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Articles

Structural breviary about the social construction of scientific water knowledge at Mexico: An approach

Breviario estructural sobre la construcción social del conocimiento científico hídrico en México: una aproximación

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Abstract

The unbridled forces in play that are undermining our social fabric (climate change, pandemics, poverty) erode societies' capabilities for resilience. Hence there is an urgent need to evaluate the strengths of institutional and community systems in vital areas such as water management. This research analyzed part of the social structure responsible for generating scientific knowledge pertaining to water resources in Mexico, taking into account the organizational patterns pre-established by experts, in order to determine the strengths and weaknesses of the existing structures. We used the social networks approach, which revealed a system permeated by patterns of social centralization that limit knowledge sharing and social cohesion and produce very little innovation within the water resources investigation networks in Mexico. We conclude that it is necessary to expand the training and managing of intellectual capital in various areas of knowledge related to water resources, especially those that are relevant for recuperating environmental sustainability.

Keywords: Social structure, water research, social resilience.

Resumen

Los sistemas de desestructuración social (cambio climático, pandemias, pobreza) erosionan las capacidades de resiliencia de las sociedades, por lo que es apremiante revisar la solidez de los sistemas institucionales y comunitarios en sectores sensibles como la gestión de agua. Esta investigación analizó parte de la estructura social responsable de generar conocimiento científico hídrico en México, considerando los patrones organizativos preestablecidos por los especialistas, a fin de constatar fortalezas y debilidades sociales en dicha estructura. Se utilizó el enfoque de redes sociales, evidenciando un sistema permeado de patrones de centralización social, por consecuencia, capacidades acotadas en la compartición de saberes, baja cohesión social y un bajo nivel de innovación en la red de investigación hídrica en México. Se concluyó que es necesario ampliar los procesos de formación y gestión de capital intelectual en las distintas áreas de conocimiento hídrico, especialmente en la recuperación de la sostenibilidad ambiental.

Palabras clave: estructura, investigación hídrica, resiliencia social.

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Introduction

A community's sustainability is based on the way it conserves, utilizes, and protects the natural resources necessary for current and future social reproduction. Water resources, given their strategic nature, substantiate this fact. Therefore, anything that interferes with the water supply is related to the breakdown of ecosystems, food supply systems, and the conditions required for human development (Soares & Sandoval-Ayala, 2016). In this context, and in times of climate change and health emergencies, it becomes imperative to analyze the processes that have an impact on water management.

Between 2004 and 2017, the number of people in the world without access to a reliable source of water rose from 1 100 million to 2,200 million (PNUD, 2006; UNICEF, 2019: 49). This is mainly due to population growth and hence the growing need for food and water. Between 2019 and 2050 the world population will grow from 7,713 million to 9,735 million inhabitants and increase the demand for food by 60 % (UN & DESA, 2011; UN & DESA, 2019). Food production systems will face unprecedented pressures, particularly in terms of the availability of water. According to UNESCO (2016: 22) and the FAO (2012: 29), agriculture absorbs 70% of the world's fresh water. The figure rises to 90% in "less developed" countries with scarce rainfall. In "developed" countries, with high incomes, the rate of extraction is 42 %. However, according to the FAO (2012: 29-30), an extraction rate above 40 % is considered to be "critical". The World Bank (2016: 23) estimates that due to the pressures of population growth, the water consumption for agriculture will have increased by 50% in the year 2050. Furthermore, the OECD predicts a 55% rise in the overall demand for fresh water, with significant increases in manufacturing industries (400%), thermoelectric power generation (140%), and domestic use (130%) (OCDE, 2012b). This rise in demand will produce more competition and lead to a decline in the volume of water available for agriculture and food production. Pressure on the water supply will also increase because of declining quality as a result of the growing "civilizational" process. Tributaries have historically been channels for the circulation of waste generated by human activity, but indiscriminate discharges and little treatment of contaminated water have led to their increasing degradation (Rivera, Chávez & Rivera, 2018). According to the OECD (OCDE, 2012a), agriculture contributes to this with nutrient leachate, pesticides, animal and livestock waste, erosion and sedimentation of soils, and nitrates derived from fertilizers. The high agrochemical agriculture of OECD countries contributes 40% of the nitrogen and 20% of the phosphorous found in fresh water. In each case, it will be 20% more by 2050 (OCDE, 2012).

According to UNICEF and OMS (2015: 43), in 2012, approximately 1,800 million people in the world used a source of potable water that was contaminated with fecal pathogens. In 2015 the figure had risen by 22.22 % (UNESCO, 2019: 20). One of the direct causes of this is that in developing countries more than 80 % of waste water is discharged without any treatment (Rivera *et al*., 2018), despite having some infrastructure for it. For example, in Mexico, slightly more than 50% of waste water discharges are treated, but the remaining 49.8% is released directly into bodies of water (Conagua, 2014: 104) where it contaminates other resources (soil, agricultural systems, etc.) and provokes human health problems such as viral hepatitis, typhoid fever, cholera, dysentery, as well as conditions resulting from the consumption of pathogenic chemicals (arsenic, nitrates, or fluorine). There are hydrological basins that have accumulated significant levels of contamination and risk for the population due to the high amounts of pollutants in the water (The & Blomqvist, 2017; Pérez-Castresana, 2017; Mejía, Bustamante, Vargas, Olvera, & Méndez, 2017). This has produced an excessive number of "dead" and/or abandoned rivers, breaking down many *hydrological dialogues* and interactions communities have had with their water sources and waterways (Chavelas, 2019; González, 2016; Legorreta, 2013). This is replicated in other regions, like Central America. In Costa Rica, most of the population receives water from underground sources that have been compromised as a result of nearby agricultural and urbanization processes. Approximately 80 % of the population expels their domestic wastewater through septic tank systems that are discharged to sanitary sewers or directly to surface water bodies. Only 37 % of this water is treated and 63% is discharged as raw water (Valverde, 2013). Furthermore, the intense use of fertilizers and pesticides in agricultural production, in zones with highly permeable soil, places Costa Rica among the leading countries in agrochemical use (Fonseca-Sánchez, 2019; Valverde, 2013; FA0, 2011). The levels of water contamination have caused outbreaks of diarrhea and dengue in the population, however, there is no mapping of the risk levels (Madrigal-Solís, Fonseca-Sánchez, Núñez-Solís, & Gómez-Cruz, 2014). The situation is made worse by the growing extraction of water, beyond the capacity for replenishment (Valverde, 2013). In El Salvador 68.7% of sewage water is discharged into bodies of water without any type of treatment, enhancing the presence of various pollutants (fecal coliforms and Escherichia coli, atrazine, nitrates, etc.) and provoking gastrointestinal diseases (gastroenteritis, dysentery, cholera, typhoid, etc.) (Quiñonez, 2017: 36; UNESCO & PHI, 2006: 82; Sanfeliú, 2001). Intestinal parasites, diarrhea, and gastroenteritis of infectious origin are among the main causes of morbidity, and the sources of organic contamination come mainly from the food and beverage industry (UNESCO, 2006: 281; PNUD, 2003).

Water supply problems are not very different in developed countries, but the rate of growth of these economies means that the people are hardly even aware of the fragility of their access to suitable water and the impact this could have on the development itself. At the beginning of the 20th century, London, New York, and Paris had rates of infant mortality similar to those that currently exist in sub-Saharan Africa, due to the high incidence of infectious diseases, diarrhea, dysentery, and typhoid fever, as well as an incipient public health system. Improvement was achieved through the increased sanitation of public services, significantly raising life expectancy (PNUD, 2006: 5). The drop in the mortality rate in the United States during the first third of the 20th century was achieved thanks to greater access to purified water, which produced, for the first time in the country's history, a rapid decline in the mortality rate (PNUD, 2006: 31).

This is a clear indication that access to clean and sanitary water multiplies favorable conditions for social reproduction while the lack of this resource can generate complex systems burdened by social contradictions. For example, scarcity and inequitable distribution of water (for geographic-environmental and/or anthropogenic reasons) (Figure 1) is provoking a map of inequities among countries and regions, thus transforming the nature of water, from being a natural resource of universal access, and converting it into a marketable geopolitical resource (Pacheco, 2014; Murillo & Soares, 2013; Padilla, 2012). This increases the pressure on the availability of water and feeds the possibilities for scenarios of confrontation and widespread destruction of the potential for human development in many regions.

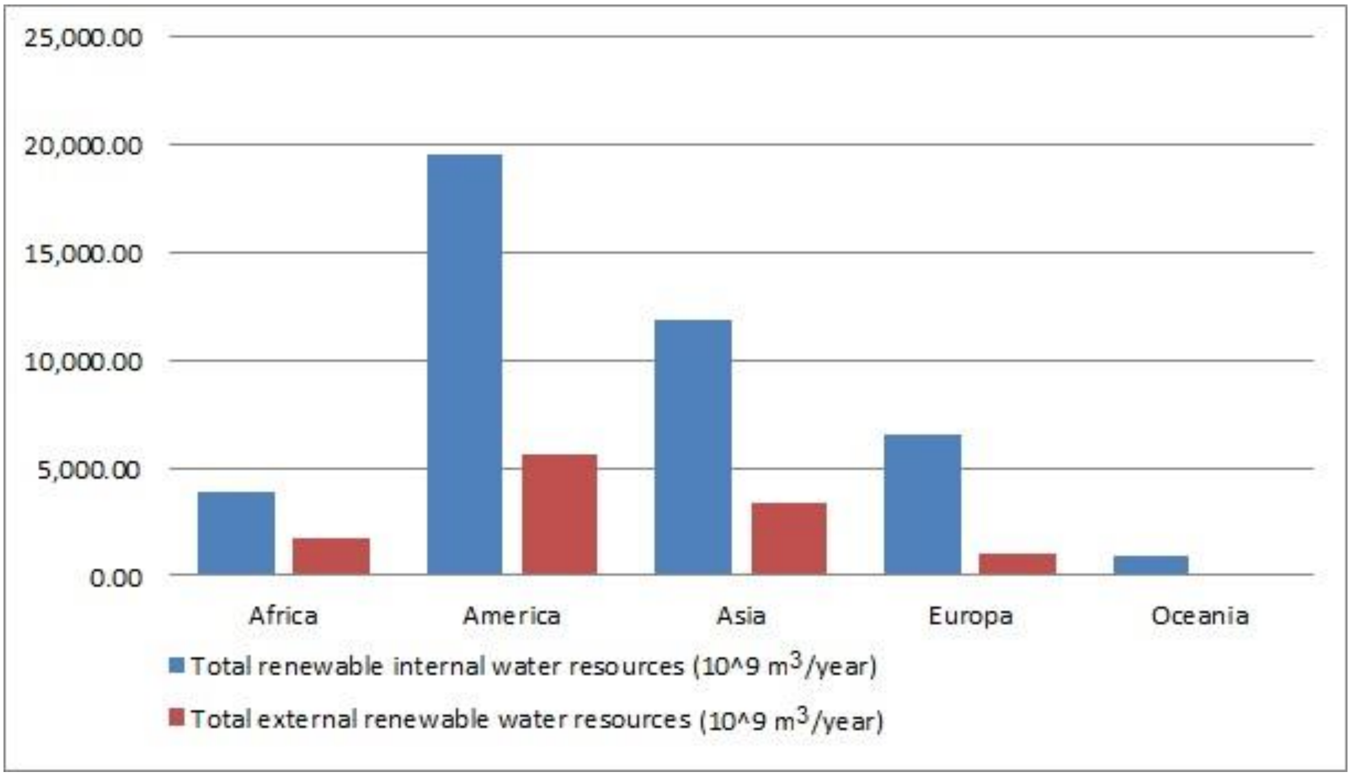

Figure 1. Regional comparisons of water renovation capabilities worldwide 2013-2017. Elaborated with data from the FAO (2016).

For at least the past 4,500 years, scarcity of potable water has been historically related to political instability and violence, within and between communities (Wolf & Giordano, 2003). The distribution of this resource, in terms of its volume, demand, and political factors, makes it possible to identify contemporary society's most fragile and complex zones (Portillo, 2008). Currently, approximately 3 125 environmental conflicts are going on in the world, 21% of these are related to access to water, and mainly occurring along the west coast of the American continent, from the south of Chile to the San Joaquin Valley in the USA, the east coast of the Adriatic Sea to Egypt's Mediterranean coast, the Pakistan-India-China Himalaya mountain range border, India's east coast, up to Bangladesh, and connecting with southeast Asia (EJAtlas, 2020) (Figure 2). Many of these conflicts occur in politically convulsed areas where disputes over control of territories and resources coincide with border zones between countries. This brings into play other factors like nation state's sovereignty and/or the distribution and allocation of their natural resources (Pacheco, 2014).

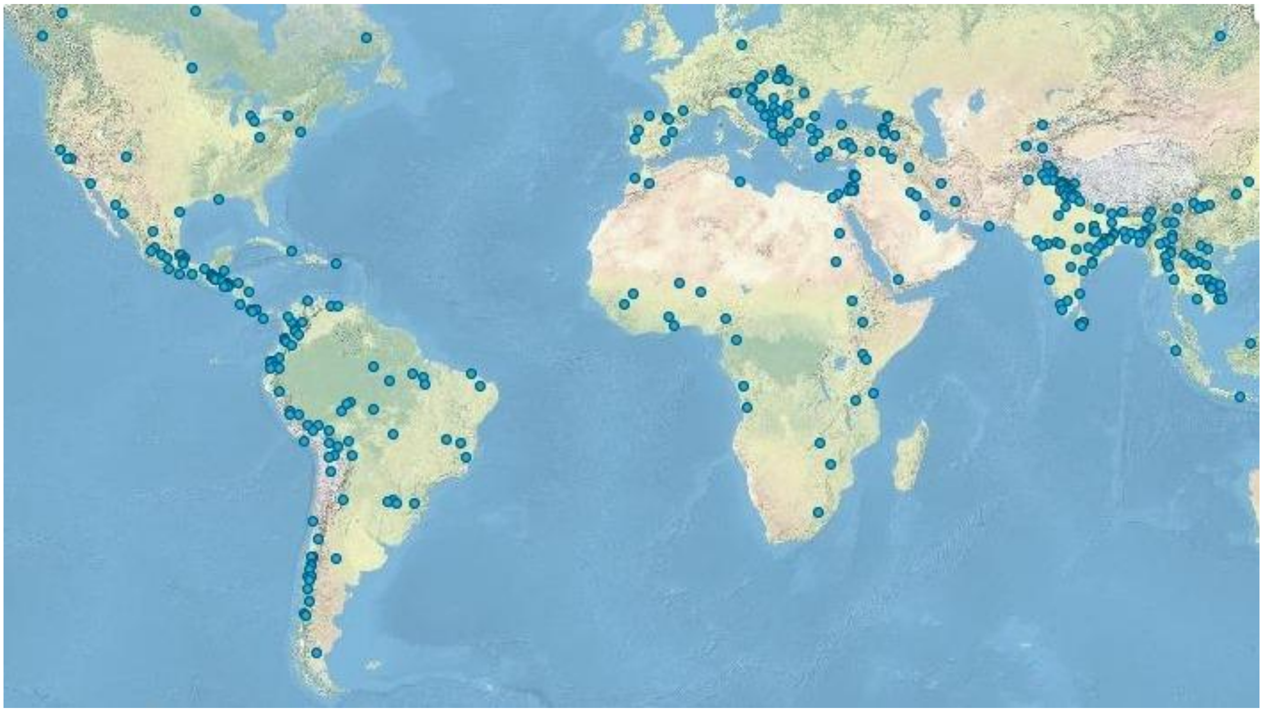

Figure 2. Water conflicts in the world (EJAtlas, 2020).

Many of these disputes seem to have no solution (Johnson & Duffy, 2014; Walter, 2003), since they are rooted in long-standing historical conflicts, and precarious systems of geopolitical balance, in overpopulated regions with low human development indices and where resource extraction affects local biotopes as well as various communities (PNUD, 2004: 92). In this sense, social decomposition is directly proportional to the degradation (and lack of availability) of drinking water and vice versa. Despite this, many of these conflicts have been "dismissed" (temporarily) due to collaborative processes or other social phenomena (Wolf & Giordano, 2003). Documentation of approximately 600 international water treaties, since the 19th century (OSU, 2020)

(Figure 3), indicates areas where such conflicts have been mitigated, but, at the same time, factors that can potentially detonate socioeconomic contradictions are still present. One example is the case of "collaboration" agreements to distribute water based on commercial criteria. In this case, part of the water distribution processes, along anthropogenic borders, have historically been associated with commercial factors (trade, economic relations, etc.), at least since the end of the 19th century (OSU, 2020). Currently, Free Trade Agreements, among countries and/or regions, constitute one of the mechanisms by which poor countries, with natural resources, transfer their water resources (under unequal terms) to other countries and/or transnational corporations, thereby generating new social contradictions (Mazabel-Domínguez, Mendoza-Fragoso, & Macías-Gloria, 2013; Sanz, 2006).

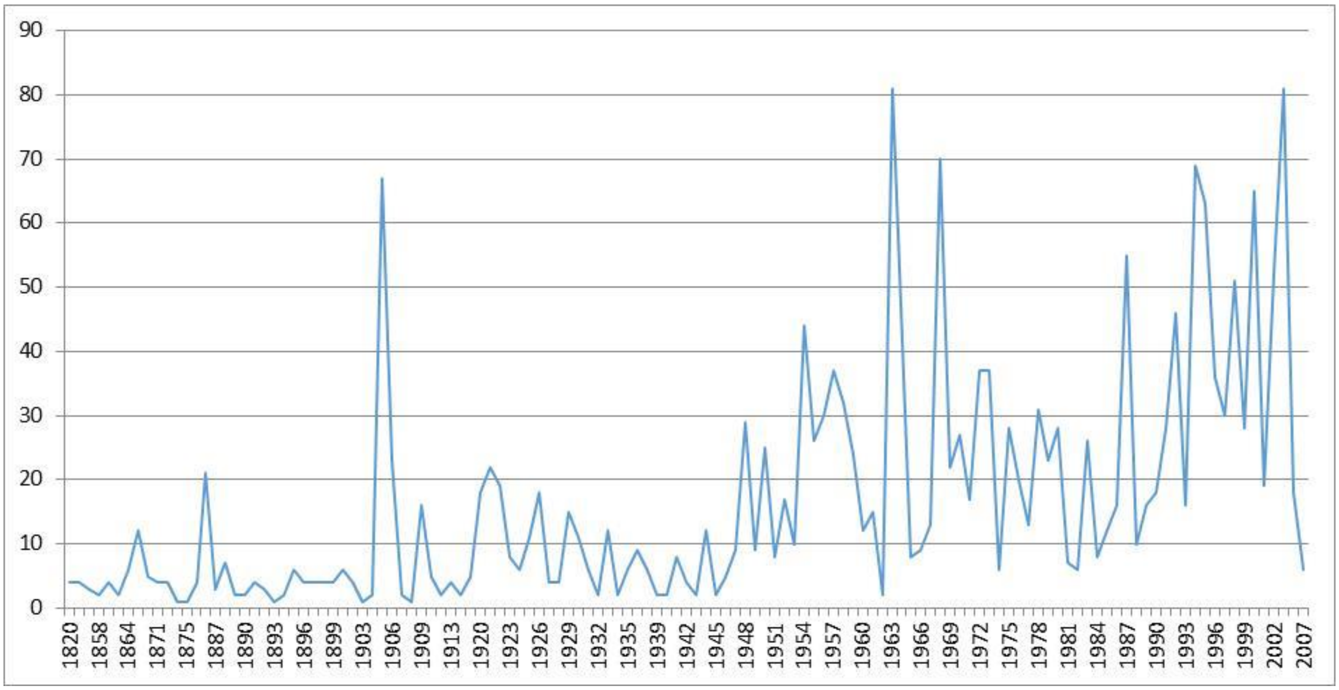

Figure 3. Water treaties in the world (1820-2007) (OSU, 2020).

These dynamics were exacerbated by the neoliberal development model, which, since the 1980s, promoted the State's withdrawal from social responsibilities. This led to deregulation of the economy, privatization of public goods, internationalization of capital, and deregulated extraction and commercialization of natural resources (such as water) (Harvey, 2007). Over the next thirty years, this model revealed itself as a false escape from socioeconomic pressures and lack of regional development, thereby exacerbating structural social decomposition and increasing the number of risks to be confronted (Ornelas, 2000; Sanz, 2006; Beck & Rey, 2002), among these, the number of water disasters (UNESCO, 2019). According to CRED (2020),

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87.58% of the registered twentieth century's water disasters took place during this period (1983-2019). (See Figure 4).

Figure 4. History of water disasters worldwide (1950-2020) (CRED, 2020).

Water vulnerability: a social construct

The process of privatizing water implied re-signifying and recoding it according to commercial criteria, directly expanding the mechanisms for accumulating (natural) capital through dispossession, facilitated (albeit legally) through national and international institutional spheres (Gómez, 2014; Mazabel-Domínguez *et al*., 2013; Sanz, 2006; Leff, 2004). The objective was to appropriate not only the means of production, but also even the ecological conditions (both macro and micro) necessary for production (March 2013; Leff, 2004), by controlling watersheds, ecosystems, and agroecosystems, and privatizing territories and bioregions in a variety of ways: diverting, transferring, and containing bodies of water (dams, waterways, rivers) for urban and industrial areas; "collateral" privatization because of contamination (industrial, biological, salinization, fracking), making it impossible for others to use; privatization (and technological monopolization) of extraction and purification services, and the sale, distribution and bottling of water (Mazabel-Domínguez *et al*., 2013). This implied re-signifying water as a commodity with exclusive access and differentiated prices, thereby violating communities' fundamental rights and their capacity to manage their natural resources, destroying ways of life, culture, and local economies, fomenting social discontent in large regions of the world (Méndez & Fuente, 2020; Sanz, 2006), and what the UNDP (PNUD, 2014: 3) has called the global erosion of the social contract.

This is related to the breakdown of water management models, where the global water problem merges with situations prevailing in various communities, feeding into more general problems: scarcity, overpopulation, overexploitation, contamination, diseases, etc. The result is an entropic glocal water system (Robertson, 2003) with multiple feedback mechanisms that affect countries and subcontinental basins, producing growing water deficits and gaps (2030 WRG, 2009; PNUD, 2006) (Figure 5). Therefore, we can list cities that might be left without water sometime during the next ten years: Cape Town (Africa), Sao Paulo (Brazil), Bangalore (India), Beijing (China), Cairo (Egypt), Jakarta (Indonesia), Moscow (Russia), Istanbul (Turkey), CDMX (Mexico), London (England), Tokyo (Japan), and Miami (USA) (BBC, 2018).

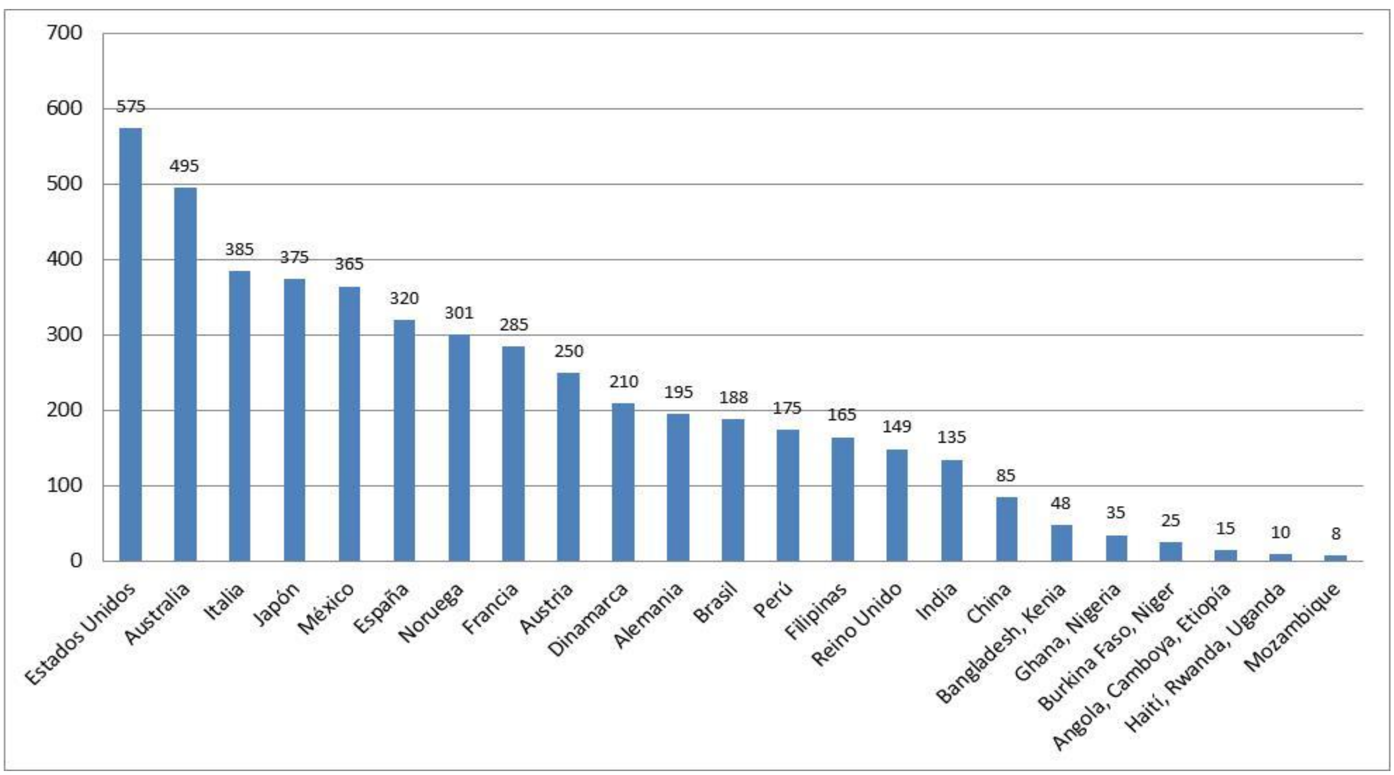

Figure 5. Worldwide water uses gaps. Average per capita water use (liters). Elaborated with UNDP data (PNUD, 2006: 34).

Latin America comprises 15% of the planet's surface, has about 30% of the world's rainwater harvesting capacity, and generates 33% of global runoff, which is enough to supply 28,000 m³/inhab. of water, per year, to its current population, which is less than 10% of the world's population. This is higher than the general average (8,000 m³/inhab./year) (Ávila, 2002; FAO, 2000: 15). However, the distribution and access to these water resources are differentiated (geographically and environmentally) and predetermined (socially, economically, and geopolitically) so there is an inter-regional water imbalance that generates a map of potential socio-environmental tensions in the medium or long run, primarily along the Pacific coast (Temper, Bene, & Martínez, 2015; Ferro, 2013). This water imbalance coincides with the socioeconomic vulnerability of Latin American countries, where deficient institutional systems exist alongside the excessive extraction of natural resources. This increases the risk indexes (PNUD, 2014: 119) and generates a regional system, in decline, in terms of the management and availability of water (Figure 6).

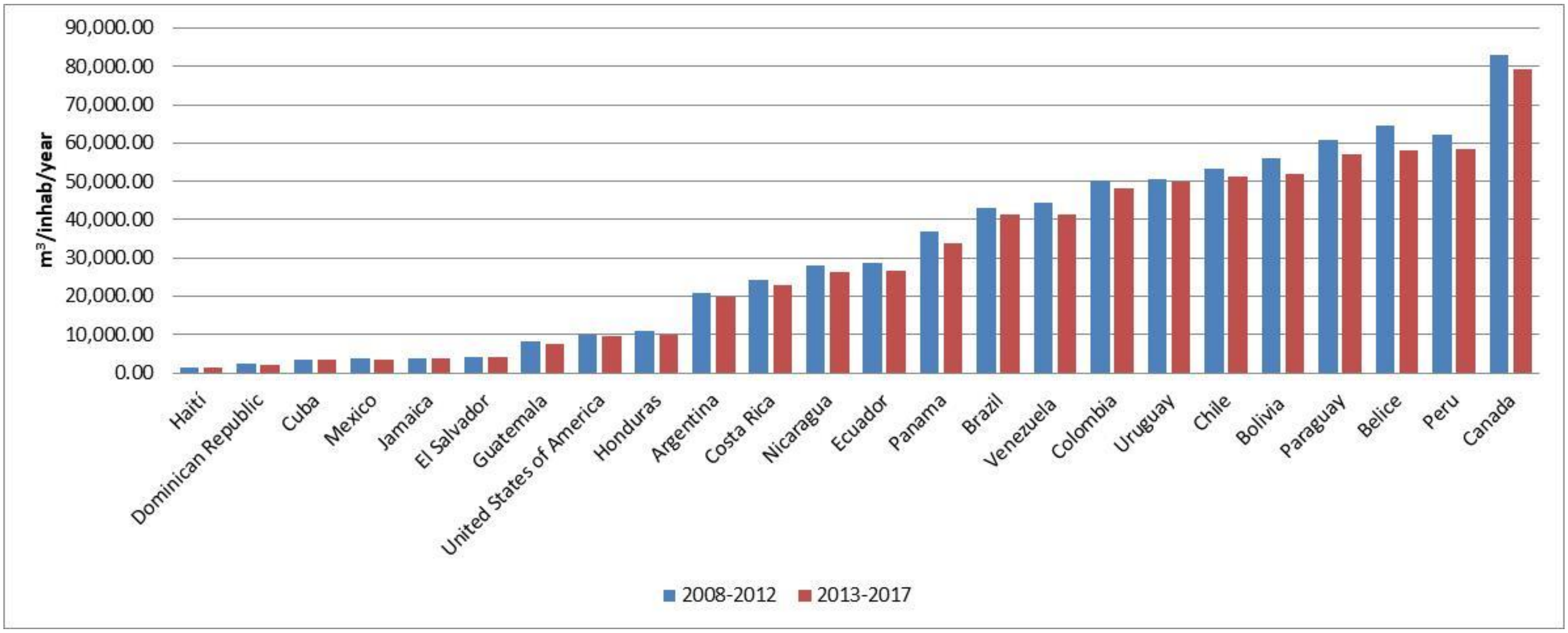

Figure 6. Total availability of water resources per capita in Latin America (two five-year periods). Elaborated with data from the FAO (2016).

According to the Water Availability Index (Falkenmark, Lundqvist, & Widstrand, 1989), the accepted standard to satisfy a society's basic water requirements (agriculture, industry, energy, and environment) is 1,700 m³/inhab./year. When the indicator falls below this level it is referred to as periodic or limited water scarcity, and, therefore, water stress (Ballestero, Arroyo, & Mejía, 2015: 12). One of the main countries that are closest to the limit of water scarcity in Latin America, based on its global (total) renewable water resources, is Mexico (4,850 m³/inhab./year) (FAO, 2000). According to the FAO (2021), water stress, in this country, has grown from 28.3%, in 2002, to 32.95% in 2017. Given Mexico's social importance in Latin America (7° in Human Development Index - HDI), its economic position (3° in the region), as well as its geographic, environmental, and population significance (20% of the region's population) (CEPAL, 2019; PNUD, 2020), a crisis of this nature would have unprecedented repercussions throughout the region. Furthermore, Mexico's water vulnerability has been socially and historically constructed over the past 40 years, having lost 60,000 hm3 of the strategic underground water reserves as a result of over exploitation, which currently occurs at a rate of 5,400 hm3 per year. In 1981 there were 36 overexploited aquifers. By 2013 there were 106, extracting around 60% of the underground water (Romero, Palacios & Escobar, 2017; Escobar-Villagrán & Palacios-Vélez, 2012). This is producing an untold and enormous gap in the country's supply of renewable water resources (Figure 7).

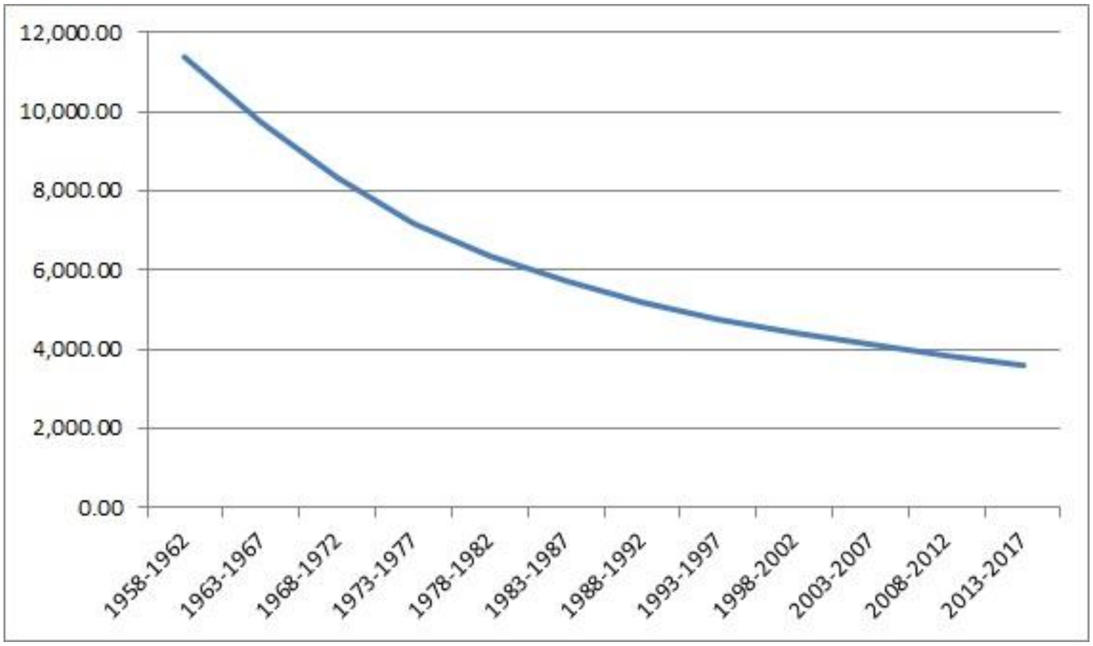

Figure 7. Total renewable water resources per capita (m³/inhab./year) in Mexico. Elaborated with data from the FAO (2016).

This is an indicator of the disparities in the available volume of water per capita in Mexico. Some areas can already be classified as having high water stress. Considering the impact of climate change, marginalization of some southern and northern regions, and the expansion of urban centers and agricultural irrigation systems, the resulting picture is one of a national water crisis linked to various local and regional conflicts (Armendáriz, 2020; Martínez, 2017; Kauffer, 2017; Campos-Cabral & Ávila-García, 2015; Pacheco, 2014; Becerra, Sáinz, & Muñoz, 2006) along with institutional breakdown generated by the privatization and neoliberal decentralization of Mexico's public sector (OCDE, CAF, & CEPAL, 2018: 256; Fix, Flores, & Valadés, 2016: 167;

Dabat, Leal, & Romo, 2012; IIJ-UNAM, 2011). A noteworthy combination of political-normative, economic, technological, as well as urban-population factors has all contributed to this breakdown (Briseño & Sánchez, 2018; Lahera, 2010). Based on all of this, it seems that the conflict has escalated and spread to the structural and glocal levels.

That raises questions about the degree of vulnerability of Mexican society and its capacity for resilience upon having placed itself in this situation of risk. Resilience is an important community asset that brings into play the collective capacities for innovation, collaboration, and protecting and managing the resources (natural, intellectual, and cultural) that enable adaptation in the face of catastrophic (de-stabilizing) events, to recover and, later, recuperate certain stability and cohesion of human nuclei, maintenance of material goods and functionality of communication among its members (Acosta, Chandra, & Madrigano, 2017; Byanyima, 2014; McManus *et al.*, 2012). Some aspects of a society's resilience can be inferred from the responsiveness of its institutional and communal systems in areas such as 1) Democratization of the information and knowledge generated to improve and/or restore these capacities; 2) Creation of policies and programs that protect the citizenry by absorbing those radical changes in the environment that could de-structure the local social model (as well as the economic, cultural, technological, environmental, etc., ones); 3) Capacity to reformulate and innovate the organizational model itself (Frankenberger, Langworthy, Spangler, & Nelson, 2012: 10; Sampedro, 2009; Hamel & Valikangas, 2003; Bell, 2002). In contrast to this, deficient institutional systems undermine the capacity for resilience

(PNUD, 2014: 119), so the breakdown of Mexico's water management system would seem to indicate a breakdown at the institutional level.

About this, we suggest that a central component of this anthropic water deficit is derived from the institutional systems responsible for managing the country's sustainability (planning for the extraction of and reinvestment in natural resources). While a water deficit may be related to natural phenomena such as droughts, the issue of water scarcity is directly related to the unmitigated extraction of this resource accompanied by unequal access and distribution (Padilla, 2012). In other words, a social construct where the anthropic environment is randomly connected with the natural environment (Garza, 2004; Meli, 2001:7), in a way that generates unpredictable and accumulative degrees of vulnerability in terms of the populations' assets and means of livelihood (Soares & Sandoval-Ayala, 2016; Blaikie, Cannon, Davis, & Wisner, 1996). The FAO (2012:30) points to three variables that have an impact on this social construct: a mismatch between supply and demand, insufficient infrastructure to satisfy the water demand, and institutional deficiencies for guaranteeing safe and equitable access. This context suggests that the country's water vulnerability is due to the presence of social and institutional systems of unequal distribution of Mexico's water resources.

This indicates the need to address water supply problems taking into account the presence of systems that magnify the deficiencies of the institutional capacity for water management. It opens the possibility of characterizing the social dynamics of the institutional subsystems responsible for this. One of these is the scientific-academic sector which has an impact on the country's water research and management processes. In this respect, the following are some legitimate concerns: What are the organizational patterns that prevail in the social structure of specialized research on water issues? What are the main scientific areas explored by this structure and its possibilities for resilience, given the breakdown of the social systems for water management? This research aims to discover and analyze the structural elements of water research in Mexico. We do not pretend to cover "all" research on water in this country, since that is far beyond our possibilities. We aim to propose a methodological approach for dealing with a complex issue in the face of totally unprecedented scenarios.

Methodology

The complexities involved in assuring availability and access to water resources reveal a set of coincidences. All societies are or will be in the short or medium term, moving towards the need to analyze the sustainability of their water management systems. Therefore, it is necessary to think about the institutional subsystems responsible for proposing the metrics, parameters, and/or the alternatives that will be used for this purpose. One of these is the scientific-academic subsystem, which is involved in the formation of institutions, human resources (technicians, researchers, government officials, etc.), and theories that will have an impact on the social construction of the water management system. This social sector has certain requirements and characteristics, and, like all social systems, it has organizational structures (both formal and informal) and is set in motion by behavior patterns derived from traditions, beliefs, and reasonings practiced among individuals (Alpuche & Bernal, 2015; Suárez, 2008). One social action affected by this is scientific collaboration; here (as in other spheres) there are underlying social structures, manifested subjectively, and expressed as a habitat of interpersonal relationships, where filial valence determines the degree of a community's social cohesion (Nuñez, 2020).

The analysis of the structural residue derived from scientific co-participation is a growing topic in social research (Molina, Muñoz, & Domenech, 2002), aimed at describing the social agglomeration in specific disciplines and research subsystems. Sometimes generic indexers are used to making inferences, at a general level of agglomeration, about disciplines, research subsystems, and institutions, to understand the structural patterns of the whole set (Ruiz & Russell, 2016; Wezel & Soldat, 2009; Gil & Ruiz, 2009). However, this type of research is often designed by the indexer's methodological, commercial, and political criteria (Devyatkin, Nechaeva, Suvorov, & Tikhomirov, 2018). Therefore, it may present limitations for analyzing these types of social frameworks and their possibilities for structural resilience, especially in specific areas of research on strategic sectors such as water management. In this context, collaboration on scientific production is also an indication of how synergies have developed within the academic community, which are expressions of both strengths and weaknesses. On the other hand, while co-participation in, and/or co-authorship of, scientific works may not express the entire scope and complexity of academic participation, since it is only a part of the process (López, 2010; Russell, Madera, & Ainsworth, 2009), analyzing the co-authorships of a given community does allow us to discover the nature of underlying internal attributes (Molina *et al*., 2002; Troyano, Martínez, González, & Velasco, 2005), and, therefore observe the cohesive behavior and the distribution of social prominence among its members.

This suggests that connections established between scientists are often based on sociability factors (reciprocity, collaboration, empathy, etc.) and spaces for mutual agreement, motivated by the levels of confidence existing among individuals. Therefore, scientific agglomeration (research, teaching, service, etc.) generates an assortative (refers to groupings of persons with similar preferences (see Newman, 2002) indicator for analyzing its structural behavior. Hence, participation in research products, such as publications, is a manifestation of the existence of associative patterns and filial complicity about a basic question. The generation of knowledge is a collective experience produced by researchers grouped in various ways (committees, teams, squads, etc.) who are interacting with each other continuously. They are collaborating, interchanging, and sharing a variety of economic, human, and intellectual resources to achieve certain products, like scientific manuscripts based on a specific associative model, a unique social experience (Milard, 2010) that synthesizes social elements such as diversity, synergy, reciprocity, trust, etc. This expresses, in turn, an inconspicuous structure, nurtured by relationships of filiation and empathy among the members of these groups.

Analyzing this makes it possible to explore the way these collectives are organized, how (and with whom) the research results are shared, to which scientific areas they belong, and from which institutions the research is carried out. This provides access to the sociability patterns underlying these collaboration processes (Mendieta & Ruiz, 2009), making it possible to verify extensive conceptual communities, or schools of thought, that are mainly invisible and dispersed throughout multiple scientific territories. In this sense, even though certain epistemological habitats can be presented as independent from one another (López, 2010), they continually overlap and are combined with others through daily practices of interdisciplinary collaboration. Considering this assumption of scientific agglomeration, for the elaboration of this text we selected a mixed deductive scheme, and for a deterministic sample, for convenience, we used two basic tools.

1. Historical archives of manuscripts published in the journal *Technología y Ciencias del Agua* during the period 2010-2018. These files are publically accessible and available for consultation and analysis at http://www.revistatyca.org.mx/index.php/tyca. The content of these

published works is obligatorily citable. Currently, Tyca is included in various national and international listings of recognized journals for the documentation and dissemination of scientific and technical knowledge in the sciences, such as Journal Citation Reports (JCR), Scopus, SJR SCimago Journal & Country Rank (2007-2020), ProQuest (Cambridge Scientific Abstracts), Scielo, and Latindex, among others. In terms of its ranking, Tyca participates in the Conacyt's Classification System of Mexican Science and Technology Journals (CRMCYT). According to subchapter VII. Engineering, Tyca is one of the two Mexican journals that have a Q3 classification; for the Journal Citation Report (JCR) it has an impact factor of 0.29 (Conacyt, 2016), and according to the Scopus / Scimago Journal & Country Rank (SJR) its citation ranking is 0.195. It is the only Mexican journal with the Water Science and Technology classification that is in the third quartile (Q3) of the SJR index classification (SJR, 2007-2020). While Tyca is not the only journal that deals with water issues, it is highly specialized in this area and also covers aspects relating to water management, utilization, uses, exploitation, conservation, care, and knowledge of water and other related natural resources like soils and forests, and thereby it reaches into other disciplines such as water and energy, water quality, hydro-agricultural sciences, political and social sciences, water management, hydrology and hydraulics (Tyca, 2020).

Achieving such a citation profile, in the realm of scientific knowledge, indicates a significant degree of confidence, which means it is considered to be a reliable and verifiable source of scientific knowledge pertaining to water. Therefore, many specialists seek to disseminate their research results in Tyca. This degree of certainty and social concurrence expresses a structural valorization for the construction of scientific knowledge. Separating Tyca from a solipsistic notion and conceptualizing it as a social space for the dissemination and discussion of water knowledge, the product analyzed is derived from the social formulas pre-established by the authors themselves and their institutions. This allows Tyca to be considered within the parameters of our research.

Each document published in Tyca provides information on the year of publication, journal number and volume, authors, the authors' institutions and countries of origin, title, themes of inquiry, etc. This permitted us to standardize a list of authors, institutions, and countries, yielding a total of 453 documents, written by 1,274 authors from 259 institutions, with 36 different nationalities. Taking co-authorship of each document as the unit of analysis, the information was organized and systematized in binary, unimodal, and bimodal adjacency matrices, while eliminating single authorships. The information on nationalities, areas of knowledge, institutions, and year of publication, offered a battery of attributes for the relational analysis units: author-coauthor, and area-area. For the latter, 49 adjacent and dependent areas of linkage and research were pre-determined, obtaining overlapping dyads of scientific themes and gnoseological overlap structures. Social Network Analysis (SNA) was used to analyze this information.

2. Social Network Analysis (SNA). Structuralism, mathematical determinism, and visual analytics integrated into SNA, help us

understand the complexity and topological dimensionality of social structures, mainly, through the analysis of the recombination of the relational attributes of the subjects, in a given social environment (López, 2010; Vélez, 2007; Sanz, 2003). Therefore, the unit of analysis is a tandem generated by sets of individuals, the links they establish with one another, and their information flows (Wasserman & Faust, 2013:37; Machín, 2012: 64). We can determine the diameter of a social network by calculating the maximum distance between nodes and the strength or weakness of the ties (Granovetter, 1983). The daily social paradoxes occurring among subjects generate an isomorphic behavior that provides social capital expressed through multiple egocentricities that exponentially produce social affiliation and/or referential structures. That is, the socio-centricity of a social phenomenon is an algebraic expression of the egocentricity of social bonding. Therefore, attributes such as cohesion, collaboration, bonding, dispersion, etc. can become measurable and analyzable units allowing us to evaluate research groups' communicational efficiency and innovation in their management of resources (social, intellectual, etc.). Henceforth, the greater the diversity of social ties, the greater the social density, and therefore, the greater the capacity for collaboration and management of potentialities (social, political, economic, etc.).

For this, part of the SNA's conceptual apparatus was used to express the centrality and grouping of the actors based on their environment:

1. The nodal degree (Degree) identifies the actors' social capacities for empathy to communicate, exchange and access privileged information about the events occurring in the network; this capacity is systematized by counting the number of direct links each actor has (Wasserman & Faust, 2013; Paniagua, 2012). According to Machín (2012: 68) the mathematical equation we need, for non-oriented and normalized graphs, is:

$$C_g(n_i) = \sum^A L\left(n_i, n_j\right)/(A-1)$$

Where $C_g(n_i)$ represents the number of nodes to which n_i is connected, divided by the width of the network minus 1, and where (A − 1) is the width of the network to be analyzed.

2. Intermediation, (Betweenness) between nodes, expresses the ability specific individuals have to customize the flow of information between two actors who do not have a direct relationship, managing to position themselves as necessary bridges between actors of a given network (Wasserman & Faust, 2013: 212). Machín (2012: 69) suggests the following mathematical formula to determine this capacity:

$$C_I(n_i) = \sum g_{jk}(n_i)/g_{jk}\ \forall j < k$$

Where $C_I(n_i)$ =the degree of intermediation, $g_{jk}(n_i)$ is the number of geodetic distances between nodes j and k that pass-through node i; g_{jk} is the number of geodetic distances linking j and k.

3. The effectiveness of any social network, for managing the flow and speed with which information is transferred from one node to another, is expressed by the concept of social density. In this case, the transitivity inside a social network is directly proportional to the multiplicity of the possible links within the group (real connections), so high values of social density mean greater efficiency in the transfer of information. The values range from 0 (no connections exist) to 100% (all the nodes are completely connected). Wasserman and Faust (2013: 154) propose calculating this property as follows:

$$\Delta = \frac{L}{g(g-1)}$$

Where Δ is the density; L is the number of real connections, and $g(g-1)$ is the number of possible connections.

4. The analysis of structural transitivity, reveals the dynamics of sub-agglomeration, due to the behavior of actors with shared interests and values, empathy, and social cohesion (Hanneman & Riddle, 2005: 175). This identifies them as dense, compact, and connected groups, which are called cliques. According to Brandes and Erlebach (2005: 114), Turán (1941) defined the calculation to determine the presence of

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cliques, of certain proportions concerning the size of a network, as follows:

$$G = (V, E)\ si\ m > \frac{n^2}{2} \cdot \frac{k-2}{k-1}$$

In this context, *G* = (*V*, *E*) is an undirected graph, so there is a clique of the size of k divided by *G*.

According to these authors, the identification of cliques, in real life, is relative, due to their constant overlap, hence a high degree of overlap indicates a greater exchange of information between such groups, although less integration and control of said flow. These values offer, in certain situations, the possibility of recognizing the network's potential for innovation and social recovery.

5. According to Girvan and Newman (2002) structural transitivity also allows for expressing the grouping capacity of two nodes, based on a common link with a third one. This increases their likelihood of meeting and participating in the same subgroup. This behavior, known as the clustering coefficient, makes it possible to distinguish specific groups. The diversity and intensity of these links indicate cohesion processes and possibilities for innovation within these groups and/or social clusters (Ramos-Vidal, 2015).

Calculations were performed and descriptive statistics were obtained using UCINET, version 6.587. The graphs were prepared with NETDRAW and Visone 2.8.1.

Results and discussion

Tyca is derived from a long line of Mexican publications specializing in the water environment, comprising a curriculum of around 80 years of publications (Tyca, 2020). Based on this, it is an important instrument specialized in water issues. According to the analysis carried out, and the time frame studied (2010-2018), between 2010 and 2014, Tyca experienced a period of consolidation with significant growth in the number of texts submitted. The most significant year on the scientific production curve was 2014. As of 2015, the curve began to descend (rebounding in 2017) reaching, in 2018, 11.26% of total production. The decrease between the peak year, 2014, and the last year analyzed, 2018, was –0.20% (Figure 8).

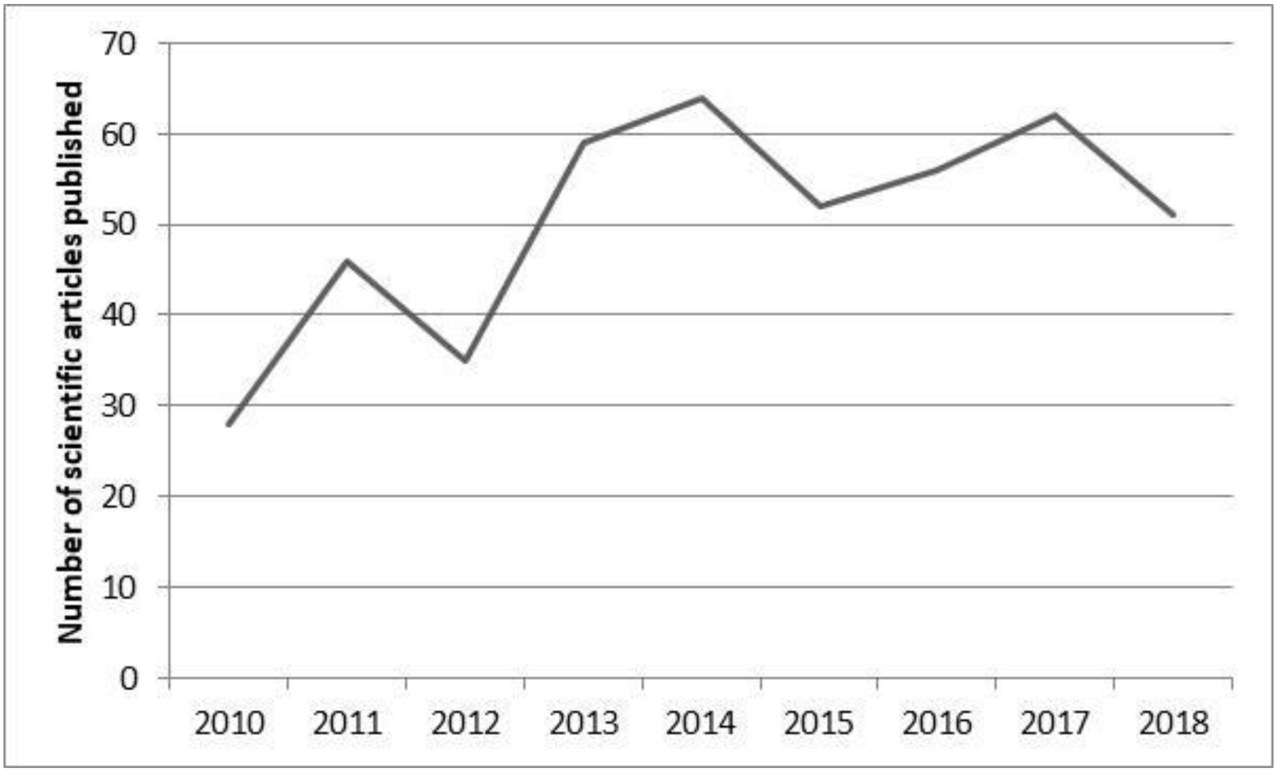

Figure 8. Evolution of scientific production on the subject of water presented in Tyca (2010-2018). Elaborated with data from Tyca (2019).

This publishing experience allows us to explore three dynamics: 1) Delimitation of fields of water research. Based on the general subject matter proposed by Tyca and the wide range of water-related topics dealt with in the articles published, we have proposed 49 areas of scientific groupings (Table 1).

Table 1. Definition of 49 areas of water research in Mexico. 2010-2018. Elaborated with data from Tyca (2019).

Areas of Research on Water				
Supply	Desalination	Hydraulics	Flooding	Rainfall
Access to Water	Rainfall Dynamics	Hydrodynamics	Irrigation	Costal Production
Agriculture	Eco-hydrology	Hydro-energetics	River Mechanics	Coastal Protection
Waste Waters	Ecology	Hydro-geology	Soil Mechanics	Water Resources
Water Balance	Beach Erosion	Hydrography	Environment	Droughts
Biotechnology	Water Erosion	Hydrology	Meteorology	SIG
Water Quality	Evapotranspiration	Forest Hydrology	Risk Mitigation	Water Footprint
Climate Change	Extreme Weather Events	Infrastructure	Geological Oceanography	Sustainability
Social Capital	Physics	Engineering	Pesticides	Transfer of technology
Climatology	Project Management	Artificial Intelligence	Water Policy	

According to these groupings, 88.08% of the scientific articles were concentrated in 20 areas (or topics) (Figure 9), the most outstanding are: Hydrology (10.60 %), Engineering (9.71 %), Agriculture (9.05 %), Hydrodynamics (7.73 %), Waste Waters

(6.84 %), Water Supply (5.96 %), Water Quality (5.30 %), Hydric Balance (4.86 %) and Climate Change (4.86 %), among others. These last five reveal the growing concern pointed out by Mejía *et al*. (2017), The and Blomqvist (2017), and González (2016): the growing pressure on existing water resources and their increasing contamination.

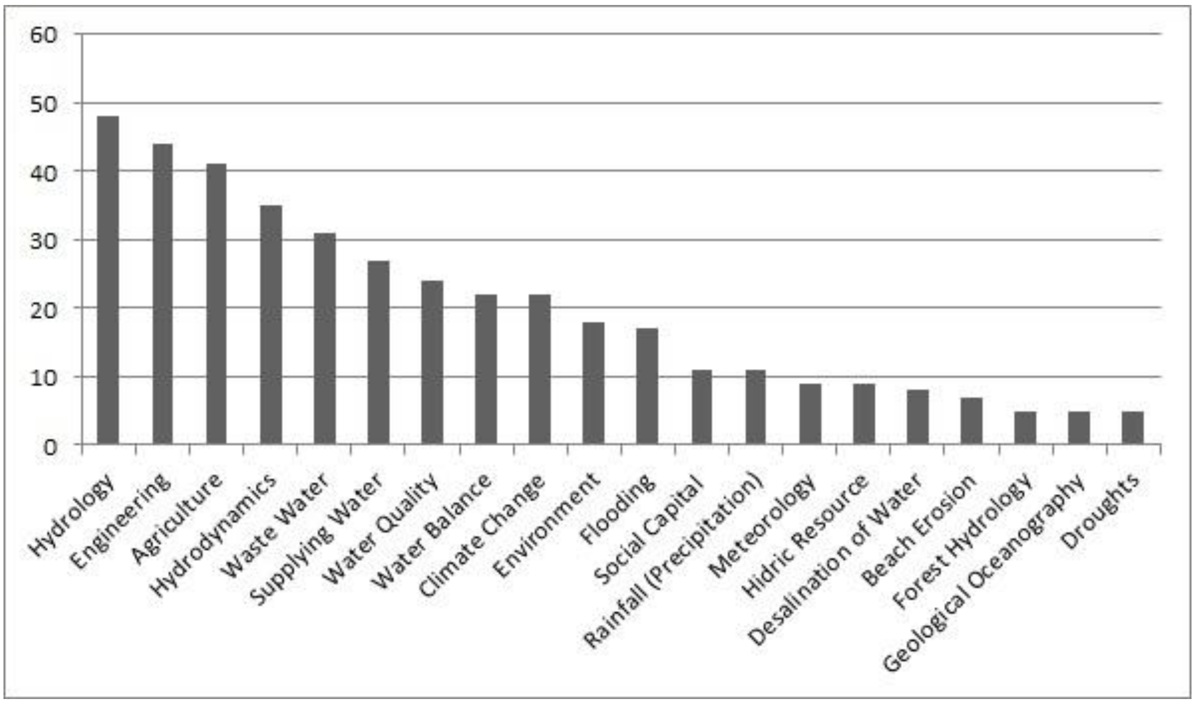

Figure 9. Main areas of scientific research in terms of the number of articles published (2010-2018). Elaborated with data from Tyca, 2019.

2. There seem to be fluctuations in scientific research on water issues by area and by year (Figure 10). In this respect Hydrology, which showed the best performance, reached a peak in scientific production in

2013 (27.08 %), however, this figure dropped sharply in 2016 (2.08 %) declining by approximately 92 %. Engineering was prominent in 2011 (27.27 %), even though a year earlier it had only represented 4.55 %. While the production of articles related to agriculture had been limited in 2010 (4.88 %), it reached 19.51 % in 2017. Hydrodynamics had its best performance in 2014 (25.71 %) but by 2017 production had declined (5.71 %) and in 2018 no articles were presented in this area. The topic of waste waters had a generally low output during the first years registered, however in 2015 it generated 22.58% of the articles produced. The issue of water supply showed a unique behavior, with very little production in 2010 and 2014, but a significant figure (29.63 %) in 2015 and 2016.

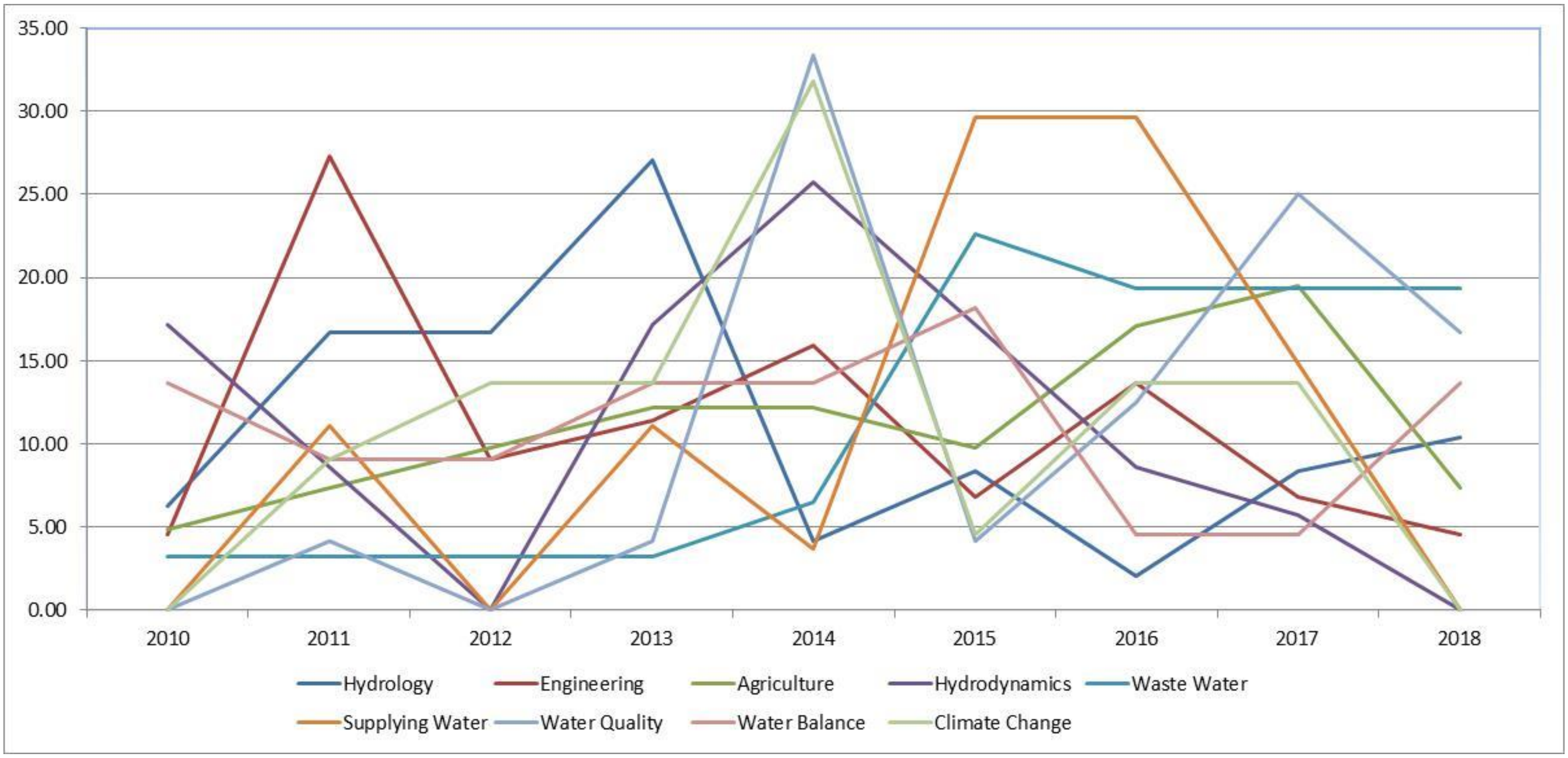

Figure 10. Dynamics of production in nine scientific areas (articles published). 2010-2018. Elaborated with data from Tyca (2019).

3. These fluctuations, in terms of research areas and within these areas, imply differentiations in the influx of authors, as well as a little-explored property of scientific journals as epistemological community spaces. This becomes even clearer upon registering the number of authors per scientific area. In this respect, 64.54 % of the researchers are concentrated as follows: Hydrology (10.83 %), Agriculture (10.37 %), Engineering (8.52 %), Waste Waters (7.36 %), Hydrodynamics (6.84 %), Water Quality (6.14 %), Hydric Balance (5.04 %), Water Supply (4.98 %) and Climate Change (4.46 %). When

analyzing these fluctuations on a yearly basis, there is a positive tendency (Figure 11), reaching a peak in participation in 2017 (14.95 %). Upon separating the data into three-year periods we can see that during the first triennium (2010-2012) 22.83 % of the authors participated, in the second (2013-2015) the figure was 38.76 % and for the last triennium (2016-2018) it was 38.41 %.

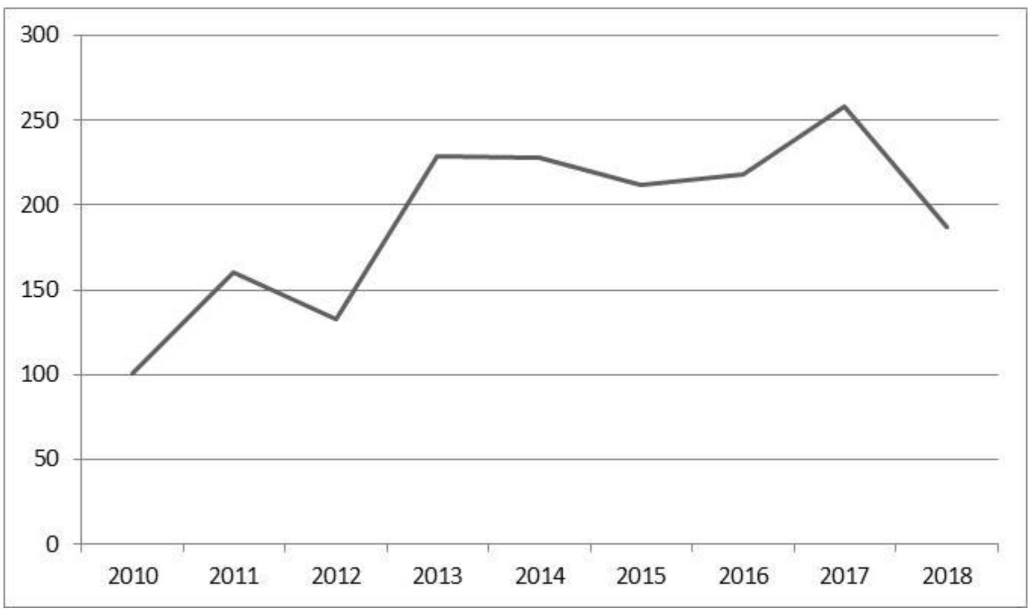

Figure 11. Several authors per the year 2010-2018. Elaborated with data from Tyca (2019).

The differences in the number of authors, by research area, suggest varying gradients of social agglomeration. This supports the argument that the community is the main source of knowledge generation. To corroborate this, we registered the number of co-authors for each published article. The average number of authors was 3.81, with a maximum of 18 and a minimum of 2. The standard deviation was 1.75 and the variance was 3.06, which indicates mainly compact and limited teams. When analyzing these statistics by area, in particular those containing 80 % of the authors (Table 2), Drought was the area with the highest average number of authors per document, 7.40, with a maximum of 18 collaborators and a minimum of 4. It is followed by the area of Water Quality, which has an average of 4.42, a maximum of 8, and a minimum of 2. Subsequently, the areas of Agriculture, Environment, Precipitation (Rainfall), and Meteorology, had an average of ± 4.34 authors. The position of the Droughts category stands out since it presents a significant trend as a node of social inclusion, as well as its cross-cutting with Agriculture, Environment, and Precipitation.

Table 2. Authorship composition (by number) in the main areas of water research 2010-2018. Elaborated with data from Tyca (2019)

Options	Average	Max	Min	Standard deviation	Var
Hydrology	3.90	10	2	1.95	3.80
Agriculture	4.37	7	2	1.26	1.59
Engineering	3.34	6	2	1.20	1.44
Wastewater	4.10	8	2	1.58	2.49
Hydrodynamics	3.37	7	2	1.33	1.77
Water Quality	4.42	8	2	1.91	3.64

Water Balance	3.95	7	2	1.36	1.85
Supplying Water	3.19	8	2	1.49	2.23
Environment	4.33	10	2	2.17	4.71
Climate Change	3.50	11	2	1.99	3.98
Flooding	3.47	6	2	1.42	2.01
Rainfall (Precipitation)	4.33	7	1	1.78	3.15
Meteorology	4.33	6	3	1.00	1.00
Droughts	7.40	18	4	5.98	35.80

Upon analyzing the number of authors by strata, we observed that most of the articles (72.41%) had from 2 to 4 authors. Looking at the results as the number of authors increases, we found that articles with 2 to 3 authors were the most prevalent (49.23%), followed by those with 4 to 5 authors (37.09%). Teams of 6 to 7 persons produced 10.60% of the articles, and the remaining 3.09% were produced by groups of ≥8 authors (Figure 12).

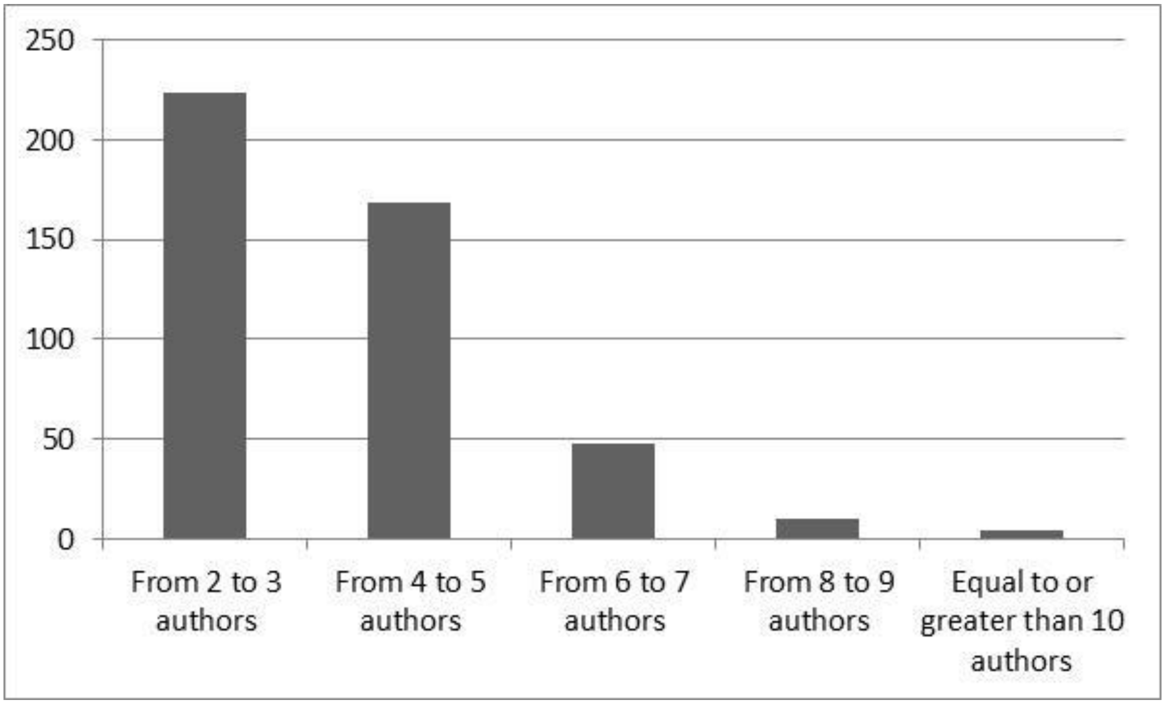

Figure 12. Social Composition (number of authors) for the set of scientific articles, 2010-2018. Elaborated with data from Tyca (2019).

The foregoing characterizes the process of association, among researchers, and generation of water knowledge in Mexico as an individual, and limited to compact and closed groups or, in other words, atomized. In other scientific disciplines, such as physics, the agglomeration processes are different, reaching averages above 8 authors. In the case of agriculture and livestock, the average was 4 authors, although it tends to be dynamic as indicated by FCCT (2018, 2006: 121). Concerning this, the fluctuations observed per year, by scientific area and number of authors, suppose certain association patterns where recurrence and overlap of authors are normal values in research communities. Thus, the average number of authors participating was 1.96, with a maximum of 18 and a minimum of 1. The standard deviation was 1.88 and the variance was 3.53. When analyzing the number of authors per article by strata, the vast majority (94.5 %) were in the range of 1 to 5. For the remaining 5.49 %, the number was ≥ 6. This indicates that although there were authors with greater participation in the generation of scientific knowledge related to some specific water issues, their participation was still somewhat low. When analyzing the number of participations per author, we found that 1.26 % of the authors produced 7.78 % of the articles. These low numbers allow for assuming a centralized scientific community and force us to think of structural characteristics such as degrees of density, integration, and social breadth of the epistemological community under study.

The ecosystem of institutional linkage

Each scientific article is the result of inter-institutional confluence. A third (33.44 %) of the authors are distributed among the following institutions: the Universidad Nacional Autónoma de México (UNAM) (7.93 %), Instituto Mexicano de la Tecnología del Agua (IMTA) (6.00 %), Colegio de Postgraduados (5.49 %), Universidad de Concepción (Chile) (2.67 %), Universidad Autónoma Chapingo, (UACh)

(2.51 %), Instituto Politécnico Nacional (IPN) (2.39 %), etc. (Figure 13). This institutional presence indicates possible resilience mechanisms, derived from being able to maintain certain governance and governability standards regarding water management (Murillo & Soares, 2013). According to Alpuche and Bernal (2015), and Bell (2020), the weight of these institutions and their capacity for leadership and harnessing society's strengths to deal with problems that go beyond the capacities of individuals, could be decisive for confronting the water dilemmas we have pointed out.

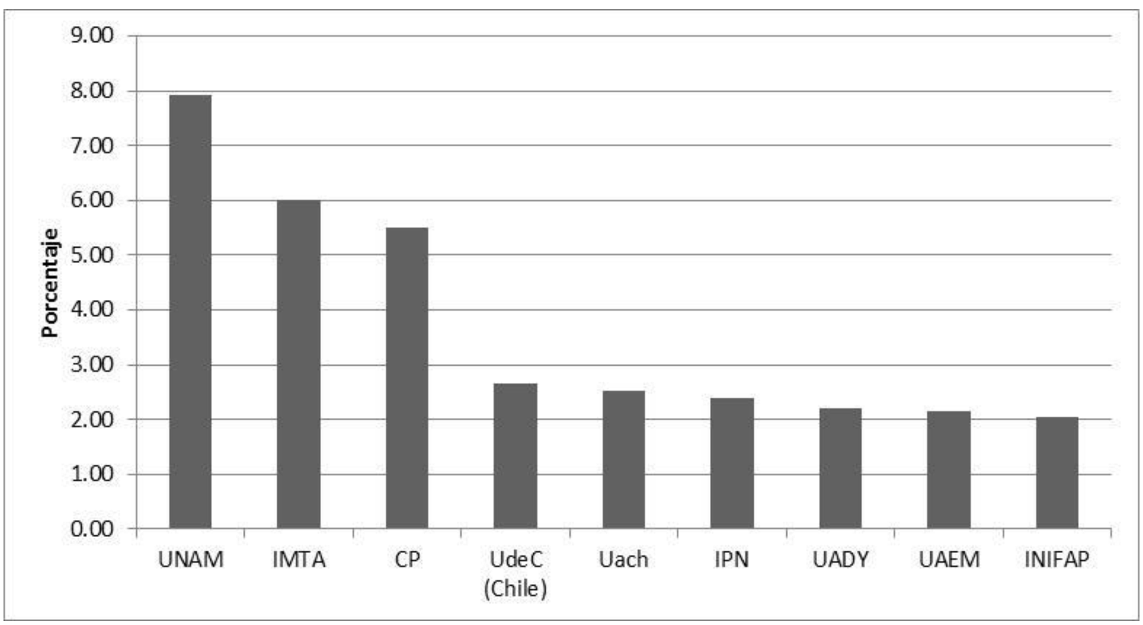

Figure 13. Authors' institutional affiliation 2010-2018. Elaborated with data from Tyca (2019).

In terms of regional water research, 83.99 % of the authors are from Latin America. Mexico is the leading country of origin for the authors (61.77 %), followed by Spain (7.46 %), Argentina (5.97 %), Chile (5.18 %), Colombia (4.55 %), China (4.40 %), Cuba (2.20 %), and Peru (1.33 %), among others. Furthermore, the scientific inter-linkage between nationalities shows Mexico's main interactions in terms of water research: the United States (23.53 %), Cuba (19.61 %), Costa Rica (7.84 %), Spain (7.84 %), Canada (5.88 %), Chile (5.88 %), etc. It is worth highlighting the United States' relations with Mexico (68.63 %), China (17.65 %), and Chile (9.80 %). Ecuador stood out for its relationships with Mexico (64.29 %), Cuba (14.29 %), and Chile (10.71 %) (Figure 14). This evidence of the regional nature of water concerns, indicated by Ballestero, Arroyo, and Mejía (2015: 12), and the FAO (2000), also illustrates, in a more concrete way, the existence of a network structure for water issues.

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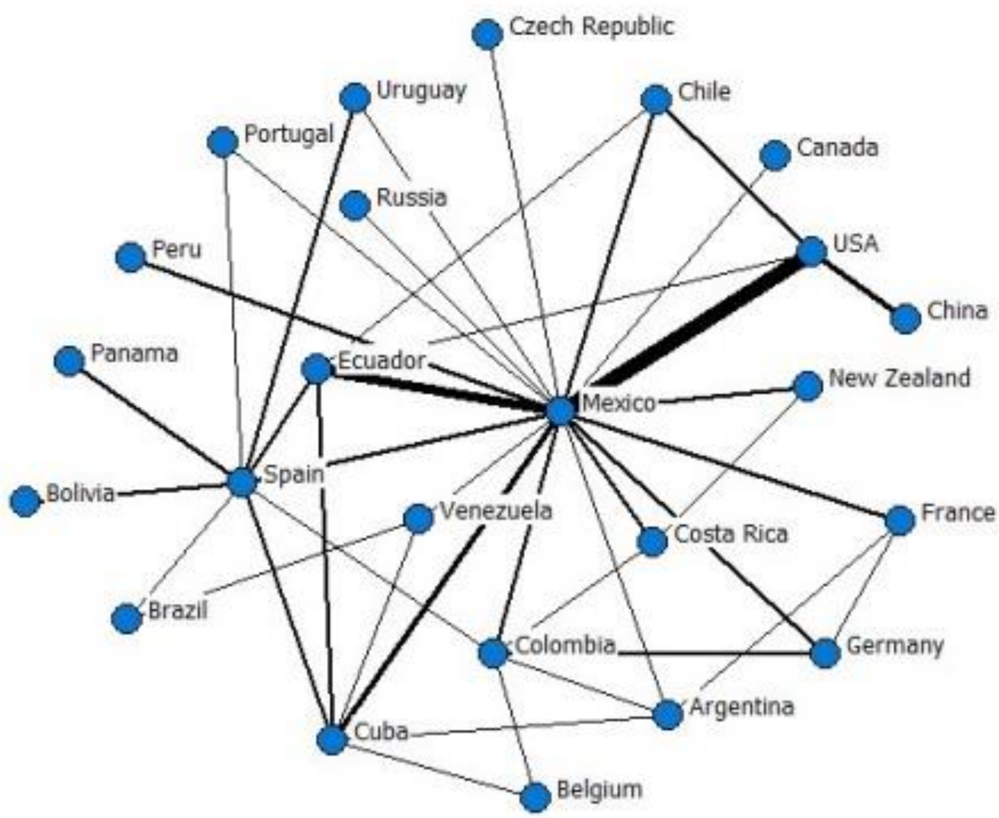

Figure 14. Collaboration on water issues across nationalities. 2010-2018. Elaborated with data from Tyca (2019).

The epistemological ecosystem of water research

Each scientific article can be conceptualized as a space of confluence for the researchers involved (Milard, 2010; Mendieta & Ruiz, 2009) and also as a structural possibility. This can be observed by combining the multiple edges and vertices that designate the commonalities among individuals with shared interests (over nine years). The result is a structural grid with flows and centers, some of which have greater social density than others. There are also peripheral areas and concentric areas that reflect the mobility of the epistemological resources concerned with water issues (Figure 15). All of this helps us gain an understanding of a part of the institutionalized community system for water management processes.

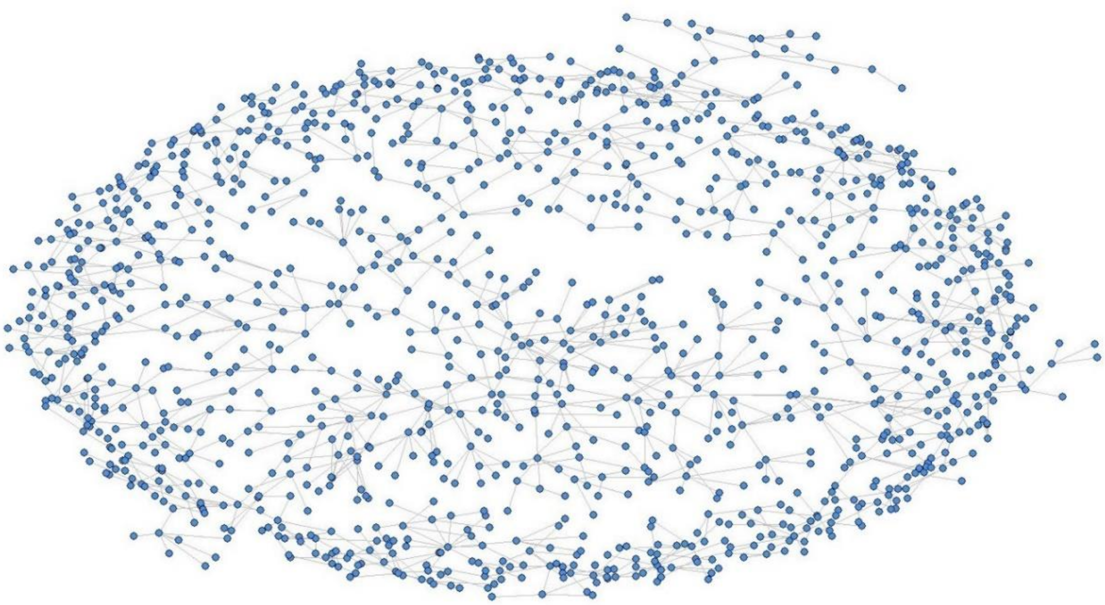

Figure 15. The adjacency of co-authorships 2010-2018. Elaborated with data from Tyca (2019).

This type of social structure reflects a system of interconnections and juxtapositions of information and knowledge related to water systems and confirms gnoseological fusion and imbrication. In this context, when analyzing the relationships of collaboration, prestige, and dependence among scientific areas, by biennium and nodal degree, fluctuation and social prominence were evidenced, thereby indicating a specific socio-epistemological concern. In this sense, the most prominent areas are those that by size and position (closer to the center) make it possible to observe this trend (Figure 16).

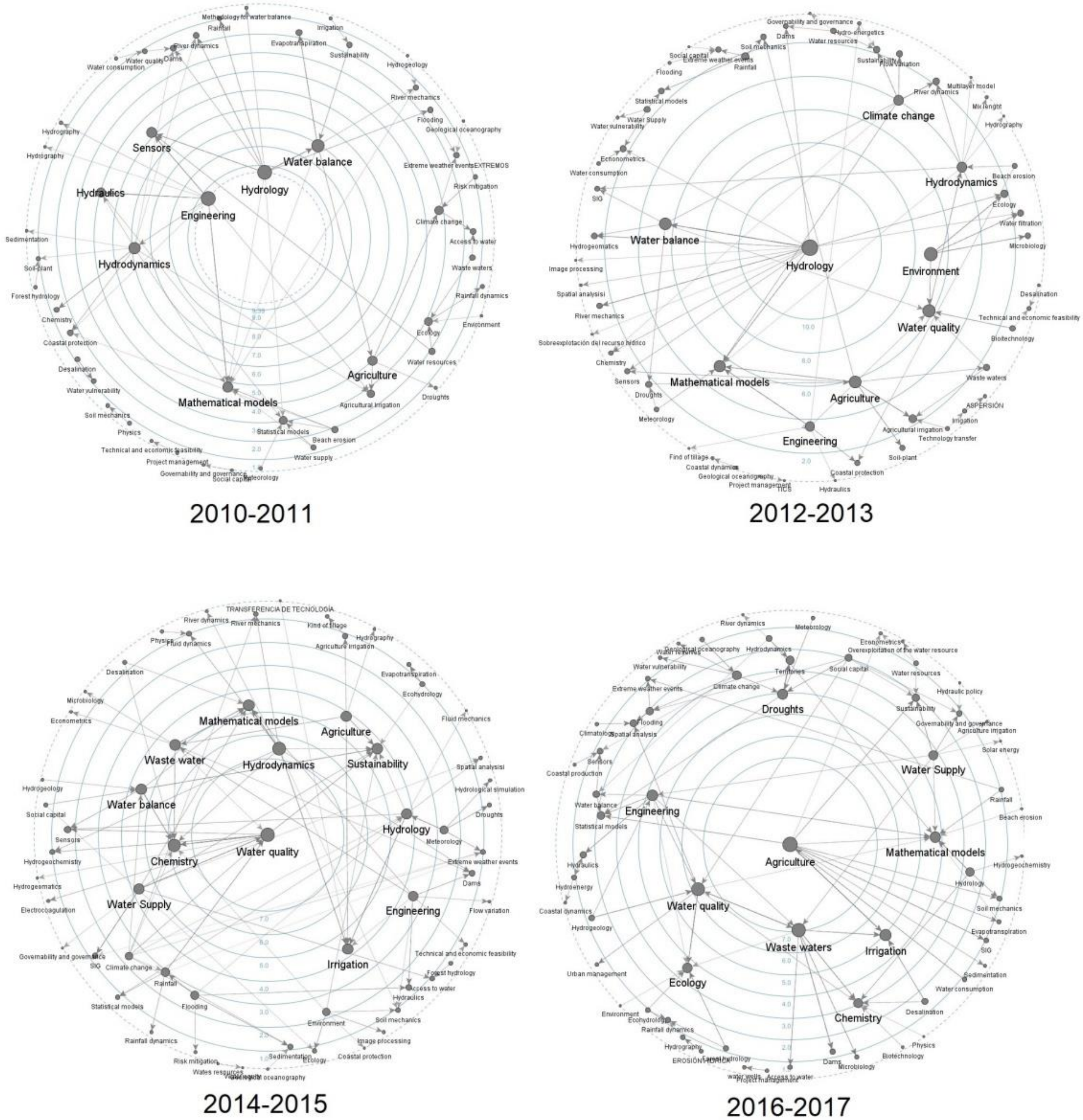

Figure 16. Nodal degrees between research areas, in 4 biennia. 2010-2018. Elaborated with data from Tyca (2019).

In the 2010-2011 biennium, the disciplines with the highest nodal degrees corresponded to areas dealing with measuring water's chemical and physical properties, as well as technologies and analysis of industrial processes. In the 2012-2913 biennium, this reticular system continued to focus on measuring the physical and chemical characteristics of water, and also the biological ones, and quality for human use, as well as issues of agricultural use, degradation, and environmental impact. In 2014-2015 the main areas were those related to measuring water's physical, chemical, and biological characteristics, and its suitability for humans, as well as the dynamics of water flows, etc. In 2016-2017 the structural composition was centered on areas of food production, domestic and industrial impacts on water quality, as well as evaluation models and technologies, and droughts. This overlapping of research areas indicates the construction of a glocal and multidimensional systemic concern in the water research analyzed, and, henceforth, its underlying complexity.

When considering seminal nuclei of "containment", the clustering coefficient made it possible to locate areas of knowledge with significant qualities allowing them to be integrated into broader epistemological layers: Coastal Protection (20.00), Irrigation (13.08), Risk Mitigation (8.91), Physics (8.36), Water Consumption (7.80), and Climatology (6.25), among others, which implies dynamics of gnoseological "empathy". An area of high social density was defined, composed of 20 research areas (Figure 17), revealing the construction of a field of epistemological imbrication, and cognitive "pollination". In other words, various conceptual schools. The empathies of Hydrology with Water Balance and Agriculture are highly evident; Hydrodynamics-Agriculture-Engineering. Another relevant grouping is Hydrology-Agriculture-Wastewater, confirming what Lahera (2010) indicated about the urgency for generating sustainable water systems.

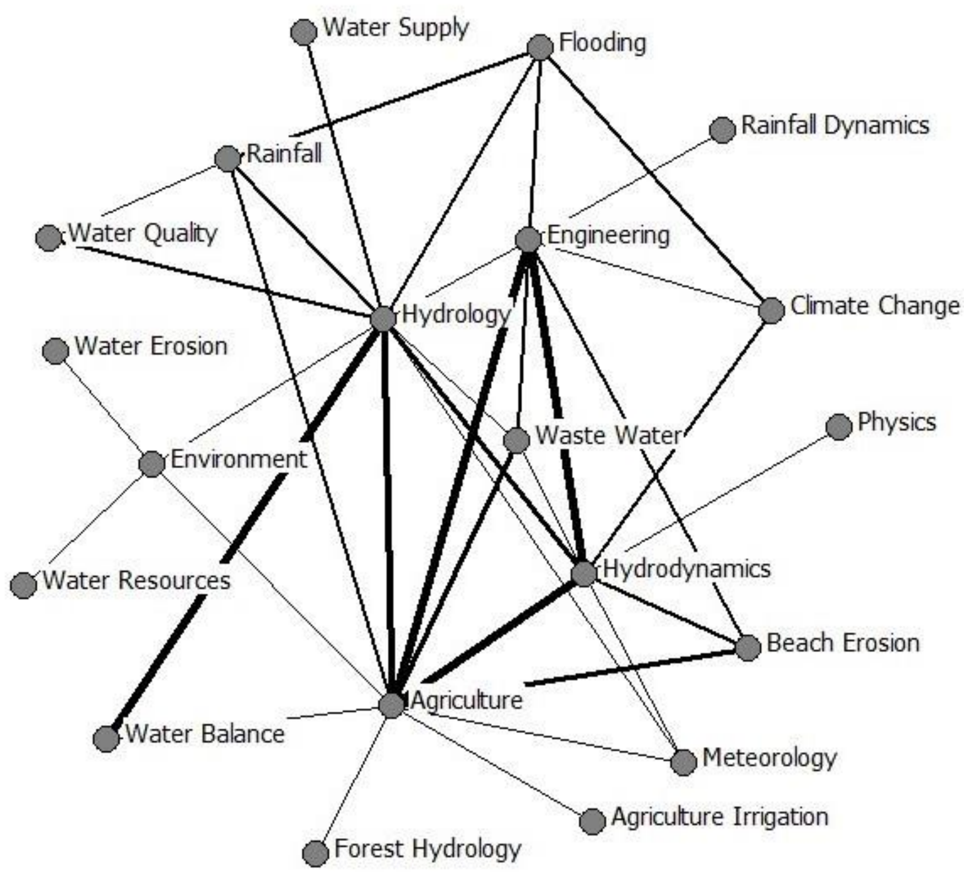

Figure 17. Structure of collaborations between research areas. 2010-2018. Elaborated with data from Tyca (2019).

The dynamics of researchers' connections and interactions with one another allow us to delineate epistemological regroupings and also enables us to analyze notions of power and influence among individuals as normative elements of these social systems (Burt, 1992). These notions depict internal tensions and prominent positions which can be used to link, communicate and/or interrupt information flows according to individual interests, modifying the behavior of the entire network. For example, the values for transitivity (1.78 %) and social density (0.08 %) are low, indicating a slowed information flow and, therefore, little linkage and multiple gaps. In this regard, Burt (1992: 65) indicates that these connection gaps express, in a directly proportional way, a greater degree of verticalness and hierarchy in the connections and, consequently, greater control over the flow of information and the communities' degree of closure, as well as a limited level of innovation. These structures are characterized by numerically small and strongly connected leaderships. However, this apparent lack of horizontalness also generates a range of opportunities that might point towards greater internal heterogeneity.

Concerning this, the number of structural holes (4 209), and the average number of links (1.96), indicate significantly low nodal degrees and, therefore, slowed information flows and a poorly connected network. These values correspond to those observed in the standard deviation, the rate of exit, and the rate of entry. This coincides with the limited variability of the actors and their limited impact capacity, which is expressed in the low values observed for the variance in the rate of exit and rate of entry. These values are characteristic of reticular subsystems that centralize social prominence (Table 3).

Table 3. Descriptive statistics. Collaborations network. 2010-2018. Elaborated with data from Tyca (2019).

Options	Rate of exit	Rate of entry
Average	0.998	0.998
Standard deviation	1.98	0.94
Variance	3.92	0.88
Centralization	0.44%	0.26%

These dynamics are accentuated when analyzing the structural component, where the linking arcs present continuous values of recurrence and collaboration. For this, the nodal value = 1 was excluded.

This procedure showed a more filtered, compact structure with higher social density (0.84%), and revealed separate, closed groups, more or less independent from one another. Nevertheless, it did allow us to distinguish, more precisely, scientific areas with differing levels of social prominence (Figure 18). In this case, the researchers with the highest nodal ranks were found in the areas of Hydrology, Food Production, Engineering, and infrastructure. The ability to determine the epistemological discourse of water research was distributed in a pyramidal and centralized way by researchers from the area of Balance and quality of water resources, followed by Engineering and Infrastructure, Oceans and Coastal Resources, as well as Climate Modifications.

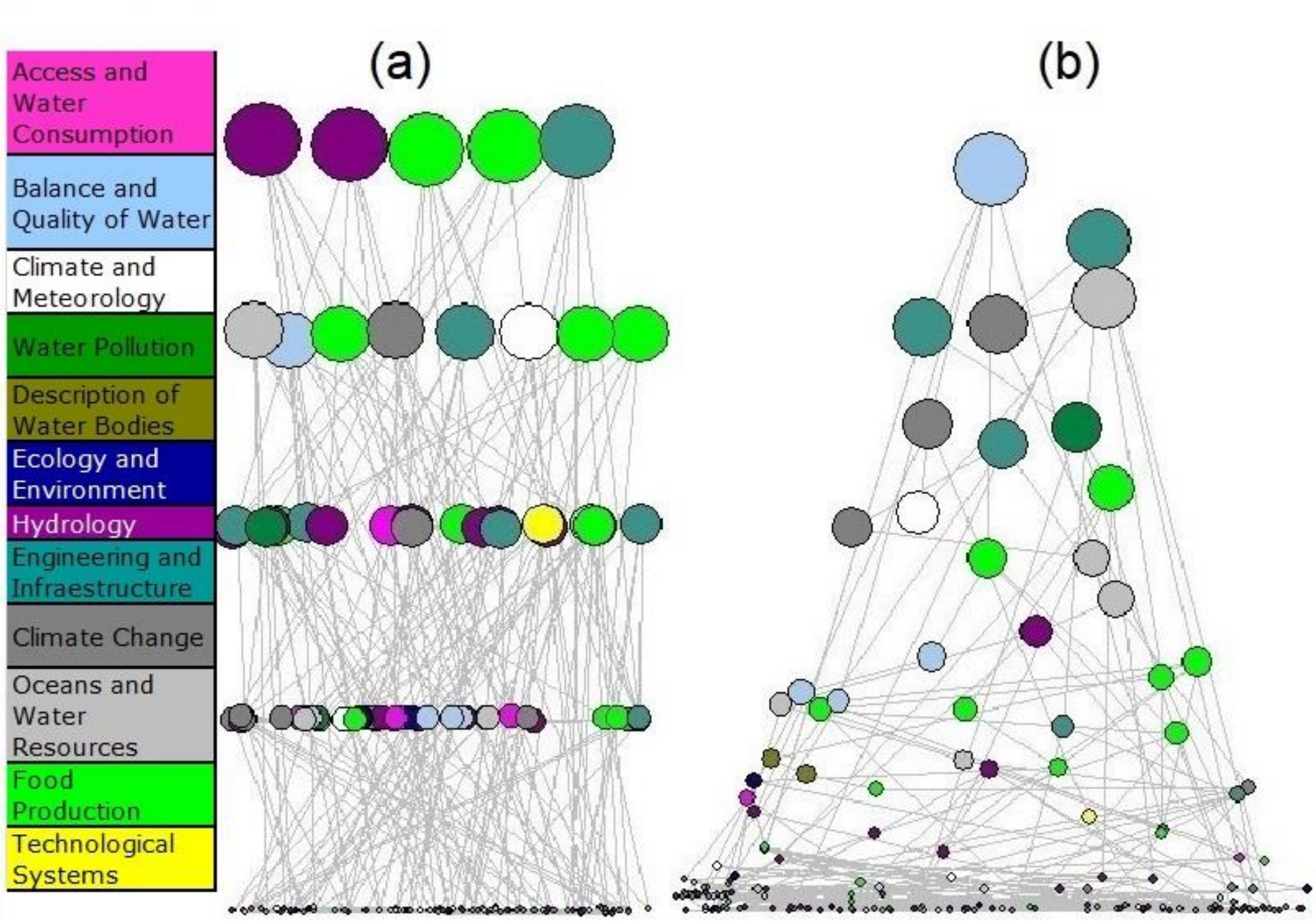

Figure 18. Nodal degree (a) and degree of intermediation (b). 2010-2018. Elaborated with data from Tyca (2019).

Based on this, and considering trust to be the structural component, there appears to be limited management of this factor (Figure 19). The values show a certain heterogeneity (thickness of the links), but only at the local level (black boxes). When considering the value for reciprocity (red color), the figure is significantly low (3.7 % of the arcs), and only in one triad (gray circle). This is supported by confirming that there are only 56 cliques, which indicates that this research structure has a limited level of innovation.

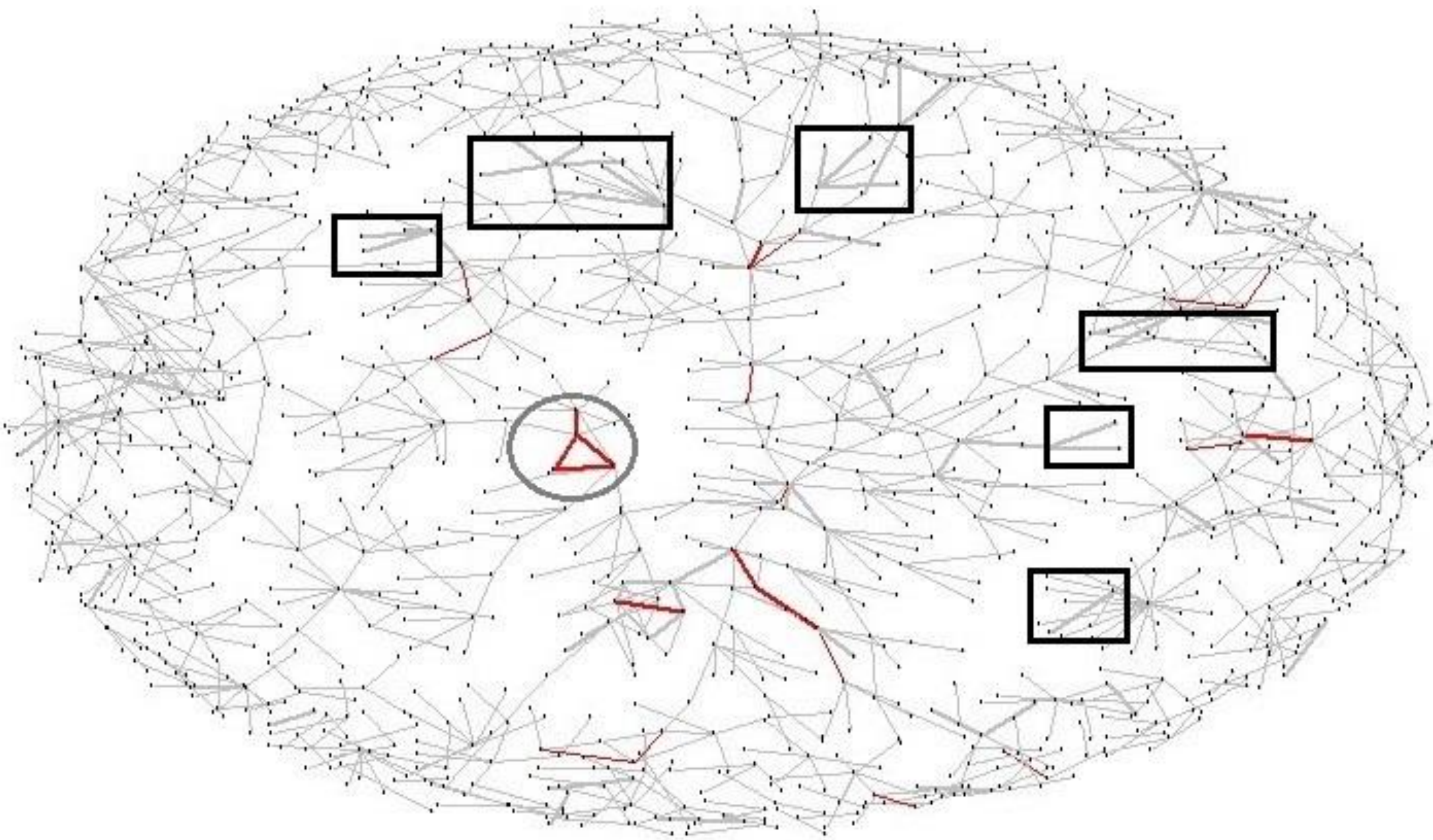

Figure 19. Reciprocity (red) and trust (thickness of the link) in the network of researchers. 2010-2018. Elaborated with data from Tyca (2019).

Conclusions and general considerations

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The Social Networks approach allowed us to gain insights into some parts of this system of scientific linkage and verify certain characteristics of water research in Mexico. The adjacency processes analyzed and the categories of centrality (degree and betweenness), transitivity, and social density made it possible to describe and measure the effectiveness of the capacity to transmit and innovate water knowledge at the social level. This evidenced the centralization of social attributes related to water research in this country, and henceforth closed and compact groups with very little social overlap, which implies isolated spheres of knowledge generation with a limited capacity for sharing information and the absence of large groups with significant degrees of social cohesion.

This social structure presents centralized processes for managing power and prominence so that social capital is atomized and not very diversified. The distribution of (social) information is limited, uneven, and interrupted by innumerable structural holes and low transitivity. This indicates consolidated but isolated work groups. Some leaders concentrate social prominence in certain social regions of the scientific structure analyzed. One consequence of this is that valuable inputs such as trust and scientific reciprocity are limited and their distribution is local and occasional, so they are managed vertically and personally. In this sense, this research network is community-based, complex, expanding, and constructed subjectively; but in terms of its topology, it is an incomplete network, since essential elements of resilience (solidarity, collaboration, empathy, etc.) are not significantly present. Concerning this, although the history of publications, recorded by Tyca, goes back 80 years, which might suggest the possibility of finding evidence of a denser research network, the network analyzed presents characteristics of an incipient structure that lacks maturity and has many social dissociations. This may be due to neglect and a lack of public policies to promote research on water issues (and sustainability). This constitutes a grave risk in current times. Consequently, faced with massive social disruptions (a pandemic, drought, and regional famine), this research system could become disabled, given its inability to reconstitute itself and propose in-depth solutions for the rescue, protection, and maintenance of water resources.

In contrast to the above, the overlap and cross-fertilization between research areas indicate that there may be an opportunity to achieve greater interaction in terms of areas and among those conducting research on water-related issues. It might then be possible to achieve greater centrality for less prominent actors and research areas and promote the formation of inter-institutional groups and thereby modify the innovation gradient by making an urgent call to train professionals in the various fields of knowledge required to manage Mexico's national waters.

In this context, the issue of Waste waters is a field of epistemological and technological crossover that should be expanded urgently, based on its various intersections and clustering capacity. This could lead, in and of itself, to meeting an unprecedented, yet unique, engineering challenge: to use the same liter of water multiple times, and then return it to the tributaries with the same quality with which it was extracted. In this sense, when observing the composition of the scientific social structure related to water issues, the diversity of the works analyzed, and the systems of social contradictions related to water management, it becomes evident that not just one solution is required, but many, in a variety of urgent areas, and at the same time interrelated, at the biotic level, and in terms of the habitat, quality, and distribution of water, and this resources' ecological conditions, etc., without neglecting local, sociocultural worldviews related to water. Perhaps we should think about (re)constructing and/or recuperating a certain systemic and liturgical discourse about the concept and uses of water to re-write a moral code for this precious liquid. As Geertz (1987) would say, this would imply recovering (and innovating) a system of symbols and beliefs that influence or give way to a powerful state of mind within the State and within societies, and that are linked to a unique reality: the survival of peoples, of the species, for which concrete innovations and/or community-wide recoveries are necessary to recuperate, rescue and preserve the sustainability of the glocal aquifer. In this direction, it is not bizarre to think of the gestation of theological discourse on water, not only under moral or ethical pretexts but in the shadow of the only concrete value that we possess: life.

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