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A brief survey on the legislation applied to floods and inundations in medium-sized municipalities in the state of Rio de Janeiro - Brazil

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Abstract: This work aims to carry out a survey on municipal legislation and other legal management instruments, related to the control and mitigation of urban floods and inundations in medium-sized municipalities in the state of Rio de Janeiro. In this context, 22 municipalities in the range between 100 and 500 thousand inhabitants were surveyed. Among the results obtained, it was found that only 13 municipalities had specific municipal legislation to mitigate the effects of inundations and urban floods. Approximately 59% of the analyzed municipalities had municipal legislation oriented to the local reality. There is a need to increase public policies and government incentives for the expansion of legal provisions in the municipalities analyzed.

Keywords: Public policies. Legislation. Inundations. Urban floods. Cities environmental management.

Uma breve pesquisa sobre legislação aplicada a cheias e inundações em municípios de médio porte no estado do Rio de Janeiro – Brasil

Resumo: Este trabalho, tem por objetivo, realizar um levantamento acerca da legislação municipal e dos demais instrumentos legais de gestão, relacionados ao controle e mitigação de cheias urbanas e inundações em municípios de médio porte no estado do Rio de Janeiro. Neste contexto, foram pesquisados 22 municípios situados na faixa entre 100 a 500 mil habitantes. Dentre os resultados obtidos, constatou-se que apenas 13 municípios possuíam legislação municipal específica para mitigar os efeitos das inundações e cheias urbanas. Aproximadamente 59 % dos municípios analisados, possuíam legislação municipal orientada à realidade local. Nota-se a necessidade do aumento das políticas públicas e incentivos governamentais para a ampliação de dispositivos legais nos municípios analisados.

Palavras-chave: Políticas públicas. Legislações. Inundações. Cheias Urbanas. Gestão ambiental das cidades.

Breve encuesta sobre la legislación aplicada a crecida e inundaciones en municipios medianos del estado de Río de Janeiro - Brasil

Resumen: Este trabajo tiene como objetivo realizar una encuesta sobre legislación municipal y otros instrumentos legales de gestión, relacionados con el control y mitigación de inundaciones urbanas e inundaciones en municipios de mediano tamaño del estado de Río de Janeiro. En este contexto, se encuestaron 22 municipios ubicados entre 100 y 500 mil habitantes. Entre los resultados obtenidos, se encontró que solo 13 municipios contaban con legislación municipal para mitigar los efectos de inundaciones e inundaciones urbanas. Aproximadamente el 59% de los municipios analizados tenían una legislación municipal orientada a la realidad local. Es necesario incrementar las políticas públicas y los incentivos gubernamentales para ampliar las disposiciones legales en los municipios analizados.

Palabras clave: Políticas públicas. Legislación. Inundaciones. Inundaciones urbanas. Gestión ambiental de ciudades.

1 Introduction

The occupation and waterproofing of soils as a result of urbanization collaborate with the aggravation of urban flood events and the urban environment degradation (TUCCI, 2007a; MIGUEZ; REZENDE; VERÓL, 2015). In Brazil, traditionally, plumbing works are employed to solve the problem of decreasing the natural storage of rainwater. These represent the classic drainage systems (CANHOLI, 2015). However, since the 1970s, new methods have emerged. Known as compensatory techniques, these basically aim to neutralize the urbanization effects on the hydrological cycle, based mainly on rainwater storage and infiltration (BAPTISTA; DE OLIVEIRA NASCIMENTO; BARRAUD, 2011).

The responsibility to manage public policies and adopt necessary measures for disaster reduction, as well as facing floods, relies on all levels of the federation, that is, at the federal, state and municipal levels (BRAZIL, 2010, 2012). These management instruments must contain general aspects and local characteristics of each municipality or region for the best applicability of each legislation. A challenging question that arises in this area is to verify what the existing local public policies are related to flood problem management. A study shows that more than half (59.4%) of Brazilian municipalities lacked tools to plan and manage risks in 2017. Only 25% of municipalities have a master plan that includes flood prevention measures and only 26% of the municipalities declared to have a Land Use and Occupation Law foreseeing these occurrences (IBGE, 2018). Given this scenario, it is extremely important to know the legal management instruments in Brazilian states and municipalities. There are limited studies on the panorama of municipal management in relation to flood mitigation and, normally, their main focus are metropolises and large municipalities, having as examples the works of Fonseca et al (2006) and Fontes da Luz et al (2020). Generally, these works deal only with structural flood mitigation techniques, such as rainwater reservoirs. It is necessary to address the issue in medium-sized municipalities that present increasing urbanization and, at the same time, low growth in its infrastructure, such as basic sanitation and macro drainage works.

In this study, medium-sized Fluminense municipalities that already face the same problems as large cities were considered. Rio de Janeiro is the state with the second highest number of floods in the southeast region, according to the Atlas of Natural Disasters (CEPED-UFSC, 2013). Disasters caused by floods, runoff and mass movement correspond, respectively, to 35%, 26% and 21% of the total disasters in the entire state of Rio de Janeiro, totaling 82% of the events (CEPED-UFSC, 2013). The characteristics of the physical environment, such as the rain regime and the relief with great unevenness in some regions of the state of Rio de Janeiro, results in more susceptible conditions to these natural events, which become disasters when harm the population.

The objective of this work is to conduct a documentary research on legal management instruments related to the control and mitigation of urban floods, in addition to perform an investigation on the use of structural compensatory techniques in medium-sized municipalities in the state of Rio de Janeiro. Firstly, this article will address urban drainage and hydrological event mitigation measures as well as their legal structure. Secondly, information resulting from research on municipal legislation will be discussed.

2 Literature review

2.1 Urban drainage and the problems of floods, inundations and overflows

The growth of cities in an accelerated and disordered way aggravated the problems of urban floods, since urbanization processes tend to waterproof the soil, occupying infiltration areas and altering the natural hydrological cycle. Urbanization is one of the anthropic actions that most generate environmental impacts, as they change the water, air and especially soil properties (TUCCI; CLARKE, 1997; TUCCI, 1997a; MIGUEZ; REZENDE; VERÓL, 2015).

According to Licco and Mac Dowell (2015), urban floods or inundations can be understood as natural processes, as these occur when the maximum level of a drainage channel is reached due to increased flow, however, the waters do not overflow. The term inundation is used to characterize the overflow of water from a stream, this occurs when river drainage is not able to contain the rain flow. The process is aggravated due to the river rectification and waterproofing of their banks. Overflow is a momentary situation generated in areas where the drainage system does not support the precipitation volume (LICCO; MAC DOWELL, 2015). In turn, flash flood can be characterized as a large volume of water that superficially seeps, usually very strongly (LICCO; MAC DOWELL, 2015).

According to Tucci (1997a; 2003; 2008), floods in urban areas are the result of two processes that occur in an integrated or isolated way:

> **Floods due to urbanization:** represents the increase in floods frequency and magnitude due to the soil occupation with impermeable surfaces and flow ducts. In addition, urban development can

> produce flow obstructions, such as landfills and bridges, inadequate drainage and silting up. (our translation)
>
> **Floods in riverside areas:** natural floods that affects the population that occupies the largest riverbed. These floods occur mainly due to the natural process in which the river occupies its largest bed, according to extreme events, on average with a recurrence interval of 2 years. (our translation)

The main conception of urban drainage in Brazil is still based on the "classic system", that is, the principle of conducting rainwater through underground ducts, pushing water away from man, historically linked as a means of proliferating diseases and vectors (NUCASE, 2007). To mitigate the effects of floods, engineers around the world have researched numerous techniques and measures. These techniques were mapped and brought together in two large groups: structural and non-structural measures (CHRISTOFIDIS; ASSUMPÇÃO; KLIGERMAN, 2019). In general, structural measures are engineering work that can be extensive or intensive. Non-structural measures, in turn, are those in which losses are reduced to guarantee a better coexistence of the population with the floods, such as the land use regulation or flood zoning (TUCCI, 2007b).

Baptista, de Oliveira Nascimento and Barraud (2011), divided the use of measures to try to control and mitigate the urban drainage problem into two large groups. First group, non-structural compensatory techniques: legislation, environmental education and better urban land use. Second group, structural compensatory techniques: One-off works (infiltration wells and roofs), linear works (paving and infiltration trenches) and basin works (detention, retention and infiltration).

Around the world, several researchers have been working in this urban drainage context, trying to mitigate cities flood and inundation problems, using manifold techniques, whether structural or non-structural compensatory.

A recent study reveals the use of large containment tanks and individual rainwater reservoirs to control flooding in highly developed urban watersheds (FRENI; LIUZZO, 2019), to mitigate risks of urban floods. In recent years, control measures such as green roofs, permeable pavements, rain gardens and vegetation ditches, have been implemented to deal with flooding in urban environments and have proven to be economical and sustainable. (MEI et al., 2018).

In addition, advanced real-time automation techniques for these centralized and decentralized reservoirs have shown satisfactory and significant effects, increasing the system's resilience, with small investments in existing reservoirs (LEE; CHOI; KIM, 2019; LIANG et al., 2019). The simultaneous application of techniques, such as the use of rainwater reservoirs, distributed storage systems and low-impact development techniques, show satisfactory results in mathematical simulations, that way, greater investments in more complete drainage systems can reduce the flood risks and damage (DA SILVA et al., 2018).

In parallel with the detention reservoir techniques, current researches execute work on rivers and channels using advanced hydrological, computational and mathematical models in software such as MOHID LAND, aimed at flood mitigation and control (TAVARES et al., 2017, 2018; JUSTINA et al., 2019; LUGON JUNIOR et al., 2019). Remote sensing techniques help to understand the geomorphological behavior of rivers and channels and to acknowledge the functioning of the hydrographic basin in its entirety (SALES; OLIVEIRA; LUGON JUNIOR, 2020).

Seeking to improve the hydrological cycle balance in urbanized areas, sustainable hydrology uses low-impact development technologies, flow control systems installed in roofs, for example, can contribute to runoff reduction and, consequently, mitigate frequent flooding. (SCHELLIN; LEINIG, 2018).

As we can see in the previous paragraphs, several studies in different areas are carried out to try to mitigate floods in urban areas. Including research on flood forecasting techniques, considering the intensity and duration of rainfall (CHOO et al., 2019).

Medium-sized cities have assumed a prominent role due to the continuous urbanization process. Characteristics such as a greater concentration of equipment, goods and services in its intra-urban space and a greater offer of jobs contributed to the rapid population growth, governments began to encourage a migration movement towards medium-sized cities, so that they work as retention places of flow, this one previously directed to large cities, at the same time contributing to regional development (COSTA; LOBO; SOARES, 2020).

There is a need to think about the environmental management of cities, and legislation is the main instrument to assist and guide in this task, provided it is adapted to the local reality of each municipality. Since medium-sized municipalities have characteristics, problems and challenges similar to those of large cities, they acquire singular relevance for this public policy.

2.2 Legislation applied to urban floods and inundations

The National Water Resources Policy (Law No. 9433/1997) is the Brazilian federal legislation that indirectly addresses the urban floods and inundations issue. Among its objectives, it is interesting to highlight: ensure current and future generations necessary water availability, in quality standards appropriate to their respective uses; prevention and defense against hydrological events due to the inappropriate use of natural resources; and encourage rainwater capture, preservation and use (BRAZIL, 1997). In agreement with Brazilian Federal Constitution (BRAZIL, 1988), we can quote Law No. 10257/2001, which sets general urban policy guidelines, whose objective is to order the development of the social functions of cities and urban properties (BRAZIL, 2001).

The National Basic Sanitation Policy was instituted by Law No. 11445/2007, which considers that rainwater management and the drainage, cleaning and preventive inspection of urban networks are part of

basic sanitation. Among its fundamental principles, it can be highlighted the adoption of methods, techniques and processes that consider local and regional peculiarities (BRAZIL, 2007), where municipal legislation plays an extremely important role in meeting these objectives.

In 2012, the National Policy for Civil Protection and Defense was created by Law No. 12608. Its main objectives are: stimulate urban and rural land use planning, considering its conservation and the protection of native vegetation, water resources and human life; monitor meteorological, hydrological, geological, biological, nuclear, chemical and other potentially disruptive events; stimulate the development of resilient cities and sustainable urbanization processes (BRAZIL, 2012).

In the Rio de Janeiro state, the main legislation on the subject is Law No. 7463/2016, which mainly addresses procedures regulation for rainwater and greywater storage, aiming at its use or discharge delay in the public network. From the date of its publication, all private or public buildings that presents over five hundred square meters of waterproofed area, must dispose a greywater and rainwater reservoir, as well as recycling the greywaters of buildings, thus creating a regulatory framework across the state of Rio de Janeiro (RIO DE JANEIRO, 2016). However, each municipality presents distinct characteristics among themselves in different economic, social, demographic and pluviometry aspects. Thus, regardless of the aforementioned State Law, these characteristics constitute the need for more specific legislation for each municipality, that is, appropriate to their local reality.

Municipal legislation manifests itself as a structure/base that must be proportional to the locally observed problems scale, always respecting regional and local peculiarities (BRAZIL, 2007). Management and regulatory instruments such as the Master Plan can guarantee less costly preventive measures and provide subsidies to improve human life conditions (TUCCI, 1997b). Combined with other normative instruments such as the Land Use and Occupation Law and the Organic Municipality Law, they are moving towards more satisfactory public and urban policies (MINAKI; AMORIM, 2012). The public manager must have the ability to promote urban and environmental planning organized in a multisectoral way. That is, elaborate and develop the planning considering the city, in an integrated and systemic way (TAMPOROSKI; ALVES, 2012).

3 Materials and Methods

For the present study, a bibliographic review was carried out on the legislation and structural and non-structural measures used to mitigate urban floods and inundations in the literature. The research was performed by consulting renowned databases, such as: Scopus, Elsevier, Web of Science, Capes Journal Portal and Google Scholar. Subsequently, a survey was carried out on the legislation and legal instruments of management related to the control and mitigation of urban floods and inundations, and the use of structural compensatory techniques in medium-sized municipalities in the state of Rio de Janeiro. Searches

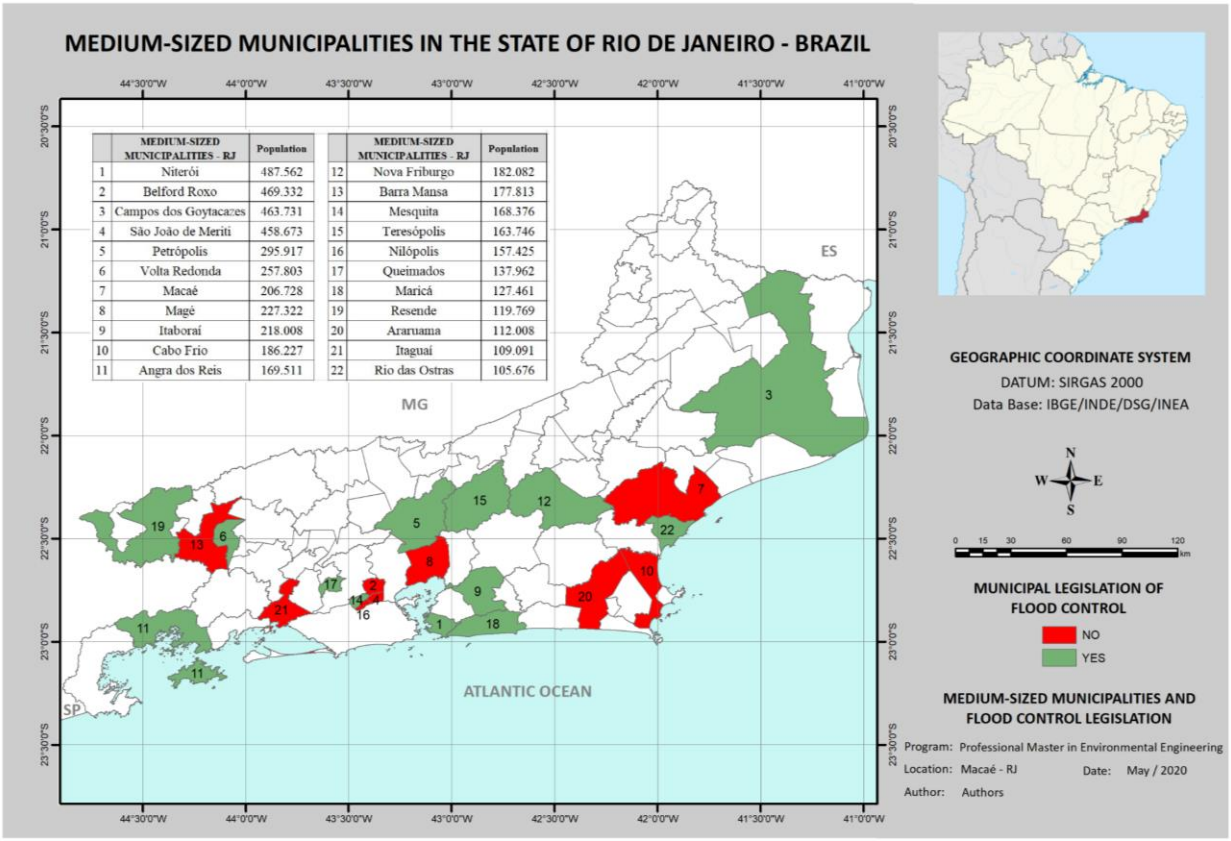
were carried out, preferably, in the last ten years in the bases. Because the literature is a little scarce, we tried to expand the research to previous years. Medium-sized Fluminense municipalities with a population between 100 and 500 thousand inhabitants in the state of Rio de Janeiro were selected. Thus, socioeconomic information from the last demographic census (IBGE, 2010a) was analyzed and scientific information from government documents made available, through of each municipalities Transparency Portal was selected.

The Zotero version 5.0 software was used for the organization and classification of scientific articles and the QGIS version 3.12 software for mapping information. Both software used in free versions.

4 Results and Discussion

Twenty-two medium-sized municipalities in the state of Rio de Janeiro were selected (IBGE, 2010b), as shown in Figure 1, and their respective urban flood mitigation laws have been identified. Thirteen municipalities (59%) have municipal legislation aimed specifically at flood control.

Figure 1: Medium-sized municipalities in the state of Rio de Janeiro – Brazil.



Source: Authors (2020).

Socioeconomic, geographic and rainfall data from the municipalities were also described, for better understanding and comparison between them. Table 1 shows the results obtained, in decreasing order of population.

In this research, only specific legislation was found, mostly focused on residential works and commercial or industrial enterprises.

Table 1: Panorama of medium-sized municipalities in the state of Rio de Janeiro – Brazil

	Medium-sized municipalities, RJ	Last census population	Is there legislation applied to flood control?	Specific municipal legislation	Area of territorial unit (Km²)	Average annual rainfall (mm)	GDP per capita (2017) R$	HDI (2010)
1	Niterói	487,562	YES	Law No. 1620/1997; Law No. 2626/2008; Law No. 2630/2009; Law No. 3061/2013	133.76	1,204	55,049.66	0.837
2	Belford Roxo	469,332	NO	-	78.99	1,363	16,514.03	0.684
3	Campos dos Goytacazes	463,731	YES	Law No. 8096/2009; Act 63/2015	4,031.99	1,073	43,013.04	0.716
4	São João de Meriti	458,673	NO	-	35.216	1,255	19,968.09	0.719
5	Petrópolis	295,917	YES	Law No. 6439/2007	791.144	1,929	42,958.85	0.745
6	Volta Redonda	257,803	YES	Law No. 5216/2016	182.105	1,366	42,626.52	0.771
7	Macaé	206,728	NO	-	1,215.49	1,126	62,961.48	0.764
8	Magé	227,322	NO	-	390.775	1,392	16,240.43	0.709
9	Itaboraí	218,008	YES	Law No. 2448/2013	430.438	1,267	18,012.86	0.693
10	Cabo Frio	186,227	NO	-	413.575	843	39,781.41	0.735
11	Angra dos Reis	169,511	YES	Law No. 2093/2009; Law No. 2087/2009	813.21	1,791	51,893.01	0.724
12	Nova Friburgo	182.082	YES	Law No. 3046/1999; Law No. 3227/200; Law No. 4062/201; Law No. 4093/2012	935,429	1.372	27,048.70	0.745

(Continuation)

Table 1: Panorama of medium-sized municipalities in the state of Rio de Janeiro – Brazil

	Medium-sized municipalities, RJ	Last census population	Is there legislation applied to flood control?	Specific municipal legislation	Area of territorial unit (Km²)	Average annual rainfall (mm)	GDP per capita (2017) R$	HDI (2010)
13	Barra Mansa	177,813	NO	-	547.133	1,394	27,211.05	0.729
14	Mesquita	168,376	YES	Law No. 929/2015	41.49	1,349	13,505.21	0.737
15	Teresópolis	163,746	YES	Law No. 79/2006; Law No. 105/2007	773.338	1,721	28,882.28	0.73
16	Nilópolis	157,425	NO	-	19.393	1,290	16,698.88	0.753
17	Queimados	137,962	YES	Law No. 35/2006; Law No. 64/2013	75.701	1,486	25,476.94	0.68
18	Maricá	127,461	YES	Law No. 2272/2008	361.572	1,181	74,760.02	0.765
19	Resende	119,769	YES	Law No. 3048/2013	1,099.34	1,488	60,915.10	0.768
20	Araruama	112,008	NO	-	638.15	993	19,840.12	0.718
21	Itaguaí	109,091	NO	-	273.414	1,308	61,819.73	0.715
22	Rio das Ostras	105,676	YES	Law No. 1402/2009; Act 015/2010; Law No. 1489/2010; Law No. 1727/2012	228.044	1,056	39,667.24	0.773

Source: Authors (2020).

It can be observed that Niterói presented the highest Human Development Index – HDI (0.837), among the twenty-two analyzed cities. Despite the high per capita Gross Domestic Product – GDP, of cities like Macaé (R$ 62,961.48) and Itaguaí (R$ 61,819.73), no specific legislation on the topic was found on the respective Transparency Portals.

To better detail each local strategy, in mitigating the effects of inundations and urban floods, Table 2 was prepared with a brief description of each municipal legislation found in this research.

As can be seen in Table 2, the municipal legislation of the vast majority of municipalities makes it mandatory to adopt structural compensatory techniques, such as the use of rainwater reservoirs, as a way of reducing the impacts caused by rains and favoring the urban drainage system.

In Volta Redonda, the current municipal legislation provides for rainwater harvesting only in public sectors, thus reducing these systems covered area in the municipality.

The municipalities of Nova Friburgo, Niterói, Rio das Ostras have the largest number of specific laws, with four each, but the municipality of Nova Friburgo stands out from the others because it has a broader and more comprehensive legislation. With several compensatory techniques of structural character in the management and mitigation of floods. An example is the program for recovery and preservation of soil permeability. Its objective is to reduce impermeable areas, promoting decrease of runoff volumes and flooding risk, increase soil infiltration and life quality. It also creates the obligation to reserve a permeable area in the building field, in a percentage defined by the City Hall. In addition, it establishes that every property built on or after January 1, 2000 must have planned a rainwater harvesting and storage project.

Numerous problems are generated through public policies late implementation to mitigate urban floods and inundations. Examples are loss of human lives, incalculable material damage, real estate devaluation, vectors and diseases proliferation, public health system overload, drastic decrease in local development, soil deterioration, among other losses (SANSEVERINO-GODFRIN, 2016).

In countries such as South Korea, Italy, Australia and China, advanced techniques for urban floods mitigation and control, are object of constant study and application in several cities (URSINO; GRISI, 2017; MEI et al., 2018; CHOO et al., 2019; FRENI; LIUZZO, 2019; LEE; CHOI; KIM, 2019; LIANG et al., 2019). However, for developing countries, such as Brazil, the wider use of these measures, whether structural or non-structural, is still a challenge to be overcomed (TUCCI, 2004; BARBOSA DOS SANTOS; BORGES MAMEDE, 2013). Legislation implementation and its mandatory enforcement plays an extremely important role in cities urban floods management and mitigation.

Table 2: Specific legislation existing in medium-sized municipalities in the state of Rio de Janeiro - Brazil.

	City	Specific municipal legislation	Description
1	Niterói	Law No. 1620/1997	Establishes the maximum Waterproofing Rate of 90% (ninety percent) for single-family residential buildings located in the Urban Area, except in places where specific legislation determines a higher rate.
2		Law No. 2626/2008	Addresses solar water heating systems installation and rainwater use in public and private constructions situated in the municipality of Niterói and creates the municipal commission for urban sustainability.
3		Law No. 2630/2009	Disciplines procedures related to rainwater storage for reuse and its discharge delay in the public network.
4		Law No. 3061/2013	Central Area Consortium Urban Operation- CUO, releases new buildings, within the CUO perimeter, from complying with the Waterproofing Rate requirement if the clearance strip adjacent to the sidewalk holds 60% of the permeable area, observing the defined criteria.
5	Campos dos Goytacazes	Law No. 8096/2009	Institutes the municipal program for water conservation and rational use in buildings and establishes, for collective building projects, the requirement for a water meter in each autonomous unit.
6		Act 63/2015	Regulates the Municipal Law No. 8096/2009, with the aim of instituting measures that induce the conservation, rational use and usage of alternative sources to rainwater capture and use in new buildings, as well as adapting existing ones.
7	Petrópolis	Law No. 6439/2007	Requires the design of rainwater collection devices for construction of new buildings with over five floors.
8	Volta Redonda	Law No. 5216/2016	Obliges Government to install rainwater collection systems in all related public sectors in Volta Redonda.
9	Itaboraí	Law No. 2448/2013	Creates the rainwater harvesting program, whose objectives are the rainwater capture, storage and use by public and private buildings, in urban and rural areas, in residential, commercial and industrial buildings.
10	Angra dos Reis	Law No. 2087/2009	Fields, when receiving buildings, should be prepared to drain rainwater and water infiltration with the adoption of control erosion measures. Prohibits rainwater or wastewater dumping, including that from equipment operation, on sidewalks, neighboring buildings and sewage collection networks. These must be connected by piping under the sidewalk to the gutter and/or its own collection network, in accordance with the rules issued by the sanitation competent institution. In sloping situations rainwater and sewage piping from upstream lots may pass through downstream neighboring properties, when it is not possible to route them to the streets on which they are located and if there is no other alternative by public domain area.
11		Law No. 2093/2009	No land parceling modality will be allowed in fields subject to flooding, before performing works and services that ensure adequate water drainage are carried out.
12		Law No. 3751/2018	Institutes Municipal Policy for Conservation, Rational Use and Water Reuse, which aims to promote necessary measures for conservation, reduction of waste and alternative sources use for water capture in buildings, as well as to make users aware of its importance for life.

(Continuation)

Table 2: Specific legislation existing in medium-sized municipalities in the state of Rio de Janeiro - Brazil.

	City	Specific municipal legislation	Description
13	Nova Friburgo	Law No. 3046/1999	Establishes that every property built on or after January 1, 2000 must have planned a rainwater harvesting and storage project, with a third of the volume of stored treated water to be stored.
14		Law No. 3227/2002	Makes mandatory in residential, commercial and industrial projects (new constructions, renovations or extensions), the reservation of permeable area in the perimeter of the land, at the choice of the owner and in a percentage to be defined by the City Hall. Condition the occupation certificate receivement to the plant of at least one tree on the public sidewalk, to be defined by the Municipal Environment Department.
15		Law No. 4062/2012	Creates the Soil Permeability Recovery and Preservation Program, with the objective of reducing impermeable areas, promoting, among other factors: the reduction of drained volumes and risk of floods and the increase of soil infiltration and quality of life, through the implementation of green sidewalks, draining floors and paving streets with draining materials, when possible. Establishes existence of no paving flower beds on sidewalks or public rides.
16		Law No. 4093/2012	Creates the ecologically correct sidewalk, to be installed in the main corridors of the city and that have few areas for rainwater evacuation.
17	Mesquita	Law No. 929/2015	Authorizes the Municipal Program for the Conservation and Rational Use of Water in public and private buildings, which aims to induce its conservation and reuse, and encouraging the use of alternative sources to collect water.
18	Teresópolis	Law No. 79/2006	Prohibits buildings existence in areas that pose a risk to health or life, in particular: on land subject to flooding, except for those objects of intervention that ensure water drainage.
19		Law No. 105/2007	Makes mandatory the implementation of systems for capture and retention of rainwater collected by roofs, terraces and discovered pavements in buildings with waterproofed areas sum greater than 500m² (five hundred square meters).
20	Queimados	Law No. 035/2006	Determines that public buildings at different government levels are obliged to capture, reserve and reuse rainwater.
21		Law No. 064/2013	Establishes for all constructions the mandatory reserve of free area, which will be used as a permeable and/or green planted area, defined by the government. If total or partial impossibility of reserving a permeable area and/or planting seedling in the construction lot is proven, a technical study must be prepared with the municipal environmental agency for environmental compensation defined in specific legislation.
22	Maricá	Law No. 2272/2008	Land parceling on fields that, in City Hall point of view, deemed unfit for building or inconvenient for housing, will not be allowed
23	Resende	Law No. 3048/2013	Establishes the Conservation and Rational Use of Water in Buildings Program, that aims to institute measures that induce the conservation, rational use and use of alternative sources to capture water in new buildings, as well as raising users' awareness of the importance of water conservation.
24	Rio das Ostras	Law No. 1402/2009	Creates the Rainwater Harvesting and Reuse Program, whose main objectives are the rainwater capture, storage and use by urban buildings, in addition to: A. Awaken ecological awareness in order to conserve this environmental resource; B. Foster water conservation and self-sufficiency for supply; C. Reduce drinking water consumption from public network; D. Avoid using drinking water where it is not needed; E. Promote savings in fees by reducing drinking water consumption from public network; F. Helping to contain possible floods, damping part of the rainwater that drains into water bodies.
25		Act 015/2010	Regulates Law No. 1402/2009, and provides for rainwater capturing, storing and using criteria in buildings.
26		Law No. 1489/2010	Discourse on the amendment of the Law No. 1402/2009, that addresses the Rainwater Harvesting and Reuse Program.
27		Law No. 1727/2012	Amends the provisions of Laws No. 1402/2009 and 1489/2010, that addresses the Rainwater Harvesting and Reuse Program.

Source: Authors (2020).

5 Conclusion

Among the twenty-two medium-sized municipalities analyzed in the state of Rio de Janeiro, only thirteen have specific municipal legislation to mitigate the effects of urban floods. The requirement for buildings rainwater reservoirs was instituted in most of these municipalities. A worrying aspect was detected in approximately 41% of the municipalities, where no specific legislation directed to urban floods mitigating was found.

There is a need for a greater number of public policies aimed at the development of legal instruments in the municipalities analyzed. These devices expansion will favor the inclusion of several structural and non-structural compensatory techniques in municipal legislation. When applied together, these techniques obtain a more satisfactory result in urban floods mitigation and control, when compared to isolated measures.

Based on the results, it is concluded that this research objectives were achieved. Such findings enable a greater understanding of municipalities laws and local characteristics. However, it is suggested to carry out further studies considering other variables, for example: the impact of simultaneous structural compensatory techniques on rivers and watersheds, in order to measure its flood control efficiency, mitigate inundations and improve cities water management.

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