Chapter 10
Adaptation to Climate Change: Institutional Analysis

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Abstract There are many challenges for water management under climate change. Institutional capacity for enabling adaptation is one of those challenges, which have to consider uncertainties, participatory processes, and monitoring. Elinor Ostrom, a Nobel winner, produced many relevant contributions to understanding institutional governance. Her work pointed to requirements of adaptive governance, institutional design principles for local common pool resources systems, and social-ecological framework analysis. Recently, Ostrom's institutional principles have been extended for the governance of adaptation to climate change in the water sector. Adaptation in water sector is a continuous process of learning. Drought management in the present and past is also a way of learning considering experiences on institutions dealing with this challenge. This chapter illustrates how Ostrom's principles, in the context of a drought management experience in Brazil, might provide a continuous way for assessing if institutions are capable to play their roles in the process of adaptation to climate variability and change.

Keywords Climate variability • Drought • Water management • Water supply • Reservoir • Ostrom

10.1 Introductory Concepts

There are many challenges for water management under climate change. Institutional capacity is one of those challenges, which have to consider uncertainties, participatory processes, and monitoring. Elinor Ostrom, a Nobel Prize winner, produced many relevant contributions to understanding institutional governance. Her work pointed to requirements of adaptive governance, institutional design

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principles for local common pool resources systems, and social-ecological framework analysis. Huntjens and collaborators recently extended Ostrom's institutional principles for the governance of adaptation to climate change in the water sector. This chapter is largely based on their works and is organized in three parts: the first briefly introduces some basic concepts on institutions, adaptation, adaptive water management, and governance; the second revises very shortly Ostrom's framework and design principles for institutional analysis; the final part shows the application to a water management case. The first two parts do not intend to present in detail or extensively the Ostrom's theoretical framework, since there is a rich literature to which the reader can consult. Our main objective is to add an application of those principles to a drought-related water management problem. Through this example, we intend to help the readers to use this extraordinary framework in other applications in the water sector.

The following paragraphs present some basic concepts, very concisely, to enable the reader to easily understand the remaining topics.

10.1.1 Institutions

Institutions can be defined "as formal and informal rules that are understood and used by a community" (Hess and Ostrom 2005). "*Rules* are linguistic statements similar to norms but rules carry an additional, assigned sanction if forbidden actions are taken and observed by a monitor. For rules to exist, any particular situation must be linked to a rule-making situation and some kind of monitoring and sanctioning must exist. Rules may be crafted in any of a wide diversity of collective-choice or constitutional-choice arenas in local, regional, national, or international domains" (Ostrom 2013).

10.1.2 Governance

According to Graham et al. (2003), "governance is a process whereby societies or organizations make their important decisions, determine whom they involve in the process and how they render account." "For a governance regime to deal with the current and anticipated impacts of climate change it first needs to have a policy or strategy in place. From this perspective, the output of a governance system is not only defined by its physical interventions, but also by means of its management interventions" (Huntjens et al. 2012).

10.1.3 Adaptation

> Adaptation is a process of deliberate change in anticipation of or in reaction to external stimuli and stress. Adaptation involves change. Adaptation is, therefore, standard practice in the human world as individuals, communities, and societies adjust their activities,

life courses, and locations to take advantage of new opportunities. But adaptation is often imposed on societies and localities because of external undesirable change. Efforts to respond to these changes frequently entail reducing vulnerability and enhancing the capacity to adapt, in effect, to enhance the resilience of people and places, localities, and ways of life (Nelson et al. 2007).

10.1.4 Adaptive Water Management

Adaptive Water Management adds value to the Integrated Water Resources Management approach. The central contribution of Adaptive Water Management (AWM) within the context of Integrated Water Resources Management (IWRM) is that it provides added value through explicitly embracing uncertainty. AWM acknowledges the complexity of the systems to be managed and the limits in predicting and controlling them. This implies an integrated management approach which adopt a systemic perspective rather than dealing with individual problems in isolation (Van der Keur et al. 2010).

10.2 Ostrom's Contributions for Institutional Analysis

Elinor Ostrom was the 2009's Nobel Prize in Economic Sciences. The Nobel Prize acknowledges her contribution as (Elinor Ostrom – Facts 2015): she "challenged the conventional wisdom by demonstrating how local property can be successfully managed by local commons without any regulation by central authorities or privatization. ... She gathered information through field studies and then analyzed this material. In her book 'Governing the Commons', from 1990, she demonstrated how common property can be successfully managed by user associations and that economic analysis can shed light on most forms of social organization. Her research had great impact amongst political scientists and economists."

10.2.1 Institutional Design Principles for Local Common Pool Resources Systems

According to Ostrom (1990), "the term 'common-pool resource' (CPR) refers to a natural or man-made resource system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use. To understand the processes of organizing and governing CPRs, it is essential to distinguish between the resource system and the flow of resource units produced by the system, while still recognizing the dependence of the one on the other." She identified a set of sustainable and robust institutional principles for good governance of CPR by individuals and communities (Ostrom 1990; Ostrom 2005), while Huntjens et al. (2012) extended Ostrom's principles for the governance of adaptation to climate change for the water sector:

10.2.1.1 Principle 1 – Clearly Defined Boundaries

Ostrom (1990) defined this principle as "Individuals who have rights to withdraw resource units from CPR must be clearly defined, as must boundaries of the CPR itself." The principle was extended by Huntjens et al. (2012) as "Completeness of water-user stakeholders in the adaptation process and clarity about who has rights to use water resources in the case of droughts."

10.2.1.2 Principle 2 – Congruence Between Appropriation and Provision Rules and Local Conditions

Ostrom (1990) defined this principle as "Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, material, and/or money." Ostrom (2005) also presented the principle as "Proportional equivalence between benefits and costs: rules specifying the amount of resource products that a user is allocated are related to local conditions and to rules requiring labor, materials, and/or money inputs."

> The second design principle is that the rules-in-use allocate benefits proportional to inputs that are required. If a group of users is going to harvest from a resource over the long run, they must devise rules related to how much, when, and how different products are to be harvested. They also need to assess the costs of operating a system on users. When the rules related to the distribution of benefits are made broadly consistent with the distribution of costs, participants are more willing to pitch in to keep a resource well-maintained and sustainable . . . (Ostrom 2005).

Huntjens et al. (2012) specified the principle for adapting to climate change in large river basins as "Equal and fair (re-)distribution of risks, benefits and costs, requiring engagement with, and strong representation of, groups likely to be highly affected or especially vulnerable."

10.2.1.3 Principle 3 – Collective-Choice Arrangements

Ostrom (1990) defined this principle as "Most individuals affected by the operational rules can participate in modifying the operational rules." Huntjens et al. (2012) extended this principle as follows: "To enhance the participation of those involved in making key decisions about the system, in particular on how to adapt."

10.2.1.4 Principle 4 – Monitoring

According to Ostrom (1990), "Monitors, who actively audit CPR conditions and appropriator behavior, are accountable to the appropriators or are appropriators." Huntjens et al. (2012) defined this principle as "Monitoring and evaluation of the process: providing a basis for reflexive social learning and supporting accountability."

"Appropriator can be used to refer to anyone who appropriates resource units from some type of resource system. In many instances appropriators use or consume the resource units they withdraw. Appropriators also use resource units as inputs into production processes" (Ostrom 1990).

10.2.1.5 Principle 5 – Graduated Sanctions

Ostrom (1990) considers that "appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, by officials accountable to these appropriators, or by both."

10.2.1.6 Principle 6 – Conflict Resolution Mechanism

This principle is presented by Ostrom (1990) as follows: "Appropriators and their officials have rapid access to low-cost arenas to resolve conflicts among appropriators or between appropriators and officials." Huntjens et al. (2012) added: "Including timing and careful sequencing, transparency, trust-building, and sharing of (or clarifying) responsibilities."

10.2.1.7 Principle 7 – Minimal Recognition of Rights to Organize

Ostrom (1990) described this principle as "the rights of appropriators to devise their own institutions are not challenged by external governmental authorities."

10.2.1.8 Principle 8 – Nested Enterprises

For resources that are parts of larger systems, Ostrom (1990) established another principle: "Nested enterprises: appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises." Huntjens et al. (2012) presented this principle as "Nested enterprises/polycentric governance in a multi-level context, as functional units to overcome the weakness of relying on either just large-scale or only small-scale units to govern complex resources systems."

The principles "Robust and flexible process" and "Policy learning" were added by Huntjens et al. (2012) to the above eight Ostrom principles, for the complex systems adaptation, such as large basins under uncertain conditions, such as climate change:

10.2.1.9 Principle 9 – Robust and Flexible Process

Huntjens et al. (2012) defined this principle as "institutions and policy processes that continue to work satisfactorily when confronted with social and physical challenges but which at the same time are capable of changing." Based on other studies, they indicate five characteristics that might build robust and flexible processes: organizational redundancy, flexibility to include new initiatives, confidence-building, integration of intersectoral policies or "integrating adaptation" ("climate adaptation does challenge integration"), and sequential and time dilemmas.

10.2.1.10 Principle 10 – Policy Learning

According to Huntjens et al. (2012), policy learning is related to "policy and institutional adjustments based on commitment to dealing with uncertainties, deliberating alternatives and reframing problems and solutions."

10.2.2 Adaptive Governance

Dietz et al. (2003) proposed some requirements of adaptive governance: *provide necessary information*; *deal with conflicts*; *induce compliance with rules*; *provide physical*, *technical*, *and institutional structure*; *and encourage adaptation and change*. They associated those requirements with Ostrom's general principles for robust governance of environmental resources:

"*Providing information*. Environmental governance depends on good, trustworthy information about stocks, flows, and processes within the resource systems being governed, as well as about the human-environment interactions affecting those systems. Effective governance requires not only factual information about the state of the environment and human actions but also information about uncertainty and values."

"*Dealing with conflict*. Sharp differences in power and in values across interested parties make conflict inherent in environmental choices."

"*Inducing rule compliance.* Effective governance requires that the rules of resource use are generally followed, with reasonable standards for tolerating modest violations."

"*Providing infrastructure*. The importance of physical and technological infrastructure is often ignored. Infrastructure, including technology, determines the degree to which a commons can be exploited (e.g., water works and fishing technology), the extent to which waste can be reduced in resource use, and the degree to which resource conditions and the behavior of humans users can be effectively monitored."

"*Be prepared for change*. Institutions must be designed to allow for adaptation because some current understanding is likely to be wrong, the required scale of organization can shift, and biophysical and social systems change."

Considering that Huntjens et al. (2012) adapted Ostrom's principles to deal with the adaptation to climate change, those principles might attend to the adaptive governance requirements. The composition of robust strategies that consider institutional adaptation might consider possible relations between those principles and requirements.

10.2.3 Social-ecological Analysis Framework

According to Ostrom (2009), "all humanly used resources are embedded in complex, social-ecological systems (SESs), ... and a common, classificatory framework is needed to facilitate multidisciplinary efforts toward a better understanding of complex SESs." Anderies et al. (2004) use the term SES to refer to "the subset of social systems in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non-human biological units."

Anderies et al. (2004) raise some interesting questions to base their proposal of *a framework to analyze the robustness of SESs from an institutional perspective*: "How do institutional arrangements affect the robustness of SESs? Why do some systems survive in highly varying environments over time and others collapse? Which attributes of the institutions are more likely to lead to the creation of robust SESs? How do these attributes depend on the underlying ecological system?"

Later, Ostrom recommends the following guidelines when applying the framework:

- The choice of relevant second or deeper levels of variables for analysis (from the large set of variables at multiple levels) depends on the particular questions under study, the type of SES, and the spatial and temporal scales of analysis (Ostrom 2009).
- At a broad level, one can begin to organize an analysis of how attributes of (i) a resource system (e.g., lake), (ii) the resource units generated by that system (e.g., water), (iii) the users of that system, and (iv) the governance system jointly affect and are indirectly affected by interactions and resulting outcomes achieved at a particular time and place. Using such a framework also enables one to organize how these attributes may affect and be affected by the larger socioeconomic, political, and ecological settings in which they are embedded, as well as smaller ones (Ostrom 2007).

10.3 Ostrom's Institutional Analysis of the Brazilian Water Policy from a Drought Management Perspective

Adaptation in water sector is a continuous process of learning. Drought management in the present and past is also a way of learning considering experiences on institutions dealing with this challenge. The following sections of this chapter are intended to illustrate how Ostrom's principles, in the context of a drought

management experience in Brazil, might provide a continuous way for assessing if and when institutions are capable to play their roles in the process of adaptation to climate variability and change.

10.3.1 Droughts

Drought is a recurrent feature of climate that occurs in all climatic zones, from wet to dry, and varies from one region to another, more likely observed in areas of high precipitation variability. It differs from aridity to be a temporary situation, which may last from months to years. In arid areas the aridity is permanent.

Drought is a complex phenomenon difficult to quantify, whose conditions develop slowly and gradually and do not usually involve structural damage, being its onset and duration difficult to be determined. In addition, its impacts spread across different sectors of the economy and affect large areas and populations. Anthropogenic activities, such as inappropriate land use and water management, can lead to worsening drought impacts. Changes in land use and land drainage have altered the hydrologic regimes in terms of water quality and water balances, which may have repercussions on the vulnerability to drought.

IPCC (2014) defines drought as an extreme climatic event characterized by below-normal precipitation over a time period relative to its local normal condition, long enough to cause a serious hydrological imbalance. But drought definition is not a closed issue. Although there is consensus that the drought is the result of lack of precipitation, which produces water deficit for a specific activity or group, drought phenomenon was not a precise definition. It can be analyzed from different perspectives related to what is appropriate to the activity, time, and place under consideration. Droughts can be classified into meteorological, agricultural, hydrological, and socioeconomic.

Meteorological drought is a period of months to years with below-normal precipitation, in comparison to some average amount of rainfall, leading to other types of droughts. Periods of meteorological drought are identified in relation to actual precipitation from average amounts on monthly, seasonal, or annual time scales. It must be defined regionally by the regional climatic variation conditions.

The agricultural sector is the first to be affected by drought because of its dependence on stored soil moisture. Agricultural drought impacts are associated with soil water deficits resulting in loss of yield and have characteristics of meteorological and hydrological drought.

Hydrological drought results from long periods of low precipitation that impacts streamflow, reservoir, lake, and groundwater levels, as well as recharge rates, producing significant societal impacts. Hydrological drought impacts lag the occurrence of meteorological drought because it takes some time for precipitation deficits to accumulate in the hydrological system components. Land use also can influence hydrological drought and may change both water infiltration in the soil and runoff patterns.

Socioeconomic drought is associated with supply and demand of some water-dependent economic good such as water supply, fishing, and hydropower, among others. It occurs when water supply is unable to meet economic or social demands due to weather-related factors.

The non-implementation of risk management strategies, with the consequent concentration only on crisis management strategies, and the growing demand for water by society also contribute to exacerbated negative socioeconomic impacts of droughts, making it even more difficult to meet the demands during all drought events, especially in areas with high climate variability and high population density.

Risk management strategies for coping with droughts are somewhat equivalent to adaptation strategies in coping with climate change and, thus, a challenge to the institutions dealing with it. The identification of deficiencies and failures, capacities, and strengths of such institutions is very important to design and improve them, to better manage the processes of dealing with climate variability and change.

10.3.2 The Brazilian Semiarid Region

The large semiarid northeastern region of Brazil (Fig. 10.1), covering about 1 million km^2, is characterized by frequent drought periods, which have caused different impacts on its water resources availability and socioeconomic systems. Annual rainfall presents a high interannual variability and amounts ranging from 400 to 800 mm. Average temperature is 27 °C, and evaporation rates are higher than 2000 mm/year. It is one of the most vulnerable regions to climate change in Brazil, with possible decrease of rainfall and increase in temperature and, consequently, evapotranspiration.

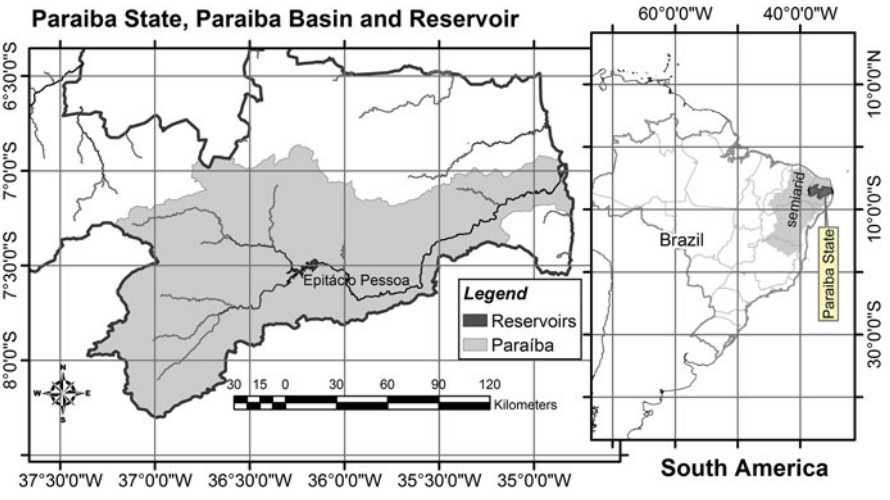

Fig. 10.1 Brazilian semiarid, Paraiba River Basin and Epitácio Pessoa Reservoir

Historically, populations and communities have dealt with climate variability through storage, in small reservoirs and shallow aquifers, of water from rainfall and intermittent streams and rivers during the 3-month rainy season for general use during the dry season. Agriculture was mostly rain-fed and also used some small-scale irrigation for the intra-season dry spells.

With population and cities' growth (currently, in 2014, 23.5 million inhabitants), water supply, either for human consumption or livestock and agriculture, became a huge social and economic problem. One of the most important measures to cope with this new context was the construction of large surface reservoirs for water storage from wet years to dry years, with the creation of the *National Department Against Droughts* (DNOCS), in 1909. Those reservoirs allowed the settlement in large- and medium-sized cities during the twentieth century and also the establishment of several irrigation districts for food production.

10.3.3 Epitácio Pessoa Reservoir

The Epitácio Pessoa Reservoir is located in the Paraíba River Basin, State of Paraíba, located in the semiarid region of Brazil (Fig. 10.1). Its drainage basin is very impacted by human actions such as deforestation (Galvao et al. 2001). This reservoir was built by the Brazilian Federal Government during the period of 1951–1957 and represents the main source for supplying a population of about 500 000 inhabitants, including Campina Grande city, an important educational and economical center for the region. The water reservoir users are a water supply company and irrigators. Only the water supply company is an authorized user by the National Water Agency, due to limitation of its regularized discharge.

This reservoir has experienced extreme water shortages, which demanded adaptation measures, such as suspending the allocation of water for irrigation and greatly reducing urban supply. These measures led to different impacts on water users, which required new efforts on social adaptation (Grande et al. 2014). One of the drought periods took place in 1997–2003. More recently (2012–2016), the region suffered another severe drought period, the biggest water crisis that ever happened around the reservoir. The high climatic variability of the region can be better observed in Fig. 10.2, which shows a time series of more than 40 years of rainfall and reservoir storages. Both big droughts are easily identifiable from this record. The reservoir has also lost part of its capacity due to sedimentation. From 2004 the new capacity of 411 million m^3 was estimated.

The reservoir's regularized discharge is 1.85 $m^3.s^{-1}$, estimated by the National Water Agency. The Paraíba State Water Resources Plan estimates its regularized discharge as 1.23 $m^3.s^{-1}$. This controversy is one of the institutional problems related to the reservoir management. In 2012, at the beginning of the drought period, estimates of reservoir's water withdrawal were approximately 2.39 $m^3.s^{-1}$, where 1.44 $m^3.s^{-1}$ was used for urban water supply and 0.95 $m^3.s^{-1}$ for irrigation. These numbers clearly demonstrate that, despite the occurrence of one of the major

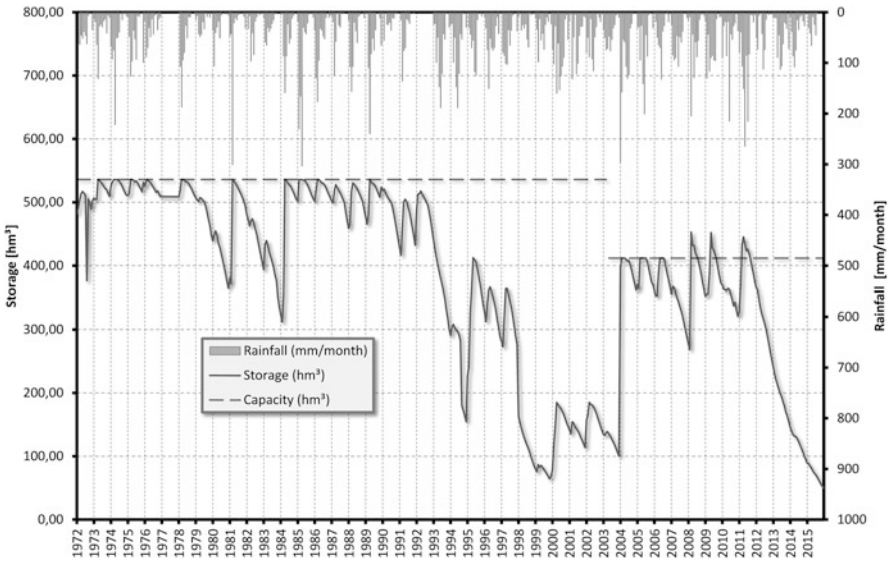

Fig. 10.2 Historical time series of water storage at Epitácio Pessoa Reservoir

meteorological and hydrological droughts ever, overexploitation of the reservoir played the principal role in consuming its water availability.

10.3.4 The Brazilian Water Policy and Management System

In Brazil, the Federal Law 9433 (1997) established the National Water Resources Policy and created the National Water Resources Management System (SINGREH). This Law addresses as main principles: water as a public and economic good, water planning at the basin level, decentralized and participatory management, priority for human water demands in drought periods, and multiple usages for water must be allowed.

Five management instruments were defined by the Law: water resources plans (at national, state, and river basin levels, to underpin and guide the implementation of the National Water Resources Policy and the management of water resources, which define management actions, programs, projects); a system for classification of water bodies according to their water quality and preponderant use (WBC); concession of water rights (CWR); bulk water charges, with the revenue to be invested in the basin (BWC); and the Water Resources Information System (WRIS).

The SINGREH is composed of a set of water management organizations including, at national and state levels, deliberation and regulation organisms (national and state's Water Resources Councils), policy implementation and operation organisms (the National Water Agency – ANA – and state's water agencies, which supervise,

monitor, and evaluate the actions and activities resulting in the fulfillment of the federal and state's legislation related to water resources), participatory and decentralized management organisms (river basin committees), and technical organisms (river basin agencies). The river basin committees and national and state's water councils are composed of elected members representing water users; federal, state public, and municipal agencies; and civil society organizations, which have activities in the basin. The Law 9433 establishes that water conflicts must be, in first instance, discussed and solved at the basin committee.

The water resources plans must be revised and updated frequently (usually at each five years). They are approved by the basin committees (basin plans), by the state's water council (basin and state's plans), and by the national water council (basin and national plans). The committees and councils are also responsible to monitor, supervise, and evaluate the implementation of the plans.

10.3.5 Institutional Analysis

This chapter focuses on the institutional analysis of the process of adaptation to climate change. It considers that the high climatic variability of the Paraíba River Basin, with drastic changes in rainfall and runoff amounts between clusters of dry and rainy years, can be a proxy of an altered climate. Droughts happening during the clusters of dry years are also proxies of possible societal impacts of climate change. The performance of the water policy and management system in coping with the high climate variability and its consequences can be taken as their capacity to lead the necessary process of adaptation to a future climate.

As seen in the previous sections, the institutional water management system was not able to deal with the 2012–2016's drought in the basin, even after the previous experience of the 1997–2003's drought. The following institutional analysis can show which problems were responsible for the system's failure.

Following the Ostrom's framework for the analysis of SES, the case is studied starting with the identification of the SES for the Paraíba River Basin. After that, the analysis assesses the adherence of the institutions to the Ostrom's institutional design principles in two analytical aspects: the contents of the water policy and management system and their performance during the past drought events (Fig. 10.3).

10.3.5.1 The Social-Ecological System Identification

The socio-ecological system is identified and characterized according to its (Fig. 10.4) social, economic, and political settings; resource system; resource units; users; and governance. Also, the climate variability of the studied period is characterized and the impact of this variability on water availability. All the SES's components interact, as shown in the figure.

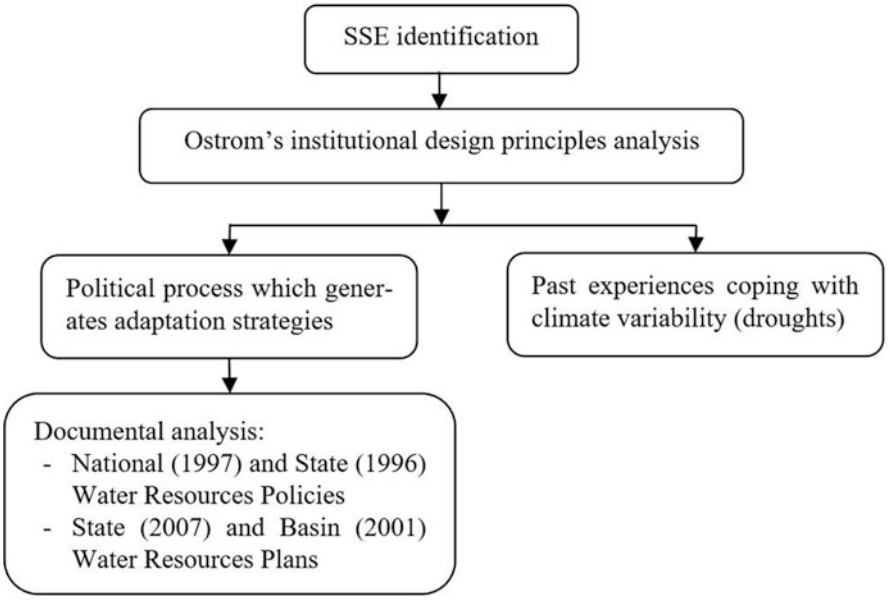

Fig. 10.3 Analytical process for the institutional analysis

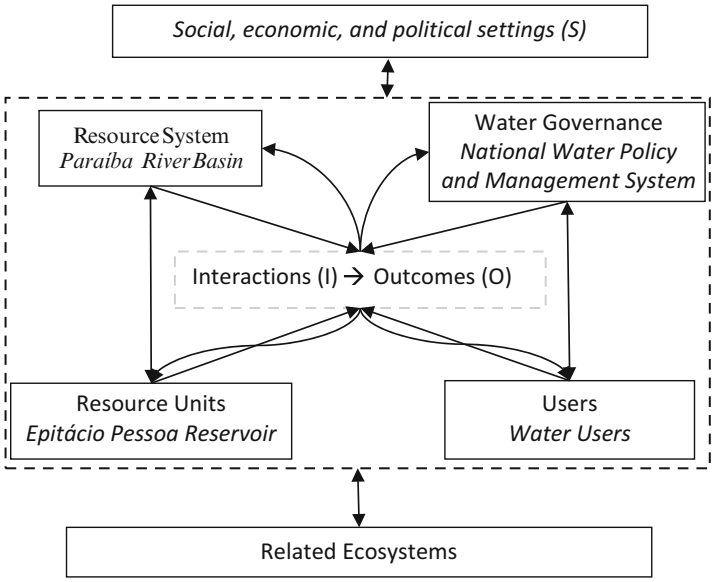

Fig. 10.4 SES configuration for the Paraiba River Basin and Epitácio Pessoa Reservoir (Based on Ostrom 2007)

Water Governance

The national water policy and management system defines the water governance of the resource system and its scope. The water policy defines the management relations between the water users, river basin, water reservoir, and the water management and policy itself.

Resource System

In the Brazilian case, the river basin is the territorial unit for the Water Resources National Policy implementation and the National Water Resources Management System activities. The Paraíba River Basin is, then, the SES's resource system.

Resource Units

The Epitácio Pessoa Reservoir is the SES's resource unit, since it is the hydraulic structure responsible for making water available to the users.

Water Users

The SES users are a water supply company and irrigators. Only the water supply company is an authorized user by the National Water Agency.

Related Ecosystems

Basin's climate variability, terrestrial ecosystems, land cover and use (vegetation and agriculture), and aquatic (reservoir lake) ecosystems highly influence reservoir water availability and quality.

Social, Economic, and Political Settings

Social, economic, and political settings might influence water governance and challenge its rules, in some cases. It influences also water users and uses. In this case the reservoir supplies a city that has increased its population, industries, irrigation, and also water demands.

10.3.5.2 Ostrom's Institutional Design Principles Analysis

Once the SES has been characterized, the analysis of the consistency between Ostrom's institutional design principles and the Brazilian Water Policy and Management system can be performed (Fig. 10.5).

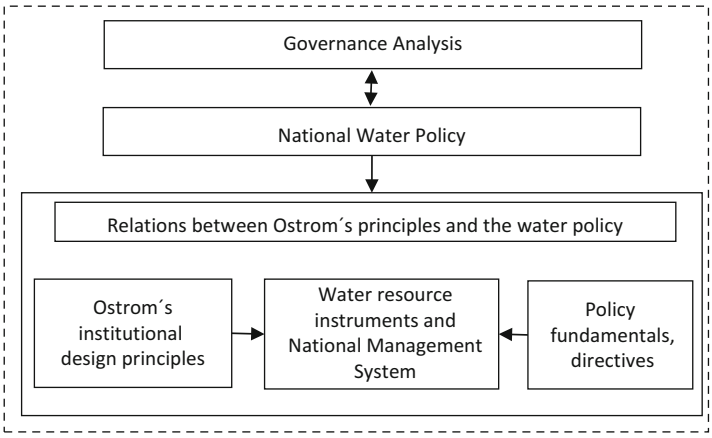

Fig. 10.5 A summary of Ostrom's principle analysis considering the Brazilian National Water Policy

Table 10.1 presents the results of the analysis, where each institutional principle is presented with the aspects of the case that are consistent, or not, with the principle.

Table 10.2 shows the main inconsistencies found in the analysis and the principles they refer to. The fragility of the collective-choice arrangements, such as the basin committees and water resources councils, is the most influential factor that challenges governance of adaptation in the case, followed by the lack of enforcement of the water management instruments. The table also shows these factors as nested reasons to the failure of the governance. The biased behavior of water agencies toward centralization can be nested into fragility of the collective-choice arrangements. Problems with monitoring and sanctions can be associated to the lack of enforcement of the management instruments. These types of clustering can help in identifying the most important problems to be addressed toward improving governance of the management system.

The following main conclusions can be drawn from the study:

The analysis of the water policy and management system shows that they are almost completely consistent with the institutional principles proposed by Ostrom and by Huntjens, as a democratic, participatory, and decentralized governance of the water resources. There is only one desirable mechanism not yet considered in the policy and management system: financial compensation to users when they lose, partially or fully, their rights to withdraw water, preventing an equal and fair (re-)distribution of risks, benefits, and costs (Principle 2).

On the other hand, the analysis of the 20-year period (1997–2016) including two drought and one rainy periods shows that the water governance was actually centralized, preventing social learning toward adaptation to climate variability and change. The main causes are identified as lack of enforcement of the water management instruments, deficient monitoring of the management process, fragile

Table 10.1 Results of the institutional analysis

Institutional principle	Consistency	Inconsistency
1. Clearly defined boundaries	Plans, CWR, and WBC: clearly define the CPR capacity (total availability in quantity and quality), users, limits to withdraw, rules, and criteria for water use in case of droughts; this information is of public access	There is lack of enforcement of plans, CWR, and WBC, and BWC is not yet implemented. Withdraw limits were not followed, and unauthorized users did withdraw water from the CPR
	BWC: clearly define charges for withdraw and changes in case of droughts	There is conflict about the reservoir's regularized discharge value between the National Water Agency and the State Water Plan
	IS: collects, processes, and makes available primary data on the CPR	Fragility of committee and councils
2. Congruence between appropriation and provision rules and local conditions	Plans, CWR, and WBC: define the appropriation and provision rules for the basin and CPR generally (plans, WBC) and for each user (CWR). CWR for one user is only approved by the Water Agency if the appropriation and provision rules are justified in relation to the local conditions	There is lack of enforcement of plans, CWR, and WBC, and BWC is not yet implemented
	BWC: defines charges considering congruence between user characteristics and local conditions	Fragility of committee and councils
	Committee and councils: designed to allow engagement with, and strong representation of, groups likely to be highly affected or especially vulnerable	There are no compensation mechanisms for users during exceptional situations, such as droughts
	In exceptional situations, such as droughts, there are adjustment mechanisms to adapt the implementation of the instruments	Equal and fair (re-) distribution of risks, benefits, and costs in case of droughts was not effective (see discussion on water justice in the basin by Grande et al. 2014)
3. Collective-choice arrangements	Committee and councils are the collective-choice arrangements. This principle, and related arrangements, is in the core of the Brazilian Water Policy (decentralization and participation)	Fragility of committee and councils Agencies try to centralize the decision and implementation processes
	Plans are defined and approved by the committee and councils	

(continued)

Table 10.1 (continued)

Institutional principle	Consistency	Inconsistency
4. Monitoring	IS and plans: provide appropriate information for monitoring	Monitoring has not been effectively used to enforce appropriate water use and user behavior or to audit the institutional management system itself
	Committee and councils: must monitor and audit CPR conditions, appropriator behavior, and the execution of the plans; they are accountable to the appropriators; their compositions include appropriators	Fragility of committee and councils
5. Graduated sanctions	Plans, CWR, WBC, and BWC: define graduate sanctions for appropriators in case of rules violation	Sanctions have not been effectively applied
	Brazilian law: defines graduate sanctions for public officials, representatives, and authorities	
6. Conflict resolution mechanism	Committees are the first-instance bodies for conflict resolution, followed by the councils	Fragility of committee and councils
7. Minimal recognition of rights to organize	This principle is in the core of the Brazilian Water Policy (decentralization and participation)	Fragility of committee and councils
	Users and appropriators are free to constitute associations and other collective arrangements and can be part of the committee and councils. CWR and BWC, for example, can be applied to these collective arrangements	Agencies try to centralize the decision and implementation processes
	Plans are defined and approved by the committee and councils	
8. Nested enterprises	Basin Committee and State and National Councils, as well as Basin, State, and National Plans, are designed as multiple layers and nested enterprises	Plans are not effectively implemented
		Fragility of committee and councils
		Agencies try to centralize the decision and implementation processes

(continued)

Table 10.1 (continued)

Institutional principle	Consistency	Inconsistency
9. Robust and flexible process	Users, appropriators, and representatives from government and society form the committee and councils. Committees are also represented in the councils	The 2012–2016's drought demonstrated that this principle is absolutely not consistent
	Policy and plans can be modified by the collective-choice arrangements	Sequential and time dilemmas are not discussed properly. Confidence-building process is weak
	Policy and plans recognize the necessity of integration of intersectoral policies	Fragility of committee and councils
10. Policy learning	Frequent reassessment and review of plans and management instruments, as well as committee and council's composition	The 2012–2016's drought demonstrated that this Principle is absolutely not consistent, particularly considering the occurrence of the 1997–2003's drought
		Fragility of committee and councils

Table 10.2 Main factors challenging governance at Paraíba River Basin

Factor	Institutional principle
Fragility of committee and councils	1, 2, 3, 4, 6, 7, 8, 9, 10
Agencies try to centralize the decision and implementation processes	3, 7, 8
There is lack of enforcement of plans, CWR, and WBC, and BWC is not yet implemented	1, 2, 8, 10
Monitoring has not been effectively used to enforce appropriate water use and user behavior or to audit the institutional management system itself	1, 2, 4
Sanctions have not been effectively applied	5
Equal and fair (re-) distribution of risks, benefits, and costs in case of droughts was not effective	2

committees and councils jointly with a centralization attitude by the agencies, and sanctions not applied to users or to managers.

Actually, Ribeiro et al. (2012), analyzing the participatory process in the Paraíba River Basin Committee, show that, recently, motivation and decision-making capacity were reduced. The authors recognize that "difficulties are increased by the lack of government institutions willing to share their power and/or able to promote public debates, and by the society's traditional lack of involvement in decision making. As a consequence, the very existence of spaces for discussion and participatory decision-making, like the basin committees, does not guarantee the success of the implemented water management model."

10.4 Conclusions and Prospects

This chapter presented Ostrom framework for institutional analysis, applied to a common problem in water resources management: drought management and water supply. The social-ecological system subject of our analysis is located in a region of high climatic and hydrological variability, which can serve as an illustration on what can be found in the future under climate change. The institutional problems present in our case are similar to those present in the efforts for adaptation to climate change. We can close this chapter with a recommendation from Ostrom (2010):

> To successfully address climate change in the long run, the day-to-day activities of individuals, families, firms, communities, and governments at multiple levels—particularly those in the more developed world—will need to change substantially. Encouraging simultaneous actions at multiple scales is an important strategy to address this problem.

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