

WATER GOVERNANCE IN VALE DO PARAÍBA PAULISTA: NETWORK OF ACTORS AND SOCIOECOLOGICAL SYSTEMS

ALEXANDRE R. MARQUES¹
MARIA ANGÉLICA TONIOLO²
MYANNA LAHSEN³
SERGIO PULICE⁴
EVANDRO ALBIACH BRANCO⁵
DIÓGENES SALAS ALVES⁶

1 Introduction

The increase in consumption, low rainfall, increase in temperature and decrease in soil moisture characterize a critical scenario for water in the region of the Macrometrópole Paulista (MMP). Studies of drought periods in the region identify an increase in the duration of droughts in the last decade (MARENGO, 2015; NOBRE et al, 2016).

According to the Master Plan for the Use of Water Resources for the MMP, the urban, industrial and irrigated agriculture demand should increase, by 2035, to about 60 m³ /s, which represents a 27% increase from the current demand. This increase tends to accentuate conflicts and disputes over water use among users of the Paraíba do Sul river basin (SÃO PAULO, 2013). The scenarios of crisis and uncertainties have justified, on the part of the state government, the expansion of hydraulic infrastructure networks, generating potentially conflicting consequences (IORIS, 2008; PIRES DO RIO, 2016, 2017).

Thus, to adapt to these changes and avoid future water crises, the government of the state of São Paulo has expanded the network of hydraulic infrastructures with the interconnection of the Jaguarí-Atibainha reservoirs (SÃO PAULO, 2013).

The increased connections between these water supply infrastructures reconfigure not only the relationship between water supply and territory, but also the control of access to water and the actors involved. The greater the interconnection between these

1. Earth System Science Doctoral Student, INPE. São José dos Campos/SP. Brasil. alexandre.marques@inpe.br, <https://orcid.org/0000-0003-4918-4616>.

2. PhD, UNIVAP. São José dos Campos/SP. Brasil. angelica.toniolo@univap.br, <https://orcid.org/0000-0001-7835-3285>.

3. PhD, Universidade de Wageningen, INPE. São José dos Campos/SP. Brasil. myannal@gmail.com, <https://orcid.org/0000-0001-5225-2048>.

4. Earth System Science Doctoral Student, INPE. São José dos Campos/SP. Brasil. sergio.ppulice@gmail.com, <https://orcid.org/0000-0002-4885-5652>.

5. PhD, INPE. São José dos Campos/SP. Brasil. evandro.albiach@inpe.br, <https://orcid.org/0000-0002-1132-8250>.

6. PhD, INPE. São José dos Campos/SP. Brasil. dalves@dpi.inpe.br, <https://orcid.org/0000-0003-0559-0671>.

infrastructure networks, the greater the need for articulation and synchronization between space units at different scales, units that were not previously interconnected. It requires the construction of an institutional arrangements that can regulate them, and networks of actors to build them and support sustainable territorial water governance (PIRES DO RIO, 2016, 2017; OSTROM, 2009; IORIS, 2008).

Vale do Paraíba specifically, in this context, requires a new level of multi-scalar articulation, and inclusive and participatory governance involving civil society in the necessary socio-ecological adaptation choices and the way of its execution. The challenge of ensuring a fair, adequate supply of water resources that also preserves ecosystem services is greater as social, economic and political structures in Brazil perpetuate inequality and short-term decisions. Participatory methods with a focus on adaptive governance are the most effective means of reducing these inequalities and ensuring a more equitable and sustainable water use and provision (FORMIGA-JOHNSSON; KUMLER; LEMOS, 2007; 2008; ENGLE et al., 2011).

Through interviews, observations and analysis of social networks with participants from the Technical Chamber of Forest Restoration and Water Resources (CT-RFRH) of the Paraíba do Sul River Basin Committee (CBH-PS), this article explores the configuration and dynamics of the actors involved in the governance of water resources in Vale do Paraíba Paulista. CT-RFRH is the central space for carrying out technical discussions, subsidizing the construction and approval of projects aimed at forest restoration and conservation strategies of water resources, as well as the decisions to be taken by CBH-PS. Therefore, this Technical Chamber is of great relevance to implement actions of socioecological adaptation.

The theoretical-methodological propositions, Socioecological Systems (SESs) and Social Network Analysis (SNA), will have as data collection techniques the interviews and participant observation applied to the actors involved with the activities of CT-RFRH. These propositions are addressed to analyze and answer two central questions:

What is the perception of the actors regarding the performance of the public power in relation to the challenges of water resources management after the 2013-2015 water crisis?

What kind of interactions between CT-RFRH network actors would be necessary to promote greater participation by society in the insertion of adaptive socio-ecological actions on the governance agenda?

In this sense, the objective of the research was to analyze, from the perspective of the actors, the participation of society for the insertion of such actions in the governance and decision making agenda. In this way, indicate possible paths within the networks of actors that can be more inclusive, participatory and cooperative for adaptive governance strategies.

2 Theoretical Methodological Discussion

2.1 Socioecological System (SES)

The concept of SSE analyzes the management of natural resources through the connection of ecological systems with socio-cultural phenomena that influence the interactions of actors in the management of resources and create feedbacks at various spatial scales (OSTROM, 1990). The ability to transform an SSE into a more desirable state leading to adaptive governance of natural resources (BERKES; FOLKE, 1998; PAHL-WOSTL, 2007).

For the purposes of this study, we seek to understand water governance as a political-institutional and socio-ecological process, understanding how civil society, state and markets are organized in their networks for the governance of natural resources. Adaptation is linked to the institutional innovation process capable of providing an institutional arrangement with sufficient flexibility for adaptive management of natural resources and thereby increasing its resilience to future crises and to the scenarios of changes and uncertainties (ROCKSTRÖM et al, 2014; PAHL-WOSTL et al, 2007; LEMOS; AGRAWAL, 2006).

It is noteworthy, however, that the concept can encompass other dimensions and strategies, according to Zwarteveen et al. (2017) and Armitage (2007) who claim the need to analyze voices, speeches and participation in the adaptive governance process. These authors focus on the analysis of the theoretical and discursive construction of governance related to the exercise of power, when inquiring about whom speaks about adaptation, who should adapt and at what cost.

Adaptation with a focus on SSE resilience seeks social transformation and emancipation from directly affected communities, redirecting governance to restore, maintain and develop the capacity of ecosystems to generate essential services through nature-based actions (RAZA RIZVI et al., 2011).

Research suggests that social participation and the dissemination of technical and scientific knowledge are indispensable requirements to promote adaptive governance (JACOBI, 2005; LEMOS, 2006). For that, sharing knowledge, learning from past experiences, promoting institutional flexibility and adaptability through experimentation and social learning are necessary conditions for the adaptive governance process (PAHL-WOSTL et al, 2007).

Following the thinking of Sabatier and Jenkins-Smith (1993, p. 191), an important political change will not occur in the absence of “significant disturbances external to the subsystem”, and natural disasters can be understood as “critical moments” that have the potential to change the historical trajectories of governance. These moments can mobilize civil society and the State in the development of new institutions that are more flexible and adaptable to scenarios of crisis and future uncertainties (OSTROM, 1990).

2.2 Navigating Socioecological Change

The windows of opportunity for the socio-ecological transition tend to occur due to shocks in the biophysical or socio-political system in relation to its resilience. These disturbances can cause changes in the functions and structures of socio-ecological systems, which depend on their ability to absorb, cushion or organize themselves (BUSCH-

BACHER, 2014). In view of the limited capacity of a system's resilience, governance is necessary that is able to identify and provide moments for socioecological transition aiming at a future scenario of greater resilience (ROCKSTRÖM, 2014; PAHL-WOSTL, 2007; LEMOS; AGRAWAL, 2006).

During the first phase of the transition, the main effort of the governance process is to create the objective conditions for navigating it. The related actions are the structuring of an institutional framework capable of providing support and that is flexible enough to allow the actors and resource management to adapt to crisis scenarios (ROCKSTRÖM, 2014; PAHL-WOSTL, 2007). These actors will have to work on social networks at different scales of the socio-ecological system in order to build a multi-actor institutional platform, which establishes an interface and is able to dialogue with public policies (Policy) at various levels (NOVAES, 2004).

Social networks understand the relational character of the organization of social life (CALMON; TRINDADE; COSTA, 2013). Social networks are presented as structures capable of integrating actors through interdependent relationships and diverse interests (NOVAES, 2004; FISCHER, 2011), sharing the same codes and information that reflect specific types of institutional and political arrangements, configuring themselves in normative and cultural structures, which impact on the behavior of the actors (NOVAES, 2004; BODIN; CRONA; ERNSTSON, 2006).

This makes them important structures in the construction of social capital and collective action for the transition from more resilient socioecological scenarios (CARLSSON; SANDSTRÖM, 2008).

To navigate the socioecological transition, brokers play a key role in building bridges between formal and informal organizations and institutional structures. Brokers can increase actors' trust and engagement by connecting them at different decision levels. These actions can promote emerging properties at different scales and thus collaborate with the institutional innovation necessary to support adaptive governance that promotes greater resilience of the water system (ROCKSTRÖM, 2014; PAHL-WOSTL, 2007).

Within the SSE concept, governance is understood as the process of defining norms and rules so that water management can act in order to prepare for the windows of opportunity for the socioecological transition, seeking scenarios of greater resilience. The norms and rules are understood as institutions (NORTH, 1990) capable of intermediating the interactions of the actors in a multilevel platform (PAHL-WOSTL, 2007).

The theoretical framework of the SSE presents a critical analysis of the ability to predict and control water resources. For Rockström (2014) the actions related to these types of strategies have become conventionally called hard strategies (Hard Strategies) to control the quality and availability of water resources. Hard Strategies are related to the management of what is also conventionally called Blue Water (ROCKSTRÖM; 2014). Blue water, which is related to the economic function of water and social development, is surface water available for collection in rivers, lakes and dams, and requires greater hydraulic infrastructure for its management (PAHL-WOSTL, 2007). Blue Water management often ignores its links and implications with the ecosystem and its services (ROCKSTRÖM; 2014; BERKES; FOLKE, 1998).

In contrast, for Rockström (2014), the Green Water concept is focused on the hydrological cycle and on the ecosystem water service, this type of management does not require large infrastructures, covering a type of intervention strategy that was conventionally called Soft Strategies, for not causing major impacts on the local landscape (ROCKSTRÖM; 2014). This concept departs from the effort of prediction and control to seek greater resilience of the ecosystem and ensure greater capacity for adaptation in the face of future crises (BERKES; FOLKE, 1998), it focuses on building governance structures capable of integrating transformation and landscape management with ecosystem services (PAHL-WOSTL, 2007).

The SSE concept proposes advances beyond a technocratic concept - Hard Strategies - of water governance (ROCKSTRÖM, 2014; PAHL-WOSTL, 2007). After perceiving the State's lack of capacity, through its top-down actions, to provide satisfactory solutions in the face of the environmental crisis and to include the actors affected by the process, the idea of water resource governance as a social and ecological function arises, able to lead society from a "collectively unwanted situation to a socially desired reality" (LEMOS; AGRAWAL, 2006).

2.3 Social Network Analysis (SNA)

Network analysis presents itself as an important technique for SSE studies. Social networks can play a fundamental role in the flow of information, distribution of material, political and financial resources. They support communicative interactions that lead to coalitions that can have a profound influence on understanding political problems. The communicative interaction in these coalitions can support long-term collective action and create a common vision (DI GREGÓRIO, 2012). Social networks are spaces of governance in which actors argue, explain, justify themselves and try to influence each other (HAJER; VERSTEEG, 2005).

Most research on social roles and adaptive governance does not have a structural perspective of analysis (CARLSSON; SANDSTRÖM, 2008). The analysis of social networks through SNA allows to spatially describe the relationship of actors in the network creating graphs as discrete mathematical structures (BODIN, 2006; BARABÁSI, 2003). The SNA methodology has the capacity to transform qualitative data, referring to the actors' perceptions, into measurable, quantitative and discrete⁷ results (DI GREGÓRIO, 2014; BARABÁSI, 2003). Through the calculation of the metrics to be analyzed, it creates a topological relationship between the actors in focus, endowing the analysis of governance from a mathematically structural and spatial perspective (SCOTT, 2000).

3 Methodology

The data were produced through semi-structured interviews and observations participating in the meetings of the Technical Chamber of Forest Restoration and Water Resources - (CT-RFRH) of the Paraíba do Sul River Basin Committee - CBH-PS. The

7. Graphs: structures formed by points and lines, are presented as discrete mathematical variables, since the set of possible results is identifiable, enumerable and finite (BARABÁSI, 2003).

Socioecological Systems (SSE) and Social Network Analysis (SNA) methodological frameworks were used to structure the analysis and interpret the results.

The SSE presupposes the concept of an arena of action that was formulated by Ostrom (1990; 2009) and describes the social space where individuals or groups of individuals interact and the results of these interactions are produced. The interaction of the actors within the action arena takes place through an “action situation”. In the case of this research, the action arena is the CT-RFRH, and the action situation is how the insertion of adaptive socio-ecological actions takes place in the governance and decision-making agenda.

The SNA method seeks to capture the articulation of the actors at the moment of its application. Even with participant observation and monitoring of monthly meetings of the CT-RFRH, the application of the method reflects the perception of the situation and the articulation of the actors at a given moment. This articulation of the actors and their perception can change according to the conjuncture and the action situation to be analyzed. The method reflects a specific result of the investigated relationships in a specific part of the management system.

Interviews and Data Collection

To answer the first question of this research about the perception of the actors about the public power in the face of the challenges imposed by the 2013-2015 water crisis, this research used semi-structured interview methods.

The perception is expressed as the experience, the empirical action of individuals on a certain physical issue (sensations) regarding the environment and feelings; or cognitive about more elaborate questions that lead to the analysis of some cultural, social or political phenomenon. The perception analysis focuses on knowing the experience of the other, through their reports, or analysis of material and secondary sources (HOEFFEL, 2006).

Listening, participant observation and semi-structured interviews are important instruments to capture the actors' perception, especially cognitive perception, as this type of perception involves, in addition to memory, mental processes, association, syllogisms, inference about the material and also symbolic world, knowledge building processes, all mediated by the cultural and social environment. Therefore, methods of immersion in culture or in the social environment become strategic for this type of research (HOEFFEL, 2006). In the case of this research, it is interesting to analyze the experience and the perception of the actors regarding social relations regarding water governance in their Action Arena (CT-RFRH) after the 2013-2015 water crisis.

To this end, the main institutional actors related to the use and governance of water, all representatives of their institutions in the CT-RFRH, were mapped. Altogether, 20 actors were considered, among them representatives of the government, civil society and third sector organizations (NGOs). Participant observation methods, questionnaires and semi-structured interviews were carried out.

This research was characterized by the interaction between the researcher and the actors of the investigated situation, since the researcher participated as an observer in the regular meetings of CBH-PS and CT-RFRH. Seven ordinary CBH-PS meetings were

monitored, from August 2018 to March 2019, and six meetings at CT-RFRH during the same period. The method of interaction with the actors through participant observation was fundamental to capture their perceptions, the subjective way of understanding the action situation, in addition to the objective and quantitative data.

The researcher accompanied the group of actors during this period not only in their ordinary meetings, but also in actions and other meetings. Most of these meetings took place in different cities in the hydrographic basin in an itinerant way, discussing local conservation strategies, a forest production pole and building a network of actors for forest restoration.

The interview explored the perception of social actors about social participation and control, social learning, the dissemination of information and adaptation strategies, aiming to identify forms of adaptive governance of water resources in the face of environmental changes.

Before the application of the questionnaires, a presentation of the project “Water Resources in the Paraíba do Sul River Basin: integrating natural and man-made aspects” was made, when the project’s objective, justifications, possible contributions to adaptive governance and explanation were addressed on the Free and Informed Consent Term - TCLE.

Interviewing as data collection on a given scientific topic in the social sciences is one of the techniques used in fieldwork. Through it, researchers seek to obtain information, collect objective and subjective data (MINAYO, 2001). This study focuses on these two types of information, objective and subjective, capturing the actors’ perception regarding water governance. Semi-structured interviews combine open and closed questions, where the informant had the opportunity to discuss the theme 2013-2015 water crisis, governance and adaptation.

There were objective questions in which the interviewee could choose the alternative that best suited him, and open questions in which the interviewee could himself indicate actors who would be relevant about issues related to the water crisis and adaptive water governance. In addition to indicating names, each actor had the opportunity to discuss his perception of water governance in the hydrographic basin, raising historical, political and social facts and physical events (floods and droughts) that occurred in recent years.

3.2 Application of the SNA technique

To answer the second question of this research, which seeks to analyze social networks within the CT-RFRH and the interactions between actors capable of promoting greater participation of civil society in social and ecological adaptation actions, the Social Network Analysis (SNA) technique was used (WASSERMAN; FAUST, 1997).

Initially, a diagnosis was made to identify and locate the most important actors within the social network. In addition, a simulation was carried out to describe potential new critical paths for greater participation by civil society, focusing on the ability to build bridges between other actors, improve the exchange of information and build common positions for adaptive governance.

In order to identify the most important actors in the network, the In-Degree metric was used through the number of connections indicated for the node (actor). By this metric it was possible to identify the degree of citation of this actor within the network and to infer about his possible leadership among other actors. Therefore, it is attributed the interpretation that this metric describes the relationship of recognition of influence of a given actor by other actors in the network (WASSERMAN; FAUST, 1997).

To identify the actors that most collaborate within the network, the Out-Degree metric was used, which describes the number of connections directed to another node (actor). Through this metric, it is possible to know which are the actors that give more information within the network, and it is possible to interpret the relationship of information flow between the actors from their respective statements.

Finally, it was also verified which actors can be considered central to the flow of information based on their degree of connectivity, interpreted in this work from the metric betweenness. In this metric it is possible to verify which actors concentrate the shortest paths in the network, and can be interpreted as intermediaries or controllers of information.

Table 1 - Relationships between metrics and their interpretations for social network analysis.

Questioning conducted	Metric	Metric Explanation	Interpretation from the data
(A) What are the most important actors (influence)?	In-Degree	Number of connections directed to the node (input)	Relationship of influence recognition
(B) What sources or actors help you make decisions?			Relationship of recognition on information flow
(C) Who do you collaborate with most by providing information?	Out-Degree	Number of connections directed to another node (outbound)	Flow relation (declared supply) of information
(D) Which intermediaries are most relevant with the potential for information leaking into the network?	betweenness	Degree representing the number of shortest paths that pass through the node in relation to the paths of the network as a whole	Identify the actors that are in the critical paths of the network and control the flow of information and resources

In Chart 1 the questions asked to the interviewees are summarized. Being: (A) which actors do you think are the most important in the network? (B) Who do you consider to be the actors and sources of information that help you make decisions about water resources management and environmental changes, helping to build agendas, discussion forums, public policies and mobilization regarding water resource governance? (Name at least five actors and / or organizations). (C) with whom do you collaborate the most, providing information and knowledge to help build agendas, discussion forums, structural actions, public policies, mobilizations in the area of water resources and environmental

changes? (Name at least five actors and / or organizations). These questions were designed to cover actions in addition to providing information.

To explore the information flow relationships, the networks derived from the questions (B) and (C) present the actors who are recognized as the most important information providers and, subsequently, the actors declared to provide information. These are questions that address the same theme from

complementary perspectives, namely, that of the network towards the actor and that of the actor towards the network.

Having identified the most relevant actors for questions (B) and (C), they were ranked according to their respective metrics. The ranks were compared in order to verify if the most recognized are also the most active in the information flow theme. The ranking cut was given only for the first quartile of the data.

Finally, as a complementary investigation, a verification was made of which actors are potential intermediaries who can increase the flow of information on the network. To identify such actors, the betweenness was calculated from the same network used in question (C).

4 Results and Discussions

4.1 Analysis of the perception of the actors on the relationship with the public power from the water crisis.

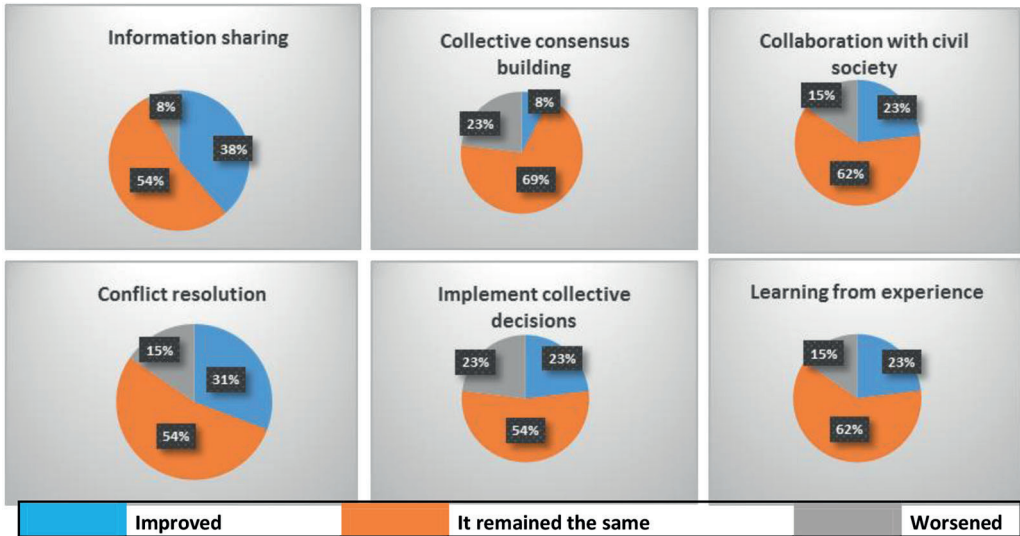
Initially, the actors' perception of the concepts that form the basis of social learning and adaptive governance is presented. The results represent how the actors see the concept of adaptation and, above all, how the government reacted after the 2013-2015 crisis in terms of social learning.

To capture this information, the interviewees were asked the following question: After the 2013-2015 water crisis, and the interconnection of the Jaguarí-Atibainha reservoirs, what could you observe regarding the government of the State of São Paulo in relation to water governance? Figure 1 shows the number of results by theme.

Regarding the State's ability to Implement Collective Decisions, 23% of respondents consider that it has improved, 54% say that it has remained the same, and 23% of respondents consider that it has worsened. This question together with the question about collective consensus building are the ones that presented the highest rejection rate on the part of the interviewees. The hypothesis is that in addition to there being a difficulty in building consensus on the part of the state government, there is also a difficulty in implementing decisions that were deliberated collectively, or that managed to reach consensus. This fact is supported by the analysis by Abers (2009) who argues that the public authorities, in general, have had difficulty implementing the deliberations of the arenas of action on water resources.

4.2. Network Actors for analysis of civil society participation

Figure 1 - Perception of the actors regarding the Public Power about water governance after the 2013-2015 water crisis and the interconnection of Jaguari-Atibainha reservoirs, by topic addressed.



Source: Own elaboration

To begin the analysis of networks of actors, a caveat is in order. Under the state law of São Paulo, LEI Nº 7,663, of December 30, 1991, the institutional architecture of representation of the CBH's of the State of São Paulo is composed of 2/3 of the public power, divided between municipal and state, the other third it is composed of civil society, including research institutes, users, associations and class entities in this category.

For the purposes of this research, it was decided to differentiate between members representing civil society, classifying them as NGOs, Academia and Research Institute and Private Sector. In addition to these segments, it was decided to incorporate actors representing other arenas besides CBH-PS. The inclusion criterion for these groups is that they were repeatedly mentioned during the interviews. It is not a specific, individual actor, but a group of actors, a space for discussion and mobilization that have an interface with the issue of conservation of water resources in the region. Among these, the Vale do Paraíba Forest Restoration Actors Network (RARFVP) and APA-SFX stand out, promoting dialogue and articulation between the agents involved in the conservation of the landscape and water resources. In this way, the position that the actors occupy in the network field, the form of cooperation and the interests at stake becomes clearer.

In order to advance the diagnosis of the network, Figure 2 represents the actors perceived as the most important for the governance of water resources. This graph was obtained through the relationship of influence recognition by all actors in the network - Metric In Degree.

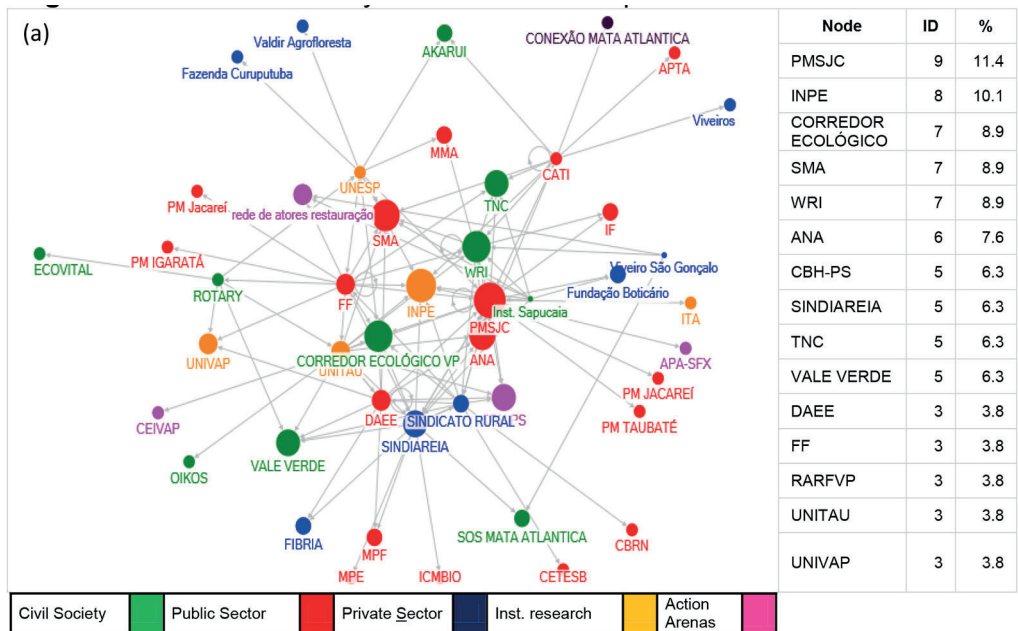


Figure 2 – Which actors do you consider most important in the network?

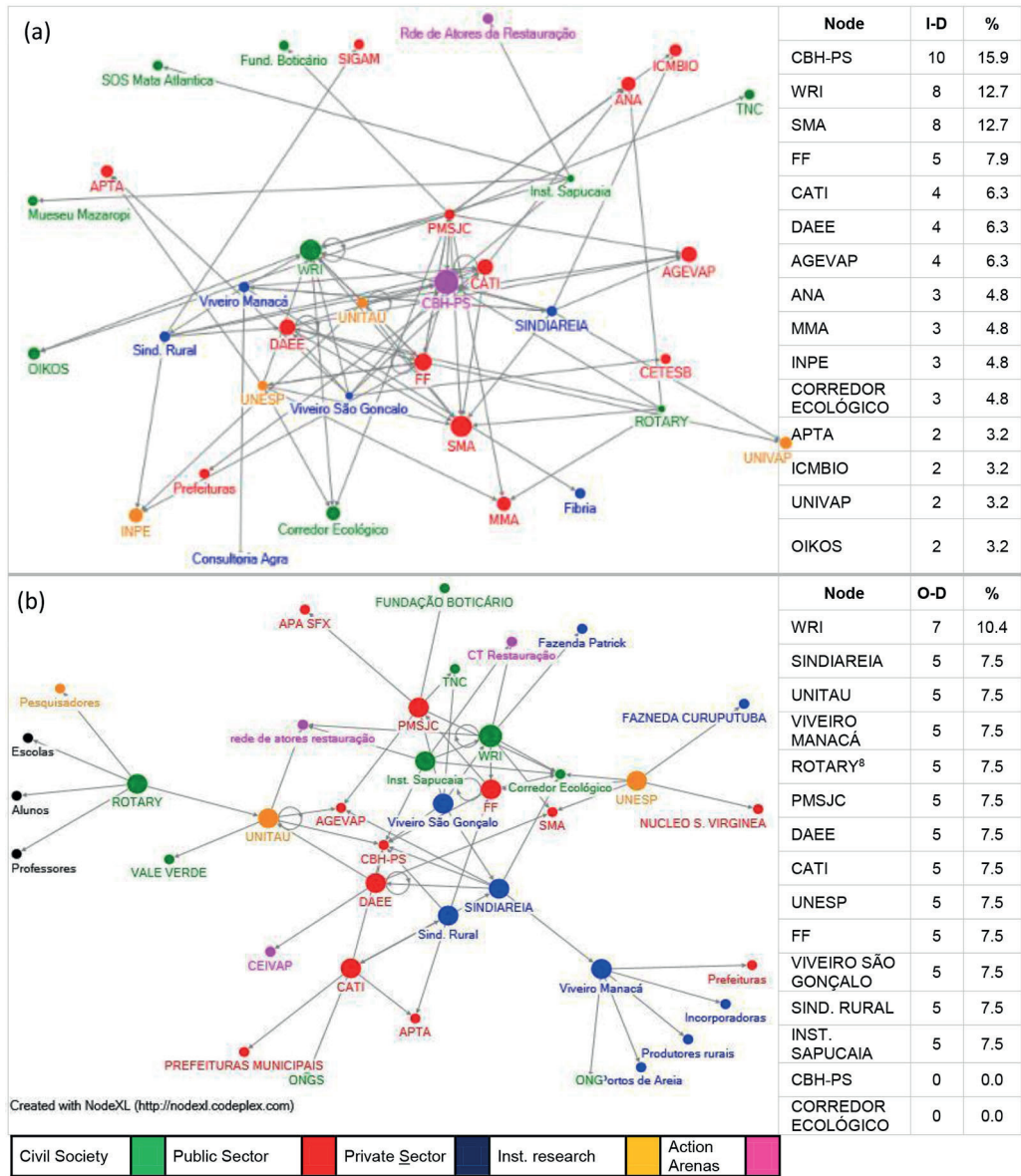
Source: Own elaboration.

According to the results of Figure 2, the Municipality of São José dos Campos (PMSJC) occupies a prominent place in the network, followed by actors linked to civil society (Ecological Corridor and World Resources Institute - WRI), to the government (Secretaria de Meio Ambiente) Environment - SMA) and the National Institute for Space Research (INPE), among the five actors mentioned as the most important in the network.

However, when asked about which actors help to make decisions (Figure 3), the actors who have greater prominence in the network are those linked to the public power such as CBH, Secretariat of Environment SP (SMA), Fundação Florestal (FF), Coordination of Integral Technical Assistance (CATI) and Department of Water and Electricity (DAEE).

Civil society actors World Resources Institute (WRI), Ecological Corridor, and research institutions are less prominent under this metric. It is possible to interpret the fact that civil society and research institutes have low levels of citation in the network because they are weakly connected. To verify this hypothesis, the information flow relationship was investigated, as shown in Figure 3, graphs (a) and (b).

Figure 3 - Analysis of the flow of information perceived and performed. a) what sources or actors help you make decisions? (In-Degree); b) with whom do you collaborate the most by providing information? (Out-Degree). Metrics presented only for nodes with higher values.



Source: Own elaboration.

It is important to note that communication between organizations linked to science and civil society is a fundamental factor to reduce information asymmetries (JACOBI, 2014).

Consolidating channels for bringing experts and laypeople, technicians and users together and co-producing knowledge, are actions capable of promoting training and motivation for changing attitudes and, thus, changing governance patterns; which can provide better conditions of adaptation in the face of crisis scenarios and uncertainties for water resources (JACOBI, 2012; LEMOS; MOREHOUSE, 2005, LEACH, 2007).

When asked, the graphs (a) and (b) show the flow of information from the network of actors in the context evaluated according to their perception (graph a), and according to their concrete activity of providing information (graph b).

In graph (a), the perception of information flow and other forms of collaboration between actors was evaluated on the network. It is possible to verify, from the perception, the CBH-PS followed by WRI and SMA with citations above 10% as major influencers. INPE and UNIVAP, recognized as research institutions, account for only 8% of the network's recognition citations.

It is worth mentioning that WRI, allied to the Forestry Foundation (FF) and the State Secretariat for the Environment (SMA), stand out in the sense of influencing other actors in the network. The FF is responsible for the management of the State's Conservation Units and, therefore, its strategies have an interface with the concepts of soft strategies and socioecological adaptation, according to Rockstrom et al. (2014). WRI has also been guided by approaches very close to the concepts of socio-ecological thinking, ecosystem services and socio-ecological adaptation.

When observing the graph (b), with regard to the declared information flow that happens on the network, in relation to the provision of content for actors, the actors recognized as influencing the graph (a) are not necessarily verified in the graph (b). Only the WRI organization appears with more than 10% of information supply activity on the network, corroborating its recognition perceived in graph (a).

UNITAU and UNESP on the other hand figure as self-declared research institutions as providers of information. Unlike the organizations represented by the graph (a) metric, they are not recognized as providers of information, demonstrating a difference between recognition and self-declared activity.

There is a contradiction between recognition and activity on the network that can be assessed by comparing graphs (a) and (b). When actors are asked who helps them most in decision-making, research institutes and academia are less cited, with little prominence in the network. In other words, it can be interpreted that these actors are little perceived as sources of information and other forms of support, such as building agendas, structural actions, mobilization, discussion forums and public policies. However, when they are asked who "you" most collaborate on the network by providing information or other forms of collaboration, research institutions and academia appear with a certain prominence.

Two possible, but not unique, hypotheses emerge from this relationship: i) that there is a collaboration on the part of this segment that is not perceived or sensitive to the network as a whole or; ii) that collaboration does not materialize in objective effects

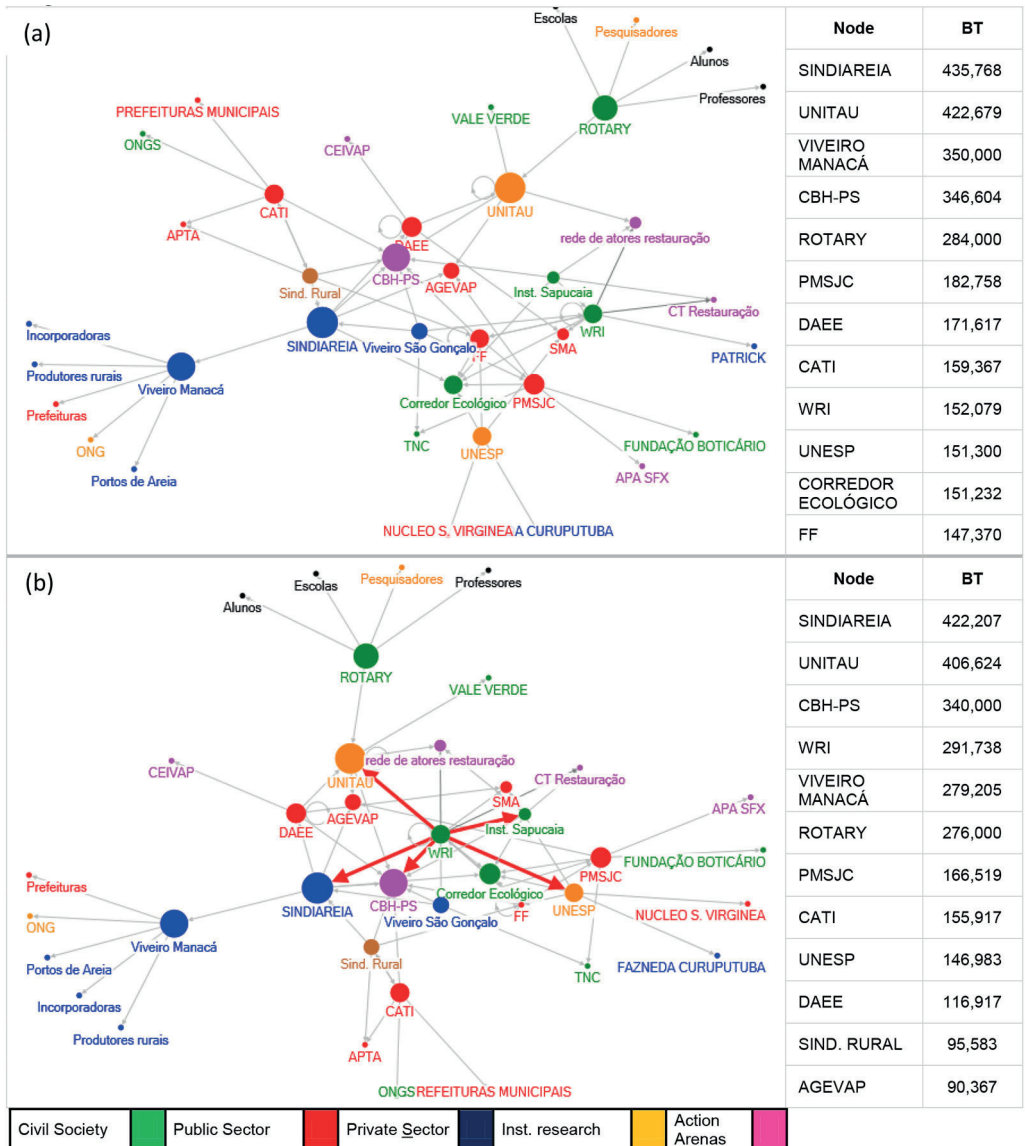
for water management, such as resolving conflicts or influencing the decision process. These hypotheses need to be verified because they can make important contributions to the understanding of the relationship of the actors within the network. Further investigation into the narrowing of the relationship between academia and civil society, can be the critical path for the empowerment of civil society, facilitating the exchange of technical-scientific information and collaboration in the construction of agendas and public policies (JACOBI, 2012; LEMOS, 2010; LEACH, 2007).

CBH-PS appears in Figure 3 (a) as influential in the network, but in Figure 3 (b) as the actor who has the least collaborative activity in the network. In contrast, the actors who most influence CBH-PS are: FF, DAEE, UNITAU, CATI and SINDIAREIA. The information from WRI comes from the following actors: CT Restauração, Rede de Actores da Restauração, FF, SMA, Ecological Corridor and Viveiro São Gonçalo. The information providers for SMA are: UNESP, WRI and DAEE.

SINDIAREIA - Union of Sand Mining Industries of the State of São Paulo, employer representative of the segment, also has a prominent place among the collaborating actors of the chain. The hypothesis about this position is due to its economic activity, which demands a large volume of environmental compensation, which ends up moving the market for forest restoration services in the region.

Another attribute observed in the information flow theme concerns the degree of connectivity of the actors in the network, measured by the metric betweenness. The complementary interpretation considers not only the supply activity declared by the actors, but the degree of intermediation that they have in the network. In this sense, it is observed in Figure 4 (a) and (b), those actors that have a greater degree of control and dissemination of information.

Figure 4 - Analysis of the flow of information perceived and performed through the relationship between the paths of the network - metric betweenness. A) Critical paths in the network with a focus on civil society participation and socioecological adaptation; B) Critical paths in the network after simulating new connections from a single actor (WRI). Metrics presented only for nodes with higher values.



Source: Own elaboration.

By the metric betweenness, SINDIAREIA presents itself as an actor that distributes information and articulates actions in the private sector of the chain. UNITAU also has prominence in the network. Public authorities have important actors such as: PMSJC, CATI and the Department of Water and Energy (DAEE); the CBH-PS main arena of action for resource management also appears prominently on the network.

UNITAU figures as not recognized in influence, but it declares itself as an active collaborator in the network. By the graph in Figure 4 (a) the institution appears as a relevant intermediary in the network. UNESP, on the other hand, appears to be less relevant in intermediating information flow, although it has been declared a major supplier of information on the network.

A possible critical path for a greater connection between academia and civil society could be given by the actors of the state public power. Actors with strong links with the state government, such as CBH-PS, occupy important positions in the network, but have little prominence in terms of collaboration. This fact corroborates the results of the previous graphs in Figure 1, on the perception of the performance of the public power to have remained the same or worsened for the items “Information Sharing”, “Collective Construction of Consensus”, “State participation and collaboration with Civil Society” after the 2013-2015 water crisis.

With a focus on the interface between academia and civil society, WRI is an organization recognized for influencing the network and active in providing information. However, it does not show itself as a prominent mediator in the network, being only in 9th position by the metric Betweenness. Up to the time of this research, WRI has no connection with the main actors of the Public Power, such as PMSJC, has no connection with actors in the private sector, such as SINDIAREIA, and also has no connection with the main actors of research institutes and academia UNESP, INPE, UNIVAP and UNITAU.

This position reflects the characteristic of the organization, which is international, without direct articulation and representation of local actors, so even though it is perceived as important in the network in relation to the source of information, it does not have a role as an articulator of actors in the network.

In this sense, this study proposes to simulate connections to promote greater insertion of civil society in the network and to increase its power of intermediation, above all, identifying critical paths with potential for percolation of information and resources in the network. By identifying such paths with the greatest potential for intermediation in the network, we can identify actors with the capacity to produce and disseminate information, distribute resources and negotiate common positions. This is strategic for the mobilization and construction of political agendas with a focus on adaptive governance.

Following the simulation of graph 4 (b), the first strategic connections could take place between actors in the segment themselves who are disconnected. These actors would be UNITAU, UNESP and WRI, and this connection, in addition to promoting greater unity in the segment, proves to be important for the diffusion of technical and scientific knowledge, reducing information asymmetries and motivating changes in the governance pattern.

Another actor who shows himself as an important intermediary in the network is SINDIAREIA, with the highest degree of betweenness. This connection would enable

the interface between civil society and the private sector, one of the critical paths for the distribution of resources, especially those linked to environmental compensation. Expanding the link between these two segments would provide opportunities for forest restoration, investment in income generation for rural communities, and increase the protection of sensitive areas of water recharge in the hydrographic basin.

When looking at graph 4 (b), the simulated connections indicate the possibility for civil society to play an important role in the distribution of information, resources and in the articulation of actions for institutional innovation with a focus on socioecological adaptation strategies for the Paraíba do Vale Paulista.

5 Conclusion

This study aimed to empirically contribute to the analysis of networks of actors, supporting the reasoning of Novaes (2004), that the conformation of the network of actors governing water resources in the Paraíba do Sul river basin impacts the socio-ecological adaptive actions by revealing the dependency relations between government, interest groups and information and resource flows. The Use of the SNA theoretical-methodological framework in understanding the action arenas and in socio-ecological systems, even though it is a portrait of a specific moment and a specific part of the management system, can reveal important elements and help in the study of policies and adaptive governance structurally, describing the topology of the governance field (FISCHER, 2011; NOVAES; 2004).

Based on the data collected by this research, after the 2013-2015 water crisis, the government of the State of São Paulo shows itself as a protagonist in the network occupying a key position of spatial centrality. These findings reaffirm that the institutional arrangements of actors governing water resources, arranged by state law No. 7,663, tends to reinforce state technocracy to the detriment of civil society participation (ABERS et al., 2009; JACOBI, 2012; LEMOS et al., 2010).

Among the results, the actors consider that there was no effort on the part of the State, after the water crisis, to share information, promote consensus, collaboration with civil society, and learn from the experience of the 2013-2015 crisis. In some cases, for some actors, the state's capacity for these issues has worsened. This fact is reflected in the articulation of the network in which actors linked to the State appear with a considerable degree of influence in the network, but with a low degree of collaboration.

In Figure 4 (a), bodies linked to the public power of the state of São Paulo, even with low values of Betweenness, occupy positions of spatial centrality in the network, describing an important axis in the spatialization of the actors. According to the SNA methodology, the actor's spatial location also describes its importance in the network, the closer to the center the greater its relevance, the more peripheral the lower its influence capacity.

CBH-PS for having a high degree of Betweenness, and for having 2/3 of its representation mostly in the hands of public actors, we can infer that these actors control a good part of the information flows and collaborative relations.

Through participant observation, it was found that civil society presents, in general, a socioecological action agenda focused on Soft Strategies, focused on the conservation of ecosystem services involving water and landscape planning. These actions are polarized with the Hard Strategies actions of the Public Power, mainly focused on infrastructure works such as the Jaguarí-Atibainha interconnection.

The critical path in the network to promote greater participation and engagement of civil society would be to establish a denser connection between civil society (NGOs) with academia and research institutes, which would promote greater synergy in the exchange and production of technical and scientific knowledge. This would provide greater capacity for intermediating information and resources, the ability to establish bridges, bring together actors and negotiate common positions. This articulation could lead to institutional innovation with a focus on adaptive governance of water resources, making them resilient to crisis and uncertainty scenarios for the hydrographic basin and, consequently, for the Macrometropolis.

There are still advances to be undertaken in this research, such as increasing the sample space, covering other groups of actors and other Technical Chambers of CBH-PS. The future objective is to compare the actors' perception of adaptive governance and the possible interfaces between other networks, information exchanges and other forms of collaboration for socio-ecological adaptation strategies.

6 References

- ABERS, R. KECK, M. Mobilizing the State: The Erratic Partner in Brazil's Participatory Water Policy. *Politics & Society*, Vol. 37 No. 2, June 2009 289-314 DOI: 10.1177/0032329209334003 2009a.
- ABERS, R. N.; FORMIGA-YOHNSSON, R. M.; FRANK, B.; KECK, M. E.; LEMOS, M. C. Inclusão, deliberação e controle: Três dimensões de democracia nos comitês e consórcios de bacias hidrográficas no Brasil. *Ambiente e Sociedade*, v. 12, n. 1, p. 115–132, 2009b.
- AGRAWAL, A. Sustainable Governance of Common-pool Resources: Context, Methods, and Politics *Annu. Rev. Anthropol.* 2003. 32:243–62 doi: 10.1146/annurev.anthro.32.061002.093112.
- ANDRADE, A.; et al. Draft Principles and Guidelines for Integrating Ecosystem-based Approaches to Adaptation in Project and Policy Design. p. 30, 2011. Disponível em: <http://cmsdata.iucn.org/downloads/draft_guidelines_eba_final.pdf>.
- ARMITAGE, D.; MARSCHKE, M.; PLUMMER, R. Adaptive co-management and the paradox of learning. *Global Environmental Change*, v. 18, n. 1, p. 86–98, 2008.
- BERKES, F.; FOLKE, C. (Eds.) **Linking social and ecological systems: management practices and social mechanisms for building resilience**. Cambridge, UK: Cambridge University Press, 1998.
- BODIN, Ö.; CRONA, B.; ERNSTSON, H. Social networks in natural resource mana-

gement: What is there to learn from a structural perspective? *Ecology and Society*, v. 11, n. 2, 2006.

BUSCHBACHER, R. A Teoria da Resiliência e os Sistemas Socioecológicos : Como se preparar para um futuro imprevisível ? *Boletim Regional, Urbano e Ambiental*, v. 09, n. 2003, p. 12–24, 2014.

CALMON, P.; TRINDADE, A.; COSTA, M. Redes e governança das políticas públicas. p. 1–29, [s.d.].

CARLSSON, L.; SANDSTRÖM, A. **Network governance of the commons**. v. 2, n. 1, p. 33–54, 2008.

DI GREGORIO, M. Multistakeholder environmental governance in action: REDD+ discourse coalitions in Tanzania. *Ecology and Society*, 2014. ISSN: 1708-3087.

ENGLE, N. L.; JOHNS, O. R.; LEMOS, M. C.; NELSON, D. R. Integrated and adaptive management of water resources: Tensions, legacies, and the next best thing. *Ecology and Society*, v. 16, n. 1, 2011.

FISCHER, M. Social Network Analysis and Qualitative Comparative Analysis: Their Mutual Benefit for the Explanation of Policy Network Structures. *Methodological Innovations Online*, v. 6, n. 2, p. 27–51, 2011.

FORMIGA-JOHNSON, R. M.; KUMLER, L.; LEMOS, M. C. The politics of bulk water pricing in Brazil: Lessons from the Paraíba do Sul Basin. *Water Policy*, v. 9, n. 1, p. 87–104, 2007.

HAJER, M.; VERSTEEG, W. Performing governance through networks. *European Political Science*, v. 4, n. 3, p. 340–347, 2005.

HOEFFEL, J. L. et al. Percepção ambiental e conflitos de usos dos recursos naturais – um estudo na APA do Sistema Cantareira. Brasília. **II Encontro da ANPPAS**, 2006.

IORIS, A.R. “The limits of integrated water resources management. A case study of Brazil’s Paraíba do Sul River Basin”, *Sustainability, Science, Practice & Policy*, 4(2), 4-11. 2008.

JACOBI, P. **Governança da Água no Brasil**. In: RIBEIRO, W C Governança da água no Brasil: uma visão interdisciplinar. São Paulo AnnaBlume, 2009.

JACOBI, P. Aprendizagem social, desenvolvimento de plataformas de múltiplos atores e governança da água no Brasil DOI: 10.5007/1807-1384.2010v7n1p69. *Revista Internacional Interdisciplinar INTERthesis*, Florianópolis, v. 7, n. 1, p. 69-95, jan. 2010. ISSN 1807-1384. Disponível em: <<https://periodicos.ufsc.br/index.php/interthesis/article/view/14257>>. Acesso em: 01 jul. 2019. doi:<https://doi.org/10.5007/1807-1384.2010v7n1p69>.

KUMLER, L. M.; LEMOS, M. C. Managing waters of the Paraíba do Sul River Basin, Brazil: A case study in institutional change and social learning. *Ecology and Society*, v. 13, n. 2, 2008.

LEMOS, M. C.; AGRAWAL, A. Environmental Governance. **Annual Review of Environment and Resources**, v. 31, n. 1, p. 297–325, 2006. Disponível em: <<http://www.annualreviews.org/doi/10.1146/annurev.energy.31.042605.135621>>.

LEMOS, M. C.; BELL, A. R.; ENGLE, N. L.; FORMIGA-JOHNSSON, R. M.; NELSON, D. R. Technical knowledge and water resources management: A comparative study of river basin councils, Brazil. **Water Resources Research**, v. 46, n. 6, 2010.

MARENGO, J. A.; ALVES, L. M. Crise Hídrica em São Paulo em 2014: Seca e Desmatamento. **GEOUSP: Espaço e Tempo (Online)**, v. 19, n. 3, p. 485, 2015.

MINAYO, M. C. S. (org.). **Pesquisa Social. Teoria, método e criatividade**. 18 ed. Petrópolis: Vozes, 2001.

NOVAES, R. Redes de Políticas Públicas e Gestão de Recursos Hídricos ; perspectivas e contribuições teórico-metodológicas da abordagem de “ policy networks ”. **Water Policy**, [s.d.].

NOBRE, C et al. Some Characteristics and Impacts of the Drought and Water Crisis in Southeastern Brazil during 2014 and 2015. **Journal of Water Resource and Protection**, 2016.

NORTH, D., **Institutions, Institutional Change and Economic Performance**”. Cambridge University Press. 1990.

OSTROM, E. **Beyond Markets and States: Polycentric Governance of Complex Economic Systems** Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington, IN 47408, and Center for the Study of Institutional Diversity, Arizona State University, U.S.A. 2009.

_____ **Governing the Commons: The evolution of institutions for a Collective Action** (4 Edition), Cambridge/UK: Cambridge University Press, 1990

PAHL-WOSTL, C., et al. Managing change toward adaptive water management through social learning. **Ecology and Society** 12(2): 30. [online] URL: <http://www.ecologyand-society.org/vol12/iss2/art30/> 2007.

PIRES DO RIO, G., et al. Água: urgência de uma agenda territorial. **Ambient. soc.**, São Paulo , v. 19, n. 4, p. 121-136, dez. 2016 . Disponível em <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1414-753X2016000400121&lng=pt&nrm=iso>. acessos em 01 jul. 2019. <http://dx.doi.org/10.1590/1809-4422asoc0075r1v1942016>.

PIRES DO RIO, G. Gestão de Águas: Um Desafio Geo-institucional. **Rev. Tamoios**, São Gonçalo (RJ), ano 13, n. 1, págs. 3-23, jan-jun. 2017 DOI: 10.12957/tamoios.2017.29156.

ROCKSTRÖM, J et al. **Water Resilience for Human Prosperity**. Cambridge University Press. 2014.

SÃO PAULO. Governo Estado. Departamento de Águas e Energia Elétrica – DAEE. **Plano Diretor de Aproveitamento de Recurso Hídrico para a Macrometrópole Paulista**, 2013.

SABATIER, P. A. & JENKINS-SMITH, H. C. **Policy Change and Learning Change: An Advocacy Coalition Approach**, Boulder, Westview Press, 1993, 306.

SCOTT, J. **Social network analysis: a handbook**. London: Sage Publications, Inc, 2000.

WASSERMAN, S.; FAUST, K. **Social network analysis : methods and applications**. New York: Cambridge University Press, 1997.

ZWARTEVEEN, M.; et al. Engaging with the politics of water governance. **Wiley Interdisciplinary Reviews: Water**, v. 4, n. 6, p. e1245, 2017.

Submitted on: 23/07/2019

Accepted on: 21/01/2020

<http://dx.doi.org/10.1590/1809-4422asoc20190139r1vu2020L2DE>

2020;23:e01381

Special Issue: São Paulo Macrometropolis Environmental Governance Forum

WATER GOVERNANCE IN VALE DO PARAÍBA PAULISTA: NETWORK OF ACTORS AND SOCIOECOLOGICAL SYSTEMS

ALEXANDRE R. MARQUES
MARIA ANGÉLICA TONIOLO
MYANNA LAHSEN
SERGIO PULICE
EVANDRO ALBIACH BRANCO
DIÓGENES SALAS ALVES

WATER GOVERNANCE IN VALE DO PARAÍBA PAULISTA: NETWORK OF ACTORS AND SOCIOECOLOGICAL SYSTEMS

Abstract: Environmental changes bring challenges to the governance of water resources in the Paulista Macrometropolis. In this context, adaptive governance and the articulation of actors in networks are strategies for coping with this type of situation. This article analyzes water governance in the Paraíba Valley in light of the challenges posed by the 2013-2015 water crisis. Objective is to analyze the network of actors, exploring ways for greater participation of civil society in socioecological adaptation actions. The method used was Social Network Analysis. The conclusion is that there is a mismatch between civil society and the state to negotiate positions. The paper identifies opportunities for enhancing connections between civil society and academia and broadening engagement and cooperation with a focus on adaptive water governance.

Key words: Adaptive Governance, Network of Actors, Socioecological Systems, Water Crisis, Jaguari-Atibainha Interconnection.

GOVERNANÇA DA ÁGUA NO VALE DO PARAÍBA PAULISTA: REDE DE ATORES E SISTEMAS SOCIOECOLÓGICOS

Resumo: Mudanças ambientais trazem desafios à governança dos recursos hídricos na Macrometrópole Paulista. Neste contexto, a governança adaptativa e a articulação dos atores em redes são estratégias para o enfrentamento deste tipo de situação. Este artigo analisa a governança da água no Vale do Paraíba frente aos desafios impostos pela crise hídrica 2013-2015. Objetivo é analisar a rede de atores, explorando caminhos para maior participação da sociedade civil em ações de adaptação socioecológica. O método utilizado

foi o *Social Network Analysis*. A conclusão é que há um descompasso entre a sociedade civil e o Estado para negociar posições em comum. O trabalho identifica oportunidades de incremento nas conexões entre sociedade civil e academia e ampliação do engajamento e cooperação com foco na governança adaptativa da água.

Palavras Chaves: Governança Adaptativa, Rede de Atores, Sistemas Socioecológicos, Crise Hídrica, Interligação Jaguari-Atibainha.

GOBERNANZA DEL AGUA EN VALE DO PARAÍBA PAULISTA: RED DE ACTORES Y SISTEMAS SOCIOECOLÓGICOS

Resumen: Los cambios ambientales traen desafíos a la gobernanza de los recursos hídricos en la Macrometrópolis Paulista. En este contexto, la gobernanza adaptativa y la articulación de actores en redes son estrategias para hacer frente a este tipo de situación. Este artículo analiza la gobernabilidad del agua en el valle de Paraíba a la luz de los desafíos planteados por la crisis del agua 2013-2015. El objetivo es analizar la red de actores, explorando formas para una mayor participación de la sociedad civil en las acciones de adaptación socioecológica. El método utilizado fue el análisis de redes sociales. La conclusión es que existe un desajuste entre la sociedad civil y el estado para negociar las posiciones. El documento identifica oportunidades para mejorar las conexiones entre la sociedad civil y el mundo académico y ampliar el compromiso y la cooperación con un enfoque en la gobernabilidad adaptativa del agua.

Palabras-clave: Governança Adaptativa, Red de Actores, Sistema Sociológico, Crisi del Agua, Conexión entre Cuencas Jaguari-Atibainha.
