Urbanization and management of hydrological risks in São Paulo

Urbanização e gestão de riscos hidrológicos em São Paulo

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Abstract

The article discusses hydrological risks of the city of São Paulo as a historical and social construction deriving from an urbanization planning that disregarded the hydrological dynamics, did not provide space for vulnerable populations, favored mobility and urban expansion, and increased land value. It is supported by indirect sources (laws, theses, academic articles) and discusses the Municipal Civil Defense System in the light of current frameworks and entities responsible for managing risks of natural disasters. Risk management is treated as an emergency issue, subordinated to the Municipal Security Department. With a fragile structure that lacks basic elements, it disdains its historical and environmental liabilities and exposes the State's withdrawal under the action of neoliberal policies.

Keywords*:* São Paulo; urbanization; valley bottoms; urban planning; public policies.

Resumo

Este artigo discute os riscos hidrológicos do município de São Paulo como uma construção histórica e social resultante de um planejamento da urbanização que desconsiderou as dinâmicas hidrológicas, não previu espaço para as populações vulneráveis, privilegiou a mobilidade, a expansão e a valorização fundiária. Apoia-se em fontes indiretas (leis, teses e artigos acadêmicos) e discute o Sistema Municipal de Defesa Civil à luz dos marcos vigentes e dos entes responsáveis pela gestão de riscos de desastres naturais. A gestão de riscos é tratada como questão emergencial, subordinada à Secretaria Municipal de Segurança. Com uma estrutura frágil, sem elementos básicos, desdenha seu passivo histórico e ambiental e expõe o afastamento do Estado sob a ação das políticas neoliberais.

Palavras-chave: *São Paulo; urbanização; fundos de vale; planejamento urbano; políticas públicas.*

Introduction

The economy industrialization project and the fast urbanization faced by São Paulo City in the early 20th century have changed river physiography and landscape for power generation and urban sanitation purposes. Massive ventures have changed water courses and dammed up water from the main rivers in order to generate electric power and to supply the city. Furthermore, riverbeds were channeled and corrected to ensure river-water flow and speed to carry sewer and urban drainage. Rivers and brooks were turned into components of the urban infrastructure system (Travassos, 2010; Alvim et al., 2006; Castro A., 2020).

São Paulo's urbanization model was supported by the trinomial "riverbed channeling, sanitation infrastructure system constructions and the implementation of several systems in riverbanks". It also encouraged the occupation of large valley bottom areas in the city. This model fulfilled the sanitary and hydrological demands, as well as opened room for the dreamed urban development (Travassos, 2010; Anelli, 2007). Besides allowing the transposition of river valleys due to floodplains' groundings, the implementation of urban infrastructures has valued soil and encouraged urban occupation. Such added-value areas were taken for real estate operations that have expanded urbanization over natural-water spaces. However, these water spaces still return to their systematic high tide cycles and cause flooding; this process got worse due to urban expansion broadening. Intense urban soil use, correction, channeling of the main rivers and of their tributaries, and the sealing of their basins have changed the hydrological cycle in the region. Thus, the installed surface outflow capacity became obsolete overtime and it has exposed São Paulo's population to frequent flooding events (Seabra, 1987; Franco, 2005; Castro A., 2020).

Public plans and policies inspired by hygienist ideals did not adopt water basins as planning units; they disregarded the hydrological and systemic dynamics of this territory. Somehow, city planning has contributed to floods that, based on a vicious cycle, get worse due to water contamination, given the incomplete implementation of sanitation infrastructure, mainly lack of sewage treatment and of an inappropriate urban-waste management system (Rutkowski, 1999; Alvim, 2003; Santos, 2004; Franco, 2005; Travassos, 2010).

Conflicts deriving from river valley occupations have overlapped environmental issues, since São Paulo's urbanization plans and projects, up to mid-20th century, did not encompass locations for poor populations that have been attracted to the city by the opportunities provided by the industrial capital. Since these populations did not find housing opportunities, they started occupying fragile environmental zones in flooding riversides or slope hillsides that were not suitable for urbanization (Travassos, 2010; Alencar, 2017; Castro A., 2020).

Therefore, it regards a social construction that has created the conditions for increasing flooding events and promoted precarious settlements that have exposed thousands of people to hydrological hazardous events, contamination and water shortage. This frame nowadays evidences one of the largest socio-environmental liabilities, not just in São Paulo City, but in several Brazilian cities.

Many authors warn about the deterioration and impacts suffered by urban rivers due to both intense population growth and the sealing of cities' surfaces. These factors lead to a turning point in the urban river-water management approach. They also shine light on increase in water crisis episodes that can affect millions of people in urbanized areas (Spirn, 1995; Hough, 1995; Riley, 1998; Delijaicov, 1998; Rutkowski, 1999; Alvim, 2003; Higueras, 2006; Travassos, 2010; Gorski, 2010; Schutzer, 2012; Kahtouni, 2016).

From the 1980s onwards, sustainability and the economy of natural resources rose in the agenda of public policies worldwide due to the emergence of the globalized economy. Actions and investments aimed at planning and river-recovery ventures to safeguard water sustainability and to rescue socio-environmental quality for populations, as well as river landscapes (Alencar, 2017; Kahtouni, 2016). These actions highlighted that models adopted by the traditional hydraulic engineering had failed and created a whole series of issues in metropolises.

Sanitation and power generation in Brazil were always subjected to the trends and interests of private companies from different countries that had invested in the basic-services sector, such as sewage systems, railroads, gas and electricity companies, telegraphs and telephones, urban transportation, navigation companies and public construction ventures (Castro C., 1979 apud Gomes and Barbieri, 2004). Accordingly, the presence of these enterprises has influenced the consolidation of some Brazilian sanitary engineering canons.

The topic 'water' in Brazil is regulated by the 1988 Federal Constitution (CF/1988) as State competence; it must be ordered by the National System of Water Resources Management, also known as Singreh, based on command and control instruments (watershed plans, licensing for water use and capture, water course classification and information systems). It regards a system that adopts economic incentives for the 'rational' use of water resources (water-use financial charging or compensations); however, the State did not provide direct investments to it, but it actually transfers such a responsibility to private agents that do not care about a broaden social participation in this process. Even the creation of regulating agencies in the 1990s, which account for public agents responsible for managing and inspecting concessionary companies, was not preceded by the debate about the best regulation model; legal frameworks were discussed prior to concepts. This process has taken these agencies apart from the political dynamics and broadened the market space by replacing the State bureaucracy by the privatization of offered public services (Rossi and Santos, 2018).

The aim of the present article is to discuss the weaknesses of the hydrological risk management system operated by public agents in São Paulo City. Such weaknesses were herein associated with an urbanization model adopted by the urban planning project and with the urban space production process, which did not respect the local hydrological dynamics and did no set locations for vulnerable populations. This article derived from a PhD thesis (Castro A., 2020),[1] which employs a historical approach that is

substantiated by documental and indirect investigations in order to assess the hypothesis that, within the urbanization, planning and urban space management process lies the causes of socio-environmental conflicts that expose its population, mainly the poorest classes, to hydrological risks. The study assumes that the State, by favoring the use of the water from many of its rivers for power generation and the erase from its landscape another fractions of its water courses, by replacing them by a road infrastructure has contributed to promote geomorphological changes and alterations in the hydrological dynamics of its water basins. Thus the city has submitted itself to the interests of investors and to the real-estate private capital; it excused itself from its responsibility for conducting the construction of a plural city that should have foreseen locations for all segments of its population.

The present article was divided into three sections. The first one addresses the association among natural hazardous events, urban processes adopted by urban planning and risk management, in light of fundamental concepts about this topic. It was done by synthesizing data about hydrological risks in the country. The second section introduces an analysis about the legal framework set for the risk management system in São Paulo City and in Brazil, its functions and competences. The study analyzed the weaknesses of this system when it comes to material support and collected data, mainly to its distance from other sectors and emergence-assistance profile. Finally, the final considerations evidence the persistence of hygiene paradigms associated with rivers and their subjection to designs that prioritize cars mobility and the permanence of an unfair special distribution of different populations, even when these populations are supported by actions from public policies in São Paulo City. Despite the existence of proper urban planning mechanisms provided by legal frameworks ordering soil occupation, the management of risks is always put at second position in the rank of priorities; it is subjected to interests of the private sector focused on real estate exploitation and on favoring private individual means of transportation.

Risks management and urban planning: integrated approach

Based on the annual report by the Centre for Research on Epidemiology of Disasters (Cred, 2020), from 2019, flooding and storm events were the natural hazards mostly causing death and financial losses on the globe.

Brazil does not have a systematic program to control floods based on its main aspects (Tucci, 2007). The Water Resources and Urban Environment Secretariat, also known as SRHU, which is linked to the Ministry of the Environment, defines the standards and instruments for sustainable water management in urban zones, which are based on low impact actions focused on preventing flooding events to avoid the loss of both lives and patrimony. It recommends to enhance project solutions for urban drainage system and to encourage innovative drainage systems, as well as rivers and streams' re-naturalization and the creation of River Parks to stop the occupation of Permanent Preservations Areas (PPA), and riparian and floodplain areas. However, these solutions

do not encompass a program or action plan, a fact that transfers such a responsibility to municipalities.

A study carried out by the National Center for Natural Hazards Monitoring and Warning (Cemaden, 2019) published in 2019 point out that Southeastern region held the largest number of areas presenting risk of mapped floods and landslides in Brazil, in 2018 (Saito et al., 2019). Assumingly, because the Southeastern region accounts for the highest rates of population density in the country, one can believe that such a scenario led to the largest number of people affected by natural hazard events over the assessed period.

The present research also featured the profile of the most affected population based on economic data. It was observed that 36% of households exposed to such events lived with income *per capita* up to half minimum wage. This situation was observed in 20% of the assessed municipalities. Yet, 71% of the population exposed to hazardous events in the Southeastern region would be living in 38 municipalities in the metropolitan regions of São Paulo, Rio de Janeiro and Belo Horizonte cities – it totaled 2,583,705 people (ibid, 2019).

Data provided by this important research have shown the effects of socio-political processes that link urban populations to natural hazard events. It goes from human actions intensifying climatic changes to the vulnerability and exposure of people to them, as consequence of urban territorial policies. Such effects are the reflex of an urbanization model based on mechanic views that do not take into account the diversity of natural systems, eliminate woods and humid zones, exhaust natural resources, change the landscape due to the occupation of environmentally weak urban areas, such as mangroves, floodplains, valley bottoms and supply waterbodies, and that promote the socio-spatial segregation of vulnerable populations (Mello and Ribas, 2004 apud Scolaro, 2012; Castro A., 2020).

Valley bottom urbanization in São Paulo and the prevalence of sectoral logics

Several studies were produced based on the analysis of the urbanization model adopted for valley bottoms, and it indicates the need of regulating and standardizing urban occupation based on an integrated and systemic approach, which must be understood as the only way to reduce conflicts, and financial and human losses, as one can see on a daily basis (Tucci and Bertoni, 2003; Tucci, 2007; Alvim et al., 2006; Gorski, 2010; Travassos, 2010; Alencar, 2017; Pellegrino, 1995). Even the doctrine basis of the National Policy of Protection and Civil Defense (PNPDEC) sees inter-sectoral articulations as essential for the management of public administration agents; it must follow an integrated approach applied to planning and management of urban soil use.

São Paulo City was settled in an extremely irrigated and rainy region; it had to learn to deal with flooding events since its foundation, mainly from the mid-19th century on, when it has expanded due to the power of the agricultural economy supported by coffee exports. At that time, due to the city's favorable topographic conditions, railroads were implemented on valley bottoms and it

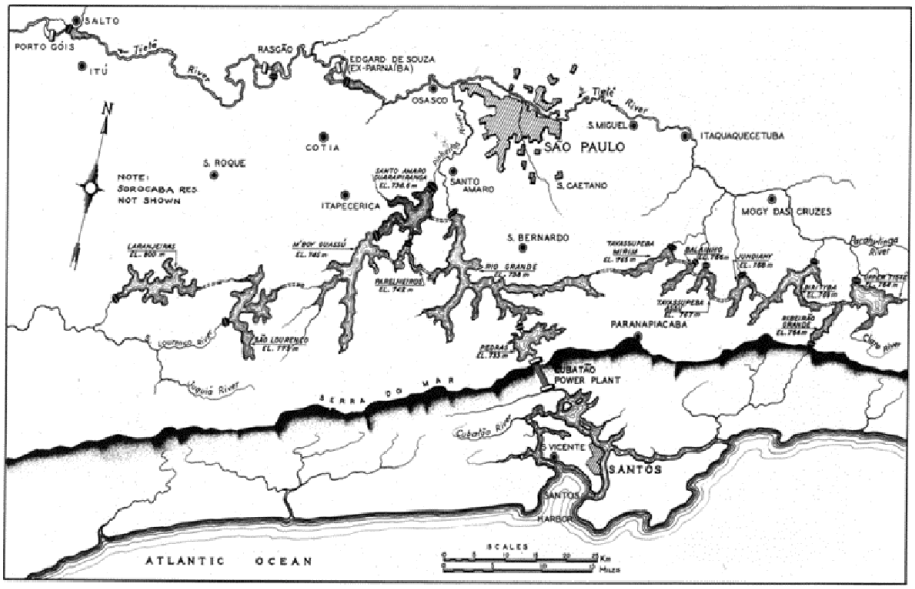
has encouraged urbanization in these areas (Franco, 2005). Changes imposed to the natural physiography of these areas, and their occupation turned flooding events into inundations, which were then featured as a complex issue to be faced by the territorial management of urban areas.

Studies, plans, projects and construction ventures focused on controlling floods and inundations became a recurrent concern for public managers since the mid-19th century; therefore, investments were made in this field. In total, 172 years have passed since the correction of Tamanduateí river during João Teodoro's administration, back in 1948. However, the association among climate, water and urbanization has been treated recklessly, either in terms of planning or management, in São Paulo City (Travassos, 2005).

The network of surface water, which was formed by rivers and brooks in São Paulo up to the mid-19th century, was used without any infrastructure projects. Demands resulting from city growth at that time forced interventions related to water supply and sanitation. This process encompassed flood control and the generation of power necessary for the industrialization process (ibid., 2005.)

In order to ensure water supply and flood control in the three main rivers in Alto Tietê[2] basin – Tietê, Pinheiros and Tamanduateí rivers –, public managers engaged in construction projects to dam some smaller tributaries, mainly of the Tietê river, between the late 19th century and the early 20th century, as well as in correcting Tamanduateí river in Glicério region (Kahtouni, 2004; Campos, 2001; Reis Filho, 2004).

Figure 1 – Schematic map of the dam system in São Paulo in the early 20th century



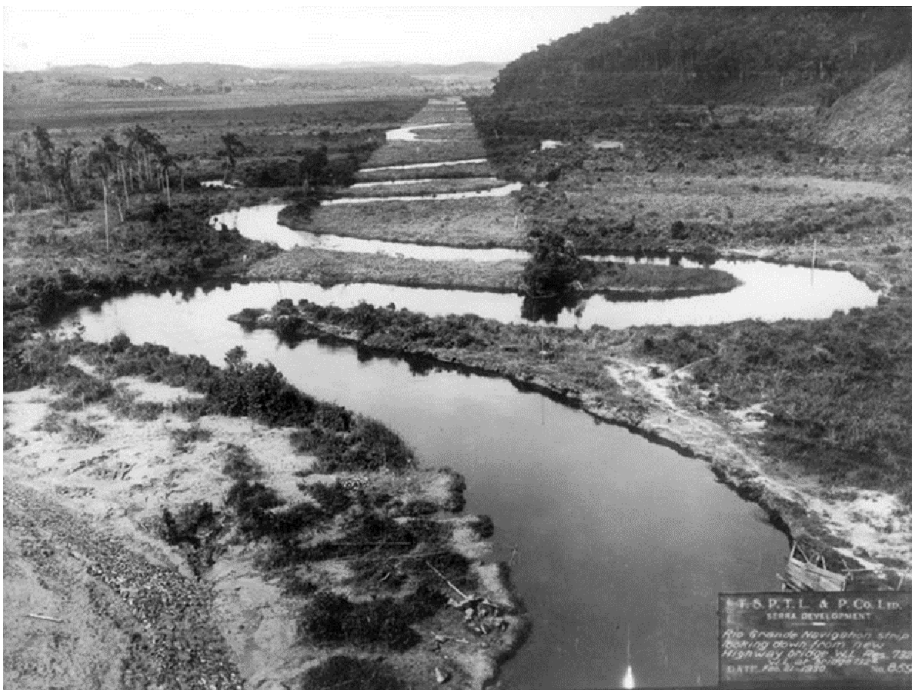
Map of the first Serra Consession based upon original studies by F. S. Hyde in 1924

Source: Franco (2005).

From the 20th century on, electric power generation also appropriated the dammed water and demanded huge construction projects, such as the correction of Tietê River's bed – between 1950 and 1960 –, as well as of Pinheiros River – between 1928 and 1950 – to ensure the volume and speed of flows heading to dams located in the municipality's Southern region. This flow had to be guided through cliffs in Serra do Mar to reach Cubatão Plant in São Paulo coastal area. These ventures were made by São Paulo Tramway, Light & Power, which was the Canadian company in charge of cable car services, and of electric power generation and distribution (Melo, 2001; Kahtouni, 2004).

Riverbed correction ventures accounted for the need of floodplains' sanitation, so rivers could be used for urban infrastructure implementation and for the urban occupation of their flooding valleys. Such interventions, which were made to ensure multiple water uses, have created a complex system that presented specific features and needs.

Figure 2 – Construction site of Pinheiros Riverbed correction in 1930



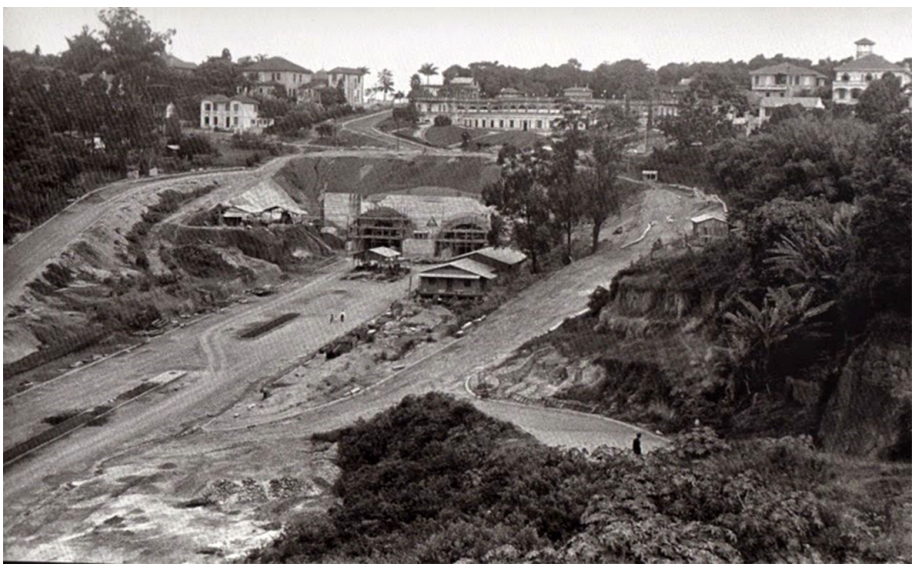
Source: Fundação Energia e Saneamento (2020).

However, given its natural conditions, this water basin had an efficient drainage system, which had flooding cycles that covered huge extensions of the valleys. It nurtured the soil and water springs in a broad water network. However, the implemented interventions broke its water regimes (Castro A., 2020; Seabra, 1987).

As a paradox, the dam projects put in place to displace power generation plants ended up worsening the flood and inundation issue, since these events reached areas that, at that time, remained free from conflict between water and urbanization (Seabra, 1987; Beiguelman, 1995; Segatto, 1995). Nevertheless, these great changes did not get limited to rivers and basins; they also regarded the structure of original reliefs in this territory.

Ab'Saber (2004) explains that the region where São Paulo was settled, which is located in the confluence between the valleys of Tietê and Pinheiros rivers, has the prevalence of Central Spike as its main feature – its peak is located in Paulista avenue. The configuration if its relief has formed intermediate landing places between valley bottoms and the highest coasts, which were appropriated for the implementation of avenues to promote internal transit through old pathways that were turned into important radial avenues.

Figure 3 – Nove de Julho avenue's tunnel construction site, and Trianon Belvedere, 1939



Source: picture by B. J. Duarte, taken in *São Paulo in Black and White* (2020).

A solution was proposed for the internal circulation problem because the high hills around the Central Spike represented an obstacle to be overcome by streets that impaired the access to neighborhood emerging in the Southern zone, close to Pinheiros River's surroundings, namely: using the gutters for Tietê and Pinheiros rivers' tributaries. It was done by building avenues on valley bottoms and tunnels, such as the case of Nove de Julho avenue (ibid.).

Travassos (2005) analyzes the main urbanistic propositions to São Paulo associated with urban rivers and their floodplains. These propositions were divided into two different phases. The first phase lasted from the mid-19th century to the early 1930s; it encompasses the sanitation stage of the main rivers' floodplains the second phase took place after the 1930s; points out how the demographic growth in the city influenced the urbanization of new areas based on the construction of road system. According to this author, the second phase witnesses the consolidated occupation system set for rivers' floodplains in place to build the so-called valley bottom avenues. This project was designed and made real by the Avenues' Plan from 1930.[3] These avenues were built in the following decades; their construction went on up to the 1970s.

Urban planning in São Paulo: environmental matters and water systems

Back in the 1960s, water supply and sanitary sewage conditions in São Paulo reached critical levels, half of the population did not have access to drinking water and only one-third of it was assisted by sewage networks. There was a great public debate about water supply and sanitation matters by the mid-1960s and early 1980s (Travassos, 2005; Alencar, 2017). The construction of Paiva Castro and Águas Claras dams in Juqueri river basin dates back to this time, and it complied with the first implementation phase of Cantareira Water Supply System,[4] which has reversed part of the water in Piracicaba's watershed. Although the implementation of the Cantareira System has fulfilled most of the demand for water supply in Grande São Paulo region at that time – this region had been growing at quite accelerated pace –, its logic followed that of the construction of Guarapiranga (1907) and Billings' (1925) reservoirs. According to Silva (2002, p. 284), "water imported from Piracicaba Basin, which is later used for urban supply, would be discharged in Alto Tietê Basin and it would aggregate at flow close to 30m^3/s and channeled through Pinheiros towards the ocean slope" to feed Billings' reservoir.

At that time, the solution was to channel rivers and brooks to build the marginal avenues (sanitary avenues), this decision was hegemonic for water courses in São Paulo City – the state and the federal governments made investments in sanitation programs. As a paradox, urbanistic plans embodied transportation and sanitation matters, but they did not follow any drain guideline. Another countersense lied on the fact that construction sites to implement the road system on river valleys did not fulfil any plan on general mobility (Travassos, 2010; Alencar, 2017; Castro A., 2020).

In addition, between the 1970s and 80s, São Paulo experienced a fast demographic expansion towards peripheral regions. Areas missing basic infrastructure were occupied by irregular allotments and slums emerged in environmentally weak areas, such as valley bottoms and spring protection areas. This process has reinforced the association between environmental and housing liabilities (Pasternak, 2010). According to Alvim et al. (2006), between 1950 and 1970, which corresponded to São Paulo's 'metropolization' and to more intense conflicts among economic growth, society and the physical medium. The implementation of a complex road system and the intense migration flow from several regions in the country – people were seeking job opportunities in the secondary and tertiary sectors – intensified the population move towards peripheral and fragile areas. This process has helped worsening environmental issues in the region. In the early 1950s, the population in São Paulo City comprised 2.155 million inhabitants, plus 500 thousand inhabitants in neighbor counties. In 1980, IBGE's demographic census recorded 9,646,185 inhabitants in São Paulo City; São Paulo metropolitan region (RMSP) recorded 12,549,856 inhabitants. Demographic rates in the 1970s pointed out the different dynamics in the core-municipality in comparison to the other municipalities in RMSP. While the population in the capital grew by 3.7% per year, the resident population in the other RMSP's municipalities was growing by 6.4% per year in the same period (Pasternak, 2010).

In 1975, *Empresa de Planejamento S/A* (*Emplasa*), which is an autarchy of São Paulo State's government in charge of metropolitan planning, provided general guidelines to drainage, water supply, sanitary sewage and garbage collection systems that were integrally analyzed and linked to several systems. It was done to review the concept of drainage from the exclusively hydraulic approach adopted for fast surface flow and transposition of flooding points, to concepts of systems integrated to drainage and sanitation plans, as well as to soil use and occupation (Travassos, 2005). The enactment of *Lei de Proteção de Mananciais* (State Law n. 898, from 1975, n. 1.172, from 1976, and State Decree n. 9.714, from 1977) also dates back to this time; it aimed at disciplining soil use in water spring areas of interest to the metropolitan area. This process forced restrictions to soil fractioning and occupation use, as well as the provision of sanitation infrastructure to 53% of RMSP as urban-control form.

Back in the 1980s, the company elaborated a preventive and normative *Plano Global de Drenagem* to ensure the proper occupation of basins that were not fully urbanized until that moment. Simultaneously, Daee launched an Urban Drainage handbook guided by these same principles, which exclusively refer to linear parks as solution for drainage issues; it proposed the "gathering of urban plans and drainage planning and of upstream river water prevention and floodplains' maintenance to linear parks" (Travassos, 2005, p. 74).

Soon after, other solutions associated with soil use and occupation type started to be taken into consideration for flooding areas. They promoted the conceptual review on the actions regarding water courses, drainage and combat to flooding events. This

questioning process led to reviews on the idea of channeling rivers and brooks as hegemonic form of public action (ibid.).

However, these concepts did not influence the actions taken and did not immediately reflect on São Paulo's urban planning. Such a statement was proven by the fact that while plans and committees were organized to discuss soil use planning matters and urban water management, the City Hall put in place its *Programa de Canalização de Córregos e a Abertura de Avenidas de Fundo de Vale*, in 1987 (Decree n. 23.440, from February 16, 1987). This program faced adjustments since its launching, it was modified by Decree n. 32.995 (February 12, 1993) and its name was changed to Brooks Channeling, Roads Implementation and Valley Social Funds Program, also known as Geoprocav.This program was run by the Urban Infrastructure Secretariat; it aimed at promoting and implementing brooks' channeling, and new roads – including the environmental and social recovery of valley bottom, based on quite restrictive actions mostly linked to treating urban infrastructure (Castro A., 2020).

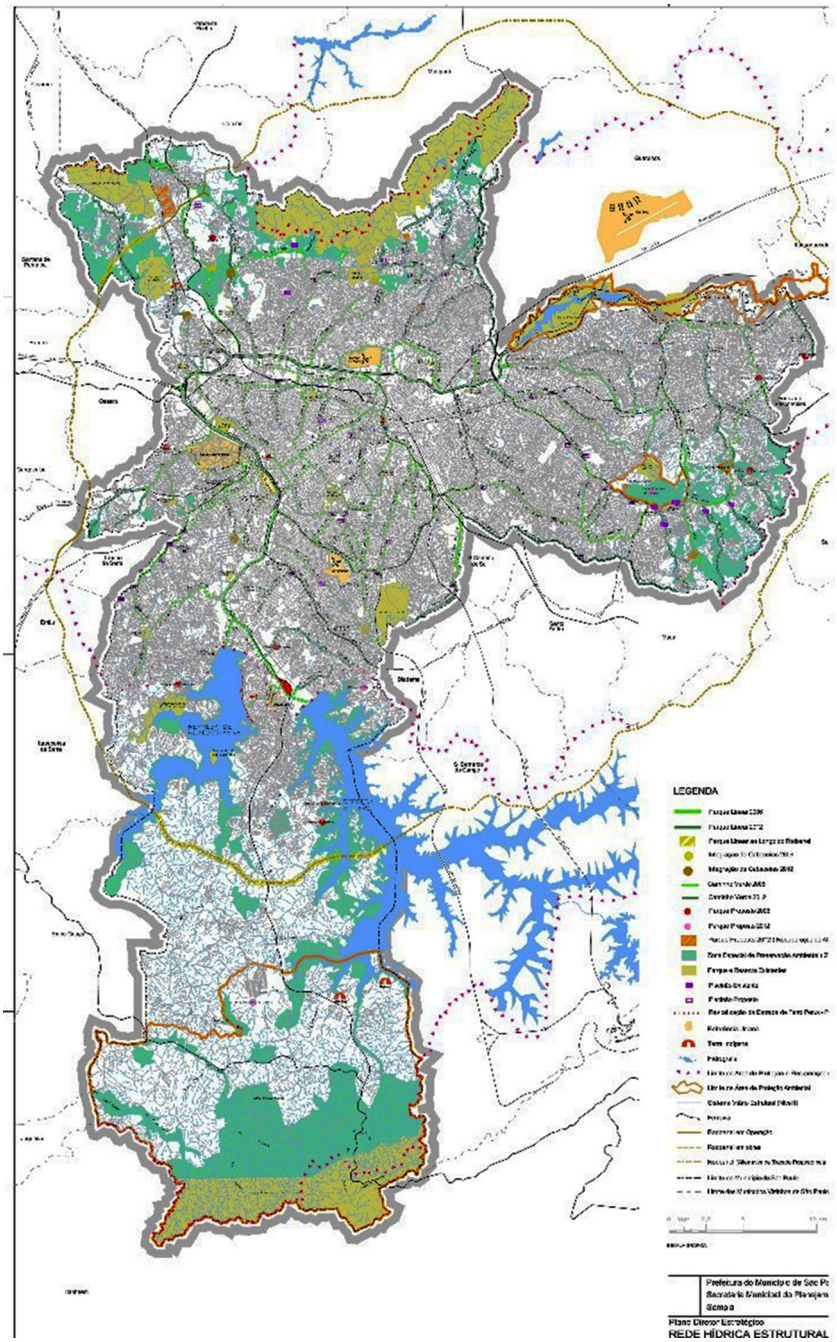
São Paulo urban planning held new parameters based on the influence of socio-environmental matters that have prevailed from the 1990s onwards, at global scale, as well as in Brazil, from the 2000s on, due to the recently published City Statute. It adopted the concepts of right to the city and of the social function of property, as well as embodied participatory social policies that opened space for environmental issues as public agenda (ibid.).

The 2002 *Plano Diretor Estratégico* (PDE 2002 – Municipal Law n. 13.430, from September 13, 2002) put the environmental and water resources issue in the mainstream of urban planning by determining the review and articulation of urbanization policies in four structural networks, among them, one finds the water network (Figure 4). It encompassed rivers, brooks and thalwegs; therefore, it should be the target of urban interventions for environmental recovery, drainage, vegetation recovery and sanitation to promote water absorption, retention and flow, and the interruption of the soil sealing process. Thus, this action was incorporated to a set of integrating elements (housing, social equipment, green areas and public spaces) aimed at promoting "the city's conciliation to its natural territory" (Tripoloni, 2008, p. 196).

The articulation of environmental policies to urban development was set by a territorial division determined in two macro-zones, namely: one for environmental protection and the other for urban structuring and qualification. Therefore, urbanization was consolidated and subjected to sub-city halls regional plans, so that it was about to encompass and respond to several scenarios in city territories. Actually, in regions housing the structuring and urban qualification macro-zone, one finds all river valleys, and good part of them are subjected to human action, a fact that opened room for conflicts between their occupation and flooding events (Castro A., 2020).

Therefore, PDE proposed to create *Programa de Recuperação Ambiental de Cursos de Água e Fundos de Vale*, which encompassed a whole set of actions coordinated by the Municipal Planning Secretariat (Sempla), by the Municipal Environment Secretariat (SMMA) and by the Municipal Housing Secretariat (Sehab), with the participatory action of local communities and the private sector.

Figure 4 – 2002 PDE, Structural Water Network



Source: São Paulo – Prefeitura Municipal de São Paulo (2020a).

This program aimed at recovering degraded areas, re-assessing populations living in vulnerable areas on the sides of rivers and brooks, improving the local road system, promoting environmental sanitation actions and locating social equipment in parks' surroundings (Travassos and Schult, 2013).

The 2002 PDE embodied the linear park concept as one of its main strategies to simultaneously fulfil urban demands and live with systematic flooding events in the region. Since it was a multi-functional approach, the strategy adopted to implement linear parks determined by the 2002 PDE was an attempt to gather several public management bureaus in their implementation. It was observed in plans and programs concerning environmental protection issues elaborated since 2002, as well as the access to green and leisure areas, sanitation, drainage and housing. It was similarly observed in *Programa 100 Parques for São Paulo*, in the Program for the Environmental Recovery of Water Courses and Valley Bottoms (Córrego Limpo), in the Municipal Plan for Basic Sanitation in São Paulo and in *Programa de Urbanização de Favelas* (Travassos and Schult, 2013).

Programa 100 Parques was created in 2005 and implemented 56 new parks; it reached the total number of 90 municipal parks, along with the previously ones (São Paulo, 2012). The adoption of the linear parks' concept was consolidated as solution to protect APP areas, to the occupation of risk areas and to combat flooding events and brook sides' recovery. It also emerged as culture promotion and leisure option for the surrounding populations. However, as a paradox, the selection of perimeters adopted for linear parks' implementation did not encompass areas presenting the highest hydrological risks as parameter, or inserted flood spots in it, because the municipality did not yet count on a drainage plan.

Programa Córrego Limpo, launched in 2007 by the partnership between the City Hall and Sabesp, aimed at broadening the depollution of water in basins in São Paulo municipality. It was acknowledged that watersheds that had faced the full implementation of sanitary sewage networks yet showed some degree of river pollution due to the discharge of clandestine sewage, to the inappropriate disposal of solid waste, to lack of sewage-collection network maintenance or to noon-systematic maintenance in them because of construction sites in course in the region (Travassos and Schult, 2013; Castro A., 2020). The Program was supported by the implementation of linear parks and, from the conceptual viewpoint, it acknowledged that "by structural construction sites, one must consider operational actions such as the elimination of clandestine connections, and the maintenance of environmental education programs" (Travassos and Schult, 2013, p. 301) that comprise a whole set of non-structural measures that are more effective to urban water management when they are associated with conventional drainage and sanitation systems.

This program has been operational since 2007, although it faced few interruptions; however, it related sanitation to the maintenance of 161 brooks in São Paulo State capital by late 2020 – it included the maintenance of water quality monitoring in 144 of these brooks (oxygen biochemical demand, OBD – mg/l) (Sabesp, 2021).

The *Plano Diretor de Drenagem Urbana* was included in *Plano de Metas* 2013-2016, although it should be under the command of a "municipal water entity" and have technical, legal and institutional connection to other municipalities composing the Alto Tietê Basin, as well as to federal and state managerial bureaus closely associated with water resources, sanitation and environmental management.

It is worth highlighting that, at that time, state law n. 7.663 (from December 30, 1991) and federal law n. 9.433 (from January 1, 1997) were already enacted. They provided on water resources policies based on the following principles: adoption of watersheds as physical--territorial planning and management units, and the integration of plans and programs to municipalities belonging to the same basin. However, this dreamed integration did not become true at that time and it is still under construction.

The bill focused on the *Plano Municipal de Habitação* (2009-2024), which was not approved, was pioneer in defining the housing policy and fundamental principles related either to land and building matters or to urban, environmental and infrastructure issues. Accordingly, among the parameters adopted to classify priorities, one finds the classification based on precariousness criteria and on water micro-basins, whose variables were added to three great dimensions: infrastructure, undercut or landslide risks, and health. The actions taken in valley bottoms for slums' urbanization programs were substantiated by settlements' maintenance. These actions were put in place through infrastructure implementation to avoid removing these populations, they could represent the maintenance of a risk situation if they were not fully implemented in locations vulnerable to flooding events – it meant the creation of a new liability.

Among goals exposed in the 2014 PDE strategies (municipal law n. 16.050 from July 7, 2014), one finds the adoption of the environmental agenda, which emerged as supporting character in the city's development. It took river valleys and axes in water networks as strategies to guide city growth by promoting densification in the surroundings of public transportation facilities and in regions presenting urban infrastructure networks and systems. Valleys of the Tietê, Pinheiros and Tamanduateí rivers were appropriated as metropolitan structuring axes; they were inserted in the Urban Structuring and Qualification Macro-zoning, which had featuring and perimeter similar to those proposed by the 2002 PDE. However, they lost their amplitude and priority as urban sustainability target.

Based on the previous plan, river valleys were seen as strategic regions for the inter-sectoral integration of urban management achieved by means of linear parks' implementation. The 2014 PDE, in its turn, opened room for an approach referring to soil use ordering in this region, which had prioritized urbanization to the detriment of water capacity recovery in valley bottom areas based on urban densification and increment of public transportation systems – it did not mention environmental issues.

The 2014 PDE launched *Programa de Intervenção Urbana*, also known as PIU, as new urban transformation and ordering instrument applicable to densification and transformation axes. It regarded technical studies elaborated

by the public power to promote ordering and urban restructuring in underused areas with transformation potential in São Paulo City. This PDE proposed the creation of PIU Arco Tietê, PIU Arco Pinheiros and PIU Arco Jurubatuba, which lay on the edges of these rivers. They aimed at urban, environmental and water recovery in these regions. Studies were carried out by taking into consideration the existing conflicts between soil occupation and sealing in these areas, as well as the impacts that have led to flooding events.

These proposals considered interventions that covered drainage systems and the recovery of brooks, green areas, public spaces and mobility. However, it was possible observing little contribution of them to landscape and riverbeds' requalification in areas close to the road system; this finding reinforced the prevalence of vehicles' mobility.

Yet, in 2016 *Fundo de Desenvolvimento Urbano* – Fundurb – was regulated by Decree n. 57.547 from December 19, 2016. It is an important mechanism to finance urbanistic and environmental plans, programs and projects that integrate or derive from the direction plan, which works with resources obtained from the sales of granting to the right of building due to onerous grant operations provided by PDE instruments. Castro and Alvim (2018), by analyzing Fundurb's applications between 2013 and 2016, have observed that most of the contemplated construction sites had associated urban drainage services with both the remediation of geological and waterbodies' risks (brooks and steams), with roads' repair and paving, and with sites, to make adjustments in public squares based on landscaping and on the installation of sports and leisure equipment.

Finally, among advancements and steps back in the application of concepts concerning socio-environmental issues, the urban planning in São Paulo municipality favored paradigms and even implementation strategies that face conflicts created by the valleys' bottom urbanization model, These advancements and steps back did not contemplate a place for waters and poor populations in the urban space; therefore, they remain exposed to all sorts of risks, the interest in mobility and occupation expansion remain as real estate strategy.

It is possible observing that there is a relapsing management issue that devalues public assets. It goes beyond the persistence of obsolete concepts associated with urban water and outdoor spaces' management, as well as with São Paulo's environmental features. Since 2017, this municipality has been witnessing advancements in the privatization of important parks and public spaces. These privatizations are excused by the "efficiency of the private sector"; this justification was supported by lack of structuring in parks' managerial councils, which have been essential participatory instances since the project was defined, mainly because of the valuing, maintenance and close 'surveillance' of the quality of these spaces – they are promoted by the public use of these spaces.

If one considers the unquestionable climate changes and the impacts that have been caused by the urbanization phenomenon at global scale, it is possible stating that the urban planning project faces challenges related to overcoming sectoral models and the discontinuity of public policies.

Despite the proper and innovative legal framework in Brazil, except for isolated experiences, Brazilian cities keep on expanding

based on the orientation supported by the soil occupation and planning model that favors the most powerful sectors and agents. Such orientation takes into account environmentally weak areas, ruins their natural patrimony and exposes their populations, mainly the poorest ones, to all sorts of risk situations and socio-environmental vulnerabilities.

Natural Hazard risk management in São Paulo and the sectoral logics

The Brazilian policy

Natural Hazard risks management in Brazil is adjusted by *Política Nacional de Proteção e Defesa Civil*, also known as PNPEDC (law n. 12.608 from April 10, 2012), which provides on civil protection and defense actions organized by prevention, mitigation, preparation, response and recovery actions regarding specific responsibilities that are, in their turn, based on a systemic and continuous management. This management type organizes itself according to standards by *Sistema Nacional de Proteção e Defesa Civil* – Sinpdec, which is managed by municipal and state civil defense bureaus and by other sectoral and support organs. The National Civil Protection and Defense Secretariat Sedec/MI – is its main organ, but it does not define any minimal structure for them, since it preserves municipalities and states' autonomy (Brasil, 2012).

PNPDEC addresses the need of articulating sectoral public policies for territorial ordering, urban development, health, environment, climatic changes, water resources, geology, infrastructure, education, among others, as well as civil society's representatives, in order to build a local system to manage civil defense and protection policies and actions. These measures aim social, economic and environmental recovery, as well as the reconstruction of ultimate infrastructure and buildings (ibid.).

Risks management presupposes a broad set of structural and non-structural measures that hold psycho-social aspects, such as material support actions to fulfil the basic needs of the affected ones, actions to encourage hope towards the recovery of daily-life activities; as well as economic aspects: subsidized credit lines, fiscal incentives, tax-free policies and other measures regarding the productive capacity to generate income and to offer new job positions; environmental aspects: measures to recover degraded ecosystem due to hazardous events; and structural aspects: infrastructure reconstruction, buildings and facilities (ibid.).

These losses worsen in Brazil due to lack of programs and policies for risks management and damage mitigation, which are tools to recover, reinforce and reestablish economic activities in affected areas and populations, mainly the ones affected by hydrological events, since they are the most frequent ones and generate material losses (Castro A., 2020).

Reconstruction is an important part of recovery in scenarios affected by hazardous events; therefore, PNPEDEC (2012) highlights that such a phase must be supported by the mandatory transference of federal resources destined to the full or partial recovery of infrastructure, buildings, and public or community facilities. Thus, these actions

must be planned from the perspective of improving the original conditions in affected areas and of incorporating preventive aspects to them. These preventive aspects demand interventions based on the analysis of disaster scenarios capable of showing all factors influencing their occurrence, as well as current and future risks.

Among the observed challenges, one finds low quality of basic projects or incomplete ones; changes made in construction projects that ended up generating high costs for expenses support, and, most of all, the maintenance of inappropriate rules and standards set for territorial ordering, which previously allowed the occupation of risk areas by human activities and buildings.

São Paulo and risks management: advancements and challenges

One of the first measures adopted by cities to manage risks lies on mapping conflict areas and on reordering their occupation by establishing new occupation rules and determining responsibility limits for the public power and the population. Accordingly, the current approach acts in establishing a combination of structural and non-structural actions, including adaptation to planning and construction laws and standards, as well as warning plans and post-event support.

The role and structures of municipal civil protection and defense bureaus account for articulating reconstruction along with sectoral bureaus at their governmental level. These organs are in charge of institutional and sectoral competences referring to construction sites, finances, social assistance, urbanization and the environment (São Paulo, 2018).

São Paulo municipality created São Paulo Municipal Civil Defense System in August 1978 through municipal decree n. 15.191/78 to promote integration efforts, use the existing resources and provide proper assistance during public calamity situations. Based on municipal decree n. 15.539/78, this system comprises two dimensions, namely: Municipal Civil Defense Commission (Comdec), which is linked to the State Civil Defense Coordination – it is composed of one representative from each municipal secretariat and from the military assistance of the mayor's office, and to the District Civil Defense Commissions (Coddec) that have free access to all Regional Administrations (ibid.).

In August 2006, this system was reorganized through municipal decree n. 47.534/2006, so it was adjusted to the standards set by the National Civil Defense System, which are listed in federal decree n. 5.376/2005. Comdec adopted the natural and anthropic hazardous event reduction as its goal; its actions included not just rescue and help, but assistance actions and the reestablishment of social normality, as well as preventive actions aimed at avoiding or minimizing hazardous events by mapping geological and hydrological risk areas.

Comdec was in charge of coordinating help and rescue actions in areas affected by hazardous events; it also counted on the Municipal Civil Defense Council, known as Consdec, which comprised representatives from several municipal secretariats. It had to make sure about the articulation of public policies related to civil defense and to other sectors of the Municipal Administration. This organization granted Comdec with a much more favorable position, since sub-

city halls have contact with all secretariats of the municipal city hall and are quite close to the mayor's office, as well as to the territory and its communities. However, in April 2018, municipal decree n. 58.199/2018 became a specific unit of the Municipal Urban Security Secretariat. Accordingly, it lost a broader articulation and got limited to actions to respond to natural hazard events. It was no longer a planning unit focused on establishing preventive actions that were not limited to structural measures or emergency actions (ibid.).

Important conceptual inquiries were adopted in Condec's deliberations after the 1988 Constitution was enacted and after the State Water Resources Policy (São Paulo). Its participatory profile stood out among the most expressive ones, for example: systemic approach in risks management; adoption of watersheds as territorial units for the establishment of preventive actions regarding flooding events and inundation, and the organization of communities to participate in discussions related to strategic actions and preventive measures to be adopted in risk areas. These measures aimed at ensuring, not just the adhesion to, but the permanence in preventive programs, regardless of the administrative management.

Since 2001, the Risk Management Plan and the Summer Rain Preventive Plan (PPCV) have been treated as permanent action in São Paulo; they aim at providing support to preventive geological and hydrological risks actions. The technological risk situations are addressed as accidents in urban infrastructures (water, electric power, gas and sewage) and in systems aimed at transporting chemical fluids and products through roads and railways crossing the city – only recently the city incorporated risks management plans (Malheiros Figueira and Candeias de Almeida, 2020). Occurrence records are carried out and the specific conditions of each region are assessed to outspread warnings; in this case, the emergency state is issued (São Paulo, 2021).

Reports in the last PPCV, 2019-2020, provide records of occurrence based on their nature. These reports corroborate the indices presented in the assessed studies and in reports by international risk monitoring bureaus that point out the great incidence of floods and inundations (ibid.).

However, vulnerabilities, disarticulation and inconsistency are notable; they put pressure over this important program to prevent inundations.[5] São Paulo municipalities do not count on a general map of inundations or on a system of historical and georeferenced records for these locations; only flooding events that lead to interruptions in vehicles' flow in public roads have records registered in systems georeferenced by *Companhia Estadual de Tráfego* (CET). This scenario evidences the persistence of wrong urbanization concepts adopted for valley bottom areas; these concepts are substantiated by public actions and policies that favor vehicles' mobility and flow to the detriment of populations living in these areas in São Paulo City – these areas are systematically exposed to risks and losses (Castro A., 2020).

With respect to the availability of data for free public access, one can find the Geotechnical Letter of São Paulo Municipality, which can be consulted in and downloaded from the Geosampa system.[6] It counts on

georeferenced data about risks' evaluation due to the assessment and classification of areas described in the 2010 mapping; therefore, it demands up-dating.

The aforementioned frame led to the need of building a prevention system and of supporting areas exposed to risk situations. However, the built system reflects an exclusion and non-prevention culture, which neglects populations exposed to risks and does not respect systems and environmental dynamics (ibid.).

The PMRR review was not fully performed, but it was carried out until December 2020; only information from 11 sub-city halls were up-dated, according to report by the Civil Defense of São Paulo City Hall published on its website (São Paulo, 2020b). It also informs that the screening of risk areas is still being done by the Municipal Urban Security Secretariat (SMSU) – it is directly in charge of the Municipal Civil Protection and Defense Coordination, also known as Comdec.

Records of risk areas occurrence and removal are kept by Comdec, at the 24-h Integrated Control Center of the City (CCOI), which manages Technical Advises for Construction Ventures and Services by the Municipal Sub-City Halls Secretariat. However, information about occurrence records is quite recent, as expressed by information collected from interviews carried out with Comdec members. As for removals of households located in risk areas, the Municipal Housing Secretariat is in charge of controlling housing assistance, and it reinforces a disperse and disarticulated action.

There were no advancements regarding the implementation of an inspection system for risk areas. Based on risk areas' mapping, which is by the way obsolete, risk situations must be monitored according to occurrence records and act by activating sub-city halls' inspection units – Sub-city halls account for all sorts of assistances within its areas of action. The structuring of this Secretariat, itself, which encompasses issues concerning Public Security and Risks Management, shows inconsistencies and misunderstandings about the importance of these public policies. Matters regarding public security do not directly concern the prevention of hydrological and geological risks, which are prone to actions and programs involving soil occupation processes. The fact that public agents such as policemen, firemen or even the military gather to help victims in case of natural hazard events does not feature the nature and object of risks' prevention policies. Water and soil cannot be policed. Functioning, without up-dated data and the consolidation of a system to monitor and map risk areas, points towards that the performance of these bureaus is not substantiated by planning, it is not based on prevention, and is limited to give support to emergence situations (Castro A., 2020).

Because most of these occurrences take place in vulnerability, and in geological and hydrological instability areas occupied by poor populations, it is not hard acknowledging the reflexes of the historical negligence with planning and public management on all urban fabric.

Final considerations

The actions taken by public management bureaus concerning the ordering of river valleys' occupation was marked by the sectorization and disarticulation that remain in place, even in the recent history of São Paulo urbanization. Although from the 2000s on the environmental agenda was addressed in discourses about public policies by direction plans and sectoral projects, the power of private agents remains in the mainstream of the agenda that must be materialized as part of privileges favoring these sectors that, in their turn, have historically set how, to whom and where São Paulo City grows and organizes itself.

From the direction plans' viewpoint, the most recent advancements in 2002 PDE and 2014 PDE are unquestionable. The 2002 PDE was pioneer in defining the city's water network as the very urban structuring axis and a set of linear parks that should privilege water courses, which are mostly buffered by the road system. The PDE 2014, in its turn, defined river valleys located in the water networks' axes of large rivers in the city as priority territories for metropolitan development in association with densification strategies adopted for public transportation axes and for regions presenting urban infrastructure networks and systems.

Despite the observed improvements, the recent experience encouraging the private initiative to develop PIUs shows, once more, that the exploration of soil value by the real estate market still prevails. Such a value has little or no counterpart from public investment itself. This process evidences the capture of good public planning and management instruments to only fulfil private interests.

Processes to restructure drainage infrastructure systems, in their turn, are not fully covered. Because the drainage system is competence of the city hall; therefore, little is done by private concessionaries, which oversee managing drinking water, sewage and urban cleaning infrastructure networks. As aforementioned, risks management nowadays is taken as public security issue, as if it was possible for urban water to respect the power of police departments.

Analyses about risk management actions taken by federal bureaus point out that still we have a lot to advance either from the regulation or, mostly, from the managerial viewpoint. Lack of clear determination about the responsibility of State agents for financial support and covering to overcome material damages deriving from hydrological events were actions not incorporated to the construction of legal frameworks or to risks management. Still, concepts guiding the neoliberal policies to reduce the presence of State prevails broadens the participation of private agents who only care about this complex territory – represented by São Paulo City. Oftentimes, these areas, which are much more valorized, are less exposed to the effects of hydrological and geological hazard events.

The fact that Civil Defense bureaus do not count on essential inundation maps to substantiate prevention studies focused on these events, as well as on a digital system to register events and calls, evidences the

socio-spatial segregation that still prevails in urban soil management in São Paulo. Such a basic structuring has to be faced in order to guide the management of São Paulo territory by adjusting and embodying the hydrological dynamics and urban rivers in its agenda.

The Emergency Management Center, known as CGE, by São Paulo City Hall has been responsible for monitoring the meteorological conditions in the Capital since 1999. It was launched in November 1999 after a large scale inundation in the Anhangabaú Tunnel region, in March of this same year. This bureau was in a room in the headquarters of *Central de Operações da Companhia de Engenharia de Tráfego* (CET). It acts in partnership with the Municipal Civil Defense Coordination (COMDEC) to prevent the harming effects of rainfall. This center stores records of inundation and flooding points, as well as keeps a website for public access. The fact that CGE acts in partnership with and under the guardianship of CET evidences how the vehicles circulation issue and transportation remains as priority to the detriment of risks' prevention. Finally, urban soil expansion and exploration in the municipality is favored by the real estate sector. This process is articulated to individual transportation means displacement, which impairs the socio-environmental agenda.

Therefore, it is worth giving back to Comdec the articulating role of managing risks São Paulo, to reach the goal of preventing, mitigating, preparing, responding to and recovering different risk situations in the city by adopting an inter-sectoral and articulated approach to sub-city halls. It is so, because sub-city halls are directly related either to the Mayor's Office or to the territory itself.

It is important highlighting that some cities in Brazil and on the globe have been updating their hydrological and geological hazard events data, by considering the unquestionable influence of climatic changes on the rainfall regimes. Accordingly, the following cities stand out in the world scenario: Blumenau, Santa Catarina State; and New York, in the USA.

Blumenau incorporated limitations to flooding areas to its Direction Plan back in 1989 by articulating a municipal civil defense plan to sanitation, housing, environment, water resources and territorial ordering plans. These municipal hydrological risks prevention plan is in compliance with the "Integrated Plan for the Prevention and Mitigation of Natural Hazard Events risks in Itajaí Rivers' Hydrological Basin" (PPRD-Itajaí) – which shows regional scale and is under the responsibility of the state government. Itajaí-PPRD results from an action of Santa Catarina government, which was taken along with the International Japanese Cooperation Agency, also known as JICA

New York City, in its turn, has been updating and making normative adjustments in soil zoning, and it has been done to reduce the impacts from extreme hydrological events. Standards in *2013 Inundation and 2015* Recovery aimed at facilitating the adjustments of construction sites to fulfil the minimal requirements set by construction patterns resistant to inundations.

São Paulo, despite the pointed out institutional advancements, still deals with these matters without integrated planning, without the support of up-dated material data, with reduced teams. All these features highlight the historical delay that affects lives, and material and financial resources, on a yearly basis, at every rainy season. Given the recent climatic changes, the risk of flooding events in the city is still growing, and it points towards an uncertain and non-sustainable socio-environmental future.

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Notes

(1) The PhD thesis was presented by Castro (2020) at PPGAU/UP, it is part of a broader research called "Urbanization Projects of Precarious Settlements and of Environmental Protection Areas: dimensions of sustainability", which is coordinated by Angélica T. Benatti Alvim and funded by Fundo MackPesquisa and CNPq (edital Universal 2018).

(2) The geographic limits of Alto Tietê basin (BAT) almost entangle the managerial limits of São Paulo's metropolitan region (RMSP) (Alvim, 2003).

(3) In 1930, Engineer Francisco Prestes Maia elaborated Plano de Avenidas in order to guide the city's development. Based on the "haussmannian" model, Prestes Maia proposed a road system capable of fully remodeling the city, which would be designed based on perimeter radial structure – the irradiation perimeter -; this is a formal model that should be adjusted to the city's topographic conditions. In 1938, Prestes Maia became the mayor and put his project in place, he implemented quite significant actions to the city, such as kept on channeling Tamanduateí River, enlarging Rangel Pestana Avenue, extending Rebouças Avenue, prolonging Pacaembu Avenue until reaching Tietê River and Nove de Julho Avenue by implementing a tunnel crossing underneath Paulista Avenue, among others. If, on the one hand, the Avenues' Plan can be seen as an instrument to picture São Paulo's modernization, on the other hand, it accounted for its unlimited expansion and for the model adopted to occupy the valley bottom avenues. (Abascal, Bruna, Alvim, 2007).

(4) Nowadays, Cantareira Water Producer System, one of the biggest of its kind in the world, produces 33 m3/s of water and supplies 8.8 million people in RMSP. Its conception encompasses the transposition between two watersheds; it imports water from Piracicaba watershed to Alto Tietê basin. Of the 33m3/s produced by this system, only 2m3/s are produced in Alto Tietê basin, by Juqueri River; 22m3/s come from Jaguari-Jacareí reservoirs, whose basins are mostly inserted in Minas Gerais State – the remaining water is found in Piracicaba River basin. Cantareira System management is ruled by the National Agency of Waters (ANA) and by the Department of Waters and Electric Power of São Paulo State (Daee), (ANA, 2021).

(5) The Drainage Book has been developed; it encompasses the Municipal São Paulo Water System Management Plan – PMAPSP. These books provide maps of inundations in water sub-basins in São Paulo municipality which are elaborated by the Technical Hydrological Center of USP Polytechnical School. It also presents data, information, studies and the proposition of measures to control critical events. So far, books about 12 of the 186 sub-basins that are catalogued by the city hall were elaborated and published. Available at https://www.prefeitura.sp.gov.br/cidade/secretarias/obras/obras_de_drenagem/index.php?p=230496.

(6) Available at: http://geosampa.prefeitura.sp.gov.br/PaginasPublicas/_SBC.aspx. Accessed on: December 8, 2021.

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