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Disputed water: Competing knowledge and power asymmetries in the Yali Alto basin, Chile

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ABSTRACT

Hydrological information – which plays a crucial role in resolving conflicts over water allocation and distribution – is commonly seen as apolitical. However, this type of information is seldom objective and free of biases. Instead, it is used to position arguments and interests in accordance with the prevailing political agendas. Information is structured by complex and conflicting networks of public and private stakeholder interests, further reconstituted in different periods of time and place. Based on a study of the upper Yali basin in the municipality of San Pedro de Melipilla, Chile, we show how knowledge about water is produced, circulated and applied in the context of water scarcity and emerging conflicts over access to groundwater. Building on the notion of the hydrosocial cycle, the qualitative study shows how the production of hydrological reports and its application in political decision-making have reinforced asymmetrical relationships between the stakeholders locked in water conflicts. The lack of capacity of local farmers and community organizations to translate experiences into codified hydrological knowledge further exacerbates these asymmetries. Agro-industrial companies operating in the basin use hydrological assessments to locate and shift the water scarcity problems to the users, whereas locals blame them for accumulating disproportionately large concentrations of water extraction rights. Results contribute to the existing literature on environmental knowledge, arguing that discourses on water scarcity are not objective but shaped by socio-political contingencies. Overemphasising on data and techno-science based information to support certain decisions may be misleading without first unveiling the knowledge production processes operating across power-laden landscapes.

1. Introduction

Technical studies such as environmental modelling are generally considered central to define the most effective, efficient and sustainable mechanisms to manage natural resources. Exchanges between political and scientific actors commonly produce and circulate such knowledge to various stakeholders (Bijker et al., 2009; Jasanoff, 2013; Weingart, 1999). Although this type of knowledge is commonly claimed to be neutral and objective, science has historically failed to remain neutral from political interests (Demeritt, 2001; Feenberg, 2010; Forsyth, 2003). Knowledge production processes involve constant interaction of agents, artefacts and institutions, which are embedded in specific socio-political and geo-climatic contexts.

Political ecology has sought to understand how the production of (scientific) knowledge is shaped by asymmetrical power relations among actors involved and consequences of creating regulatory and normative frameworks for resource management (Goldman et al., 2011; Perreault et al., 2015; Walker, 2005). In case of water conflicts, the concept of the hydrosocial cycle has emerged as an attempt to analyse both the socio-political and geo-climatic factors shaping the water cycle (Bakker, 2012; Boelens, 2014; Budds et al., 2014). This approach focuses on how the interaction between actors concerning the control of water resources leads to different hydrosocial regimes and unequal access and distribution (Boelens, 2014; Budds, 2008, 2009; Palomino-Schalscha et al., 2016). It has also explored how actors and political rules and regulations shape the discourses of technical expertise. The concept has been proven useful to uncover how the so-called 'scientific assessments' have impacted water policies in perpetuating existing inequalities (Budds, 2009).

In a neoliberal context, private actors have amplified influence on

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the political sphere. Chile has been experiencing significant political transformations since the 1980s which established highly deregulated and privatized systems in sectors such as mining (Kronenberg, 2013), forestry (Manuschevich, 2016) and fisheries (Barton and Fløysand, 2010), as well as education (Torche, 2005), labour (Leiva, 2012), health (Helmke, 2011; Olavarria-Gambi, 2011), and housing (Hidalgo et al., 2016). Conflicts over the control of resources and access to basic goods and services have affected the country ever since (Mascareño, 2010).

In the case of water, the creation of a market-based system that allocated private water usage rights has seemingly led to severe problems of accumulation and concentration of water rights with specific actors. It is also blamed for over-exploitation of water resources in some catchments (Bauer, 1998; Galaz, 2004; Larraín, 2010). Albeit several legislative reforms (Szigeti-Correa, 2013), problems of over-exploitation and distribution of water persist. One of the reasons identified is the failure in improving the institutional structure of water management (Larraín, 2010; Modrego et al., 2011; Valenzuela et al., 2013). This is particularly problematic in the arid regions of Northern and Central Chile (Larraín, 2010), where dry periods with low precipitation are expected to become more frequent (Falvey and Garreaud, 2009). Management problems have also escalated significantly in areas relying on groundwater systems because of its increased exploitation since the 1990s (CEPAL, 2012) vis-à-vis a historically prevalent scarcity of groundwater in the region (Peralta, 1993).

Previous research on water management in Chile focused on water availability and land use change (Aitken et al., 2016; Donoso et al., 2014; Molinos-Senante et al., 2016; Oyarzún and Oyarzún, 2011; Valdés-Pineda et al., 2014). Studies analysed the operation of the water market and its impact on access to and availability of water (Bauer, 1998; Donoso, 2006; Galaz, 2004; Valenzuela et al., 2013) as well as resulting conflicts (Romero Toledo et al., 2009; Larraín, 2010; Prieto, 2015). Some studies also explored the implicit narratives of rationality and efficiency of water exploitation (Molina-Camacho, 2012; Palomino-Schalscha et al., 2016), and assessed how the implementation of free-market policies transformed local identities and traditions (Budds, 2010; Prieto, 2016).

Despite these contributions of previous studies, little attention was paid to the production of hydrological information, its role in decision-making, its political consequences, and its impact on water systems. Budds (2008, 2009, 2012) has sought to understand how water studies are produced in the Aconcagua river basin in Chile from a hydrosocial perspective while considering their territorial consequences. However, more studies are needed in other areas of the country to better understand how knowledge on water is produced, applied and shaped by geophysical and socio-political conditions of the territory.

We aim to contribute to the existing discussions based on findings from our empirical study in the upper Yali basin in the dry coastal area of Chile's central zone, which entirely relies on groundwater resources. In the Yali basin, land use change and the unregulated allocation of water rights appear to have led to serious water shortages affecting agriculture, household consumption and basic needs. The crisis has further exacerbated because of scarce precipitations over the last years (Rojas et al., 2010).

Following the framework of the hydrosocial cycle (Budds, 2009; Linton and Budds, 2014; Swyngedouw, 1999, 2009), we analyse the production, circulation, and application of information in the Chilean water management system and the resulting territorial impacts in the Yali basin. We especially focus on the relations among actors participating in such a cycle and the impact of groundwater information within the management processes and in conflict resolution. Findings highlight that hydrological information is selectively scaled and employed to position different interests and demands. This constricted participatory spaces in the decision-making process for some while allowing greater spaces to some other actors. We contribute to the ongoing discussions by showing that asymmetrical relations not necessarily result from lack of knowledge, but are related to the powers and authorities of mobilizing actors and stakeholders, drawing evidence from the hydrological data and models.

2. Water information, ecology and politics: The emergence of the hydrosocial cycle

Political ecology has effectively analysed water and development, conflicts over water and water governance (Birkenholtz, 2008; Boelens et al., 2016; Budds and Sultana, 2013; Loftus, 2009; Sultana and Loftus, 2013). Over the course of a little over a decade, the concept of the hydrosocial cycle has evolved as a key concept for analysing water-society interrelations (Bakker, 2012; Boelens, 2014; Linton and Budds, 2014; Palomino-Schalscha et al., 2016; Swyngedouw, 2009). Drawing from political ecology and critical geography, the concept looks at the dialectics between water and social power by defining them as hybrids that constantly shape and reshape each other (Swyngedouw, 2006, 2009). It analyses socio-political and geo-climatic factors with equal importance while assessing hydrological dynamics, overcoming the idea of water as a natural element behaving in a consistent, uniform and rational pattern. The notion of hydrosocial cycle includes a multiscalar perspective that moves beyond the concept of a strictly defined watershed (Budds, 2009; Budds et al., 2014; Swyngedouw, 1999, 2009). The strengths of the approach lie in its acceptance that water is "inherently political" (Linton and Budds, 2014, p. 175), shaped by social relations and power structures. Water is conceived not as a passive element, but as an asset immersed within a complex network of stakeholders (Bakker, 2012; Schmidt, 2014). While implementation of new technologies and subsequent management mechanisms affect water behaviour, the variability of the flow or the occurrence of an extreme event generates new responses from the local stakeholders and decision-makers.

For Budds (2009, p. 420), "the hydrosocial cycle provides a framework for approaching the role of environmental science in relation to water in two key ways: by extending existing work on the production of 'expert' knowledge by technical water managers, and by exploring the production and use of hydrological data". Water knowledge, according to this approach, is not neutral but situated and shaped by the hybridity of water and society (Linton and Budds, 2014; Swyngedouw, 2009). Thus, its production, circulation, and application are power-laden (Goldman et al., 2011; Linton and Budds, 2014, p. 171). In words of Boelens (2014, p. 236), "water control discourses – beyond just language and conceptual ideas – put knowledge and power to work to establish and legitimize water governance practice".

Understanding knowledge as shaped by socio-political and geo-climatic factors moves beyond the simple idea of knowledge as grouped facts, theories, and ideas mentally developed by individual actors. This approach attempts to recognize knowledge production as a process in which certain explanations are considered to make sense of the world, while other opinions and experiences are excluded from the discussion (Forsyth, 2011; Turner, 2011). Such understandings are embedded in enduring and extensive sociotechnical networks of people, artefacts and institutions that interact with each other (Edwards, 2010). Studying knowledge production is the exploration of how and by whom facts are articulated in order to give coherent explanations of reality (Latour, 1999). Defined by Callon (1984) and Callon et al. (2011) as a translation of the social and natural worlds, this explanatory process is the mechanism by which certain entities achieve to represent and talk in the name of other actors. It is a constant negotiation between and delimitation of identities, possibilities of interaction, and margins of action of the actors involved. Knowledge production, then, is the process in which problematization, interessement, enrolment and mobilization of actors – the four moments of translation – are coherently and explicitly articulated (Callon et al., 2011).

If knowledge is understood as an explanatory process by which the world makes sense, information concerns mechanisms used to describe and understand reality based on the analysis and interpretation of facts

in different periods of time and place (Adolf and Stehr, 2014). However, unlike knowledge, information is only a fraction, a concrete codification of the world to understand the original problem (Cohendet and Meyer-Krahmer, 2001). Even this codification is never free of tension. It requires the use of instruments, resources and skills, which, according to Callon et al. (2011), increases the division between actors who have access to such instruments and those who can only have access to "frozen knowledge". In the case of water, this includes access to data from weather stations, computational programs for modelling hydrological systems, and deep wells to estimate hydrological parameters such as temperatures and precipitation levels, surface runoff and ground water levels. The capacity of deciding what information to include or exclude from reports and studies rests largely with scientists and technicians, making them vital actors in the production of scientific knowledge, namely, the generalization of arguments and explanations of local phenomena (Castree, 2015; Klenk and Meehan, 2015). Vernacular knowledge of local and lay actors, on the contrary, cannot be extrapolated from the complexity of local and singular situations (Bustos et al., 2015; Callon, 1999; Krueger et al., 2016).

Different knowledge systems lead to different ontological visions, what Mol (1999, 2003) defines as "multiple realities" which are constantly enacted in the course of diverse practices. Understanding the characteristics of institutionally scientific and local knowledge is necessary to unveil existing frictions, antagonisms, and power relations inherent in different ontological projects (Klenk and Meehan, 2015; Yeh, 2016). Birkenholtz (2008) argues that the encounter of different environmental knowledges in northern India led to overexploitation of groundwater resources and severe water conflicts. Historically rooted tensions between farmers and state groundwater engineers created separate alliances with local actors and private drilling companies respectively, leading to hybridized knowledge practices that marginalized the role of the state.

Preconceived categories of knowledge can present a risk, since they reduce the multiplicity and complexity of knowledge systems into oversimplified stereotypes. Agrawal (1995) claimed that the division between indigenous and scientific knowledge serves the utilitarian goals of neo-indigenistas groups in order to attempt the development of the "underdeveloped", without inquiring about existing inequalities and understanding the links between power and knowledge sustaining the western-indigenous division in the first place. Robbins (2000) finds dividing state and local knowledge inconsistent that respond to epistemological categories of colonial invention. According to the author, the state generates fractured knowledge and allies with diverse actors. This debunks the myth of state agencies as environmental villains. Privileged actors with access to different sources of information and instruments can appropriate categories related to local knowledge in order to legitimize and validate said positions. This in particular has been the case in transdisciplinary research on climate change, where scientists commonly take control of participatory processes of knowledge production and maintain the existing power imbalances with "non-experts" (Klenk et al., 2015; Klenk and Meehan, 2015).

This theoretical background provides the entry-point into understanding how technical information is employed to explain water scarcity in areas with unequal distribution of water resources and witnessing overexploitation. The hydrosocial cycle considers that the stakeholders interact to generate new perspectives, which help understand the territory and its characteristics. In addition, it includes the mechanisms and networks used to encourage or restrict the sharing of information with other stakeholders and organizations. Finally, it takes into account the common and location-specific understandings to use certain information in the solution of environmental problems and conflicts (Boelens et al., 2016). This, as de Laet and Mol (2000) argue, moves beyond the exercise of approving and disapproving technologies, people, situations, and arguments existing in the critical tradition, and focuses on the necessity of truly understanding the emergent dynamics between actors. At the same time, it maintains the explicit consideration of relations of power assumed by political ecology, "understanding that there are better, less coercive, less exploitative, and more sustainable ways of doing things" (Robbins, 2004, p. 20). How, then, is power in water conflicts shaped by different types of water knowledge? What type of hydrological data is accessed for the production, circulation and application of such knowledge? We address these questions in the empirical case study.

3. Methodology

Fieldwork was carried out between January and April 2014 and follow-up interviews were conducted in November 2014. For a deeper understanding of the production, circulation and application of water knowledge in the upper part of the Yali basin, we followed a qualitative approach. We combined methods of network analysis, document analysis and in-depth interviews. We chose a purposive sampling for the 31 interviews conducted. The main criterion was the type of organization linked to water management in the upper Yali basin, selecting interview participants from different government organizations (12) as well as agro-industrial companies (5), small-scale producers and cooperatives (6), local organizations (5), and other relevant organizations – i.e. academics, a multilateral agency and sanitization companies (3). In addition, we conducted one focus group interview with local organizations. All interviews were recorded and transcribed. Since the interviews were conducted and transcribed in Spanish, direct quotations have been translated to English by the authors.

Concerning the analysis of published and unpublished documents, studies and reports issued by public and private agencies were analysed in order to better understand all data sources linked to the water situation of the basin. Special attention was paid to public reports on the availability of water as a way to analyse the criteria and mechanisms used to officially estimate groundwater levels in the Yali basin. Finally, for the analysis of the data obtained, a framework based on the creation of codes (Glaser and Strauss, 1967) was used to understand and structure patterns present in both interviews and documents (Glaser and Laudel, 2013).

4. Land-use and water conflicts in San Pedro de Melipilla, Yali basin

San Pedro de Melipilla is one of the 52 municipalities in the Santiago Metropolitan Region (SMR). The municipality has a population of 8049 of which 2360 inhabitants live in its main town San Pedro and the rest are distributed among the villages El Prado, Loica, Santa Rosa, Nihué, Longovilo and Corneche (Fig. 1) (INE, 2007a, 2013). Its vast extension and rugged topography contribute to problems of inaccessibility, particularly linked to the distribution of potable water, public transportation and roads (GORE, 2012).

Located in a coastal dry zone and in the foothills of the coastal mountains, San Pedro has a Mediterranean climate with an average precipitation in the range of approximately 200–400 mm per year (INE, 2005). Due to the lack of glaciers or bodies of snow in this part of the territory, the basin is exclusively recharged by precipitation. About 90% of rainfalls occur during the wet season between May and August; surface runoff dries up during the rest of the year (DGA, 2005a). Groundwater resources are the key to meet the drinking water and irrigation needs of the region. Due to its proximity to coastal weather systems, the municipality is characterised by abundant morning mist, comparatively less extreme temperatures and less precipitation than the interior areas of the SMR.

The main hydrological system of San Pedro is the upper part of the Yali basin (Yali Alto) and divided into six sub-basins: San Pedro and Diucas in the north, Middle Yali to the west, Yali Alto to the east, and San Vicente and Loica to the south. As each of these sectors is considered an independent sub-basin by government authorities, water rights are assigned in individual sub-basins.

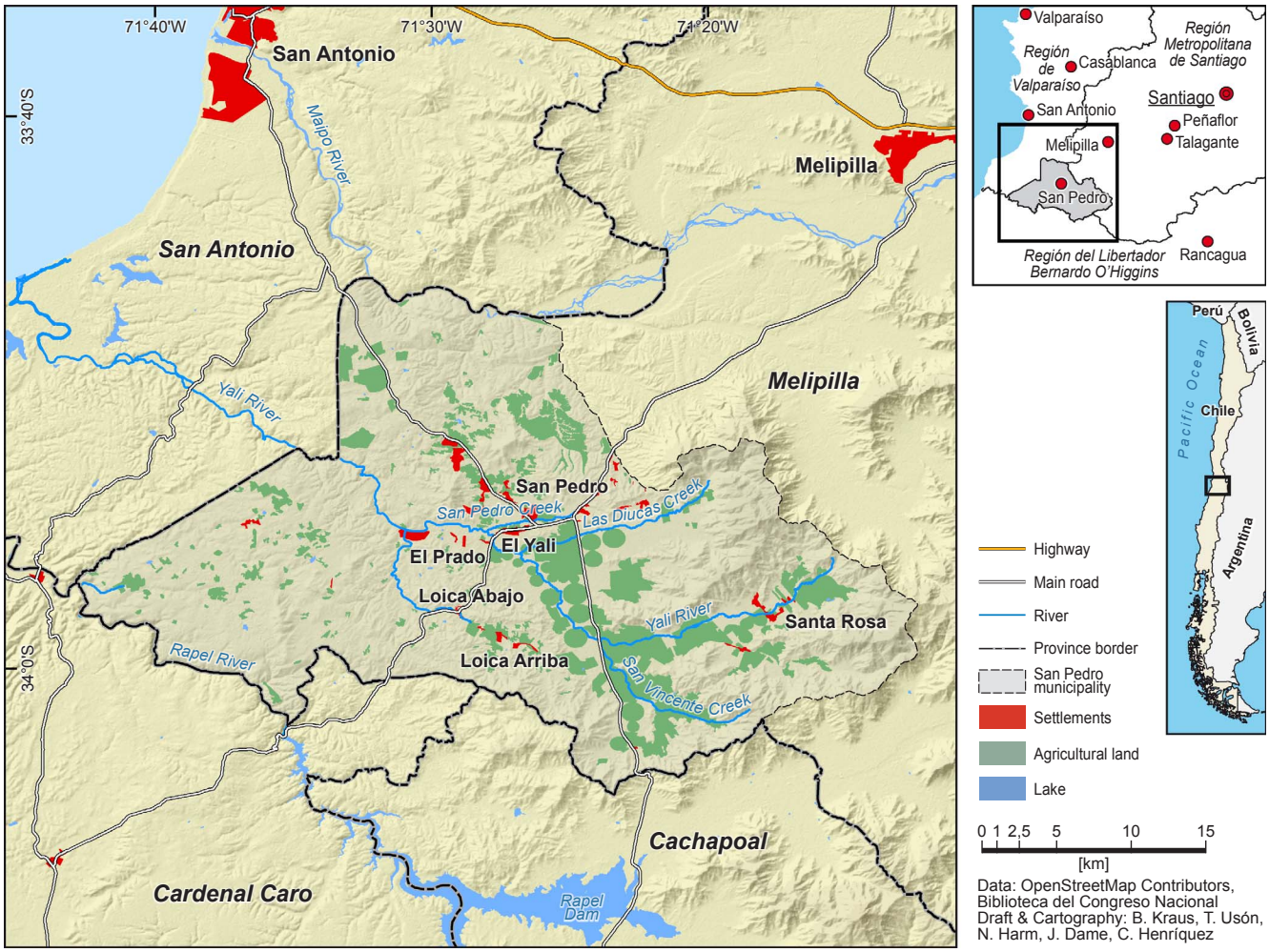

Fig. 1. Urban settlements and agricultural land-use in San Pedro municipality, Chile.
Source: Developed by the authors.

San Pedro is characterised by small and large-scale agricultural production. According to local informants, the history of agriculture in the municipality dates back to the early 20th century, when charcoal producers settled in the area and started wheat cultivation. Besides, small-scale farmers owned a small number of livestock. During the 1960s and 1970s, the Chilean government introduced a series of policies and programs for strengthening irrigated agriculture and livestock production, leading to what was called the 'modernization of the Chilean countryside' (González, 2010). These initiatives allowed for the introduction of new types of crops to the municipality. Favourable climatic conditions along with technological advances and public incentives fostered the cultivation of strawberries in various sectors of San Pedro municipality. Since then, its production has become the main source of income for local farmers and a large number of seasonal workers (*temporeros*) between September and April.

Agro-industrial development started in San Pedro during the 1990s, with pork and poultry farming as well as the large-scale cultivation of olives, grapes, and other fruits as cash crops. According to the last two agriculture and livestock censuses conducted in Chile, the area under grape and other fruit cultivation increased from 992 ha in 1997 to 2320 ha in 2007 (INE, 1997, 2007b).

Although agro-industrial companies created new employment opportunities and income sources, various local stakeholders believe that their economic activities provoked a series of environmental problems, directly affecting the quality of life and agricultural production in the region (Rojas et al., 2010). Large-scale agriculture is blamed for water scarcity, particularly in small settlements located in the vicinity, such as Santa Rosa, Los Culenes, El Prado, and Longovilo. Here, water scarcity has affected the local livelihoods and led to a considerable decrease in available groundwater, forcing local farmers to abandon parts of their land.

5. Knowledge in the context of water scarcity and emerging conflicts in Yali Alto

During the last decade, considerable debates and discussions have surfaced criticizing the government's capacity to evaluate the sustainable use of water resources (Bauer, 2004). The production, circulation, and application of knowledge for water management have been particularly problematic (Budds, 2009, 2012). This situation is the result of a complex network of actors including government agencies, private entities and social organizations involved in the hydrosocial cycle.

In the case of water conflicts in Yali Alto, questions linked to how hydrological data have been collected and managed in order to estimate water availability are central. These aspects shed light on the hydrosocial cycle in the area under study and the role of different actors with regard to knowledge generation, the political implications, and the eventual consequences for the resolution or escalation of the water conflict.

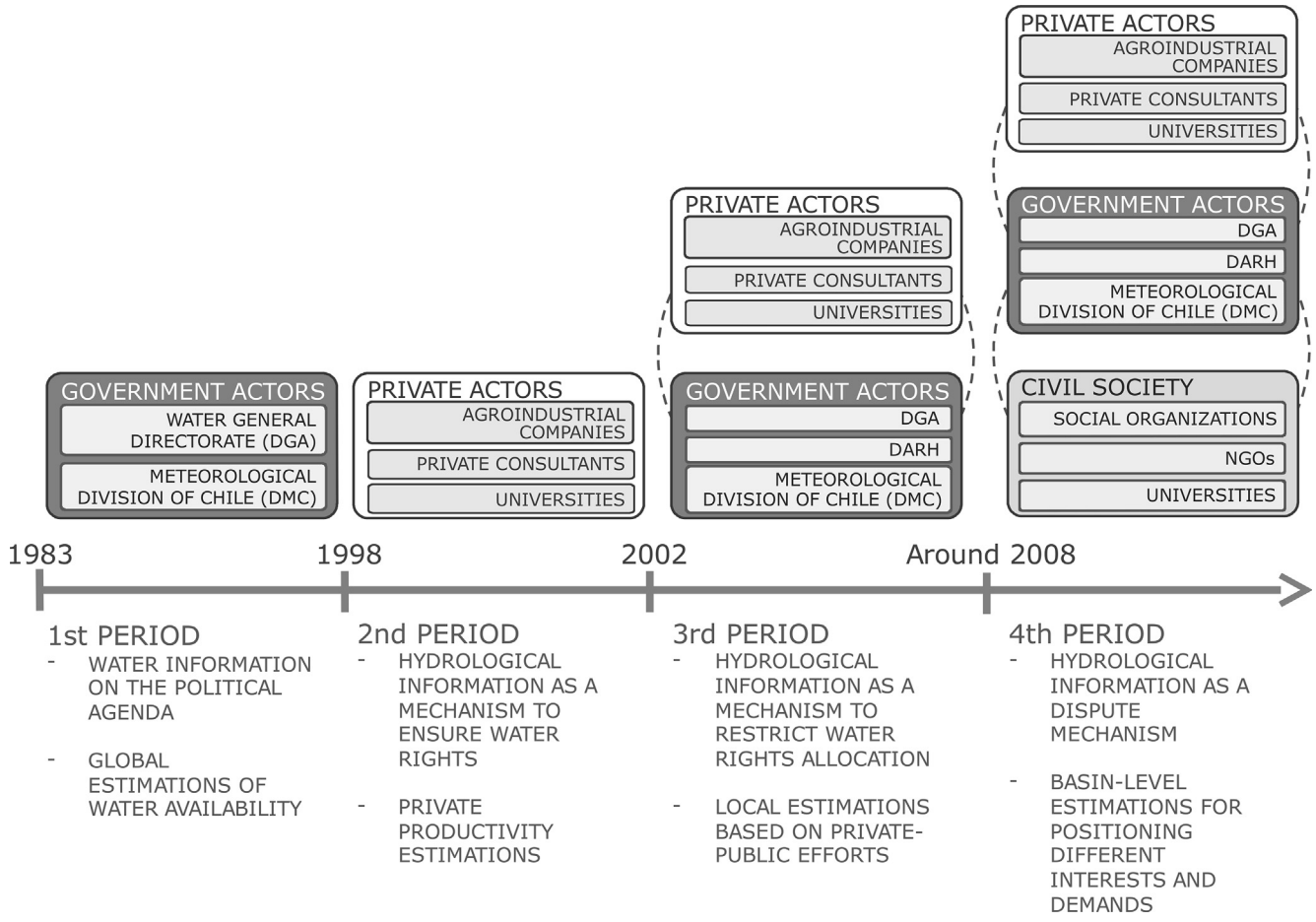

Fig. 2. Periods of information production based on agencies involved and the role of information.
Source: Developed by the authors.

5.1. *Water management and hydrological assessments in Chile*

The Yali Alto case is embedded in the neoliberal political and legal context of the privatisation of water rights in Chile. The core idea of the 1981 Water Code, the central water legislation to this day, was to introduce the market as a fundamental mechanism to trade and distribute water resources (Bauer, 1998). The main assumptions guiding privatisation were that markets would transfer water from lower to higher value activities, and that it would delegate the collection of basic hydrological data to private users in order to avoid problems of information asymmetries commonly associated with centralized systems (Donoso, 2006).

Since the enactment of the Water Code, the General Waters Directorate (*Dirección General de Aguas*, DGA) operates as the central government agency in charge of defining and coordinating the allocation of water rights. Within the DGA, the Water Resources Administration Directorate (*Dirección de Administración de Recursos Hídricos*, DARH) is responsible for determining the amount of water rights available in the different areas of the country and controls possible excess extraction of the resource. The DARH works closely with the Research and Planning Division (*División de Estudios y Planificación*, DEP) within the DGA, responsible for generating updated hydrological data throughout the country. If a basin witnesses high levels of overexploitation, the DARH can declare it a "restricted area", prohibiting new water rights from being granted for a given hydrological catchment.

Since water rights are granted in perpetuity and can be sold by users at any moment, they are transferred from one user to another within the water markets. Private users become regulators of water exploitation quotas in different areas based on the existing residential and production needs (Budds, 2009). Local water communities (*asociaciones de canalistas* and *juntas de vigilancia*) around each basin are in charge of monitoring that users do not use more water than their rights allow (Vergara, 1998). Moreover, Rural Potable Water Committees (*Comités de Agua Potable Rural*, APR), comprising members of the community, are responsible for the management and distribution of drinking water in the rural areas (Bauer, 1998).

Although the DARH is responsible for managing and updating hydrological data, many actors are involved in the hydrological studies today, especially private users who can conduct studies to request new estimations on water availability. These studies assess aspects such as precipitation estimates, rates of aquifer recharge, and water availability in basins. Furthermore, private studies complement the reduced working capacity of the DEP and DAHR due to their scarce budgets and inadequate number of staff. Nevertheless, as international agencies like the World Bank (2013) have previously shown, these diverse actors demonstrate low levels of coordination and suffer from poor communication, and a lack of relevant basic hydrological information. According to a government authority:

> "If you ask different organizations in Chile and consider several studies on what is the amount of available water and what is the water resource demand, you're going to find quite different data. You can't even say "well, there is a similar order of magnitude". Even the order of magnitude is considerably different in some cases."
>
> (Officer of a government authority, 04/09/2013)

In the case of groundwater, the situation is even worse because of

the difficulty in estimating water availability beneath the surface. In many parts of Chile, geological baseline studies are not available. Adding to this problem is the little number of local water communities monitoring the water extracted from aquifers.

> "There are few groundwater communities in the country presenting a serious problem because there are no management organisations for a better understanding of the aquifers. We need to know how much is being pumped out and if water quotas are being respected or not."
>
> (Officer of a multilateral agency, 12/09/2013)

Absence of consistent hydrological data and inclusion of private actors in the production and collection of this type of information increased possibilities of users to influence political agendas and decision-making processes considerably. With proper documentation, users can demand the allocation or restriction of new water rights. Information then becomes a powerful instrument to alter the flow of water, its distribution, and availability.

5.2. Understanding the Yali: Hydrological reports and the production of knowledge

Commissioning of studies and reports relevant for the conflictive situation in Yali Alto can be divided in four periods (Fig. 2). The first period, starting in the 1980s, is characterised by the prioritisation of basic hydrological data on the political agenda. Since the enactment of the Water Code in 1981, hydrological balances formed the basis to define water availability in the country's catchments. In 1983, the "First Hydrological Balance for Regions V, VI, VII and the Santiago Metropolitan Region" was conducted by the DGA and the Meteorological Division of Chile, and supported by the work of UNESCO-ROSTLAB for the development of methodologies (DGA, 1983). The data this study assessed about the amount of water available for all areas of central Chile were rough estimations. In the particular case of Yali Alto, a lack of weather stations to provide reliable data on precipitation and temperature caused the authorities to use data from the neighbouring Rapel river basin. Based on the resulting inaccurate hydrological estimates, authorities granted a large number of water rights to agro-industrial companies, who considered Yali Alto an underexploited area in which to expand their production. At the same time, local farmers and residents remained cut-off from the institutional changes because of a lack of information on the rights allocation process. They continued to use water resources informally, and regulated them by applying traditional mechanisms such as seasonal reviews of well levels:

> "[The water rights assignment] was carried out from 1981 onwards, in particular during that decade. It was developed completely ignoring local farmers, agriculturalists. (…) There was a lack of knowledge, misinformation, and additionally there were businessmen, big agriculturalists with knowledge, information, directly connected to the government."
>
> (Member of a social organization 12/03/2014)

During the second period, hydrological data has evolved as a means to ensure water rights. The large number of water rights granted to agro-industrial companies resulted in massive land-use change. Particularly, the advancement of large-scale pig and poultry rearing triggered the first water dispute in Yali Alto in the late 1990s. In San Pedro, social movements began discussing the problems of water scarcity and, subsequently, pollution. Therefore, Agrosuper, the major agribusiness company in the region, decided to conduct studies on the hydrological conditions of the basin. Agrosuper appeared to pursue two main objectives: first, to prove that its activities were not affecting water conditions in the area. Second, they aimed at restricting water consumption - authorized by the DGA. The idea behind this strategy was to avoid new water rights allocations and also to safeguard the legality of water consumption. According to one agro-industrial agent, "our logic was basically to delay the request [made to the DGA] in order to have enough time to regulate our own water rights, because at that time we requested more rights for new wells" (12/03/2014).

Between 1998 and early 2000 private consultants and universities were commissioned to conduct a series of studies. These surveys assessed the surface water resources of the Yali river and its main tributaries (Brown and Vargas, 1998). They also identified the recharge areas of certain aquifers and estimated groundwater availability. Despite the persistence of problems linked to the reliability of the climatic data, these results were essential for the region since they provided basic hydrological parameters used subsequently for all follow-up studies conducted in the upper Yali basin.

A key result of these earlier studies was the description of the main geological units of the basin and their physical characteristics (DARH, 2005). The Agrosuper study identified two types of aquifers in the basin: free aquifers associated with high permeability units and aquitards or confined aquifers associated with low permeability units. While the free aquifers emerged at the surface in the form of wells, confined aquifers were protected at a greater depth by less permeable soils (DARH, 2005). The diagnosed two distinct groundwater aquifer types served as the basis of follow-up hydrological studies. Agro-industrial companies from then on employed the argument of separated aquifers to justify that their water extraction does not affect the water availability of superficial sources, on which farmers and individual households relied:

> "Shallow wells are supplied by rainwater, while the deep wells of 80, 100, 150 meters are supplied by water coming from the Andes through underground rivers. That is what studies have shown. (…) If rain does not fall, shallow wells do not have water, and that is how it is. Some people say that the deep wells of [names of agro-industrial companies] have dried up the shallow wells. But that does not have any technical support; if you pumped water from one source you do not affect the other one"
>
> (Agent of an agro-industrial company, 21/02/2014)

In a third period, starting 2002, hydrological reports served as a mechanism to restrict water allocation. DARH commissioned new studies by advising entities like universities in order to re-estimate flow levels and water demand in the basin. DARH once again used the studies originally conducted for Agrosuper in the 1990s. New modelling techniques aimed to improve the infiltration levels previously considered by including average infiltration rates proposed in the scientific literature. Consequently, high rates of return were assumed for irrigation (82% for agricultural and 30% for residential uses). However, the authors did not take the widespread use of efficient technology in the basin into account. For example, agro-industrial companies had started to employ drip irrigation in Yali Alto. Additionally, climatic input data was not updated for running the new hydrological models; instead, precipitation rates of the Rapel river basin were reused.

The studies from the third period revealed serious over-exploitation problems in large parts of the upper Yali basin. The reports affirmed that the current levels of consumption exceeded sustainable groundwater consumption levels by up to four times, which resulted in "risks of a serious decline of water levels in the aquifer and consequent injury to constituted water rights of third parties" (DARH, 2011, p. 8). Over-exploitation mainly resulted from excessive groundwater rights granted during the 1980s, 1990s, and early 2000s. However, groundwater rights were still being processed. As an agro-industrial agent stated:

> "Back then it was possible to request water rights and they were granted without any kind of conditions. Little was known about the consequences that would have for the aquifers. And that is how the conflict started, due to the water scarcity."
>
> (Agent of an agro-industrial company, 21/02/2014)

During the fourth and current period, hydrological information has been employed as a dispute mechanism. As a response, social

organizations, supported by foundations and NGOs, began raising awareness among local stakeholders and decision-makers about the scarcity problems experienced in areas of the San Pedro municipality since the 1990s. This network includes organizations such as the communal movement *Juntos por el Agua*, neighbourhood associations, and mothers' centres. Furthermore, supra-regional organizations like *Chile Sustentable* Foundation and the Melipilla Water Defence Network (*Red de Defensa por el Agua*) have strongly supported this network by publishing books and articles. This not only broached the current water conflict in San Pedro but also gave voice to the local actors and their concerns. Despite the previous geological studies, local organizations and farmers blame agro-industry for over-consuming underground sources by drilling deeper wells:

> "I heard that they [the agro-industrial companies] conducted a study to demonstrate that there are two water sources: superficial sources and groundwater sources, which have nothing to do with each other. They wanted to make us believe that superficial phreatic layers are not related with… that a deep pumping-well will never take water from superficial sources. That's what they wanted to make us believe, because they didn't want to be blamed for drying out superficial wells. But what I see is that every time there is a deep well, superficial wells dry out. There is a relation between them."
>
> (Member of a social organization, 20/02/2014)

Some local farmers even sought to give a logical explanation to that problem, arguing that current irrigation policies did not regulate the way wells are constructed. The legislation did not require closing around the drill string in order to seal off the well. According to them, non-sealed wells affected the availability of superficial water sources since they worked as a connection between superficial and deeper, confined sources. If deep wells were properly sealed, water would drain down to the bottom of the basin, leaving superficial wells, mostly used by local farmers and residents, without water:

> "Superficial wells are between 5-10 meters underground. Deeper water sources are 15-20 meters below the ground level. If a deep well is drilled, superficial sources should be protected by law and be sealed, right? (…) However, there are no regulations on how wells should be done, so if I am a private user and I have the resources to drill a deep well, I will try to catch as much water as possible in my well. So, I do not seal the well properly and I leave water drains around the pipe. That is known by those who own the wells; they know where the superficial water sources are located."
>
> (Local farmer, 21/02/2014)

Social organizations gathered data mainly linked to the water rights allocated in the basin and their distribution in order to show what they considered the inequitable distribution of water rights and uncontrolled use of water resources by large agro-industrial companies. Their reports relied on data available online, and testimonies from local farmers, members of APRs, and the affected communities. Alliances with the academic sector, especially student volunteers, interns and thesis students, helped to conduct these studies despite limited financial resources. Their work analysed links between agro-industrial production and levels of water consumption. These assessments estimated the number of pigs and poultry produced by Agrosuper in the municipality and extrapolated the amount of water necessary for their production. Activists also supported local actors by explaining legal aspects of the water management system. Since then, the central idea of social organizations has been to increase awareness among the population and to provide technical tools for their empowerment:

> "Environmental engineers, historians, professors and others with jurisdictional studies started collaborating, simplifying the existing information, because lawyers always talk with confusing terminology. So we started clearing up certain things."
>
> (Member of a social organization, 12/03/2014)

5.3. Circulation of water knowledge

The involvement of social organizations and local actors led to two distinctly polarised positions of arguments that related to the opposing groups of actors. Agro-industrial companies utilized and promoted the commissioned hydrological studies as a mechanism that helped them to position their demands towards local and regional authorities. They argued that water scarcity was the result of unregulated water use by different actors, including local small-scale farmers. In the fear of potentially negative impacts on their lucrative production, the companies formally requested the DGA to declare upper Yali a restricted area, hoping to avoid the granting of further water rights.

Given that the main objective of the agroindustry was to provide the reports conducted by their own assessors during the first and second periods to the DGA, these hydrological studies were circulated between major land-users and the government. According to agro-industrial actors, sharing reports with others was irrelevant. Representatives from the companies argued that local actors would not understand the technical information. This led to their exclusion from the circulation of reports and working sessions with authorities. As one agro-industrial officer stated, "they lack education and technical training. When you start talking about these issues most of them do not understand anything what you are saying" (21/02/2014).

In response, non-government organizations and local movements started to consolidate their own networks for circulating their claims. These actors used mass media to disseminate information about the water problems that people faced in the upper Yali basin. At the local level, activists distributed newsletters and magazines. In addition, testimonies were presented in a series of regional and national newspapers. The groups directly linked over-exploitation of aquifers to the concentration of water rights within the agroindustry. They argued that the current water rights distribution leads to unfair and excessive allocation of water rights to large enterprises, which, by virtue of the technology and resources for drilling deeper wells, pumped huge amounts of water:

> "The problem nowadays is that the water is deeper in the ground due to the 200 meters wells drilled by the agroindustry. They pump all the litres per second they own as water rights, which recharge underneath the groundwater. (…) Thus, the solution should not be deepening the wells but redistributing the water rights. That is the most beneficial for the smallholders."
>
> (Member of a social organization, 12/03/2014)

Social organizations have also engaged in more direct and controversial actions such as the closure of roads and public protests. These measures challenged government officials working on water management as well as rural agriculture and livestock production and accused them of failing to develop medium- and long-term policies for solving problems in the upper Yali basin.

Media campaigns and public protests have been useful in highlighting the concerns of social organizations. However, there has been limited impact in promoting these groups as relevant actors within the management system. In particular, they were still not involved in the production of hydrological data, which ultimately served as the basis for government-led reconciliation of water disputes in the basin. This is largely because of the groups' inability to translate their experiences into codified hydrological knowledge. The government actors involved in the water management of the basin have pointed out the lack of "technical" information. Moreover, agro-industrial companies considered the understandings of the water resources shared by the social organizations to be unsubstantiated and biased towards serving their own vested interests:

> "Not everyone provides information in a transparent manner. (…) There are pamphlets here arguing that there are eight thousand people in San Pedro and 2 million pigs. That's cruelly false. They say

that a pig consumes 45 litres of water. That's a lie! From where did they get that information? They got it from the Clinic.[1] Why didn't they ask me directly? I think there are too many emotions involved."

(Agent of an agro-industrial company, 21/02/2014)

As a result, agro-industrial and social organizations have developed mistrust, mutually delegitimizing their respective claims. Both groups agree that deliberative spaces between various stakeholders were necessary, including roundtable discussions and other meeting mechanisms.

"We prioritize informal meetings and gatherings with them. You can go to their homes or a meeting and talk to them at their level instead as someone superior. You try to be empathetic, to find the level that benefits both sides."

(Agent of an agro-industrial company, 21/02/2014)

However, while local actors stated that the companies were not willing to sit down to discuss the water problems in the basin; agro-industrial companies argued that local stakeholders were not prepared to discuss the technical aspects. Some local voices expressed the necessity of dealing with technical information to counter the agroindustry and legitimize their own position. According to them, "proper information" could have a "real impact" on the regulation of the basin:

"If we are going to support something, we need to fight for it, but with fact-based knowledge. We need someone who speaks about water use, but with agronomical arguments. We need a lawyer with legal knowledge, who knows the law and if I'm right or wrong. We also need someone who has made a reliable study, like a hydraulic engineer or a geologist, someone who has detailed information about the problem."

(Local assessor, 28/02/2014)

5.4. Impacts of competing knowledge claims on the water conflict in San Pedro

The contested knowledge claims regarding the water situation in San Pedro have an effect on management decisions in the municipality. A comparatively small group of stakeholders utilized the studies commissioned by them, shaped by their interests and attempted to inform political stakeholders to influence the decision-making process. By 2011, the DARH had declared all of the Yali sub-basins as restricted areas following continuous requests by the agro-industry. Moreover, the allocation of provisional water rights was only possible for the upper Yali and Las Diucas, its tributary. Although this helped to limit overexploitation of the aquifers by impeding the allocation of new water rights, it did not solve the problems of excessive use and inequitable water right distribution that already existed. In addition, application of hydrological information for the declaration of restricted areas has not included local stakeholders when searching for alternatives. This is particularly relevant when considering the consequences for small-scale farmers and APRs, who have been unable to maintain their historical water consumption regulations and practices.

In response, social organizations started using their own networks for sharing knowledge in an effort to position their concerns and demands. They disseminated testimonies about water disputes in the basin linked to unequal access and distribution of water in order to raise awareness. Their goal was to pressurise government officials to solve the problems of scarcity in the basin. While they have been less effective with regard to implementing policies, they generated social mobilizations at the local and national levels. This public opinion provoked short-term responses by government agencies (Fig. 3).

One of the actions taken was the purchase of water rights by the government in 2011. In order to guarantee the provision of drinking water to the local communities, authorities provided these newly purchased rights to several APRs in the basin, especially one recently formed in Santa Rosa village. However, this measure has not solved the long-term problem because it only redistributed the levels of over-exploitation that already existed in the basin without reducing current levels of consumption. Some local actors deemed this as a complete defeat of their demands:

"The APR committee in Santa Rosa was approved, everything was settled and readied to work, but the most important was missing: the water rights. Agrosuper could easily solve it; they worked with lot of people from Santa Rosa. Why was it so hard for Agrosuper to give 2 litres per second? That would have solved everything and we could have built a good relationship. (…) In sum, there was an offer made by a person who was selling 3 litres per second in Yali Alto. And then the big mistake comes, the precedent for the water issue here in San Pedro: the government accepted to pay $30 million pesos [ca. US$ 45,000]. In total, $90 million pesos were spent to solve the water problem in Santa Rosa. What does this mean? It means that the state agreed to buy something that was initially given for free."

(Local assessor, 28/02/2014)

Another step has been the distribution of water to isolated settlements through water trucks hired by the municipality. According to some interviewees, this measure helped to reduce the lack of water in Diucas, Upper Yali, San Vicente, and Loica sub-basins, but did not present an effective solution to the long-term scarcity problem either. Considering the distribution of the settlements across the municipality vis-à-vis the limited capacity of the trucks to store water and to deliver it to all settlements regularly, the amount of water received by the households failed to meet basic needs.

"Over the past two years, we have been updating our information. Around 160 families in San Pedro do not have water in their wells and depend only and exclusively on water distributed by the municipality every 15 or 20 days. Sometimes, when it rains, the roads are impassable and people have been without water for four months."

(Local farmer 20/02/2014)

As an additional measure, the National Institute for Agricultural Development (*Instituto Nacional de Desarrollo Agropecuario*, INDAP) has constructed storage ponds in some ravines of the basin for water harvesting. However, this programme has received strong criticism. Some small-scale farmers argued that private companies built the ponds inefficiently. Local producers complained about the lack of a follow-up inspection by INDAP and future users of the water harvesting structures.

As a means of conflict mitigation and community support, agro-industrial companies started educational initiatives linked to water efficiency. Companies conducted training workshops and distributed equipment for efficient household water use to the population as a way to increase awareness in the community. However, social organizations criticized these measures and described them as actions that only sought to "clean up the images of these companies":

"In the training seminar, I received low-flow faucets and showerheads, which drew loud laughter from people who must clean themselves with jars. We were there as a movement when they were talking to children at school about water efficiency. But they didn't tell the children that a pig consumes 45 litres daily. The same company who was teaching them how to use water is wasting 45 litres per day in one swine, almost twice the amount that some people receive. Kids don't know that. They teach you how to use water when you have to get by only with water drops."

(Local farmer 20/02/2014)

These contestations have exacerbated a highly conflictive situation

[1] The Clinic is a left-wing weekly newspaper from Chile known by its satirical articles and notes.

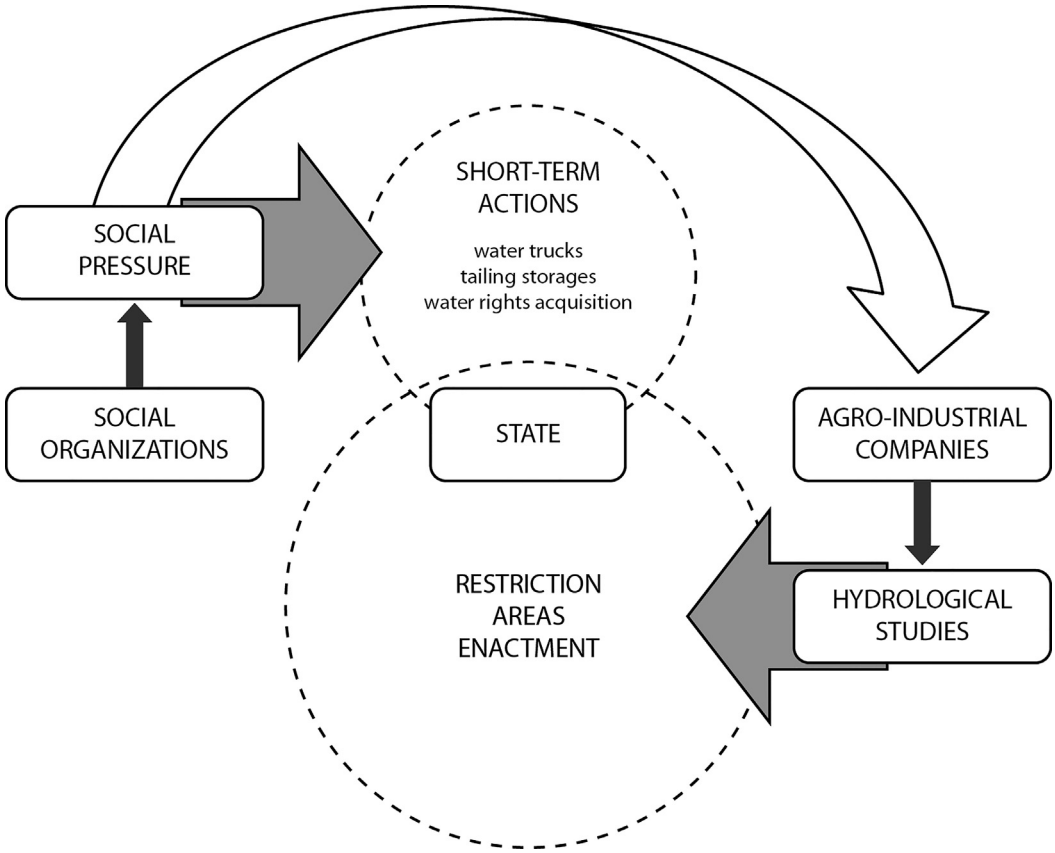

Fig. 3. Application of water information: water management decisions in San Pedro.
Source: Developed by the authors.

between the agro-industry and local farmers and residents. Agro-industrial companies have become influential actors in the water management of the basin, supported by the unbalanced scenario of the production and circulation of information.

6. Discussion: Water knowledge, asymmetries of power and water disputes in Yali Alto

The landscape of conflicts presented above reveals different knowledge claims, which largely follow two lines of argumentation. On the one hand, agro-industrial companies like Agrosuper have argued for stronger restrictions on water allocation supported by early hydrological studies, which identified two types of groundwater sources: confined and superficial aquifers. Since the agro-industry obtains water mainly from the former, they claimed that the scarcity of water had nothing to do with their own consumption. Instead, they asserted that water scarcity problems, mostly affecting local smallholders and residents, were due to extraction from several illegal wells in the area. Thus, policies and actions should focus on restricting water extraction and shut down illegal wells.

On the other hand, smallholders and communal organizations claimed that concentration of water rights with a few was the main problem in Yali Alto. The unrestrained use of water by a small number of pork and poultry companies as well as large-scale crop production reduced the amount of water available for the original residents of Yali Alto. According to some small-scale farmers, the lack or regulation on well seals reduced the water levels of superficial aquifers. Local residents believed that water policies in the basin should be focused on water rights redistribution, prioritizing usage for direct human consumption.

The results from the Yali Alto case study resonated with previous studies in which water policies were conceived as a flexible field of work and negotiation (Agnew, 2011) and, as Birkenholtz (2008) and Robbins (2000) argued, a field of alliances for the creation of knowledge. Competing positions and interests tried to set the agenda according to users' needs and biophysical elements of the territory. Multiple arguments along with their respective logics emanated from different groups leading to the creation of opposing socially-constructed narratives of water scarcity. However, decision-makers only recognised arguments that were presented as unbiased objective facts, based on technical and economic factors (Budds and Sultana, 2013).

In contrast to agro-industrial actors, local farmers and residents presented an alternative understanding of environmental problems affecting the availability of water in the zone. Their perceptions and claims, however, were not substantiated by scientific studies as they lacked the financial resources for research. Their positions were further weakened by the absence of official recognition from the local and regional authorities. According to Budds (2009) and Palomino-Schalscha et al. (2016), the prioritization of narratives based on technocratic and efficiency concerns within the Chilean political-economic framework has restricted the space available for alternative discourses. This included personal experiences, traditions and, in general terms, knowledge not corroborated by hydrological information. This ought to be considered within the official decision-making processes.

Just like the case of La Ligua, Chile (Budds, 2008, 2009), water assessments have reproduced the existing unequal patterns of water-right distribution without improving the water security of the basin. Despite hydrological studies suspending allocation of new water rights in the basin, water consumption has not reduced. Instead, restrictions have favoured agro-industrial companies, legitimizing their positions and shifting the debate to the legality of water consumption rather than disproportionate accumulation of water rights. This settles the relation between illegality and scarcity as a causal, commonsensical phenomenon, which has also been argued by Alatout (2007) for the water

conflict between Israel and Palestine.

Markets are expected to solve information asymmetries by levelling out unequal access to scientific assessments on resources like water, a problem commonly associated with centralized distribution systems (Donoso, 2006). Yet as the case of Yali Alto shows, delegating the collection and production of water information to private actors was inherently biased against smaller farmers and benefitted larger agro-industrial companies more. With their greater financial and political capacities, these actors were able to validate their interests through a commissioning of technical studies and reports with direct effects on water management.

More significantly, the study reveals large power asymmetries that resulted in disproportionately calibrated capacities of the involved actors in translating their experiences and arguments into valid knowledge towards decision-making. The capacity of convincement, or interessement and mobilization of local farmers and social organizations – according to Callon (1984) – was restricted to the resources at their disposal. In contrast to the agroindustry, their water consumption was based on the restrictions in water control and limited access to pumping technologies as means of adaptation. They did not rely on hydrological data or models, but their arguments were based on direct engagement with the resource and experiences of community members facing critical shortages of water.

This article has shown that authoritative knowledge should not be considered inherently neutral or impartial. Instead, it is the result of biophysical conditions, stakeholder networks with disparate levels of power and the capacity of certain actors to mobilize public opinion and promote their interests more than the others. The need to sustainably manage the water resources in Yali Alto, following legislative reforms and the agricultural intensification in the area, has led to a formation of collaboration between agro-industrial companies and the state agencies. This has helped agro-industrial companies to push their demands on the political agenda with substantial possible impact on the resource management. Large companies developed their arguments based on hydrological data and models of aquifers, validating their knowledge productions and arguments towards practical applications. Absence of institutional mechanisms to regulate the relations between private and public actors in water management as well as scarce public resources for producing robust and consistent studies about the current hydrological situation of Yali strongly and negatively enhanced the influence of private actors on resource management.

The case of Yali Alto shows a need to recognize all water users as active political actors in the decision-making processes. It is only in this way that a more just mechanism for the creation and circulation of knowledge can be achieved. This entails abandoning the idea that technical information was a neutral, apolitical set of facts describing nature objectively (Goldman et al., 2011; Latour, 1999; Lave, 2012). Recognising political impacts of different water knowledges can help level the deeper power inequalities between different actors and their respective abilities to influence the water politics of the region.

7. Conclusions

The case of Yali Alto shows how varying capacities to produce hydrological information was a politically entrenched mechanism, which in turn disproportionately and biasedly impacted water allocation and utilisation protocols. Circulation, legitimisation and application of data that are products of highly politicised, unequal, exclusionary and power-laden processes can lead to development policy paradigms detrimental to local communities and their rights to water. In the long run, it may also lead to biophysical and geological instability or unsustainability.

Unequal access to water in San Pedro has been reinforced and also legitimised by the hydrological studies. Framed within the notion of the hydrosocial cycle, this study has shown that stakeholders with abilities to translate groundwater resources into hydrological information gained significant political advantages over those with lesser capacity to do so. Valorising such knowledge-based policy approach also shifted the discourse from structural drivers of scarcity to external drivers such as illegality of wells, which suited the agro-industrial sector. Local farmers and residents, on the other hand, argued that conflicts on water resulted from excessive concentration of water rights with large corporations. Results show that unregulated systems of water management like the Chilean case elicit and encourage private interventions – agro-industrial sector in this case – to regulate water access and distribution through scientific reports. Moreover, overemphasizing scientific and technical approaches undermines alternative visions and marginalises the claims of actors with little resources to conduct such studies, downplaying their demands within the public agenda. The findings strongly support the idea that science and politics should not been seen as separate and independent systems, but as closely linked networks immersed in complex processes of production, circulation, and application of knowledge.

Sustainable resource governance needs to better understand knowledge production processes and their impacts on decision-making. A number of stakeholders, their networks and power relations shape scientific-technical information. A deeper understanding of these networks and their territorial impacts is a prerequisite to resolve disputes and institutional conflicts. This entails the necessity to think about public policy mechanisms that calibrate power inequalities between private, government and community stakeholders. In this context, it is important to ensure equal participation in the decision-making processes that approve projects with high socio-environmental impacts. Direct participation of local actors in water management can be beneficial for them, which would recognize them as equal stakeholders for understanding the territory and making decisions about the future of their environments.

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