

Mainstreaming climate adaptation in the megacity of São Paulo, Brazil

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ABSTRACT

City governments worldwide are increasingly introducing adaptation actions and climate responses in their policies and agendas, but the speed and success of these initiatives vary widely. Understanding these interventions, barriers and opportunities for urban adaptation remains a challenge for scholars and policy-makers. In this paper, we assess climate adaptation policy in the megacity of São Paulo, Brazil, paying special attention to missed opportunities and potential synergies. We focus on climate policies and urban interventions in São Paulo, specifically on the analysis of documents related to the Municipal Climate Change Policy (launched in 2009) and New Master Plan (concluded in 2014). We describe local responses to climate change already implemented in the city and explore some of the factors that affect its adaptation. We argue that although the megacity has recently implemented innovative urban policies and a set of municipal actions that aim to overcome many of the city's challenges, São Paulo is missing an opportunity to mainstream climate change to improve its adaptive capacity. In exploring some of the local initiatives implemented in recent years, we seek to understand responses to climate change that emerge in Brazilian cities, particularly considering that cities learn from each other to adapt.

1. Introduction

City governments worldwide are increasingly introducing adaptation actions, but the speed and success of these initiatives vary widely. While early adopters, such as Rotterdam and New York City, have actively and openly placed climate adaptation in their governmental agendas (Mees, Driessen, & Runharr, 2012; Rosenzweig et al., 2011), action in most cities, especially in countries where climate change action is lower priority or politically controversial, has lagged (Kalafatis & Lemos, 2017; Woodruff & Stults, 2016). In many contexts, adaptation-related action is mainstreamed into city policies through “experiments” embedded in the city's specific context and justified through positive frames such as (i) how innovative policies on climate change help cities meet their own goals and reduce risks (Anguelovski & Carmin, 2011; Basset & Shandas, 2010); (ii) how initiatives on climate change positively distinguish cities, promote their profiles, and elevate their political leadership (Anguelovski & Carmin, 2011); and (iii) how actions on climate issues can help cities achieve other goals such as green or sustainable initiatives, social justice, reduction of potential costs, support economic development, as well as

attract investments and funds (Aylett, 2014; Barclay et al., 2013).

With more than 12 million inhabitants, the Brazilian city of São Paulo is the largest urban conglomeration in South America (IBGE, 2016) with 15% of its residents living in precarious settlements (CEM/Cebrap & Fundap, 2013). It is also the largest municipal economy in Brazil (GDP – US\$ 175 billion, SEADE, 2013) and the center of a metropolitan region comprising 39 municipalities and 20 million people. Defined as one of the 31 megacities globally (United Nations, 2016), São Paulo is located in the state of São Paulo, the largest in terms of population and economic development, and the leading state on climate adaptation strategies (Simões et al., 2017).

Similar to many megacities in less developed regions, São Paulo concentrates both the resources and problems that plague urban systems, making them critical cases to understand opportunities and constraints for mitigating and responding to climate impact (Meeron & Newell, 2016; Seto, Sánchez-Rodríguez, & Fragkias, 2010). This complexity also challenges straightforward assessments of success and failure, with cities often showing both in different policy areas, including adaptation. On the one hand, São Paulo, as the richest city in Brazil, combines a leadership role in scientific research in the area of

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climate change (FAPESP, 2017¹; Barbi, 2015) and boundary organizations (Graham & Mitchell, 2016) that can connect academics to policy (Di Giulio et al., 2017), transnational interaction that helped the city establish a legal framework (Setzer, Macedo, & Rei, 2015), and institutional and financial capacity to undertake climate change actions (Martins & Ferreira, 2011). On the other hand, São Paulo struggles with land-use planning and curbing CO₂ emissions as well as preventing and responding to climate-related impact, such as flooding, landslides, drought, and heat island effect, that seriously affect its population and economy (Marengo et al., 2015; Nobre et al., 2010; Setzer et al., 2015). Because adaptive capacity is about combinations and experimentation in cities, and adaptation is happening everywhere with different degrees of success (Bulkeley, 2010; Bulkeley & Broto, 2013), there are many pathways for designing governance arrangements to achieve more efficient climate adaptation policy-making (Huang-Lachmann & Lovett, 2016). In this sense, São Paulo may be seen as an example of the complexity of urban systems in that they may simultaneously combine experiments and innovations with tremendous deficits.

Building upon a literature review focused on climate policies and urban interventions in the megacity of São Paulo and interpretation of documents related to the Municipal Climate Change Policy (launched in 2009) and New Master Plan (concluded in 2014), in this paper we describe local responses to climate change already implemented in the city and explore some of factors that affect its adaptation. We argue that although the megacity has recently implemented innovative urban policies and a set of municipal actions that aim to overcome many of the city's challenges, São Paulo is missing an opportunity to mainstream climate change in strategies to improve its adaptive capacity. In the next section, we review the literature that supports our analysis. Next, we present local climate projections and some interventions that have emerged to deal with climate change. In the following section, we discuss the factors that affect the city's adaptive capacity and suggest where more research might be needed to inform climate policy. Finally, we discuss some opportunities for future actions in addressing climate change in São Paulo. With this paper, we seek to contribute to the literature related to the local dimension of climate change and adaptation, highlighting the synergies between urban development, infrastructure, and adaptation responses.

2. Policy experiments and climate adaptation

Ryan (2015) argues that local governments are more likely to develop and advance climate-friendly policies if they can be framed in relation to local problems and generate other socio-economic or environmental benefits. Aylett (2014), analyzing the International Council for Local Environment Initiative (ICLEI) global survey reports, points out that promoting sustainable urban development and improving communities' quality of life are among the top motivations for municipal governments to adopt and implement climate policies. Kalafatis and Lemos (2017), in examining drivers of climate adaptation in over 300 mid-size cities in the US Great Lakes region, find that being part of a large metropolitan area and friendly competition between cities to attract people and resources are great motivators for climate-related action.

Climate adaptation can be (and often is) integrated into existing policies and actions, such as urban planning, water resources management, and public health. Uittenbroek et al. (2014) highlight that, in contrast to the “dedicated approach” where climate change is seen as a new policy domain, mainstream responses to climate adaptation occur through seeking synergies between existing policies and resources. Climate adaptation is considered something that adds value to other cities' purposes. In contexts where this mainstreaming can be politically

difficult, cities often ‘hide’ adaptation action behind more palatable initiatives, such as sustainable development or the green economy, in what some scholars have called ‘adaptation by stealth’ (Vang Rasmussen et al., 2017).

In Brazil, where climate models project serious negative social and economic impacts in this century (Ambrizzi et al., 2012; Darela-Filho et al., 2016; Magrin et al., 2014), particularly in urban areas (Hogan & Marandola, 2009; Nobre et al., 2010; Ribeiro, 2009, 2010; Vargas, 2011), more attention has been paid to mitigation than adaptation. While mitigation has been on the governmental agenda for many years (Ferreira & Barbi, 2016; IPEA, 2011; Martins & Ferreira, 2011; Viola & Franchini, 2012), the country's first National Climate Adaptation Plan (Plano Nacional de Adaptação à Mudança do Clima – PNA) was launched May 2016, which indicates that effective long-term adaptation planning has lagged (Darela-Filho et al., 2016). The reasons for this delay are well known. Considering the uncertainties related to climate change projections (Lindoso, 2015) and economic, institutional, and political constraints that stretch the countries and cities' ability to provide basic services and support its current populations, infrastructure, and ecosystems (Wise et al., 2014), adaptation is a much more complex task.

Like other cities in Latin America (Lehmann et al., 2015), Brazilian cities are embedded in specific political-economic realities, which are played out in their dynamics and responses. Moreover, while there might be an overall perception that mitigation responses might be associated with potential economic gain (e.g. “the green economy”), adaptation is mostly perceived as cost for cities (Denton et al., 2014), especially for cities where most of the investment is likely to happen. A rich scholarly literature focusing on cities describes and analyzes the barriers to developing climate policy and adaptive actions at the city level. These barriers include the presence of short terms for local authorities, mismatch between the scale of urgent urban issues and local government authority to address them, lack of financial and human resources, lack of autonomy to regulate specific sectors and economic agents, lack of vulnerability assessments, gaps between policy discourses and political reality, and information management (Aylett, 2014; Bulkeley, 2010; Bulkeley & Broto, 2013; Lemos & Kirchhoff, 2016; Martins & Ferreira, 2011; Ryan, 2015).

3. São Paulo: climate projections, risks and interventions

In the megacity of São Paulo, climate issues will aggravate environmental and urban problems and increase risk, especially for communities already living in vulnerable conditions (Nobre et al., 2010; Silva, 2010; Vargas, 2011). Climate projections indicate that by 2040, in the south/southeastern portion of the Atlantic Rainforest biome (where São Paulo is located), there will be a slight rise in temperature (0.5 °C–1 °C) and a 5–10% increase in the intensity of rainfalls. By the mid-century (2041–2070), a gradual rise in temperature of 1.5 °C–2 °C and an increase in rainfall of 15–20% are expected. By the end of the century (2071–2100), temperatures are projected to rise between 2.5 °C–3 °C, and rainfall should increase by 25–30% (Ambrizzi et al., 2012). In this context, the city must prepare to deal with changes in the distribution, intensity, and geographic frequency of risks related to climate events, which threaten to exceed its capacity to absorb losses and recover from impacts (Ambrizzi et al., 2012; Nobre et al., 2010).

This is especially critical because climate impact stressors are expected to compound serious problems associated with São Paulo's historically bad and haphazard process of urbanization (Bonduki, 2011; Carlos, 2004). For example, the megacity has already dealt with heat islands that make it more difficult to disperse pollution and increase the probability of torrential rains (Lombardo, 1985) and even more frequent extreme events, such as drought (e.g. water scarcity in 2013–16) and flooding (Cohen, 2016; Marengo et al., 2015; Nobre et al., 2016). However, the city government's lack of basic administrative and policy capacity means that it has been unsuccessful in developing required

¹ <http://www.fapesp.br/en/4485>.

social technologies to monitor urban growth and propose spatial planning solutions (Di Giulio & Vasconcellos, 2014).

Nevertheless, São Paulo can also be a source for innovation and lead transformative processes (IPCC, 2014; Leite, 2010; Seto et al., 2010). As a global city, it is currently undergoing big transformations and has a fundamental role in climate responses, taking a leadership role in adaptation processes (Martins & Ferreira, 2011; Barbi, 2015; Setzer et al., 2015; Di Giulio & Vasconcellos, 2014; Di Giulio, Martins, Vasconcellos, & Ribeiro, 2017).

Climate change has been part of the local agenda in São Paulo since 2003, when the city joined the Cities for Climate Projection Campaign. In the same year, the Secretary of Green and Environment (SVMA) attended the network's meetings, which ICLEI coordinated. In 2005, São Paulo joined the Cities Climate Leadership Group (C40), which brings together cities committed to reducing GHG emissions and mitigating climate threats (C40 Large Cities Climate Summit). Setzer et al. (2015) argue that São Paulo's participation in ICLEI - Local Governments for Sustainability and C40 encouraged the city to undertake commitments that include the development of a GHG inventory and a climate action plan to set reduction targets and created a monitoring procedure.

In 2009, São Paulo became the first Brazilian city to launch a Municipal Climate Law with specific goals, which include a mandatory 30% reduction of aggregate municipal GHG emissions in CO₂e by 2012 relative to the 2003 baseline values reported in the municipal inventory published in 2005. This policy has influenced other Brazilian cities and states to adopt climate policies (Setzer et al., 2015; Barbi, 2015; Martins & Ferreira, 2011). The megacity also has a Municipal Committee on Climate Change and Sustainable Ecoeconomy, an advisory body created in 2005 that brings together a range of stakeholders (including representatives of municipal government and civil society) to support the implementation of the Municipal Climate Change Policy (Prefeitura Municipal de São Paulo, 2011).

As part of its climate mitigation efforts, São Paulo undertook two GHG emissions inventories. The first one (2003–2005) indicated that energy use was the largest emissions source (76.14%), followed by solid waste disposal (23.48%) (Setzer et al., 2015). The second inventory (2003–2009) pointed out that energy and waste sectors accounted for 82% and 16% of São Paulo's 2009 municipal emissions, respectively. Combined, these sectors represent 98% of the Municipality of São Paulo's emissions (Prefeitura Municipal de São Paulo, 2013). The municipality updated its 2010 and 2011 emissions for the energy and waste sectors based on their contribution to overall emissions. Emissions increased in 2008, 2010, and 2011, mainly due to the energy sector. The waste sector did not present a significant variation in the inventoried period (Prefeitura Municipal de São Paulo, 2013). A third inventory is already planned to cover years 2010–2015.

Besides these specific climate policies and actions, the megacity has contracted a thermoelectric plant for the capture of methane gas (2003), implemented installations of biogas capture plants to electric power generation in landfills (2003 and 2005), launched the Sustainable Procurement Program (Programa de Compras Sustentáveis, in 2005) and the 100 green parks program to expand green areas (2008), and installed solar heating systems in new buildings of a certain scale (2007). In addition, the city has implemented the following policies: city's green procurement policy (2007); Vehicular Pollution Control Plan (2007); Taxi fleet with cleaner fuel and motor technologies, including electric, ethanol, flex fuel vehicles (2012); Municipal Solid Waste Integrated Management Plan (2012) (Back, 2012; Setzer et al., 2015); and more recently a Municipal Mobility Plan (2015).

However, despite of all these initiatives, the Municipal Climate Law is not achieving its goal. Setzer et al. (2015) point out that implementing legislation is still a challenge for most of these local initiatives. While the Municipal Climate Law engaged a set of actors in its elaboration and adoption throughout a participatory process, this might not be reflected in its policy implementation, particularly considering diverse interests from different stakeholders (Setzer & Biderman, 2013).

This may explain the lack of success of the Motor Vehicle Inspection and Maintenance Program. It was expanded in 2009 and became mandatory for the entire city fleet in 2010, but it was cancelled in 2014 (Setzer et al., 2015). Even the Municipal Committee on Climate Change and Sustainable Ecoeconomy's meetings were suspended from November 2012 to April 2014 (Di Giulio & Vasconcellos, 2014).

4. Master Plan and proposals linked to climate issues

In addition to these policies and interventions, new possibilities for innovative urban policies in the last few years have stemmed from the significant reduction in population growth rates, advances in the scope of regulation, and the accumulation of experiences in participatory planning processes (Franco, D'Almeida, & Abreu, 2015). The City of São Paulo's Program of Goals (Programa de Metas da Prefeitura de São Paulo 2013–2016²) included a set of municipal actions that aim to overcome many of the city's challenges, the consolidation of urban infrastructure projects, and a review of urban policy regulation.

The new Master Plan (Plano Diretor Estratégico – PDE concluded in 2014), in particular, may be interpreted as a sign that São Paulo is trying to change its culture and urban sociability in the coming years (Di Giulio & Vasconcellos, 2014). In São Paulo, master plans are reviewed every 10 years. The United Nations recognized the most recent Master Plan as an example for the rest of the globe. This initiative also received the University of Michigan's Mobiprize for projects with participative platforms that advance sustainable solutions for urban mobility.

An analysis of the PDE finds that the plan addresses many issues indirectly connected to climate change, without explicitly describing the synergies. The implications of not directly addressing climate-related impacts are twofold. First, it may signal the issue's low priority on both societal and governmental agendas as suggested by surveys indicating that although people in São Paulo recognize the effects of climate change, climate issues are not a high priority for most of them. Those issues compete with other stressors in the megacity, such as mobility, air pollution, water crises, and sanitation (Datafolha, 2014; Di Giulio & Vasconcellos, 2014; Di Giulio et al., 2015). Second, it may provide an opportunity to address climate change actions in the context of other urban and environmental concerns, development pressures and goals, and a range of often-conflicting values and priorities. For example, the PDE pays substantial attention to future mobility and transportation alternatives, such as bicycle lanes and networks of bus lanes. Because transport and traffic are very high in the city's societal agenda (Fajersztajn, Veras, & Saldiva, 2016; Nossa São Paulo, 2015), tackling it may offer an opportunity to meet public demands and address the relationship between transit GHG emission and climate change. Moreover, looking at the PDE through the lens of climate change, Bonduki (2014) points out several other areas of overlap, as shown in Fig. 1.

Despite the connections with climate issues, these PDE proposals are currently not tied to climate discourse, and the current city Administration's hesitancy to use the term “climate change” might suggest that integration by stealth is a viable option to explore (Di Giulio et al., 2015). An analysis the PDE's implementation two years after its conclusion reveals that only one issue has been partly carried out: mobility and transportation. The megacity added 468 km of bike lanes and 30.3 km of paths where signals indicate the presence and preference of bicycles to other vehicles. There are 6149 bicycle parking spots, and 121 spots in bus terminals, and train and subway stations (Prefeitura de São Paulo, 2017³). More than 600 km of roads give some

² The Program of Goals is an official document that includes municipal committed proposals for a specific mayor's mandate for 4 years.

³ <http://www.cetsp.com.br/consultas/bicicleta/mapa-de-infraestrutura-cicloviaria.aspx>.

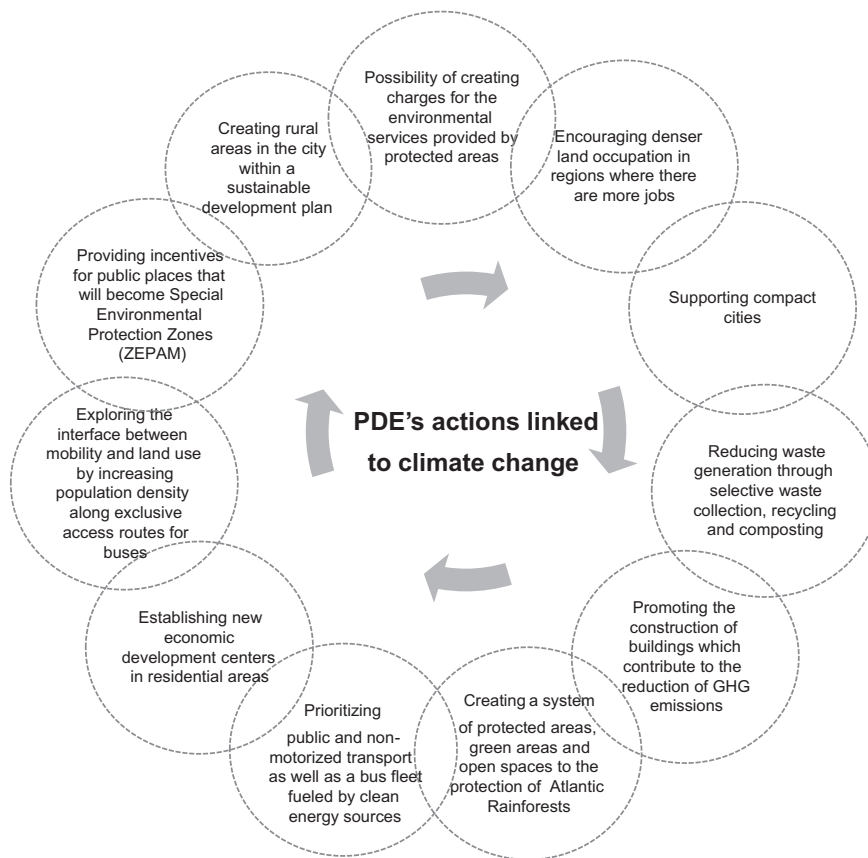


Fig. 1. PDE's issues linked to climate change.
Source: Elaborated by authors.

priority to public transport, and 484 km of exclusive bus lanes were implemented in 2013–2015 (PlanMob/SP, 2015). Although these numbers indicate some progress, one important aspect related to mobility and transportation is still far from being achieved: the use of non-fossil fuel for all municipal public bus system. In 2016, less than 4% of the 14,800 municipal buses had operated with some clean fuel (Época, 2016⁴) – the Municipal Climate Law had established that all bus system should use non-fossil fuel up to 2018. São Paulo awards multi-year concessions to private companies for the provision of public transportation is imperative. However, enterprises and private companies have been largely absent from the implementation of the Climate Law (Setzer & Biderman, 2013). This may explain this delay in terms of green buses.

Green infrastructure, the other areas included in the PDE connected to climate change, has been far from being successfully implemented. Political disputes and successive leadership changes at the SVMA may explain the delay in implementing important points proposed in the PDE. Pressures from the private housing market and other sectors also influenced the delay (Isto é, 2017⁵).

The way planning is carried out in Brazil, characterized by technocratic and bureaucratic activity focused on prediction models, explains the difficulties and delays in planning and implementing public policies in cities (e.g. Municipal Climate Law, PDE) (Oliveira, 2006). Focused on urban policy in the megacity of São Paulo, D'Almeida (2016) suggests two important issues that describe the management of urban policies: (i) the structural problems presented in urban space production, which in the case of São Paulo are closely related to the socio-spatial segregation of the city, and (ii) problems associated with the reproduction of public administration mechanisms. In this case,

there is a need for innovation of urban planning tools and mechanisms to implement and control public policies. This author highlights that disconnections among sectorial policies, the lack of definition of responsibilities, competencies, and priorities in terms of investments and strategic actions may explain the gap between elaboration and execution of PDE. Other barriers include the current urban legislation related to the PDE, constraints of public financial resources, and difficulties in innovating and managing mechanisms to self-fund urban projects in long term (D'Almeida, 2016). The Brazilian federal government's delay in approving and implementing the multipurpose cadastral system⁶ is another difficulty for PDE execution. This tool has been used for land management, environmental protection, and sustainable development, bringing benefits for governments and private sectors related to municipal planning (Jolyne & Donovan, 2016).

Political will (Ferreira & Barbi, 2016), risk perception (Di Giulio et al., 2015; Di Giulio & Vasconcellos, 2014), power and influence of social groups and social capital (Engle & Lemos, 2010; Pelling & High, 2005), economic resources, and technological capacity (Fankhauser & McDermott, 2014) are the main obstacles to implementing climate policies at the local level. Environment-friendly approach, and how it is (or not) internalized by the political and economic agents, is another element to be considered in the scenario of São Paulo that may explain why the Municipal Climate Law, for example, has failed. Studies have highlighted that politicians and entrepreneurs, two of the main interested groups involved in the process of production of urban space (Carlos, 2004, 2017), are still resistant to accept and internalize climate issues in their decisions (Ribeiro, 2009). Despite expressing some “concern”, most of them seemed to be committed to maintain the status quo instead of implement new ideas and policies (Ribeiro, 2009). Civil society, another relevant actor in this process, has

⁴ <http://epoca.globo.com/colunas-e-blogs/blog-do-planeta/noticia/2016/07/mp-exigira-de-sao-paulo-o-uso-de-combustivel-limpo-na-frota-de-onibus.html>.

⁵ <http://istoe.com.br/gestao-doria-quer-flexibilizar-plano-diretor/>.

⁶ <http://www.camara.gov.br/proposicoesWeb/fichadetramitacao?idProposicao=2058449>.

demonstrated that, in general, climate issues are not a daily concern public in São Paulo (Di Giulio & Vasconcelos, 2014, 2015). Consumerism that encourages the acquisition of goods and services (Jameson, 1993, 2001) with high impacts in the energy sector still attract new consumers (Pochmann, 2006). Although some social urban movements have recently emerged in São Paulo around the ‘right to the city’ and in favor of more sustainable urban interventions (Santos, 2014), other groups protested against lowered speed limits in urban and metropolitan areas and bike lanes – interventions aligned with the process of climate adaptation and mitigation.

5. Factors that affect the city's adaptive capacity

Recognizing São Paulo's social, political, and economic complexities and their interconnectedness, it is reasonable to suggest that the city's climate solutions need to be considered in the context of its urban governance. Many of the economic, political and social factors that affect cities' governance are discussed in the literature as relating to the adaptive capacity of cities (Pelling & High, 2005; Bulkeley, 2010; Anguelovski & Carmin, 2011; Engle, 2011; Lemos, Kirchhoff, & Ramprasad, 2012; Lemos et al., 2013; Bulkeley & Broto, 2013; Barclay et al., 2013; Fankhauser & McDermott, 2014; Eakin, Lemos, & Nelson, 2014; Uittenbroek et al., 2014). In this paper, we explore two of these factors and suggest where more research might be needed to inform climate policy in the city of São Paulo, specifically: (i) production, access, and use of climate-related information in decision-making; (ii) economic resources and technological capacity.

5.1. Production of and access to climate information

There is an assumption that investing in both the production of applied information and knowledge and the mechanisms that narrow the gap between scientific information and use will increase adaptive capacity (Lemos, 2015). These mechanisms include interaction with stakeholders (co-production of knowledge and decision-making), increased access to information, and better communication that encourages social learning, and action research (Lemos et al., 2012; Carvalho & Furtado, 2015; Serrao-Neumann, Di Giulio, Ferreira, & Choy, 2016). Bulkeley et al. (2009) argue that the lack of data and expertise at the local level is a more critical obstacle to policy development when it comes to adaptation than mitigation. Lemos et al. (2012) argue that the use of scientific information in (collective and individual) decision-making depends on three inter-linked factors: (i) users' perceptions about available information; (ii) how new knowledge interacts with existing and available information; and (iii) the depth and frequency of iteration between knowledge producers and users (co-production). Other constraints that limit the dissemination and adoption of scientific information include decision contexts, understanding the role of uncertainty, issues of communication, accessibility of science in affecting use and institutional arrangements that facilitate or impede information uptake (Lemos & Kirchhoff, 2016).

In São Paulo, the level of interaction between scientists and decision-makers is low, especially regarding climate science and action. Martins and Ferreira (2011), in their work on climate change action in two big Brazilian cities, including São Paulo, suggest that poor understanding in terms of the extent of climate change and its impacts and a mismatch between policy makers and the scientific community as obstacles and constraints to developing city-level climate policy. More studies are needed to understand the potential climate impacts on specific areas in the megacity, as well as studies on disconnects at the intersection of scientific knowledge and climate adaptation. Recent attempts to bridge this gap with the federal government's creation, in 2011, of a Center for the Prediction of Extreme Events (CEMADEN) that could inform disaster prevention and response have been slow in coming to fruition. Even the recent drought in São Paulo (2013–16), a previously announced water crisis by scientists and experts (Marengo

et al., 2015) and considered a combination of a set of elements – including low rainfall, expanded growth of water demand, absence of adequate planning for water management, and lack of collective awareness of consumers for the rational use –, did not result in ecological and climate responses that developing adaptive capacity for future. On the contrary, political and bureaucratic issues motivated solutions (Cohen, 2016). Serrao-Neumann et al. (2017, p. 20) argue that “by omitting the impact of future changes and uncertainties in statutory policies for land-use planning, decision-making can be dominated by political interests instead hampering, to some extent, the adoption of future-oriented alternatives that are not politically acceptable despite being supported by best available science (Kato & Ahern, 2008)”.

5.2. Economic resources and technological capacity

Fankhauser and McDermott (2014) argue that adaptation deficit is linked to the lack or inefficiency of technological, institutional and financial capacity. Theoretically and practically, it is well established that, at the city level, there is certainly a close relationship between the availability of economic resources and investments to reduce vulnerabilities to extreme events and better preparedness (Eakin et al., 2014). Economic resources and technological capacity also influence the ability to conduct urban climate studies and vulnerability assessments.

São Paulo, although it is the largest municipal economy in Brazil, has been affected by the worst economic recession in Brazil's modern history with around 7% drop in its municipal revenue over the past two years, according to government data. From an economic and technological point of view, even with some recently implemented innovative urban policies – including the digital platform Geosampa⁷ with its updated statistical and geospatial information as well as quantitative and qualitative indicators of urban and environmental policies, it is possible to think about the barriers São Paulo may face in the next few years, given that urbanization processes have always been marked by unequal access to public goods and services (Carlos, 2004). Urbanization of favelas, removal of houses in risky areas, and restructuring slums, critical points to the local agenda (Mello-Théry et al., 2014; Setzer et al., 2015), are expensive adaptation measures. Limited financial resources, combined with the fact the climate is low priority, may have contributed to the adaptation deficit in the megacity.

In this sense, partnerships, networks, strategic alliances, and other forms of non-sectoral and inter-organizational collaboration may be relevant for local climate adaptation policy and practice (Leck & Roberts, 2015). Future studies focused on the engagement of economic actors, both public and private, in the design and implementation of São Paulo's responses to climate change may be helpful. Understanding what motivates local stakeholders to support or oppose climate policies would also be important (Ryan, 2015).

6. Opportunities for the megacity

Linking public policies related to climate change with housing policy, sanitation, water management, and urban mobility is an opportunity and challenge for São Paulo. Case-based research has identified that a combination of different capacities that synergize to allow for both development and risk management (Eakin et al., 2014; Lemos et al., 2013) affects a system's ability to respond to climate threats (Engle, 2011; Lemos et al., 2013). However, there is scant empirical evidence that this may also be true for São Paulo. At this point, little is known about São Paulo's opportunity to implement what the literature calls ‘win-win’ and ‘triple-win strategies’ (Sherman et al., 2016), and making better understanding of how mainstreaming climate risk management can create synergistic opportunities with other priority policies. Urban interventions that can help cities solve some of their

⁷ <http://gestaourbana.prefeitura.sp.gov.br/>.

pressing service delivery and urban environmental problems, while simultaneously mitigating rising urban GHG emissions and vulnerability to climate change (e.g. mobility and transportation alternatives), reflect linkages between climate interventions and development. The megacity also has the opportunity to promote a form of development that mitigates risks without negatively influencing the well-being of humans and ecosystems, while focusing on adaptation and reinforcing the importance of sustainability.

Ecosystem-based adaptation (EbA) can be another interesting possibility for São Paulo. EbA can play an important role in urban contexts because it includes management, conservation, and restoration of ecosystems that deliver services that could help to reduce climate change exposures (Brink et al., 2016; Geneletti & Zardo, 2016) and allow the city to introduce more critical discussions of socioeconomic vulnerability (Chu et al., 2017). This approach can help the city deal with increased temperature, flood events, and water scarcity, by reducing soil sealing, mitigating heat island effect, and enhancing water storage capacity in urban watersheds. Today, São Paulo has 107 parks distributed across the city and four Green Plans that will be implemented in coming years (PDE, 2014). These include a plan for protected and green areas, one focused on conservation and restoration of environmental services, an urban forest plan, and another one plan for Atlantic Forest. Through green infrastructures (e.g. urban parks) improvements and other types of interventions that use ecosystem functions to provide some form of adaptation to climate risks, EbA offers the advantage of promoting “no regrets” interventions and potentially delivering multiple economic, social, and environmental co-benefits that go beyond climate adaptation (Cortekar et al., 2016; Geneletti & Zardo, 2016). This may offer an opportunity to meet public demands and address relationship between urban forest and climate change in São Paulo.

7. Conclusions

Understanding how cities across the world address climate change and the barriers and opportunities for urban adaptation is still a challenge. The megacity of São Paulo is an example of how political, social, and economic realities play an important role in the dynamics of and responses to climate change. Since it started implementing climate policy, São Paulo has achieved some results, but they do not meet what is needed. In this paper, we presented some of the reasons for this gap. As discussed earlier, the new Master Plan addresses issues indirectly connected to climate change and opens a window of opportunity to change the city's culture and urban sociability in the coming years. The PDE intersects with a set of climate efforts that embed adaptation and mitigation perspectives, while seeking to promote an urban order that ensures a better city for its residents. Despite this initiative, its implementation has been far from successful. In this paper, we shed light on some of the causes that explain the gaps between elaboration and execution of the PDE. We reinforce that the application of those proposals in coming years is crucial at this moment of political transition in São Paulo: the left-leaning Worker's Party (PT) lost the mayorship to the centrist Brazilian Social Democrat Party (PSDB), and a new government started in 2017. A permanent assessment of the PDE proposals, in terms of results, synergies, and opportunities for addressing climate adaptation, is necessary.

Moreover, investments in better understanding how some factors affect the adaptive capacity of the city are critical. Understanding how existing knowledge can be better applied in this effort and narrowing the gap between the production and use of specific knowledge to inform climate policies in the city are urgently needed. Moreover, there need to be investments in key sectors for adaptation responses at the local level. Linking public policies related to climate change with urban infrastructure services, housing policy, sanitation, water management, and urban mobility is both an opportunity and challenge for São Paulo. Focusing on adaptation aligned to urban interventions and improvements of green infrastructures may offer the advantage of delivering

multiple co-benefits that go beyond climate adaptation. São Paulo may have the opportunity to explore this promising path in the next years.

Future studies focused on diversities and contexts in other Brazilian cities are critical to better understand climate adaptation in Brazil and how they can anticipate and respond to impacts at the local level. These studies must pay attention to a set of critical variables that affect the Brazilian scenarios, where the challenge is both to understand possible synergies between these variables to explain adaptive capacity and explore the extent to which they define and explain the action (or lack of) in the process of adaptation.

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