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*Barriers and Opportunities for Climate Adaptation:  
The Water Crisis in Greater São Paulo*

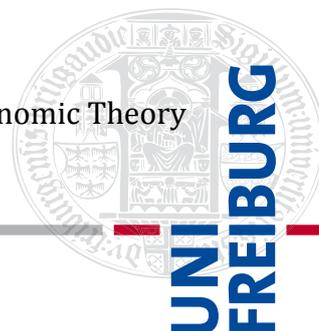
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# **Barriers and Opportunities for Climate Adaptation: The Water Crisis in Greater São Paulo**

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## **Abstract:**

This paper analyzes the current water crisis in Greater São Paulo. It is based on a diagnosis of the main barriers that impeded government and other stakeholders at different governance scales to take action to guarantee a secure water provision. The objective was to discuss why there was a lack of preparation of this region to the occurring of a prolonged drought and which adaptation measures could have been taken to avoid or diminish its effects on water supply. The analysis is the result of an in-depth explanatory case study and field research, which had as its primary evidence a set of twelve semi-structured interviews made in the studied region in March and April 2015<sup>1</sup>. Further evidence was extracted from newspaper articles, government reports and scientific publications. The key reference of this lecture is the literature on barriers to adaptation to climate change. Ostrom's (2009) Social-Ecological Systems (SES) framework provided the analytical framework used to analyze the collected data and to understand the interactions among core subsystems that affect each other and are linked to social, economic, and political settings and related ecosystems. The results comprehend ten barriers that were encountered in the interactions that contributed to the water crisis. We conclude that the misrepresentation of the interests of the population in having a secure water provision and the risky behavior of water managers influenced the crisis. Further we argue that the lack of governance mechanisms and the political power concentration, which characterizes the actual governance system, are central in the explanation of the ongoing crisis.

## **Keywords:**

Resource access/control, water security, climate adaptation, Brazil, urban development

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## **TABLE OF ABBREVIATIONS**

ANA – National Water Agency

BAT- High Tietê Basin

CBAT- Committee of the High Tietê Basin

CPRs - Common pool resources

DAEE – Department for water and electric energy

FUSP- Foundation of the University of São Paulo

IAD- Institutional Analysis and Development

IBGE – Brazilian Institute for Geography and Statistics

IWSS - Integrated Water Supply System

MMA – Brazilian Environment Ministry

NAAS - Network of adjacent action situations

PAT - Plan of the High Tietê Basin

PCJ – Committee of the Piracicaba, Capivari and Jundiaí Basin

RMSP – Metropolitan Region of São Paulo (also known as Greater São Paulo)

SEADE – São Paulo State Foundation for Data Analysis

SES- social-ecological systems

SigRH - Integrated water system in the state of São Paulo

SINGREH - National Water Resources Management System

SP – State of São Paulo

URGHIs - Water management areas

## 1. INTRODUCTION

A growing economy generates different kinds of challenges to those who are a part of it. One of them is how to provide the material resources that are needed to keep on a certain growth path and development. When it comes to natural resources, one of the most mentioned is oil, but we cannot forget that water is also an essential input of productive activities. Growth in population, in consumption also generates a greater demand for water. As the amount and mobility of water has its specific restrictions, it is essential to understand its particularities and interplay with political decisions to be able to guarantee a safe provision of this resource, not just for economic growth, but also for human security.

The main focus of this work is the analysis of the challenge mentioned above, focusing on Greater São Paulo, also known as Metropolitan Region of São Paulo (RMSP). This region (see appendix 1 for the localization) was chosen because it has been facing a water crisis since at least the summer 2013/2014 when it was hit by a prolonged period of drought in the southeastern region of Brazil that began at the end of 2013. The main water supplier of this region, the Cantareira system that used to supply water for about half of the population of the region (9 million people) reached 15.3% of its full capacity on the 15<sup>th</sup> of May, 2015.<sup>2</sup> In October 2014 water shortage affected about 60% of the population<sup>3</sup>. This is not the only region in Brazil affected by the drought; other Brazilian states like Minas Gerais and Rio de Janeiro were also affected. We decided to focus on the Metropolitan Region of São Paulo as it is responsible for 17.89% of the Brazilian GDP (IBGE and SEADE 2012)<sup>4</sup>, concentrates about 10% of its population (IBGE and SEADE 2014)<sup>5</sup> and corresponds just to 0.09% of the Brazilian territory. The RMSP also contains South America's most dynamic financial center and is between the largest metropolitan areas in the world. Besides, it is one of the most affected regions by the drought in the southeast of Brazil and is now under risk of suffering a water provision collapse. This crisis makes clear the fact that the region was not prepared to face changes of its climatic variations and that it has difficulties adapting to extremes. Thinking about water crisis in a water rich country such as Brazil may be controversial, but we cannot forget that about 80% of Brazil's water availability is concentrated in the Amazon region (ANA, 2013, p.38).

The key reference of this research project is the literature on barriers to adaptation to climate change. This literature can be used to understand different phenomena, not just those strictly related to anthropogenic global warming. In our case study, the issue of climate variability is one of the important backgrounds of the water crisis, as we could see that the water provision in the region collapsed in a moment that followed a period of drought. We use the recent synthesis paper by Eisenack et al. (2014) as our starting point. Eisenack et al. stress that current research is "still far from conclusive on causal explanations for the occurrence of barriers and on how they can be overcome" (p. 867). There is still room and necessity for improvements in this field, what can result from new case studies or comparative analysis and synthesis of already existent studies. The authors remember that barriers are not necessarily problematic and suggest that barriers can arise from three different resources: the actor's decision making, the context in which it takes place and "the system that is at risk of being

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<sup>2</sup> Available at: <http://www2.sabesp.com.br/mananciais/> (Accessed on 7 July, 2015).

<sup>3</sup> On a research made by Datafolha on the 17th of October 2014, 60% of the people living in the region said that they were not provided with water at some moment in the 30 days previous to the research. Available at: <http://www1.folha.uol.com.br/cotidiano/2014/10/1535091-corte-no-abastecimento-de-agua-atinge-60-dos-paulistanos-diz-datafolha.shtml> (Accessed on 7 July, 2015).

<sup>4</sup> Available at: [ftp://ftp.ibge.gov.br/Contas\\_Regionais/2012/pdf/contas\\_regionais\\_2012.pdf](ftp://ftp.ibge.gov.br/Contas_Regionais/2012/pdf/contas_regionais_2012.pdf) and [http://produtos.seade.gov.br/produtos/perfil\\_regional/index.php](http://produtos.seade.gov.br/produtos/perfil_regional/index.php) (Accessed on 7 July, 2015).

<sup>5</sup> Available at: <http://www.ibge.gov.br/apps/populacao/projecao/> and [http://produtos.seade.gov.br/produtos/perfil\\_regional/index.php](http://produtos.seade.gov.br/produtos/perfil_regional/index.php) (Accessed on 7 July, 2015).

affected by climate change” (p. 867). This conceptualization induces a descriptive and explanatory approach to barriers. We utilize their definition of barriers as:

“... an impediment to specified adaptations for specified actors in their given context that arise from a condition or set of conditions. A barrier can be valued differently by different actors, and can, in principle, be reduced or overcome. In this definition, conditions are the attributes of adaptations, actors, and their context” (Eisenack et al., 2014, p. 868).

In line with this concept of barriers, we define climate adaptation as actions by individual or collective actors in response to anticipated or experienced impacts of climate variability, change, and extreme events. (Eisenack and Stecker, 2012; Klein and Johula, 2014; Oberlack, 2014). Institutions are seen as “the formal and informal rules and procedures that structure action situations within which individual and collective decision-making takes place” (Ostrom, 2005).

Our research problem is connected to the causes of the current water crisis in Greater São Paulo and, in particular, to the barriers that impeded government, stakeholders and responsible actors to take action against an eminent crisis. The point here is to find out why there was a lack of preparation of the region to the occurring of a drought and which adaptation measures could have been taken to avoid or diminish the effects of the drought on water supply. Thus our central question is: why was there not a better preparation for a possible drought period in the Greater São Paulo? We disentangle this central research question into three sub-questions: (1) Which barriers to adaptation (water security) were encountered? (2) How and why did the barriers emerge, why did they persist, how did they change over time? (3) What are specific entry points and intervention strategies through which specific actors could overcome specific barriers? The first question is about listing and describing the important barriers that impeded relevant governance processes. Subsequently, the second seeks to explain their occurrence and change over time. Finally, the third is about identifying opportunities that either have changed barriers in the past or that may change still existing barriers in the future.

Lehmann et al. (2013) remember that the literature on barriers to adaptation already contains a significant amount of case studies. However, they say, only some of them address the level of local decision-makers and most of them are focused on industrialized countries. Focusing on a local governance level, also having in mind the influence of the multiple governance arenas, and handling about an emerging country, our study has the potential to contribute to the literature on barriers.

In particular, the notion of barriers itself is connected to a desirable objective which is – due to barriers – not fully achieved, i.e. the barriers concept has an inherent normative component. Concerning the concept of adaptation, there are “some considerable conceptual gaps in what the act of adapting actually entails” (Biesbroek et al., 2013, p.1126), what generates a difficulty to define boundaries of a barrier to adaptation. To deal with this broadness, we deconstruct adaptation “towards a more definable problem (e.g. water safety)” (p.1126). Thus we frame our research problem as a water security problem, which will be discussed in the next chapter.

The paper is organized in five further chapters. In the second chapter the broader context of the global water crisis, the current water crisis in RMSPP, our working hypotheses and evaluative criteria are presented. Chapter three is constituted by the explanation of the conceptual framework, theory and methods used in the study design. In chapter four we apply the framework to describe our focus social-ecological system. Chapter five presents the results of the field research, and discusses how these findings contribute in answering our research questions and whether they are related to the study’s propositions and hypotheses. Finally, chapter six draws possible conclusions in the light of our results.

## **2. ON WATER CRISES**

### **2.1. The global water crisis**

To understand the issue of water security in the region of Greater São Paulo it is essential to observe the different contexts it is inserted in. This region, in an economic and political sense, a key part of the São Paulo state itself and of Brazil as a country. These political organizations are also under influence of international trends and groups. To be able to capture the important processes of the recent crisis in the Greater São Paulo, it is necessary to understand how it is connected to extra regional tendencies.

It is important to note that the role of water is not just constrained to a regional level. The international flow of goods can also be seen as a flow of water in different forms, crops trade e.g. is also water trade (Jacobi et al., 2013). Hence the role of water has to be understood through holistic lens, as it is not restricted to direct consumption by households, but is also present in sectors like agriculture, energy production, industry and in nature.

The process of giving a direct economic value (price) to water expanded in the beginning of the 1990s, following the logic of the economic policy prescriptions set by the Washington Consensus. One of its prescriptions concerning the provision of water was the privatization of water treatment and provision, the creation of an economic value to it and of markets for its commercialization, based on the concepts of decentralization and participation (Jacobi et al., 2013). One milestone of our study is to go beyond such panaceas for water institutions, as it can be observed that the results of any type of institution vary between sites and throughout time (Meizen-Dick, 2007).

Additionally when we observe the worldwide growing urbanization and middle class with west alike consumption patterns, it is evident that the issue of water provision in urban centers is a current and future challenge. According to the UNESCO “by 2050, global water demand is projected to increase by 55%, mainly due to growing demand from manufacturing, thermal electricity generation and domestic use, all of which mainly results from growing urbanization in developing countries” (2015, p.42).

Proposing good governance is not enough to deal with this challenge. It is often said that state, civil society and markets should work together as this could take place as a symmetric and triangular interaction (Castro, 2007, p.103), what is actually an idealized version of how interactions between these actors take place. It urges a need to understand governance beyond the free-market liberal tradition and to understand how this view has influenced the shaping of public policies. Interpreting governance as an objective and technical tool, without observing the interests and motivations behind actors that take part of interactions, is misleading. As described by Castro, actors seek to define the ends and values that form social development. That is why we decided to make a deeper institutional analysis as it helps us to understand the working rules and norms that individuals use in making decisions (Ostrom, 2011, p.18).

### **2.2. The current water crisis in the Greater São Paulo**

To understand the current crisis in São Paulo, it is interesting to observe some data that translate the actual situation. Figure 2.1 (see appendix 2) represents the evolution of the water levels of the Cantareira system, the main water system of our target region. In this figure, we can observe that along the years of 2013 and 2014, the level decreased drastically. Additionally we identify that already in the period between 2003 and 2004 there was a great decrease of the level of the Cantareira, which reached about 20% including the dead weight (not taking it to account, it would be about 1.6%)<sup>6</sup>. In 2003 there were alerts about the

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<sup>6</sup> Here there are some newspaper articles that describe the drought in the period 2003/2004:

incapability of the water system to attend future demands and that supply could only be guaranteed until 2010<sup>7</sup>. So the actual crisis is not a new fact, something very similar had happened about ten year ago. At that time there were already discussions and recommendations for water security, an example was the seminary on water supply organized by the Engineering Institute of São Paulo in November, 2003<sup>8</sup>.

The dry period<sup>9</sup> 2013/2014 can be interpreted as the climate-related *stimulus* that influenced the water provision system of Greater São Paulo, the *exposed unit*. This exposure and the sensitivity of the system to the drought shaped the water crisis, which is the *impact* of this exposure (Oberlack, 2014). The drought was one between other factors that are usually described as the cause of the ongoing water crisis. The Water Alliance (Aliança pela Água), a group of NGOs and civil society organizations, enumerates other factors, like a water management based on endless resources, the degradation of watersheds and water sources and the lack of transparency by responsible organizations and of participation.

A report of the Brazilian National Water Agency-ANA (2013) puts in evidence the problem of disparity between water demand and supply in many Brazilian regions, including the RMSP. If nothing is done, they pointed out, the future scenario will be characterized by an increase of this disparity as a consequence of the Brazilian economic growth. For them it is important to adopt policies to expand water availability as a way to guarantee the attendance of the different demands (p.198). The problem of water availability in RMSP is also described by other studies (Ribeiro, 2011; Plan of High Tietê Basin, 2009; Rodrigues, 2007; Johnsson and Kemper, 2005; Porto, 2003) and has been in evidence in the literature on water governance in Brazil in the last years.

The governor<sup>10</sup> of São Paulo, Geraldo Alckmin, and other representatives have tended to blame the drought which occurred in the summer of 2013/2014 as one of the main causes of the crisis. They ignore the existence of such studies and argue that such a crisis could not have been anticipated<sup>11</sup>. Julio Cerqueira Cesar, hydraulic engineer, explains that an efficient water system has the capacity to supply water also in periods of drought. He adds that in the last 30 years there was no large-scale investment for the amplification of water sources and in the same time the population increased in approximately 10 million in the region. For him that is the biggest reason for the water scarcity<sup>12</sup>. According to Ivanildo Hespanhol, sanitation

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- 7th November, 2003 . “Duas das seis represas do sistema Cantareira estão secas”:  
<http://www1.folha.uol.com.br/folha/cotidiano/ult95u85212.shtml> (Accessed on 26 July, 2015).
  - 20th September, 2003 . “Reservatório da Cantareira atinge nível crítico”:  
<http://www1.folha.uol.com.br/folha/cotidiano/ult95u82510.shtml> (Accessed on 26 July, 2015).
  - “Qualidade da Água de SP piorou em 2003”:  
<http://www.agr.feis.unesp.br/fsp21042004.php> (Accessed on 26 July, 2015).
  - 9th February, 2004. “A crise da água em São Paulo virou questão de fé “  
<http://site-antigo.socioambiental.org/nsa/detalhe?id=1563> (Accessed on 26 July, 2015).

<sup>7</sup> See: <http://www1.folha.uol.com.br/fsp/cotidian/ff1210200301.htm> (Accessed on 26 July, 2015).

<sup>8</sup> More at: <http://ie.org.br/site/ieadm/arquivos/arqnot8375.pdf> (Accessed on 26 July, 2015).

<sup>9</sup> In 2013 in almost all months rain fall was below average in Cantareira. In 2014 was even worse, rain fall was far below historical levels in almost all months. See:

<http://www2.sabesp.com.br/mananciais/DivulgacaoSiteSabesp.aspx> (Accessed on 26 July, 2015).

<sup>10</sup> In 2009, the state government received an alert about the fragility of the Cantareira System. The report on the plan of the High Tietê Basin (BAT), the basin in which RMSP is located in, pointed that Cantareira had a great deficit and advised the government to take action to avoid a collapse.

<sup>11</sup> Here is an example of a statement that confirms this position: “Until December 2013 there was no meteorological study that forecasted the crisis, neither its gravity. Between 2014 and 2015 nevertheless, the crisis was there.” Marcio Aith (Secretary of Communication of the state of SP, 29 January, 2015) See: <http://app.folha.uol.com.br/#noticia/514528> (Accessed on 26 July, 2015).

<sup>12</sup> See: <http://spressosp.com.br/2014/10/29/sp-por-tras-da-falta-dagua-privatizacao-e-ganancia/>(Accessed on 26 July, 2015).

engineer at the University of São Paulo (USP), "we don't plan; we do crisis management" and "we continue doing the same thing (...), bringing water from even farther regions"<sup>13</sup>.

According to the Brazilian Geographer's Association in Campinas, the water crisis is a political and not a climate issue. What is in crisis is the planned water provision by the state governors. Already ten years ago, when the grant for Sabesp (see table 4.4, appendix 4) was renewed (2004), it was demanded that they expand the treatment of sewage, reduce Cantareira's dependence and increase the control of water loss. The Association adds that the knowledge about natural phenomena is already enough to preview periods of drought and rain. Besides, according to them, in 2012 Sabesp alerted their shareholders about the problem, but this information was not transmitted to the population<sup>14</sup>.

In its report, ANA (2013) shows how the water withdrawal increased in the Paraná hydrological region (in which RMSP is included) between the years of 2006 and 2010, from 492.7 to 736m<sup>3</sup>/s; what occurred mostly due to the increase of the demand for irrigation purposes (from 108 to 311m<sup>3</sup>/s). This increase, they explain, is not just due to the increase in economic activities, but also due to the increase of the information quality<sup>15</sup>. Within the Brazilian hydrographic regions, Paraná is the one with the largest irrigated area; about 2.1 million hectares in 2012 (ANA, 2013, p. 99). Here it is important to remark that the hydrological integrity is dependent of the protection of the vegetation around fountainheads, rivers and reservoirs. Actually, basins surrounded by forested areas tend to supply more and better water than those occupied by industries, cattle and farming<sup>16</sup>. It is noteworthy that one of the most important Brazilian biomes, the Cerrado, which is the region that gives birth to many of the Brazilian rivers and partly covers the hydrographic region of Paraná, has lost 82% of its original area in this region. This deforestation possibly generates direct impacts on the water production in the Paraná hydrographic region and indirectly on the Greater São Paulo region.

Summing up, we can see that there are different visions about the origins of the current crisis and of the optimal ways to solve it. The Government of SP tends to overweight the drought as the origin and experts from different fields point out to institutional, political, environmental and technical problems in the governance of water as main issues. Having these conflicting points in mind, we come to our research hypotheses, which aim to guide our explanation building on the barriers that affected water security negatively.

### 2.3. Hypotheses

There are two hypotheses that guide our research on the water crisis and our path to answer our research questions. The first hypothesis states that the key barriers to adapt water governance in Greater São Paulo to achieve higher water security are of institutional nature, i.e. there was a governance failure. We expect that neither a lack of information or financial resources nor the longer period of drought were the key drivers of the crises, but a lack of initiative and interest by key decision-makers of the water governance system that affects RMSP.

Our second hypothesis is related to the expansion and intensification of land use in the state of São Paulo, especially in the Cerrado region and is related with the phenomena of

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<sup>13</sup> See: <http://veja.abril.com.br/noticia/ciencia/a-falta-de-agua-em-São-paulo-tem-solucao> (Accessed on 26 July, 2015).

<sup>14</sup> Available at: <http://agbcampinas.com.br/site/2014/crise-hidrica-uma- crise-politica/> (Accessed on 26 July, 2015).

<sup>15</sup> Mainly because of the elaboration of the Paranaíba River Basin Plan (p.91)

<sup>16</sup> Medeiros et al. (2011, p.89) affirm that the cost of treating the water from the Piracicaba basin, which has just 4.3% of its forest cover, is about 13 times bigger than the cost to treat the water from the Cantareira system, which maintains 27.2% of its native cover. They use this information and further discussion to argue for the advantages of preservation of forests for the water quality maintenance.

“land grabbing”<sup>17</sup>. It suggests that the expansion of land use impeded the constitution of a more resilient water supply and contributed to the decrease of water offer in the RMSP. Some symptoms of this problem are the increase of water use showed in ANA's report. As stated by Biggs et al. (2012), “modifications to the water cycle through agriculture can lead to changes in the timing and flows of water, contributing to regime shifts in downstream water bodies” (p. 431). We expect that part of the explanation of the current water crisis in Greater São Paulo is related to institutional deficits in regulating land-use expansion in São Paulo and neighboring states with which it shares water basins.

#### **2.4. Evaluative criteria: water security**

The evaluative criteria we chose, water security, has been cited in different papers and reports with a variation of meanings. An often used definition states that water security is “the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water related risks to people, environments and economies” (Garrick et al., 2013; Grey et al., 2013; Wang et al., 2012; Grey and Sadoff, 2007). Grey et al.<sup>18</sup> (2013) argue that this definition is more adequate to a policy-oriented discourse; they propose a risk-based framework as a way to provide a link to a science-based approach. This framework is translated in the definition of water security as a “tolerable level of water-related risk to society”, being the tolerance level context and value dependent. They remember that one of the greatest challenges of water security is the fact that it has to cope with complexity, while policy-makers want certainty. In the face of an uncertain future, the best strategy to be aimed at is the development of institutions which are more adaptable to uncertainty and adequate for ongoing and past hydrological variations. Unlike the cases of food and energy security, water security is not just a problem of scarcity, but also a problem of excess (Grey and Sadoff, 2007, p.547). As we are here focusing on the water crisis that followed a period of drought, we are going to discuss water security in what concerns absence of water, and not excess, remembering that floods are also a problem in the region but not an object of this work.

### **3. CONCEPTUAL FRAMEWORK, THEORY AND METHODS**

#### **3.1. Conceptual framework**

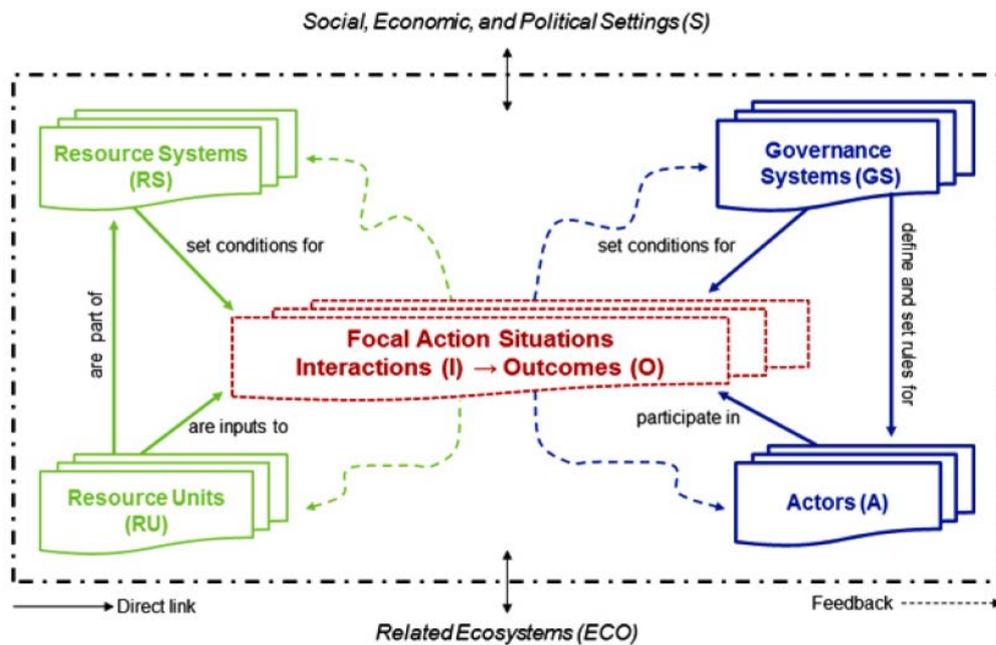
The analytical framework used to develop this project is the social-ecological systems (SES) framework (Ostrom 2009, McGinnis and Ostrom 2014). SES offers a way to describe the relationship among core subsystems that affect each other and are linked to social, economic, and political settings and related ecosystems. The SES framework is an extension of the Institutional Analysis and Development (IAD), which is designed to focus on the actions leading to interactions and outcomes (Ostrom, 2011). Based on Garrick et al.'s (2013), Nagendra and Ostrom's (2014) and Oberlack et al.'s (forthcoming) application of the SES in field research, we see as an important step the identification of which SES variables (see table 3.1, appendix 3) are particularly important for our research questions and study context and the linking of the broader contextual variables with the microsituational variables. As described by Nagendra and Ostrom:

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<sup>17</sup> “Land grabbing” can refer to elite capture, loss of local livelihoods and cultural values, increased food (and water) insecurity, structural and physical violence and human rights violations as consequences of large-scale land acquisitions (Land Research Group. Available at: [https://www.wipo.uni-freiburg.de/land-icp?set\\_language=en](https://www.wipo.uni-freiburg.de/land-icp?set_language=en), accessed on 26 July, 2015)

<sup>18</sup> The actual president from Sabesp, Jerson Kelman, is one of the authors of this publication.

“... the SES framework identifies the broad characteristics of Resource Systems and related Resource Units, Governance Systems, and Actors that together affect the structure of Action Situations leading to Interactions and Outcomes, as well as being embedded in Social, Economic, and Political Settings, and with Related Ecosystems. Within each of these broad structures are second-tier variables.”



**Figure 3.1.** Revised SES Framework with multiple first-tier components

Source: McGinnis and Ostrom 2014.

In our case the SES on which we focus on is the water provision in the region of Greater São Paulo. The targeted social and ecological dynamics are those related to water governance, which does not only involve governance units at the local level, but also at adjacent, state and federal levels. To understand the interplay between these different levels, it is helpful to have the McGinnis’ concept of adjacent action situations in mind. He explains that “an action situation X is adjacent to Y if the outcome of X directly influences the value of one or more of the working components of Y” (2011, p.53). As we observe that private, state and federal organizations are at the same time affecting the institutions that are used to organize water governance in Greater São Paulo, we observe a complexity of interactions, which can be better understood through the lens of the adjacency concept and the notion of a network of adjacent action situation (NAAS).

McGinnis states that “typically, several operational level action situations operate simultaneously, and may directly affect each other, and any one operational level situation may be affected by multiple processes of collective or constitutional action choice” (p.53). At the operational level, actors make choices among their options; these options are previously defined by both the collective and constitutional-level. The first concerns the determination of strategies, norms and rules available to individuals and their role in society. The second is related to who is or should be empowered to participate in the rule making (Ostrom and McGinnis, 2014). When we focus on the operational level, we see that it involves different actors and different types of activities. Thus when we are observing the water governance in Greater São Paulo, we are not just looking to choices made on the operational level in this

region, but also in the state of São Paulo and in the Brazilian federal government e.g. We are not just looking to one action situation, but to various, which may involve activities like provision, coordination and resolution of disputes of water resources.

Here it is essential to be aware of the concept of polycentric governance, which was originally used by V. Ostrom et al. (1961) to describe units of different scale acting in a metropolitan area, what is also the case of our study. A polycentric order, according to a latter essay by V. Ostrom (1999) can be defined as “one where many elements are capable of making mutual adjustments for ordering their relationships with one another within a general system of rules where each element acts with independence of other elements” (p.57). The concept of polycentricity applied to governance emphasizes that contemporary societies organize individual and collective action in a wide diversity of institutional arrangements (McGinnis, 2011). They utilize a multitude of contextualized rules and procedures, operate under different modes of interaction (e.g. markets, hierarchies, networks, discourses), at a variety of spatial, temporal, and jurisdictional levels, and by involving different kinds of actors (Ostrom, 2005).

### **3.2. Theoretical background**

Water allocation in the Greater São Paulo can be seen as an example of a collective action dilemma, which is related to a polycentric order. As noted by Garrick et al. (2013), “a large body of interdisciplinary research advanced by Elinor Ostrom and colleagues has investigated characteristics of actors, institutions and the environment contributing to sustainable self-governance of common pool resources (CPRs)”(p.4). Evaluating self-governance in small-scale CPRs has been the focus used by many of these researchers. In what concerns large-scale CPRs – basins e.g. - there are additional challenges and they are “defined by costly exclusion and risk of collapse due to overextraction” (Garrick et al., 2013, p.4). Ostrom et al. (1999) reinforce that the establishment of global institutions to manage biodiversity involves new challenges and some of these apply to our case. The first one is the scaling-up problem: having larger numbers of participants in a CPR increases the difficulty of organization, agreeing on and enforcing rules. The second is about the complications of interlinked CPRs: interactions between systems (e.g. climate and water) are complex and therefore difficult to manage. The last one is about the accelerating rates of change, which concerns the fact, that “population growth, economic development, capital and labor mobility, and technological change push us past environmental thresholds before we know it” (p.281), which is intensively related to the case of São Paulo. During our analysis we will keep these challenges in mind to help us understand the developments in the case of São Paulo.

Further a “diagnostic assessment must be grounded in theory and empirical evidence to avoid a ‘checklist’ approach that strips away complexity and creates “blind spots” (Garrick et al, 2013, p.7; Basurto et al.). Following this reasoning, we use the three propositions formulated by Garrick et al. to institutional fit in large-scale CPRs and of their proposition concerning water security and climate adaptation (difficult hydrology<sup>19</sup>). We hypothesize that the challenges faced by Greater São Paulo are similar to those faced by the federal rivers analyzed by the authors for three reasons. Firstly, both studies focus on regions, which have scarcity problems and involve a complex institutional network of governance. Secondly, in both we observe the influence of federalism on the development of institutions to access allocation problems in what concerns water security. And finally, both are about cases, which concern challenges of large-scale CPRs. Therefore we use their (adapted) institutional propositions to guide our study and these are:

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<sup>19</sup> “Water systems ... become more complex with ‘difficult hydrology’ — defined by a mixture of natural aridity, flood vulnerability and high inter- and intra-annual rainfall variability, with the last being the most complex.” (Grey et al., 2013, p.4). Garrick et al. (2013) summarize difficult hydrology as high interannual variability, low mean runoff and high storage (p.16).

- Jurisdictional complexity elevates the risk that constituent government will behave opportunistically.
- Interstate allocation rules that divide water rights in terms of shares of available supplies share risks better than allocation rules assigning a fixed volume of priority.
- Outcomes of water allocation improve with multi-level decision-making venues, monitoring, planning and conflict management to address extended droughts and overallocation.

These propositions offer us some clues about which may have been the problems in our case. Furthermore the authors analyze in their paper the case of three river basins that successfully shared hydroclimatic risks tied to scarcity and identify three design trends, which are connected with the improvement of water security: “transition to proportional allocation rules; emergence of multi-layered river basin arrangements for planning, conflict resolution and joint monitoring; and new flexibility to adjust historic allocation patterns” (p.18).

The proposition on water security, which is based on Grey and Sadoff (2007), suggests that regions with difficult hydrology require (comparably) high levels of infrastructure and institutional development to create and share benefits and to achieve tolerable levels of hydroclimatic risks.

These propositions help us in focusing on some variables of our SES, which can help us to access our questions and analyze our hypotheses. As stated by Ostrom (2011, p.22), the most important SES variables for a particular study depend on the research question. Garrick et al. reinforce that “institutional fit in large-scale common pool water resources requires attention to the design and evolution of the governance system” (p.12). Thus we will focus on some second-tier variables of our governance system to be able to evaluate our research question. These are the rule-making organizations (GS5), the “rules-in-use for multi-level river basin planning” (GS6), historic continuity of prior water allocation decisions (GS10). We decided not to include the variable (GS7), about property rights, as we observe them as part of the rules-in-use. GS8 and GS9 are neither suggested as relevant by Garrick et al.; nor are seen as essential for our case study. Concerning the variables GS1 to GS4, they have a more descriptive character of our governance system and are specified in chapter four. The interactions of our SES to be analyzed include harvesting (I1), information sharing (I2), deliberation processes (I3), conflicts (I4), investment activities (I5) and lobbying activities (I6) that affected the water security in the region and either enabled or influenced the current crisis (O1).

Concerning the resource system (RS) and resource units (RU), its important particularities are going to be described in the next chapter, focusing on the second-level attributes (RS3, RS4/8, RS5, RS6, RS7, RU7) selected as essential to identify difficult hydrology by Garrick et al.’s proposition on water security (2013, p. 8). Concerning the actors (A), especially relevant for us is the second-tier variable on importance of resource (dependence) (A8) as suggested by the authors. Additionally, we identified the variables climate patterns (ECO 1), flows into and out of the focal SES (ECO 3), economic development (S1) and demographic trends (S2) as key in our understanding of the water provision system in RMSP.

### **3.3. Method**

The study implements an in-depth explanatory case study of the current water crisis in Greater São Paulo. Primary evidence was collected from a set of twelve semi-structured interviews (45min to 2 hours each) with experts, government officials, key operational actors, social and natural scientists, NGO’s representatives and politicians in Greater São Paulo in March and April 2015; as well as from newspaper articles and government reports and

complemented by scientific publications. The general interview guideline used to guide our inquires can be found in appendix 3.

Data Analysis follows the principles of Qualitative Content Analysis (Gläser and Laudel, 2006; Yin, 2009), where we extract information from the sources mentioned above using the Macro collection for qualitative content analysis (MIA)<sup>20</sup> and process this information separated from its origin. We use the selected SES variables (described above) to operate the extraction. We follow a mixed deductive and inductive procedure similar to the case study of Oberlack et al. (forthc.). The variables of the SES framework initially structure our coding scheme by interpreting the data as manifestations of the first-tier and relevant second-tier variables of the SES framework.

Besides, the analysis of the material will be based on two general strategies. The first is relying on the theoretical propositions and on the hypotheses described above. The second involves the concern of trying to define and evaluate rival explanations to our case study and being aware of other evidences (Yinn, 2003). Additionally we will use the explanation building technic, which has as its goal “to analyse the case study data by building an explanation about the case” (Yinn, 2003, p.120). The process in our case consists of firstly making an initial proposition or hypotheses<sup>21</sup>; then comparing the findings of our field research against these first statements and then revising the statements. As shown by Yinn, “the final explanation may not have been fully stipulated at the beginning of a study (...). Rather, the case study evidence is examined, theoretical positions are revised, and the evidence is examined once again from a new perspective in this interactive mode” (p.122).

As a tool to diagnose barriers to adaptation, we will use the “Typology of Barriers to Adaptation” designed by Ekstrom and Moser (2012), which they inductively derived from the interviews they made for a case study in the São Francisco Bay in the U.S.. They identify four main categories of barriers for the urban context: institutional, attitudinal, financial and political. We will use these and further categories of barriers identified by them to classify our encountered barriers.

## **4. GREATER SÃO PAULO AS A SOCIAL-ECOLOGICAL SYSTEM**

### **4.1. Explaining key aspects of the Resource System and Resource Units**

The sector (RS1) on which we focus on is the water sector in RMSP. The boundaries (RS2) of the resource system are defined by the region of the High Tietê Basin (see figure 4.1, appendix 4), which is *a priori* the resource system responsible for water provision in RMSP. Of the 39 municipalities that constitute the RMSP, 35 are part of the High Tietê Basin (BAT)<sup>22</sup>. The size (RS3) of the resource system can be represented by the basin area, which has 5,720 km<sup>2</sup> (FUSP, 2009). The human constructed facilities (RS4) of the system, also known as gray infrastructure are represented by dams, canals, water transposition networks and wells. It is important to note that one of the problems in our SES is the focus given on

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<sup>20</sup> More at: <http://www.laudel.info/wp-content/uploads/2013/12/Manual-MIA-eng.pdf> (Accessed on 26 July, 2015).

<sup>21</sup> The function of the hypothesis in the Qualitative Content Analysis is to guide the investigation and analysis through the refinement of the research questions(s) and to make the investigators' presuppositions explicit. Its function here is different from the usual role it plays in quantitative analysis, as just in some exceptional cases of Qualitative Content Analysis are the hypotheses going to be tested e.g. confirmed or refuted. Thus here we use hypotheses rather as an orientation tool (Gläser and Laudel, 2006, p.77).

<sup>22</sup> And 33 have their water and sewage services provided by the same company, Sabesp (for more about Sabesp, see the next item).

gray infrastructure, having the green infrastructure<sup>23</sup> a marginal role. According to one of our interview partners, the restoration of forests in the watershed areas is essential to guarantee water security. When there is no vegetation in the reservoirs area/watersheds, then both floods and droughts are even more extreme (Porto, 2015<sup>24</sup>).

The region (RS9) is surrounded by other water demanders; east of it we can find the Paraíba river tail, which include the states of Minas Gerais and Rio de Janeiro. To the north and south are located the metropolitan regions of Campinas and of Santos (see figure 4.2. in appendix 4), which have high concentration of population and petrochemical, automobile and textile industries. Therefore water governance clearly transcends the limits of the metropolitan region of São Paulo, including other metropolitan regions and other states with which the state of São Paulo (SP) shares water or gets its water from (Ribeiro, 2011), like Minas Gerais (MG) and Rio de Janeiro (RJ).

The High Tietê Basin is naturally a region of low water availability due to the fact that it is a riverhead region. The productivity (RS5) of the resource system of High Tietê is since the 1970s complemented by the Cantareira<sup>25</sup> system (ECO3)<sup>26</sup>, which is the transposition of the water from the Piracicaba River<sup>27</sup> to the BAT (see figure 4.2. in appendix 4), representing since then the main water source for the RMSP. The resource units below represent the reservoirs of the Integrated Water Supply System (IWSS)<sup>28</sup>, responsible for water provision in RMSP:

<b>Table 4.1. Resource Units (RU)</b>			
located within the High Tietê Basin			
<b>Unit</b>	<b>Beginning of use</b>	<b>Distance (km)</b>	<b>Supplied population in 2009 (millions)</b>
<b>Alto Cotia</b>	1914	41	0.4
<b>Alto Tietê</b>	1993	36	3,1
<b>Baixo Cotia</b>	1960	36	0.46
<b>Guarapiranga</b>	1929	16	3.8
<b>Rio Claro</b>	1937	82	1.2
<b>Rio Grande</b>	1958	26	1.6

Source: FUSP, 2009, V.2 and Sabesp (www.sabesp.com.br)

<sup>23</sup> “The underlying principle of Green Infrastructure is that the same area of land can frequently offer multiple benefits if its ecosystems are in a healthy state”. Available at:

[http://ec.europa.eu/environment/nature/ecosystems/index\\_en.htm](http://ec.europa.eu/environment/nature/ecosystems/index_en.htm) (Accessed on June 2, 2015)

<sup>24</sup> See Monica Porto (current Adjunct Secretary in the Secretaria de Saneamento e Recursos Hídricos do Estado de São Paulo, SSRH/SP, Brazil) on the video made by FAPESP (São Paulo Research Foundation):

<https://www.youtube.com/watch?v=lyp83uYdtbk> (Accessed on June 2, 2015)

<sup>25</sup> More about Cantareira at:

<http://www2.ana.gov.br/Paginas/servicos/outorgaefiscalizacao/sistemacantareira.aspx> (Accessed on June 10, 2015)

<sup>26</sup> Also important for neighboring cities of RMSP like Campinas and Piracicaba and to the state of Minas Gerais (Braga et al., 2008).

<sup>27</sup> Located in both the states of Minas Gerais and São Paulo.

<sup>28</sup> Sistema Integrado de Abastecimento de Água

<b>Table 4.2.</b> Flows into focal SES (ECO3) Origin: PCJ (Piracicaba, Capivari e Jundiá rivers) Basin			
<b>Unit</b>	<b>Beginning of use</b>	<b>Distance (km)</b>	<b>Supplied population in 2009 (millions)</b>
<b>Cantareira</b>	1973	79	8.1

Source: FUSP, 2009, V.2 and Sabesp (www.sabesp.com.br)

<b>Table 4.3.</b> Comparative analysis between production and operational water availability in the production units of the IWSS				
<b>Production Unit</b>	<b>Production with guarantee of 95% (m<sup>3</sup>/s)<sup>2930</sup></b>	<b>Production in 2009 (m<sup>3</sup>/s)<sup>31</sup></b>	<b>Percent used in 2009 (%)</b>	<b>Guarantee of production in 2009</b>
<b>Alto Cotia</b>	1.5	1	67	100
<b>Alto Tietê</b>	14	10	71	100
<b>Baixo Cotia</b>	1	0.9	90	98
<b>Cantareira</b>	29.9	33	<b>110</b>	<b>65</b>
<b>Guarapiranga</b>	13	14	<b>108</b>	<b>91</b>
<b>Rio Claro</b>	4.4	4	92	100
<b>Rio Grande</b>	4	4.8	<b>120</b>	<b>80</b>
<b>Total</b>	<b>67.8</b>	<b>67.7</b>	<b>100</b>	<b>80</b>

Source: FUSP, 2009, V.2, p.117

Above, it can be seen that the total runoff of the integrated system with a guarantee of 95%<sup>32</sup> is 67.8 m<sup>3</sup>/s (FUSP, 2009, V.2). In the year of 2009, the production of the units equaled the guaranteed runoff, what demonstrates that the system was already operating on its limit. Considering this information, the Plan of the High Tietê Basin (PAT)<sup>33</sup> (FUSP, 2009) strongly recommended the expansion of the production units Cantareira, Gurapiranga and Rio Grande to keep the guarantee of 95%. As it can be seen in table 4.3, the production in 2009 of these units just had a guarantee of 65%, 91% and 80% respectively. Using a weighted average, the guarantee of the IWSS was 80%. Based on these facts, on the growing population in the RMSB, the Plan concluded that there was an eminence of collapse of supply (p.123). The Plan called attention for the importance of the expansion of transpositions to future supply and remembered the importance of negotiation with surrounding regions (p.135).

The IWSS is complemented by the aquifers located in the region, which supply water to industries, condominiums and isolated enterprises. The withdrawal of water is controlled by a state agency (the DAEE, for more see the next item) and is not under responsibility of Sabesp. It is estimated that about 11 m<sup>3</sup>/s of water are extracted from the aquifers in the basin

<sup>29</sup> High Tietê Basin Plan, June/2007, FUSP

<sup>30</sup> X percent of guarantee represents the water provision that was guaranteed in X percent of the months registered in the historical of runoffs.

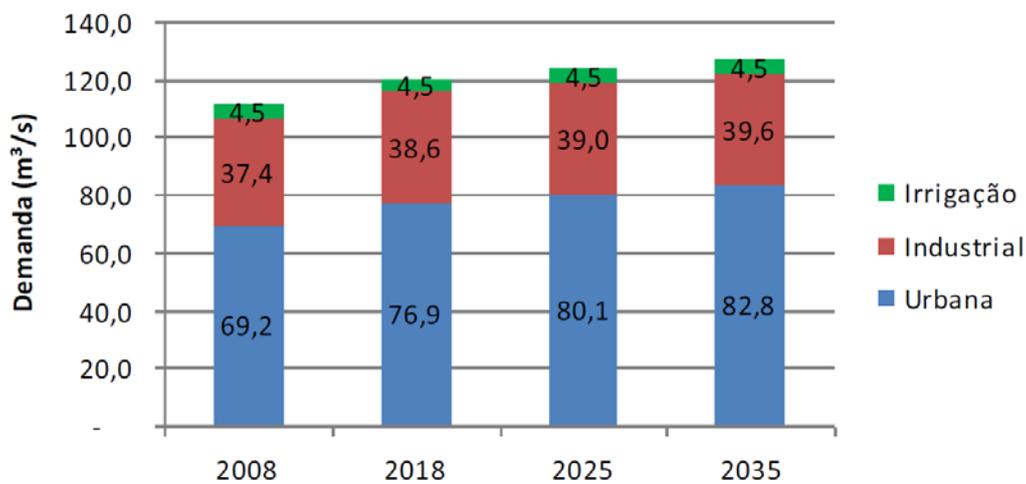
<sup>31</sup> Available at: www.sabesp.com.br (Accessed on 26 July, 2015).

<sup>32</sup> X percent of guarantee represents the water provision that was guaranteed in X percent of the months registered in the historical of runoffs.

<sup>33</sup> The Plan of the High Tietê Basin of 2009 was elaborated by FUSP (Foundation of the University of São Paulo) for the Committee of the High Tietê Basin and is constituted of 10 chapters that explain the challenges of the basin, diagnose its problems and show solutions to these problems.

(FUSP, 2009, V.1, p.169). The problem is that just about 57% of the wheels have a formal permission to operate (FUSP, 2009, V.1, p.172). Considering both the IWSS and groundwater system, the total demand for water in RMSP at the time of the Plan was about 75 m<sup>3</sup>/s (p.181).

In what concerns the equilibrium properties (RS6) and system dynamics (RS7), we have to look on both the demand and supply sides. The official plans that we use here (Macrometropole Plan<sup>34</sup>, 2013 and PAT, 2009) discuss the issue of supply, but based on the historical runoffs of the region. These plans did not take into account projections for possible changes in the historical patterns of the runoff due to climate change e.g. Concerning the development of demand, they made projections based on the expected development of industry, irrigation and population growth. The projection of the trend scenario of the Macrometropole Plan can be seen in the graph below:



**Figure 4.4.** Projection of water demand in the RMSP  
Source: Macrometropole Plan, 2013, V.I, p.103

The demand for water in 2008 was estimated in about 111 m<sup>3</sup>/s<sup>35</sup>. Transforming the data in figure 4.4 for the year 2008 in percentage points, we can see that about 62% of the water demand comes from public provision and about 33% from industries. Agriculture in this basin has not a significant role and represents less than 1% of the demand. For the following years of the projection we can observe that the demand proportions do not tend to change.

The Macrometropole Plan estimated the scenarios for water resources demand for public provision, industrial and irrigation uses for the years of 2018, 2025 and 2035 using population projections, further data and assuming that the demand patterns will remain on the same growth path. As it can be interpreted from the data above, the difficult hydrologic situation in RMSP is related to conjugation of the high population density of 2,555.27 habitants/km<sup>2</sup> (A1/S2)<sup>36</sup> and economic growth perspective (S1) with the low specific runoff.

<sup>34</sup> The full name of the plan is Director Plan of Water Resource Use in the Macrometropole of São Paulo. In this plan they discuss the relation between urban and economic development in the *Macrometropole Paulista* (a macro region composed by the metropolitan regions of São Paulo, Santos and Campinas, mentioned in the beginning of this chapter), the limits and possibilities for water offer in the present and future, focusing on the compatibility of water quality and availability with the demand. This plan was written by a consultancy called Coprabe for the DAEE.

<sup>35</sup> Here the industrial demand includes the water withdrawal permit given to the Empresa Metropolitana de Águas e Energia S.A. (EMAE), which amounts 27,8 m<sup>3</sup>/s and was not included in the previous calculations, that's why we have here a demand of 111 and not 75. EMAE uses the water to produce electricity through the Thermoelectric Plant of Piratininga.

<sup>36</sup> Information available at: [http://produtos.seade.gov.br/produtos/perfil\\_regional/index.php](http://produtos.seade.gov.br/produtos/perfil_regional/index.php) (Accessed on 10 June, 2015).

In the region of High Tietê, the water availability is just 217.9 m<sup>3</sup>/person.year<sup>37</sup>, which is seen as critical according to the classification of Rebouças (1994) and of scarcity by Unesco (2003) as cited in the MMA (2006, p.57).

Based on its prospects of demand, the Macrometropole Plan recommends the elaboration of a contingency plan for situations of scarcity and points to the necessity of a new water production unit with a big provision capacity. Besides they suggest the water reuse, the interference in clouds to increase the water availability in reservoirs, payment for environmental services, maintenance of forests in watershed areas, depollution and other measures (Macrometropole Plan, 2013, V.II, p. 384).

Jacobi et al. (2013) e.g. argue that combined with complex and irregular urban land uses, the problem of water provision intensifies. Concerned about these environmental and social dynamics, the authors observe that the “accelerated rate of urban expansion (S2) into areas of environmental risk and delays in the implementation of adequate infrastructure” (p.13) show that the Brazilian cities are not prepared to face changes. They argue that “water scarcity combined with complex and irregular urban land uses have an impact on the provision of water” (p.3). Thus issues like urban land use and pollution (ECO2) do also play an important role on water security. The majority of rivers and water reservoirs in the metropole have a high level of pollution. The water of one of the biggest dams in the region, the Billings dam, cannot be easily used because of the high costs of making it adequate for human use.

## **4.2. Explaining the Governance System and Actors**

### **4.2.1. Water governance in Brazil (GS6 and GS10)**

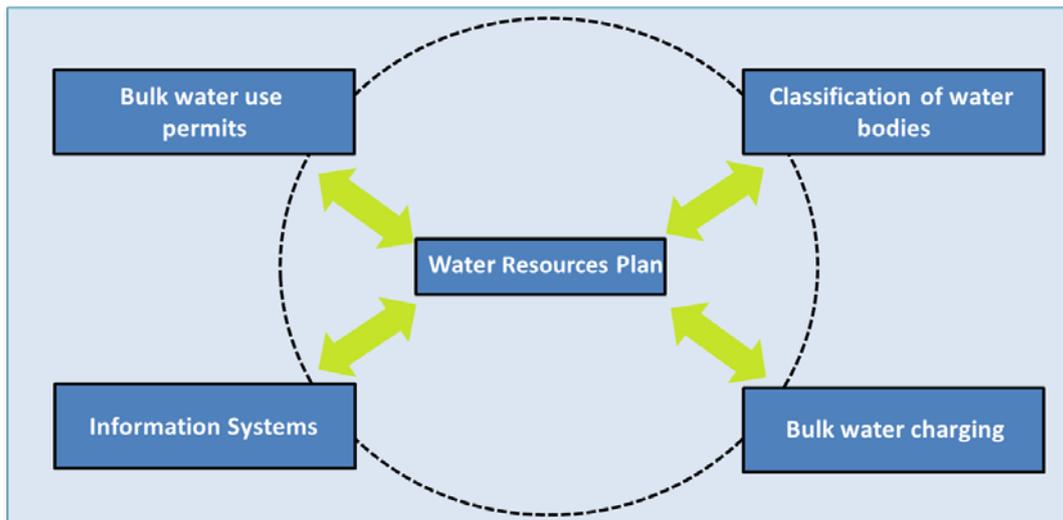
The contemporary Brazilian water governance model is a consequence of a process that began between the 1970s and 1980s (Campos and Fracalanza, 2010). During this time, the political system and its decisions structures were increasingly questioned; in particular, the role of the state and its responsibilities concerning the management of natural resources. The direction that this debate took, coinciding with the redemocratization of the Brazilian political system during the 1980s, was towards a system that includes the negotiation between different levels of government and social actors.

The participation of different social groups is one of the challenges of this system, as the evolved relationship between the state during the dictatorship and the dominant elites is difficult to overcome. Still today, about 30 years after the end of the dictatorship, many sectors of the Brazilian society struggle to have an influence on the political processes, including those related to water governance. The principle of participation in the political process has been reintroduced in the Brazilian society in the 1980s, but the key question or problem is how to bring this principle into practice. Following the Brazilian Constitution (1988), an important legal milestone was the federal law n° 9.433 of 1997, which instituted the National Water Resources Policy (Water Law).

The Water Law recognizes water as a public good with economic value; guarantees the multiple uses of water; in periods of scarcity prioritizes the use for human and animal consume and calls for the participation of the different levels of government, users and civil society in the decision making process. In addition the Water Law institutionalized the National Water Resources Management System (SINGREH) and instituted the following governance instruments:

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<sup>37</sup> MMA, 2006, p.57



**Figure 4.5.** Instruments of the National Water Resources Management System  
Source: ANA, 2013, p.278.

The Water Resources Plan is an instrument to be used in the federal, state and basin levels. Its objectives are *inter alia* to guide grants, monitoring, charge, information systems; to promote the use, control, protection and recuperation of water resources; to guarantee the equilibria between water offer and demand and to contribute to the integration between actors (ANA, 2013). Concerning the Federal/National Plan, its “general aim is to establish a national pact to define guidelines and public policies towards the improvement of water offer, in quality and quantity, managing the demand and considering water as a structuring element for the implementation of sectoral policies under the view of sustainable development” (ANA, 2013, p. 270).

One of the innovations of SINGREH was the use of economic mechanisms for the water management; it introduced the polluter-pays and user-pays principles (Braga et al., 2008). Hence water received a direct economic value in this institutional change. A further innovation of SINGREH was the creation of the basin committees, which are advisory and deliberative bodies, where not just politicians but also users and civil society representatives e.g. have the right to participate. The functions of these committees are *inter alia* to discuss the plans for their respective basin and the price that will be charged for bulk water use. In what concerns the autonomy to manage water resources, states and the federal government are the responsible actors. But in what concerns the management of water services like waterworks and sanitation, the municipalities are responsible (Braga et al., 2008).

To implement SINGREH, the National Water Agency (ANA) was created as an organization that has the capacity to act nationally. ANA was established by the law n° 9.984 in 2000 and has as its function to implement the Water Law and to coordinate the SINGREH, in particular the execution and operationalization of technical and institutional instruments of water management (Braga et al., 2008). ANA is also responsible to regulate the use of federal rivers through bulk water use permits and inspection. ANA has to respect the adoption of basins as management units and acts together with other public and private members of SINGREH.

#### 4.2.2. Water governance in the state of São Paulo and in RMSP (GS6 and GS10)

In 1991 it was instituted the law n° 7663 in the state of São Paulo, which actually was the inspiration for the later federal law of 1997. It adopted a decentralized, participative and integrated management. In 1993 the São Paulo state was divided in 22 water management areas (URGHIs), which were designed based on the basins as basic units (Campos and Fracalanza, 2010, p.373). Each of this is managed by a basin committee. Additionally to the

basin committees, there are the basin agencies which are responsible for the execution of decisions. It is important to be aware that “water management practices in São Paulo state have historically been a local affair (...). This is the case of the (High) Tietê Basin where all waters are under state dominion” (Johnsson and Kemper, 2005, p.15)<sup>38</sup>.

As shown in item 4.1, the region of RMSP coincides with the area of the High Tietê Basin and consequently with domain area of the Committee of the High Tietê Basin (CBAT). Thus when we analyze water governance in the RMSP, we have to analyze the CBAT. Additionally we have to analyze the other organizations that are involved in this governance process, for the description and function of these organizations, please read table 4.4 in appendix 4 (GS5).

Nevertheless as described before a great amount of the water that supplies the RMSP comes from the Cantareira system, which on the other hand is controlled by the Piracicaba, Capivari and Jundiaí (PCJ ) Basin Committee, which unlike the CBAT is not exclusively a state committee, but a federal committee (located in both São Paulo and Minas Gerais). So to understand water governance in Greater São Paulo, it is also necessary to be aware of the activities in this related ecosystem (ECO3), which is the Cantareira system. Thus the governance system of High Tietê is also influenced by an adjacent governance system, the system of PCJ. Both systems are certainly part of the broader structure of the water governance system which is represented in the table 4.4, appendix 4.

Our governance system to be analyzed is formed by organizations at the High Tietê Basin level, at an adjacent level, at the state level, at the regional level and at the national level (GS2). These different levels reveal the complexity of the regime type to be analyzed, which is a federal regime (GS4) and the various types of organizations acting on the water governance that affects about 20 Million people (GS3). Based on the information given up to know, the focus of our analysis could be on the rules being made by those organizations indicated by the mentioned laws as the highest authorities for water governance with deliberative power on the local level, which are the High Tietê Basin Committee and the State Council for Water Resources of São Paulo (see table 4.4 in appendix 4). Nevertheless our field research has shown that this approach is too restrictive, as we could observe that key decisions are not necessarily coming from these organizations. Therefore our analysis was made having an opened approach concerning the observed organizations, allowing for the inclusion of further organizations that were important to answer our research questions.

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<sup>38</sup> It is interesting to note that the committee composition differs between the state (1991) and the federal (1997) law. The first divides the seats of the committees equally among representatives from municipalities, state government agencies, and organized civil society groups. The second groups users together and establishes that they must occupy at least 40% of the seats and civil society at least 20%. “For this reason many have called the São Paulo model overly state-based” (Johnsson and Kemper, 2005, p.18).

## 5. RESULTS

### 5.1. Taking stock and explaining barriers to water security

This section identifies 10 encountered barriers to water security, having in mind our first and second research sub-questions. These barriers were encountered in the interactions that contributed to the crisis and thus are part of the different action situations that influenced the water governance system in our focused region. Table 5.1 provides an overview of the identified barriers and classifies them according to Ekstrom and Moser's (2014) typology. The text subsequently describes each barrier and its implications for decision-making and water security.

BARRIER		TYPE
1.	Path dependency	Political
2.	Missing contingency plan and rules for droughts	Institutional
3.	Elections and the high cost of assuming the crisis	Political
4.	Exclusive political system	Political
5.	Resistance against water charging	Political
6.	Lack of binding mechanisms in water plans	Institutional
7.	Sabesp's management model	Financial/Political
8.	Non-inclusion of water security in the political agenda	Expertise/Political
9.	Metropole model	Political
10.	Dialog between organizations	Institutional

**Table 5.1.** Encountered barriers to water security

#### 1. Barrier: Path dependency

Most related SES variable(s): GS10 (historical continuity).

There is strong evidence from our field research that the conversion of the water governance system in the RMSP to a new model did not occur and still needs further endeavor to be completed. It could be noticed that the rules-in-use are different from those established in the constitutional/collective level of the new model (Constitution of 1988, Water law from Brazil and SP). Concerning the RMSP, one of its particularities is its physical proximity to the government of SP, where the center of the state power is concentrated, what according to an informant hampers the development of the Committee of the High Tietê Basin. The main challenge remains to transform the Committee "from only a social force into an authoritative arena for decision-making" (Johnsson and Kemper, 2005, p.41). What prevails then is a water governance structure that is centered in the state government (including Sabesp) and not in the multi-layered structure described in table 4.4. In the current governance system the traditional power, which is centralized in the state government, overrules the division of power described in the table. In times of crisis this fact becomes more evident, when it is observed that the main decisions are taken at the governor's cabinet. Our informants speak about "the existence

of two structures that do not work harmonically or are not coordinated”, “the difficulty for the committee to occupy the space for which it was created for”, and the “centralization in the state government”. In summary “the system is like Frankenstein, its body is the participative model and its head, the old system”<sup>39</sup>. Thus we identify a path dependency on the old state centralized water governance system. This system tends to favor certain interest groups like industrialists and large-scale farmers and to disregard others like the layers in society with less income. This inequality is in turn reflected in the decisions concerning water allocation and investments in sanitation.

## 2. Barrier: Missing contingency plan and rules for droughts

Most related SES variable(s): GS5-6 (rule-making organizations and rules-in-use) and I1 (harvesting activities).

During the crisis decisions on water governance were clearly coming from another level and the basin committees (CBAT and PCJ) were not a platform for discussions on actions. Without an organized demand by the committees of their place in this debate, decisions are made not considering their positions. Thus the crisis makes things clear that are not so visible in regular times. An important issue here is the domain for discussions on the crisis. Who has the authority to manage and make decisions in times of crisis? There were no rules to delimit this domain. There are different opinions on which should be the locus for debates and negotiation during the crisis. Some think that the committee does not have the proper conditions because decisions there take time to be made. Others think that the committee is an adequate locus and that this *ad hoc* situation just put more in evidence that the integrated system is not taken seriously.

Thus a barrier that impeded a better preparation to the crisis was the absence of a contingency plan<sup>40</sup> for a period of scarcity. The Macrometropole Plan discussed this issue and stated that this was one of the items of most importance of the plan. It also drew attention to the fact that the Basin Plan of High Tietê (2009) did not encompass contingency measures for the case of a water provision collapse (p.207). According to the National Sanitation Policy (Law n° 11.445/2007), contingency plans are to be elaborated by municipalities and water and sewage concessionaries (in the case of RMSP, Sabesp). Besides, there is another federal law (Law n° 9.984/2000) that assigns to ANA the promotion and planning of actions to prevent and minimize extreme events (p.208). Then there are different actors that according to the law should be involved in the formulation of a contingency plan, being Sabesp the most important one in the regional level and ANA in the national level. Indeed as Sabesp received the renewal of its permit to use Cantareira’s water in 2004, it agreed on drawing a contingency plan for emergency for floods, and not for droughts.

One interviewee emphasized the importance of adaptiveness of rules to periods of droughts. The problem is that the permission the majority of bulk water users have does not consider variations on the allowed amount in case of a drought; the permitted amounts are fixed. This shows that the lack of proportional rules is partially a problem of the governance system. To enter a crisis without a rule for this purpose is very complicated; it is much easier to decide on such a rule from an ex-ante perspective. According to an interviewee, policies and institutions work relatively well when water availability is around its mean. But in periods of floods and droughts, mostly in droughts, it is evident that more efficient management instruments are needed. One example is the existence of eight industries in the Cantareira region which have the permit to together withdraw 8.4 m<sup>3</sup>/s<sup>41</sup>. The Water Law

<sup>39</sup> Engineer Carlos Zuffo in the debate of the newspaper Folha de São Paulo on 27 March, 2015.

<sup>40</sup> A contingency plan is a normative document that clearly describes risks, actors, responsibilities and actions to be taken in cases of extreme events (Macrometropole Plan, 2013, V.I, p. 189).

<sup>41</sup> Available at: <http://www1.folha.uol.com.br/cotidiano/2015/05/1624047-oito-industrias-de-sp-tem-o-dobro-da-agua-de-toda-a-cidade-de-campinas.shtml> (Accessed on 26 July, 2015).

states that water for human consumption has priority, but it is not clear among other sectors like industry, agriculture, energy, which has the priority under climate extremes. Thus it is difficult to establish clear reduction targets for these sectors. The dependency on Cantareira puts into evidence the importance of operative rules that avoid collapse and diminish political influence on decisions (FUSP, 2009, V.1, p.76). According to an informant, important to note is that among Sabesp's clients there are some with special contracts, while the rest of the population pays for overconsumption. Additionally we could observe that no clear water consumption reduction goals were posed to industry and agriculture.

### 3. Barrier: Elections and the high cost of assuming the crisis

Most related SES variable(s): I3 (deliberation process) and I2 (information sharing).

A barrier that contributed to the intensification of the ongoing crisis was the elections that took place in Brazil in October 2014. Three of our interview partners notified the interference of the election year on the initiatives to be taken by the government of SP together with Sabesp to regulate the water use. One said that no action was taken because of the belief that this was just an atypical period of drought; another noticed that the government of SP was not working with the idea of climate change or climate variability. In the beginning of 2014 the former president of Sabesp, Dilma Pena, said that rationing will be necessary and informed the state authorities. Later on a leaked recording of hers came out. In this recording she stated that orders from "higher ups" prevented her from revealing the severity of the drought<sup>42</sup> to the public. Besides Sabesp's publicity pieces were not allowed to use words like "drought" and should talk exclusively about "water saving"<sup>43</sup>. The denial of the crisis in 2014 by the government of SP due to the elections impeded the adoption of saving measures in advance, what would have diminished the severity of the crisis<sup>44</sup>.

### 4. Barrier: Exclusive political system

Most related SES variable(s): I3 (deliberation process) and I2 (information sharing).

A next barrier is the lack of integration of the community in the water governance system and in the deliberation processes. Six of thirteen interviewees pointed to this fact, saying that there is a general lack of understanding of what a committee is and what its functions are. Few people even know about its existence. Without the participation of the public in the debate governance turns out to be more unequal. "If people do not know about the committee's existence and mission, how are they going to demand something?", raised one of our interviewees. Further there are few organizations of the civil society developing activities to indeed influence decision making; the majority does not have enough resources to support activism. The lack of participation and of inclusion of many social groups in the political system influences the results of the water governance. Those who are politically less organized and less able to put pressure on decision-makers, were the first to suffer with water provision cuts (people in poorer neighborhoods and homeless people).

### 5. Barrier: Resistance against water charging

Most related SES variable(s): I6 (lobbying activities).

Bulk water charging is an instrument of water governance that was created by the Water Law. Nevertheless the creation of this instrument does not mean that its implementation is guaranteed. Different groups were resistant against this water charging and saw it as an

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<sup>42</sup> Available at: <http://www.reuters.com/article/2014/10/31/us-brazil-water-idUSKBN0IK1RL20141031> (Accessed on 26 July, 2015).

<sup>43</sup> Available at: <http://São-paulo.estadao.com.br/noticias/geral,apos-vazamento-de-audio-vereador-quer-reconvoar-presidente-da-sabesp-em-cpi,1582073> (Accessed on 26 July, 2015).

<sup>44</sup> Available at: <http://www1.folha.uol.com.br/poder/2015/02/1591570-raquel-rolnik-desastres-nao-São-naturais.shtml> (Accessed on 26 July, 2015).

additional tax burden. The idea of this pricing established by the Water Law is actually to recognize water as a public good and to indicate the real value of water to users and to provide a mechanism to allocate a scarce resource. The revenues from this charging are to be used to finance plans, projects, and constructions in the basin where these revenues are levied.

Two sectors were very resistant and organized against this charging, the industrial and agricultural. They put a lot of pressure on the government and in committees to hinder the implementation of bulk water pricing<sup>45</sup>. These lobbying activities were reported by many of our informants (6), including those which were/are working inside the state. The agricultural sector in the state of SP does not pay for bulk water use in almost all parts of the state. The industrial sector in the region of BAT is an example of an actor that pays a very low price for each m<sup>3</sup>.

According to Johnsson and Kemper (2005, p.34) this incapacity of the state of SP to implement the bulk water pricing was a sign of failure of the system as a whole. The revenues coming from this charging are one of the financial bases of the committees and agencies activities. One interviewee remembers that by looking to the budget of a sector, one can more or less know if this sector is prioritized or not. When one knows that the budget from committees should come from water bulk charging and this is either not implemented or this charging is very low, then one knows that the committees are not a priority.

#### 6. Barrier: Lack of binding mechanisms in water plans

Most related SES variable(s): GS5-6 (rule-making organizations and rules-in-use)

Many interviewees (6) pointed out to the difficulty of putting the basin and state water plans into practice. The Plan of High Tietê (2009) already calls attention to the tradition of plans to be just dead letter. Regulations are needed to put new policies into practice, states the plan (p.209). Planning is an important step, but it is not enough. Historically the water plans are not binding. If there are no binding mechanisms, then they are more like a recommendation, because there is nothing that forces this plan to be incorporated in the public and private management. There is no public (federal, state or basin level) instrument that requires actors to incorporate the plan in the management of their activities. The existing plans, says an interviewee, can even have reached a Pareto optimum, a possible negotiated solution. But that is not enough; the next step that has to be taken is the design of plans which are binding. The lack of planning is not a problem, but the execution of these plans, which has the high potential to enhance water security.

#### 7. Barrier: Sabesp's management model

Most related SES variable(s): I4 (conflicts), I5 (investment activities) and GS6 (operational rules)

As Sabesp received the renovation of its bulk water use permit for the Cantareira System in 2004 (Portaria DAEE n° 1213, de 06 de Agosto de 2004), they agreed to diminish their dependence of this system and to present alternatives to water provision. Sabesp also agreed to make efforts in diminishing the linking in its networks. The rules to which Sabesp agreed on also established a gradual decrease in water withdrawal in accordance to the level of reservoirs. This means that the deficits during a drier period should be distributed throughout time.

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<sup>45</sup> According to Johnsson and Kemper (2005), the "Federation of Irrigators (FAESP-Federação dos Agricultores do Estado de São Paulo) has always demanded that this group be exempt from water charging until rigorous studies prove that they can afford to pay". And "the industrial sector, through its powerful state federation (FIESP- Federação de Indústrias do Estado de São Paulo), has actively resisted the introduction of any charges for water use. Up to the mid-1990s, the industrial sector maintained a moderate position. It then began to aggressively and publicly lobby against water charging"

In 2013 Sabesp began the negotiations for this permit (see *Renovação da Outorga do Sistema Cantareira 2014*. Ofício DAEE/SUP/0965/2013, de 24.07.2013). In this document, Sabesp reported the expansion of water production through three new projects, which added 5, 0.7 and 4.7 m<sup>3</sup>/s of water. The last one was still not concluded and should cost about 1.6 Billion Reais. They reported an investment of about 3.5 Billion Reais in a program to reduce linking and losses and had the target to achieve the level of 19% of losses by 2020.

Despite these investments, Sabesp was still very dependent on Cantareira's water in 2014 and water losses in networks were still high, about 27%. Two key questions here are: why did Sabesp not prioritize these key investments? And: does the Sabesp management model as a private (49.8%) and public (50.2%) company fit its mission of providing water and sewage services in a sustainable way? The company yielded considerable profits in the past years (see table 5.2, appendix 5). In the face of the crisis, it was clear which the priorities of the company were. In a period when the effort of employees was most demanded, the company fired at least 560 people until April 2015. 80% of these worked directly in operations that generate impacts on the population<sup>46</sup>. According to an informant that worked for the state of SP, operations against linking were not more widespread because the company had to generate profits. According to this person, Sabesp was neglecting the urgency of the expansion and maintenance of its networks. The lack of the necessary investments to assure water security can be seen as the result of interest conflicts, a political matter<sup>47</sup>. Indeed the lack of investments on further reuse, maintenance of networks and expansions contributed to the water insecurity. According to a document drafted by different entities that represent actual and previous employees of Sabesp (*Proposta para a nova gestão da Sabesp, 2015*<sup>48</sup>), the company decisions on delay and prioritization of investments are mainly prescriptive (p.6). Yet it is notable to remember that the state of SP receives 50.2% of the dividends distributed by Sabesp and is not obligated to reinvest this revenue in water services. That is, this revenue is distributed between different activities of the state.

#### 8. Barrier : Non-inclusion of water security in the political agenda

Most related SES variable(s): I2 (information sharing) and I3 (deliberation processes)

A further barrier is the non-inclusion of water security and adaptation issues in the political agenda of SP. This issue can hardly be found in the plans of water resources. The representatives of ANA and government of SP said that the issue now has to be part of the agenda and that initiatives are being taken to insert them in the agenda. Other than the São Paulo state, the Ceará state had water management reform on the top of its political agenda and succeeded in implementing water charging already in 1996 (Johnsson and Kemper, 2005, p. 43). According to the authors a "strong and determined public sector" was essential to "overcome the skepticism and active opposition of both government agencies and water users" (p.43). According to an informant, it is essential to "mobilize energy and intelligence to get over with business as usual". However, there is still not a clear integration of adaptation concerns in the water planning of SP, when the issue of climate change comes up, some water planners are mostly focused on mitigation issues (diminishing energy consumption, carbon

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<sup>46</sup> Available at: <http://www.valor.com.br/empresas/3956710/funcionarios-da-sabesp-aceitam-suspender-greve-ate-dia-23> (Accessed on 26 July, 2015).

<sup>47</sup> See Santana: <http://revistaforum.com.br/digital/147/o-colapso-da-agua-em-Sao-paulo/> (Accessed on 26 July, 2015).

<sup>48</sup> Available at: [http://www.apu.com.br/assets/imagens/publicacoes/publicacoes\\_20150126094815.pdf](http://www.apu.com.br/assets/imagens/publicacoes/publicacoes_20150126094815.pdf) (Accessed on 26 July, 2015).

foot print) and not on adaptation<sup>49</sup>. Besides we could observe that the majority of water plans (Macrometropole Plan e.g.) have a predominately demand side based approach, focusing mostly on how to attend demand and not on rethinking or changing this pattern of demand.

#### 9. Barrier: Metropole model

Most related SES variable(s): S1 (economic development).

One of the difficulties described by the interviewees is the metropole model of São Paulo itself, i.e. the concentration of a huge amount of people, activities and services in a specific place. This concentration of demand poses more challenges concerning the provision of natural resources, including water, to sustain life in this location. Besides, the occupation pattern of the territory that belongs to RMSPP has not been ordered and contributed to the devastation of the important green areas in the watersheds. Connected to the occupation pattern of the city is the problem of social inequality and the impossibility of about half of the population in the region to afford a real state with their income. The option for those is the informal living, in slums for instance (FUSP, 2009, V.I, p.68). This process of occupation was very strong from the 1960s to the 1980s, and remains nowadays at a slower path. Thus the metropole model, which is a political choice of those who have governed the region and encourages the concentration of production and markets, is a remarkable barrier to the design of a water secure region.

#### 10. Barrier: Inadequate dialog between organizations

Most related SES variable(s): I2 (information sharing).

The last barrier is related to the dialog between organizations (I2). At the state level there are three main organizations which deal with water-related issues, DAEE, CETESB and Sabesp. To get the coordinators of the three together takes time, says an informant. Besides, there is the difficulty to transform information into a decision tool. The articulation between the organizations should improve, to enable the functioning of the integrated system. The Committee and the CRH are the places where this articulation is previewed to take place, but that is not the reality. Johnsson and Kemper (p.15) summarize this problem: “Thus, despite having better financial and human resources than other agencies in Brazil, the São Paulo state management agencies were still unable to control, or even to keep up with, the speed and intensity with which water resources in the Alto-Tietê basin were being appropriated and used”. This incapacity is also related to the lack of integration between the organizations mentioned above, which work mostly separately and barely articulate decisions.

### **5.2. Comparison of results with hypotheses and propositions (design trends)**

To be able to compare our results with the stated hypotheses, we classified the barriers described above according to the typology developed by Ekstrom and Moser (2014). As shown in table 5.1, it can be observed that the majority of the encountered barriers are of political and not of an institutional nature, what is somehow different from what our first hypothesis. Here it is important to remember that we have developed a method neither to order nor to quantify the intensity of each barrier (cardinal). Rather our method aimed to identify the different types of barriers and we were able to show that the key barriers were not exclusively institutional, but also political. There are three institutional barriers, all of which are related to the absence of key governance instruments that could have contributed to a more secure water governance system according to the statements collected during the

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<sup>49</sup> An example for that is the document “Diretrizes para o plano de acao da cidade de São Paulo para mitigacao e adaptacao às mudancas climáticas” (2009), a plan of the city of São Paulo for mitigation and adaptation measures. In this plan adaptation measures are indirectly mentioned and not really issued.

interviews, in the Macrometropole Plan and in the Basin Plan of High Tietê. As for the political barriers, we encountered seven, two of them with a mixed typology.

Based on the evaluation of the barriers, we could see that power relations play a key role. The government makes decisions under considerable pressure of specific interest groups like industries and agricultures. The political system remains exclusive due to the path dependency of old power structures and this also affects the broader governance system, which tends to favor specific groups in the allocation of financial and natural resources. Besides, the last governments in the region did not challenge the metropole model, i.e. the land occupation paradigm that remains. The concentration of capital and production triggers huge demand for water in the region. However, there was hardly any government which deeply rethought São Paulo's growth in the last decades.

As for our second hypothesis, we found no compelling evidence that land grabbing is a key point in explaining the present crisis. The water reservoirs important for RMSP are neither in regions of recent agrarian expansion nor under influence of recent large-scale land acquisitions. The deforestation problem in the watersheds regions is not a new one and is also related to the disorganized growth of the city. Interesting is to remark that the actors related to the large-scale land sector in the state of São Paulo are part of those who lobbied the government for not paying for water (see barrier 5). The absence of revenues from water charging decreases the available resources to finance the establishment of the multi-level water governance as previewed by the Water Law. Still, concerning the second hypothesis it is interesting to highlight the scientific hypothesis that deforestation in the Amazon and in the Cerrado region in Brazil, which is a consequence of large-scale land acquisitions, is related to the drought in the southeast. Nevertheless on this hypothesis there is no consensus in the scientific debate and thus we cannot draw a connection between large-scale land acquisitions in these regions and the drought in São Paulo<sup>50</sup>. Also when our second hypothesis would proceed, it is clear that our ten barriers contribute to the instability of water security. Even when not considering this kind of climate stimulus (drought) and focusing just on the growing demand for water in the region, it is clear that the situation is critical, as explained in chapter four. The drought in the summer 2013/2014 was the last drop of water (or the absence of the drop) that lacked for the water insecurity in São Paulo to be so clear, that it could no longer be ignored.

When we compare our results with the design trends that Garrick et al. (2013) derived from their propositions, we find some important connections. The first design trend, which recommends transition to proportional rules, is connected to the second barrier, missing contingency plan and rules for droughts. The lack of proportionality in the bulk water use permits was indeed a problem and the existence of ex-ante proportional rules could have helped in the more efficient management of water allocation. The difficulty for the multi-layered river basin arrangement (second design trend) to be implemented was also identified as a barrier (see path dependency, barrier 1) for water security in São Paulo. Additionally the lack of flexibility to adjust historic patterns (third design trend) is part of barriers like path

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<sup>50</sup> Antonio Nobre (researcher at Brazil's Center for Earth Systems Science – CCST/INPE) "warned that Amazonian deforestation could interfere with the forest's function as a giant water pump; it lifts vast amounts of moisture up into the air, which then circulate west and south, falling as rain to irrigate Brazil's central and southern regions. Without these "flying rivers," Nobre said, the area accounting for 70 % of South America's GNP could effectively become desert. (...) In January and February of this year, when rain is usually abundant in central and southern Brazil, the flying rivers failed to flow south". Available at: <http://www.wri.org/blog/2014/11/3-maps-help-explain-s%C3%A3o-paulo-brazil%E2%80%99s-water-crisis> (Accessed on 26 July, 2015). Nevertheless this conclusion is not unanimous and still issue of discussion in the scientific community. See: <http://www.cartacapital.com.br/sustentabilidade/para-especialistas-causas-da-seca-vaio-alem-do-desmatamento-na-amazonia-2901.html> (Accessed on 26 July, 2015).

dependency and resistance against water charging. The conservative forces that gain with the historic allocation patterns are part of the barriers that increase water insecurity.

According to Engle and Lemos (2010), “in theory, more flexible, democratic, and participatory designs are hypothesized to increase adaptive capacity” (p.6). They remember that there are few examples that confirm this theory. Concerning our case study, we identified not necessarily the lack of participation and opportunities as a key barrier to water security, but the misrepresentation of the interests of the population in having a secure water provision and the risky behavior of water managers (Sabesp and government). One of our interview partners pointed clearly to the resistance of the government in SP in taking the needed measures and others commented the silence in the state and in Sabesp concerning the crisis. Here we can observe that the government was more risk-averse concerning its popularity than concerning the water provision. As shown by Estadão and argued by the new president of Sabesp, if water withdrawal would have been proportional to water inflow in the system since 2012, the level of the system would have decreased much less as it did<sup>51</sup>.

### 5.3. Overcoming barriers

As it was described before, the encountered barriers were mainly of either political or institutional character. Concerning entry points and ways of overcoming these barriers, we identified some interesting attitudes described by interviewees and initiatives from other regions that could inspire initiatives in our case region.

To overcome political barriers seems to be one of the hardest challenges of adaptation in the context of the RMSP. Some interviewees pointed to the importance of mobilization of the society and gave the example of the Water Alliance (Aliança pela Água) as a successful example of about 60 organizations of the civil society engaged together on water security. They also pointed to the importance that other social movements put more pressure on the state and organize themselves. Here we would also suggest social and political inclusion through governmental programs as a method to overcome some of the political barriers. An example of a successful program is the “Cultivando Água Boa”<sup>52</sup> (Cultivating Good Water) in the region of the ITAIPU dam<sup>53</sup>. Among other activities the program motivates farmers to preserve fountainheads and cultivate organic products. It won in 2015 the Water for Life UN-Water Best Practices Award<sup>54</sup>. This program is an example of how an active engagement of key organizations based on new paradigms on land and water use is fruitful for water security. This is also a method to overcome barriers like the exclusive political system (barrier 4), as it stimulates the inclusion of stakeholders, and the inclusion of water security in the political agenda (barrier 8).

Notable is that the water crisis itself gave input to dynamics in the society that then develop the capacity to overcome the barriers, which originally helped to generate the crisis. The population e.g. became more aware about the issue and is making more efforts to defend their rights and to look for political channels to influence decisions. So, the crisis is partially the remedy for itself. In the case of England and Wales, something similar happened (Arnell and Delaney, 2006). There, awareness to the problem of climate variability also increased after an extreme event, the droughts of the mid 1990s and was then used to motivate the inclusion of the issue in the political agenda. In the case of the water sector in this region,

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<sup>51</sup> Available at: <http://São-paulo.estadao.com.br/noticias/geral,sabesp-poderia-ter-evitado-uso-do-volume-morto-do-cantareira,1682611> (Accessed on 28 July, 2015)

<sup>52</sup> This program was created in 2003 and is based on a strategy for that takes into account the effects of climate change. The program establishes a network of protection of water resources in the Paraná River basin and involves about 2 thousand organizations among schools, NGOs, governmental organizations, associations and companies.

<sup>53</sup> The second largest hydroelectric facility in the world.

<sup>54</sup> More under: <http://www.un.org/waterforlifedecade/winners2015.shtml> (Accessed on 26 July, 2015).

similar struggles were identified like the predominance of concerns related to increases in demand for water, due to demographic change and population movements, than about the implications of climate change” (Arnell and Delaney, 2006, p.237). These struggles are related to our eighth barrier, non-inclusion of water security in the political agenda. For this kind of struggle the authors pointed to the work of the Environment Agency that demands companies to investigate the effects of climate change and variability on supply. For our case would be interesting to suggest that DAEE and ANA demand water companies like Sabesp, to take into account adaptation measures and changes in supply in their business plans.

As for the institutional barriers, the suggested initiatives are more straightforward. One suggestion to overcome the lack of binding mechanisms for water plans was to transform water plans into contracts. Through contracts stakeholders who do not implement their share of the plan can be called to court. Another suggestion was the creation of water pacts like the Convention on the Protection of the Rhine, which would involve parties in the compromise of certain levels of water quality and quantity. For the case of RMSP, the state could establish contracts with big stakeholders like water companies and industries to secure that they would attend the compromises described in the basin and state water plans. Another tool would be financial schemes to motivate the accomplishment of the water plans. Further the formulation of a contingency plan for scarcity scenarios is essential to address the barrier 2, missing contingency plan and rules for droughts.

Concerning initiatives to overcome the non-inclusion of water security in the political agenda (barrier 8) in the past, an interesting one was the study “Environmental Scenarios”<sup>55</sup> of the Secretary of Environment of SP (2009), which proposed middle and long-term measures for the public environmental management. This initiative aimed at the incorporation of the climate change theme in the governmental agenda. However, the project was not received warmly by higher officers according to an interviewee, what evidences the resistance of politicians to include this concern in the agenda.

## 6. CONCLUSION

The present work aimed at building an explanation of the barriers to water security in the RMSP having the ongoing crisis as its main background. In the second chapter we argued on the relationship of this crisis with a wider global context of crises related to the scarcity of resources and to the challenges of economic development in emerging countries. In chapter three we explained the methodology that framed our research and analysis. In chapter four we described the water provision system of the RMSP, the focal SES of this work. In this chapter it was possible to see how connected this region is to its surrounding and that the provision of water in this region operates on its limits at least since 2009. Further, the crisis of 2003-2004 evidences that the disequilibria between water availability and water demand in the region is not a recent issue. In chapter four we also showed how complex the water governance system in this region is and presented the organizations (actors) at different levels involved in the control, allocation and distribution of water and also described the main juridical milestones of the actual water governance system in the RMSP. This chapter attempted to describe a more or less static picture of the water provision system in Greater São Paulo and the actors, resource units, resource system and governance systems that influence the outcome, which is water (in)security. This step was essential for chapter five, as it gave us a first grasp of the existent connections between variables and first clues of the weaknesses of the focal SES.

Chapter five exposed our general results and described the encountered barriers. The described barriers indicate that political struggles have a big influence on the allocation of water resources and on investments on infrastructure related to the distribution of water.

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<sup>55</sup> Available at: <http://www.ambiente.sp.gov.br/wp-content/uploads/2013/01/Cen%C3%A1rios-Ambientais-2020.pdf> (Accessed on 26 July, 2015).

Water insecurity is a complex outcome and was here described as the result of different interactions at various governance levels. Our objective was to disentangle this complexity and build an explanation on the barriers that either enabled or intensified the crisis.

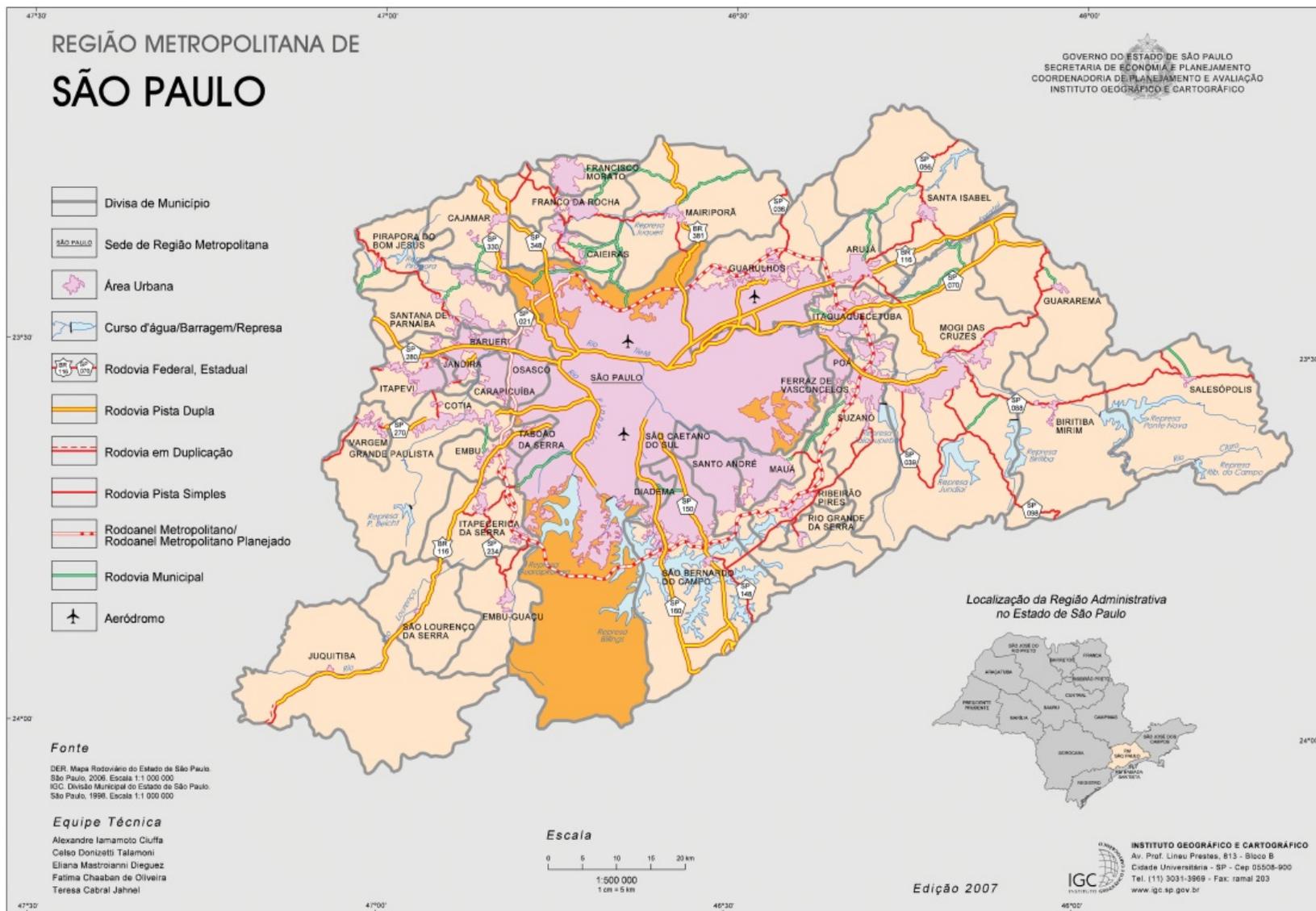
Concerning our central research question, on the reason why there was not a better preparation for a possible drought period, we could see that the reason to that is mostly related to institutional and political factors. More specifically, related to factors like the predominance of the representation of certain groups in the state of São Paulo and to the absence of ex-ante institutional tools to share water related risks. Above (item 5.2) we declared that we found no compelling evidence that land grabbing is related to the ongoing crisis. But we could observe that the lack of governance mechanisms and the political power concentration, which characterizes the actual governance system, are central in the explanation of the ongoing crisis. We interpret the crisis as the symptom of a bigger problem, which is the inability of the existent governance structure to successfully manage and share risks in the field of water provision. The risk that the water managers (Sabesp and SP) took is not tolerable, as they put into risk the quality of water provided for human consumption and the availability of this water. Thus we identify a governance failure by those directly involved in the water management, which are the state government of São Paulo and Sabesp. Nevertheless it is important to be aware of the other factors that contributed to the outbreak of the crisis, as explained by the ten barriers. We conclude that a governance failure was a key driver of the crisis, but not the only one.

**APPENDIX 1:**



**Figure 1.1.** Location of the state of São Paulo in Brazil

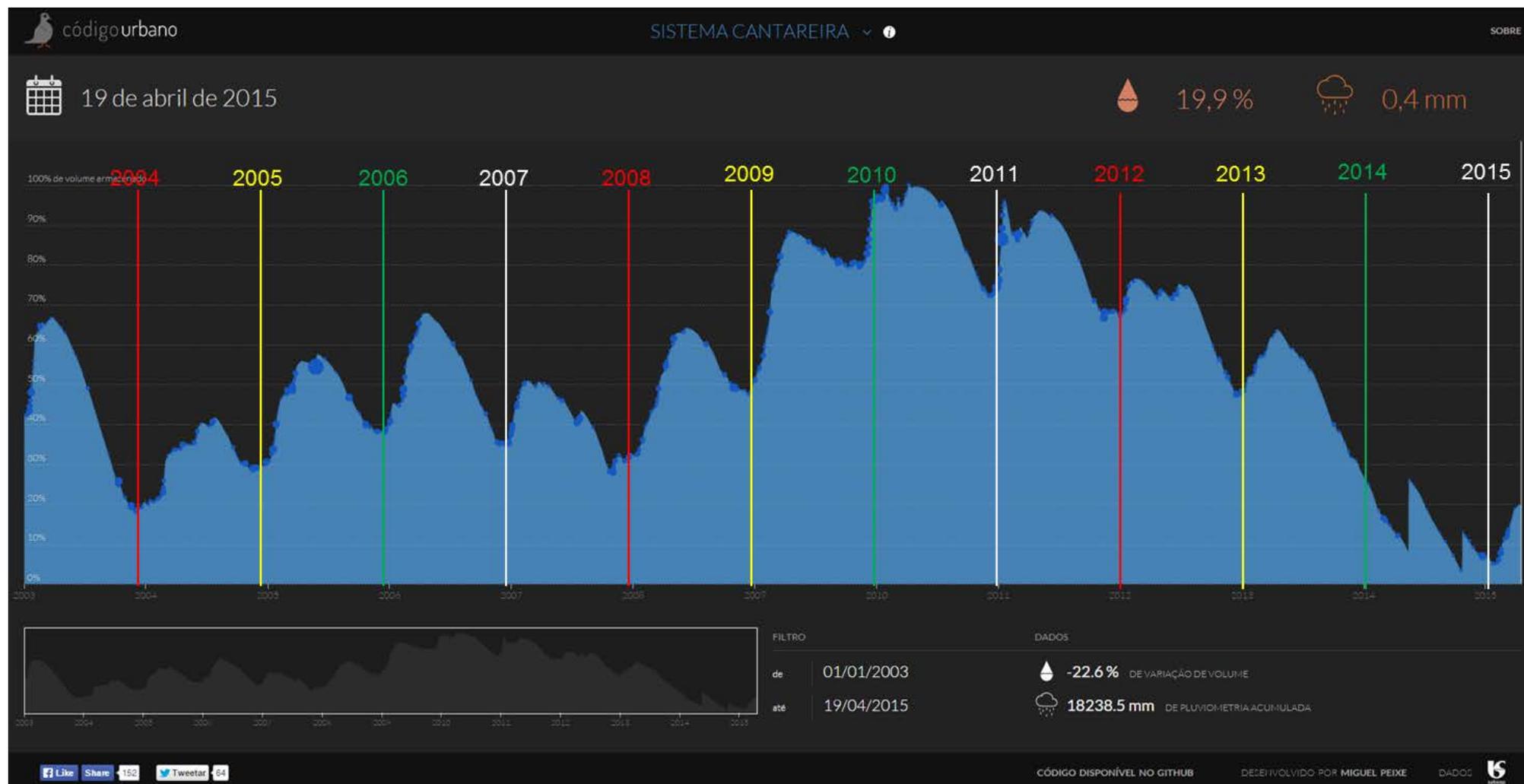
Source: Wikipedia



**Figure 1.2.** Location of RMSP in the state of São Paulo

Source: Instituto Geográfico e Cartográfico (IGC)

## APPENDIX 2



**Figure 2.1.** Water levels of the Cantareira System from 2003 to 2015  
Sources: Sabesp (data) and Miguel Peixe/Código urbano (graph design)<sup>56</sup>

<sup>56</sup> Available at: <http://mananciais.tk/> (Accessed on 28 July, 2015)

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**Social, economic, and political settings (S)**

S1 Economic development, S2 Demographic trends, S3 Political Stability, S4 Other governance systems,  
S5 Markets, S6 Media organisations, S7 Technology

**Resource Systems (RS)**

RS1 Sector  
RS2 Clarity of system boundaries  
RS3 Size of resource system  
RS4 Human-constructed facilities  
RS5 Productivity of system  
RS6 Equilibrium properties  
RS7 Predictability of system dynamics  
RS8 Storage capacities  
RS9 Location

**Resource Units (RU)**

RU1 Resource unit mobility  
RU2 Growth or replacement rate  
RU3 Interaction among resource units  
RU4 Economic value  
RU5 Number of units  
RU6 Distinctive characteristics  
RU7 Spatial and temporal distribution

**Governance Systems (GS)**

GS1\* Policy area  
GS2\* Geographic scale of governance system  
GS3\* Population  
GS4\* Regime type  
GS5\* Rule-making organizations  
Public sector organization (government agencies, etc.)  
Private sector organizations (for-profit)  
Nongovernmental, non-profit organizations  
Community-based organization  
Hybrid organizations  
GS6\* Rules-in-use  
Operational-choice rules  
Collective-choice rules  
Constitutional-choice rules  
GS7\* Property-rights systems  
GS8\* Repertoire of norms and strategies  
GS9\* Network structure  
GS10\* Historical continuity

**Actors (A)**

A1 Number of relevant actors  
A2 Socioeconomic attributes  
A3 History or past experiences  
A4 Location  
A5 Leadership/entrepreneurship  
A6 Norms (trust-reciprocity)/ social capital  
A7 Knowledge of SES/mental models  
A8 Importance of resource (dependence)  
A9 Technology available

**Action Situations: Interactions (I) → Outcomes (O)**

**Interactions (I) (Activities and Processes)**

I1.1 Harvesting  
I1.2 Information sharing  
I1.3 Deliberation processes  
I1.4 Conflicts  
I1.5 Investment activities  
I1.6 Lobbying activities  
I1.7 Self-organising activities  
I1.8 Networking activities  
I1.9 Monitoring activities  
I1.10 Evaluative activities

**Outcomes (O)**

O1 Social outcomes  
O2 Ecological outcomes

**Related Ecosystems (ECO)**

ECO1 Climate patterns, ECO2 Pollution patterns, ECO3 Flows into and out of focal SES

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**Table 3.1.** Coding scheme: second-tier variables of the SES framework  
(Adapted from McGinnis and Ostrom, 2014)

## General interview guideline

### Beginning of the interview

a) Explain:

Interview's objective

Role of the interview for the project

b) Ask if the interview has to be anonymous

c) Ask if I am allowed to record the interview

### Questions:

1 – As a first question ask something to warm up, easy to answer and that the interviewee likes.

### About the interviewee's function:

2 – Since when have you been involved with the water governance issue? In which way have you been involved?

3 and 4 - What are your tasks and responsibilities in the process? What is / was your role in the process?

### About the water governance process

5 - Have all the stakeholders previewed by the law (7663/1991) been present in the governance process in the last 20 years?

6 – Which difficulties were there for the participation of some groups?

7 – Who makes the decisions? Where are the decisions concerning the water policies indeed being made? Which interests, interactions do they have to take into account?

8 – Under whose and which pressures are they making decisions?

9 – How do you see the relationship between agriculture and other activities in what concerns the water use?

10 – Which are the remarkable actors in the decision-making process?

11 - Would it be possible to identify the different interest conflicts in the Alto Tietê Basin Committee, in the CRH? How were these conflicts generated? How were they solved?

12 – How are initiatives from citizens, social movements, NGOs integrated in the decision-making process?

### About centralization and decentralization:

13 – Was there a mixture of centralization and decentralization in the governance process? Was one of the predominant? Were there discussions with the municipalities, organized groups, citizens? Was it possible to negotiate? What was made with the feedback given by NGOs and citizens?

14 – Is there a decentralized governance system in practice? Which are the different levels in which decisions are made?

15 – Was it possible to make negotiations between the municipalities, Alto Tietê Basin Committee and CRH?

### About climate adaptation initiatives:

16 – In which way are climate adaptation initiatives present in the municipalities' and state's policy? If they are not present, why not?

17 – Which are the difficulties to bring such an issue in the political agenda?

18 – How does the communication about the water crisis between the decision-makers and the technical specialists take place? How does the public sector connect itself to the knowledge that is being generated in academia and research centers?

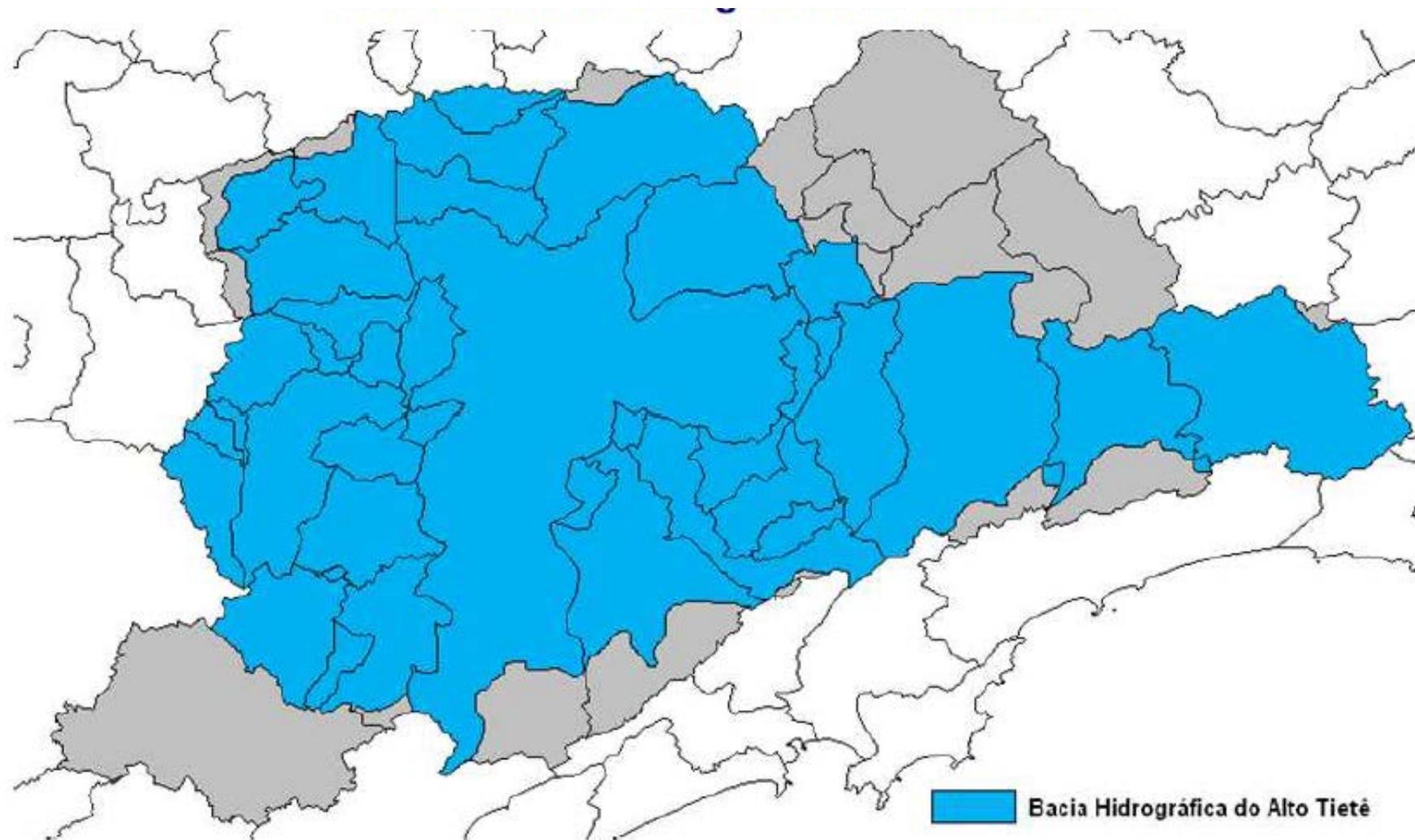
19 – Which were the barriers encountered by those who tried to implement policies or initiatives which could had guaranteed a higher degree of water security? (26)

### About opinions:

20- How do you think that in a context of crisis was possible to approve the PL 21914?

22 – How do think the crisis is impacting and will impact on the environmental policies in municipalities and in the state of São Paulo? Could you already observe something interesting? Which one? How did it take place?

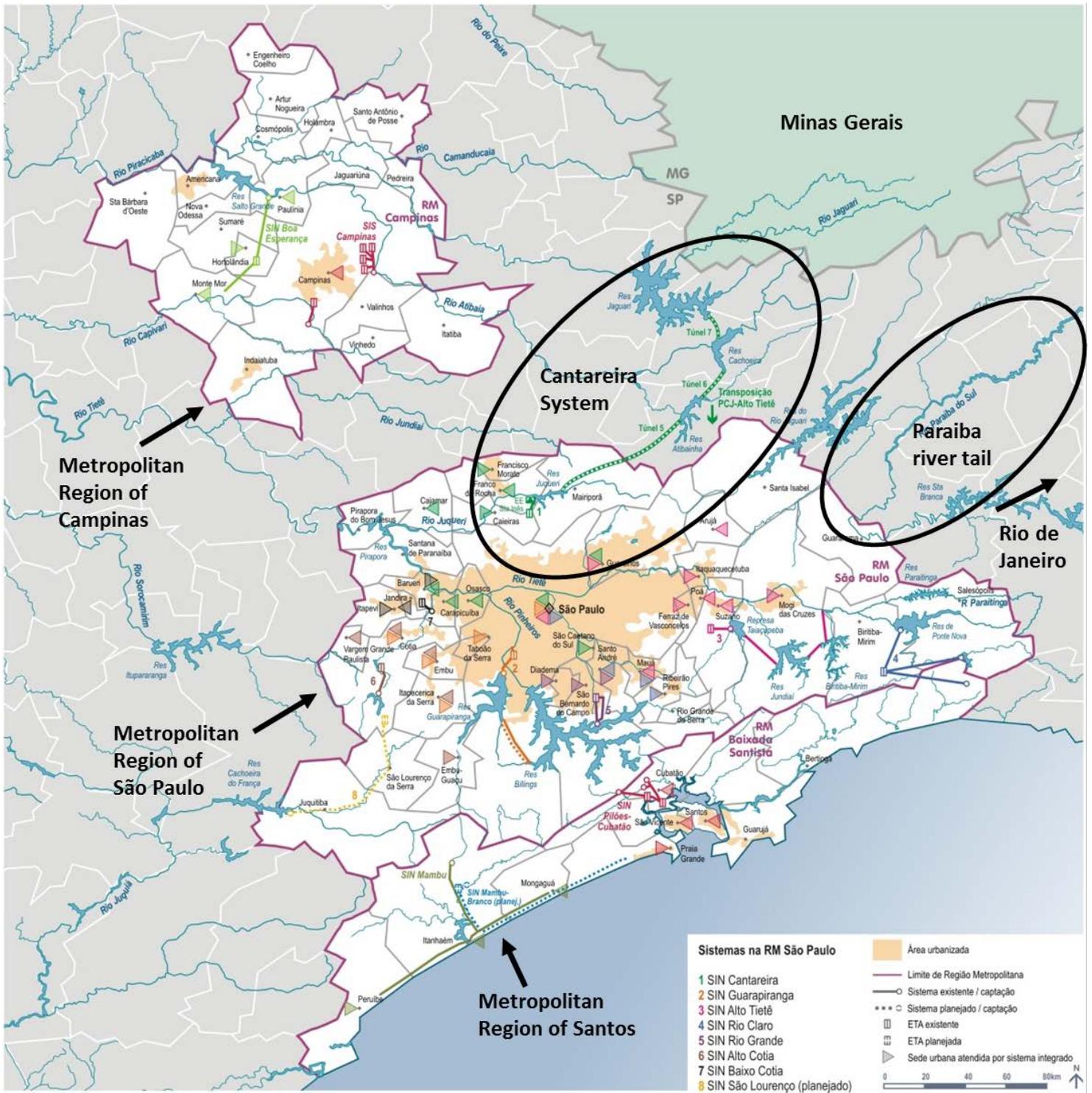
## APPENDIX 4



**Figure 4.1.** Map of geographic overlapping – RMS (blue and grey) and High Tietê Basin (blue)

Source: Prefeitura de São Paulo (Câmara). Estudo Água<sup>57</sup>

<sup>57</sup> Information available at: <http://www2.camara.sp.gov.br/CTEO/Boletins/Estudo-Agua.pdf> (Accessed on June 10, 2015)



**Figure 4.2.** Metropolitan Region of São Paulo (RMSP) and its neighborhoods

Source: ANA<sup>58</sup>

<sup>58</sup> Available at: < <http://atlas.ana.gov.br/Atlas/forms/analise/RegiaoMetropolitana.aspx?rme=24>>



**Table 4.4:** Main rule-making organizations (GS5 and A) for water resources management in the BAT

LEVEL	INITIALS	ORGANIZATION	FUNCTION(S)
Federal government	CNRH	National Water Resource Council	<ul style="list-style-type: none"> <li>• Highest Authority of Singreh.</li> <li>• Articulates the integration of water public policies</li> <li>• Mediates conflicts</li> <li>• Approves the National Water Resources Policy and conducts its execution.</li> </ul>
	SRHU/ MMA	Water Resources and Urban Environment Secretariat	<ul style="list-style-type: none"> <li>• Formulates the National Water Resources Policy</li> <li>• CNRH's executive secretariat</li> </ul>
	ANA	National Water Agency	<ul style="list-style-type: none"> <li>• Management department.</li> <li>• Implements the National Water Policy and coordinates Singreh.</li> <li>• Implements and coordinates the integrated management</li> <li>• Controls grants and inspection of water use.</li> <li>• Priority for combating pollution and drought</li> <li>• "ANA (and others federal organizations) have little influence in the Alto-Tietê basin, except regarding hydropower issues and inter-basin transfers from federal rivers" (Johnsson and Kemper, 2005, p.22)</li> </ul>
State government	CRH	State Council for Water Resources	<ul style="list-style-type: none"> <li>• Highest Authority in the state of São Paulo.</li> <li>• Collegiate organ, with a consulting and deliberating character</li> <li>• Supervises and regulates state water policies</li> <li>• Members: state, municipalities and civil society</li> </ul>
	CORHI	Coordination Committee for the State Water Resources Plan	<ul style="list-style-type: none"> <li>• Technical body of the water system in SP</li> <li>• Executive Secretariat for the CRH</li> <li>• "Coordinates the revision of the state water resources plan every four years; promotes institutional integration among all the state water related institutions, including the establishment of technical working groups when necessary."</li> </ul>
	SERH	Energy, Water Resources and Sanitation Secretariat	<ul style="list-style-type: none"> <li>• Establishes the State Water Resources Policy</li> <li>• Coordinates the state water management system, including DAEE and SABESP, which are subordinated to SERH.</li> </ul>
	DAEE		<ul style="list-style-type: none"> <li>• Controls grants and water uses (water bulk permits)</li> </ul>

		State Water Resources Management Agency of São Paulo	<ul style="list-style-type: none"> <li>• ANA from SP</li> <li>• Technical and administrative support for the basin committees</li> </ul>
	CETESB	São Paulo State Environment Agency	<ul style="list-style-type: none"> <li>• Environmental agency</li> <li>• Issues environmental permits</li> <li>• Monitors pollution</li> </ul>
	FEHIDRO	São Paulo State Water Resources Fund	<ul style="list-style-type: none"> <li>• Offers financial support to the Water Resources Policy of the São Paulo state.</li> </ul>
<b>State government /private agency</b>	SABESP	State Water and Sanitation Company of São Paulo	<ul style="list-style-type: none"> <li>• Mixed capital company responsible for providing urban water supply and sewage services in 33 municipalities of Greater São Paulo</li> <li>• One of the largest in the world</li> </ul>
<b>Basin level</b>	CBAT	High Tietê Basin Committee	<ul style="list-style-type: none"> <li>• Discuss plans for the basin, prices for water use and intermediate in a first plan the conflicts in the basin</li> <li>• Members: state, municipalities and civil society</li> </ul>
		Sub-committees of Alto- Tietê Basin	<ul style="list-style-type: none"> <li>• Responsible for the regulation and implementation of headwater conservation, protection, and recuperation policy at the local/regional level.</li> <li>• Formal institutions submitted to the CBAT's regulation</li> </ul>
		Foundation High Tietê Basin Agency	<ul style="list-style-type: none"> <li>• Executive arm of the basin committee of Alto Tietê</li> <li>• Contracts projects, builds human capacity</li> </ul>
<b>Municipal level</b>		Municipal Water and Sanitation Services	<ul style="list-style-type: none"> <li>• “Only a few municipalities are not supplied by SABESP and have their own local urban water supply services” (Johnsson and Kemper, 2005, p.22)</li> </ul>

Source: Johnsson and Kemper (2005) – adapted

APPENDIX 5

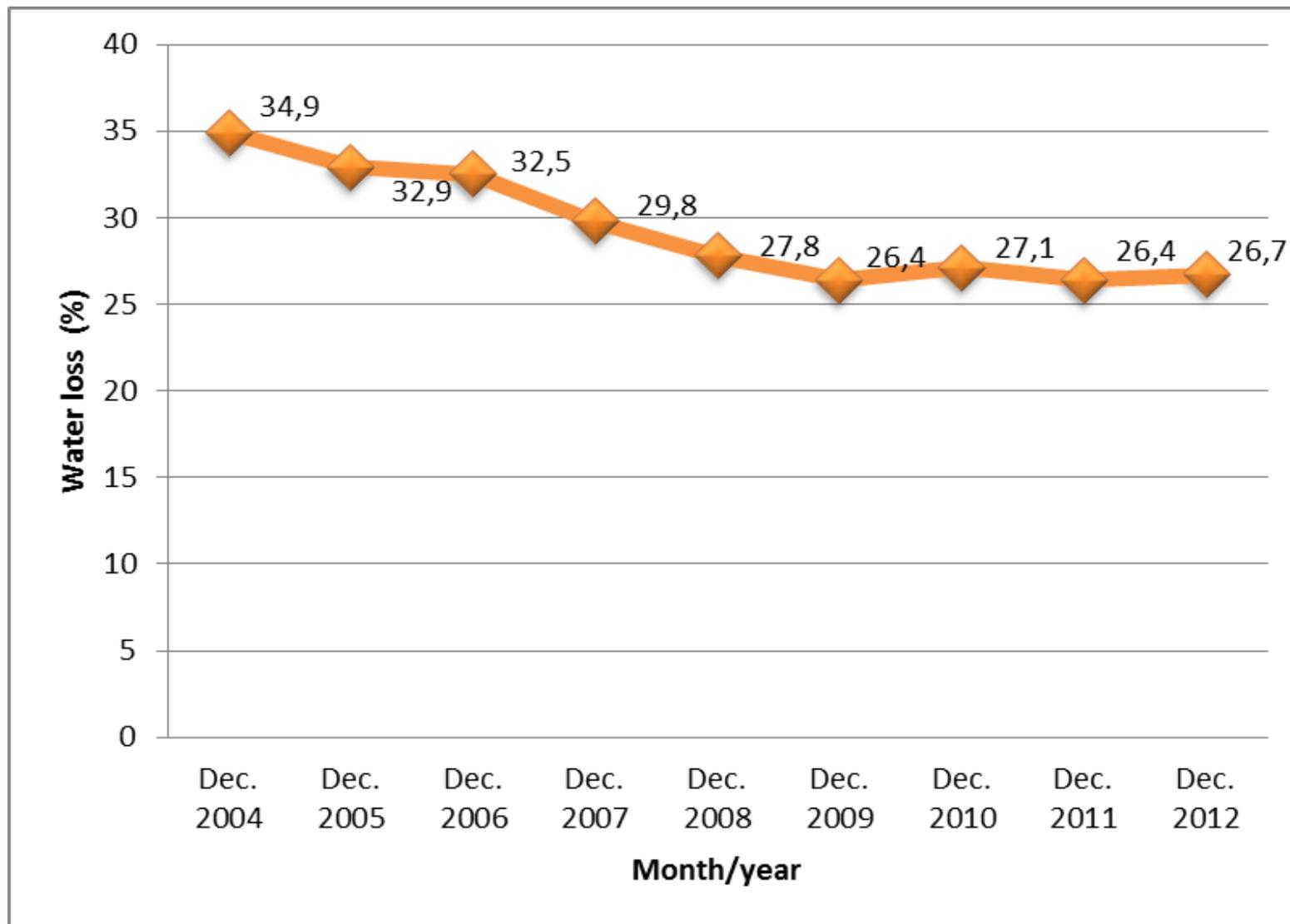


Figure 5.1. Water losses in the RMSP from 2004 to 2012

Source: Sabesp (Renovação da Outorga)

<b>SABESP'S FINANCIAL INDICATORS</b> in millions of Reais			
<b>Year</b>	<b>Profit</b>	<b>Revenue</b>	<b>Investments</b>
<b>2014</b>	903,0	11.213,2	2.716,0
<b>2013</b>	1.923,6	11.315,6	2.535,6
<b>2012</b>	1.911,9	10.737,6	2.440,2
<b>2011</b>	1.223,4	9.927,4	2.457,3
<b>2010</b>	1.630,4	9.230,3	1.852,8
<b>2009</b>	1.373,9	6.730,5	1.960,7
<b>2008</b>	63,6	6.351,6	921,1
<b>2007</b>	1.048,7	5.970,8	2.716,0
<b><u>Total:</u></b>	10.078,5	71.477,0	17.599,7

**Table 5.2.** Sabesp's financial indicators in millions of Reais

Source: Sabesp<sup>59</sup>

<sup>59</sup> Available at:

<http://www.sabesp.com.br/CalandraWeb/CalandraRedirect/?temp=4&proj=investidoresnovo&pub=T&db=&docid=842251991A09555B832570DF006605BA&docidPai=AB82F8DBCD12AE488325768C0052105E&pai=filho6&filho=neto-1> (Accessed on 3 August, 2015) and

<http://www.sabesp.com.br/CalandraWeb/CalandraRedirect/?temp=4&proj=investidoresnovo&pub=T&db=&docid=D63CA1FCA51B05E9832570DF006D5ADC&docidPai=AB82F8DBCD12AE488325768C0052105E&pai=filho8&filho=neto1> (Accessed on 3 August, 2015).

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