

# Public Policy Networks in the Pánuco River Basin

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## **Abstract**

An exhaustive analysis of the public policy network in the Pánuco River Basin area of Mexico has been conducted. The objective is to identify the structural conditions within the policy subsystem that promote an integrated, adaptive, and participatory approach to water management, particularly advancing environmental water policies. The approach to this policy network analysis focuses on the characteristics of the community of actors, including both public and private entities, associated with key public issues related to water management in the Pánuco River Basin from 2012 to 2022. Additionally, it examines the nature of interactions, whether cooperative or conflictual, among these actors. Methodologically, the analysis utilizes policy network analysis using secondary sources of information, primarily official documents and newspaper sources. The information obtained was processed using Gephi software. The results reveal a highly centralized policy network, dominated by federal authorities and state governments, with identified conflicts on various issues. This configuration shapes the network as a system of asymmetrical dominance and negotiation, posing a significant impediment to a shift in orientation in the basin's water policy. The presence of conflicts and the centralization of decision-making that hinder greater actor participation in policy design and operational instruments are discussed. The discussion emphasizes the necessity to promote an inclusive and participatory structure that fosters collaboration to advance towards sustainable and equitable water management in the Pánuco River Basin.

**Keywords:** Public policy networks, Basin Management, Water for the environment, Centralization, Participation.

## Introduction

The text addresses a series of fundamental questions related to the public policy network in the Pánuco River Basin (PRC) in Mexico over the past decade. It aims to understand the structural conditions present in this network and examines how the public affairs agenda for water management has been configured at the basin level from 2012 to 2022, a period during which public policy cycles can be analyzed as suggested by the literature (Sabatier, 2010). The study investigates the potential for implementing a shift in public policy towards integrated, adaptive, and participatory water management in the basin, based on the identified structural conditions within the public policy network. Additionally, it explores the feasibility of advancing water policy for the environment in the PRC, considering the structure of this network.

Initially, the work provides a general context on watershed management from a political ecology perspective, articulating the notion of the basin as a hydrosocial territory (Bolens *et al.*, 2017). This conceptual framework is then connected to the policy networks approach, highlighting its analytical capacity to identify the structural conditions of the relationships between the actors involved in the specific policy subsystem for institutional change (Adams & Kriesi, 2010; Ostrom, 1990). In this case, the focus is on water management at the river basin level.

The results obtained are presented in a descriptive phase that addresses the main problems identified through a qualitative analysis supported by Atlas.ti software in the PRC. Subsequently, an analysis of public policy networks is conducted and presented in modules that group policy communities with similar structural conditions, classified by processing information obtained in the previous phase using Gephi network analysis software.

The discussion segment focuses on the configuration of the various policy networks in each module analyzed, highlighting key dimensions such as the concentration of power (centralized versus fragmented networks) and the type of relationships (cooperative or conflictual). It identifies the potential for these structural conditions to influence policy changes or maintain the status quo. Finally, the conclusions derived from the entire proposed analysis are presented.

## **Holistic approach: the political ecology's view of the watershed**

Water is undeniably essential for human survival, socio-economic well-being, and environmental preservation. However, it is crucial to recognize that the nature of water is intrinsically linked to the socio-political interactions within a territory, including dynamics of conflict, cooperation, and negotiation.

In water management, the concept that best facilitates an understanding of these processes is the hydrological basin. At its most basic, it refers to the "natural depression where rainwater accumulates, flows into a mainstream, and eventually reaches a common point of exit, either through storage, runoff, or recharge" (Semarnat, 2018).

From this perspective, a derivative concept emerges: the hydrosocial cycle in the basin (Boelens et al., 2017, p. 86). In this holistic approach, the watershed not only exhibits the dynamics of the natural water cycle but is also shaped by the interactions of society, including political, cultural, and economic aspects, technology, and nature itself.

In this context, the notion of Integrated Water Resources Management (IWRM) is presented as the optimal approach for formulating public policies in this area. Despite being a widely accepted paradigm by governments worldwide, IWRM is not without controversy regarding the content of its practices and the spaces for their implementation. Behind these perspectives on IWRM are two clearly defined policy projects: (1) the set of policy responses grounded in the idea of water as an economic good, and (2) approaches that consider water as a human right. Both projects have influenced decentralization processes and their scope at the regional and local levels, as well as openness to social participation in decision-making, and a utilitarian or conservationist stance towards the environment (Caldera Ortega, Torregrosa & Armentia, 2010).

The community of actors in this policy arena has been predominantly dominated by a coalition that embraces the perspective of "market environmentalism" (Bakker, 2014, p. 474). This coalition, supported by the considerable influence of multinational corporations and financial institutions, promotes the notion that the construction or management of systems for distributing and transferring the volumes of water necessary for territorial, urban, and human development can only be financed with private sector involvement.

These same actors have used the discourse of the human right to water to favor urban centers experiencing economic expansion under neoliberal logic. In this process, the impacts on ecosystems from which the water resource is extracted have not been considered, nor the negative effects on inhabitants who see their territories deteriorate or are deprived of the water that originally belongs to them. All those benefits that humans derive from ecosystems are ecological services, which are maintained through proper management of both the quantity and quality of water (Alpuche-Álvarez et al., 2021, p. 136).

Understanding the reasons behind water conflicts reveals that they are not caused exclusively by the natural availability of water resources in the basin (and beyond). Rather, they are intrinsically related to water management and the resulting distribution, which can be perceived and experienced as fair or unfair by the actors involved. These conflicts also stem from the impacts on water quality or sufficiency needed to maintain ecosystem balance. In other words, conflicts arise because of how water scarcity is addressed and governed (Kloster, 2017, p. 77).

### **Specific focus: policy networks and the water management subsystem**

Building on the previous discussion from the political ecology perspective on the basin as a hydrosocial territory, a medium-range conceptual approach for empirical analysis is now proposed. To this end, the public policy network approach is used, selected for its ability to generate diverse assumptions related to phenomena associated with complex problems, focusing on the structural conditions of interactions between actors (Sabatier, 2010).

State and non-state actors are interdependent on various resources and continually strive to coordinate in order to achieve collective objectives and goals. Sometimes they succeed, but more often they face many difficulties, even encountering conflictive or tense situations that persist for long periods (Ramírez de la Cruz, 2016, p. 20).

Under this premise, the structures of the networks themselves are configured as independent variables, encompassing both the different configurations around the number of actors involved in decision-making and the relations of both conflict and cooperation between them. These relationships are decisive for outcomes, both in terms of institutional change and, more specifically, the effects of public policies. Such policies are understood as structured actions,

formulated and implemented by the public sector, with the support or resistance of non-state actors, whether social or private, who seek to address a situation that has become socially problematic. In particular, the definition of public policy networks by Kickert, Klijn, and Koppenjan (1997, p. 6) is considered, which states that they are "(more or less) stable patterns of social relations between interdependent actors, which take shape around policy problems and/or policy programs."

In this sense, the theory recognizes that the emergence of policy networks is an empirical phenomenon that developed in the last quarter of the twentieth century, a process that arises as there is decentralization of the State towards the market or the societal in the public space. This shift is propelled both by neoliberal reforms and, possibly, exclusively or alternatively, by processes of democratization. That is, by political pressure from civil society to question and break with clearly hierarchical arrangements of authority in the exercise of power (Caldera, 2016; Zaremborg & Martínez, 2020).

Understanding the structure of the policy network can be achieved by configuring two fundamental dimensions: the distribution of power—whether centralized or fragmented—and the type of interactions present—conflict, negotiation, and cooperation. The combination of these dimensions generates six types of policy network structures, as presented in Table 1:

**Table 1.** Types of policy network structure.

<b>Power Distribution</b>	<b>Type of interaction</b>		
	<b>Conflict</b>	<b>Negotiation</b>	<b>Cooperation</b>
<b>Concentration</b>	Domain	Asymmetric Negotiation	Hierarchical cooperation
<b>Fragmentation</b>	Competence	Symmetrical Negotiation	Horizontal cooperation

Fuente: Adams & Kriesi (2010, 145).

These configurations of the policy network structure can be associated with the potential for change, which aligns with the institutional levels proposed by Ostrom (1990) and presented in the upper horizontal axis of Table Two. Additionally, they can be correlated with the speed of these transformations. We refer to serial change when the transformation is radical and gradual when it is incremental (Adams & Kriesi, 2010, p. 156).

**Table 2.** Order of Potential Change from Policy Network Structure

<i>Institutional level/ Content of the change</i>	<i>Constitutional level</i>	<i>Level of Choice</i>	<i>Collective</i>	<i>Operational level</i>
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<b>Type of network structure</b>	<b>General Orientation and Policy Objectives</b>	<b>Organizational Structures, Instruments of Collective Choice</b>	<b>Operating Rules, Organizational Plans, Procedures, Projects</b>
<b>Domain</b>	High potential for maintaining <i>the status quo</i>	Moderate potential for maintaining <i>the status quo</i>	Potential under gradual change
<b>Competence</b>	Low potential for gradual change	Moderate potential for gradual change	High potential for gradual change
<b>Asymmetric Negotiation</b>	Low potential for gradual change	Low potential for gradual change	Moderate potential for gradual change
<b>Symmetrical Negotiation</b>	Low potential for serial change	Moderate potential for serial change	Moderate potential for serial change
<b>Hierarchical cooperation</b>	Low potential for gradual change	Moderate potential for gradual change	High potential for gradual change
<b>Horizontal cooperation</b>	Low potential for serial change	Moderate potential for serial change	High potential for serial change

Source: Authors' own elaboration based on Adams & Kriesi (2010, 157)

In contrast to the original proposal by Adams & Kriesi (2010), it is proposed that maintaining the status quo is a situation more typical of networks of domination—centralized and conflictive—since this configuration favors actors who centralize the network, enabling them to maintain an asymmetrical and hegemonic distribution of power. Thus, all configurations with centralization in the network can only yield scenarios of the status quo's perpetuation and, potentially, gradual change (low or moderate). Sequential changes would be more feasible in environments where conflict is low or moderate, and there are opportunities for negotiation and cooperation among actors.

We associate the normatively preferred change, whether gradual or sequential, with the polycentric management approach proposed by Ostrom (1990), applied at different institutional levels in watershed management as follows:

- At the level of constitutional rules, the core idea is that watershed-centered action is appropriate by providing clarity on the physical boundaries of the natural system. This makes it possible to establish limits for the appropriation and use of water resources, as well as the general orientation of policy based on water security.
- At the level of collective choice rules, it is proposed that the intervention of actors in the basin's territory, from a comprehensive and participatory management approach, materializes mechanisms of collective choice that integrate users in designing strategies for rights assignment, management planning, regulation, participation,

dispute resolution, sanctioning of opportunistic acts by certain actors, and the generation and use of information for decision-making.

- At the operational level, this implies having clear rules in managing water bodies (natural system) or technological systems (storage, regulation of volumes used and distributed) aligned with achieving policy results oriented toward social equity in access and environmental sustainability, considering the limits defined by the basin itself.

### **Description and problematization of the Pánuco River Basin, Mexico**

The Pánuco River Basin (CRP) is located in the central and northeastern part of the Mexican Republic, with a slope in the Gulf of Mexico and with an approximate area of 84,966 km<sup>2</sup>, covering the entities of San Luis Potosí (27.7%), Hidalgo (20%), Tamaulipas (19.5%), Veracruz (12.1%), Querétaro (11%), Guanajuato (6.2%), State of Mexico (2.7%), Nuevo León (0.6%), and Mexico City (0.8%) (Pereyra Díaz, *et. al.*, 2010, 92). Since 2007, the National Water Commission (Conagua) has grouped the CRP into the Hydrological Administrative Region IX Golfo Norte and identifies it as the 26th Hydrological Region (RH).

The hydraulic use is based on an extraction of 4,712 million cubic meters (Mm<sup>3</sup>) per year, which includes agricultural uses (3,549 Mm<sup>3</sup>, which represents 73.4%), industrial (332 Mm<sup>3</sup>, which represents 7%), public-urban (433 Mm<sup>3</sup>, which represents 9.2%) and hydroelectric (12 Mm<sup>3</sup>, which represents 0.3% of the Zimapán Thermoelectric Power Plant on the Tula River. 476 Mm<sup>3</sup> for the rest, which reaches 10.1% in other parts of the basin). Surface water represents 73% (3,092 Mm<sup>3</sup>) of the total water extracted (4,236 Mm<sup>3</sup>) compared to 27% of groundwater (1,144 Mm<sup>3</sup>) (Pánuco River Basin Council, 2018, 20).

**Map 1.** Location of the RH 26 Pánuco River Basin.



Source: Authors' own elaboration based on INEGI (2010).

The Tula, Moctezuma, Tampaón, Guayalejo-Tamesí, Tempoal and Pánuco rivers are the main tributaries. Of singular importance is the Pánuco River with a runoff of 20,330 mm<sup>3</sup> in a total drainage area of 84,956 km<sup>2</sup>, flowing into the coast of the Gulf of Mexico in the coastal area of Tamaulipas and Veracruz but reaching San Luis Potosí, with a dimension of 150 km wide by 285 km long, and an area of approximately 35,000 km<sup>2</sup> (Arroyo Amezcua, 2015).

The idea that the different actors have that "there is an abundance of water" in the Pánuco Basin is an element fed by the declaration of water availability by Conagua, which contributes to a scenario of growing conflict in the immediate future (Peña & Granados, 2021, 11). The potential conflict identified in this research is configured by the territorial heterogeneity within the basin, because although there are humid areas such as those of the northern sub-basins, there are others that are very dry such as those of the Salado, Tamaulipas (zone of influence of two irrigation districts, the 092-A Río Pánuco Unidad Las Ánimas, and the 092-B Río Pánuco Unidad Pujal-Coy), in addition to the fact that there are economically depressed rural areas, or socially marginalized, that have been left out of the infrastructure both for the distribution of water for human consumption, and for productive activities, mainly the ejido lands where the drought scenario is constantly present (Navarro, 2017, 4).

Following this line of development, the socioeconomic dynamism in the territories that are properly in the basin has led to competition for their flows by neighboring population centers

or on the margins of the basin, which some are already taking advantage of, as is the case of the city of Santiago de Querétaro since 2011 from the 120 km aqueduct that transfers 50 Mm<sup>3</sup> of water annually from the Moctezuma River (Granados-Muñoz, 2022), and the city of San Luis Potosí and its conurbation since 2015 with the El Realito Dam located in the course of the Santa María River in a reservoir built in San Luis de la Paz, Guanajuato that transfers 12.23 Mm<sup>3</sup>, but which is also expected in a second stage to bring water to the municipality of Celaya, Guanajuato, in an amount similar to that transferred to the city of Potosí (Conagua, 2017). In 2022, two presidential decrees were published, to reserve water for public-urban and domestic use of 17 rivers in the Huasteca area at the intersection between the states of San Luis Potosí and Tamaulipas for a volume of 147 Mm<sup>3</sup> per year (Presidency of the Republic, 2022a); and the other published in December of that same year to reserve water and exercise "protection, improvement and conservation of hydrological basins Río Santa María 2, Río Santa María 3, Río Victoria and Río Extóraz", to benefit the provision of public-urban and domestic use of 17 municipalities of Guanajuato with a volume of 182 Mm<sup>3</sup> per year (Presidency of the Republic, 2022b).

Another instance of water demand within the CRP involves the flow already concessioned since 2011 to the city of Monterrey, Nuevo León. The Monterrey Water and Drainage Services (SADM) agency obtained federal authorization for a 30-year period for a volume of 473 Mm<sup>3</sup> annually. Initially, this volume was intended to be realized through the Monterrey VI aqueduct project, which was halted in 2017 by the then Governor of Nuevo León, Jaime Rodríguez Calderón, argued concerns regarding transparency in concession processes for aqueduct construction. Additionally, there was significant social pressure and resistance from politicians and social organizations within the state itself, as well as from neighboring states of Tamaulipas, Veracruz, and San Luis Potosí. The projected investment for this endeavor was estimated at 14 billion pesos, utilizing a mixed investment scheme where the public sector accounted for 20% and the private initiative for 80% (Arteaga, 2015). After the severe drought of 2022 that kept Monterrey in critical days of availability for urban public use of the sources from the surface supply system of the Cerro Prieto, El Cuchillo and La Boca dams, both Governor Samuel García Sepúlveda, and President Andrés Manuel López Obrador, proposed resuming the construction of the aqueduct for the transfer, even to benefit Tamaulipas (Maldonado, 2023).

Faced with the government-imposed paradox of water abundance in the CRH, various analyses suggest that the pressure on the basin due to extraction volume requirements from the mentioned urban centers may not be sustainable (Carbajal Tradacete et al., 2015; Casanova del Ángel, 2017b). On one hand, there are questions regarding Conagua's calculation of an average annual runoff of 19,673 Mm<sup>3</sup> (compared to 971.27 Mm<sup>3</sup> per year of aggregate water reserves and concessions already granted for San Luis Potosí, Querétaro, Guanajuato, and Monterrey). This discrepancy arises due to the problem of annual variability in available flows, with 80% of rainfall runoff concentrated between June and September and the remaining 20% between October and December. Moreover, there is a period of drought from January to May, compelling concessioned users to cease using surface water from the basin during those months of the year (Arroyo Amezcua, 2015). The combined demand for these concessions by 2080 is projected to be 25% higher than the current availability, and where the climate change scenario will increase the dry periods (The Nature Conservancy, 2015, 6).

A criticism from specialists regarding the calculations made by government actors, both federal and state, who have requested flows for their transfers, is that the calculation outlined in NOM-011 by Conagua (Presidency of the Republic, 2015) to determine the average availability of national waters—being precisely annual—does not account for the aforementioned variations. Additionally, the calculation fails to encompass the entire scope of actual availability, neglecting elements such as pollution, the effective calculation of water for the environment (ecological flow), as well as losses due to evaporation or exports, variations in storage in reservoirs, and the inclusion of runoff, returns, and imports (Carbajal Tradacete et al., 2015, p. 17).

In addition to the components of the problematic scenario in the Basin, there is the contamination of the tributaries, since there is the salting of the flow near the mouth of the Pánuco River in the Gulf of Mexico, which worsens precisely in the dry months, and the discharges from Mexico City into the reservoirs of the State of Mexico and Hidalgo. the same discharges and eventual spills of hydrocarbons in the oil zone of Tamaulipas, the industrial discharges of areas of the lower and upper Pánuco (Casanova del Ángel, 2017a).

One final problem to highlight is the institutional weakness of user organization in influencing water policy within the Basin. In August 1999, Conagua established the Pánuco River Basin Council (CCRP), which comprises users of national waters (agricultural, agro-industrial, services, industrial, livestock, and urban public), with an equal number of representatives as the government counterpart. Notably, Conagua is represented through the director of the Basin Agency (Golfo Norte), along with representatives from the states and municipalities of the basin. This structure also encompasses monitoring and evaluation groups and specialized units. At the micro-basin level, users are organized into basin commissions and committees (including those for clean beaches) and groundwater technical councils (COTAS) (Pánuco River Basin Council, 2018, 6).

Administrative issues, primarily the need to update the validity of concessions, dominate the agenda of the Basin Council. Concerns regarding transfers have been expressed marginally, with occasional requests to authorities to address drought and storage infrastructure issues also added to the agenda, mainly by agricultural users (Conagua, 2016). Since 2019 there has been a reduction in support to the Basin Council and auxiliary agencies by Conagua to finance the operational management of these bodies and their day-to-day operating expenses, which has been reflected in the reduction in the number of meetings and actions from these spaces representing the interests of users (Palomares, 2023).

The above is particularly relevant for this analysis, as it pertains to the presidential decrees of June 2018, wherein existing closures in 10 basins of the country, including the CRP, were lifted with the intention of releasing flows to ensure the preservation and conservation of the basin's natural wealth. Basin Councils play a fundamental role in ensuring the allocation of ecological flow volumes is respected. The reserve decrees empower Conagua, based on NOM-011, to determine the average annual water availability and to consider necessary volumes of water for the environment in these basins. Additionally, it is imperative to ensure that Basin Councils establish specialized groups for evaluating and monitoring these reserves, while also contributing to basin regulation and specifying respective management plans (Presidency of the Republic, 2018).

## Methodology

The methodology employed consisted of four stages. The first involved the selection and operationalization of both holistic and specific analysis approaches as described above. The second stage encompassed the search for information aligned with the previously defined objectives. During this step, a review of periodicals accessible via the Agua.org repository (<https://agua.org.mx/categoria/cuenca-del-panuco/>) contributed to a database of approximately 90 documents, comprising journalistic notes, official reports, and academic works, all pertaining to the CRP within the period of 2012-2018. This dataset was supplemented with additional documents to extend coverage up to the period of 2022. This extension was achieved through direct searches conducted within specialized spaces for news and academic articles on internet browsers.

The next step was to obtain information in these documents about actors, events, discourses and situations associated with the CRP in an information processing in the Atlas.ti program. This qualitative analysis yielded eleven topics of discussion and approach in the interaction between actors in the CRP present in the period 2012-2022.

**Table 3.** Issues identified in the analysis of the public agenda in the Pánuco River basin

ID	Theme
I1	Monterrey VI
I2	Hold the Knife
I3	Resuming of the Pánuco-Monterrey aqueduct
I4	Drought
I5	Contamination
I6	El Realito
I7	Irrigation water
I8	Access to water for municipalities in the basin
I9	Hydraulic infrastructure
I10	Hydroelectric
I11	Reserve decrees

Own elaboration based on the analysis in Atlas.ti.

The fourth stage involved conducting a comprehensive analysis of all the actors involved, addressing the identified issues within the specified period. For this relational study, Gephi

network analysis software (version 0.10.1) was utilized, enabling a focused examination to be conducted based on specific topics.

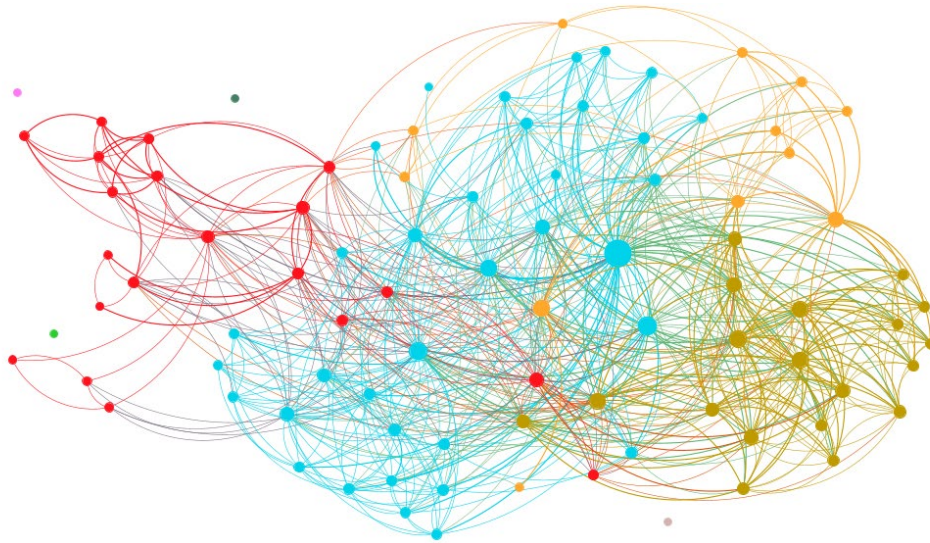
- The tables resulting from the preceding analysis, which served as the basis for subsequent analysis in Gephi, were as follows:
- The first table comprised actors identified in the qualitative analysis for each of the identified topics, with a value of 1 indicating presence and 0 indicating absence.
- The second table depicted interactions among actors, with values: 0 for null interaction, 1 for cooperative relationships, and 2 for conflict relationships.
- In the specific analysis, descriptive statistics provided by the software were utilized to evaluate the structure of the public policy network for each topic. Special attention was given to dimensions of power distribution and the type of interaction present in each case. Detailed descriptions of specific variables are provided within the body of the respective analysis.

A first graphical approach to the network of public policies in the CRP, based on a basic analysis of "modularity," shows us that there is agreement between some of these issues in terms of participating actors and type of interaction.<sup>1</sup> 5 modules or communities with similar distinctive features are identified in the first general graph: on the one hand, there is a community made up of the actors of themes I1, I2, I3, as well as I11 (community in brown, which represents 21%); the actors of themes I4, I7, I8 and I10 (community in blue, 38%); the actors of theme I5, next to I9 (red, 22%); and finally, only the I6 actors appear (orange, 13%).

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<sup>1</sup> Modularity is a measure of the structure of networks that measures the strength of the sharing of the network itself in modules (groups or communities) that have not only connection to each other, but similarity in the number and type of relationships. The connections in these communities are more than just random, but given their similarity they are compact and well-defined (Kuz, Falco, & Giandini, 2016, 94).

**Graph 1.** Communities (modularity) in the policy network in the Pánuco River Basin



Source: Authors' own elaboration with Gephi.

Based on the aforementioned, a synthesized analysis of graphs grouped according to modularity is conducted. In the discussion section, the analysis of graphs by module utilized Fruchterman Reingold's visualization algorithm (or spatial ordering).<sup>2</sup> This algorithm was chosen due to its presentation of symmetry, uniformity of size among other graphs compared in the analysis, and its aid in visualizing the centrality dimension versus the fragmentation dimension integral to the analysis. Finally, a discussion was held concerning the conditions of the public policy network in the CRP to advance an agenda for environmental water security.

### **Results: Policy networks in the CRP and associated issues**

As previously mentioned in the preceding section, the analysis of policy networks in Gephi revealed high levels of modularity among actors across different significant issues. This facilitated the synthesis and presentation of an acceptable number of graphs representative of issues grouped within each community. Communities within modules share a high degree of common traits, which is why these topics are presented together. While there could have been eleven graphs presented, one for each identified topic, due to the high degree of modularity, only four communities (modules) can be presented. The topic of El Realito has

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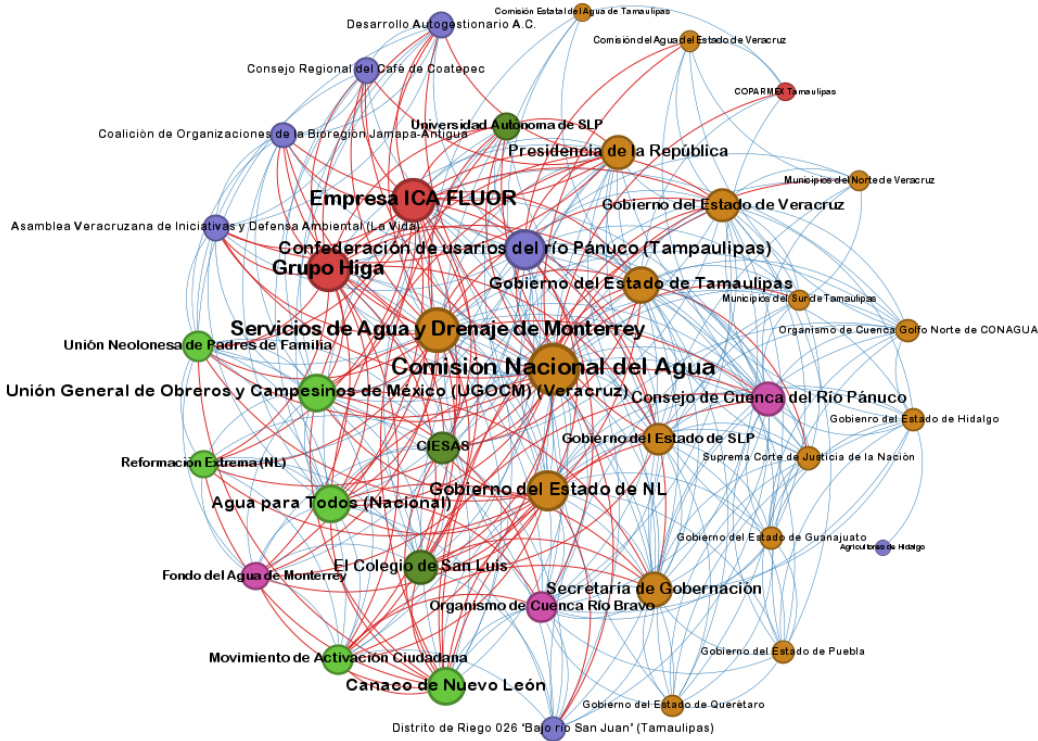
<sup>2</sup> Fruchterman Reingold's algorithm shows us the gravitational force between two nodes and represents how these two are joined forces of both attraction and repulsion (Grandjean, 2015, 5).

been integrated into the Water Infrastructure module (Graph Four), while the issue of reserve decrees (Graph Five) has been separated from the transfer issue to Monterrey (Graph One).

To identify the types of actors involved in each graph, nodes have been assigned colors based on the following categories: government actors (brown nodes), private sector actors (companies) (pink nodes), civil society actors (light green nodes), academic actors (dark green nodes), producer organizations (blue nodes), and finally, collective actors (purple nodes), which represent a hybrid interface of authorities and representatives of water users. The edges represent cooperative and conflictual relations, with the former depicted by blue lines and the latter by red lines.

The first graph (number two) presented groups the issues of transfer to Monterrey from the CRP (I1, I2, I3). The topics included in this graph relate to the construction of the Monterrey VI aqueduct, the El Cuchillo dam, and the recent reactivation of water transportation from the Pánuco to the metropolitan area of Monterrey.

**Graph 2. Transfer network to Monterrey.**

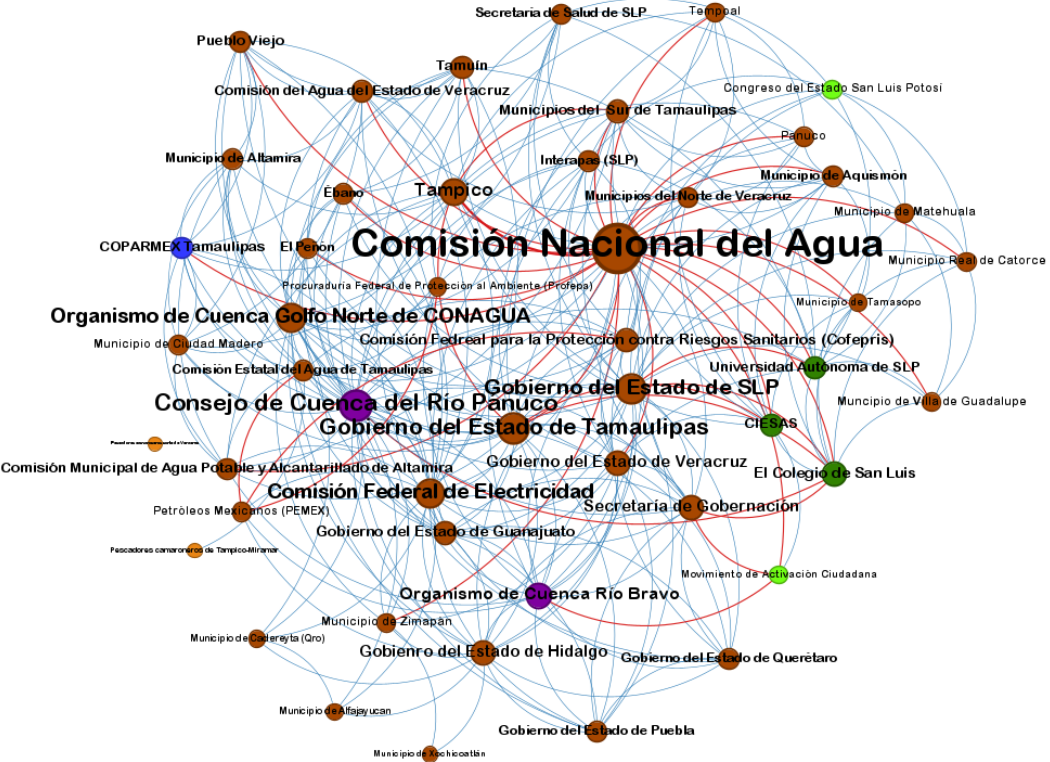


Source: Authors' own elaboration with Gephi.

This graph illustrates the centrality of Conagua as the strongest entity among all others. Additionally, significant centralities are observed within the governments of Nuevo León, Tamaulipas, San Luis Potosí, Veracruz, and Hidalgo, all of which are associated with the federal agency. Notably present is the Monterrey operating agency (Water and Drainage Service), as well as the companies proposed for the construction of the Monterrey VI aqueduct, namely the Higa Group and ICA/FLOUR. Also prominent are the users organized in the CCRP and the Confederation of Users of the Pánuco River, both of which oppose the transfer. Conflictive relations predominate in the graph, particularly resistance from actors such as agricultural producer organizations, civil society organizations, academia, and other users against the centrally positioned governmental actors.

The subsequent graph (number three) addresses the most pertinent issues discussed within the basin, focusing on topics such as drought, irrigation water, and access to water for urban and rural municipalities.

**Graph 3. Water for municipalities in the basin, drought and pollution**



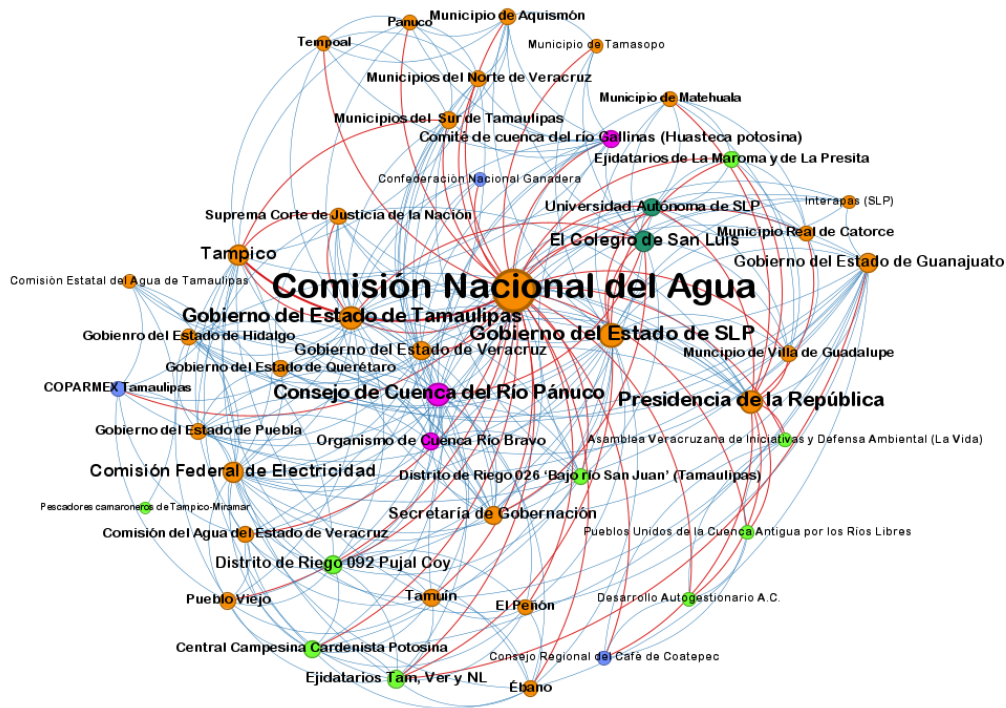
Source: Authors' own elaboration with Gephi.

In these issues, while there is a strong centrality of Conagua, as it is the entity from which everyone seeks resources and support during emergencies when water levels are low, it is also evident that the governments of the basin states play a significant role, along with user representation entities such as the basin council, basin and COTAS committees, and irrigation districts. Furthermore, centrality is observed not precisely at the center of the graph, but rather towards the upper right, indicating a heavier focus on issues concerning access to water by rural and urban municipalities within the basin. Other notable centralities include state governments (lower left), which are also called upon to take action and coordinate with local actors.

This graph also depicts the involvement of many municipal governments, where authorities from other levels of government are also called upon to provide resources and responses to drought emergencies and water access issues in the basin's municipalities. Additionally, there is a significant presence of social actors and academics aligned in advocating for water access in rural municipalities and addressing periods of drought. Actors involved in addressing pollution are situated in the left-central and lower part of the graph, where Conagua's centrality diminishes, and other federal government actors (state-owned productive companies) such as the Federal Electricity Commission or PEMEX are represented.

Graph four addresses the demand for water infrastructure, including issues such as the Querétaro II aqueduct, the Zimapán dam hydroelectric dam, and the El Realito dam.

**Graph 4.** Hydraulic and hydroelectric infrastructure



Source: Authors' own elaboration with Gephi.

In this graph, it is evident that collaboration primarily occurs among authorities at different levels of government, while conflicts arise from civil society and academia, which have sought mediation to resolve conflicts involving entities such as Cofepris, the Ministry of Health, or even the Supreme Court of Justice. Notable are the state governments, particularly those of Tamaulipas and San Luis Potosí, as well as Querétaro, Veracruz, and Puebla, with Guanajuato playing a lesser role. These entities have led negotiations with the federal government, including Conagua and the Presidency of the Republic, regarding infrastructure resources (such as El Realito, the Querétaro II aqueduct, and hydroelectric projects). Civil society actors are less prominent in this graph compared to previous ones, except for producer associations, business groups, and representatives of users and authorities in mixed interface spaces.

Given the importance of environmental issues in this study, graph five highlights the topic of water for the environment. This graph reflects discussions that occurred in 2018 when reserve decrees were published during the final period of President Enrique Peña Nieto's administration.



of all vertices in the network), as well as the average path length within the network (the average distance between all pairs of nodes, encompassing proximity, intermediation, and eccentricity).<sup>3</sup>

**Table 4.** Centrality values in network modules

<b>Module/ Variable</b>	<b>Transfer to Monterrey</b>	<b>Water in the basin (municipalities), drought and pollution</b>	<b>Hydraulic and hydroelectric infrastructure</b>	<b>Reserve decrees</b>	<b>Full Network</b>
<b>No. Nodes</b>	41	49	46	33	90
<b>Middle Grade</b>	16.680	11.755	12.333	11.030	19.957
<b>Average clustering coefficient</b>	0.748	0.664	0.725	0.739	0.688
<b>Average Length/Diameter</b>	1.597/3	1.860/4	1.781/3	1.529/3	1.963/4

Source: Authors' own elaboration based on results in Gephi.

The highest levels of centrality are observed in the modules (actor communities) related to both the issue of transfer to Monterrey and the reserve decrees. While centrality is prominent in all modules, primarily measured by the average clustering coefficient and the average path length coefficient, it is significant across all modules except for water for municipalities, drought, and pollution. The average degree merely indicates the average number of interactions between actors within the network as a whole. A higher clustering coefficient suggests greater cohesion within the network. Conversely, a lower average path length/diameter indicates greater centrality.

In all cases, this centrality is predominantly represented by Conagua, including its regional dependencies (basin organizations), various federal government agencies, followed by state governments, and to a lesser extent, the CCRP. Nonetheless, this centrality is shaped by governmental bodies at all three levels: federal, state, and municipal.

In the water modules for municipalities in the basin, as well as in those focused on drought, pollution, and hydraulic infrastructure, we observe a reduced centrality of the federal

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<sup>3</sup> Intermediation measures the frequency with which a node appears on the shortest path between nodes in the network; proximity is the average distance from an initial node to all other nodes in the network; and eccentricity is the distance from a node to the farthest node in the network (Franco-Bermúdez & Ruiz-Castañeda, 2018).

government, leading towards fragmentation, with a preference towards state and municipal governments. This trend is evident in the average path length indicator within the network, which illustrates the extent of interaction at the network's periphery relative to its center. Similarly, the clustering coefficient indicates a lower value in these modules, signifying a less cohesive network. The diameter value represents the number of levels (or layers of interaction) within the network, where, for instance, in the water module for municipalities, drought, and pollution, we observe four levels of interaction (equivalent to the complete network), whereas in the other three topics, only three levels are present in comparison.

The results for the transfer module to Monterrey align with those of the Reserve Decrees. It is essential to note that the modularity analysis presents them together; however, for the specific purpose of this paper, we have separated them to allow for a more detailed examination and consideration at the conclusion of the discussion section.

The dimension of interaction types in this case is only measured within the conflict-cooperation dichotomy; negotiation relations are not included due to the nature of the available information from the consulted sources. Gephi's measurements rely on the values of the variable "Mean degree with weight" (the average sum of the edge weights connected to each node). The edges are assigned a dichotomous weight: cooperation or conflict, with each edge receiving a value of one or two, respectively. The weighted average degree value indicates both the number of interactions and their respective weights. A higher value of this variable indicates a higher degree of conflict within the network. In a continuum of values ranging from zero to two —assigned to each interaction between actors in the database— a higher value signifies a closer proximity to the maximum value (in this case, two), as opposed to the minimum (which is zero, indicating no interaction).

**Table 5.** Network Interaction Type Values

<b>Module/ Variable</b>	<b>Transfer to Monterrey</b>	<b>Water in the basin (municipalities), drought and pollution</b>	<b>Hydraulic and hydroelectric infrastructure</b>	<b>Reserve decrees</b>	<b>Full Network</b>
<b>No. Edges</b>	344	288	285	182	755
<b>Medium Grade with Weight</b>	45.268	26.612	29.417	28.606	42.348

Source: Authors' own elaboration based on results in Gephi.

Undoubtedly, the issue of transfers to Monterrey stands out as the most conflictive, even exhibiting a value higher than the average grade, which has a strong impact on the entire network. It is followed in level of conflict by the hydraulic and hydroelectric infrastructure module, which addresses issues such as the transfer to Querétaro and El Realito. In contrast, the water module for municipalities in the basin, drought, and pollution is notable for its lower conflict and greater presence of cooperative relationships. The results related to the reserve decrees reveal a low level of conflict, highlighted by a greater weighted weight of cooperation relations and with it the possibilities of change in public policy.

Based on the preceding information, the following table is provided to identify the type of network structure present in each module analyzed in this work, as well as in the policy network as a whole..

**Table 6.** Type of policy network structure in each module

<b>Module/</b>	<b>Transfer to Monterrey</b>	<b>Water in the basin (municipalities), drought and pollution</b>	<b>Hydraulic and hydroelectric infrastructure</b>	<b>Reserve decrees</b>	<b>Full Network</b>
<b>Distribution of power</b>	Concentration	Concentration (moderate)	Concentration (moderate)	Concentration	Concentration
<b>Type of interaction</b>	Conflict	Cooperation	Conflict (moderate)	Conflict (moderate)	Conflict (+) Cooperation (-)
<b>Type of network structure</b>	<i>Domain</i>	<i>Symmetrical Negotiation</i>	<i>Negotiation asymmetric</i>	<i>Domain</i>	<i>Dominance (+) Asymmetric negotiation (-)</i>

Fountain. Own elaboration.

When discussing a network with moderate power distribution, we indicate that power is not solely centralized in one actor, such as Conagua, but that other instances of the federal government or state governments also share this centrality. In this general scenario, the likelihood of change in the public policy subsystem in the PRC is low, with a moderate possibility of gradual change. In contrast, in situations of strong concentration, the clearest scenario is that of maintaining the *status quo*.

It is evident that scenarios characterized by heightened conflict prevail over those of cooperation, resulting in general configurations of political networks primarily characterized by domination and asymmetrical negotiation. This situation only permits gradual changes at the level of operational rules (at the micro-basin level) and rules of collective choice (spaces

for dialogue and mediation of actors' demands, as well as management programs and plans within the basin).

## **Conclusions**

The public policy networking approach has proven valuable in addressing various issues that may arise in a specific territory, such as a large-scale watershed. It facilitates the segmentation of the treatment of public problems, involving diverse actors, both public and private, with different capacities for action, scope, and objectives. The nature of actors' interactions and influence is equally defined by the environments in which they operate, the institutional frameworks that enable or constrain them, and the particular histories that shape them.

A specific observation related to this last aspect includes an agenda complementary to what was addressed in this work, which focused exclusively on the structure of the public policy network. The network analysis tool is essential for studies of this type, as it not only facilitates the segmentation of complex interaction networks but also allows for visual presentation. Moreover, it enables the identification of values that help translate and measure the weight of interactions, as well as the configuration of different governance regimes, beyond formal structures. This is especially relevant in the context of scarce resources, such as water.

Concentrated power generates problems associated with the absence of checks and balances, such as the imposition of positions and the myopia of local problems. Highly centralized policy networks, characterized by permanent or potential conflict relationships, often present a challenging scenario for altering the direction of public policies towards a more adaptive, participatory, and comprehensive management of public affairs.

Any gradual change could be more feasible through the micro-watershed level in terms of regulating interactions. User representation spaces, with greater actor participation, operate minimally and intermittently. Their influence depends on the central authority, which also controls negotiation and dispute resolution spaces. The most significant advocacy comes from government actors and those with the capacity to act on behalf of productive and business sectors.

The general thrust of the policy will continue to promote solutions for expanding supply and transfers to urban centers outside the basin itself. This statement is based on the results

obtained in the set of modules analyzed, indicating that issues associated with transfers outside the basin dominate the public agenda and water policies in the CRP. In the modules addressing transfer issues, the network is configured with highly dominating and conflictive relationships, a scenario conducive to maintaining the *status quo*.

The module or set of topics where change is most possible, albeit gradually, is the one focusing on water for the municipalities of the basin, drought, and pollution. This is due to the greater involvement of municipal governments and civil society actors, beyond economic actors. In this area, greater pressure can be exerted by a diversity of actors, both at the level of micro-watersheds and in the rules governing the operation, distribution, and use of water. Additionally, efforts can be made in the design of spaces for greater formalized and permanent social participation. Public policy orientation on these issues can strengthen a demand-side approach.

It is considered that the hydraulic infrastructure module and its associated issues, despite sharing a scenario of greater concentration of power and conflict relations (moderate), can gradually shift towards a different orientation if actions are taken to enhance demand adjustment and strengthen spaces for expanded participation of actors within the basin itself, who have the capacity to influence the design of public policy.

When examining the issue of reserve decrees individually, a structure of concentration in the central authority persists, but the interaction is characterized by moderate conflict. This opens up opportunities for gradual change at all levels, from operational rules to collective choice rules and the general orientation of public policy, i.e., consolidating the premise of water for the environment.

The approach to water for the environment is emerging; however, paradoxically, its main obstacle lies in the demand for water by cities located on the margins of the CRP. These cities, due to their expansion driven by economic growth and regional integration with North America, require water not only for human consumption but also as an essential economic resource in the dynamics of production and trade in the basin's catchment area. Only a policy network that fosters more adaptive, participatory, and integrated water management governance can simultaneously contribute to advancing the water agenda for the environment and recognizing the human right to water.

Therefore, the great opportunities lie in: 1) materializing the necessary instruments, such as regulations and management plans, in accordance with the reserve decrees; and 2) encouraging actors and organizations to establish the necessary counterweights of collaborative governance to define and uphold the right to access safe drinking water and sanitation, as well as the right to a healthy environment. These opportunities unavoidably require the participation of social and economic actors in institutionalized spaces of representation during the design of public water policy instruments. The social, economic, and environmental benefits for all users, including the environment as a supplier, depend on managing water as a holistic resource where each and every one of the multiple interactions established around water is considered.

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