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Water security in a context of crisis:
an institutional analysis of Jundiaí's water management framework

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Water security in a context of crisis: an institutional analysis of Jundiaí's water management framework

By

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Abbreviations and Acronyms

ANA – *Agência Nacional de Águas* – National Water Agency

APA - Area of Environmental Protection

APP – Permanent Protection Area

ARES-PCJ - *Agência Reguladora da Bacia dos Rios PCJ* – Regulatory Agency of the PCJ river basins

CERJU - *Comitê de Estudos e Recuperação do Rio Jundiaí* – Committee of Studies and Recuperation of Jundiaí River

CETESB - *Companhia Ambiental do Estado de São Paulo* – Environmental Company from SP state

CPO - Causal-process observation

CSJ – *Companhia de Saneamento de Jundiaí* – Sewage Company of Jundiaí

DAE - *Departamento de Água e Esgoto* – Department of Water and Sewage

DAEE – *Departamento de Águas e Energia Elétrica* – Department of Water and Energy

DSO - Data-set observation

EM - Environmental Ministry

GWP - Global Water Partnership

HDI – Human Development Index

IAD - Institutional Analysis and Development Framework

ICWE - International Conference on Water and the Environment

IWRM - Integrated Water Resources Management

MASP - Metropolitan Area of Sao Paulo

NRRMS – National Water Resources Management System

NWRP- National Water Resources Policy

PCJ – River Basin formed by the Piracicaba, the Capivari and the Jundiaí Rivers

PSDB - *Partido da Social Democracia Brasileira* – Brazilian Social Democratic Party

PT – *Partido dos Trabalhadores* – Workers' Party

RBC - River Basin Committees

SCWR - State Council on Water Resources

SE – Secretary of Environment

SWRE – Secretary of Water Resources and Energy

SES - Socio-ecological Systems

TCE - *Tribunal de Contas da União* - State Audit Court

UGRHI - *Unidade Hidrográfica de Gerenciamento de Recursos Hídricos do Estado de São Paulo* - Hydrographic Unit of Water Resource Management of the SP state

UN – United Nations

US – United States

WRIS - Water Resources Information System

WRP - Water Resources Plans

WVS - World Values Survey

Abstract

Sao Paulo is facing a big threat of lacking water supply in the short-term, and many reasons explain this build-up context of water insecurity. As a contrast, a city called Jundiaí, located 60km away from the largest and doughtiest Brazilian financial center, was able to achieve relative stable status of water security by doing its water management 'homework' in the past years. The present research investigates how Jundiaí's water supply and management system have fostered water security in a macro context of water scarcity. Here it is proposed the Institutional Analysis and Development framework (IAD) as theoretical underpin for understanding water management outcomes constructed in institutional settings. By focusing on the arena of water management, actors and action situations are explored and their contribution to the water security status are unveiled, thus contributing with lessons on water governance and with a new example of application for the IAD model – on water management and supply frameworks.

1. Introduction

> The fact is there is enough water available to meet the world's growing needs, but not without dramatically changing the way water is used, managed and shared. The global water crisis is one of governance, much more than of resource availability, and this is where the bulk of the action is required in order to achieve a water secure world (UN-Water/WWDR, 2015, p. 7).

This passage from an UN conference about 'The future of water – A vision for 2050' go straight to what has been a common cause of water-related problems in many places: poor water governance. Following the Global Water Partnership, water governance refers to "the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society" (GWP, 2003, p. 7). It covers the manner in which allocative and regulatory politics are exercised in the management of resources, being these natural, economic or social ones, and it embraces formal and informal institutions by which authority is employed. Poor governance is said to cause "political and social risks, institutional failures and rigidity, and a deterioration in the capacity to cope with shared problems" (GWP, 2003, p. 9). In this sense, the poor exercise of institutional jurisdictions related to water management accounts for a great deal in understanding water crisis events.

Water is a primordial resource, essential for almost all types of life in the planet. The non-substitutability of drinking water for human life is only a small part of the picture, which also involves the essential role of forests' evaporation for climate maintenance and rainfalls, the biological role of oceans and watersheds as home of millions of species, its key role for food production, and so on. In short, "water is the essential primary natural resource upon which nearly all social and economic activities and ecosystem functions depend" (UN-Water/WWDR, 2015, p. vii).

To manage such a fundamental and ever-present resource is indeed a challenge with the complexity of balancing between resource protection and resource use. How to share water among its various uses and in the same time protect it from threats and guarantee long-term availability, is a

persistent concern for policymakers worldwide. Not surprisingly, consistent policies for water management have been the exception rather than the rule, and policies usually address water in a fragmented way, for instance disregarding the intimate relation between water resources and land occupation (Louka, 2008) (GWP, 2000). Moreover, water has an economic value as it is manipulated and delivered by water providers in much of the world, and it is a key economic input to a variety of industrial, agricultural and corporate activities. However, water has a range of religious, spiritual, and environmental meanings, which undermine its treatment solely as an economic good. Accordingly, scholars define water as a common-pool resource, as it is impossible to exclude its access (due to the non-substitutable character) and its consumption is rivalrous (over consumption by one individual can reduce the benefit or access for others). Too little water can lead to food scarcity, thirst, health problems, poverty and so on. Too much water causes floods and destruction. Contamination of land and water resources, deforestation and silting are also negative impacts to water resources. Therefore, quantity and quality are inseparable in water management, as well as water competing uses, inter-territoriality of streams and the role of water within ecosystems (Bakker, 2007) (Louka, 2008) (Bakker, 2010).

The process of water governance has become increasingly complex and intertwined within the various crosscutting roles that water plays in urban development. Real world institutionalism entails that a range of organizations, agencies and governance bodies, with distinct and sometimes conflictive functions, interact with each in the build-up of water management procedures, processes and policies. The fragmentation of administrative jurisdictions and the institutions' inability to exert coordination and communication within the governance system put additional limitations for the achievement of effective water management, constraining the ability of actors to deal with problems in a successful way. In addition, this polycentric framework of governance is diffuse through multiple levels of authority, from national to state, local and also the river basin domain. Thus, a key element of governance is a strong institutional and administrative framework where people with different interests and perspectives can peacefully discuss and achieve cooperation agreements and coordinated actions.

In sum, water governance involves multiple actors, capabilities and institutions, and it should regard both inter-sectoral water issues and cross-sectoral concerns such as energy, food production,

environmental services, land use and human development. However, this is not the case in the majority of geographies around the world, thus entailing the emergence of water-related issues and crises. Scholars interested in understanding situations within water crisis contexts should, therefore, look into institutional settings and actors' interactions in these water management environments. The study of these elements should provide clarifying insights about governance patterns that contributed to specific outcomes in water management.

1.1 Brazilian context of crisis

Deforestation, urbanization, pollution and over-exploitation of natural resources are examples of human practices that undermine the environment's capacity to provide ecosystem services, including clean water. Amazon deforestation have reached 19% and specialists showed how it has affected ecosystem dynamics of surrounding regions, for instance misbalancing precipitation levels in the Southeast region of Brazil (Nobre, 2014). Likewise, the sub-tropical biome *Mata Atlântica* has intrinsic relation to surrounding water resources' vitality and maintenance of humidity levels, but this forest has also suffered degradation and largely depredation, remaining only 12.5% of its native coverage and not necessarily in areas of hydric strategical function (for example riparian and percolation areas). Hence, vegetation clearing contributes to disturb ecosystem dynamics and cause atypical climate events, such as harsh droughts (SOS Mata Atlantica, 2013).

Large urban centers usually concentrates a large portion of the population, the pollution, and the demand for water. In the case of Brazil this is not different. Brazilian largest metropoles are located in the Southeast region of the country, the same region that has suffered from a severe drought since middle of 2013. The decrease of rainfalls frequency and intensity since 2012 had fast effects into the dams systems that supply metropolitan areas such as Sao Paulo, Campinas and other 75 municipalities within Sao Paulo state. These systems rely on water resources from the PCJ River Basin, which is composed by three large river basins (Piracicaba, Capivari and Jundiaí) that were largely affected by the lack of rainfall recharge. Since the doughtiest season in 2014 and 2015, thousands of households have faced lack of water and rationing, and the threat for a total shortage is still close as rainfall levels have not retrieved (AESBE, 2015) (SABESP, 2015).

The majority of river basins located in this region are polluted with industrial and domestic sewer, and the striking deficit of household sanitation and wastewater treatment foster this badness. Lack of investments in sewer treatment was replaced by large investments in expanding supply networks, thus increasing water demand. However, it was not accompanied by investments in expanding supply, resulting in an unbalanced water provision system that depletes remaining volumes within natural hydric resources (Dezem, 2015). Additional explanations for this crisis are the lack of riparian vegetation around the majority of water bodies, undermining their capacity to absorb and retain water, and the widespread cultivation of eucalyptus and pines in both riparian and hilltop areas, which constraints infiltration and percolation abilities (Maddocks, Shiao, & Mann, 2014) (Nobre, 2014) (Vigna, 2015).

The PCJ River Basins supply water for about 14 million people, located in municipalities within the region and at the Metropolitan Area of Sao Paulo (MASP). *Cantareira* is the dam system that provide water for 50% of MASP's households, and its reservoirs (that are recharged by PCJ River Basins) have achieved the lowest filling rates in history, currently at a negative level of -11% of the normal capacity[1]. In the case of other dependent municipalities it may be even worse, as the majority of them do not have reservoirs or dams to accumulate water for distribution. Most of these cities rely upon catchment directly from the river streams, so in drought events they simply do not have any water to supply (G1, 2015). These evidences show how poor governance and lack of well-driven investments can aggravate a situation of drought.

Amidst this scenario, few municipalities were able to maintain distribution and pass through the drought without rationings or shortages. This is the case of Jundiaí, a large municipality located just 60 km away from MASP, and which enjoyed enough volume in its reservoirs to keep water supply since the drought eruption. The city's dams system also receives water from the PCJ River Basins as main source of recharge, thus it was affected by the scarcity along this hydric basins, although the

[1] The reservoirs compounding the *Cantareira* reached 0% of its water level capacity in the dry season of 2014, starting then to use the remaining water quantities under the level of catchment – the so-called 'dead volume'. This water volume needs to be pumped in order to be caught through the treatment catchment system, as it is located in the lower bottom of the reservoirs' ground and it is a poor quality water, full of sediments. Therefore, the indications of volume regarding the 'dead volume' are always with a negative sign (-) in the front.

damage felt by its citizens was much lower than what other cities' residents have been facing (Mendes, 2015). What does explain the water security condition that Jundiaí's water providers have held in the middle of a drought situation? This is main quest guiding this research project.

1.2 Research questions

The ultimate goal of water managers to prevent water-related issues and urban water crisis has not been accomplished across the world, neither in the state of Sao Paulo. Lack of water is an acute situation that require immediate action, hence putting big pressure in water governance leaders and institutions responsible for providing services and managing water resources. In the middle of an insecure context of water run-out, the unusual occurrence of water security intrigues analysts interested in understanding water management paths and outcomes. Thereby, the puzzling value of water security sits at one side of the causal mechanism that this research is interested in.

In the other side of the causality, the independent variable resulting in the outcome of interest, here relates to water governance. The water management framework that Jundiaí is located at, and the way governance has been carried out in this institutional environmental are coupled as explanans of this causal mechanism.

Therefore, the substantive concern of this project is to understand how institutional arrangements affect the achievement of outcomes such as water security in urban contexts of water crises. Addressing this concern requires the use of theoretical work grounded on institutionalism, public choice and governance. The operationalization of these theories is enabled through the use and application of the IAD framework, which is a conceptual map to structure and guide investigations concerning institutional environments. Based on the puzzle and the theoretical framework proposed, a central research question and additional sub-questions were elaborated to guide this research:

- How is it possible that Jundiaí is able to offer secure provision of water in a macro context of water scarcity and governance failures?
    - How does the IAD framework explain this water management outcome?
    - What are the conditions within this water management framework and the environment that have contributed to this positive outcome?

- Which were the main actions that decision-makers had taken that consolidated this positive result?
- What do these actions and the way actors pursued them say about governance approaches?

In order to answer the questions a case study is conducted in Jundiaí, assessing the institutional setting and specific circumstances that have led to this atypical condition of water security within the region. The application of the IAD framework is expected to provide explanations about the causality and inferences about governance pathways that have led to successful outcomes in water provision. The concepts addressed in the investigation derive from water scholars, social scientists and organizations engaged in producing knowledge on water-related issues and solutions. The operationalization of these concepts is based on interpretations about concepts' mechanisms, and the analysis is enabled by the IAD framework.

The purpose of using IAD in this project is to understand the action situations and interactions that have led to the outcome of water security enjoyed in Jundiaí. The framework will assist in clarifying the external factors that have affected the action situations, which in turn have resulted in the outcome of interest. The focus on the actions is important to elucidate how they have led to the outcome and how the action was concretized. Actors are also an essential element of this analysis, and in order to grasp governance approaches, it is fundamental to understand actors' behaviors, actions and interactions in water management collective-choice situations.

In sum, the reasons for the case selection are clearly based on the deviant value of Jundiaí among municipalities that depend on the PCJ River Basins for water distribution. This contrast situation features as a puzzle in a sense that water management systems from the same region, facing the same environmental constraints, have developed differently their water distribution system and now confront challenges in different levels of severity, for instance ones facing cutbacks while others not. Thus, the investigation of this curious situation under perspectives of Political Sciences and Water Management should elucidate the causal-mechanism of this successful outcome, and provide lessons for supporting other localities' decision-makers in solving (or dealing with) the region's water crisis.

1.3 Scientific and Societal relevance

This project's relevance is bonded to both the empirical context and the theoretical background chosen here. Primarily, the investigation of a positive and deviant outcome of water security embedded in a macro situation of water shortage features as a prominent change of deriving lessons about water governance. Such lessons would valuably assist water managers and decision-makers that have been facing problems with the development and establishment of a secure system of water provision. Secondly, the study of water-related institutions through the application of the IAD framework has not been extensively explored so far, thus offering an opportunity to contribute with new knowledge for academic subjects such as institutionalism and public administration.

The IAD was chosen because it is a framework that demands multiple disciplinary perspectives, assuring its potential in producing a very rich understanding of social situations and institutional diversity. The application of IAD in multi-organizational, multi-level arrangements of local public goods economies has successfully contributed to enhance overall understanding of organization and governance of complex metropolitan areas, as well as protected areas (Oakerson & Parks, 2011). Similarly, the application of IAD in common-pool resources analysis have been conducted extensively, in the attempt of explaining predictability of overexploitation problems through open-access mathematical modeling and institutional investigation (Ostrom, Gardner, & Walker, 1994). However, until now there was no application of IAD in water resources management systems operating in urban water supply crisis contexts. Thus, this research aims at testing the extent that this framework can explain outcomes of water governance in urban water supply frameworks.

In other words, the scientific relevance involves assessing how far the IAD framework enable analysts to comprehend mechanisms and outcomes in water management institutions. The research should demonstrate whether this framework explain the causality completely, or not, and why this was the case. In the end, the conclusion gives a final consideration upon these concerns.

Finally, it is suitable to emphasize this research's groundbreaking character in assessing an empirical case within a macro ongoing water crisis context affecting millions of people that current live and depend on the PCJ River Basins for urban water supply. The severity of this crisis and the

possibility of total water shortage in the following months place some challenges for the region, mainly related to public health, water quality, equitable water supply and future availability of this precious resource. While the *Cantareira* system is under threat of collapse, other supply systems enjoy relative safe conditions of water provision, such as Jundiaí's. How come this is the case in one city, but not in the majority of municipalities within the PCJ River Basins, is the curiosity approached in this project. Thereby, the seriousness and immediateness of the crisis' circumstances, combined with the puzzling fact about Jundiaí's water security reaffirm the societal relevance of this topic and leverage this research's purpose.

1.4 Chapters overview

The theoretical framework used in this research project is introduced in chapter 2, showing an overview of the scientific reasoning and the analytical framework employed in the investigation. Chapter 3 offers the scientific methodology of research and details regarding case selection and data collection. It also provides with the key concepts used in the analysis and its operationalization proposal. Afterwards, the empirical investigation starts, providing with a complete description of the external three variables within the IAD framework. The subsequent chapter presents an exploration of the investigated outcome and causalities involved, and it closes with the action arena analysis, which is the core of the IAD application. Chapter 6 wrap-ups the findings, highlights research's limitations, desirable avenues for future research and give some recommendations based on the lessons distilled from this case study.

2. Institutional Analysis and Water Governance

Institutions are everywhere, in almost all instances of societal life, governing the way things should be done. The operationalization of institutions, political actions itself and the formal and informal instruments of institutional operation are all concerned in the idea of governance (Tortajada, 2010). Governance is defined by Bakker (2010, p. 8) as "practice of coordination and decision-making between different actors, which is invariably inflected with political culture and power". Ergo, governance is the practical exercise of institutional structures. Conceptually, institutions are abstract and invisible elements, which difficult their analysis and definition. They are understood as widely internalized rules, norms, or strategies that create incentives for behavior in repetitive situations and stability maintenance (Polski & Ostrom, 1999, p. 3). In this way, organizations can be thought of a set of institutional arrangements and participants, which share common goals and interact with each other across various action situations at different levels of activity (Polski & Ostrom, 1999, p. 4). The role of institutions in shaping political behavior and governance approaches is highly recognized by public choice and institutionalism theories (Polski & Ostrom, 1999), hence an institutional analysis is recommended for any research aimed at investigating governance patterns. Accordingly, this chapter presents a framework for the research conduction and its theoretical backbone.

2.1 Institutional Frameworks and Theories

The understanding of rules and institutions is usually supported by theoretical work at different conceptual levels. Theories, models and frameworks often serve as precise tools and rationales in the development of institutional analysis. In Social Sciences, these nested concepts reinforce and support each other in the construction and development of research projects (Ostrom, 2011).

Theories are a conceptual level of scientific work that commonly provide metatheoretical explanations of a certain phenomenon. Well-reasoned theories are empirically grounded and can be generalized for several models, thus offering assumptions that are necessary for the analyst to diagnose a specific phenomenon, explain its process or predict outcomes (Ostrom, 2011) (Ostrom, Gardner, & Walker, 1994). Frameworks, in turn, are simply an organizing tool that helps researchers in

pursuing inferences about real-world situations, in light of theoretical reasoning. By employing frameworks, analysts can identify the broad working parts of a certain phenomenon and their posited relationships, acquiring a wider picture of the interested situation. Hence, frameworks provide a set of variables and a map of analysis that often can be used to analyze all types of institutional arrangements (Ostrom, 2011) (Ostrom, Gardner, & Walker, 1994).

The use of these two nested conceptual levels – theories and frameworks – together provide a proper pathway for research conduction and inference reaching in institutional setups. In the case of water-related institutionalism, water resources management are usually under co-responsibility of several organizations, either publicly or privately run and from multiple levels and dimensions, composing the broad institutional conjunction enabling water governance processes. Hence, this research aims at drawing up this broad institutional configuration with special attention to the elements and interactions that have led to the water security outcome. The pursuance of this goal is enabled by the IAD framework, a conceptual map grounded in social choice and institutionalism theories

2.1.1 The IAD Framework

The framework used here is the so-called Institutional Analysis and Development (IAD) Framework. It was developed and improved by various scholars in the past 30 years[2], and applied in a myriad of studies from privatization in developing and developed countries, through macro-political systems, theory of public goods and common-pool resources problems[3]. It has its roots in economic, political and institutional theories (Ostrom, Gardner, & Walker, 1994), and it provides a multi-tier conceptual map for analytical research of causal mechanisms in institutional sets. Public choice, social choice and institutional economics theories are embedded in this analytical tool, thus featuring as a multidisciplinary approach to understand human behavior in institutional environments.

[2] See Kiser and Ostrom, 1982; Oakerson, 1992; E. Ostrom, 1986a, 1986b, 1991; Tang, 1992 and Schaaf, 1989

[3] For privatization in developing and developed countries see Oakerson et al., 1990; for macro-political systems see Kaminski, 1992 and Yang 1987; for theory of public goods see V. Ostrom and Ostrom, 1977; and for common-pool resources problems see Oakerson, 1992; E. Ostrom, 1990; and Thomson, Feeny and Oakerson, 1992.

The theoretical underpinning of the IAD proposes that decisions in public administration involve interaction of several actors within the institutional settings that may constrain or enable certain actions. The institutional settings are "intentional constructions that structure information and create incentives to act or not to act in a particular situation", and these settings interact with existing conditions from the cultural and physical world, thus shaping and being shaped by social behavior (Polski & Ostrom, 1999, p. 5). These observable patterns of behavior reinforce the institutional structure, but they may also shape it differently and contribute with changes (mostly incremental ones) and new behaviors, which in a long-term sight can be identifiable and diagnosed as new practices and norms. In this sense, it is clear that institutional design matters when one wants to understand human choices that have led to certain outcomes. Here the structure of interorganizational arrangements within water institutionalism are seen as elements that influence actor's behavior and affect the performance of local water services.

As institutions are fundamentally shared concepts and internalized norms, they are intangible pieces of knowledge crafted from diverse disciplines in several technical languages. These rules shape human behavior in a variety of situations at multiple levels, from micro to meso and macro instances of regulation. It is useful to distinguish the levels of rules that cumulatively affect actions and define the way things should be done. Kiser and Ostrom (1982, cited in Ostrom, Gardner, & Walker, 1994) define three levels of nested rules that often are identifiable in political institutions: (1) Operational rules are the set of norms that affect day-to-day decisions and practices at a local level; (2) Collective-choice rules determine who is eligible to change operational rules and the procedures to do so, thus affecting operational activities and its results; (3) Constitutional-choice rules define who is eligible and how to craft collective-choice rules, which in turn affect the set of operational rules that define operational activities and their effects. This nested set of rules is a particular difficulty in the analysis of institutions, and scholars have to find ways to communicate accros these levels and link relevant information in order to be able to grasp the whole sctruture affecting the outcome of interest. Therefore, an analytical tool that facilitates comprehension of multiple analytical levels in interdisciplinary seetings composed by multiple linguistic elements is required for a proper developing

institutional analysis. The IAD framework offers a range of features that make possible complex analyses of a wide diversity of institutional arrangements.

The IAD framework is interesting when the investigation wants to assess how governance systems enable individuals to solve problems democratically. It helps to organize diagnostic, analytical, and prescriptive capabilities of actors, structures and practices involved within the multi-organizational setting analyzed (Ostrom, 2011). The framework also aids in the accumulation of knowledge from empirical studies and in the assessment of pieces of evidence and information about specific situations and actions that have led to outcomes. Figure 1 illustrates the complete structure of the IAD framework:

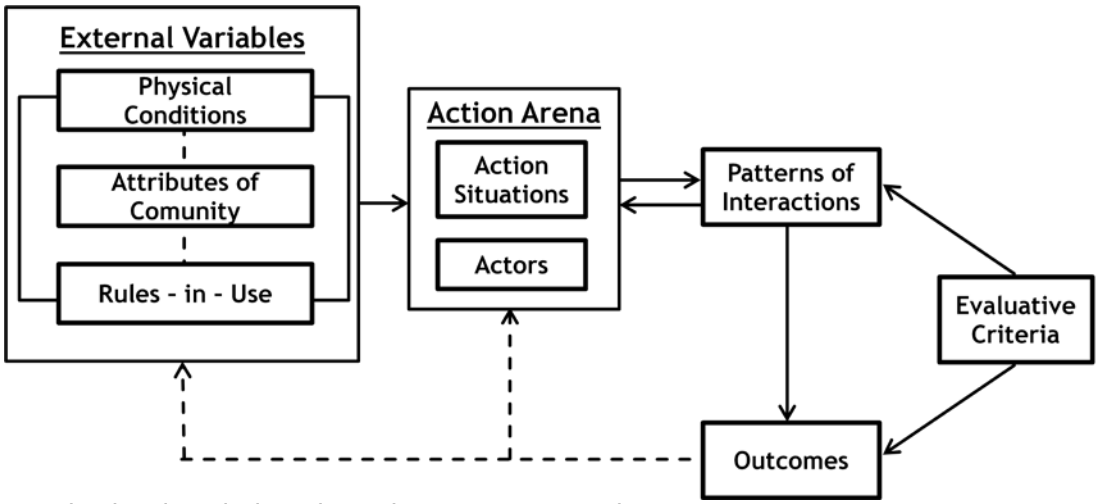

Figure 1 –Institutional Analysis and Development Framework
Source: (Ostrom, 2007)

The framework proposes that outcomes are the result of interactions within an action arena. The action arena is composed by action situations and actors, which interact and lead to potential outcomes. Three external variables are assumed to influence the action arena, which is also affected back by the interactions and the outcomes. The external variables are also influenced by the outcomes, thus closing a cycle of continuous feedback looping. The evaluative criteria relates to the outcome of interest, and it allows selecting patterns of interactions that are associated to the researched outcome. Next pages provide with a deeper explanation about the framework's elements.

Physical conditions

The surrounding environment accounts for specific characteristics and conditions that impact processes in organizations, especially those accountable for managing resources inherent into the environment. Certain attributes of the physical world influence the possibility of actions, the likelihood of outcomes to be generated, the linkages of actions to outcomes and the actors' level of knowledge within the situations. Different physical environments requires distinct actions and approaches in order to achieve desirable outcomes. To illustrate such logic, imagine switching the balls used in football and soccer. This would modify the strategies that players use in the game, affecting the whole structure of playing and reaching outcomes or in this case, making scores (Ostrom, Gardner, & Walker, 1994). In this case, certain attributes imply specific conditions to produce the good (water) and to provide it, thus affecting management and action taking.

Recently the IAD framework was reread and adapted to be applicable in socio-ecological systems (SES), which is a concept that recognizes the interdependence and co-evolving of humans and non-human life in a spatially determined bio-geo-physical setting (Halliday & Glaser, 2011, p. 2). Ecologists who employ IAD in SES analysis usually go deeper in the physical world investigation as they have knowledge and expertise to specifically define resource systems and resource units involved in the action situations. The adapted model of IAD for SES includes additional variables of analysis such as resource units, resource systems, governance approaches and it extends the physical aspects into biological, geological and physical conditions. Here it is suitable to include the biological and geological aspects of the physical world, as the project is dealing with a common-pool resource - water resources for urban water distribution – and water production is intrinsically linked to biodiversity, the hydrological cycle, geological and ecological aspects. Hence, a question that can be done to start up the mapping of this variable is which aspects of the physical world, including biological and geological aspects, affect behavior and outcomes in the management structure of water resources for urban water supply in Jundiaí?

Attributes of the Community

A community is a group of people that live in the same territory and/or that hold particular characteristics in common. The territory of study is the one where action situations were employed in. The attributes of the community refer to all relevant aspects of the social and cultural context that affect the structure of an action arena. These attributes are shared characteristics within the society that influence decision-making, operations and processes in a given organization or institutional environment. These characteristics can be norms of behavior, common meanings within action arenas, the level of homogeneity of preferences and the distribution of resources among citizens. The level of association and cohesion of the community members is also important here, as it relates to the social capital inherent in this society. Other aspects such as the level of trust among members, the reciprocity and cultural repertoire are also present in this variable. In addition, relevant political and socioeconomic factors can be included in the range of information gathered for this variable. The community in this case is composed by the citizens within the municipality of Jundiaí, and a proper question to initiate the investigation would be which cultural attributes influence behavior and outcomes in the governance patterns of water resources in the Jundiaí urban water supply system. The set of answers here should lead to the map of attributes within Jundiaí citizens that have contributed to the outcome of water security enjoyed by this citizenry.

Rules-in-use

This element refers to constitutional definitions and prescriptions that are in play within institutional arrangements. These constitutional settings allocate authority and responsibilities to a set of actors at national, state and local levels, stablishing a structure of jurisdiction and action for specific services or goods to be provisioned. They define what actions or outcomes are required, prohibited or permitted, and what are the sanctions imposed if these rules are not followed. By creating classes of persons, or positions, and defining the set of actions that are required, permitted or forbidden to be taken by each position, an institutional framework begins to be configured (Ostrom, Gardner, & Walker, 1994).

Rules are the result of efforts to achieve order and predictability within organizational environments. They are contextual, in a sense that they apply to a specific arena but not everywhere; they are prescriptive, as those who acknowledges a rule also know that they are accountable to the sanctions in the case of breaking the rules; and they are followable, as those who are subject to certain rules can physically perform or not such rule. To understand an institutional setting one has to look precisely at the rules delimiting this setting and investigate the origin of such rules. In democratic governance systems, there are usually many sources of rules configuring multi-organizational environments. The rules of interest here are the working rules used by participants in the ongoing action arenas of water governance.

Yet, rules are not static pieces of law, and are not as predictable as physical or biological conditions are. They are susceptible to be shaped and modified any time by individuals who decide to adopt a new rule or to change certain behavior fashion. Usually rules are initially enacted at federal and/or state instances, and they might be also incrementally molded at the municipal level. Moreover, rules are formulated in human language and thus they may lack clarity and depict as ambiguous or misunderstandable definitions, depending on its complexity and the shared meanings that its compound words imply. All these characteristics may interfere researchers' capacity of distilling clearly the working rules that play a role in the action arena of investigation.

Past applications of the IAD framework proposed a typology of rules that operate configurally to affect action situations. The typology states seven types of rules: (1) position rules, which prescribe the set of positions in which actors are assigned to and the number of participants in each position; (2) boundary rules, which specify how participants enter or leave these positions, according to the characteristics they must have in order to hold a particular position; (3) authority rules, which define the set of actions that is assigned to each position; (4) aggregation rules, which specify the transformation function linking actions to intermediate and final outcomes, so any rule relating to how interactions among participants accumulate and lead to outcomes; (5) information rules, which specify the types of information available to each position; (6) payoff rules, which define the benefits and costs, or rewards and punishments related to positions, based on a set of actions taken and outcomes reached; and (7) scope rules, which determine a set of outcomes that may be affected by the action

situation. It may be the case that these seven rules are distillable from an institutional setting. If not, the researcher could proceed by asking, for instance, which rules and regulations are in practice, and thus shaping, water management organizations involved in urban supply frameworks. This question would lead to the regulatory framework that defines fundamental aspects of action situations, such as positions, authorities, and so on. Figure 2 depicts the seven rules and their contribution to define each element compounding an action arena:

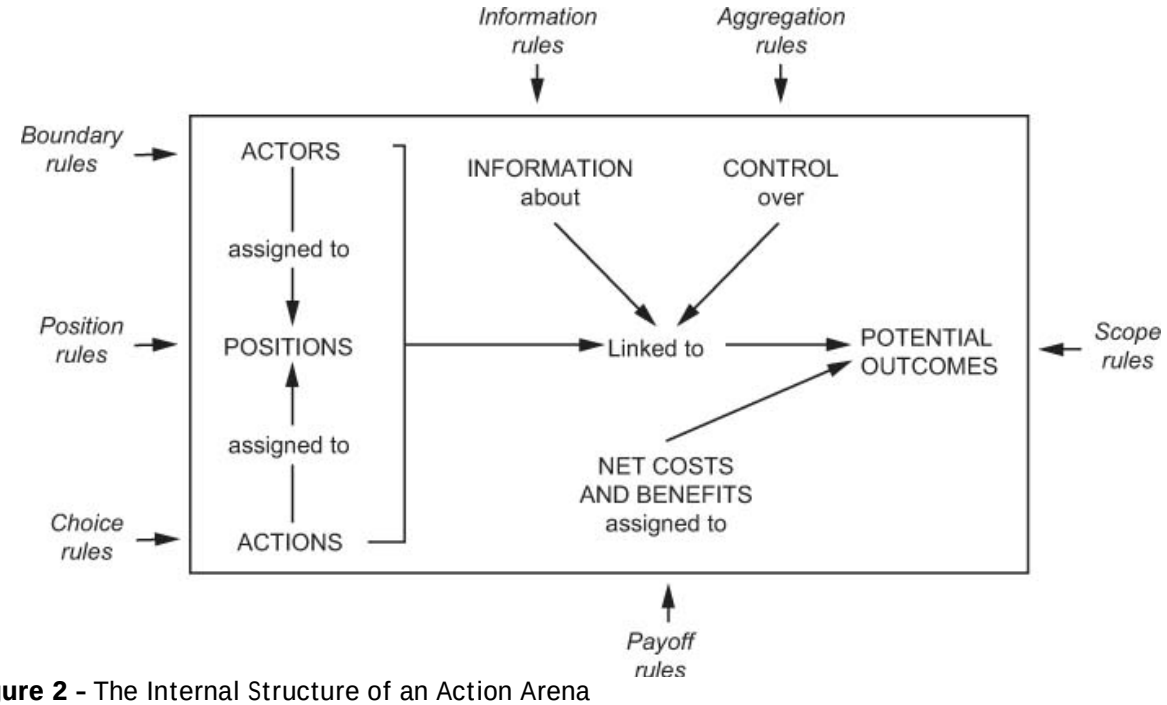

Figure 2 – The Internal Structure of an Action Arena
Source: (Ostrom, 2011)

Action arena

The action arena concentrates larger attention in the analysis as it refers to the interactions between actors and action situations that have led to outcomes. A key part of the analysis development is the identification of relevant action situations that have contributed to the specific outcome under investigation. The analytic concept of an action situation refers to the isolation of an immediate structure affecting a process of interest. Action situations are "social spaces where individuals interact, exchange goods and services, solve problems, dominate one another, fight" and so on (Ostrom, 2011, p. 11). Within the action situation, much attention is given to the interaction between actors, costs,

benefits and information control, and this is due to the complexity of actors' analyses and power relations.

In real-world institutions, it is hard to define when one situation ends and a new one begins, so a difficult first task is to find ways of separating one action situation from another in order to conduct analysis. The IAD helps in the comprehension of these complex social situations by breaking them into manageable activity parts. After electing the key action situations for investigation, it is necessary to focus analysis in the behavior within the action arena. This is done by looking into the action itself and its components, which are the (a) participants, (b) participants' positions, (c) participants' actions, (d) information, (e) potential outcomes and (f) trade-offs of actions and potential outcomes. Since many of these elements are relatively complex, there is a variety of action situations that can be drawn from them, according to the theorist's intentions (Ostrom, Gardner, & Walker, 1994). Sometimes these elements are not overtly shown in the conduction of the analysis. In some cases, not all elements are essential for explaining the outcome, so it is up to the scholar modify and adapt the framework structure. This project proposes to explore these rules in the draft of the action arena of interest.

The arena of interest in this project is the water management framework that encompasses Jundiaí and its water resources. This framework is composed by multiple organizations, from different levels, with multiple jurisdictions and functionalities, and these agents interact with each other in the operationalization and deployment of its responsibilities. This operationalization can be understood as governance, and the governance patterns will reflect trade-offs among partially competing values and interests, and the interaction of these actors in collective-constructed outcomes.

Following Oakerson & Parks, it argues that in multi-organizational, multijurisdictional and multi-level institutional frameworks, like water management frameworks, a certain type of polycentric governance arises. A polycentric governance is a "process of decision-making where multiple independent actors interact to produce an outcome that is commonly valued" (Oakerson & Parks, 2011, p. 154). Polycentricity describes a multi-authority setting where various agents with partially competing values and interests interact and exert governance reflecting in potential outcomes. Moreover, polycentric systems of management may allow for more open governance structures that include greater space for civil society and nongovernmental actors to influence and express their

opinion in decision-making processes. Thus, two important characteristics of polycentric governance are that (a) there are multiple independent centers of authority and (b) there is an interdependence among these centers of authority considering the nested structures of governance, which are horizontally and vertically differentiated, for instance according to the levels and jurisdictions assigned to them.

Hence, the water management framework investigated here characterizes as a polycentric governance system in a sense that it acknowledges multiple organizations, each holding (sometimes-overlapping) authority and jurisdictions, which interact with each other in an interdependent structure of decision-making and action performance, thus resulting in mutually constructed outcomes. By understanding the processes involved in the outcomes' construction, one may expect to grasp patterns of interaction and governance that played a role in this arena of action.

2.2 Wrapping-up

The framework proposed here is an instrument of theory testing and case investigation, as it allows the comprehension of outcomes in institutional settings because it considers that interaction of actors and actions, in a determined situation with particular rules, conditions and cultural aspects, lead to results that are collective constructed in an institutional environment. In other words, it relies on institutionalism assumptions and analytical structures to explain social behavior that, in a broader view, results in service delivery.

By applying the IAD framework and tracing the process of water security build-up, it is expected that dynamics of polycentric governance flourish and demonstrate key behavioral management practices that played a role in the outcome achievement. Therefore, the study of the explants, here regarded as patterns of governance, is expected to clarify the explanandum, here the water security status, and details about the causal mechanism that generated this outcome of interest. Lastly, based on the theoretical framework just proposed, one may expect as hypothesis the notion that certain actions employed by key actors, within patterns of interactions and governance, result in water services embedded with water security conditions. This preliminary answer to the research question will be assessed in the subsequent chapters and recaptured in the conclusion, as to verify the

suitability of the IAD framework in explaining water management outcomes. Next chapter approaches the research methodology and conceptualization used in the project.

3. Research design and procedures

The development of scientific research projects requires the definition of several items related to the pathway pursued during the elaboration. The research pathway items include the research design and techniques used, the concepts that sustain the theoretical framework of analysis, the way these concepts will be applied and measured, and so on. In this chapter, the research approach chosen for this project is presented, as well as the method of case selection used and the justification of picking up Jundiaí as empirical unit of analysis. Furthermore, there are some key concepts supporting this research that requires clarification on their definition and measurement. The steps for the application of the IAD framework and the procedures for data collection are also indicated here.

3.1 Research methodology

The correct way of choosing the research method is to select according to the research problem guiding the project, the level of measurement applied in the data, the quantity of case studies and the level of detail the research is intended to provide about the cases. Qualitative research method is indicated when a small number of cases will be assessed or when only one case will be explored in-depth, thus this methodology usually results in thick analyses. Nominal measurements are the most frequent used in qualitative approaches, while ordinal measurements, statistical tests and large number of cases are characteristics of the quantitative method (Collier, E. Brady, & Seawright, 2010).

The investigation proposed here focuses on a causal process mechanism of effective water management actions that have contributed to achieve water security. Causal mechanisms are "the processes and their interactions with intervening variables through which an explanatory variable exerts a causal effect on an outcome variable" (Bennett, 1997; cited in Mahoney, 2000, p. 412). The independent, explanatory variable in this research is thus the water management institutionalism and the dependent, outcome variable is the status of water security. In evaluating this causation process, it is necessary to have the support of a theoretical framework for analysis. Thereby, the IAD framework is here the backbone for research development and each of its elements is applied and assessed in the empirical case. By using a combination of nominal and ordinal measurements, this causal process

investigation analysis the IAD elements and their interaction in the process of water security enhancement in Jundiaí, thus featuring as a qualitative exploratory research design.

The idea of tracing a causal process and its mechanisms is the central idea of the so-called Process Tracing research method, which involves the "examination of 'diagnostic' pieces of evidence within a case that contribute to support or overturning alternative explanatory hypotheses" (Bennett, 2010, p. 208). The sequence and mechanisms within the hypothesized causal process are the most important features of this method, and scholars use the name causal-process observations to refer to these pieces of information. A causal-process observation (CPO) is "an insight or piece of data that provides information about context, process, or mechanism, and that contributes distinctive leverage in causal inference", and this information is an in-depth knowledge collected within one or more particular cases (Collier, E. Brady, & Seawright, 2010, p. 277) . This type of evidence is different from a data-set observation (DSO), which is a score, or observation measured through normal statistic sense of a systematized array of variables. CPOs are commonly used in qualitative approaches whereas DSOs are the central element of quantitative methods (Mahoney, 2010).

There are three types of CPOs for theory-testing purposes: independent variable CPO, mechanism CPO and auxiliary outcome CPO. The independent variable CPO is responsible for providing information about an existent independent variable and its interrelation with the particular outcome under investigation. Mechanism CPO "provides information whether an intervening event posited by a theory is present" (Mahoney, 2010, p. 128), so in other words, whether there is an alongside event or mechanism intervening in the main causality under investigation. Auxiliary outcome CPOs provide extra information that has occurred besides the main outcome of interest, if the cause under investigation really affected the main outcome (Mahoney, 2010).

For the present research, the type of CPO that fits better is the Independent Variable CPO, since the main purpose here is to find the causal relation of two variables – Jundiaí's water management institutional setup and the water security status achieved. These elements are not static events or facts, rather they depict as decision-making processes and mechanisms in a given context. Even though, they will be assessed under the same evaluative criteria and are considered here as a single independent variable, instead of an interaction of independent variables, in order to simplify the

causality analysis. Including more explanatory variables would increase understanding and accuracy of the research, but also it would require more time and data to develop such analysis. These constraints posited limits to the present research project, so the purpose here is summarized in explaining a single independent variable, its contribution to the dependent outcome and to assess whether the theoretical proposition used here explains this causality.

3.1.1 Case selection

The case selection for study is closely related to the agenda of analysis and the strategy for research, either if it is conducted through qualitative or quantitative approach. Scholars argue that pure pragmatic case selection, based on factors such as time, access, expertise and so on, as well as random selection may pose problems of representativeness and selection bias. They state that purposive case selection, based on rigorous and detailed explanations of cross-case relations is a better outlet in small-N analysis. Yet, there is an inherent unreliability of generalizing inferences from small-N samples to a broader universe of cases, but it is true that purposive selection methods may sometimes overcome this pitfall. It is important to have in mind what the population of interest is, what the variables under investigation are and how the cases within the population score in the variables. This first step depict as a large-N technique of cross-case analysis aimed at case evaluation and selection. By doing this, the researcher will be able to choose a case based on its behavior within the universe of interest (Seawright & Gerring, 2008).

This project has its roots in the Brazilian water supply crisis that has stood out in 2014, which has the most drastic figures in the Southeast region of the country, mainly in the state of Sao Paulo. The situation of water shortage was pervasive in the doughtiest months of the year among the majority of the municipalities that depend on rivers within the Piracicaba, Capivari and Jundiaí river basin for urban water supply (the PCJ River Basin). Approximately 87 municipalities, including 11 cities from the MASP, rely upon water provided by rivers and water streams from the PCJ River Basin, which is simply referred as the 'PCJ', or as the Hydrographic Unit of Water Resource Management of the SP state number 5 - PCJ (*Unidade Hidrográfica de Gerenciamento de Recursos Hídricos do Estado de São Paulo número* 5 PCJ - UGRHI). This region accounts for about 14 million people, and has rapidly developed in

the past century expanding the urban and impermeable sprawl all over the territory, and hosting ever more companies, factories and buildings. Historically it is also a region of intensive agricultural activity mainly with coffee, orange and sugar cane crops. It represents 33% of the entire SP state population (7% of the Brazilian population), and it is responsible for producing around 17% of Brazil's GDP (IBGE, 2015) (IBGE, 2012). During the dry season of 2014, thousands of people faced cutbacks for some hours (and are still facing nowadays) and in some acute cases, the lack of water has lasted for weeks (Sampaio, 2015) (Tomazela, 2014). In the middle of this serious situation, there was a big threat of total water shortage for the majority of these cities, which resulted in a great fear and uncertainty among citizens and led some companies to start planning a move away from the region (Portal JH, 2015). All the urban water supply networks and reservoirs of these cities rely upon the PCJ, which is composed by river basins that are gradually drying up. Hence, the population of interest here is the municipalities within the PCJ region.

Notwithstanding, journalistic reports from 2014 were pointing out to a case that did not follow the pattern observed in the geographies within the PCJ watershed region. The city of Jundiaí attracted attention of the media due to the deviant pattern of holding water security in a surrounding context of insecurity of water availability. Although this status is not a static and permanent feature, Jundiaí was tranquil in terms of water availability for supplying its citizens for more than two months considering the worst scenario of total long-standing drought. In this sense, the cross-case characteristic of water shortage was the predominant value for the dependent variable, whereas the value of water availability observed in Jundiaí's case posited the city as an outlier high-residual case. (Seawright & Gerring, 2008).

Therefore, the method of case selection employed here was the deviant case, which entails a case that demonstrates a surprising value by reference to some general understanding or to some general cross-case relationship. The deviantness of a case is thus relative to the general model used for reference. In this case, the deviantness of Jundiaí is due to the different outcome of water security, since the city's water supply system also depends on partially drought water resources, just like the other cases. The purpose of studying deviant case is to probe for new explanations that elucidate causal processes culminating in unusual outcomes, based on cross-case relations within the population.

In sum, by investigating causality in deviant cases, researches may find out general propositions that explain deviantness and may be applicable to other deviant cases (Seawright & Gerring, 2008). There should be other deviant cases within the population used here, but few Jundiaí's features show how interesting and insightful can be to learn from it: a 360 years old urbanized municipality, highly industrialized with well-developed markets and services, partially located in a natural reserve and owner of the 11th highest human development index (HDI) in Brazil. For all the reasons mentioned in this section, the Jundiaí's water management framework and governance system is now under exploration.

3.2 Conceptualization and Operationalization

The literature reviewed so far provided support for researching water management institutions in critical urban water supply contexts. The theoretical framework proposed is grounded in essential elements of institutionalism and public administration, and it presupposes the construction of outcomes from the interaction of such elements. It is necessary then to explore these elements and their interaction in order to understanding their contribution to the outcome of interest for this project. The task of conceptualizing such elements in clear-cut definitions, possible to be applied, measured and evaluated, is developed here.

3.2.1 Water security

As a salient topic in international forums and events, being highlighted by several international organizations, from UN bodies to neoliberal agencies and development banks, water security is certainly a hot subject. The importance of water and its interconnection with many areas of society's life is constantly reinforced in international platforms. Following UN-Water (2013, p. vi), "Water security encapsulates complex and interconnected challenges and highlights water's centrality for achieving a larger sense of security, sustainability, development and human well-being" […], (therefore) "investment in water security is a long-term pay-off for human development and economic growth with immediate visible short-term gains".

A broadly used definition states that water security is "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability" (UNEP, 2009) (UN-Water, 2013). This definition, which is used worldwide, was provided by UN bodies in an attempt of elucidating the interrelation of water with ecological services, socio-economic development and human well-being. When disassembling this definition, the most important elements compounding it are (a) safeguarding sustainable access to (b) adequate quantities of (c) acceptable quality water, ensuring (d) protection against water-born pollution and (e) protection against water-related disasters. So based on this definition, to hold a water security status a municipality should guarantee current and future availability of enough quantities of acceptable quality water for urban supply, thus preventing citizens from suffering from urban water issues such as pollution and supply interruption.

Other definition provided by the GWP states that "water security, at any level from the household to the global, means that every person has access to enough safe water at affordable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced" (GWP, 2000, p. 12). The elements of quantity, quality and sustainability are also embedded here, but this definition goes further and include the idea of affordable price allowing water access. The need of holding water access' prices at a bottom, life-line is an important factor in assuring the 'right to water' and fostering water security in daily citizen's life (Bakker, 2010). In this sense, the conditions to enjoy a complete water security status involve acquiring enough quantities of good quality water which is withdrawal sustainably (thus allowing self-recharge of water resources), and commercialized in affordable prices.

The water crisis under investigation here is related to the lack of sustainability within the water distribution setup, and the unbalance of water demand and supply in the majority of cities in the population of interest. The price charged for water services, both supply and sanitation, in SP state is regulated by independent agencies, according to the location of the watersheds. These agencies' main roles are to coordinate price revisions and adjustments periodically, to monitor water services and

quality of water in their municipalities of jurisdiction. They assure that prices do not prevent access for water services and are only raised based on inflation and annual budget reasoning. Hence, the condition of water security taken here is not related to price, as this is an external element if we consider the macro situation of scarcity. The price charged is not a barrier for access, but the volumes of catchment and recharge in the watersheds. Based on that, the definition employed here encompasses the elements of quantity, quality and sustainability of water supply services.

The elements of 'quantity' and 'sustainability' are interrelated in a sense that depending on the quantities of water 'production' and catchment in the watersheds, it can be analyzed how current figures of consumption might jeopardize future availability within these watersheds. The measurement of these elements can be done by looking at some values: (1) average quantity of water consumption; (2) average water capacity in Jundiaí's reservoirs, so it is possible to calculate the storage capacity of the city's water supply system; (3) the numbers of inflow and outflow of the city's reservoirs, so it allows to grasp the situation of the dams used compounding the water distribution system. By using these numbers and calculating the system's situation in respect of water quantity, one can infer about the sustainability and the quantities of use in the case of Jundiaí.

Quality is also related to sustainability, as it implies the level of contamination present in the water, usually due to pollution and waste disposal. Physical-chemical and micro-biological analyses are conducted to identify the substances in the watersheds and water reservoirs, each month, and it provides the parameters to classify the water bodies according to the regulatory policy regarding quality. Thus, the measurement of quality is done based on the indexes of quality provided by the state and municipal agencies of water quality control. According to the figures provided by these agencies, it is possible to conclude about the proprieties within the water and how the water bodies in Jundiaí are being preserved. For reasons of simplification, sustainability in this project is considered an embedded feature within the elements of quality and quantity. So if the analyses regarding the quantity and quality of water supply points to a scenario of preservation of good water quality and balance between catchment and recharge, then it will depict as a sustainable scenario. In the case that one of these two parameters are in a bad condition, the value for sustainability will be then negative. This analysis is relatively superficial, but it addresses the main idea of water security in urban water supply systems.

Refined analyses considering other aspects of sustainability would be more accurate but it would also require deeper and longer multi-dimensional and multidisciplinary researches. For the purpose of this project, it is enough to infer about the sustainability of Jundiaí's water supply framework by investigating the quality patterns and quantities used in the city's system.

3.2.2 The IAD Framework

As complex units of study, institutions can be separated in their component parts for conducing independent analyses, and then recombined later in order to produce inferences of the complete causal process. In doing so analysts may make use of ceteris paribus as to allow for simplification. Yet, it is important to know the value of the variable before asserting that they are considered constant in a certain situation. The key element of interest in this institutional framework is the action arena, composed by the action situation and the actors. Complex action arenas are influenced by a myriad of rules, conditions and attributes from the surrounding world. The identification and further classification of such variables is essential when developing a cumulative body of information about their effect in outcomes. Thus, some steps were defined as to employ such analysis and apply the IAD framework in the water management and governance system in Jundiaí. These are:

0. **Set the evaluative criteria**: highlight the arguments supporting the reasons why this is a case of water security, based on the conceptualization and operationalization of the water security definition.
1. **Selection of action situations:** the selection considers the outcome of water security status. All actions that were fundamentally relevant for improving water quality, water quantity or sustainability, developed and implemented in the past years, are considered as key elements of the analysis. Thus, the actions selected are the ones that have contributed to the construction of the secure status, not all actions that decision-makers pursued. In other words, selected action situations should clearly enhance, foster or enlarge levels of water quantity, quality and/or sustainability in water resources that comprehend Jundiaí's urban water supply system. In this case, a possible trick to quick identify such actions is to look at large-scale civil

engineering construction water projects. Additionally, actions that have been developed but are under process of implementation will also be considered here, as long as its effect towards water security have started to be accomplished.

2. **Exploration of external variables:** in the background of each action situation there are the three dimensions of external variables affecting it. The bio-geo-physical conditions within the situation correspond to characteristics of the environment, including information about the biodiversity, local ecosystem services, water resources, their level of degradation, precipitation levels, hydrology, geology, committed inflows and outflows, processes of production and provision of water supply and their scales, information about all different water uses, and so on. In parallel, the attributes of community relates to the number of inhabitants, demographic and social figures, cultural aspects of the community members and all related information that encompass the community conditions within the action situation. Additionally, the analysis of the rules-in-use are largely important to understand the legislation, delegated responsibilities, organizational structure and governance framework that enable actors to interact and make decisions, solve problems, make plans and actions in the context.
3. **Exploration of the action arenas:** it follows the typology of rules proposed by IAD theorists: (1) position rules, (2) boundary rules, (3) authority rules, (4) aggregation rules, (5) information rules, (6) payoff rules, and (7) scope rules. By considering the actors involved and identifying the rules related, it is possible to map the functionalities within the action situation and draw a scheme showing all knowledge available about the action situation, which will assist in understanding actors' interactions. In parallel, an investigation about interactions among these actors and the actions they conducted that contributed to the outcome is necessary to clarify the mechanisms within each action situation. The action situation will probably be composed by a chain of events linking actors' actions to outcomes, so by looking at this interaction it will be able to recognize the extent of influence that a specific actor have posited in the particular outcome. In addition, individual actions may provoke actions that are conducted in the future, in a feedback looping mechanism. Therefore, individual actions will be analyzed and if necessary aggregated and organized in a way that the feedback looping is recognizable.

By following these steps, it will be possible to understand water management institutions in which Jundiaí takes part and have a complete picture of the situations and conditions that have culminated in the outcome of water security enjoyed in this city. To make the research easier understood, the content was separated differently than the sequence of steps above presented. Chapter 4 will give a complete picture of Jundiaí's macro-environments, bringing about all characteristics regarding the three external variables. Chapter 5 will then start by evaluating the outcome of water security, and draw back to the action situations, actors and interactions that have contributed to this achievement. Chapter 6 closes with a gathering of all accumulated findings and conclusions about the causal mechanism explored here.

3.3 Data collection

The process of data gathering and information collection is essential, and sometimes challenging in doing social scientific research. Especially when analyzing institutional settings, researches face additional barriers due to the fact that many rules-in-use and institutional characteristics are not written down. Instead, they are deeply understood and practiced norms and routines that participants are used to and do not even think about them, just behave. Thus, obtaining information in institutional arrangements requires spending time in field research based on nonthreatening and context-specific questioning. This may consume much time and effort but it is fundamental for researches to distill rules configurations that support institutional analysis. Another barrier that may occur relates to political nuances that might play a role in specific situations. Considering these constraints, collecting data for institutional studies in a political environment surrounded by water crisis is a challenge since the beginning.

The CPOs or pieces of evidence used here compose the action-situations that have fostered water security in Jundiaí. The criteria of action situation selection is based on the concept of water security and its core elements – sustainability, quantity and quality of water. The main actions that contributed to increase the availability of water in Jundiaí, and the actions that resulted in improving water quality of the city's water resources are then selected for investigation. Information about the water inflows and outflows, consumption, quality reports and additional information related to the

watersheds investigated can be accessed in the internet, at the websites of the river basins agencies. Journalistic information and specific evidences are also collected in the web. Historical documents from the water management organization in Jundiaí – the Department of Water and Sewage (*Departamento de Água e Esgoto – DAE)* –provide the evolution of constructions, projects and decisions adopted in the past years. In addition, semi-structured interviews with DAE's employees and water experts are essential in exploring the action situations within each project, and they were conducted during the field research in June 2015, where the author visited Jundiaí and collected empirical data for this project. In sum, the techniques of data collection employed will be documental research, web research, literature research and field research.

4. Jundiaí's Institutional Analysis and Development

The framework chosen for this research is based on institutional arrangements and existing factors that shape organizational decision-making and governance. The application of the IAD framework starts with the understanding of external variables that affect behavior within water management institutions. The elements compounding the conditions within the biological, geological and physical world will be the first target of investigation, followed by a study on community cultural aspects, development and demographics. The last section of this chapter focus on the regulatory framework embedded in Brazilian water institutionalism. The objective here is to clarify the key impacts that these three variables place in governance in the process of water security achievement in Jundiaí's case.

4.1 Bio-geo-physical conditions

In order to have a complete grasp about these conditions, next section presents not only the pre-existing conditions but also includes some information about the actual situation within these resources. The idea is to understand the main resources with a special detailing on water resources, their current situation in regards to quality and quantity, and information about the processes of water production and provision involved in the water supply system.

Natural Resources

Jundiaí is a Brazilian municipality of 431.9 km² located in the state of SP, 60 km away northwest of the capital, Sao Paulo. It borders on 11 municipalities with total conurbation with Várzea Paulista and Campo Limpo Paulista at east, and partial conurbation with Itupeva at northwest. Jundiaí is situated in an average elevation of 762 meters and comprehend the altitude tropical climate. This climate is characterized by hot and rainy summers with mil and dry winters, with annual average temperatures of 27°C at maximum and 15°C at minimum (Prefeitura de Jundiai, 2010). The average annual rainfall is around 1,390 mm, with a mean of 46.3 mm per month in the dry season, and 202.8 mm in a month within the rainy season. Brazil's historical average rainfall is 1,761 mm (DAE, 2015).

The city's territory encompass part of an important natural reserve, the Japi's Ridge (Serra do Japi), which is one of the largest areas of native *Mata Atlântica* forest that remains preserved in the state of SP. With 354 km² and a peak of 1.250 meters of altitude, the Japi's Ridge contributes in regulating climate and precipitation of the surrounding region as it is an important barrier for the coastal wind flows that reach SP plateau (*Planalto Paulista*). It is an ecotone zone, meaning that it comprehends a transition area of two ecosystems, in this case the Seaside Ridge and the *Planalto Paulista* (Portal Jundiai, 2011). Figure 3 shows the wind flows direction and the location of Japi's Ridge.

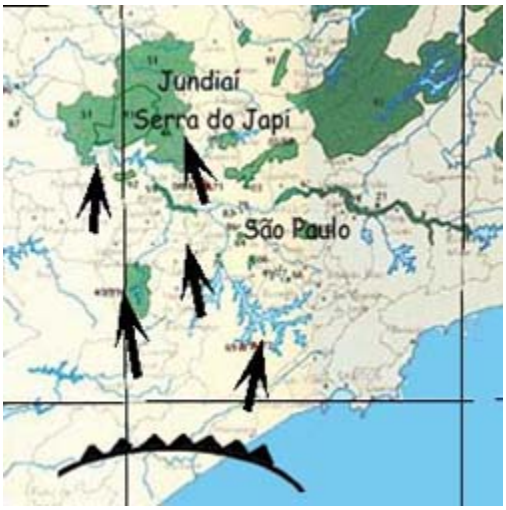

Figure 3 – Wind flows affecting the Japi's Ridge
Source: (SAB, 2015)

The Ridge's composition includes quartzites, granites and gneisses, and its rich biodiversity with more than 947 fauna species and 303 fauna species is a remarkable natural landscapes originally of this region. In the 80s, it was target of researchers that elucidated about the important hydrological services that the Ridge performs as through rainfalls regulation, water storage and cleansing. This led to the famous nomination of the Japi's Ridge as the 'Water Castile, and to the formal toppling as an official inherited patrimony in 1983 by the state-level Council of Historical Heritage, Archaeological, Artistic and Tourist Protection (CONDEPHAAT). Additionally, UNESCO recognized the Japi in 1992 as a Biosphere Reserve, due to its eccentric genetic value for the ecosystem. The name 'Japi' has its roots in the Indian word 'iapy', which means 'river's spring' in *tupi-guarani* (DAE, 2002) (Portal Jundiai, 2011).

As the Ridge's ground is composed largely by rocks, there is just a portion of around 30cm of soil, meaning that the vegetation cover is essential to prevent floods, erosion, silting, and to make rain water infiltrate into the ground and recharge both groundwater reserves and surface freshwater streams (Ribeiro, Audio 1, 2015, p. 17:35').

Although under legal protection, the Japi's Ridge integrity has faced many pressures and threats mainly from urbanization and real estate expansion, especially in the past decade. Due to its location between two big metropoles, Sao Paulo and Campinas, and the proximity with busy interstate highways, the Ridge's green area is frequently harmed by deforestation, extractive activity, irregular allotment and garbage disposal. As it is a large extension of wood, the monitoring and law enforcement is compromised and poorly performed. Still, there is a large portion of the natural landscape that remains preserved and thus contributing significantly to the region's microclimate and water resources recharge.

According to the mapping done so far, there are about 360 springheads, 30 waterfalls, 10 water bodies and 170.4 km of water streams within Japi's area, and these sources are fundamental recharge bodies for the sub-basins close to the Ridge space. There also some appropriators and landowners within the Ridge's area, which has been historically claiming to possess such land space. They make use of Ridge's resources, most of them in a small scale, but few affecting negatively by, for instance, pastoring or planting intrusive crops that may imbalance the local ecosystem dynamic (usually eucalypts and pine crops) (Ribeiro, Audio 1, 2015, p. 16:11'). Albeit, some landowners are nowadays engaged in the recuperation and restoration of the native vegetation within their properties, in order to fulfill obligations prescribed by the National Forest Code (which was reformulated in 2013 and will be further presented) (Ribeiro, Audio 10, 2015, p. 01:00'). There is one company (paper producer) situated in the area, at a private owned terrain, and they make use of the local water resources legally, by paying granting fee to the state water management body (DAE, 2015) (Ribeiro, Audio 11, 2015, p. 00:01'). The Town Hall also explores Japi's water resources through an ecotourism project with guided excursion to the waterfalls and trekking the woods (Nossa Serra, 2015).

Water Resources and the distribution system

The Jundiaí's water supply system is composed by four reservoirs: the Catchment weir with the approximate capacity of 350 million liters, the Accumulation weir with the current capacity of 8 billion liters, the Moisés weir with a storage capacity of around 50 million liters and a smaller weir located at the Japi's Ridge with the approximate capacity of 30 million liters. The two larger reservoirs are responsible for 95% of the distribution while the Moises weir represents 2% and 3% of the water supplied comes from the Japi's reservoir.

This system of dams has evolved through the past century and it relies on several natural water resources for recharge and supply. The water streams that flow through Jundiaí's territory compounds a hydric chain of five sub-basins flowing into three river basins (DAE, 2015)(DAE, 2002) (Ribeiro, Audio 1, 2015, p. 18:50'):

- **Jundiaí-Mirim sub-basin**, effluent of the Jundiaí river, it supplies both the accumulation and the catchment weirs, and it has 55% of its extension passing through the northwest area of Jundiaí's territory;
- **Estiva sub-basin**, located in the center of the city, it springs out in the Japi's Ridge and supplies the Moisés reservoir, further flowing into the Jundiaí River;
- **Guapeva sub-basin**, located at the southwest part of the city, it starts at the Japi's Ridge and flows further into the Jundiaí river basin;
- **Caxambu sub-basin**, springs out in the Japi's Ridge, compounds the Jundiaí river basin and supplies the Japi's reservoir, thus it is located at the west side of the city, inside the Ridge's preservation area, flowing further to Itupeva city;
- **Jundiúva sub-basin**, springing out in the Japi's Ridge and ending up in the Tietê river basin, with its streams passing through the southwest of the city's territory;
- **Jundiaí river basin**, the city's principal water resource, which springs out in Mairiporã city and flows through the central region of Jundiaí, from east to west, integrating the PCJ River Basins;

- **Tietê river basin**, which does not pass through the city's territory but in its borders with Cabreúva city, and it is formed by the Jundiuva water streams that belongs to Jundiaí;
- **Capivari river basin**, which is part of the PCJ River Basins and has its main springhead in the Jundiaí's northern border, in the limit with Itatiba city.

The Jundiaí-Miriam sub-basin is the main resource supplying water for the both largest reservoirs. Its average water inflows into the weirs is highly irregular, and depends on recharge inflows, precipitation levels and other river's inflow. The measurement done so far by the responsible agency is not very precise; as it does not measure the water flows from tributaries streams compounding this sub-basin, and does not include recharge flows from soil absorption and percolation (Ribeiro, Audio 1, 2015, p. 21:20'; Ribeiro, Audio 6, 2015, p. 05:00'). Since the crisis' emergence, the calculation is primarily based on the external contribution from the Atibaia River to this sub-basin, which is currently 1.2 m³/s and comes through an 11km-length pipeline system. Normally, the adduction pumps were only necessary during the dry seasons (May to August), but since the sharp rainfalls reduction started around 2012, the transference pipes has kept sustaining Jundiaí-Mirim's flows constantly (Ribeiro, Audio 19, 2015, p. 01:50'). Figure 4 summarizes the system's catchment flows, stressing the adduction from Atibaia River:

Catchment flows	**total**	**1.5 m³/s**
Atibaia contribution	*1.2*	m³/s
Accumulation reservoir Catchment reservoir	1.4	m³/s
Moises reservoir	0.05	m³/s
Japi's Ridge reservoir	0.05	m³/s

Figure 4 – Catchment flows of Jundiaí's water supply system
Source: (SAB, 2015)

The Atibaia River is an affluent of the Piracicaba River, which compound the PCJ River Basins together with the Capivari and the Jundiaí river basins, both also inserted in Jundiaí's territory. The fact that Jundiaí's distribution system depends on eventual contribution flows from the Atibaia River, especially on the dry season, places the city in the context of water crisis that the PCJ region has been struggling with (Consórcio PCJ, 2015). The average outflow to supply the monthly water consumption is 1.5 m³/s,

or 130.000 m³ per day, so the system relies upon the added up inflows from the Jundiaí-Mirim sub-basin, the Atibaia River and the water accumulated in the reservoirs (DAE, 2015).

In conclusion, there is a large focus on the Jundiaí and the Piracicaba river basins as main sources of recharge, while the Capivari river basin, Jundiúva and Guapeva sub-basins are not used so far, thus featuring as new possibilities to expand the supply side of the water distribution system (Ribeiro, Audio 1, 2015, p. 12:00'). The Caxambu sub-basin also offers a great potential of water that is so far underexplored. According to the NGO Coati, these unexplored sources may increase from 7% to 30% the system's water distribution capacity, considering that the Japi's Ridge maintains the level of vegetation hitherto (COATI, 2013). Figure 5 shows the main river basins within the PCJ region:

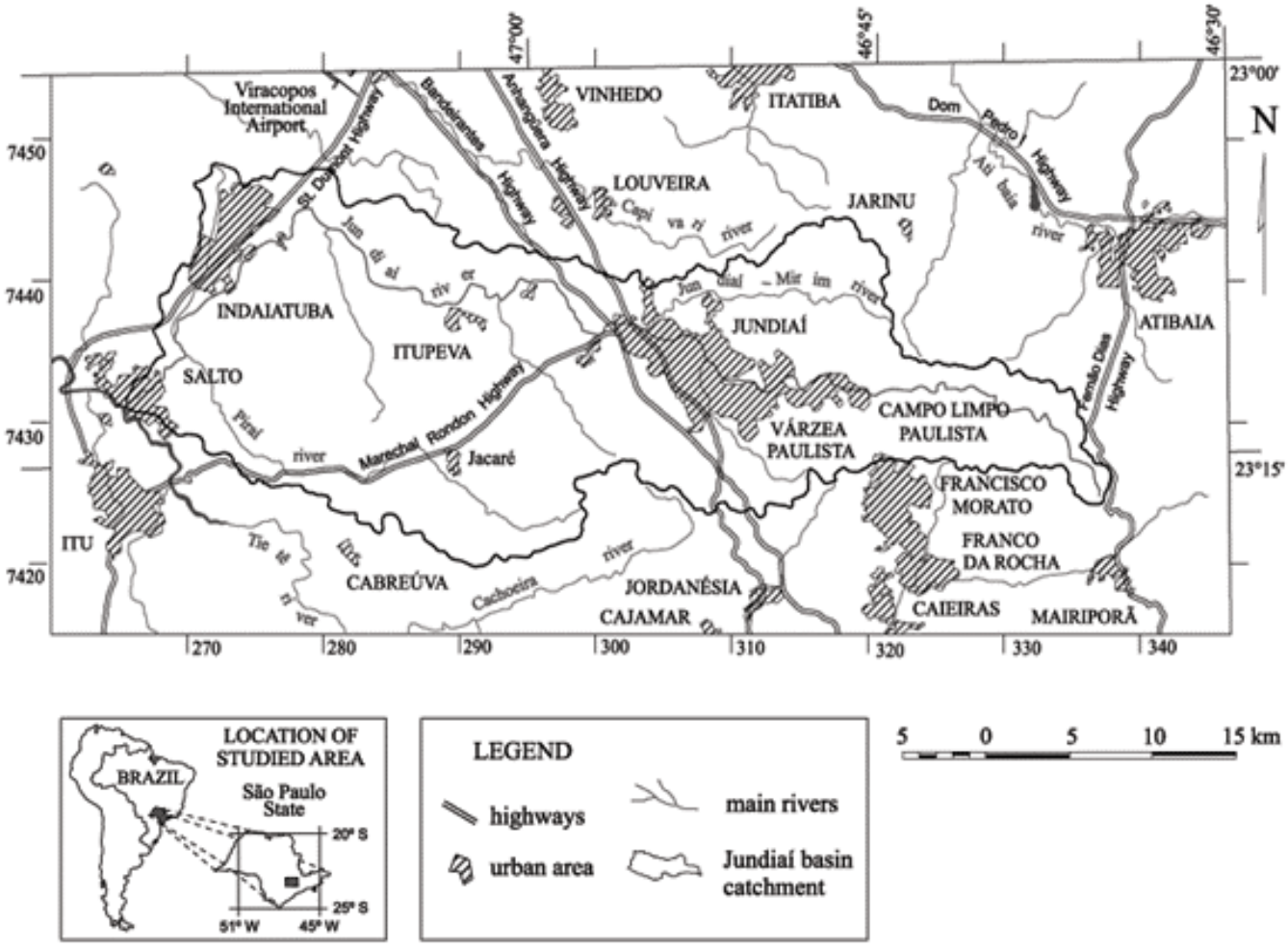

Figure 5 – PCJ River Basins, Tietê River Basins and Jundiaí-Mirim Watershed, the main highways and urban areas
Source: (Neves & Morales, 2007)

Concerning the quality of water, there are monitoring activities constantly in both reservoirs and in river basins, conducted by municipal, state and river basin level agencies. The measured parameters indicate the level of contamination, eutrophication, balneability, and quality of water for human consumption and aquatic biodiversity protection (ANA, 2015) (DAE, 2015). The Nacional Environmental Council issued in 2005 a resolution about the classification of water resources on regards to their quality, as well as definition of quality standards and environmental directives about wastewater release. This piece of law states five levels of quality for fresh water: I – special class, the purest sources, indicated to conservation of aquatic ecosystems and human consumption after disinfection; II – class 1 indicated to irrigation, protection of aquatic biodiversity, recreation and human consumption after treatment; III – class 2 destined to aquiculture, ecosystem preservation, irrigation, recreation and human consumption after conventional treatment; IV – class 3 aimed to irrigation of trees only, angling, recreation of indirect contact, animal watering and human consumption after advanced treatment; V – class 4 indicated only for navigation and landscaping. Each class has a long list of parameters, from organic to inorganic and visible indicators, in order to enable classification (CONAMA, 2005).

Quality monitoring in Jundiaí's water resources is conducted by the municipal water supply provider, DAE-Jundiaí, in a monthly periodicity. They collect water from 23 strategic spots in the reservoirs and at the entrance of water from the rivers (DAE, 2015). Other agencies such as the state-level CETESB (*Companhia Ambiental do Estado de São Paulo* – Environmental Company from SP state) and the river basin level ARES-PCJ (*Agência Reguladora da Bacia dos Rios PCJ* – Regulatory Agency of the PCJ watershed) also conduct monitoring in other spots of the water resources compounding the PCJ river basins. The quality situation of each water resource is currently:

- **Jundiaí-Mirim sub-basin**, class 1
- **Estiva sub-basin**, class 1
- **Guapeva sub-basin**, class 2
- **Caxambu sub-basin**, class 1
- **Jundiuva sub-basin**, class 1
- **Jundiaí river basin**, class 3
- **Capivari river basin**, class 3

The process of Jundiaí-Mirim's depollution has started in 1983 and will be detailed in the next chapter, as it is part of a larger project of water supply development executed in Jundiaí and the riparian municipalities. For now, it is interesting to stress that the Jundiaí-Mirim River holds class 1 quality standard in all its extension, throughout 71 municipalities, which is a remarkable feat as it is uncommon to have good water quality within a region of poorly preserved rivers (DAE, 2015) (DAE, 2002). As an effluent of the Jundiaí River, the cleansing of Jundiaí-Mirim River contributed to the recent quality improvement that Jundiaí River has reached. The advance from class 4 to class 3 settled in 2014 was a result of this large project employed by several actors. The projects core objective was to remove sediment, and enhance sewage collection and treatment in riparian cities. As a consequence, Jundiaí's River downstream is already possible to find fishes and genuine flora, and it will start to serve as water resource for human consumption in the near future (Agência Estado, 2014) (COATI, 2013).

The production and provision processes in Jundiaí's water supply system comprehend five phases. Initially, this water receives ferric sulfate and flocculants, both to fix the pH and accelerate clot flocculation process. The next step is the flocculation where sediment particles are grouped into larger flakes. Formed the flakes, the next step is the decantation where the heavier flakes are deposited in the bottom of the tank. Then, the water passes through activated carbon filters to remove the finer particles. Once filtered, the water undergoes disinfection, which receives chlorine and fluoride before being distributed to the residences. There are two stations of water treatment in Jundiaí, the bigger one covering 95% of the water distribution and the smaller covering 5% of city's networks. The production and provision system runs 24/7 at an average scale of 1.5 m^3/s, reaching 100% of the city's networks with treated water. Numbers of water use in Jundiaí show a sharing configuration 34% consumed by agriculture, 19% by industry and 47% by household and commercial buildings. According to DAE, personal consumption rate is between 6 to 7m^3 per month, higher than the average world rate of 5,4m^3 per person per month (DAE, 2015) (DAE, 2002) (PROCON, 2010).

Jundiaí's sewerage system has recently being appointed as the TOP 1 sanitation service in Brazil (Instituto Trata Brasil, 2015). The coverage reached 100% of the urban households and 25% of the rural homes (98,3% of total households), and the waste collected is treated in three sewage treatment

stations through a compost process, thus discharging 'clean' water back to the Jundiaí-Mirim River and generating organic fertilizer as a product of wastewater treatment. The resultant organic fertilizer is safety used in sugar cane and eucalyptus crops, which are not destined to human consumption but to wood and fuel production. This sewage treatment system was launched in 1998 and today it collects around 1m³/s of wastewater, which after the treatment process becomes a 14.000m³/month sludge destined to composting (Instituto Trata Brasil, 2015) (CSJ, 2015) (DAE, 2015).

This panorama of the physical conditions has shown how Jundiaí is rich in natural resources, especially native landscapes and water sources, although the majority of the vegetation had been destroyed and the still crescent, poorly projected urban development is incentivized. So as to Brazil's territory, the large extension of the Japi's Ridge hinders monitoring and law compliance, thus the city's officials have to strategically develop ways to overcome these hindrances in order to assure an unproblematic future. Still, local water resources were recuperated and hold good quality standards, coupled with sanitation universalization, thus showing how the city's past achievements may serve as incentive for actual politicians strive in solution seeking and innovation. As a municipality posited among the better-off Brazilians indicators, Jundiaí has the opportunity to advance development through a sustainable and intelligent pathway, and also endeavor to protect Japi's treasures. All in all, these desires might not be so enlightened in the citizen's mind, even less in some representative ones. The development of the city and the aspects influencing community behavior and governance are the focus of the next lines.

4.2 Community attributes

This section is about cultural characteristics and behavioral aspects embedded in the Jundiaí's citizenry. These attributes are studied because they are relevant in understanding attitudes and values that actors may express. However, to infer about these abstracts inherent meanings and mores one needs to know the community in deep and have at hand overarching surveys and data to distill conclusions. This is the major limitation here, so this section intends to extract the best content possible from the information available.

General aspects and demographics

Settled in 1655 by a Portuguese colonizer, the village of Jundiaí was an important spot for extractive activities until the rise of agriculture around 1785. Crops of sugar cane, beans, cereals, cotton and coffee were initially developed and well succeeded, thanks to the fertile soil. Later on, more European migrants developed an extensive fruticulture, which is still largely practiced, especially the plantation of strawberries and grapes. Still today around 27 thousand hectares is dedicated to rural production of fruits and cattle, both for internal consumption and exportation, accounting for about 0.2% of the city's GDP. Before its colonization, the area was inhabited by indigenous tribes originated from 'tupi, and these partially nomad partially sedentary groups lived mainly from the corn and manioc cultures, hunting and fishing (DAE, 2002).

The industrial activity started around 1874 when the first weaving manufacture settled down, thus attracting a massive amount of Italian, Spanish and English migrants that came through the just-built railways (connecting the countryside to the coast, for trade purposes). In 1865, the village of Jundiaí was elevated to a municipality status, and it kept with urban and industrial expansion following the path of Sao Paulo and other cities in the region. In 1920, the city already counted more than 40 thousand inhabitants and in the subsequent decades industrialization and highways construction evolved fast, featuring the city as an important urban center for SP state. Today Jundiaí hosts one of Brazil's largest industrial concentration, contributing to reach the 24th largest Brazilian GDP – US$ 7.032.430 billion in 2012. Big companies such as Coca-Cola, Kraft Foods, Akzo Nobel, Sadia, Ambev and Siemens are situated in Jundiaí. Several distribution centers as well as manufacturers of ceramic, plastic, rubber, beverage, food, and durable goods are also located in the city. Moreover, service companies and commerce are also largely developed, representing about 65.78% of the wealth production, while industry accounts for 34.02% (Prefeitura de Jundiai, 2010).

The estimated population for 2014 is 397.765 and the demographic density is around 858 inhabitant per km², depicting as a highly concentrated community. Around 95.7% of the city's territory is urbanized, following the same pattern of the surrounding cities. Figures from 2000 show that 85% of the households have adequate urban infrastructure and sufficient internal space, considering the

number of residents, although nowadays this percentage should be slightly higher. Current coverage of public services such as garbage collection, water distribution, sewage collection and electric energy is practically universal, a very rare situation among Brazilian municipalities. In regards to education services, the city has expanded the educational coverage and is gradually reducing the illiteracy rate, graduating increasingly more students in the middle, high and superior school. In 2010, about 87% of the children between ages 4 and 5 attended school regularly, half of the middle-school pupils have reached the adequate level of knowledge in the national test, and 10% of high school students were delayed. However, all these figures have improved in comparison to past figures, reflecting investments made in educational infrastructure, teachers' remuneration, adult education and towards an approximation of the school and the community (L. F. NOVAIS, 2012) (Tribuna de Jundiaí, 2015).

Health services are rated as good in Jundiaí, although there is a deficit of access in the public services due to the large amount of people (1/3 of the citizens) depending on public health care and the fact that the city has only two public hospitals. Even though Jundiaí enjoys a better situation in health care compared to its neighbors, especially in terms of quality of the service. Teenager mothers represents about 6% of the population, which is in line with state figures (L. F. NOVAIS, 2012) (Tribuna de Jundiaí, 2015).

The main problems faced in Jundiaí are linked to the high population density (the 15th most populated city of SP state) and urban development challenges, such as high criminal occurrences, especially auto thefts, real estate speculation and irregular allotment. These last two are the main causes of land use issues, deforestation and degradation of remaining green spaces. Precisely, real estate speculation has largely grown in Jundiaí between 2004 and 2012, and evidence indicates it is related to the consecutive mandates of this period's mayor – Miguel Haddad. He is well known for the construction companies his family owns, and the personal linkages his family has with other builders and landowners (Ribeiro, Audio 1, 2015, p. 11:00'). This shows how private interests can be harmful when it comes to involve political exercise.

Jundiaí has the fifth largest rural population among the Brazilian cities, although this represents just 6% of the total population. Around 14% of the population is above 60 years old, and 20% is below the 15th age, so the economic active group correspond to about 65% of the inhabitants. Formal

jobs from the service sector correspond to 45% of the vacancies, followed by 28% from the industry sector, 21.7% form commerce, 4.6% from civil construction and 0.3% of formal vacancies from the agricultural sector. Worker's monthly income varies from an average of US$ 260 in the agricultural sector to a mean salary of US$ 800 in the industry and US$ 500 in the service sector, compounding a total average of about US$ 570 per worker, per month. The minimum wage in Brazil is currently US$ 236, but it is well known that such amount is not enough to afford the standard living costs, especially in urban centers. The average monthly household expenditure in Brazil is about US$ 533, but in the state of SP this average jumps to US$ 940, so considering a standard family of four members where there is one breadwinner their living situation is not easygoing. When compared to the GDP per capita of around US$ 19.000 it is visible that the earnings are quite concentrated and not equitable spread out within the labor force. This inequality is partially explained by the centralization of power and command within productive chains of high aggregated value and high wealth production, which are largely present in Jundiaí. Yet, around 23% of the households perform with more than three minimum wages per month, while 66% rely upon one to three minimum wages, 10% of the households are under poverty standards living with ¼ to ½ of the minimum wage and 1% of the families live in extreme poverty, with less than US$ 60 per month. Even with these negative figures, Jundiaí performs better than the majority of the Brazilian municipalities, with better indicators than the average from SP state (L. F. NOVAIS, 2012) (Tribuna de Jundiaí, 2015).

Although the municipality has space to improve in education, social equity, human development and many other areas, Jundiaí features as one of the most developed Brazilian cities holding the 11th highest value of human development index (HDI) of the country, and 4th highest from SP state (0.822). This show how good the city can be when compared to other Brazilian municipalities. It is considered the fifth best Brazilian city in term of quality of life, with one of the lowest homicide rate (6.66 per 100 thousand inhabitants). Moreover, since the first pool in 2000, Jundiaí features in the group 1 (of four) from the Social Responsibility Index from Sao Paulo (*Índice Paulista de Responsabilidade Social* – IPRS), where the first group refers to municipalities with high level of wealth and good social indicators. This index is similar to the HDI but it is based on municipalities' wealth, longevity and education calculated through multi-dimensional and more detailed figures. Mortality

rates have diminished year by year, as well as life expectancy has augmented and is now around 77 years old. Elderly people participation in sports activities, cultural and tourism programs is high and in accordance with the region pattern, although figures for social protection of the older are lower in comparison with neighbor municipalities (IPRS, 2010) (IBGE, 2012).

Amenity and leisure activities are a strength of Jundiaí, especially due to the cycling and soccer traditions. The city has several cultural spots such as educational and cultural complexes, libraries, theaters, museums, parks and a winery circuit throughout its traditional wine farms. Its location close to large amusement parks like Wet n' Wild and Hopi Hari, and shopping mall like the Premium Outlet boosts the tourism and hospitality sectors. Furthermore, seasonal events such as the Italian Party, Grape's Party, Strawberry's Party and the Expo Wine attract thousands of tourists each year. Hence, the city offers opportunities to develop tourism and for citizens to enjoy spare time and leisure activities (Prefeitura de Jundiai, 2010).

Social Capital and political engagement

Other important indicator about communities is their level of social capital. Social capital is understood as the benefits and values derived from cooperation between individuals and groups, so the collective value within social networks and embedded norms of reciprocity[4]. In other words, it is related to the extent that the community members are involved to each other, mobilized or associated into groups or organizations. It is not an easy task to determine the extent of social capital present in a certain community, but it is possible to have a picture of it by looking at number of associations, clubs, committees, and other social gathers within the community. Other relevant information is the level of trust among the members and confidence towards institutions, which is usually measured through surveys. Education is also highly interrelated with social capital, as it involves collective activities, the development of virtues such as mutual respect, sense of common good and empathy. There is no studies on social capital about Jundiaí citizenry so far, therefore this section intent to offer a brief idea about levels of association and engagement in the community, based on the limited information

[4] For further explanations on social capital see Coleman (1988) and studies available in Harvard University's Kennedy School of Government (2015).

available. Additionally, few generalizations can be made from information about Brazilian society in general, for instance the ones that follows.

Data from the World Values Survey (WVS, 2014) showed that in Brazil both indicators on trust among citizens and confidence in institutions are eroded. All institutions listed received more than 50% of negative impressions (not very much confidence and none at all). Political parties and the national parliament scored worst, with 80% and 70%, respectively, of negative responses, thus showing the predominance of a wide sense of disbelief and discredit about public institutions and politics as a whole. Another research showed that in Brazil both educational deficits and some political aspects have a great impact in social capital. The latter assumption has a clear general relation, but the former has its foundations in the development of Brazilian society, cleavages and the formation of the political elite. Evidences showed that there is a high concentration of resources, especially financial and decision-making power within officials and positions that hold clientelistic characteristics (Nazzari, 2004). Thereby, political-electoral interests and clientelistic linkages are two decays within Brazilian institutions and politics, and they affect various instances of social life and social capital, including behavior and attitudes in daily life.

When thinking about Jundiaí, it is not possible to assess to what extent this situation is noticed in the city's political environment, but one can certainly assume that it is present and embedded in its institutions and society likewise in Brazil. Nevertheless, Jundiaí holds good social indicators and features a high level of welfare compared to Brazilian cities. Education levels and civic engagement are also evolving and reflecting into a higher level of cohesion and association within citizens. Today there is about 60 entities per 100 thousand inhabitants, which is still moderate when compared to the most associative communities in Brazil that concentrates about 370 entities per 100 thousand people. Entities considered here are clubs, associations, non-governmental organizations, foundations and cooperatives (G1, 2012) (Apontador, 2015). All these facts about the *jundiaense* community indicate that social capital levels might be higher than the average Brazilian fashion, yet one cannot assume it as a scientific inference.

Concerning political participation, the Brazilian Constitution acknowledge modern rights related to direct democracy and citizen participation, including the establishment of Councils,

Assemblies and Committees in several public domains. In Jundiaí, the City Councils functions as a channel of civic engagement and political participation, where citizens and civic collectivities can take part into assemblies when public policies are to be created or modified. These councils have deliberative and consultative characters, and were created to promote social accountability within public policies and their execution, as well as to foster practical citizen participation in the political sphere. In Jundiaí, there are about 15 City Councils, related to minority rights, social care, economic development, environment, education and so on. Although the councils offer a real opportunity for political exercise, it is not clear the extent of participation that ordinary citizens can perform, neither whether decisions within the councils have effective influence in decision-makers. The councils' coverage is also a weakness as there are no councils related to subjects like transparency and accountability, as prescribes a specific federal law about city councils. Councils' internal procedures and structure of plenaries are also said to be deficient, hampering the capacity of involvement and articulation of participants. Furthermore, whether a large number of citizen really care about participating and taking part into the councils is another gap in the comprehension of council's effectivity (Parimoschi, 2013).

Participatory budgeting is other practical exercise of direct democracy and well known in many Brazilian cities, but not practiced in the majority of them. In Jundiaí's case is not different, as it has never been held by past administrations. More recent, during the pre-election campaign, incumbents advertised their will for providing citizenry with more instruments of participation, and to perform a transparent administration, closer to the constituents. However, after elections these promises were not fulfilled and instruments like participatory budgeting were not held, although they have recently started the articulation of a participatory Directive Plan of the city. Civil initiatives promoting political accountability and consciousness have followed incumbents' behavior, informing population about their good achievements and also their failures and noncompliance. This is an example of spontaneous political exercise and engagement of some members from Jundiaí's community, which are interested in building up a better and more politicized city (Filho, 2014).

By having all these knowledge at hand, it is still difficult to infer about incumbents' beliefs, values, preferences and information collection in their daily functions. Based on the data available, it

is only possible to conclude that Jundiaí's community has evolved in terms of quality of life and social capital, but the extent that this progress has affected institutions is not clear. Limitation of data and information hinders research ability of concluding scientifically in regards to community attributes. Next section will provide a broad understanding about rules that determine how water is governed in Brazil, in Sao Paulo and specifically in Jundiaí, thus showing the interactions within this multi-organizational, multi-level framework of hydric management. Then, the following chapter approaches the developments within the management action arena, and it should clarify some particularities within actors' beliefs, preferences and relationships.

4.3 Rules-in-use

According to the IAD framework, there are specific rules that determine how actions are decided and executed in institutional environments. In the case of water-related institutionalism, it include miscellaneous bodies. As water resources are usually not bounded into one territory, the governance of hydric streams has to combine organizations from all riparian localities, since local until federal level, and in some cases international bodies too. Thus, water management institutionalism normally encompass multi-level governance, as organizations within nested domains work together in the management of water resources, and multi-organizational frameworks of decision-making and regulation. Next lines presents and explores the Brazilian framework of water policies.

4.3.1 Policies, Regulations and legislatures

The Brazilian National Water Resources Policy (NWRP) was first prescribed in the Constitution of 1988 as a remarkable start point for a democratic and participatory approach towards water resources management. The Federal Policy itself was only drafted and sent for parliament approval in 1991, and it was elaborated in accordance with previous approved State Law (from SP state), and grounded in principles of decentralization, Integrated Water Resources Management (IWRM) and the participatory approach. After 5 years in the slow line of new laws for parliamentary approving, the NWRP was enacted in 1997, and was considered one of the most advanced water legislation in the world (ANA , 2002).

The final text of the NWRP defined, among other things, the creation of the National Water Resources Management System (NWRMS). Inspired by the Dublin Statement, the basic principles enduring the National Policy are (Porto, 1998) (Magrini & Veiga, 2013):

- Water is public property;
- Water is a limited natural resource, which has economic value;
- When there is a shortage, priority in the use of water resources is given to human consumption and the watering of animals;
- The management of water resources should always allow for multiple uses of water;
- The river basin is the territorial unit for the implementation of the National Water Resources Policy and the actions of National Water Resources Management System;
- The management of water resources should be decentralized and should involve participation by the Government, the users, and the communities.

The Policy's main objectives are: (a) to ensure to all society and to future generations the availability of water resources in good quality standards; and (b) to promote rational and integrated use of water resources, including aquatic transportation, water catchment, hydraulic energy, etc; and (c) to prevent and protect against water crises due to either natural causes or the inappropriate use of natural resources. The NWRMS has the main goals of coordinate IWRM, manage and arbitrate conflicts related to water, and promote the billing for water multiple uses (Porto, 1998). Moreover, it prescribed the creation of several water-related organizations, in different levels and with specific jurisdictions, which are explored in the next section.

Some instruments for policy implementation are the Water Resources Plans (WRP), the resolution 357 on classification of water bodies and quality standards (CONAMA, 2005), the award of rights to the use of water resources in the form of bestowals, fees for the use of water resources, and the Water Resources Information System (WRIS) (Magrini & Veiga, 2013). All these tools are employed by multiple water organizations in the exercise of their jurisdictions, thus compounding the Water Management System.

Other relevant federal directive is the National Policy of Sanitation, which determines the separation of the planning, regulatory and service provision functions for all services embedded in sanitation (water supply, sewer collection and treatment, urban drainage and solid waste handling). The policy determines that the planning functions are a municipality responsibility, while the service provision can be pursued by a municipal autarchy or a concessionary, either public or private run. The regulation and surveillance of these services must be employed by an independent entity, endowed with technical capacity and with administrative, financial and decisional autonomy (CASA CIVIL, 2007). In the case of Jundiaí, planning on water services is a responsibility of DAE, while sewerage is conceded to CSJ through renewable concession contracts, and the regulation and surveillance functions is performed by ARES-PCJ.

Concerning land use and occupation on water resources areas, there is an important federal policy - the Forest Code - that was recently modified in a long-standing, highly articulated policy-craft process, and defines obligations in regards to the use of terrains. Among other modifications, the new code changes the protection area surrounding water resources, from the previous 30 ratio meters to 15 meters of protection on the riparian vegetation (one of the reasons why environmentalists voted against the final code). These areas are called Permanent Protection Area (APP) and correspond to important areas for matters of water resources preservation, and fauna and flora protection, which must be covered by native vegetation (G1, 2011). In addition, the law defines the Areas of Environmental Protection (APA), which are key areas for preservation of remaining native landscapes, such as *Mata Atlântica* in the Japi's Ridge. Hence, Jundiaí is defined as an APA, which determines that any construction should be previously communicated to the City Hall and authorized by specific organs. The law also states that big industries cannot be installed within these areas anymore, although the ones that are already situated can stay, and that rural proprietors should be recorded in the municipal tracking system of APA. (Fundação Florestal, 2015) (DAE, 2015).

Recently a project of payment for environmental services was introduced in Brazil, precisely in a city within the PCJ River Basins, and it consists of a mutual agreement between small and medium landowners located at key areas for water resources conservation that are currently depredated or deforested, and the Environmental Ministry. It establishes a period of activities for recuperation and

preservation of these forest areas that the proprietor should perform, in exchange of a monthly money grant. These new mechanisms of partnership government-proprietor have fostered environment conservation in the US and Japan, in previously implemented similar projects. In Brazil it is still a not widespread initiative, might becoming more propagated and deployed in the next years though (Pereira, Cortez, Trindade, & Mazochi, 2010) (G1, 2014).

There are many other legislatures, at federal and state level, defining directives for water treatment, multiple water uses and water distribution (DAE, 2015), but for the purpose of this research, it is not relevant to know them all. For now, it is relevant to know that municipal legislation prescribes functions of natural resources protection to the municipal water provider, hence, DAE is in charge of preserving and protecting water resources within Jundiaí's territory, besides managing the system of water distribution.

4.3.2 Structure of Governance

The structure of governance for water-related matters is quite wide, as it englobes management for purposes of hydric energy, water supply and water resources conservation. Departing from the NWRP, it institutes the NWRMS, which comprises the following entities:

- The National Council on Water Resources (NCWR);
- The State and Federal District Councils on Water Resources (SCWR);
- The River Basin Committees (RBC);
- The organs at the Federal, State, and municipal levels whose respective areas of competence are related to the management of water resources;
- The Water Agencies (WA).

These organizations are spread among three levels of governance – national, state and river basin - and have multiple functions in sometimes overlapping domains. When first enacted, the NWRMS did not prescribe a centralizing body, however in 2000, the government recognized the need of having a national centralization entity for operational and monitoring matters, thus prescribing the creation of a federal autarchy with the main goal of implementation of the NWRMS. The agency is called ANA

(Agência Nacional de Águas, or National Water Agency), and it is a body attached to the Environment Ministry (EM). Its main attributions are to assign the implementation, operationalization, control and evaluation of the water management instruments within the whole country, through project and programs assisting other organizations' activities. It is also ANA's responsibility to decide upon bestowal grants regarding Federal Rivers, thus possessing a normative power. To be defined a Federal River, the water resource should be an interstate stream, otherwise intrastate ones rely under state-level organizations for the purpose of bestowal (ANA, 2015).

The National Council on Water Resources (NCWR) is the higher instance within the Brazilian water management system, and it is responsible for promoting dialogue and articulation on WRP in state and local levels, as well as institute new River Basin Committees (RBC), formulate new policies and evaluate any law alteration, and arbitrate in conflicts about water resources. Its jurisdiction applies for Federal Rivers and this body holds consultative and deliberative power. It is composed by some National Ministries, State Councils on Water Resources (SCWR), water users, for instance industries, irrigators, fisherman, among others, and by civil organizations' representants, like consortiums, associations, NGOs or research organizations on water matters (CNRH, 2015). Still at National level, there is the Secretary of Water Resources and Urban development (SWRUD), attached to EM, and responsible for articulating and propose policies concerning water resources laid in national authority (intra-state streams), and also coordinate national programs and plans related to water resources conservation (MMA, 2007).

At the state level, there is the SCWRs, which has similar functions compared to NCWR, but with authority upon interstate rivers. It holds decisive, normative and consultative characters, as it formulates state-level WRPs and any modifications in state policy on water matters, besides a long list of additional duties. This council is attached to the state-level Secretary of Environment (SE), which centralizes all functions related to conservation, planning, control and management of natural resources and the environment in SP state (SIRGRH, 2015). Under this secretary, there is also CETESB, which is the agency responsible for monitoring, controlling, surveillance and license of activities causing environmental impact. Its main tasks involves water resources quality monitoring, license issuing, and the development of evaluation reports concerning construction's impacts and

compensation requirements (CETESB, 2015). In parallel, there is other important state-level actor, DAEE, which is attached to the Secretary of Water Resources and Energy, and has the main functions of plan and coordinate the multiple uses within intra-state river basins. This organ is the one responsible for grating bestowals within the PCJ River Basins, and it also issue permissions for water-related constructions and works within this region (DAEE, 2015).

At the River Basin level, the law prescribes the creation of a Committee and a Water Agency. The Committee has a deliberative character, while the Agency holds an executive function. The main attribute of the Committee is to express a technical opinion towards new regulation or modification, while the Agency's main roles involves to develop the River Basin Plan (and later submit to Committee's evaluation), besides managing financial resources collected with the River Basin's multiple users, and developing annual report about water resources situation. Both bodies are linked to both inter- and intrastate rivers, each within its own basin jurisdiction. Water agencies are created upon resources availability and interest, not being compulsory to establish one, whereas the Committees establishments are among priorities within the NWRMS (AMBIENTE BRASIL, 2015) (Comitê PCJ, 2015) (Agencia PCJ, 2012).

The PCJ Committee is one of the most articulated and integrative water deliberative bodies in Brazil. It encompass 12 technical chambers and more than 600 member engaged in its daily tasks and deliberations. It is composed by national, state and municipal representatives, as well as the civil society, mostly represented by experts, professors and associations. The Committee is assisted by the PCJ Agency, which is the water agency and has the main role of collect and manage financial resources raised through charging PCJ's multiple users (Agencia PCJ, 2012) (Comitê PCJ, 2015).

Additionally, municipalities within the River Basin may gather and create independent bodies to jointly exert specific activities. This is the case of the PCJ Consortium, which is a nonprofit organization created in 1989, with the main goals of restauration and preservation of the PCJ region, and awareness promotion and engagement towards PCJ resources. This intermunicipal group later aggregated companies and other agents interested in promoting water resources preservation within PCJ watersheds and river basins. They develop projects and programs focused in enhancing water resources and assisting municipalities in their duties towards water services. For this reason, the PCJ

Consortium created the ARES-PCJ, a regulatory agency responsible for regulate and monitoring water-related services, uses and conditions within the cities compounding the PCJ region (and that are members of the consortium) (Consórcio PCJ, 2015). Jundiaí is part of the PCJ Consortium and thus have the local water services regulates and surveilled by ARES-PCJ.

According to ANA, The PCJ watershed has pursued an advanced and well-articulated water management conjuncture, especially when compared to other Brazilian river basins. This conclusion backs from the river basin articulation, the existence and ongoing execution of WRPs, and due to execution of both usage license and water use billing (ANA, 2013). Figure 6 illustrates the structure of water governance stablished in Brazil, focusing on the PCJ river basin:

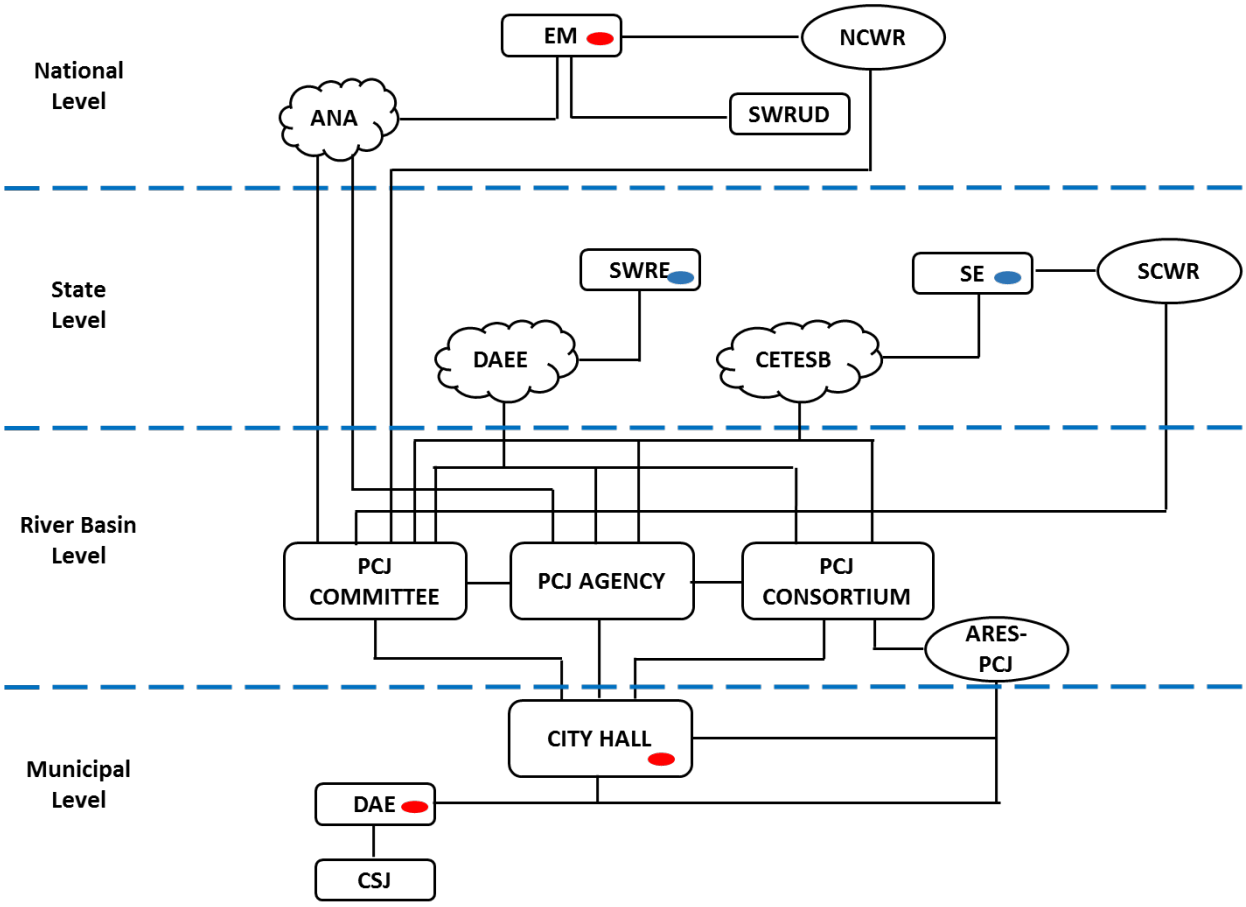

Figure 6 – Water governance framework focused on Jundiaí territory
Source: (Neves & Morales, 2007)

The colorful marks indicate the organs that are directly subject to an elected instance. For instance, the EM is subject to the National Executive branch, thus the elected president indicates EM's decision-

makers. The same happens with the state secretaries, and with DAE, where the board is appointed by the City Hall officials, or more specifically, the Mayor. The colors correspond to the party color, so red means incumbents belonging to the Workers' Party (*PT – Partido dos Trabalhadores)* and blue means the mandate belongs to PSDB (*Partido da Social Democracia Brasileira* – Brazilian Social Democratic Party). This indication was made for purposes of understanding political influence in decision-board formation, which may affect continuity of policies and planning, as next chapter will exemplify.

For this project, the largest interest resides with the municipal organization responsible for water supply and water resources management in Jundiaí. DAE-Jundiaí is a mixed company, or joint open-market (stock) company, which has as major shareholder and decision-maker the Jundiaí's City Hall. It turned into an open capital company in 1999, after being a municipal autarchy since the municipalization in the 10s. Its main functions include building infrastructure for managing water supply and collection of water resources and wastewater, although sewage services were conceded to CSJ in 1996. It is also DAE's responsibility to operate, explore and protect water resources and watersheds used for the water supply system, and the ones affected by the sewage system. Thus, DAE develops planning, execution and management of natural water resources and dams used in the supply system (DAE, 2015) (DAE, 2002).

DAE´s structure is divided into six departments (Administration, Operations, Maintenance, Finance, Commercial and Water Resources), which are centralized in one superintendence and one presidency. These eight instances compose the board of decision-makers within DAE, and the incumbent mayor and its advisors indicate the head of each instance. There is also a Council that holds a consultative role, not interfering in decisions indeed. Planning and budgeting functions are centralized in these eight directories, thus it has a certain link with incumbents' interests and preferences (DAE, 2012) (Ribeiro, Audio 7, 2015, p. 02:18) (Ribeiro, Audio 1, 2015, p. 04:20).

In sum, governance of water in Brazil involves many actors from several levels and domains, which interact in a broad process of management and operation. This governance framework is affected by political preferences and conveniences whereas indicated positions concentrate decision-making power, and this might influences governance patterns and outcomes. For the purpose of this project, the most relevant bodies are DAEE, CETESB, the PCJ Committee, and the three ones located

at municipal level. These are the main agents involved in water resources management of Jundiaí. They interact mainly in activities related to water bestowals, license for constructions and operation, municipal policy creation and enforcement, among other functions. Next section places together the most relevant considerations within the three variables explored in this chapter.

4.4 Conclusion

The exploration of the external variables allowed comprehending some aspects about Jundiaí's water management framework. First, this management framework has as main responsibilities to protect the city's water resources and to manage them according to legislation on land use and water services provision. The management policies and actions, even when it refers to resources within the city territory, are subject to authorization from higher levels bodies, according to the activity that it intends to perform. Various organizations play roles in the governance structure, each one with its own range of functions and jurisdictions. This multi-level, multi-organizational framework is affected by political nuances, as the main agencies (or actors) have their decision-makers being appointed by elected officials. There are six main agents performing water management in Jundiaí - DAEE, CETESB, the PCJ Committee, City Hall, DAE and CSJ - are they are the main actors in the subsequent action arena analysis, and their roles can be of decision-maker, executor and facilitator.

In regards to bio-geo-physical conditions, it was evident the hydric potential that Jundiaí's territory enjoys, mostly thanks to the presence of the protected forest area of the Japi's Ridge. The city possess sub-basins that are so far unexplored for water supply, which depicts positive conditions for development of this system. The current quality conditions of these water resources is overall good, although in the past some streams were completely polluted and degraded. In short, the city enjoys a rich water resources conjuncture and it has evolving in the way it deals with these treasures.

The investigation on the community's aspects clarified about Jundiaí's high human development level, and low incidence of extremely-poor families, which places the city in a privileged position among Brazilian cities. As a highly developed and industrialized municipality, it accounts for a significant GDP production, which is not equally spread within the population, although it is less unequal than commonly in Brazil. By comparing with other Brazilian cities, it is also possible to affirm

that, in general, Jundiaí's citizens holds better education indicators, and are more civic and politically engaged, thus indicating a higher level of social capital. Notwithstanding, it is assumed that institutions in Jundiaí, as so in Brazil, are infected by clientelistic features, which may influence preferences and values in the exercise of public administration and politics. However, this assumption is not based on data specifically about Jundiaí or any scientific inference, but on generalizations about Brazilian institutions. Therefore, the assumption is not regarded here in a conclusive way, but in a supportive manner in a sense that in the action arena analysis and in the conclusion it may cross with other findings and leverage such conclusions. Ultimately, further inferences about actors' beliefs and preferences based on community aspects were not possible to be distilled, due to data limitation and lack of previous studies about Jundiaí's community.

5. Analysis

Chapter 4 provided the whole picture about the external variables influencing water management arena in Jundiaí. The current section approaches the situation of study, providing details about the governance that have been employed in the city's water management agency in the past years, and connecting it with the actions that supported Jundiaí water distribution system in the drought seasons of 2014 and 2015 especially. It closes with an analysis of the water management arena where the actions were projected.

5.1 Water Security in a Context of Crisis

How Jundiaí did not interrupt water services when the majority of neighboring cities did? Which actions were undertaken that culminated in water availability? Why the situation in this region is considered as a water crisis? These are examples of questions addressed in the following pages.

The development of a status

Jundiaí's water supply system was settled in 1901 and sewage services were launched in 1904, both private run until the municipalization in 1910. The first water resources studies of mapping and diagnostics were conducted in the 30s and 40s, period in which the city was developing fast. Consequently, the rising pollution levels and population expansion led to the creation of the first two reservoirs (Catchment and Moisés weirs) catching water from the Jundiaí-Mirim River, in the 50s, and the first water treatment station. In the 60s, the Town Hall administration created the Department of Water and Sewage – DAE – as an external municipal body, which granted a certain extent of autonomy for water management and planning (DAE, 2002) (DAE, 2015).

In the 70s, Jundiaí had many industries and a dense urban population, which started to put pressure in the city's water supply system, as the River's flows had become insufficient to recharge the reservoirs. The solution came up by DAE was to require a bestowal to catch water from the Atibaia River in order to supplement Jundiaí-Mirim's water flows and thus enhance the supply system. The bestowal granted by the state water management body – DAEE – offered an addition of 0.7m^3/s, which

for that period was good enough to supply water for the whole city. Several constructions and few years later, the 11km pipeline adduction with 700mm diameter started to work. At that time DAEE did not impose conditions for the bestowal, but it did indicated some goals that DAE should aim at in order to keep with the bestowal in the future. They included depollution of water resources, investments in sanitation and maintenance of water networks.

Nevertheless, in the 90s the bestowal amount was not sufficient anymore, so DAE requested an augment of 500l/s, resulting in an addiction rate of 1,2m³/s. This request was authorized under certain conditions: (a) they should pursue a depollution program for the Jundiaí-Mirim River including expansion and modernization of the sewer collection system; (b) they should construct a new reservoir attached to the main one, as there would be an increase in the amount of stored water; (c) they should invest in loss reduction within the networks and pipelines (Ribeiro, Audio 1, 2015, p. 07:50') (Botan, 2015, p. 07:50') (DAE, 2002). Thus, during the 80s and the 90s several important actions and constructions were conducted by DAE and some partners, in order to fulfill such requirements and scape from water scarcity threats (Lima, 2015, p. 00:40').

The construction of the Accumulation reservoir was first projected in 1983, but the plans only started to be executed in the 90s, being concluded in 1998 at an amount of US$ 15 million. It resulted in a total storage capacity of 5 billion liters of water (DAE, 2015). The project also included the creation of a new park in the weir's basin, launched in 2001, aimed at preserving the green area, and retrain the allotment onward (DAE, 2002). However nowadays, there are some residential condominiums placed in an important recharge area close to the weir, thus hampering rainfalls absorption and recharging capacity (Ribeiro, Audio 1, 2015, p. 05:50'; 08:50'). Later on, this reservoir was expanded, reaching the capacity of 8 billion liters in 2010, at an expenditure of US$ 5.4 million (DAE, 2015). During this period, the water networks were also expanded and reached 97% of the urban area, and the treatment capacity was enlarged too. (DAE, 2002).

In parallel, the depollution project was developed in partnership with the City Hall of the six riparian municipalities, CETESB and CIESP/Jundiaí (the association of industries from Jundiaí), thus forming the CERJU (*Comitê de Estudos e Recuperação do Rio Jundiaí* – Committee of Studies and Recuperation of Jundiaí River). The project included sewage network expansion and treatment, as

Jundiaí was responsible for throwing almost 42 tons of garbage and disposal in the streams. The constructions started with establishment of collector pipes and interceptors throughout the urban networks, but later in the early 90s, neither DAE or the Town Hall had enough financial resources to conclude the plans and construct the sewer treatment station. The solution was to concede sewage services to a private agent, so in 1996, through a public concurrence targeting the lowest tariff, the Sewage Company of Jundiaí (CSJ – Companhia de Saneamento de Jundiaí) was granted with the concession. CSJ built Jundiaí's sewer treatment station and in the end of 1998 the city started to collect, treat and discharge into the River 98% of its wastewater (CSJ, 2015) (DAE, 2015) (DAE, 2002). In addition, DAE has invested in a continuous program for modernization and loss reduction in water pipes, exchanging old pipelines for new ones, installing new measure dispositive, and so on. They also have created a specific department for coordination and monitoring of these network corrections (Ribeiro, Audio 32, 2015, p. 00:01'; 04:10').

It is important to mention that in 2001 the region suffered from a drought and many geographies experienced water rationings and scarcity. Cities like Itú, Americana and the MASP had their water supply system affected by the diminished rainfalls, especially in the rainy season. At that time Jundiaí did not face problems with water distribution mainly due to the recently concluded expansion of its supply system (the recent finished Accumulation reservoir as fundamental to maintain distribution) (DAE, 2002).

The construction of the Accumulation reservoir involved several large-impact civil works, resulting in the expropriation of many residents, creation of new roads and deforestation of a large extension of green surface. As a consequence, the project generated an EIA RIMA document, which is an official report issued by CETESB indicating the resultant environmental impact and the corresponding actions that the constructor should carry out. Usually the EIA RIMA prescribes the compensation in vegetation restoration, reintroduction of fauna species, among other exigencies (Braga, 2013). The fulfillment of these requirements is compulsory to the constructor in order to obtain the operation license for the project's object. In this sense, DAE has held a partial operation license since then, and it only started to address the EIA RIMA requirements in 2004, after hiring the biologist Martim Ribeiro. He was the first biologist hired to conduct projects for environmental conservation and

restoration, and his work started with the creation of a plants nursery, followed by the reintroduction of fish cultures in the reservoir, reforestation of the weir's basin vegetation, and the accomplishment of the EIA RIMA statements. Currently, the compensations were conducted and those in charge are now monitoring and evaluating the outcomes to further report to CETESB how the compensations were accomplished, and thus request for the definitive operation license (Ribeiro, Audio 1, 2015, p. 29:30') (Ribeiro, Audio 3, 2015, p. 01:10') (Guimarães, 2015).

The original project of the Accumulation reservoir included a new expansion phase with the goal of reaching a 12 billion liters capacity in 2005 (DAE, 2002, p. 20). Until 2012, some steps were accomplished like expropriations of the area destined to inundation and the dam reinforcing, however when the new management team took over in 2013, they decided to freeze this project, claiming that they had new plans and new visions for the future of Jundiaí's water management. As most of large-scale civil engineering works, the weir expansion would take several years to be completed, so it is impossible to start and finish such work within one mandate. Incumbents decided to retake this expansion project right after the first symptoms of drought have reached the region, in 2014, but still there is no expectation when this project will be concluded. This situation illustrates a case of planning disruption caused by political convenience and failures in planning execution/continuation (Ribeiro, Audio 1, 2015, p. 24:15'; 25:20') (Ribeiro, Audio 2, 2015, p. 00:01').

Notwithstanding, other previous plans were not carried continuously by incumbents. It includes the usage concession of a private reservoir located nearby the Japi's Ridge, within a propriety of 700 bushels that cultivates tilapia, oranges and lychee. The 'Rio das Pedras' reservoir has an approximate capacity of 1 billion liters, and since late 2000s it was targeted by a DAE's visionary director as a new source for Jundiaí's water supply system. This director started informal talks with the owners regarding a concession of use, but few months later he passed away, and the project was not carried on until this year, when the crisis rattled incumbents and they decided to look towards faster solutions for a possible long-stand drought situation (Ribeiro, Audio 2, 2015, p. 06:20') (Lima, 2015, p. 07:40'). This same visionary director (Sr. Milton Takeo) was among the decision-makers responsible for the water management planning actions of the 80s, 90s and the 2000s, which have provided the city with the relative comfortable position among the region in terms of water availability (COATI, 2013). Figure 7

shows the evolution of Mayors and DAE's main decision-makers in the period of interest for this research project:

Period	1973 - 1976	1977 - 1984	1985 - 1988	1989 - 1992	1993 - 1996
Party Coalition	PMDB	PTB	PSDB	PSDB	PSDB
Mayor	Ibis Pereira Cruz	Pedro Fávaro	André Benassi	Walmor Barbosa	André Benassi
Super-intendent	Aloysio Ferrao	Pedro Baldris	Ruy Luiz Chaves	Pedro Baldris	Luiz Roberto Del Gelmo
Main Director	José Eugênio Vieira	Milton Takeo	Milton Takeo	Milton Takeo	Milton Takeo

1997 - 2000	2001 - 2004	2005 - 2008	2009 - 2012	2013 - 2016
PSDB	PSDB	PSDB	PSDB	PC do B / PT
Miguel Haddad	Miguel Haddad	Ary Fossen	Miguel Haddad	Pedro Bigardi
Jorge Yatim	Ademir Pedro Victor	Eduardo Santos Palhares	Wilson Roberto Engholm	Jamil Yatim
Milton Takeo	Milton Takeo	Milton Takeo	Milton Takeo/Aray Martinho	Aray Martinho/Walter Maia

Figure 7 – Evolution of Mayors and DAE's board between 1973 and 2016
Source: (DAE, 2002) (DAE, 2015)

Between 1983 and 2012 the city was governed by the same political party, the conservative PSDB. As the mayor selects DAE's director board, the PSDB hegemony allowed continuity also within DAE's decision-makers, which contributed positively for the conclusion of planned actions (Ribeiro, Audio 1, 2015, p. 04:20'). In 2013 the opposing party's candidate was elected, and the board was modified. The incumbent mayor from the Workers' Party coalition kept some collaborators and changed the majority of decision-makers. Even with some older directors left, in the beginning of its mandate, the new board decided to allocate resources in different projects than the ones that were already planned, which have delayed most of the planned works (Ribeiro, Audio 3, 2015, p. 01:10'). Another political nuance hindering DAE's performance relates to criteria of choosing these indicated decision-makers. In practice, the winning coalition usually make a discretionary selection, pointing people that worked in the campaign or have relations with the party or its partners, and only in few cases the indication is based on previous experience, meritocracy or technical skills. This happens in innumerous Brazilian

institutions due to this acquired power of selecting decision-makers within public organs. Besides that, there are the enormous benefits and stability that civil servants enjoy in Brazilian public service. It is not hard to find servants that do not fulfill work time, do not attend work correctly, and even some that do not develop work activities at all, acting like a ghost employee. Thus, one can say that prevarication and malfeasance are embedded in some Brazilian organizations, and hamper institutions' ability to effectively perform their roles (Ribeiro, Audio 7, 2015, p. 02:18'; 04:25') (Ribeiro, Audio 21, 2015, p. 00:02') (Ribeiro, Audio 4, 2015, p. 02:20').

The main challenges that Jundiaí faces nowadays can be summarized in two: (1) to regulate and control land use and occupation, and (2) a possible cutback of Atibaia's current bestowal of 1.2 m^3/s. The former is related to the urban expansion and the ongoing allotment that harms the remaining vegetation, springheads and water resources that are still providing the population with ecosystem services and common-goods (Botan, 2015, p. 08:20'; 14:15'; 15:20';). The latter is a possibility due to the drastic situation that other municipalities are facing in their water supply systems, which are dependent on the PCJ river basins (Lima, 2015, p. 06:30') (Ribeiro, Audio 2, 2015, p. 05:00). In the peak of the drought in 2014, both the mayor of Campinas (one of the largest metropolitan regions of Brazil) and SP state governor asked DAE to turn off Jundiaí's adduction pumps for some hours of the day because Atibaia's downstream flow was too low at Campina's catchment area (as the adduction for the Jundiaí-Mirim River was catching almost all of the volume of water remaining). Campinas is an example of municipality that does not have built-up reservoirs to complement the water supply system, relying on direct river streams to perform water services. In face of this, DAE's managers acknowledge the threat of DAEE coming to change current levels of water bestowal for Jundiaí, as the city enjoys the best condition of water security among the municipalities within PCJ watershed (Ribeiro, Audio 2, 2015, p. 05:40').

Just as Campinas, various densely populated municipalities have not develop a solid water supply system. Most of them do not have reservoirs, hold low rates of sewage collection and even lower or inexistent sewage treatment (SNIS, 2013). Besides disposing wastewater into the rivers, there is overall lack of riparian forest restoration or conservation, combined with an environmental liability estimated in 200 million trees (related to previous deforestation for constructions), thus resulting in

the promiscuous situation of water scarcity (Comitê PCJ, 2006) (Costa, 2015). In front of these facts, it is not difficult to figure the crisis context. Next section presents the conditions positing the PCJ region in a situation of water scarcity.

A build-up crisis?

Brazil is overall a rich country in terms of freshwater availability, but the uneven urban development resulted in large concentrations of people and industries in the certain areas, overcharging natural resources. The Southeast region encompasses the most developed urban centers, and consequently the largest figures of water demand. The situation of water resources in this region is critical, especially within the PCJ, the Tietê and the Paraíba do Sul river basins. The intense urban and industrial activities generates greenhouse gases, pollution, deforestation and have several impacts in ecosystems, in particular hampering heat dispersion and misbalancing natural phenomena (ANA, 2014).

Since 2012, the PCJ region sees a continuous decrease in precipitation levels, reaching the lowest figures in the rainy season of 2013/2014, with an average reduction of 55% in rainfall mm. The formation of a high atmospheric pressure zone at 6000 meters of altitude in the region was the meteorological cause of this dynamic change. 2014 followed with low levels of rain, thus worsening the situation of the PCJ water resources, which came to have, in the worst cases, ¼ of the annual average water flow. This reality had impacts in water supply systems of at least 87 municipalities, including the MASP that concentrates 50% of its distribution in the *Cantareira* System. The *Cantareira's* reservoirs are spread out through the PCJ River Basins and receives inflows from its watersheds, historically at a rate of 31 m^3/s, but during the crisis period it dropped to 15 m^3/s and keeps lowering (SABESP, 2015). The growing drought posited an acute harm of water total cutback in the case rainfalls kept scarce, but luckily the months of February and March of 2015 alleviate the situation a bit (SABESP, 2015).

The rainfalls reduction also affected Jundiaí, as the largest reservoir lowered to 58% of its water capacity in the end of 2014 (Mendes, 2015). The flows from Atibaia decreased to a rate of 0.7 m^3/s, thus increasing the system dependence on the reservoirs. The smallest reservoir, at the Japi's Ridge, was completely drought by the end of 2014, but the larger weirs supported the city's consumption levels during the crisis peak (Ribeiro, Audio 9, 2015, p. 09:00'; 10:10'). Thus, Jundiaí's

citizens did not face one day of water services interruption, while other municipalities' residents were struggling with limited access. Charts 1 and 2 show the precipitation levels registered in Jundiaí in the past 19 years. The average annual rainfall in 2014 and 2015 was half of the minimum levels observed in the drought years around 2000. Until last year, the first semester of 2000 was the most drought period of the past two decades, with the consequent water restriction. However, in the first semester of 2014 it rained just half of the levels observed in the 2000 drought, thus demonstrating an extraordinary drought situation. Fortunately, the first semester of 2015 was not as rough as in 2014 due to higher levels of rain in February and March, although the overall pluviometric rate is still far from the historical average.

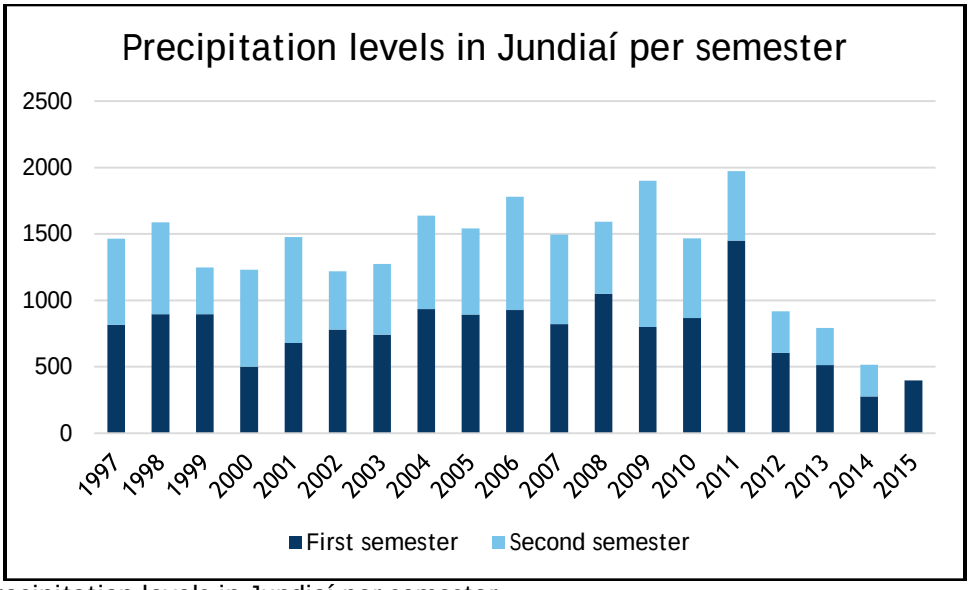

Chart 1 – Precipitation levels in Jundiaí per semester
Source: (DAE, 2015)

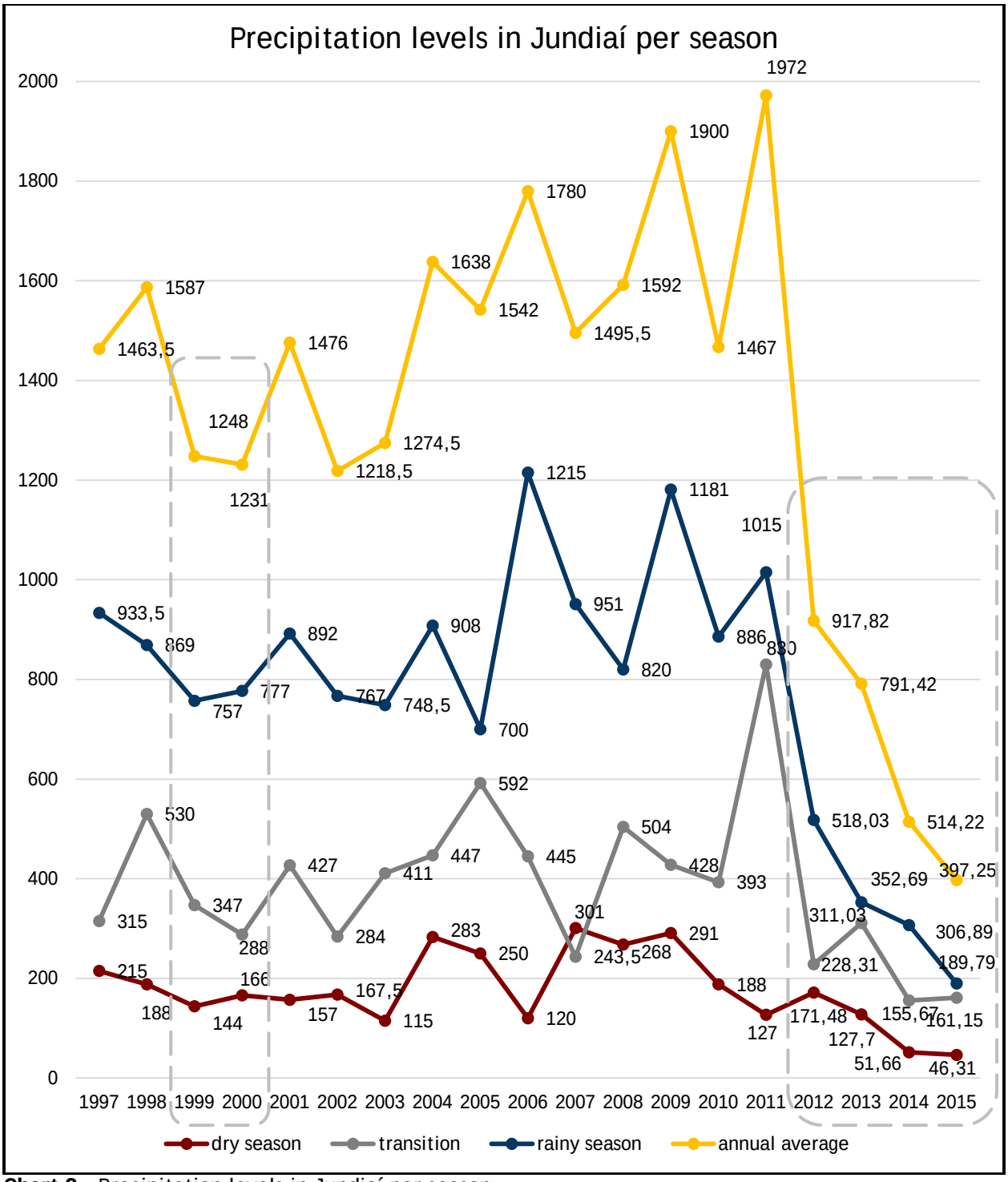

Chart 2 – Precipitation levels in Jundiaí per season
Source: (DAE, 2015)

The lower levels of rainfalls in 1999 and 2000 culminated in a widespread drought among the PCJ and other Southeastern watersheds in 2001, which resulted in water scarcity and rationing in many cities,

including MASP. The *Cantareira* System reached 38% of its capacity in that period, and specialists already pointed to the necessity of seeking autonomy from this supply system (Viveiros, 2001) (Estadão, 2014) (da Silva, 2015) (Franco & Gomes, 2015). The collapse of the *Cantareira* was previously announced, but in 15 years, the system's operators did not manage to minimize such threat. The current hydric level in the system is about -11% of the 'dead volume', thus draining the very last volumes of water remaining in the bottom of the weirs. The system is about to collapse if precipitation levels remain low and the water provider keeps to collect the last quotas of the 'dead volume' (G1, 2015). A *Cantareira* breakdown would affect at least 14 million people and various productive sectors, besides entailing health and security issues and enormous environmental impacts.

Currently, the water rationing within the region is not official communicated, although thousands of households have limited access to water, especially those located in peripheral neighborhoods or slums, and not surprisingly, the bills do not reflect the service reduction. Cases of intoxication, nausea and diarrhea have risen in these neighborhoods and doctors indicate that it might be correlated with the quality of water that has been distributed lately (Felix, 2015) (Martín M. , 2015) (Martín, 2015) (Maranhão & Ramalhoso, 2014) (Cardin, 2015) (Sartorato, 2014). Sewer disposal is still largely discharged into the rivers that are used by the supply system. Within the PCJ region, only 40% of the wastewater is collected and treated, and there are also high levels of water loss within the outdated pipelines, reaching the average of 50% in some municipalities' networks, although these figures had slightly improved in the last years (ABCON, 2015) (Agência PCJ, 2014). In addition, depollution programs in surrounding river basins, for instance Tietê, have been extended for more than two decades without achieving significant parcels of conclusion and costing more than US$ 300 million (Afiune & Mota, 2015). The Tietê and other highly polluted water resources would be an outlet for MASP supply system if their cleaning projects were seriously carried out and combined with enlargement of sewage treatment.

All these evidences make it clear that the reasons for this water crisis are not totally originated from natural disturbances, but have deep roots in governance failures and recklessness. There was no construction of new large reservoirs, only small ones in areas that had no weirs before, and these were highly costly projects (Coelho, 2015) (PCO, 2014). More recently, a just-concluded 'emergency

construction' of river transposition, supposedly projected to reduce dependence from the threatened supply systems, have not performed according to the governor's plans. The large-scale engineering project was supposed to transfer 1m³/s from a local river to the reservoirs for treatment and supply, but the river's flow has continued to lower and now the adduction pumps cannot catch any volume. The construction work costed US$ 8,6 million and was target of criticism beforehand due to the drought these rivers were already facing (Leite, 2015). This is another evidence of governance poorly performed, and excessively focused on large scale, costly engineering projects.

Besides, key decision-makers like the SP state governor, Geraldo Alckimin, make use of unreal discourses, underestimating the roughness of the water crisis and promoting illusory assurances on water availability and guaranteed access (Martín M. , 2015). In front of this, MASP's water supply company and the state of SP are responding to several civil public suits[5] raised by the Public Ministry, with accusations about negligence on water resources management, lack of recuperation plan for the *Cantareira* streams and lack of transparency.

Despite all, civil society and NGOs have articulated to reduce crisis harms and charge actions from decision-makers. In the city of Extrema where there are around 400 springheads that compounds the Jaguari river basin (part of PCJ and key contributor to the *Cantareira* system), a pioneer project launched in 2007 has restored, protected and revitalized these water sources and the surrounding forest within an area of 7.3 thousand hectares. It represents a restoration of 7% of *Cantareira's* springheads, and the result is visible as the river flows have risen, although it is difficult to measure the exact addition (G1, 2014) (Pereira, Cortez, Trindade, & Mazochi, 2010) (Ribeiro, Audio 1, 2015, p. 01:37'). Additionally, social groups have articulated educational projects and actions aimed to raise awareness about the crisis and water consumption, and to enhance resilience and autonomy in extreme cases, for instance by using cisterns, tanks and wells (Aliança pela água, 2015).

In sum, the current crisis challenges the ability of problem solving of the incumbent decision-makers. As the crisis explanations are grounded in structural constraints, ultimate solutions would require overarching actions including ecosystem recuperation, sewage treatment and water resources

[5] See suits at (GAEMA, 2015) and (GAEMA, 2014)

depollution. Although these might sound long-standing, costly actions, evidence[6] has shown how local articulation can achieve positive results with lower investments and some years of work. Still, the actions that have been conducted by incumbents show pathways of water governance strongly guided by large-scale constructions involving river transpositions, system interconnection and dam creation. Little is said about environment or precautionary actions. The mind-set is towards corrective actions based on status-quo conditions. Furthermore, delayed constructions and sub-optimal planning execution are other frequent hindrances these large-scale water projects posit. This serious panorama requires governance approaches based on innovative solutions including environmental actions, transparency and community-close dialogue, and long-term planning with *de facto* execution. Governance failures are present in any water management arena worldwide, but when failures largely outweigh successes, cautionary attention should be payed in seeking the root causes and acting to prevent crisis continuity or escalation.

Jundiaí's current situation and prospects

Based on numbers provided by DAE, calculations were made with the goal of demonstrating how the current situation of Jundiaí's water supply system depict as water security. The simple calculation does not aim at proving water security with elaborated and scientific methodologies, rather it is a pedagogical explanation backed in simple interpretations of the water security concept, previously introduce in chapter 3. The simulations bases in a scenario where there is no precipitation, neither river inflows in the system, thus featuring a situation of total drought and lack of system recharge. Figure 8 illustrates how long Jundiaí's water supply system would keep distribution in such drought context, with consumption levels maintained at the average:

[6] See (Instituto Terra, 2015) (Costa, 2015) (Lamas, 2015).

Average water consumption	**1.5**	**m³/s**
Reservoirs capacity	total m³	current m³
Accumulation	8,000,000	7,680,000
Catchment	350,000	336,000
Moises	50,000	48,000
Japi's Ridge	30,000	28,800
Total	8,430,000	8,092,800
Monthly supply simulation without Atibaia contribution and without rain		
Average water consumption	3,888,000	m³/month
	months	days
Accumulation + Catchment	2.21	66.27
Moises	0.37	11.11
Japi's Ridge	0.22	6.67
Total water storage	**2.08**	**62.44**

Figure 8 – Figures about Jundiaí's water supply system and simulation of total drought
Source: (DAE, 2015)

Considering the current level of 96% of capacity (grey area), and the catchment flows of each reservoir in separate, the system would survive for approximatively 66 days without service interruption. If considered the sum of all reservoirs capacity together, the city would have 62 days of uninterrupted water supply. As they do not consider any precipitation or river flow, the real-life situation may be slightly better, although one cannot make further conclusions on it. Here, these numbers show how reservoirs are essential for any supply system to have leeway in events like droughts, or even in cases of floods, by water drainage and accumulation.

Likewise, it is extremely important to assure that areas surrounding these weirs are covered by native vegetation. The green coverage acts like a filter straw, draining rainfall water and recharging groundwater and superficial weirs with clean, filtered water. Furthermore, lack of vegetation may cause floods, silting and river sedimentation, as there would be no trees and vegetation to retain water and recharge. Today Jundiaí has around 13% of native vegetation remaining, considering the area around the Jundiaí-Miriam river basin. The development of agricultural activities is difficult due to topographic and soil conditions, although there is a large sprawl of eucalypt crops, pasture and fruticulture of grapes, strawberries and peaches. Figure 9 shows the evolution of an analysis regarding

the quality of the remaining forest fragments within the river basin area. It is evident the spread of urban occupation and deterioration of native vegetation between 1972 and 2013. The legend indicates the level of quality according to the methodology used in the analysis, from dark green - high quality passing through high, intermediate, low and extremely low quality, based on the colors (Fengler, et al., 2015) (IAC, 2015).

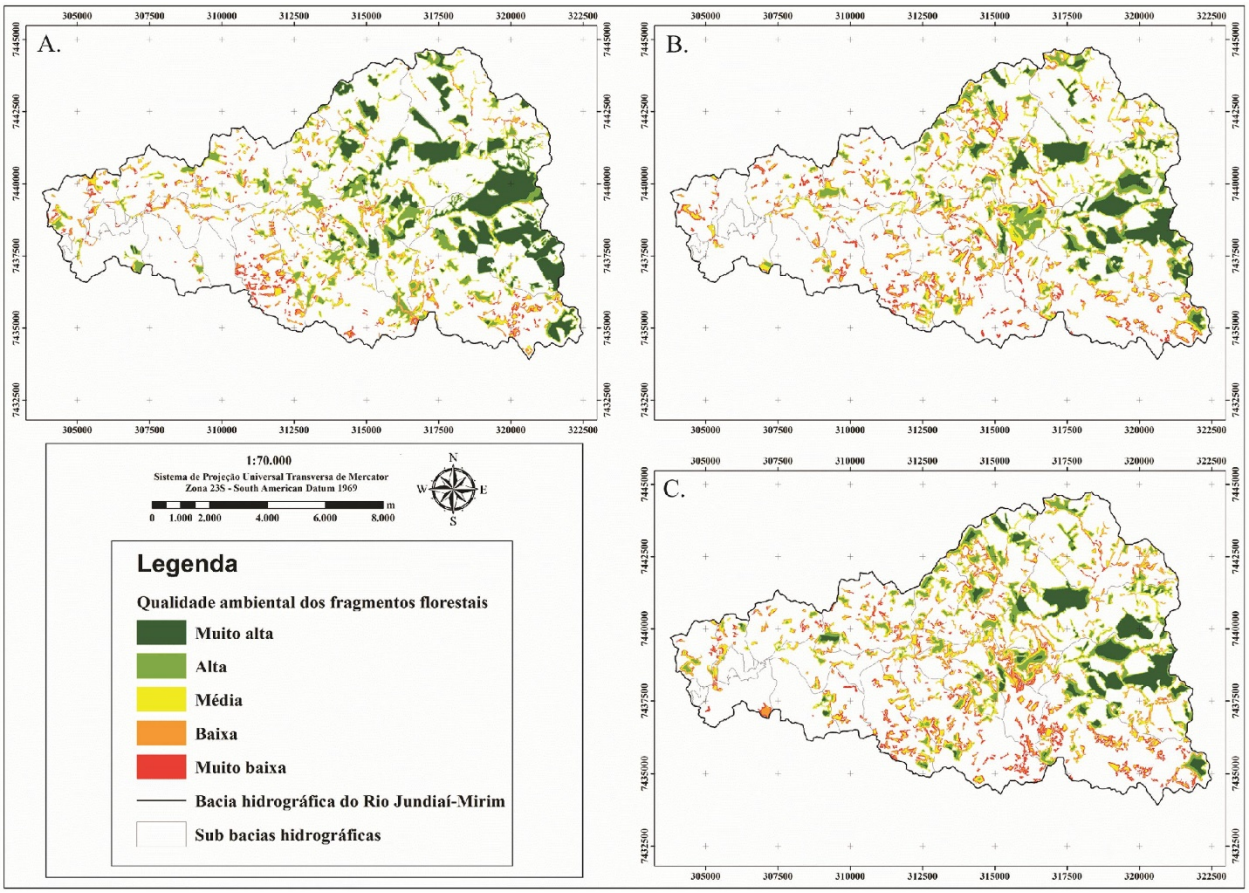

Figure 9 - Environmental quality of forest fragments in Jundiaí-Mirim river basin: 1972 (A), 2001 (B) and 2013 (C)
Source: (Fengler, et al., 2015)

Since early 2000s, DAE has invested in the fulfillment of its environmental compensations, primarily to be in accordance with license obligations, but also to pursue its role of protecting water resources and assuring future water availability. The establishment of a seedling nursery allowed DAE to have plants enough to start cover former deforested areas with native flora, which later on attracted the genuine fauna, recomposing the local ecosystem little by little. The reintroduction of fish cultures in the reservoir was also an important feat, and now the responsible team is carrying out monitoring and

evaluation analysis to report progress and achievements (Ribeiro, Audio 3, 2015, p. 00:08'; 01:10'). These actions, and the reforestation of the riparian vegetation, have been carried by the DAE's department of Water Resources, in partnership with Town Hall's secretaries of Planning, Agriculture and Environment. These organs are assisting with authorization of land recover, registration of landowners situated in APPs, and by providing resources for the project. DAE's Water Resources department has also been developing a study of mapping and evaluation of water springheads and tributaries for all Jundiaí's sub-basins. This project will contribute with key information about hydric recharging dynamics all over the city space and will serve as reference for future land occupation and urban planning. These environmental projects have attracted attention from companies interested in fulfilling their EIA RIMA requirements, and from Environmental NGOs too. These actors have developed partnerships with DAE and Jundiaí's Town Hall in the performance of such eco-aid actions (Ribeiro, Audio 6, 2015, p. 09:50').

Recently DAE promoted awareness campaigns incentivizing the reduction of water consumption among Jundiaí's population. The campaigning and the threat of water scarcity had effects, and consumption levels went down, reflecting in a shortening of DAE's revenues by 15% in 2014/2015 financial year. This is positive from the view point that citizens are becoming more aware about water issues and conscious about their water footprint (Mendes, 2015). On the other hand, as DAE is a private company, with shareholders and profit-seeking strategies, such revenue decrease affects future budgeting allocation and may constraint projects execution (Ribeiro, Audio 2, 2015, p. 11:38'; 11:15'; Ribeiro, Audio 18, 2015, p. 01:03'). Ultimately, decision-makers could focus on reduced-cost, and 'almost ready' projects for the near future, for instance the utilization of established private weirs to expand water availability for supply, and actions related to environmental recuperation and recovery (Ribeiro, Audio 18, 2015, p. 00:02'). The latter are usually actions that produce a medium to long-term result, not easily visible in the short-term, and compared to civil engineering works they may cost extremely less and generate unerring ecosystem contributions (for instance recuperation of forest leading to strengthen water recharge) (Ribeiro, Audio 2, 2015, p. 10:38; 12:52). Moreover, unexplored local water resources show as opportunities for supply expansion and creation of autonomy from the PCJ River Basins (Ribeiro, Audio 2, 2015, p. 08:30).

Above all, Jundiaí still holds a privileged position among PCJ municipalities, and keeps attracting new residents, ventures and constructions. In the beginning of 2015, the region went on the opposite of the current dismissal trend all over Brazil, and generated many jobs in the construction industry (G1, 2015). This has positive impacts for short-term employment creation and development, but it might be extremely harmful from the standpoint of sustainable development (Mendes, 2015). As long as the city's Construction Code do not acknowledge important directives for land use and planning, rooted in environmental criteria and natural resources preservation, this misplanned development may affect Jundiaí's capacity of water provision in the near future. According to Botan (2015, p. 18:20'), although recently precarized, Brazilian environmental protection laws are straightforward in prescribing compensation obligations and previous environmental diagnostic and planning for new incorporations. However, what is faulty is the ordinance of these laws, so a municipal instrument of law operationalization and enforcement is necessary, and it should be bound to the city's Construction Code.

In sum, the current situation of Jundiaí's water system puts the city in a watchful position, though still much more comfortable than its regional neighbors. As showed before, the amount of stored water supports distribution for two months; thus, in a situation of total lack of rain and total cutback of Atibaia's river flow, the PCJ cities would enter in a collapse of water access and Jundiaí would have more two months of uninterrupted water supply services to deal with this drastic event. Obviously, this conclusion do not mean that Jundiaí's water system does not have problems, or that the current positive status is ultimate. Rather, it might denote that water security can be fostered even in locations where the overall context is extreme, and through the performance of responsive and ahead water governance.

Next section recapitulates the key actions employed by water decision-makers and adjacent actors in Jundiaí, and clarifies the interactions within the action arena, which may support conclusions about governance pathways in water security outcomes.

5.2 Action Arenas

After a complete investigation on the actions that resulted in the current water availability in Jundiaí's system, this present analysis intends to separate the actors involved, the action situations they were engaged in, and highlight the key interactions within this arena. All action situations and actors were already mentioned in the last section, so here the analysis will focus more in the mechanisms involved in action conduction, and any relevant detail about these governance deployments.

Action Situation, Actors and Interactions

When analyzing the development of water management in Jundiaí, some actions stand out as the most contributive ones in terms of quality, quantity and sustainability enhancement. Before bringing these actions into light, it is relevant to mention that the period considered here was from 1975 until today, because when analyzed the status of water supply and the key build-up actions for it, the post 1975 actions were the main contributive ones. Secondly, the actions highlighted in this analysis follow the criteria of 'contributing to water security enhancement', thus only actions that were assumed to strengthen the water supply system were picked up. The reason for this chosen is based on the initial interest of tracing a process of water security build-up, hence the actions that did not contribute to this outcome directly, or even actions that hampered the outcome achievement were disregarded in this analysis, as to look exclusively to the process of developing a water security status. Accordingly, the individual actions selected are presented as follows:

Foremost, the first water bestowal from Atibaia's River depicts as a venture and innovative solution for the time it was proposed, as river transpositions were seen as risky and audacious projects, while for civil engineers these were the best solutions for augmenting local river flows. Thus, the construction of Jundiaí's water security status has started with the first river bestowal.

Secondly, the bestowal expansion involved negotiations between DAEE and DAE's officials and conditions for its approval. The conditionality imposed actions related to expanding water storage capacity by construing a new reservoir, modernizing network connections, and depolluting local water streams by improving sewage collection and treatment. These instructions are directly related to the

enhancement of water quantity and quality. Therefore, the bestowal itself and its conditionality were also identified as key action situations that have led to the outcome of water security, thus closing circles of feedback looping where previous actions affect sequential ones, and so on.

Thirdly, the environmental compensations conducted by DAE, combined with recent projects of diagnostic and restauration of water sources were interpreted as important actions for sustainability of water services, therefore they were included as the last action situation that contributed, and will contribute more in the future, with water security enhancement.

Summarizing, the criteria for action situations' selection followed the major interest of this project: to understand the actions of water governance that have led to water security in Jundiaí's case. Departing from the concept of water security, the governance actions picked up here were related to enhancement of quality, quantity or sustainability conditions within the supply system, or the environment affecting the system (e.g. water resources). The individual actions were aggregated in four action situations according to its contribution to the outcome. For each individual action, there is the indication of the year that the action has started, and the element of water security that the action is supposed to enhance. Note that although some are considered to enhance quantity only, or quality only, or sustainability only, they indeed enhance all three elements together, as sustainability is intimately related to quality and quantity of water for supply. Therefore, the indication of 'enhancement of what' considers the main contribution of the actions, but not as an exclusive contribution.

Finally, it is important to emphasize the relations between the individual actions and the four action situations proposed for analysis. The first Action Situation (AS) proposed (A) correspond to the water bestowals, and they share this character of increasing water in the system through transposition of river flows. The two bestowals generated the conditionality which correspond to the action situations B and C (the signal [*] indicates an interrelation with previous actions). AS – B includes two actions directly related to depollution and sewage services enhancement, and AS – C involves works related to reducing water loss and increase water storage capacity, thus contributing to an expansion of the supply system. The action situation D was also partially resultant from a previous action, in this case the construction of the new reservoir (belonging to the AS – C) that generated environmental

compensations that have started to be executed in AS D. Hence, at least two feedback looping were recognized in the analysis of the action situations, considering the time frame studied and the outcome of interest, the first related to the conditionalities, and the second related to the environmental compensations. Figure 10 sums up the four AS explored in this section:

Action Situation (AS)	Criteria	Enhancing water security through:
A – First and Second Atibaia's bestowals (1975 and 1994)	Adding water to the watershed system	Quantity
B – CERJU project and sewage services* concession (1983 and 1996)	River depollution and improve sanitation services	Quality
C – New reservoir and network maintenance* (1996 and 1995)	Water supply expansion and water losses reduction	Quantity
D – Restoration of riparian vegetation* and water sources mapping/recuperation (2004 and 2013)	Water resources diagnosis, recuperation and enhancement	Sustainability

Figure 10 – Summary of the four Action Situations explored in the IAD framework
Source: Own authoring

Figures 11, 12, 13 and 14 summarizes the IAD analysis, following the typology of rules presented in chapter 2. For each action situation, there was a mapping of the seven rules (positions, participants, action, action capacity/control, potential outcome, information and pay-off), and further an explanation of the interactions among actors. The positions identified were classified in three main groups: the decision-makers, that make up the solutions and decide upon actions, planning and resources allocation; the executors, which are either responsible for implementing the actions by practical work, or for enabling execution through financing; and the facilitators, which take part in the action by providing assistance, or executing obligatory procedures (e.g. license for construction).

Action Situation A – First and Second Atibaia's bestowals (1975 and 1994)			**Criteria:** Adding water to the watershed system		
Positions	Decision-makers		Executors	Facilitators	
Participants	DAE's board	DAEE	DAE's workers	PCJ Committee	Cetesb & DAEE
Action	Bring about the solution, request for bestowal, allocate funds and enable execution	Concede bestowal and come up with conditions*	Employ the construction work involved	Assist in bestowal analysis and granting, affecting approval	Approve the construction, analyze environmental impacts and define compensations and conditions for license grant
Action capacity & control	Definitive, regarding solution creation and budget allocation, but partial considering bestowal request	Definitive, but had to consider Committee's position in the second bestowal request	Partial, depending on resources' availability, worker's capacity and time-frame planned	Partial, issue an opinion towards bestowal request	Definitive, based on studies and evaluations
Potential Outcome	Viable solution that address future challenges or misplanned, unfeasible solution & Allocate enough funds or not	Bestowal approval or neglect	Accurate and effective work execution or poor work execution, it may relates to capacity, timing and resources available	Opinion on bestowal approval or neglect	Construction liberation or stoppage & License grant or neglect, based on conditions' fulfillment
Information	Solution seeking analysis, planning, budgeting and costs analysis	Technical reports and evaluations considering multiple use and resources' sustainability	Worker's experience and knowledge, and action planning	Technical reports, documents and analysis on uses balance and system health	Studies, EIA RIMA reports and monitoring of conditions
Costs X Benefits	Financial costs X Expanding water offer	Reduction of water from natural source X Expand water supply	Operational constraints X Work accomplishment	Impact in natural water source X Expand water supply	Constructions' negative impacts X Positive impacts

Figure 11 – AS – A: First and Second Atibaia's bestowals (1975 and 1994)
Source: Own authoring

The sequence of interactions start with DAE's decision-makers coming up with the idea of bestowal request, developing the project scope and then contact DAEE to propose it. At the time of the first bestowal, the PCJ Committee did not exist, so DAEE analyzed the request and made up a decision. The decision was an approval with some conditions for bestowal continuity and future expansion. In addition, there was a license assessment regarding the subsequent construction works that the project foresaw. After the work approval, DAE allocated necessary funds and resources, and indicated to its own workers to start up the construction workers. The conclusion of this first action was around 1977 and it allowed an addition of 700 mm/s in the water supply system. After the project finalization, CETESB issued an operation license and the bestowal was held until the request for expansion.

The analysis for the second bestowal's approval, requested in 1994, considered the status of conditions fulfillment and the PCJ Committee evaluation. DAE issued a new request to DAEE, which in turn requested the Committee's position, and also evaluated the status of previous conditionalities. At that time, some conditionality have started to be accomplished but were far from conclusion. The Jundiaí River's depollution project was in development, slowly, and it was missing the project of the sewer treatment station. Investments on network loss reduction has started but it did not have much planning or results evaluation, and the Accumulation reservoir construction project had a timid start, as by the plan definition and eviction of the area for inundation.

Thus, in August of 1994 the PCJ Committee started the technical analyses and deliberations to come up with a position. In the advisory document issued in December 1994 (Comitê PCJ, 1994), the Committee stated in favor of the bestowal approval, but it also stressed the following conditions and particularities:

- The bestowal expansion to 1.200 l/s should expire in the end of 1995;
- The bestowal continuation would be bound to DAE's pursuit of the planning and execution of (a) the new reservoir; (b) the sewage treatment station; (c) installation of new hydrometers; (d) installation of flowmeters in both the Atibaia side and the Jundiaí-Mirim side of the adduction pipeline; and (e) a program to incentive water consumption reduction.

Hence, the Committee's final position was positive for Jundiaí, and it reinforced the previous posited conditionality. In November 1995, DAE issued an official report addressing all conditions and

indicating a chronogram for actions, including the treatment station creation, awareness campaigns, and construction works on the new reservoir, and network maintenance. In sequence, the Committee approved the non-expiration permission for water adduction from Atibaia River, in March 1996, but it was bound to the commitments stated in DAE's report (Comitê PCJ, 1996). The DAEE followed the Committee's decision, conceding the bestowal, and it was supposed to surveil the actions development and interfere in the bestowal grant once conditions were not fulfilled. The construction of the second adduction pipeline was finalized in 1994 and since 1995 there is an increment of 500 l/s inflow in the Jundiaí's water supply system (DAE, 2002) (DAE, 2015).

Action Situation B – CERJU project and sewage services* concession (1983 and 1996)			**Criteria:** River depollution and improve sanitation services			
Positions	Decision-makers		Executors		Facilitators	
Participants	DAEE	DAE's board and workers	CSJ – concession winner	CAIXA	CIESP	License agent – CETESB
Action	Come up with conditions*	Plan, allocate funds and enable execution of conditions* / Employ the construction work involved	Employ the construction work involved and carry out sewage services	Provide loan	Project tracking and partial financing	Approve construction, analyze environmental impacts, define compensations and conditions for license grant, and later allocated resources for CERJU
Action capacity &	Partial, as it just has set conditions of previous work	Definitive, regarding budget allocation, but partial considering worker's capacity, resources and time	Definitive, based on agreement and contract conditions	Definitive, based on its own risk analysis	Definitive, based on industries' financing and resources for tracking	Definitive, based on own evaluations and assessments
Potential Outcome	Conditions meet and bestowal prosecution or not meet and bestowal refuse	Allocate enough funds and resources or not/ Accurate and effective work execution or poor work execution	Accurate or poor work execution, it may relates to the time and other contract agreements	Financing work construction or not	Financing work construction or not	Construction liberation or stoppage and License grant or neglect, based on conditions' fulfillment

Information	Monitoring and evaluate conditions' fulfillment	Planning, budgeting and costs analysis / Worker's experience and knowledge, and action planning	Customary preferences on contract clauses and agreements	Risk and profitability analyses	Instruments of tracking, reports and communication with executors	Studies, EIA RIMA reports and monitoring of conditions
Costs X Benefits	Reduction of water from natural source X Improvement of sanitation services and river recuperation	Financial costs X Sanitation services improvement and river recuperation / Operational constraints X Work accomplishment	Operational costs X Service contract	Loan cost X Interest rate and time frame	Financial costs X Decrease industries' environmental impact with waste disposal, no costs with own treatment station	Constructions' negative impacts X Positive impacts

Figure 12 – AS – B: CERJU project and sewage services* concession (1983 and 1996)
Source: Own authoring

The CERJU commission, settled in 1983, developed studies within the watershed, mapping and identifying the polluting agents, and come up with solutions. The commission involved six riparian municipalities, but this analysis considers just the Jundiaí's part of the project. After some years of planning, the works started through installing intercepting pipelines alongside the river, in order to move sewer to a future treatment station. After the first constructions, the project became famous and attracted attention from state organs, which decided to also allocate resources in the project through CETESB.

At that time, Jundiaí was responsible for 72% of the organic waste and 87% of the industrial disposal in the Jundiaí River, so it was reasonable that the city should host a treatment station. DAE and CETESB developed a pilot-station for studies regarding the best alternative for sewage treatment in that case. Between 1988 and 1990 biologists and specialists in sanitation developed analyzes with different treatment techniques, and later it was elected the 'Australian model' of sewage treatment, with the use of lakes and tanks, the best method to employ in Jundiaí. In parallel, DAE's workers were executing the collector pipelines works and developing the sewage network.

DAE was the main executor of the project's first phases, and received support by Jundiaí's main industries, represented by CIESP (Industry Association). The works included in the project were subject

to CETESB's assessment on impacts and construction conditions. However, until middle 90s CETESB did not issue environmental compensation requirements, so the first phases of this project were not targeted by these requirements, only the post-1995 works.

After the conclusion of the sewage networks and the pilot-station project, DAE opened a bidding for the construction of the treatment station and further sewage services provision. In 1996, the concession winner, CSJ, started the construction of the treatment station (after CETESB's approval). In 1998 the station was launched, and at that time Jundiaí had already a large amount of urban area connected with wastewater collectors and conductors. The funds involved in network development and river cleaning were partially provided by the municipalities, partially from industries through CIESP, and the third part was financed by CAIXA (a federal bank). The treatment station deployment was financed by CSJ. CETESB issued an EIA RIMA document of the station construction, but this was a CSJ matter. Therefore, from 1999 onwards, Jundiaí's wastewater started to be collected and treated, which later on resulted in a depollution accomplishment of the Jundiaí-Mirim watershed and the Jundiaí River (DAE, 2002) (CSJ, 2015) (DAE, 2015).

Action Situation C – New reservoir and network maintenance* (1996 and 1995)			**Criteria:** Water supply expansion and water losses reduction			
Position	Decision-makers		Executors			Facilitators
Participants	DAEE	DAE's board	DAE's workers	Camargo Correa	CAIXA	CETESB & DAEE
Action	Come up with conditions*	Plan, allocate funds and enable execution of conditions*	Employ the construction work involved	Employ the construction works and repairs involved	Provide loan	Approve the construction, analyze environmental impacts and define compensations and conditions for license grant
Action capacity & control	Partial, as it just has set conditions of previous work	Definitive, regarding action planning and budget allocation	Partial, depending on resources' availability, worker's capacity and time-frame planned	Definitive, based on agreement and contract conditions	Definitive, based on its own risk analysis	Definitive, based on studies and evaluations about construction works

Potential Outcome	Conditions meet and bestowal prosecution or not meet and bestowal refuse	Develop well planned actions, allocate enough funds and resources or develop misplanned, unfeasible actions, allocate not enough funds and resources	Accurate and effective work execution or poor work execution, it may relates to the time and other contract agreements	Accurate or poor work execution, it may relates to the time and other contract agreements	Financing work construction or not	Construction liberation or stoppage and License grant or neglect, based on conditions' fulfillment
Information	Monitoring and evaluate conditions' fulfillment	Planning, budgeting and costs analysis	Worker's experience and knowledge, and action planning	Customary preferences on contract clauses and agreements	Risk and profitability analyses	Studies, EIA RIMA reports and monitoring of conditions
Costs X Benefits	Reduction of water from natural source X Expand water supply by reducing loss and expanding storage capacity	Financial costs X Expanding water offer by reducing loss and expanding storage capacity	Operational constraints X Work accomplishment	Operational costs X Service contract	Loan cost X Interest rate and time frame	Constructions' negative impacts X Positive impacts

Figure 13 – AS – C: New reservoir and network maintenance* (1996 and 1995)
Source: Own authoring

As a conditionality, the construction of the new reservoir was conducted by DAE and its execution was outsourced. The outsourcing contract was supposed to be established through a bidding process with all interested service providers, and the criteria for selection was based in the lowest price offered. The bidding offer occurred in 1994, and the service contract was signed in the same year with Camargo Correa, one of the largest construction company in Brazil. The CAIXA bank was again the financing agent of this work. The project involved large-scale civil engineering works and caused several environmental impacts in the affected area. CETESB and DAEE worked together in the construction evaluation, and issued a long EIA RIMA document stating all required compensations for license grant. DAE was the actor supposed to pay all these compensations, but as mentioned before, the fulfillment

process is still ongoing and so far DAE holds a partial operation license for the new reservoir employment (Ribeiro, Audio 2, 2015, p. 20:04').

Although the first project was elaborated in 1983 together with the bestowal request, the construction itself started in 1996 under a suspicious service contract with Camargo Correa. A journalistic article from 1999 stated that the TCE (Tribunal de Contas da União - State Audit Court) investigated the contract between Camargo Correa and DAE, and the bidding offer, and interpreted several irregularities, including restriction to competition, advanced payment and overpayment for civil works, summing up a loss of US$ 500,000 for public funds. Even being judged illegal, the work was completed and the involved officials just had to pay a fine to the justice, and were absolved (Baryolomei, 1999). Still nowadays Camargo Correa has contracts with many public organs from all levels of administration, and even being accused and condemned many times, legitimate juridical resources and well grounded political alliances maintain this and others construction companies accumulating illegal service contracts throughout Brazil (JusBrasil, 2009) (Castro, Justi, Kaniak, & Dionísio, 2015).

The new reservoir was planned to be expanded in some phases, and reach the maximum capacity in 2005. The first expansion phase delayed and was concluded in 2010, and the following expansion was also not conducted as planned, being recently retaken by incumbents, with new construction contracts and new funding Due to lack of data, only the first construction was included in the analysis (indeed, the most important one). Hence, the first plan of offering 12 billion liters to the system by 2005 has delayed in at least 10 years. It is not possible to affirm whether the planning was mistaken and unrealistic time wise, or that the disruption in execution and lateness in construction works account more as causes in this case. The lack of precise information about this leads to an assumption that all these causes play a role, each one in an unknown extend. Anyway, the major lesson here is that planning execution is essential in order to reach settled goals, and to keep up with chronogram is important to ensure that goals will be achieved in the desirable manner.

Additionally, in the 90s, DAE established a new department to coordinate and monitor actions aimed to reduce network losses and improve pipelines and connections. The department is in charge of all maintenance tasks, including installation of new water connections, exchanging old pipes and old

hydrometers, expanding water treatment capacity and so on. Historically DAE's workers conducted maintenance and infrastructure development, without an official department being responsible for tracking and coordinating these actions. After the conditionality, DAE structured an area to be in charge of it, and thus having goals settled. Therefore, the indication of 1995 as the initial year for this action is merely due to the creation of the department, although maintenance works have been conducted since the beginning of sanitation services provision. The current loss rate is around 35%, which is still not a low loss rate, but it has diminished from a previous 47% in the past decade though. This action is therefore an ongoing activity in DAE's functionalities.

Action Situation D – Restoration of riparian vegetation and water sources mapping/recuperation (2004 and 2013)				**Criteria:** Water resources diagnosis, recuperation and enhancement	
Positions	Decision-makers	Executors		Facilitators	
Participants	CETESB	DAE – Municipality (Environment, Agriculture and Planning secr.)	DAE's workers	Service providers	Partners - ONGs PROEMPI	Land-owners
Action	Indicate environmental compensations as conditionality of previous works/license grating	Plan, allocate funds and enable execution of conditions*	Employ the work involved	Assist in plantation and reforestation	Provide resources, funds and/or assist in work execution,	Allow for action execution in their propriety
Action capacity & control	Partial, define conditions and indicate compensations	Definitive, regarding action planning and budget allocation	Definitive, but dependent on resources' availability, worker's capacity and time-frame planned	Partial, assistance in execution	Partial, assistance in execution	Definitive, giving permission to work in their propriety
Potential Outcome	Compensation fulfillment and license grant or not fulfillment and license neglect	Develop well planned actions, allocate enough funds and resources or develop misplanned, unfeasible actions, allocate not enough funds and resources	Accurate and effective work execution or poor work execution, it may relates to capacity	Provide with good or sub-optimal assistance	Provide with good or sub-optimal resources and assistance	Allow work or do not allow

Information	Monitoring and evaluate conditions' fulfillment	Planning, budgeting and costs analysis	Worker's experience and knowledge, and action planning	Customary preferences on contract clauses and agreements	Action planning and partnership agreements	Communication about project development and action execution
Costs X Benefits	Previous works' negative impacts X Repair and compensation	Financial and operational costs X Protecting water resources, saving future offer by reducing loss and expanding storage capacity	Operational constraints X Work accomplishment	Operational costs X Service contract	Assistance and resources employed X Recognition and payment of own compensations	Having people working in their propriety X Vegetation recuperation and enhancement of local ecosystem services

Figure 14 – AS – D: Restoration of riparian vegetation and water sources mapping/recuperation (2004 and 2013)
Source: Own authoring

The Accumulation reservoir construction induced an EIA RIMA with various compensation requirements, which indicated what DAE should address in order to be granted with definitive operation license. The payment actions started to be performed by DAE's workers, in partnership with Town Hall's secretaries. The Agriculture secretary has issued licenses for DAE to clean water tanks and water streams within private properties, as well as it has enrolled landowners in the rural APA records. The Planning secretary has accompanied the projects, and will further use the reports regarding the hydrologic diagnosis project in the city's urban planning. The Environment secretary had contributed with implementation and viabilization of reforestation projects and other restoration actions. The execution of these projects involved outsourcing planting services with service providers specialized in reforestation and plantation.

Before starting the planting itself, DAE needed to have a seedling nursery, which was also one of the environmental compensations. The nursery was installed in 2001 and in 2004 it was strong and full enough to not just pay DAE's compensations but also to donate for NGOs interested in reforestation. DAE also promoted actions of environmental education in parallel, as it was included in the compensations' report. Until 2009, about 50,000 seedlings and trees were planted, thus greatly reducing DAE's environmental liability. DAE's workers and the outsourced service provider conducted the planting execution, regarding the compensation payment. It is important to mention that allocation

of resources in the nursery was larger in the 2000s than it is nowadays, thus reaffirming decision-makers' power in strengthen or weaken action taking (Ribeiro, Audio 3, 2015, p. 03:20').

The document prescribed planting at least 37,000 trees, which were planted in two years of work. It was on that time that DAE's directors acknowledged the importance of biologists and environmentalists participating in projects. Since then, Martim took part in meetings and discussions about future projects, until the incumbents assumed the mandate and change this multi-disciplinary approach of governance (Ribeiro, Audio 18, 2015, p. 09:13"; 10:20").

The reforestation became a well-known action and attracted the attention of external actors, such as PROEMPI. PROEMPI is the association of companies and professionals from the real estate and construction sector. Due to their core business, these companies always have environmental compensations to fulfill, hence they were interested in become DAE's partner and contribute to the reforestation project in order to pay their own environmental liability. They have contributed with financial resources, as well as borrowing machinery and cleaning equipment to execute certain activities in rural proprieties.

The role of CETESB in this action situation relates to issuing the compensations and to intervene in case of difficulties in project's implementation (for instance, land-owner resistance). In this sense, the successful execution of these projects is related to the landowners' willingness in cooperation, as they are closer to the resources and can provide key information about the local ecosystem. Additionally, they can execute surveillance and monitoring concerning the development of ecological restauration, and communicate to DAE any issue or disruption. It is also essential that these proprietors acknowledge their role as enabling agents for this type of environmental recuperation work, and also play their part to preserve and enhance current employed actions. Their facilitator role can be fostered through allowances and subsidies, just as the case in Extrema at the Jaguari river basin and springheads, where landowners executing environmental services receive monthly grants from federal government to keep developing such practices. Likewise, in Jundiaí such instruments of cooperation can enhance green protection and approximate the small landowner to the municipality (Ribeiro, Audio 1, 2015, p. 01:37'). Indeed, what happens now is that these proprietors collaborate voluntarily, but some of them are allured by real estate and construction companies to sell their propriety for future

construction projects. Therefore, the allowances would be also important to oppose the action of speculators in acquiring rural land that is valuable for water resources and forest preservation (Ribeiro, Audio 18, 2015, p. 11:50').

In 2013 the water resources operational team has launched the project of mapping and diagnosing of Jundiaí's water resources. The project consisted of walking through Jundiaí's territory, talk to landowners, collect information about the land conditions, and water resources within the propriety (Ribeiro, Audio 1, 2015, p. 00:02'). This diagnostic indicates how many springheads are conserved, degraded or under risk of disappearance. This action is essential to enable DAE and the City Hall to have knowledge about Jundiaí's water resources, thus allowing for accurate planning and restoration of important sources of water that the supply system have not focused on so far. The facilitation of PROEMPI, the secretaries and landowners play a role here too. This action is ongoing and has been carried by the water resources operational team, which is formed by two long-time workers and two interns from FATEC College. Recently a partnership between DAE and FATEC was settled in order to provide with the internship programs and some projects related to environmental management (this is what these interns study at FATEC). These interns have developed the mapping and diagnosing actions, and are also proposing revisions within the city's Construction Code and other urban planning procedures.

In conclusion, the outcome of water security in Jundiaí was constructed with several action situations carried by actors from different levels, distinct functions and authorities. Figure 15 brings actors together and indicates key characteristics of them:

Actor	Characteristics of Composition	Level
CETESB	Political influence as it is subject to the state secretary of environment	State
DAEE	Political influence as it is subject to the state secretary of water resources	State
PCJ Committee	Civil society, but not ordinary. Composed by specialists, experts, professors and professionals	River Basin
City Hall secretaries	Political influence as elected point the secretaries' officials	Municipal
DAE - Board	Political influence as elected point the board	Municipal
CSJ	Private actor, service provider	Municipal
DAE - Workers	Depend on the department and on the person. It can be workers that hold prevarication and malfeasance features, or responsible and ethical workers.	Municipal
CAIXA	Private actor, financial provider	Municipal
Camargo Correa	Private actor, evidence of corruption	Municipal
CIESP	Association of private actors - industries	Municipal
PROEMPI	Association of private actors – real estate and construction sector	Municipal
NGOs	Civil society associated with a purpose	Municipal
Landowners	Civil society, ordinary citizens	Municipal

Figure 15 – Actors and its main characteristics
Source: Own authoring

When looking at actors involved in Jundiaí's water governance, few points highlights. First, the multi-actor governance is employed at three levels (State, River Basin and Municipal), according to the functions assigned to each actor. Six actors concentrate the main roles of decision-making and service execution, while four actors within these have a certain political bias, one has a private character and one holds participative features. The political bias is related to the fact that political incumbents, which were previously elected, indicate officials and heads within these actors. In this sense, political nuances can affect governance and influence decision-making and action conduction, as it was seen in the case of the projects that were paralyzed in DAE since incumbents assumed.

The participation of civil society, although still timid in terms of ordinary citizens, it has shown an important role as facilitator and strengthening agent for actions carried out. For instance, the role of NGOs in enhance reforestation activities shows how opening space for civil society can be advantageous for all actors involved and contribute with action implementation. On the same logic, the participation of private actors' associations had also an important character, and it was enabled due to the opening willingness within the governance approach executed by the actors.

In the other side, governance can be hampered by corruption and malfeasance as it was evident in the case with Camargo Correa's contract. The poor execution of ethical principles in daily work can be harmful for organizations' roles employment. In the case of the Camargo Correa, the corruption generated a hole in public funds, which might have affected DAE's resources allocation in the following years, although the action was executed even though some funds were deviated. In this same logic, prevarication of civil servants, especially at DAE, also affect negatively the functions that are DAE's responsibilities. However, there was not enough information available for this project to clarify the exact participants that are more inclined to hold prevarication features. Therefore, one can assume that these harmful attitudes affect governance negatively, but it is not possible to say in what extend.

Due to lack of information about participants' beliefs and values, this actors' analysis has focused on characteristics that influence the patterns of governance. Next section will clarify the main findings about interactions among actors and water governance in Jundiaí.

5.3 Conclusion

The analysis of the institutional framework of water management in Jundiaí provided with important findings about governance of water resources and services in the city. It also clarified the reasons why Jundiaí is said to enjoy water security, and why the macro context is assumed to be facing a water crisis. Here these findings and clarifications are summarized, and serve as a bridge to the final conclusion.

First, Jundiaí is acknowledge as having a water security status in comparison with other cities in the PCJ region due to the leeway of little more than two months of independent water supply. Here, independent means disregarding any river flow or rainfall adding water into the system. Therefore, while other cities depend on river flows to provide water, Jundiaí has the reservoirs system, which grants a certain security of water distribution for a determined period.

Even though, Jundiaí's reservoirs are recharged by PCJ rivers, so the city depends on these threatened river basins for system's continuity. In the case of a collapse, Jundiaí would be affected, although later than the other cities. When comparing Jundiaí and the surrounding cities, the main

differences are that the former has developed a reservoir system for water supply, holds universal sewage treatment, and has invested in reforestation actions. These three actions are the major responsible for providing Jundiaí with the water security condition, as they are related to enhancing quantity, quality and sustainability of water services. The idea here was not emphasize Jundiaí's security status, but to understand how this condition was developed, and it is held in the middle of a water crisis. The analysis of the action situations addressed the understanding of the status build-up and the exploration of the contexts, both in Jundiaí and in the PCJ region, allowed to grasp how the status is held within the crisis.

When one looks at the action arenas, some insights highlight. For instance, the interdependence of actors in the action carry, and the sequence of actions accomplished. Actors hold their essential role in the situation, and according to the action itself, they may participate more or less times in the carryout. Decision-makers are usually more involved as they decide upon actions and resources allocation, thus being a fundamental agent enabling execution. Some actions may affect future action situations, as was the case with the conditionality imposed by DAEE, the PCJ Committee and CETESB. The sequence of action execution follows the purpose of each action for the entire action situation, and it relates to actors' function. The interdependence of actors goes through multiple levels (state, river basin and municipal) and multiple organizations (at least six main entities, four political biased, one private and one participative).

Another important lesson relates to anticipation of challenges and action planning beforehand. It became clear how innovative and anticipated projects, such as the water bestowals, were fundamental for Jundiaí's water supply system development. Actions deployed over time are the explanations for the current water security status, not random actions but the ones related to enhancement of water quality, quantity and sustainability within the supply system. Thereby, time also plays a role in the construction of a security condition. In this same line, execution of planned actions is crucial for developing a water supply system successfully, thus not only the anticipated planning but also the assurance of plan execution were essential for Jundiaí's water security development.

Furthermore, the involvement of various actors, from industries to civil society organizations and individuals, and elected and well as indicated official bodies, illustrates how a multi-actor and

diverse set-up can emerge when participation is allowed. In this case the governance system 'enforce' multiple actors participation through splitting the functions and authorities, for instance involving two state-level and one river basin level entity to decide upon actions. However, the engagement of other actors like CIESP, NGOs and PROEMPI show how an open governance scheme can be considered inviting towards other interested actors. In addition, the involvement of landowners, which is fundamental for action taking within proprieties, has space to widen and evolve as it is now timid and subject to DAE's initiative. An open and inviting approach combined with an incentives program could foster participation of landowners from their own initiative.

Moreover, one can say that since middle 2000s a multi-disciplinary governance approach have flourished and contributed positively to the status build-up. This assumption backs in the fact that biologists have carried environmental compensations, and have been included in project discussions since then. The acknowledge of ecology and biology as essential facets of water management has been identified in this case study, and it depicts as an 'ecologization' of governance. It can be said that this 'ecologization' was triggered by CETESB through the EIA RIMA issuing, as this led to DAE start to look at environmental actions and compensations. Next chapter summarizes these and other findings and provide with answers to the research questions from the beginning of the paper.

6. Conclusion

This research project sought to investigate an empirical case of water security, in order to explain the achievement of this status and the governance pathways that have led to it. In pursuing it, the project applied the IAD framework in a water management multi-organizational setup, with the aim of operationalize institutionalism theories and assess the extent of analysis that this tool enabled to develop in this type of water institutional arrangement. This conclusion follows the path taken in the IAD application, thus starting with findings from the external variables' analysis, followed by inferences on Jundiaí's status and the actions that have contributed to this achievement.

After a deep dive into Jundiaí's natural landscapes, it was possible to realize how the richness of Japi's Ridge biosphere enhance the city's water resources. The large variety of natural resources and biodiversity, combined with topographic and geological aspects gives to the Ridge an important function of water producer, besides other ecosystem services. Thus, hosting part of the Japi's Ridge is an advantage in a sense that it offers opportunities to expand water supply by making use of still unexplored sub-basins nearby Japi. Obviously, such utilization must be conducted in a non-harmful basis, developing a sustainable usage system which preserves Japi's strengths and characteristics.

The analysis of the *jundiaense* community has offered important insights about demographics, behavior aspects and beliefs. It showed that education levels are not outstanding, although they have been evolving fast in the past decades and are higher than in the majority of Brazilian cities. As well as demographic indicators like HDI and IPRS, they place Jundiaí among the most developed municipalities, while holding lower criminality rates compared to other better-off urban centers. The level of civic association and engagement is also higher than the average, and it reflects in civic participation in City Councils and social initiatives of political surveillance and accountability. However, traits of clientelism and patronage are embedded in Brazilian society, and in Jundiaí is not very different. The high level of distrust towards public institutions is a consequence of a decayed and corrupted public exercise, where customary mores and vested interests take over good political will. It is common to see politicians possessing large portions of land, construction enterprises or agricultural crops, and being well articulated within party's allies. These highly influential individuals sometimes make bad use of their

power, by doing discretionary job-position indications, political maneuvers for its own benefit, or for a small group of allies, among other foul attitudes. Moreover, it is not difficult to observe prevarication and malfeasant among civil servants, neither it is hard to find low educated and cognitive disempowered persons in political and public organizations in Brazil. Therefore, there is limited confidence in public power and political exercise, fostered by lack of accountability and discretionary attitudes, and this fact influences governance and city's development.

The third step pursued in the IAD application was a study about the rules-in-use within water institutionalism, and it was evident how complex and dense the water regulatory and organizational framework is in Brazil. It encompass a large number of organs and agencies, from public and private law, at national, state, municipal and river basin levels, and with multiple and, sometimes shared, functions. The focus was in DAE and the key organizations that play a role in water management for supply services in Jundiaí. In this sense, it was clear that DAE's main functions involve protection and enhancement of Jundiaí's water resources, besides providing water and wastewater-related services. These services are inspected and monitored by ARES-PCJ, and quality and quantity measurements are carried by three organizations (DAE, ARES-PCJ and CETESB). In addition, the development of large-scale construction works has to be approved and licensed by CETESB and it is conditional to fulfillment of environmental compensations and determinations. All these rules affect water governance in Jundiaí in a way that they posit requirements and procedures that shape management and action execution. This was evident when the action arena analysis has started.

The arena under exploitation here was compounded by action situations that enhanced quality, quantity and sustainability features within Jundiaí water supply system, and the actors that participated in such actions. This analysis sought to primarily respond why Jundiaí is said to hold water security in a macro situation of water scarcity, and how this is possible. Additionally, the research was interested in governance pathways and management approaches present in this case that have led to the outcome.

The condition of water security in Jundiaí is mainly explained by the fact the city has four reservoirs compounding its water supply system, which contributes with a large amount of accumulation and serve as hydric support in events of drought. Other reason is the good quality

standard that the city's water resources hold, as they are part of the supply system as well. This explain why Jundiaí can rely partially upon local storage water for urban supply, and has a relative lower dependence of the PCJ river basins when compared to the region's municipalities. Even though the reservoir's recharge is primarily done by stressed and overexploited water resources within PCJ region, therefore the water security status is constantly challenged by long-standing periods of drought and continuous resources overuse. In this sense, incumbents should be aware that as long as the city's water supply system does not reach a larger extent of autonomy from PCJ streams, Jundiaí`s water security status will be threatened and the water supply continuity may become undermined.

It is relevant to stress that even having a robust system of water storage, Jundiaí came to have one of its weirs totally empty in the drought season of 2014, thus dealing with a problem within its system. The provision of water was not interrupted as the larger reservoirs could absorb the demand from the small weir that dried. This fact reinforce the importance of developing large weirs and reservoirs to accumulate water for supply, especially in regions with incidence of drought, and the equally important execution of planned actions.

When looked at the water management actions developed in the past years, it stood out the characteristics of sewage services offered in Jundiaí. Besides reaching 100% of the urban area, the sewer treatment process generates organic compost and disposal unpolluted water back to the city's streams. The universalized service is offered by a concessionary agent and is pointed as one of the best sewage treatment companies in Brazil. The concessionary also treats wastewater from some neighboring cities, and it is fundamental part of the depollution accomplishment recently achieved in Jundiaí's River. The improvement of water quality within this stream was possible with an overarching project aimed at reducing pollutant and sewer disposal in the Jundiaí's River and affluent. After 30 years of actions, and with the engagement of several municipalities, agencies and partners, the CERJU project was acknowledge as a national example of successful water resources recuperation project. The role of DAE in this accomplishment was essential, as it had the initiative of conceding sewerage operations to an independent concessionary, thus allowing for CSJ to be created and to employ the treatment station. Furthermore, the CERJU project was a DAEE's proposal as a conditionality of the Atibaia's bestowal to Jundiaí's water supply system. Hence, this was an action-situation created and

conducted in a multi-level governance fashion, where multiple actors were involved and took part of a long-term, visionary project of river depollution.

Visionary ideas, long-term planning and solutions proposed in advance of challenges, are characteristics that emerge when one investigates the construction of water security in Jundiaí. Solutions such as river transposition and water accumulation were somewhat innovative in the 70s, even more for being advancing a future increase in water demand, according to the population growth at that time. Moreover, at that time, these large-scale engineering works were seen as audacious and visionary projects, which might be costly and time-consuming, but in the same time they were seen as the best solutions to deal with water supply challenges, thus depicting the embedded paradigm of hard engineer for water solutions that has protrude historically. Altogether, the 'hard engineer' paradigm is still strong, but it has opened space for 'green actions' such as reforestation, in an attempt of combine 'soft actions' with 'hard works' in the enhancement of supply system.

Another important factor enabling the status construction relates to political conditions. The political continuity that the city's Town Hall has enjoyed until 2012 allowed the prosecution of the projects planned. The DAE's board of decision-makers suffered small changes during the 20 years of PSDB consecutive mandates, and the experienced water managers and directors kept in high influential positions, thus performing planning and resources allocation in a way that enabled conclusion of key projects of water supply expansion. The conclusion of the Accumulation reservoir and the correction in water networks were successfully carried out by three or four administrations committed to fulfill previous projected actions. Nevertheless, the last phases of the reservoir's project and other reservoirs planned were not continuously carried out by the administration that assumed in 2013. The opposition party took over and some changes in the DAE's decision-makers boards, which in the end affected strategic actions that were strongly delayed, rather than concluded. Hence, political stability had an important role in the case of Jundiaí's positive water supply achievements.

In the other hand, political continuity can be harmful when it is linked to private interests or political conveniences. In the case of real estate speculation, repetitive mandates of the same mayor is supposed to be related with expansion of civil construction and residences' building, thus the harm relates to conservation of natural and water resources in spend of urban and household development.

Although some people argue that urban development and household construction are essential for the city's development, their missing point is that most of these incorporations are build-up without an intelligent and synergic urban plan, thus depriving vital resources and ecosystem services that are far more essentials than new residences or urban roads.

In this same vein, malfeasance, corruption and prevarication can be detrimental for organizations and their functional exercise. In daily work, ethical principles and morality are precious characteristics that contribute positively to the proper exercise of organizations' functions. However, sometimes due to private interests, some others to lack of motivation, or political interests, or any other personal reason, civil servants and officials surrenders their moral in exchange of personal benefits. The case of the contract with Camargo Correa illustrated a frequent situation in Brazilian institutions, where the space to obtain illicit money (and the easiness to do so) tempts officials to establish irregular contracts with embezzlement. The execution of the contracted service was concluded, although delayed and committing a larger amount of public funds than it was supposed to use. It was also evident that the Judiciary tries to hold these officials account for their attitudes and to enforce the law, however moroseness and juridical instruments, such as recourse or privileged punishment disrupt the exercise of justice.

The situation of continuing deforestation, lack of riparian vegetation and silting in Jundiaí's natural landscapes is a worrying issue for all citizens and professionals that acknowledge ecosystems interactions. The large scale constructions made in the past, like the Atibaia's adduction pipeline and the Accumulation reservoir, had big environmental impact, thus being target of compensation requirements. The fulfillment of such requirements has been pursued by the DAE's Water Resources department since the admission of its first environmental biologist, in 2004. This move can be interpreted as an 'ecological turn' in DAE's governance, according to Disco's analysis on a similar case in the Dutch Water Management. He observed a trend of multidisciplinary project development where biologists and ecologists were gradually starting to take part in hard-engineering works, in the Dutch case (Disco, 2002). Similarly, the admission of Martim, his work with the environmental compensations and further development of the restauration projects depict as a start of ecological thinking within water management in Jundiaí. Moreover, the recent partnership with FATEC has brought more

environmental professionals to DAE and their studies have stressed the importance of improving Jundiaí's Construction Code with norms about ecosystem preservation and intelligent urban development. Thus, it is expected that this 'ecologization' of projects and organizations do not remains within DAE, but spread out in other jurisdictions in Jundiaí and, fundamentally, in geographies strongly affected by the water crisis.

The research's relevance

The original idea of this research project was to make a comparison of Jundiaí and MASP, in order to understand the processes that have led to water security in the former case and insecurity in the latter. However, due to time constraints, it seemed more reasonable to analyze a successful case and distill lessons from it rather to make a comparison of two different scale cases. The latter option would require much more effort in data collection and analysis then the single case option. Hence, this project sought to elucidate lessons from Jundiaí's achievements so to serve as reference for other cases to trace similar governance pathways.

In regards to the lessons about Jundiaí's governance pathways, in sum, they made clear that forwardness is important when dealing with water challenges, and execution of planned actions is even more important, especially when these plans are grounded in realistic and well-elaborated forecasts. They also demonstrated how well conducted concessions and partnerships can bring about successful and highly desired achievements such as services universalization and water resources depollution. The importance of involving multiple actors in overarching projects was evident in the analysis of action situations employed in Jundiaí.

The participative character within the governance approach was also remarkable and it was possible by the engagement of different actors, especially the ones composed by civil society members. By practicing an opening and welcoming governance, prone to aggregate all agents that show interest in action contribution, Jundiaí's water management has benefited from partnerships and collective work that enhanced the actions employed by decision-makers. The interdependence of actors is also a feature within this multi-level, multi-organizational framework of water management. The execution of action situations depend on execution of individual actions by each agent. These agents have their

roles and functions within the ruling system, which determines the sequence of actions and the interdependence character. In short, these evidences relates to the concept of polycentric governance that was mentioned in chapter 2 as a probable

Furthermore, the analysis enlightened that enhancing water services production is not the same as enhancing water services provision, in a sense that provision may include network expansion, reservoirs increase, and so on, whereas production involves springheads strengthening, forest restoration and protection of recharging and percolation areas. And having this in mind, it is not the case that hard-engineer solutions are solely the best options in both provision and production enhancement. Rather, the ecological mind-set should fit well and improve any project related to land use and occupation, especially when it involves areas of impact in natural and water resources. Therefore, one important lesson is about merging ecological and environmental reasoning with hard project development, especially in water resources management. In other words, a multi-disciplinary governance is important when dealing with natural resources.

The 'ecologization' lesson can also be inferred by looking at the CERJU project and the universalization of sewage services. To invest in sanitation services and water streams restoration is to invest in water quality, quantity and sustainability, so water authorities should strive to provide sanitation services, especially sewer collection and treatment primarily than any large scale, highly impacting construction work. If sewer do not come to stop being discharged into water streams, none other larger project will provide water security, just solve short-sight issues of exclusively water quantity matters. Although environmental actions usually takes longer to show results, they are long-term realistic solutions, which backs in scientific knowledge and practical experience to explain the relation between water resources enhancement and vegetation conservation/restoration. Moreover, they normally cost less than large scale, hard engineering projects, and obviously are employed without causing environmental impacts. Again, water security is about offering enough quantities of proper quality water, based in a sustainable production and provision system, hence solutions for water crisis should involves these three dimensions in order to *de facto* address the problems.

The application of the IAD framework was very fruitful and contributed tightly to the development of this research. The framework's contents addressed well the research scope and

empirical case, as it enabled a good flow through a research pathway that responded the project's questions defined in the introduction. Thus, the IAD framework is granted with a brand new example of application, focused on water management institutionalism in multi-organizational settings of water governance for urban supply systems. The tool showed as an appropriate instrument to conduct causal process investigations and to explain water management outcomes. In addition, the methodology used here sat right with the theoretical framework, as process tracing and the CPOs identified were fundamental for compounding the IAD scheme and providing with structured knowledge about the case.

Limitations and future avenues for research

Brazilian institutions are known as extremely dense, complex and bureaucratic rules, which are deployed also in a not simple organizational setting without clear-cut functionalism. These characteristics, combined with political nuances embedded in all public organs posit big challenges for researchers interested in understanding governance in Brazil. The limitations found in this research were mainly due to information gathering and unwillingness of some individuals to participate in interviews and contribute with data collection. Some key information about action situations are only available in participants' memory, not registered in project's report or meetings' minute. Details about large and expensive projects were not completely available, neither details about actors interactions, hence these missing elements have affected the analysis to a certain extent, although some insightful findings were still possible to be distilled.

In the same way, some documents and web sources give information that do no match, especially regarding timing and numbers of water capacity and flows. Dealing with mismatching data required a certain sagacity and sapience to set all information collected and riddle which information seems more accurate and which appears to be wrong. In addition, information about the community attributes was also limited as not so many analysis about Jundiaí is available, although empirical data, indicators and generalizations provided enough resources to infer about the *jundiaense* community.

Future researches could improve understanding about the MASP case, and trace a comparison with Jundiaí, or other municipality that did not suffer from water cutbacks. Focus can be given to the pathway that MASP's governance have been tracing in the past years, that explains the insecurity in

this case. In addition, in the near future it would be interesting to develop research in Jundiaí's case again and investigate how the city managed to deal with real estate speculation and urban planning, whether they could revise the Construction Code or not, and whether the water resources have enhanced protection or not.

The project on springhead diagnosis and restauration have gained attention from regional water authorities and other actors, and it is also attracting media attention. As through the partnerships with association and NGOs, restoration projects may serve as an instrument for other agents to invest resources and reduce their harmful environmental footprint. Future prospects are positive for Jundiaí's vegetation recover, although they might depend on project continuity and prioritization from next administration's decision-makers in order to be accomplished. Furthermore, the FATEC partnership promises to highlight the importance and urgency of the revision of Jundiaí's Construction Code, in terms of indications on urban planning, drainage, vegetation maintenance, among others. In parallel, the ways for future water availability rely on autonomy from regional rivers, use of local 'ready' weirs, local water resources that are not used so far, and innovative solutions including rainwater collection and use. The paradigm of 'hard engineer' has to keep opening space for ecology and environmental solutions, in order to deal with challenges in a new, less costly and autonomous way.

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