Larissa Ferentz
Carlos Garcias
Murilo Noli

Drainage master plan and its influence on development: urban allotment in Fazenda Rio Grande, Paraná

Abstract

The Drainage Master Plans aim to present the flood areas in the municipalities, where, consequently, real estate expansion is not allowed. The problem is that these documents are outdated, as they are used as a basis for analysis for making official decisions. The research aims to present the influence that the Alto Iguaçu Drainage Master Plan can have on urban development. By conducting a case study in the city of Fazenda Rio Grande, it was possible to confirm that the Plan influences not only the promotion of subdivisions, but also people's daily lives, with the occupation of the area for illegal activities, waste dumping and local insecurity. Such problems can be solved through the involvement of the government and society, seeking a balance between the best environmental conditions and an increase in the quality of life of the local population.

Keywords

Municipal Management. Flood. Urban Allotment.

http://dx.doi.org/10.11606/issn.2317-2762.posfau.2020.167937

Pós, Rev. Programa Pós-Grad. Arquit. Urban. FAUUSP. São Paulo, v. 27, n. 51, e167937, 2020.

PLANO DIRETOR DE DRENAGEM E SUA INFLUÊNCIA NO DESENVOLVIMENTO: LOTEAMENTO URBANO EM FAZENDA RIO GRANDE, PARANÁ

Resumo

Os Planos Diretores de Drenagem objetivam a apresentação das áreas de inundação nos municípios, onde, por consequência, não é permitida a expansão imobiliária. O problema está na desatualização desses documentos, pois eles são utilizados como base de análise para tomada de decisões oficiais. A pesquisa tem como objetivo apresentar a influência que o Plano Diretor de Drenagem do Alto Iguaçu pode ocasionar sobre o desenvolvimento urbano. Com a realização de um estudo de caso na cidade de Fazenda Rio Grande foi possível confirmar que o Plano influencia não apenas na promoção de loteamentos, mas também no dia-a-dia das pessoas, com a ocupação da área para atividades ilícitas, despejo de resíduos e insegurança local. Tais problemas podem ser solucionados a partir do envolvimento do governo e da sociedade, buscando o equilíbrio entre as melhores condições do ambiente e o aumento da qualidade de vida da população local.

Palavras-chave

Gestão Municipal. Inundação. Loteamento Urbano.

Introduction

Urban growth in Brazil had its mark in the 1970s, when the urban population surpassed the rural. Between 1950 and 2000, there was a jump from 19 to 138 million people in cities (BRITO & PINHO, 2012). In 2012, the Brazilian urban population already exceeded the rate of 86%, and could reach 90% in 2020 (COSTA, 2012). However, the fast urbanization process in Brazil, linked to the absence of a land use and occupation planning policy and the non-observance of the State towards territorial planning, as of the second half of the 20th century, caused a heterogeneous and disordered occupation in the territory (SANTOS, 1993). This process was based on an exclusive economic development model, where, areas with high environmental fragility and lacking appropriate infrastructure began to be occupied. That is, a portion of individuals is subject daily to socio-environmental risks and vulnerabilities (DESCHAMPS, 2004; MENDONÇA, 2004), which are capable of triggering disastrous natural or technological events, such as floods.

Such disasters have occurred more frequently in cities due to the high rates of soil waterproofing, changes in water courses and deforestation, reasons for which natural processes are intensified, thus resulting in great economic, social and environmental losses (RIEGEL & QUEVEDO, 2015), becoming a major challenge for city planning and management (SOUZA, 2010). According to Ximenes (2010, p.10), "floods are among the natural catastrophes that cause the most damage to public health and heritage and correspond to 40% of the natural disasters that occur in the world". In Brazil, according to IBGE, between 2008 and 2012, there were 20 thousand occurrences of gradual and sudden floods, with more than 2 million homeless people. To minimize the impacts resulting from such events, strategies that vary between engineering projects (structural) and legislation and plans that mark the regions at risk of flooding (non-structural) are used (TUCCI, 2003). These plans aim to prevent the development of cities from occurring in areas that may have negative impacts on the environment and individuals.

In Brazil, the plans that help to reduce the impact of extreme events, such as floods and inundations, are the Urban Drainage Master Plans (UDMP). These plans are developed from the delimitation of large hydrographic basins, that is, greater than 1,000 square kilometers. This definition is based on the principle that cities transmit impacts to downstream municipalities. In view of the scope of the plans, they do not have specific characteristics for each region, but, in general, points to be fulfilled in relation to the quality and quantity of water (TUCCI, 2012).

Although some states have already developed their UDMP's, such as Rio Grande do Sul, São Paulo, Paraná, Pernambuco, Minas Gerais and Brasília, the implementation of these plans in Brazilian cities is still inconsistent (ZAHED FILHO, et al., 2013). In addition, the reality of Brazil regarding urban drainage management is precarious. The services are of low quality, there are not enough qualified and trained personnel and the financial resources for investments and purchase of materials are scarce (ONEDA, 2018; TUCCI, 2012). There is also the problem of local culture, in which managers tend to act only after the events have occurred, without having a preventive planning (TUCCI, 2012).

In addition, approved projects often do not undergo strict inspections, as well as strategic plans and measures are not maintained (TUCCI, 2012). As a result, plans and legislation that have been used as an aid base in official decisions for new real estate developments are outdated (CARDOSO JR., 2015). This situation triggers and aggravates social health and safety problems, such as the accumulation of waste and the improper use of areas that have been classified as flooding and, for this reason, must be preserved. For these reasons, both national and international environmental agencies recognize the need to improve instruments related to environmental processes (MOTTA and PÊGO, 2013).

Based on this circumstance, and on the need to strengthen flood risk reduction, this article aims to present the influence that the Alto Iguaçu Drainage Master Plan (CH2MHILL, 2002) can have on urban development. To this end, a case study was adopted for a project for urban subdivision based in the municipality of Fazenda Rio Grande, in the Metropolitan Region of Curitiba (MRC), Paraná.

Urban development and flooding

Floods are natural phenomena that occur when large amounts of water overflow from river beds, lakes, channels and dammed areas, and reach their banks. According to Article 3 of Federal Law No. 12,651, of 2012, such areas have the environmental function of preserving water resources and are considered permanent preservation (APP). Federal Law No. 6,766, of 1979, in its Article 3, determines that there should be no buildings "on wetlands and subject to floods, before taking steps to ensure the drainage of the waters" (Figure 1). However, it is noteworthy that there is still an imprecision regarding the definition of official levels for floodable areas, considering that federal legislation has a general character. Therefore, states and municipalities should institute more specific rules, according to their local reality.

Nevertheless, the accelerated process of urban expansion and the State's failure to comply with territorial ordering and real estate interests caused significant changes in cities, without proper planning and in a disorderly manner, which became worse with the occupation of areas of high environmental fragility without the presence of basic infrastructure (XIMENES, 2010).

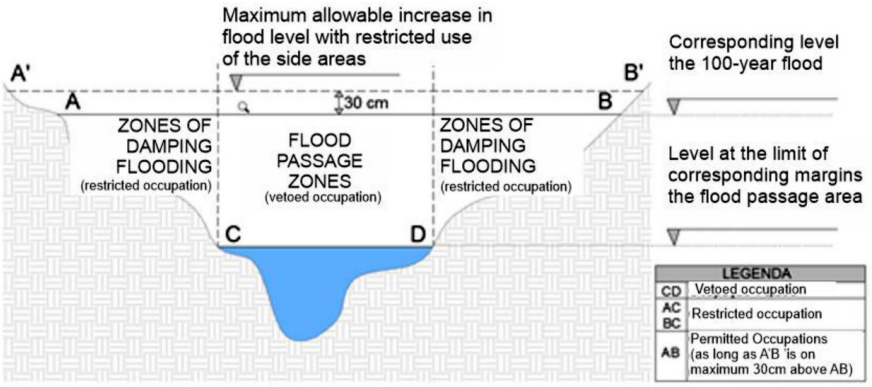


Figure 1 - Regulation of coastal areas
Source: the authors.

The factors that intensify the magnitude of the floods are related not only to social and cultural issues, but also to the drainage management adopted for the city, to the environmental characteristics and to the production and destination of solid waste. The aggravation of this problem starts with housing systems, with the removal of green areas and the waterproofing of the soil, which helped to decrease the flow of rainwater. It can be observed that there is a cycle of negative impacts, while the green areas help to control the temperature and air quality of urbanized areas, the waterproofing of the centers results in an increase in the flow of rivers, providing flooding in the peripheral areas (ZUCCOLO, 2000).

Another important factor is the reduction of the natural retention capacity, in view of the need to regulate the water cycle in the environment. This reduction, provided by the permeability areas, accelerates the drainage process, causing the rapid rise in the level of the rivers. Silting also influences the water support of the river and, considering deforestation, irregular occupation of the banks and incorrect disposal of waste, the problem tends to worsen. The influence of these factors on urban drainage is worrying, especially considering the measures used today to contain floods. The containment works are at a local level and do not consider the consequences that can trigger beyond their limits, resulting in flooding processes in other territories, especially downstream, or even in the aggravation of existing floods (XIMENES, 2010).

This is a characteristic that directly reflects the challenges encountered by urban public policies. Efficiency in the legal and normative sphere is fundamental for the functioning of the system, mainly when dealing with basic sanitation and housing, which must be in accordance with local, cultural or environmental characteristics. In addition to this search, other challenges encountered refer to technical, institutional and bureaucratic restrictions, which are major obstacles to urban management (MOTTA and PÊGO, 2013).

In addition, two determining factors refer to the insufficiency of the instruments currently available, as well as the difficulty of implementing them, and it is not possible to follow the processes of urban expansion. "The inefficiency and inadequacy of urban planning and management instruments can contribute to the establishment of irregular and informal patterns of

occupation and urbanization, especially for the poorest segments of the population" (MOTTA and PÊGO, 2013, p.13-14). In other words, without adequate planning and the necessary instruments, inspection professionals are unable to keep up with this growth, to prevent these areas from being inhabited. (SILVA & ZAIDAN, 2004).

Reduction measures and flood risk

Law No. 12,340, of 2010, in its Article 22, emphasizes the obligation of municipalities regarding the elaboration of mappings of areas subject to landslides, erosions and floods. These mappings assist in disaster prevention in areas at risk. However, the mapping carried out in the country is out of date, in addition to the presence of cartographic voids (CAMBOIM, SLUTER and MENDONÇA, 2008). Therefore, cities must consider integrated strategic planning, not only with government sectors, but also with all regional bodies and other agents (VILLANUEVA, TASSI and PICCILLI, 2011).

An example is the management of urban rainwater. Its management can be integrated with land use and occupation planning, as well as urban infrastructure planning, aiming at maximizing the benefits of structural and non-structural measures, and minimizing the risk of flooding and inundation (VILLANUEVA, TASSI and PICCILLI, 2011). Most of the time, the existing drainage plans do not integrate natural, social and institutional systems. This results in a lacking methodology, especially when considering that drainage is part of the urban environment, being directly articulated with the systems that form cities (ZAHED FILHO, et al., 2013).

Environmental licensing, for example, is used in the implementation and regularization of land parceling projects in urban areas, to guarantee the prevention and mitigation of negative impacts resulting from the installation of new projects. This guarantees to future residents that their subdivisions are in adequate conditions of security and habitability, because it regularizes basic infrastructures, the minimum percentage of green areas and the protection of conservation units and permanent preservation areas (APPs). With the areas properly delimited and protected, the guarantee of urban environmental quality is reflected in the entire community, especially to low-income populations who live in situations of risk and vulnerability (MOTTA and PÊGO, 2013).

Control measures are adopted according to the progress of projects that require works in urban drainage, and can be classified by source (lots), microdrainage (subdivisions) and macrodrainage (urban rivers). At the source, the interferences can be based on the choice of permeable materials for the external areas, the construction of small reservoirs to control the flow and the directing of water from impermeable areas to infiltration sites. In micro and macro drains,

the works are for the construction of detention areas, such as squares, and retention areas, such as parks (TUCCI, 2003).

Other structures used in Brazil are dams and swimming pools. Dams are widely used in cities that are below water level, however, as they are areas of natural flooding, the problem only tends to be transferred to downstream areas. Another risk that these cities face is that of the rupture of these dams, such as the one that occurred in Bento Rodrigues (MG), because maintenance is necessary, but is not always attended to regularly. Swimming pools are still widely used in the city of São Paulo for containment, however, due to the accumulation of waste and lack of maintenance, some of these areas have lost their original function, starting to silt and overflow contaminated water (XIMENES, 2010).

Interventions also result in major changes in ecosystems, which can compromise regions with worsening floods (XIMENES, 2010). But the control measures suggested by the Master Plans do not only look at structural alternatives – which aim to balance the economic development of cities and their expansion without risks, avoiding impacts through low-cost works, but with prior planning. Non-structural measures are also based on legislation for new real estate developments, being present in the Urban Master Plan and in municipal laws and decrees. (TUCCI, 2003). However, the problem is that the worsening impacts may occur in this sphere more frequently, for example, from incorrect decision-making and professionals incapable of management (MOTTA and PÊGO, 2013).

Nevertheless, one of the great challenges to be overcome today is the need to improve the environmental licensing legislation, to meet the specific environmental and housing developments. With this, it is possible to reduce the situations of irregularity in the urban area, especially when considering a reformulation in the agility of processes, thus serving a greater number of people, and respecting the balance of environmental conditions and urban management. (MOTTA and PÊGO, 2013).

Methodology

The present investigation seeks to assess the influence that the flood spots described in the Alto Iguaçu Drainage Master Plan (CH2MHILL, 2002) can have on the implementation of a real estate development. The aforementioned Plan is an instrument of the State Water Resources Policy (Law No. 12.726, of 1999), "as it deals with the prevention and defense of the population and the economy against critical hydrological events of natural origin, or resulting from the inappropriate use of natural resources" (CH2MHILL, 2002, p.4). This instrument aims to balance development with the environment, integrating with municipal plans, such as basic sanitation, solid waste and the director (ABIKO and MORAES, 2009). Therefore, it is a basic tool for the implementation of new projects, being used as a condition for new land parcels.

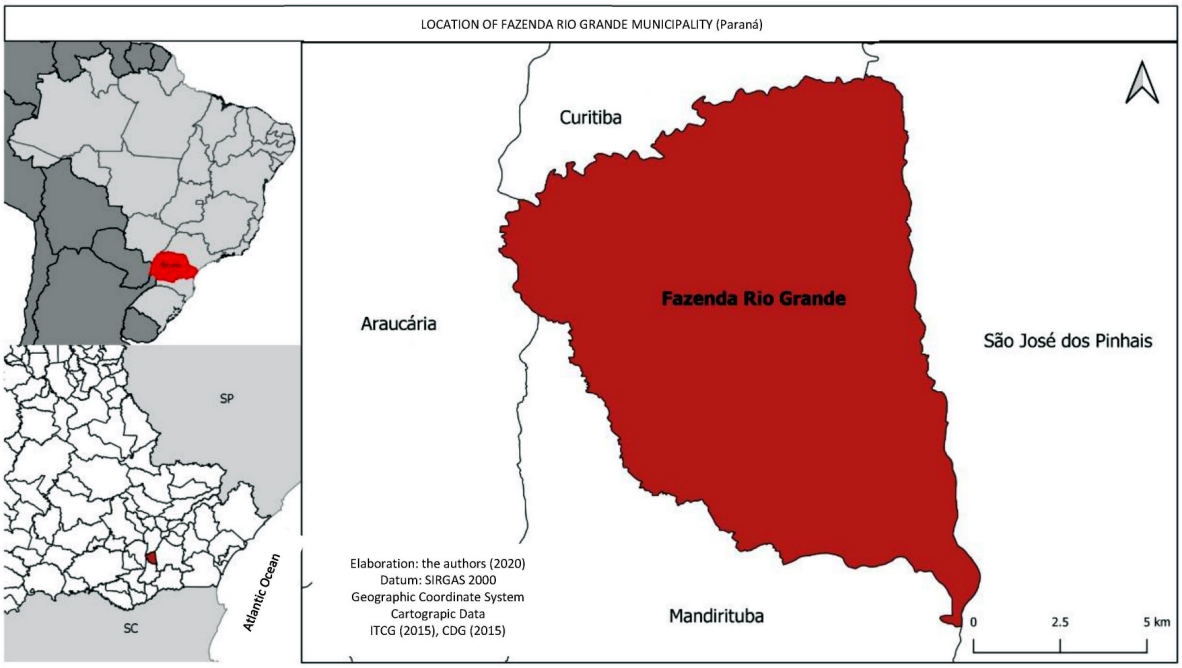
The data were substantiated and based on the current legislation, as well as on the use of specific tools and techniques for the collection of information, such as questionnaires, meetings, analysis of documentation and procedures, interviews and local surveys, framing itself as a qualitative verification methodology.

Study area

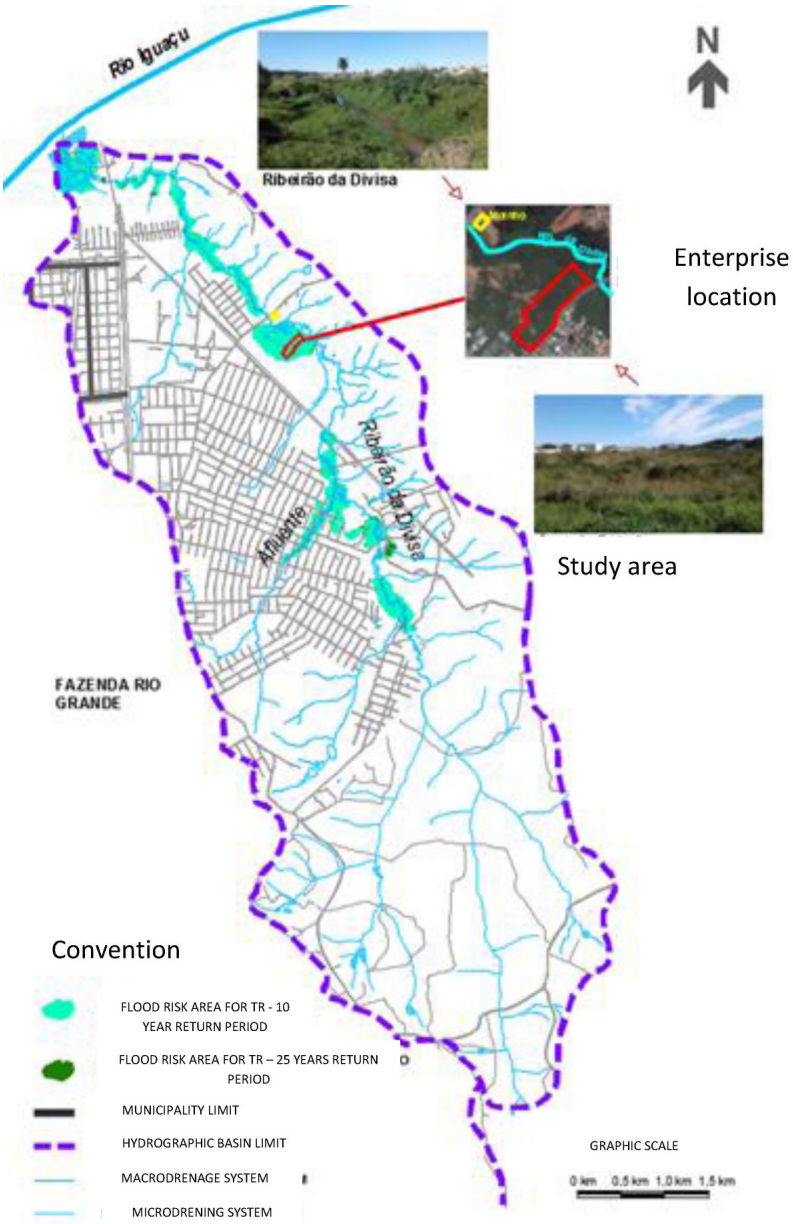
A The choice of city for conducting investigative research was restricted to the Metropolitan Region of Curitiba (MRC), opting for one of the municipalities that does not depend on the Environmental Institute of Paraná (EIP) for the elaboration of its environmental processes, that is, for one who is a licensor in the municipality itself, the municipality of Fazenda Rio Grande being adopted (Figure 2). It has a population of approximately 93 thousand inhabitants and belongs to the hydrographic basin of Alto Iguaçu, more specifically within the Ribeirão da Divisa sub-basin.

To choose the area, the Ribeirão da Divisa Drainage Master Plan was analyzed. Subsequently, it was considered the location, which is within the urban area, is characterized as a vacant lot (without native vegetation) and is located within one of the flood spots. Therefore, a land of 17,665.81 m² was adopted. Based on the UTM coordinates, 7,162,882mN and 670,768mE, it was found that the real estate development is in a ZR2 - Residential Zone 2. This classification allows the use of the area for the parceling of the soil in medium density homes, expanding the infrastructure, the road system and guaranteeing social inclusion (Complementary Law No. 6/2006, Art. 24).

Figure 2 – Macro-location of the Municipality of Fazenda Rio Grande, Paraná
Source: the authors.



According to the Drainage Master Plan of Ribeirão da Divisa, three projections were considered for the presentation of the flooding scenarios: current scenario, with the conditions of the time of the macro-drainage system; trend scenario, with future conditions for waterproofing the macrodrainage system; and targeted scenario, with the urban spot for 2020 and the future situation of the macro-drainage system (Figure 3). The data for the characterization of waterproofing were acquired through geological characterization, demographic studies and urban occupation (CH2MHILL, 2002).



Methodological procedures

In the first moment, an analysis was made of the municipal mappings available from the City Hall of Fazenda Rio Grande, the published maps of the CPRM (Geological Service of Brazil) and the analysis of the evolution of satellite images in the Google Earth software. From the sources, it was possible to identify changes in the area since 2000 - two years before the publication of the Plan - where it was already possible to observe changes in the urbanization of the place. In addition to urbanization spots, other changes occurred in the terrain, in the design of local rivers and streams.

As stated by Villanueva, Tassi and Piccilli (2011), when the municipality has the Urban Drainage Master Plan, it is essential that the information that is not included in it must be obtained by field surveys. With urbanization, regions tend to have higher impermeability rates than those provided for in these documents, especially when considering the existence of irregular housing. This statement is directly reflected in the

Figure 3 – Location of the study area in the Ribeirão da Divisa Drainage Master Plan
Source: the authors.

evaluation of projects for new ventures, in such a way that, before final decisions are taken, the agencies must look for the history and evolution of changes in these areas.

Thus, the analyses of the present study are directly based on information collected in loco. For this reason, we also sought to conduct interviews with local residents to understand the existence of the present stain. However, the statement received was that none of the participants witnessed situations of flooding in the area under study, not even during the period when the Plan was released. Based on these affirmations and on-site inspections, the process of searching the history of the site was initiated, to understand the reasons that led the agencies to consider the present area as flooding.

Analysis of results

The Alto Iguaçu Drainage Master Plan, specifically in the Ribeirão da Divisa Basin volume, was published in 2002. From the time the plan was published to today, several local changes have occurred, which are not considered in the mappings used as basis of decision making. When observing the location of the study area, the urban subdivision would be entirely within the flood area. However, it is noteworthy that in addition to it, other occupations present themselves on the site, such as public undertakings (College, Municipal School, CRAS, Nursery and Health Unit), commercial undertakings (Aviary, Cafeteria, Stationery), new streets and several residences (Figure 4).

In the 1940s, an area of 4 bushels was used to build a dam for the purpose of generating electricity for the mill that still exists today at the same address, next to Ribeirão da Divisa. During the period in which the tank was active, the

Figure 4 – Enterprises located in the flood spot
Source: the authors.

community used the area for fishing and leisure and the Environmental Institute of Paraná (EIP), carried out Fauna surveys to monitor the location. In the 1990s, the owners of the area filed for a permit to extract clay from the IAP. With the extraction, the tank started to be emptied, which can be seen in satellite images, in which it has not presented its original size since 2000 - before the publication of the Alto Iguaçu Drainage Master Plan (Figure 5).

When carrying out the analysis of satellite images, it was observed that, from 2000 to 2006, the presence of a puddle of water in the vicinity of the land under study was existing, and, over the years, the water decreased until it ceased completely, from the end of 2014. These images also reinforce that the water that existed in the vicinity of the site did not belong to the overflow of the river, as there is no evidence of possible flooding (Figure 6). It is noteworthy that

Figure 5 – Aerial image of the tank built in the 1940's Source: the authors.

some of the residents warned about the accumulation of water seen in the vicinity of the mill (opposite side of the study area). This accumulation of water is caused by interference from urban drainage, so that the increased runoff from Av. Brasil, towards Moinho, ends up affecting the region.

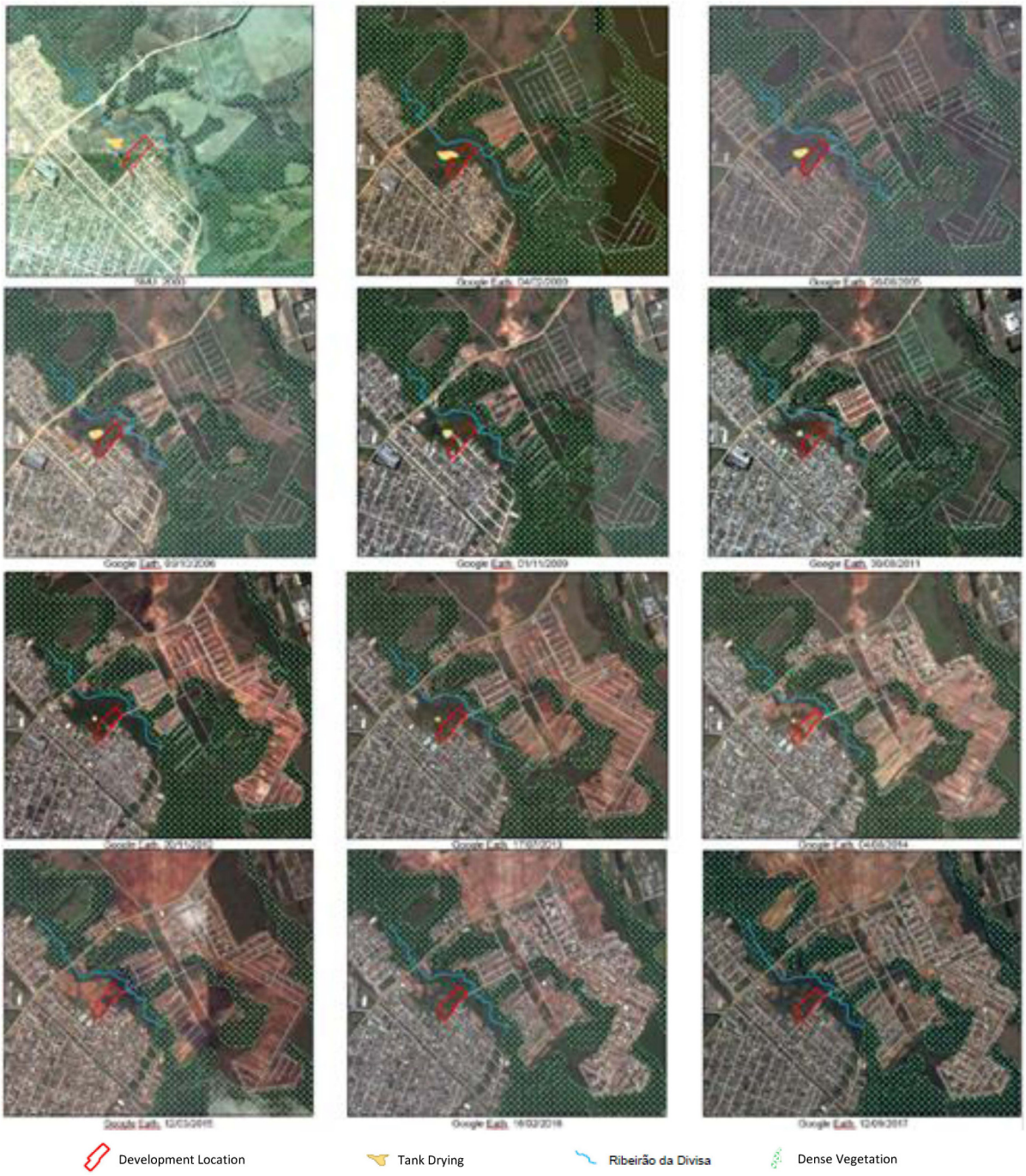


Figure 6 - Evolution of the drying of the old tank near the study area (2000 – 2017) Source: the authors.

Currently, the area under study is abandoned, considering that the competent agency does not authorize the execution of land subdivisions on site because it is using outdated maps as a basis for land use decisions. In general, the elaboration of the Urban Drainage Master Plans has inconsistent information, since at the time they are elaborated, data on the existing infrastructures are lacking and, subsequently, there is no updating of new characteristics of the surroundings or of rules and regulations that have been instituted after its publication (ONEDA, 2018).

In the interviews, residents complained about the current state of the area, so that, with it being considered unsuitable for the construction of subdivisions and new developments, people feel insecure due to the vacant, open terrain and without lighting. Some residents also pointed out the use of the land as a meeting point for the use of illicit substances, as well as for the constant inappropriate disposal of waste and dead animals, causing strong odors in their surroundings.

When analyzing the Brazilian plans, it is observed that the measures developed at the time aimed at solving existing problems in the urbanized areas of the municipalities. This profile ends up limiting the actions necessary for the new problems that have arisen in cities (ONEDA, 2018). As ways to minimize the problems found in the study area, some structural and non-structural measures can be mentioned.

It should be noted that non-structural measures do not necessarily need to be initiated by public bodies, and each citizen or professional in action can propose changes. Examples of local actions can come from meetings of residents' associations, from which claims are taken to city halls, such as petitions with letters of complaints and/or suggestions for improvements; interventions with local councilors; or even the elaboration of studies, such as the present project, which can be presented to entrepreneurs helping them to claim for more in-depth analysis, prior to the final decisions of the responsible bodies.

As structural measures, the construction of a containment basin could be carried out in the vicinity, which would reduce the water load of the site, being a sufficient option to alter the temporary water storage area. Other measures that were suggested by Villanueva, Tassi and Piccilli (2011, p. 15), in a case study in the city of Porto Alegre, can also be considered, being the "flood damping reservoirs, as well as the expansion of several sections of conduits. [...] the implantation of open-air detention structures, with grassy slopes".

To confirm if the stain presented in the Drainage Master Plan of Alto Iguaçu, Ribeirão da Divisa, is out of date, a map was elaborated from the official quotas provided by the Instituto das Águas do Paraná, from the characterization of the strips. APP and qualitative analysis of residents (Figure 7). Thus, it is possible to observe that, according to the maps presented in the Drainage Plan, the elevation next to the river is 870 m, while the elevations present in the area of the enterprise reach 876 m, being 6 meters above the level of the Ribeirao da Divisa.

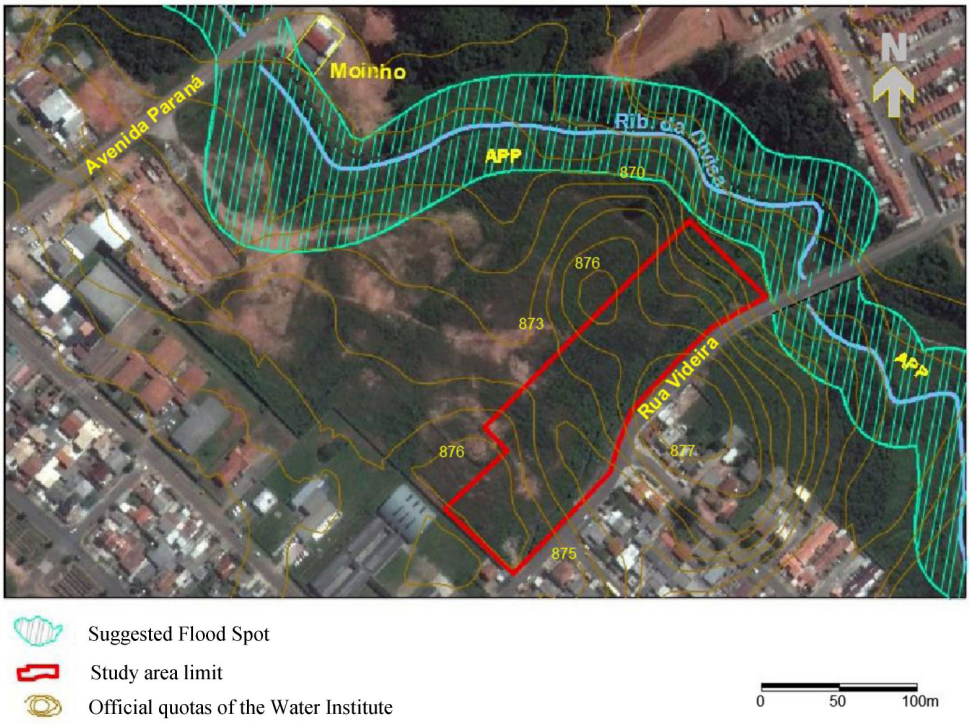


Figure 7 – Suggested Flood Spot in the Study Area
Source: the authors.

It is important to highlight that this problem does not happen only on a local scale, but in several Brazilian municipalities. As examples, in Manaus (Amazonas), the Plan was presented to the population after 11 years of delay (VALOIS, 2015); in Feira de Santana (Bahia), in addition to the projects and mappings being outdated and not being shared, making it difficult to prepare projects for development, the city has not yet prepared its UDMP (CARVALHO, 2010); in Aracaju (Sergipe), the Plan also remains out of date, causing the lack of investment in infrastructure to result in several floods (OLIVEIRA, 2017); the same outdation occurs in Apucarana - Paraná (MORENO, SCHACHT and BOBIG, 2017), in São Carlos - São Paulo (PIRES et al., 2016), and other municipalities.

As the identified area has no evidence of flooding over the years, instead of adopting the suggested structural measures, technological instruments can be adopted. The most used instruments are the rain gauges, water level meters, weather radars, satellite images, as well as the mathematical models created to forecast rains and floods (VASCONCELOS, 2018). In Brazil, some municipalities already carry out the monitoring of the water level of their basins and, in some of them, this monitoring can be followed in real time by the official websites, as in the city of Blumenau, in Santa Catarina, with AlertaBlu (PREFEITURA, 2018).

In the city of Rio Branco, in Acre, the application "Rio Level" is being launched, in such a way that it will warn the population when the water level reaches critical levels of flooding (MUNIZ, 2018). In the city of São Paulo, on the other

hand, investment has been greater in the wireless "e-Noé" sensors. In this system, data does not need to be collected by a person at the location where the sensor is installed, considering that, because they are wireless, they send the information directly to the Civil Defense and the Population. Another interesting point of this equipment is that it can be incorporated, for example, with the identification of pollution, helping the municipality in terms of the water quality of its rivers and streams (VASCONCELOS, 2018).

It should also be noted that all investments in prevention and monitoring are high, be they in the long or medium term. Therefore, for this specific situation, two local alternatives are suggested, in which the residents themselves have the initiative to prevent themselves. The first one is about the construction infrastructure and material goods. Choosing water-resistant buildings, as well as defining the appropriate location of equipment that can be lost in flooding situations is the first step to minimize economic losses. The second suggestion concerns the individual sensors, called "Leak Sensors". These sensors can be installed in strategic locations, so that when the water reaches them, an alert will be sent directly to the homes and/or to the residents' cell phones (WROCLAWSKI and MURPHY, 2020). This will help people with the agility of actions that must be taken to keep the place safe.

The Urban Drainage Panels should be considered as an essential element of public management. Currently, they are seen as technical documents that have not evolved over time. However, the plans are important instruments for assessing the risks and vulnerabilities of municipalities, both in the economic, social and environmental areas. Therefore, it is necessary to change the update deadlines, as well as the methodologies currently used. It is important to consider factors of interaction with the population and professionals in the area, in addition to investments to prevent the impact of extreme events in the long term (ONEDA, 2018).

Based on the above, the construction of an urban subdivision in the area under study would allow improvements in the region. The economic improvements would occur with the addition of value to the community; social ones, with increased local security; environmental improvements would be visible with the mandatory correct disposal of waste; and finally, those of public health, with the end of discards and, consequently, of strong odors. Thus, the importance of maintaining the regular updating of official plans, especially the Alto Iguaçu Drainage Plan, is highlighted, to avoid problems with the community due to outdated information.

Final considerations

This article aims to reinforce the need to use resources and updated information to official documents, which can be presented in a complementary way. As long as there is no availability of accurate information that can assist in the development of cities, many problems will continue to happen, with the possibility that the consequences may be worse than if there were the publication of updated Plans.

Floods are one of the biggest problems today for the government. For this

reason, the importance of more restrictive legislation, thorough planning and strict management is essential. However, the legislation has several loopholes, which allow the construction of enterprises without prior authorization, causing several drainage problems for cities, so the elaboration of Master Plans that can be used as a basis for decision making.

However, even the regions that have an Urban Drainage Master Plan to follow, often remain in ambiguous situations, not knowing what decisions to make. These situations occur due to the lack of updating of the Plans, which directly interferes with urban development. From the moment cities change, urbanized areas increase and land designs change, causing zoning and other municipal projects to be updated.

Thus, it is essential to consider that, in addition to constant updating, these plans need to include important elements in their structure, such as: training for technicians who are part of the drainage sectors of the municipalities; environmental education for the population to assist in monitoring urban drainage; focus on preventing negative impacts, to promote measures to reduce risks and not only to act in the event of events; and, budget planning for the purchase of equipment and materials essential to the execution of activities.

Finally, it is highlighted that, for future works, it is possible to use different methods from those adopted in this research. Among them are the simulation of hydrological models to determine the flood levels according to the return periods; the predefined structural measures to be installed in the region to modify the runoff basin and its respective impacts; and mappings that consider all the intersections raised in this article. With the deepening of these other methodologies, it will be possible to have a broader view of the problems and achieve greater precision in the identification of flood levels.

References

ABIKO, Alex; MORAES, Odair. **Desenvolvimento urbano sustentável**. São Paulo: USP, 2009.

BRITO, Fausto; PINHO, Breno. **A Dinâmica do Processo de Urbanização no Brasil, 1940-2010**. Belo Horizonte: UFMG/CEDEPLAR, 2012.

CAMBOIM, Silvana; SLUTER, Cláudia; MENDONÇA, André; JORGE, Teresa. Mapeamento sistemático: a base para as Infraestruturas Nacionais de Dados Espaciais. In: **Anais** do II Simpósio Brasileiro de Ciências Geodésicas e Tecnologias da Geoinformação. Recife, 2008.

CARDOSO Jr., José Celso (org.). **Planejamento Brasil século XXI**: inovação institucional e refundação administrativa: elementos para o pensar e o agir. Brasília: IPEA, 2015.

CARVALHO, Karollyne. Drenagem pluvial urbana convencional x sustentável: estudo de caso nos bairros Baraúnas e Centenário - Feira de Santana – Bahia. 80p. **Trabalho de Conclusão de Curso** (Graduação em Engenharia Civil). UEFS, Feira de Santana, 2010.

CH2MHILL. Plano Diretor de Drenagem para a Bacia do Rio Iguaçu na Região metropolitana de Curitiba: Relatório. SUDERHSA, 2002.

COSTA, Fernando. **Estado das Cidades da América Latina e Caribe 2012**. Campinas: Sociedade & Cultura, 2012. Disponível em: https://fernandonogueiracosta.wordpress.com/2012/09/01/estado-das-cidades-da-america-latina-e-caribe-2012/. Acesso em: 05/12/2019.

DESCHAMPS, M. V. Vulnerabilidade socioambiental na região metropolitana de Curitiba/PR. Curitiba, 2004. **Tese** (Doutorado em Meio Ambiente e Desenvolvimento) - Universidade Federal do Paraná, 2004.

MENDONÇA, Francisco. Riscos, vulnerabilidade e abordagem socioambiental urbana: uma reflexão a partir da RMC e de Curitiba. **Desenvolvimento e Meio Ambiente**, n. 10, p. 139-148, 2004.

MORENO, Herivelto; SCHACHT, Gustavo; BOBIG, Sergio. (org.). **Plano Municipal de Saneamento Básico. Caderno 2 Prognóstico**. Apucarana: SEMA, 2017

MOTTA, Diana; PÊGO, Bolívar. (org). **Licenciamento Ambiental para o Desenvolvimento Urbano**: avaliação de instrumentos e procedimentos. Rio de Janeiro: IPEA, 2013.

MUNIZ, Tácita. Aplicativo que alerta quando rio atinge cota de inundação é lançado na capital do Acre. G1 Acre, 2018. Disponível em: https://g1.globo.com/ac/acre/noticia/aplicativo-que-alerta-quando-rio-atinge-cota-de-inundacao-e-lancado-na-capital-do-acre.ghtml. Acesso em: 03 dez. 2019.

OLIVEIRA, Tanuza. **Aracaju alaga e Plano Diretor não deslancha**. Aracaju: JL Política, 2017. Disponível em:

http://jlpolitica.com.br/reportagem-especial/aracaju-alaga-e-plano-diretor-nao-deslancha. Acessado em: 24 jan. 2020.

ONEDA, Tânia Mara Sebben. Planos Diretores de Drenagem Urbana: uma análise comparativa entre planos de países desenvolvidos e em desenvolvimento. Joinvile, 2018. **Dissertação** (Mestrado em Engenharia Civil) – Universidade do Estado de Santa Catarina, 2018.

PIRES, Ivo Redigolo Moreira; LIMA, Raul Sampaio de; DORICI, Mariana; SILVA, Ana Elisa Teixeira da; PUGLIESI, Erica; MOSCHINI, Luiz Eduardo; CATOJO, Adriana Maria Zalla. Proposta de manejo de águas pluviais e drenagem urbana do município de São Carlos – SP: aplicação da análise SWOT como método de avaliação de política pública**. Revista Brasileira de Geografia Física**, v.9, n.6, p. 2104-2120, 2016.

PREFEITURA Municipal de Blumenau. AlertaBlu Sistema de Monitoramento e Alerta de Eventos Extremos de Blumenau. Blumenau, 2018. Disponível em: http://alertablu.cob.sc.gov.br/d/nivel-do-rio. Acesso em: 03 dez. 2019.

RIEGEL, Roberta; QUEVEDO, Daniela. Uso de geotecnologias na análise das áreas de risco do município de Novo Hamburgo e a relação do risco com a evolução urbana. In: LADWIG, Nilzo Ivo; SCHWALM, Hugo. **Planejamento e Gestão Territorial**: Experiências Sustentáveis. Florianópolis: INSULAR, 2015.

SANTOS, M. **A urbanização brasileira**. São Paulo: Hucitec, 1993. 157p.

SILVA, Jorge; ZAIDAN, Ricardo. **Geoprocessamento e análise ambiental**: aplicações. Rio de Janeiro: Bertrand Brasil, 2004.

SOUZA, Marcelo. **Mudar a Cidade**: Uma Introdução Crítica ao Planejamento e a Gestão Urbanos. 7 ed. Rio de Janeiro: Bertrand Brasil, 2010.

TUCCI, Carlos. Drenagem Urbana. **Ciência e Cultura**. v.55, n.4, p. 36-37, 2003.

TUCCI, Carlos. Drenagem Urbana. **Gestão da Drenagem Urbana**. Brasília: Cepal, Ipea, 2012. 50p.

VALOIS, Isabelle. Com 11 anos de atraso Plano Diretor de Drenagem Urbana terá audiência pública, em Manaus. Manaus, 2015. Disponível em:

https://www.acritica.com/channels/manaus/news/com-11-anos-de-atraso-plano-diretor-de-drenagem-urbana-tera-audiencia-publica-em-manaus. Acesso em: 16 jan. 2020.

VASCONCELOS, Yuri. **Alerta contra inundações**. São Paulo: Revista Pesquisa FAPESP, 2018.

VILLANUEVA, Adolfo; TASSI, Rutinéia; PICCILLI, Daniel; BEMFICA, Daniela; TUCCI, Carlos. Gestão da drenagem urbana, da formulação à implementação. **REGA**, v.8, n.1, p.5-18, 2011.

WROCLAWSKI, Daniel; MURPHY, Rachel. **The Best Smart Water Leak Detectors of 2020**. Reviewed, 2020. Disponível em: http://smarthome.reviewed.com/best-right-now/best-smart-water-leak-detectors. Acesso em: 13 jan. 2020.

XIMENES, Elisa. Enchentes e Saúde: levantamento das diferentes abordagens e percepções, Região do Médio Paraíba, RJ. 145p. **Dissertação** (Mestrado em Saúde Pública e Meio Ambiente). FIOCRUZ, Rio de Janeiro, 2010.

ZAHED FILHO, Kamel; MARTINS, José Rodolfo Scarati; PORTO, Monica Ferreira do Amaral; CUCIO, Maíra Simões. **Coleção Águas Urbanas - Fascículo 6: Planos Diretores de Drenagem** Urbana. São Paulo: Universidade de São Paulo, 2013. 11p.

ZUCCOLO, Renato. **Algo do Tiête Hoje**. Leito, Várzea e Afluentuba. São Paulo: Nova Bandeira Produções editoriais, 2000.

Acknowledgmentss
Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES/ Coordination for the Improvement of Higher Education Personnel) – Código de Financiamento 001.

Editor's note
Submission: 19/03/2020
Acceptance: 01/11/2020
Review: RMO

Larissa Ferentz
Pontifícia Universidade Católica do Paraná (PUCPR). Programa de Pós-Graduação em Gestão Urbana (PPGTU).
Rua Imaculada Conceição, 1155, Prado Velho, Curitiba, Paraná, 80215-901
Bloco 2 (azul), 2° andar, PPGTU
Orcid: http://orcid.org/0000-0001-5804-0361
ferentzengenharia@gmail.com

Carlos Garcias
Pontifícia Universidade Católica do Paraná (PUCPR). Programa de Pós-Graduação em Gestão Urbana (PPGTU).
Rua Imaculada Conceição, 1155, Prado Velho, Curitiba, Paraná, 80215-901
Bloco 2 (azul), 2° andar, PPGTU
Orcid: http://orcid.org/0000-0001-7982-5803
carlos.garcias@pucpr.br

Murilo Noli
Pontifícia Universidade Católica do Paraná (PUCPR). Programa de Pós-Graduação em Gestão Urbana (PPGTU).
Rua Imaculada Conceição, 1155, Prado Velho, Curitiba, Paraná, 80215-901
Bloco 2 (azul), 2° andar, PPGTU
Orcid: http://orcid.org/0000-0002-0718-3087
murilonoli@gmail.com