non-structural measures contribute to risk and disaster mitigation, and on the other hand, non-structural measures, such as planning and spatial planning, educational campaigns, and socio-educational community work in schools are examples of activities that corroborate significantly for risk and disaster reduction.

Even highlighting as a priority goal, to implement an alert system to inform the population residing in areas of risk of disasters on heavy rains, these measures are significant, but still insipient given the reality of risks of the Municipality. In this sense, (Marchezini, 2015) points out that there is an institutional vulnerability at the national level, related to what is considered alarm and alert.

The author points out that concern about misunderstandings about alert and alarm is disturbing and comments that "weather warning" and / or "hydrometeorological warning" - which refer to the environmental phenomenon, the natural threat - are confused with the disaster risk alert - which encompasses the extent of potential material and human damage in the face of the interaction between a natural and / or technological threat and the vulnerabilities that present themselves in the territory. In this case, although the Municipality has a contingency plan, it is possible to notice that there is a limitation in the instrumentalization of the alert system, considering what (Marchezini, 2015). It is important to prepare the institutional instruments and population to be ready for the risks and potential of disasters in the reality of the scenario. (table 5)

However, it should be pointed out that management tools need to be implemented in an appropriate way, being monitored to see to what extent they need to be expanded, improved or reformulated.

Table 5 - Responses obtained from the application of a questionnaire in the municipality - Indicator

Planning and Management Instruments.

INDICATOR	SUBINDICATOR	USE OF THE TOOLS	RANGE OF THE EFFECTIVENESS OF USE	VULNERABILITY DEGREE
Planning and Management Instrument	Municipal Risk Reduction Plan	ALWAYS	EFFICIENT	MEDIUM
	Contingency Plan and Alert System	ALWAYS	EFFICIENT	MEDIUM
	Georeferencing	SOMETIMES	POORLY EFFICIENT	HIGH
	Multi-year plan focusing on risk management	ALWAYS	EFFICIENT	MEDIUM
FINAL DEGREE				MEDIUM

5.2 Management Structure

In this regard, it was analyzed that the management has tried to structure its actions to act in risks and disasters situations. It was verified that there is fundraising for investment in risk areas, availability of a logistic structure to act in the prevention and preparation, register of the population at risk and registration of shelter structures for emergency situations. However, these measures are still not enough (table 6). The investments in preventive works in the order of \$ 13 million dollars, being \$ 2,968,750.00 dollars foreseen in the municipal budget according to the Municipal Multi-Year Plan (2017) and another \$ 10,416,667.67 million dollars at the project stage, with funds from the Federal Government for the execution of works to reduce the risk of disasters in precarious settlements, are not sufficient to guarantee the significant reduction of the risks existing in the areas susceptible to mass movement. On the other hand, the logistic structure, with both prevention and preparation and support in emergencies, is also not sufficient, when the size of the population exposed to the risk of the municipality is verified. Also, it is necessary to analyze in which level the reception of the affected population has been carried out when it refers to the spaces for shelter available and their level of organization. In this sense, in this indicator, municipal management obtained an average degree of vulnerability. The Sendai Framework emphasizes that it is important "to ensure a rapid and effective response to disasters and related displacements, including access to safe shelter, essential food, and non-food relief supplies, as appropriate to local needs".

INDICATOR	SUBINDICATOR	USE OF THE TOOLS	RANGE OF THE EFFECTIVENESS OF USE	VULNERABILITY DEGREE
Management Structure	Design and procurement for structural works	ALWAYS	EFFICIENT	MEDIUM
	Logistic structure for action in the prevention and preparation phases	ALWAYS	EFFICIENT	MEDIUM

	Register of the population at risk	ALWAYS	EFFICIENT	MEDIUM
	Registration of shelters for emergency situations	ALWAYS	POORLY EFFICIENT	HIGH
FINAL DEGREE				MEDIUM

Table 6 - Responses obtained by the municipal management, on the indicator Management Structure

5.3 Preventive Actions Promotion

On the indicator of preventive actions, it integrates non-structural and structural actions. An analysis of the Nupdec formation was carried out, taking into account its scope in the risk areas, the development of actions in conjunction with environmental health, highlighting the endemic agents. Another verification was the resilient city program and, as this has been accomplished, it was also considered the work of implementing community pluviometers in the areas of susceptibility to risks and disasters and the execution of structural works, observing how municipal management has prioritized investments to improve safe habitable conditions in slopes. The Sendai Framework stresses that "public and private investment in disaster risk reduction and prevention through structural and non-structural measures is essential to improving the economic, social, cultural and health resilience of people, communities, countries, and assets, as well as the environment". (2015, p. 15) In this evaluation, the management obtained the level of average institutional vulnerability, because despite developing significant actions for prevention, it still needs to move forward in all the sub-indicators. It is considered that for the municipality's risk dimension, the level of investment in prevention and mitigation needs to be more comprehensive. It was also noted the need for Federal Government support to improve management levels in this area. Public protection and civil defense policies at the national and regional levels have failed to expand investments and the implementation of public policies for DRR, taking into account the specificities of risks and disasters geological hazard – landslides, in the municipalities of Brazil, according to the law 12.608/2012. (Table 7).

Table 7 - Responses obtained from the application of a questionnaire, on the indicator Preventive actions promotions.

INDICATOR	SUBINDICATOR	USE OF THE TOOLS	RANGE OF THE EFFECTIVENESS OF USE	VULNERABILITY DEGREE
Preventive Actions Promotion	Formation of Nupdecs in schools	ALWAYS	EFFICIENT	MEDIUM
	Integrated work with health agents and endemics	ALWAYS	EFFICIENT	MEDIUM
	Resilient city program	ALWAYS	EFFICIENT	MEDIUM
	Project community rain gauges	ALWAYS	POORLY EFFICIENT	HIGH
	Execution of structural works	ALWAYS	POORLY EFFICIENT	HIGH
FINAL DEGREE				MEDIUM

5.4 Multidisciplinary work

In the perspective of the multidisciplinary work, it was verified to what extent the municipal administration acts in intersectoral form, with integrated actions. The average level of vulnerability. Despite the municipal management, it is working with the multidisciplinary approach, joining even interdisciplinary actions in the community, when it comes to management of proximity, it is understood that there should be an orientation action, permanent awareness with the population for the construction of a process of co-responsibility related to risk and disaster management. In that sense, it is important that local governments may "promote national strategies to strengthen education and public awareness on disaster risk reduction, including information and knowledge on disaster risk". (Unisdr, 2012, p.11)

Table 8 shows the importance of indicators that are extremely relevant in the perspective of shared and integrated risk management.

Table 8 - Responses related to the indicator Multidisciplinary Work

INDICATOR	SUB-INDICATOR	USE OF THE TOOLS	RANGE OF THE EFFECTIVENESS OF USE	VULNERABILITY DEGREE
Multidisciplinary work	Proximity management	ALWAYS	EFFICIENT	MEDIUM
	Intersectoral management between public policies	ALWAYS	EFFICIENT	MEDIUM
	Integration in preventive actions among municipal institutions	ALWAYS	EFFICIENT	MEDIUM
FINAL DEGREE				MEDIUM

5.5 Emergency Fund

In this case, the degree of institutional vulnerability was evaluated on average, considering that there are previously defined procedures for emergency action and public calamity, where it appears the attributions and the instruments that should be made available due to the need to attend to the population in case of disasters.

It was verified that a logistic structure has been defined for action in the phases of prevention, preparation, and response, as well as training of the technical staff and the availability of work tools to improve the effectiveness of actions. Another sub-indicator analyzed was the adhesion of the civil defense card, which is made available nationally by the Federal Government to municipalities that decree emergency or public calamity. In this case, although it is on the priority list of critical municipalities, municipal management has demonstrated that it has not used the card since it has made possible its own means for the management of emergencies (table 9).

Table 9 - Responses to the indicator Emergency Funds

INDICATOR	SUBINDICATOR	USE OF THE TOOLS	RANGE OF THE EFFECTIVENESS OF USE	VULNERABILITY DEGREE
Emergency Funds	Adhesion to the civil defense card	ALWAYS	EFFICIENT	MEDIUM
	Procedures for action in an emergency	ALWAYS	EFFICIENT	MEDIUM
	Intersectoral actions to act with the population	ALWAYS	EFFICIENT	MEDIUM
FINAL DEGREE				MEDIUM

The management has been working to reduce the level of waiting on the part of the population concerning the response when the disaster occurs and emergency solutions in the medium and long term. Nevertheless, it must be acknowledged that these measures are still not enough and that municipal management needs to further increase the burden on prevention work, where effective intersectoral management is possible before the disaster happens and thus remove the population from the disaster-prone areas and control their reoccupation.

5.6 Examples of non-structural measures for the municipality

5.6.1 Practices of the Center for Protection and Civil Defense (Nupdec)

The Center for Protection and Civil Defense (Nupdec), is within the guidelines of the National Policy of Protection and Civil Defense and aims to take preventive measures and environmental education in schools and communities with the view to strengthening the dialogue on risk perception and guidelines on good practice in order to change habits in the face of local risks and disasters. In this sense, environmental education (EA) "can be used as a contribution to encourage social participation in DRR decision-making processes" (Rosa, et al, 2015).

(Londe, et al, 2014) "show that the insertion of the theme of disaster prevention in schools opens up the possibility of building community behavior and solidarity, aiming at collective concern for the security of the entire community."

In this sense, the municipality of Jaboatão dos Guararapes works to implement Nupdecs in schools located in disaster risk areas and has been taking prevention education measures with a view to managing proximity to students and teacher. According to data gathered from the municipality's Superintendence of Protection and Civil Defense (Supdec), currently this work is being carried out with 19 municipal schools with systematic activities focused on risk prevention with children and young people and, on the other hand, with teachers and managers for a cross-sectional analysis of the topic of disaster risk reduction in the school.

It so happens that the project does not cover the entire municipal education network and as yet there are no strategies to universalize this work in a broader scenario. It would be significant, considering that most schools are located in risk areas of mass movement or flooding. It must also consider the importance of working on teaching tools that can corroborate the practice of disaster risk prevention in the daily life of the school. It is fundamental to provide teachers with didactic resources, improving their approach to the subject in the classroom in order to consolidate the ongoing culture of disaster risk reduction.

5.6.2 Critical rainfall analysis of for the municipality of Jaboatão dos Guararapes

The understanding of critical rainfall mechanisms and knowledge that trigger mass movements in the short and long term are important technical parameters for drafting preventive plans. Obtaining these parameters for the municipality of Jaboatão dos Guararapes should contribute to the management of urban risk areas.

The following results were taken from the work developed by the authors (Bandeira and Coutinho, 2015).

The authors state that distributing near-critical rainfall gauges in the risk areas helped to obtain a better correlation between rainfall and recorded mass movements. In the example presented by the authors, precipitation occurred on April 13, 2009, with 160 mm of rainfall registered in the rain gauge located in the Cavaleiro regions, while in the regions of Prazeres, rainfall was 80.75 mm during the same 24 hours. This information shows how important it is to extend the rain gauge network for the actual study and for civil defense actions. Throughout the base year of this study (2009), 380 mass movement events were registered in Jaboatão dos Guararapes, with three fatalities. Most of the landslides occurred in Jaboatão and Cavaleiro (77%).

Regarding the technical parameters of the rainfall that caused landslide events, it is expected that the study proposed by the authors may contribute to the support of the local civil defense teams. The work sought to establish in a well-ordered manner a scheme for the performance of civil defense at four levels: Observation, Alarm, Alert and Maximum Alert; table 10 summarizes the rainfall parameters – I_{72h} , P_{ac} and R_{crit} established for the municipality of Jaboatão dos Guararapes.

It is recommended that the civil defense organize its actions on December 1, to the Observation level, since the region's monthly historical average is over 50 mm, which is a benchmark value to start this operation. At this level, field visits should be carried out to monitor risk situations, take preventive measures and instruct the local population.

For the Alarm, Alert and Maximum Alert states, parameters were proposed that are characteristic of each region in the study area. The benchmark values differed in general for each area, confirming the importance of having specific rainfall data (table 10).

When cumulative rainfall is expected to reach critical values within 72 hours (I_{72h}), particularly within 24 hours, or to achieve long-term critical rainfall values (P_{ac}) or the R_{crit} , the Alarm status starts. At this level the civil defense technical team should intensify actions in risk areas to check the need for temporary or permanent removal of families living in areas with a high and very high-risk degree, considering the possibility of landslide occurrences.

Table 10 - Recommendations of parameters for operation levels in Jaboatão dos Guararapes (early warning system).

Level/ regional	Jaboatão Centro	Cavaleiro	Curado	Muribeca	Prazeres
Observation	From December 1°				
Alarm	$I_{72h}=80 \text{ mm or}$ $P_{ac}=600 \text{ mm or}$ $R_{crit}=48.000 \text{ mm}^2$	$I_{72h}=80 \text{ mm or}$ $P_{ac}=750 \text{ mm or}$ $R_{crit}=60.000 \text{ mm}^2$	$I_{72h}=100 \text{ mm or}$ $P_{ac}=750 \text{ mm or}$ $R_{crit}=75.000 \text{ mm}^2$	$I_{72h}=100 \text{ mm or}$ $P_{ac}=600 \text{ mm or}$ $R_{crit}=60.000 \text{ mm}^2$	$I_{72h}=60 \text{ mm or}$ $P_{ac}=750 \text{ mm or}$ $R_{crit}=45.000 \text{ mm}^2$
Alert	$I_{72h}=80 \text{ mm &}$ $R_{crit}=48.000 \text{ mm}^2$	$I_{72h}=80 \text{ mm &}$ $R_{crit}=60.000 \text{ mm}^2$	$I_{72h}=100 \text{ mm &}$ $R_{crit}=75.000 \text{ mm}^2$	$I_{72h}=100 \text{ mm &}$ $R_{crit}=60.000 \text{ mm}^2$	$I_{72h}=60 \text{ mm &}$ $R_{crit}=45.000 \text{ mm}^2$
Maximum	When Alert occurs in all areas of the municipality				

Alert	
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When it is expected that R_{crit} and I_{72h} arrive at the same time, the Alert level is issued for Civil Defense, remaining in this parameter when the weather forecasts indicate heavy continuous rainfall. At this operational level, the Civil Defense can inform the population about the possible need for total evacuation of the risk areas, using various forms of communication, such as sirens, social media, messaging, etc. The Gides Handbook (2018) adds that at this stage it is important to provide pre-established points of support and shelters, to record occurrences of mass movements by means of field inspections and to undertake training drills with the population, among other actions.

So in table 11 the authors summarized the criteria for the operational levels and their actions (early warning system).

Table 11 - Levels of Civil Defense performance and recommended actions for the municipality of Jaboatão dos Guararapes.

Operating level	Criteria	Actions
Observation	From December 1°	Follow up of rainfall indices and meteorology
Warning	When I_{72h} is expected to occur at any time of the year; or when Pac or R_{crit} is expected to occur within the wet season (Feb-Sep)	Inspections in risk areas to check the possibility of isolated landslides
Alert	When I_{72h} and R_{crit} are expected to occur at the same time in the wet season, with expected continuing rainfall	Inspections in risk areas to check the possibility of generalized landslides, alert, alarm and preventive removal of families living in high and very high-risk areas
Maximum alert	When R_{crit} and I_{72h} are reached throughout the municipality in the wet season, with expected continuing rainfall	Warnings of general alert and mass removal of families living in the risk area

It should be added that Cemaden is currently responsible for managing the monitoring and alarm system for a number of Brazilian cities, including Jaboatão dos Guararapes. The protocol used to transmit the alerts was described in Marchezini et. al. (2017), summarized as follows: Cemaden alerts are sent to the National Secretariat for Civil Defense and Protection (*Sedec*), which forwards them to the state and municipal Civil Defense teams. Municipalities are responsible for warning the population.

(Marchezini, et al, 2017) adds that in recent discussions Civil Defense representatives as well as monitoring institutions have suggested improvements in the assertiveness of alerts. It was understood that the improvement should start with the development of critical rainfall thresholds.

In this sense, it is recommended to evaluate and compare the parameters presented by (Bandeira and Coutinho, 2015) that are the indices used by Cemaden. With this increase the accuracy of the critical rainfall parameters used in the disaster risk governance adopted by the municipality.

5.7 Integrated Results Analysis

In the governance structure studied, considering the analysis of specific vulnerability indicators and based on this, it was found that the degree of vulnerability of the five indicators was medium, as detailed in item 6, where the positive aspects and limitations of each indicator are to be noted. According (Suassuna 2014, p. 258) it is important to say that the fact that the municipality reaches the maximum score in the indicators does not mean that it will be resilient in the face of an extreme event, but that it will have the institutional mechanisms adequate for the prevention and coping of moments of crisis. In which, it is possible to interpret the reality of each municipality analyzed, considering its intrinsic specificities to each scenario.

An integrated analysis of all the indicators according to the methodology described shows that the management of the municipality of Jaboatão dos Guararapes has an average degree of vulnerability (table 12). It is, therefore, necessary to expand existing mechanisms and update regulations, standards, and procedures that strengthen disaster risk governance, as provided by the Sendai Framework and Law 12,608/2012.

According to (Suassuna, 2014, p.137), governance capacity includes both the capacity of the public power to perform its functions and the capacity of the population, private and nongovernmental institutions to participate in the process of defining and implementing public policies on the subject in question.

In this sense, table 12 shows the main recommendations for each indicator measured:

Table 12 - Integrated analysis of results with key recommendations

Indicator	Degree of Vulnerability	Main Recommendations
Planning and Management Instrument	MEDIUM	To extend discussion and revisions of the instruments in order to reduce environmental, material, economic and human losses. It is important for municipal management to appropriate the critical rainfall parameters presented by (Bandeira and Coutinho, 2015), thus enhancing disaster prevention and mitigating actions. To also prepare the population for emergencies and improving interfacing with Cemaden, depending on the aspects of rainfall monitoring.
Management Structure	MEDIUM	To consider the increase in population risk exposure in the municipality and increase the project structure and fundraising for structural works in vulnerable areas, highlighting resilience infrastructure.
Preventive Actions Promotion	MEDIUM	To further investments in disaster risk reduction to ensure prevention of future losses. Work tools that promote universalization of non-structural measures such as Nupdec in order to consolidate a permanent action by institutionalizing procedures, such as defining activities and didactic resources in the school curriculum, in order to reduce disaster risks.
Multidisciplinary work	MEDIUM	To strengthen disaster risk reduction practices with multidisciplinary and interdisciplinary prevention activities, socio-educational practices and interfacing between public policies.

Emergency Funds	MEDIUM	To improve forecasting and early warning systems, ensure access to risk information and provide emergency communication and disaster risk mechanisms.
Institutional Vulnerability Degree (Final)	MEDIUM	To strengthen integrated policies, implementing mechanisms of assessment, monitoring and participatory decision-making processes for disaster risk governance.

Considering the analyses carried out for each indicator, we can summarize that in order to take actions for disaster risk reduction (DRR) the municipality has adopted the Sendai Framework (2015 – 2030), with full commitment of institutions at the local level, also highlighting management tools, such as the use of legislation and implemented plans, without neglecting the articulations, attributions and responsibilities of each stakeholder in the process.

On the other hand, considering that the limitations identified in the indicators were observed when analyzing the responses compared with the documents and reports. An example of this was the verification of the Jaboatão dos Guararapes Municipal Risk Reduction Plan that although it is used, has lagged data where the diagnosed risk sectors already have new configurations requiring updates. Here it was considered that it is opportune to apply the methodology, be careful with regard to the comparison between the results of the form produced from the interviews and documentary analysis, field observations, which are examples of procedures that use techniques to understand and analyze documents that are related to the indicators raised. Finally, it is opportune to understand that this methodology has the differential between the qualitative and quantitative evaluation. This offers greater rigidity in defining the degree of institutional vulnerability for the synthesis of indicators integrated into the documents in a qualitative way.

5.8 Complementary Recommendations

In order to contribute to the municipal management in the performance of its indicators, the following is recommended:

Management must continue working to reduce institutional vulnerability, strengthening intersectoral management and population proximity management. This represents an investment process that involves short, medium and long-term actions, with economic resources and investment in social empowerment on an ongoing basis.

Considering that the indicators rates the management of the municipality of Jaboatão dos Guararapes average vulnerability, it is worth emphasizing that its managers can construct a guideline protocol based on the reality of local risk, and this can act as a basis for defining action strategies that go beyond local decision-making, such as, for example, geotechnical maps, risks and disaster risk monitoring and critical rainfall. This further strengthens the work already underway with Cemaden for better communication risk assessment with the population and the triggering of the alert system, which are essential initiatives for the coordinated disaster risk management process. It should be emphasized that the Sendai Framework (2015-2030) calls attention in priority 1 to enhancing the development and dissemination of science-based methodologies and tools to record and share disaster losses, as well as "to strengthen disaster risk modeling, assessment, mapping, monitoring and multi-hazard early warning systems".

To analyze the indicators, according to the view of (Debortoli, et al, 2018), access to data and its authenticity are essential for a reliable and realistic result. Thus, in order to replicate this methodology in another reality, care is recommended with the comparative data and that these are properly analyzed considering the specificities of the researched area.

6. CONCLUSION

The purpose of this article was to provide a reflection on disaster risk governance based on the evaluation of key institutional vulnerability indicators in building paths to be tackled with a view to disaster risk reduction (DRR), taking as an example the municipality of Jaboatão dos Guararapes in the State of Pernambuco, Northeast Brazil, which was the basis for the study.

Based on the objectives of the analysis of the five indicators related to the degree of institutional vulnerability in terms of disaster risk governance, the municipal management of Jaboatão dos Guararapes was rated with a medium degree of institutional vulnerability, having taken non-structural measures for DRR.

However, there are gaps in the assessment of the five indicators, for example, in relation to the Alert System, as well as requiring investment in developing technologies for data analysis and emission. There is also a need for "engagement and cooperation of all society", as advocated by the Sendai Framework (2015). On the other hand, the Nupdecs that reinforce social communication depend significantly on the structure of teams operationalizing the activities for stakeholder empowerment and protagonism. This process needs to be addressed

further, since good governance depends first and foremost on social participation in the decision-making processes.

The results of the study show that the degree of institutional vulnerability influences the level of municipal management response in several aspects. In the case of Jaboatão dos Guararapes, the difficulty of implementing inter-sectoral policies for DRR geological hazard – landslides affects its governance, as seen in the analysis and discussion of results.

Finally, in relation to the methodology, it is found that the indicators applied were well suited to the current situation and could be replicated in other realities in order to identify the degree of institutional vulnerability. However, it should be stressed that the specificities of each reality to be evaluated and the importance of developing more detailed statistics for analysis of the indicators, together with the documentary analysis for good applicability, should be considered, as well as to minimize the limits presented throughout the study research.

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