



Exploring water (in)securities in a water-abundant setting: hydrosocial dynamics and local strategies in Central-South Chile

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ABSTRACT

Chile is experiencing complex hydrosocial crises, exacerbated by a prolonged period of drought. In the context of water scarcity and related resource conflicts, not only limited availability, but also questions of access to water play a crucial role. While most studies have focused on water insecurities in the semi-arid and arid regions of the country, less attention has been paid to southern Chile. However, the construction of hydropower plants in Indigenous territories has put a strain on relations between the state, the Mapuche populations and hydroelectric companies, and affected water availability in this part of the country.

Drawing on concepts of water security and environmental governance, we investigate water insecurities in seemingly water-abundant areas, using examples from the Los Rios region in Central-South Chile. Through qualitative social research methods including interviews and ethnographic observations conducted between 2019 and 2023, we found that problems of access to water surface within the green scenery affect population groups unequally. Based on the empirical case study, we argue that specific cultural, social and economic contexts influence decision-making processes regarding access to resources. Multiple factors limit or grant access to water, including financial issues, disputes within local communities and social networks, as well as the emergence of new economic activities, particularly tourism. In addition, a lack of coordination between governmental agencies at horizontal and vertical levels affects water governance. Therefore, our results are of socio-political relevance for possible reforms to water legislation and for the discourse on environmental justice and adaptive water governance.

1. Introduction

According to the Environmental Justice Atlas (Temper et al., 2015, Environmental Justice Atlas, 2024), South America is a “hotspot for environmental conflicts” (Fragkou et al., 2023: 87). The high number of socio-ecological crises relates to the specific political context from its colonial history to current neoliberal policies, favoring extractive industries, agrobusinesses and large-scale energy projects (Martinez-Alier et al., 2016; Pinto et al., 2017; Svampa, 2019). Since the 1980s, in particular, extractivism has been fostered by a reduced role of the state, strong privatization and incentives for private investment (Haarstad & Campero, 2012), exacerbating social conflicts (Humphreys Bebbington & Bebbington, 2012). Nowadays, climate change mitigation strategies, such as renewable energy projects, and mineral mining for the energy transition, perpetuate this extractive tradition. As 73 % of these minerals

are explored in or near Indigenous territories, new impacts and dynamics of resistance are emerging across Latin America (Owen et al., 2022). Demands are no longer focused on monetary compensation only, but rather on competing visions on how (economic) growth should be sustained, what levels of ecological and social impacts are bearable and how the benefits of these extractive activities should be distributed (Barandiarán, 2019; Hinojosa et al., 2015; Perreault & Valdivia, 2010). Environmental struggles and conflicts around agricultural land-use change, mining and hydroelectric projects typically centre on water use and access (Prieto et al., 2019; Larraín & Poo, 2010; Larraín and Schaeffer, 2015).

Chile is a typical example. On the one hand, the water crisis is closely linked to general situations of physical water scarcity, which is particularly prevalent in the semi-arid and arid regions of the country. Since 2010, the situation has deteriorated further due to the onset of a

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megadrought, characterized by below-average rainfall levels (Garreaud et al., 2020) and intensified conflicts over water, particularly in proximity to extractive industries. On the other hand, legal regulations are a significant factor in the emergence of water conflicts. The Water Code passed in 1981, has resulted in the full privatization of water rights thereby strengthening economic sectors such as mining, hydroelectricity and large-scale agribusiness and thus sustaining the Chilean economic model (Bauer, 1998, 2015; Budds, 2013, 2020). The impact of the introduction of a water market that defines water as an economic good has been assessed using empirical case studies across the country (e.g. Budds, 2012; Romero Toledo, 2014; Torres-Salinas et al., 2016). These studies often relate to large-scale extraction projects in the agricultural sector (Usón et al., 2017; Perez-Silva & Castillo, 2023), mining (Camacho, 2012; Prieto, 2016; Gentes & Policzer, 2022; Dame et al., 2023), or hydropower (Borgias, 2018; Romero Toledo, 2018; Kelly, 2021).

Drawing on critical perspectives from political ecology, hydrosocial studies and environmental governance, scholars have addressed water insecurities and analyzed how water access and use are entangled with infrastructural constraints and social relations and practices, understanding water scarcity as being of hybrid origin (Budds, 2009; Oppliger et al., 2019; Nicolas-Artero et al., 2025). For the hyper-arid Atacama region, Prieto (2015; 2016) and Prieto et al. (2019) have shown how local Indigenous communities have been marginalized in struggles over water in the context of an expansion of copper mining and urbanization processes. Cantillana and Iniesta-Arandia (2022) stress the relevance of socio-cultural practices and discourses in the emergence of the water crisis in the Atacama. However, less attention has been paid to rural communities' water needs in areas, which are not affected by large extractive projects (Nicolas-Artero et al., 2025).

Questions regarding the use of and access to water in the Chilean south, with its apparently green scenery, lakes, and waterbodies and the resulting inequalities have received less attention. Nicolas-Artero et al. (2022) argue that domestic water supply in rural areas in Chile is not an issue in water-abundant regions. Nonetheless, the case of Chaihuín in the Los Ríos Region has been documented to be an exception (Nicolas-Artero et al., 2025). Other authors have shown that problems occur, for example due to the exclusion of stakeholders from participating in community based drinking water committees (Delgado et al., 2013; Rojo et al., 2018). However, only few authors note that scarcity amidst plenty arises (e.g. Fragkou et al., 2023). The same holds true for the specific concern of domestic water supply. In rural Chile, a decentralized system established in 1964 under the Rural Drinking Water Program (RWP), and operated by the Ministry of Public Works (Ministerio de Obras Públicas, MOP), grants access to drinking water through Rural Drinking Water Committees (Comités de Agua Potable Rural, CAPR). These committees comprise the direct consumers, and are responsible for the administration, operation, and maintenance of the local drinking water systems. Specific tasks include the supervision, repair and extension of the supply network, funded by the MOP. Furthermore, CAPRs organize regular drinking water quality controls, which are supervised by the Health Authority (Autoridad Sanitaria), and oversee the financial management of the drinking water supply. In the future, CAPRs will also take on responsibilities for wastewater management (Fuster & Donoso, 2018; Pareja Pineda et al., 2022). Research on this system has found that, since its implementation, water supply in rural communities has improved in terms of quantity, quality and continuity (Fuster & Donoso, 2018; Nelson-Núñez et al., 2019).

Against this background, this paper assesses the challenges of water use and access in water-abundant areas. It addresses two key questions based on evidence from an empirical case study in the Los Ríos region: To what extent do people in a water-abundant area face water insecurities? How are these water insecurities produced and governed?

Our study combines an analytical governance approach with the concept of water (in)securities to understand how hydrological resources are accessed and used in water-abundant regions. From this

perspective, water (in)securities are an outcome of governance processes and structures (Jepson et al., 2017) and are directly related to different geographical scales. For whom and how water is secured is linked to social and cultural dynamics, political contexts, entitlements and human capabilities (Wutich et al., 2017). Our analysis aims to understand how a complex interplay of physical and social factors (re) produces water shortages at the household level and in the daily practices of accessing water, revealing a broad diversity of water scarcities.

Following this introduction, we describe the conceptual background of the study, which departs from an integrative perspective on water and society and discourses on water governance. In the next section, we present the qualitative research approach and the case study area in the municipality of Panguipulli. The results section is divided into two parts. First, we describe how access to water is generally provided in the study area and identify different types of rural water supply and their challenges. Secondly, we assess situations of water insecurity and analyze how these are produced. In the remainder of the paper, we discuss our findings highlighting how decision-making processes about water access and use influence water scarcity. We argue that uncoordinated and individual decisions by water users at a micro level, alongside constraints such as water rights possession and available infrastructure options at the meso and macro level, lead to water insecurities even in water rich areas.

2. Water security

Water security research has often focused on understanding how water supply is secured for human, economic and environmental purposes. Accordingly, the term water security has been used as a policy objective or a strategy, e.g. in the context of Integrated Water Resource Management (IWRM), or in the assessment of physical scarcity (Grey & Sadoff, 2007; Gupta et al., 2013). However, according to Cook & Bakker (2012), water scarcity is not only linked to its biophysical availability, but it becomes a scarce resource due to quality, financial, and infrastructural constraints. Over the past decade, new approaches in water scholarship within the fields of sociohydrology and hydrosocial studies have emerged within different paradigms and disciplines that recognize the need for integrative and interdisciplinary perspectives (Flaminio et al., 2022; Krueger et al., 2016; Linton & Budds, 2014; Wesselink et al., 2017; Yu et al., 2022).

Particularly, Budds (2020) sheds light on how water-society relations underpin water (in)securities and on their role in securing water supply in different physical, social, political and institutional settings. Hydro-social relations play a crucial role for water access and use (Budds 2020; Jepson et al., 2017), and analysing them sheds new light on how water (in)securities are produced, legitimized, part of a wider agenda, and influenced by power. In addition, this perspective allows the inclusion of cultural knowledge, values, and practices at the local level that impact water (in)securities (Jepson et al., 2017). Inspired by the capabilities framework, a relational perspective on water security acknowledges the relevance of human well-being, as well as environmental and social justice. Accordingly, Jepson et al. (2017: 48) define that “water security informed by the capabilities approach necessarily attends to water as part of a hydro-social process that is simultaneously material, discursive, and symbolic, differently valued – as not solely material or social, but relationally, based on negotiation and interaction at individual and collective scales”. This research perspective explicitly embeds water security in political and social contexts implying a dynamic, multidimensional and multiscale understanding. It aims at refocusing water governance responses and shifting away from understanding the water crisis in terms of a material water scarcity (Jepson et al., 2017), which is addressed through technological solutions and infrastructural responses (Budds, 2020).

3. Water governance

An analytical lens on water governance seeks to understand how societies interact with water within specific physical, social, political and institutional contexts (Glückler et al., 2019; Woodhouse & Muller, 2017). Governance refers to the ways in which state and non-state actors address collective problems such as water use and access (Höhl et al., 2021; Rhodes, 1996). These underlying processes are characterized by negotiation, collaboration and legitimacy (Glückler et al., 2019). Thus, this governance perspective aims at a deeper understanding of the entanglements between water and social structures (Ostrom, 2009).

Governance addresses water use and access not only from a material, water supply point of view, but also links these to decision-making at different geographical scales (Yates et al., 2017). The decisions taken by the stakeholders involved differ across scales and places, and are intertwined with specific historical or contextual circumstances as well as power configurations. This can prevent consensus on water use and access, as different actors may disagree on the evolution of decision-making processes and on their degree of participation (Gupta et al., 2013). One example is Indigenous resistance against extractive industries, agrobusiness and large-scale energy projects in Latin America. Indigenous rights were strengthened throughout Latin America in the late 1980s and early 1990s within the wave of “multicultural constitutionalism” (Lee Van Cott, 2000: 17). Indigenous laws were proclaimed, and most countries signed the International Labour Organisation Convention No. 169. However, the newly created mechanisms such as (prior) consultation processes are lagging behind in established international standards exhibiting various technical and political challenges (Tomaselli & Wright, 2019). According to Bakker (2007) and Yates et al. (2017), water relations are place-based and influenced by policies, legal frameworks and locally organized water management and community norms.

The water governance approach enables us to identify the role of infrastructural and technical development, as well as the legal arrangements, rules, customs and behaviours through which access to and use of water are organized and framed (Dame & Höhl, 2023; de Loë & Patterson, 2017). It is, for example, important to understand water ownership and its impact on access to the resource for identifying how the governance system operates and how legitimate, equitable and effective it is (Gupta et al., 2013). Furthermore, water governance comprises understanding implications of modular, adaptive, and decentralized solutions for water access and use in comparison to centralized technical fixes and mechanistic responses (Wutich et al., 2023).

4. Water governance and (in)securities in Chile

A relational perspective on water (in)securities allows understanding the broader linkages between regulations and society. In the Chilean case, the Water Code as the legal framework aims to promote certain economic sectors such as export-oriented agriculture, mining, and hydropower generation by decoupling water rights from land ownership. In accordance with the Water Code, access to water is entirely privatized (Bauer, 1998, 2015; Budds, 2013, 2020). Once the law was passed in 1981, users could register titles for water rights – either surface or groundwater – free of charge with the responsible government agency, namely the National Water Directorate (Dirección General de Aguas; DGA). Once registered, holders are authorized to trade or inherit water rights. This system is conducive to the concentration of water rights in the hands of a few powerful actors, which has resulted in their accumulation in several regions. This has been identified as a significant driver in conflicts over water use that have emerged in the country (Budds, 2020; Oppliger et al., 2019; Prieto, 2015, 2016; Urquiza et al., 2019; Usón et al., 2017). Water conflicts are further exacerbated by a lack of supervision of water rights (Vergara, 2015). Until 2022, economic sectors such as tourism did not benefit from the logic of the water

market and remained excluded.

The DGA not only registers water rights, but also administers the water system. Solutions to water scarcity are found to be state-led, with infrastructural and technical solutions playing a pivotal role. While the DGA is primarily responsible for the administration of the water system, several public agencies are involved in ‘water governance’. Water user organizations, such as irrigation canal user associations and basin-wide vigilance committees (Juntas de Vigilancia), both influence decision-making at the local scale. The resulting dispersion of state functions causes fragmentation, coordination problems, and an overlapping of responsibilities (Urquiza et al., 2019). Moreover, regulations are applied uniformly from northern to southern Chile, despite the highly diverse geographical contexts presenting a broad range of water use and access challenges due to territorial differences (Valdés-Pineda et al., 2014) which provokes water (in)securities (Costumero et al., 2017; Urquiza et al., 2019). Consequently, water resources lack clear and consistent administration (Montana et al., 2016). In addition, Budds (2020) highlights the significant underrepresentation and notable absence of participation of water users in decision-making processes.

In terms of responses to drought and water conflicts, it becomes evident how the supply side is prioritized to serve the economic and political interests of Chile’s elite (Budds, 2020). The organization of drinking water supply around two different formal systems underscores this argument. Private companies supply drinking water in urban areas, while CAPRs provide drinking water in rural settlements. In 2019, 1,939 rural drinking water systems were registered in Chile, counting 1,843,919 beneficiaries (DOH, 2025).

In the beginning, CAPR served the goal to administer supply infrastructures set up by the state (Nicolas-Artero et al., 2022). Nowadays, self-organized CAPRs are responsible for rural water distribution, financial management, and control of water infrastructures as well as drinking water quality. Based on the legal framework and the privatization of access to water, CAPRs as legal entities must be holders of water rights. This regulation can lead to conflicts with other users or to speculation (e.g. Lukas et al., 2020). Each CAPR is headed by a board of directors elected from among all its members, whose qualifications and administrative abilities are key to the committee’s effectiveness. To further regulate CAPRs, the Ministry of Public Works passed Law No. 20,998 on Rural Sanitary Services (Servicios Sanitarios Rurales, SSR) in 2019. This law provides a legal framework for the technical, management and financial aspects of rural drinking water provision as well as sanitary services through CAPRs. Yet besides the CAPR, 46.3 % of Chile’s rural population – roughly one million inhabitants – use alternative forms of decentralized access to water, such as wells, springs or trucks (Fragkou et al., 2022; Nicolas-Artero et al., 2022). While research has focused on CAPR systems, less is known about these other forms of local access to water, which are partly or entirely privately organized (Nicolas-Artero et al., 2022).

5. Methods

To investigate water insecurities and local adaptation strategies in territories without natural water scarcity, we use examples from the Los Rios region in Central-South Chile. Our study follows a qualitative approach combining ethnographic observations with qualitative interviews with different stakeholders (Flick, 2022). Data collection was part of a broader research project on water governance in Indigenous territories in Central-South Chile and took place during three research stays in the study area between 2019 and 2023. A total number of 33 qualitative interviews were conducted in the municipality of Panguipulli. 12 interviews were with interview partners from government departments responsible for environmental assessments and water regulation (5), administrative members of the municipality of Panguipulli (3), social interest groups (3) and one member of a CAPR. Furthermore, conversations with representatives from Indigenous communities (10) in the area took place. Both the interviews and the

conversations provided insights into water utilization, access to water and related issues. Several interview partners were consulted more than once. All participants provided informed consent to participate in the study. All interviews were conducted in Spanish, recorded where consent was given, and transcribed. Where interviewees did not agree to digital recording, handwritten notes were taken.

To account for positionality and reduce cultural and idiomatic barriers our research team involved an Indigenous researcher. This participation facilitated the classification of statements accordingly and the avoidance of misinterpreting results (Herod, 1999; McDowell, 1998). Furthermore, we followed the Indigenous methodological understanding that representatives from Indigenous communities transmit knowledge between generations and people through personal narratives, stories, and general conversations (Kovach, 2015). We therefore distinguish between interviews and conversations, understanding the latter to be more adequate to refer to our interaction with Indigenous people. In addition, we respected Indigenous timeframes and ancestral protocols when establishing contacts and conducting the conversations (Datta, 2018). According to these protocols, we did not record any conversations but took notes to co-construct knowledge on water access and use.

We assessed the data based on Kuckartz' (2014) qualitative content

analysis with thematic analysis as the basic method. The codes used were established inductively based on the principal issues raised by the different actors regarding water use and access, such as economic, social, and cultural challenges, as well as water quality and pollution. The analysis of qualitative interview data was performed using the software program MaxQDA. Our self-collected qualitative data was complemented with information from official statistical data, (unpublished) reports, and media reports. For example, additional information on land use from official documents by CONAF (sit.conaf.cl) was obtained. This allowed to triangulate the data and to validate the information obtained during fieldwork (Creswell, 2014).

6. Land use and water governance in the municipality of Panguipulli

The case study was conducted in the municipality of Panguipulli, located in the Los Ríos region in Central-South Chile (Fig. 1). The region extends from the Andean Cordillera to the Pacific Ocean and is characterized by several pre-mountain lakes of glacial origin (North Patagonian lakes), with Lake Panguipulli being one of the largest (Huovinen et al., 2019).

The administrative center of the municipality of Panguipulli, located

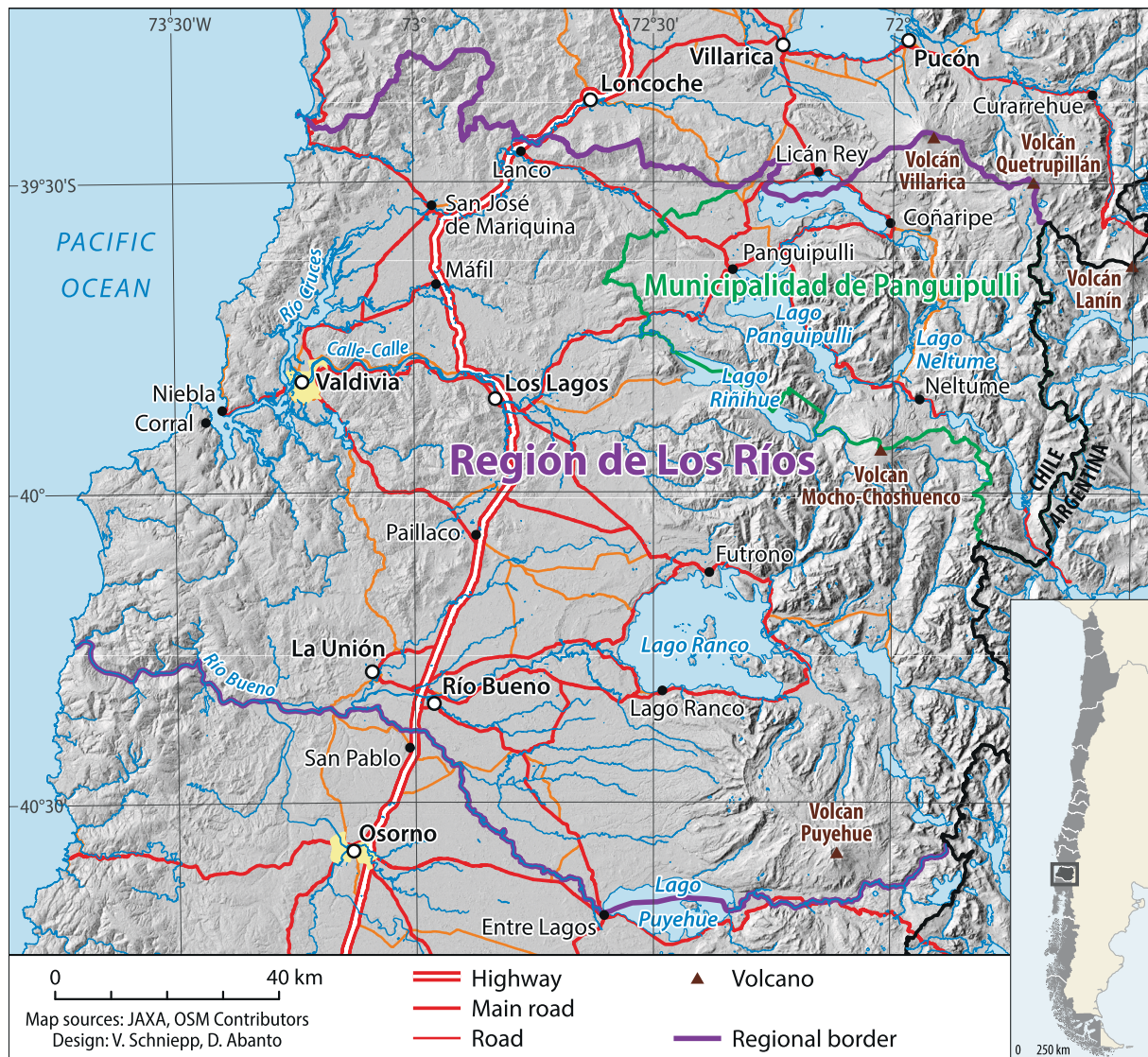


Fig. 1. Location of the study area Fig. 1 shows the location of the study area where the data was raised.

at the foot of the Andes and in close proximity to the Argentinian border, is a small town with a population of 34,539 inhabitants (Censo de Población y Vivienda, 2017) also called Panguipulli. The town was officially founded in 1946. However, Mapuche communities had settled on the shores of Lake Panguipulli before this date, and the locality has been mentioned in historical records dating back to 1776 (<https://municipalidadpanguipulli.cl/comuna>). Until today, about one third of the municipality's population identifies themselves as belonging to the Mapuche (Pino et al., 2014).

The study area is characterized by rainy-temperate Mediterranean climatic conditions with a mean annual precipitation between 1800 and 2900 mm, the highest amounts of which occur during the winter season (Pizarro et al., 2016). Traditionally, Panguipulli has been a water-rich area. Nonetheless, according to climate projections the region will experience decrease in annual rainfall and snow, and an increase in snowline. Climatic shifts are expected to lead to a loss in glaciers and perennial snowfields (Pizarro et al., 2016; Valdés-Pineda et al., 2014). In November 2021, the Chilean government announced water shortage in the entire Los Ríos region, and in March 2023, water shortages for human consumption in the municipality of Panguipulli were formally declared.

The area with the characteristic Valdivian temperate forests has been identified as a hotspot of biodiversity, where most of the area is covered by natural forests (Fig. 2). In the 20th century, the area used to be a hub for forestry. Since the 1940 s, large-scale commercial forest exploitation around Neltume had expanded and dominated the socio-economic development of the region with significant impacts on the natural forests (Pino et al., 2014). After 1970, forest exploitation was organized under the state-owned *Complejo Forestal y Maderero de Panguipulli* seeking to employ integrated forest development. Following agrarian reforms, large-scale estates were expropriated, and the forest area was self-managed by the forest workers. The introduction of neoliberal policies in the 1980s, resulted in the resolution of the state-owned company in 1988, with its landholdings being sold to large investors.

In 2007, the eastern parts of the municipality were declared a UNESCO Biosphere Reserve. These are part of the *Reserva de la Biosfera Bosques Templados*, an area in the regions of Los Ríos and Los Lagos, with a total extent of almost 2.3 million ha and its core zone in the national reserve *Mocho Choshuenco* (CONAF, 2007). The Biological Reserve Huilo Huilo, a private park open for tourism, is also located within the

Biosphere Reserve. It encompasses an area of approximately 100,000 ha in the municipalities of Panguipulli and the neighboring municipality of Futrono (Hora, 2017).

While 83.5 % of the municipality is covered with native forests (Pizarro et al., 2016), agricultural land use and livestock pastures are typical in the Indigenous communities. Land use change, as well as the expansion of touristic activities as a growing economic sector, make the municipality an interesting case to study. Following the Covid19 pandemic, the number of tourists continues to increase (Vera et al., 2021). The region is advertised under the brand 'Destino Sietelagos' (Destination Seven Lakes) and attracts both national and international tourists interested in a wide range of activities such as rafting, kayaking, hiking and mountaineering, mountain biking, skiing and thermal springs.

Three Indigenous communities (Manuel Curilef, Valeriano Callicul and Juan Quintuman) live in proximity of Lake Neltume (see Photo 1). Their agricultural livelihoods are characterised by the combination of small-scale livestock rearing and horticulture. With the growth in tourism, additional income is generated through the production of handicrafts and the rental of camping cabins. Wage labour, for instance in forestry, contributes to the off-farm income of the families (Neira & Delamaza, 2018).

Water supply in the municipality of Panguipulli differs between urban and rural settlements in accordance with the legal framework. In the urban area of Panguipulli drinking water is supplied by Suralis, an international water supply company whose 51 % share has been in the hands of the Canadian company Algonquin Power & Utilities since 2020 (Algonquin, 2025). The privatisation of the water supply in Chile was part of structural adjustments of the 1980s. The market-, external- and stabilization orientation, which has been maintained since that time (Ritter, 1990), explains this decision; further fostered by the need for investment in wastewater treatment (Baer, 2014). In the rural areas of the municipality, including the settlements of Neltume, Huellahue, Choshuenco and Liquiñe, CAPR systems provide water access for domestic purposes. Private water supply and CAPR services need to be paid for. The fare includes payment for wastewater treatment in case of the urban area. Panguipulli counts on highly saturated sewage treatment plants, while in rural areas mainly cesspits are used.

7. Water availability in Panguipulli

We identified water access and supply problems due to infra-structural and social constraints in both, urban and rural areas. Besides the regulated modes of access of a CAPR, people reported the use of partly privately organized drinking water provision within the

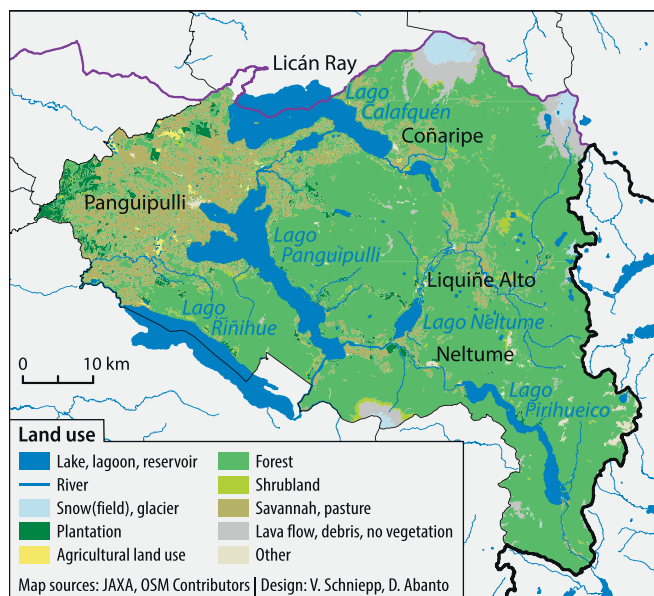


Fig. 2. Land use in Panguipulli Fig. 2 shows the main land uses within the case study area.



Photo 1. Agricultural land-use in the municipality of Panguipulli.

Source: Taken by the authors This photo shows the land use in Indigenous communities next to the Neltume lake in Panguipulli

municipality, particularly in Indigenous communities. This includes wells and surface water. However, the people who use these sources of water rarely hold formal water rights or rely on networks that provide water through constructed infrastructure. Despite the implementation of a network supply system, such as a CAPR, private supply systems often remain in use, primarily due to water shortages within the new system.

A local CAPR official has attributed the occurrence of water shortages to a lack of attention to the hydrological sources. He further observes the impacts of deforestation and overexploitation on hydrological sources:

“The water sources (...) were not taken care of and that is why today we have this problem of the misuse of water (...) Until a couple of years ago (...) water was very abundant, [the canal] had a lot of water. Over time, (...) due to the clear-cutting of the native forest, the flows, springs and wetlands dried up, and today I dare say that from the 100 % we had 25 years ago, (...) I think the flow has dropped by 30 %, 40 %.” (Interview, local CAPR, October 2022).

Besides the impact of large-scale forestry since the first decade of the 21st century, Panguipulli is becoming increasingly promoted as a tourist destination, attracting both foreign and Chilean visitors. To increase the number of tourists, access to the area has been enhanced by newly paved roads along the northern shore of Panguipulli Lake. This has led to a broad offer of activities, including rafting, kayaking, and hiking (see Photo 2).

In order to accommodate the growing number of tourists and

amenity migrants, new settlements have been developed. This has intensified the pressure on physical water availability exacerbating the impact of climate change as reported by inhabitants of the municipality:

“Today I dare say that (...) the [water] flow has decreased a lot in the summer season. (...) the amount of water we have (...). Fifteen years ago, it used to snow a lot, (...) this winter we had about fifty centimeters of snow, but before it used to fall a meter, a meter and a half, and all that has disappeared. In fact, in the summer season which we can consider from 15 December to 15 March, the amount of water we have to have in our ponds to supply the town is quite affected” (Interview, local CAPR, October 2022).

This perspective is shared by other local actors in charge of the water provision:

“One can see with the naked eye, and the [Indigenous] communities themselves explain to you that the springs are bringing less water, some are drying up, we are working with the larger tributaries to bring water to the people” (Interview, local state representative, December 2019).

In addition, cabins and swimming pools were constructed, even in more remote settlements including Neltume increasing pressure on water resources:

“The lack of water here in Neltume is caused by the excess of people who have come to the area (...) It has grown by more than half of what Neltume used to be and as this has now become a tourist area (...) Last year, or rather this summer, the number of people quadrupled and the consumption [of water] that we deliver quadrupled. For example, in wintertime, if during the day or within twenty-four hours we consume 500 cubic meters, in the summer, we increase the amount to 1,500 cubic meters.” (Interview, local CAPR, October 2022).

To understand how water shortcomings are produced, the distribution of water rights has to be considered. In Panguipulli, large consumptive water rights (>700 l/s) are held by agribusinesses and the forestry industry and are territorially concentrated. In Chile, non-consumptive water rights mainly serve the hydroelectric sector, as they need to be restored to their source (Prieto & Bauer, 2012). Companies such as Colbún and Enel concentrate large amounts of these water rights and are present in the municipality of Panguipulli. Smaller consumptive water rights, held for example by small and medium-sized farmers, are instead scattered across the territory.

Furthermore, a range of water uses is not regulated through formal water rights, including forestry, subsistence agriculture, as well as tourism and recreational activities such as rafting or scenery. Neither has spiritual use of water been considered in the Water Code. For the Indigenous communities living in the vicinity of Panguipulli's lakes and waterfalls, these have special functions and spiritual roles, e.g. in ceremonies. Additionally, Indigenous communities in the case study area have historically relied on water for irrigation purposes without counting on formalized water rights. Only the latest reform of the Water Code enacted in 2023 seeks to allocate non-consumptive water rights to projects that promote environmental conservation or sustainable, recreational tourism or sports. This is an attempt to address the issue of overvaluation of the productive value of water (Prieto, 2015; Urquiza et al., 2019).

Currently, members of the Indigenous communities employ different modes of water use. Among them are governmental programs in the agricultural sector, which aim to enhance irrigation, or the recognition of ancestral water use practices, which are particularly pertinent in the context of mounting disputes over water resources and the need to safeguard these practices. Thus, Panguipulli is an example of a “multiplicity of water-related worlds” and “ways of being with water” (Yates et al., 2017: 2), as it presents a diverse and complex scenario when it comes to water supply and demand, particularly for domestic use.



Photo 2. Rafting advertisement.

Source: Photo taken by the authors. This photo shows the emergence of tourism in Panguipulli, especially rafting in the rivers in the area

8. Key factors for water insecurities in Panguipulli

While authors such as [Nicolas-Artero et al. \(2022\)](#) maintain that water extraction from surface sources for domestic consumption does not result in conflicts over water use and access in water-abundant regions, we have identified four key factors causing water conflicts in Panguipulli: infrastructural shortfalls, regulatory constraints, financial limitations and social entanglements.

8.1. Infrastructural shortfalls, regulatory constraints and financial limitations

Water shortages in the municipality of Panguipulli are produced through different constraints ([Table 1](#)), such as a lack of grid connections and regulatory restrictions. Furthermore, access to water is inequitably distributed, e.g. between households and the agroindustry. This is related to how water rights have been allocated in the past and concentrated, privileging certain users over others, also regarding information about the amount of water which each actor can access ([Bauer, 1998](#)). Thus, infrastructural and regulatory constraints are deeply entangled and shaped by financial limitations. The latter are also linked to social entanglements that we observed during our fieldwork. In the following, we show how the different key factors are linked to each other and how their combination exacerbates water insecurities in Panguipulli.

The detachment of water right owners from the physical location of the water leads to decision making about water use being disconnected from local needs and realities. This can be shown through the CAPRs in Panguipulli. On the one hand, CAPRs have limited financial resources which restricts their possibilities to acquire further water rights from non-local owners who engage in speculation with water resources ([Bauer, 2004](#)). On the other hand, water scarcity decrees limit the possibility to assign water rights required to increase the water volumes to be delivered as most water rights may have been allocated previously. CAPRs therefore must manage their system with the available water rights and are hindered to implement any expansions to the existing system:

“[The CAPRs] do not have the possibility of giving more outlets, because they no longer have enough water flow from the ground-water, or the connection. They told me that there is no possibility. In

fact, some CAPRs are losing the capacity to deliver sufficient water flow to everyone” (Interview, local state representative, December 2019).

Apart from financial and regulatory restrictions, CAPRs also deal with infrastructural constraints that impede water provision to additional households. As the piped system in Neltume is gravity-based, issues of water shortages are unequally distributed within the settlement:

“We have enough water, but we don’t have the abduction that brings the water to the ponds, the diameter is very small (...) it’s not enough to supply the entire population. (...) there is no pumping system or anything, no hydro-pack pumps, nothing, everything is gravitational. So, what happens? That when the water comes out of the pond, it first begins to fill the lower sector here in Neltume and once it fills there begins to rise the water pressure upwards and generally in the summer in the upper sector, we do not have much water pressure” (Interview, local CAPR, October 2022).

To solve these challenges and to meet the growing demand, expanding existing infrastructure is requested:

“I think that we are easily going to reach two thousand water starts, because there are families that have only one service and it is not enough, so they are asking for one or two more services, multiply that by one and we are around two thousand services. The demand has increased, (...) we started with four hundred and fifty underground water supply points in each home and now we are close to one thousand water supply points and there are about three more towns of about one hundred houses each (...) So, we hope that we will have better water pressure, because as I said before we have water, but we do not have the capacity to meet the need that our community has” (Interview, local CAPR, October 2022).

However, the extension of infrastructure is costly and permeated with high bureaucratic barriers. The expansion of CAPRs is financed and authorized by the Ministry of Public Works as drinking water provision in Chile is considered a necessity covered by the state. The CAPR program was designed decades ago with the underlying assumption of a rather stable rural population, with comparatively lower water demand compared to urbanites ([Nicolas-Artero et al., 2025: 4](#)). The revision of an extension of the system is a time-consuming process, and once the enlargement is approved the actual situation at the local scale may be different. We found that once approved the measures are already insufficient before being in place as there are more users than initially anticipated.

Moreover, neither the state nor the CAPRs survey for what purposes the water provided is used. Drivers of water demand such as tourism and the installation of private swimming pools are neither economically restricted nor are water supply systems able to manage this demand:

“We have some of the cheapest water in the country, imagine that a cubic metre costs \$200 [Chilean pesos] here, a cubic metre is a thousand litres of water and there are pools in homes that have a minimum pool of three thousand, five thousand litres of water, so how much does it cost to fill that up? So, we don’t take care of the water here, or we water a lot, we wash a lot of vehicles, we throw water in the street to reduce the dust in front of the house and if you say “look, we have a water deficit, we don’t have water pressure in the pipes to deliver to the people” “I’m paying”, that’s the answer” (Interview, local CAPR, October 2022).

However, issues on the supply side due to infrastructural and technical constraints are only one side of the coin. In addition, the expansion of tourism as well as the influx of amenity migrants and related economic shifts have provoked problems with wastewater management in the urban area of Panguipulli. The current wastewater treatment plant of the town has exceeded its capacity with severe environmental implications, as illustrated by a representative of the Environmental Assessment

Table 1
Variables and examples for water insecurities in Panguipulli.

| Water insecurity key factor | Variable | Example |
|-----------------------------|---|--|
| Infrastructural shortfalls | Technical limitations of water supply systems | Low pressure due to gravitational supply system |
| | Water pollution | Superficial water source and non-covered pipe system |
| Regulatory constraints | Infrastructure changes involve the state | Costly and bureaucratic expansion system |
| | Unequal distribution of water rights | Agroindustry concentrates many water rights in comparison to CAPRs |
| Financial limitations | Economic limitations of water supply systems | Prices are not subject to change in response to varying levels of demand |
| | Economic inequalities | Price increases are difficult to implement |
| Social entanglements | Disputes between water supply network users | Pipe cuts |
| | Social embeddedness | Closeness among local community complicate enhancing of sanctions |

Service in an interview. The representative further highlighted that wastewater treatment has been privatized in Chile and is not considered financially viable, which has led to postponing the extension of the system:

“Panguipulli grew so much, so much, so much that the number of [water] treatments is totally surpassed (...), so that plant is saturated, it bursts everywhere, poop comes out everywhere in Panguipulli. (...) they used to dump, supposedly in an emergency, (...) the waste into the lake, which they couldn't treat, when it rained, (...) But finally they were so overwhelmed that they were dumping into the lake all the time, there was a citizen complaint, the municipality, the superintendence, no, PDI, no, everything. (...) their treatment plant is up here, it's in Huellahue, it's up there. So, they drive everything with motors here and pour into an estuary, which is a field estuary and not even a river” (Interview, regional state representative, October 2022).

Population growth in rural areas necessitates improved wastewater management facilities, particularly to protect groundwater resources, as its pollution would further exacerbate water insecurities. Currently in Neltume, the utilization of cesspits, predominantly absent of septic tanks, poses a risk for groundwater resources. Yet, the installation of sewerage is costly, which has led companies that won the concession to abandon the projects (Interview, local CAPR, October 2022).

However, it is not only groundwater that is susceptible to contamination, also, the surface water supplied by CAPR systems in Neltume is considered vulnerable:

“Our catchments (...) are superficial and we bring water from the mountains, in wintertime when it rains a lot here, in fact, it rains a lot here, our water becomes cloudy and dirty” (Interview, local CAPR, October 2022).

To address this challenge, water is rigorously chlorinated, ensuring that the final consumer receives water of a quality that meets the legal standards.

8.2. Social entanglements

Social cohesion also influences water insecurities in the rural areas around Panguipulli, as infrastructural and technical proposals need to be aligned with local circumstances. Around Panguipulli, people reported cases of manipulation of the pipe system. These encroachments caused interruptions of the supply infrastructure and resulted in water scarcity:

“There are problems of coexistence between [the communities], the pipes are broken. (...) There are two people where I live who have broken the pipes, and they cut off their water, (...) But we repair them, and they destroy them again every year. (...) Unless you do something that costs more, for example bury a PVC at one metre” (Interview, local state representative, December 2019).

In addition, people's imaginaries are linked to the green scenery of the region. According to interviewees, water is perceived as an abundant resource that can be used free of charge. Inhabitants are thus reluctant against supply service fees: “Because people (...) don't see the associated costs behind it. They want the water... there are people who have water who got used to not paying for water, you know what I mean? (...)” (Interview, local state representative, December 2019). The social fabric of the comparatively small communities not only leads to effective cooperation within CAPR systems but can also hinder regular collection of fees and possible sanctioning. Community structures and close relations (table 1) between water users and providers make it difficult to enhance a more efficient use of water, to increase prices or to implement sanctions if the service provision is not paid:

“The prices are set by the committee (...) and they have not been raised, because the people themselves are members of the committee

(...). [Also], people are reluctant to come and pay for their services (...) the service will be withdrawn from the home [if they don't pay], but we don't do it either, because we all know each other” (Interview, local CAPR, October 2022).

The relation between social cohesion and the solving of the financial situation of the CAPR systems is a major challenge. As shown, enforcing sanctions established on paper is very difficult. Interviewees illustrated the cases of families who are economically vulnerable, receive water for domestic purposes basically free of charge and not being sanctioned. In other cases, defaults would be solved through informal conversations between neighbours instead of applying the sanctions established in the CAPR regulations.

“You go and have a conversation, because there are others who are very crafty, so you must have character and personality as well. You also have to use a little bit, be a little bit crafty, because if not, they do not take the weight and less comply” (Interview, local CAPR, October 2022).

This evidences that collective, community-based forms of water supply management do not necessarily lead to equal resource allocation or diminish inequitable power relations (Bakker, 2007; McCarthy, 2005; Mehta, Leach & Scoones, 2001).

Socio-economic disparities have been intensified by amenity migrants from cities such as Santiago, who increasingly come to the region after the onset of the Covid19 pandemic in search of “nature” and green, recreational spaces (Nicolas-Artero et al., 2025), have financially stronger backgrounds and different imaginaries with regard to paying for water supply: “It's cheap, it's not expensive. When I overdo it in the summer, when I fill up my granddaughter's pool and all that, it's about USD 5, USD 6” (Interview, civil society representative, December 2019). This perspective is opposed by other community members who cannot afford the prices for water supplied by a CAPR or another system, affecting the social fabric:

“The biggest problem is that the people do not have the necessary resources to bring water to their homes. It is not that there is no source of water that they could turn to (...). We have many communities (...) people do not have the resources to buy a tank, then to buy a hose to bring water to their homes. Also, as I was saying, that it is an efficient use, that water is not wasted, because the amount of water is not unlimited either” (Interview, local state representative, December 2019).

Especially Indigenous communities decline payment for water supply. Members of a community on the shores of Lake Neltume reported that their CAPR project had been designed, but the system was not implemented. Community members indicated a preference for a program by the Agricultural Development Institute (Instituto de Desarrollo Agropecuario; INDAP), which aims to enhance irrigation in situations of prolonged water deficit, adverse weather conditions or in risk situations, such as droughts. Through this program, they access water without having to pay for each cubic metre. However, the INDAP program does not secure water quality, nor does the water provided meet the standards for potable water. Community members have argued that this is a negligible factor. They are used to the untreated water for cooking and drinking (Interview, local CAPR, October 2022). However, as indicated before, both surface and groundwater in the municipality are prone to suffer pollution. Here different perceptions of “clean” water and water quality are evidenced, showing how different relations with water (Yates et al., 2017) lead to water insecurities.

Most rural communities refuse to pay for water supply systems. Being free of charge is more important than an increased quantity, continuity and quality of water supply. Accordingly, interviewees reported that many families and individuals prefer water provision by water trucks to connecting to a CAPR system, even though this is less reliable. In addition, although water users provided through water

trucks are not charged, accessing water through this system is risky as some areas may not be reached. In 2019, the municipality of Panguipulli distributed water to households via water trucks throughout the year:

“We currently deliver 300 l per person. A week. The houses add up, they are around 1000 l, it depends on the pond the person has. We try to leave them with as much water as possible, for a family of three people 1000 l is nothing. Well, during the week we deliver about 135.000 l of water” (Interview, local state representative, December 2019).

Water provision through water trucks is inefficient and extremely costly for the municipality (Budds, 2020), but cheap for the users. Our case study is of interest as it shows how Chilean water regulation fosters an inefficient system that diverts public funds to indirectly subsidize domestic water supply not only in arid and semi-arid areas as demonstrated by Fragkou et al. (2022), but also in water-rich regions. The case of Panguipulli proves how the municipality is constrained to secure water supply in its territory, obliging it to buy water from CAPRs and the urban water supply provider for the water trucks: “We pay per m3, it is USD 1 per m3. (...) Before we paid a CAPR here in Huellahue, which cost us almost 3 USD per m3. Finally, we handed it over to Essal [a private water supply company] because they have the ability to sell it to us at a cheaper price, because in the end we ended up paying a lot for the water for the people” (Interview, local state representative, December 2019).

9. Discussion

The analysis of water scarcity must consider the complexity and multidimensionality of hydrosocial relations within its specific context. The case of the municipality of Panguipulli has shown how these heterogeneous entanglements are the main drivers for water insecurity. Social structures and practices shape water use and access, and need to be considered in technical and infrastructural proposals if they aim at being accepted and successful. Our results show that water insecurities, collective values and waterscape identities (Jepson et al., 2017) are closely intertwined, which underlines that infrastructural solutions and social structures need to be assessed from a holistic perspective. However, the current water supply planning in Chile is concentrated at the central government level and disconnected from local conditions and challenges. In addition, decision-making processes are very lengthy and cannot react to spontaneous requirements and changes at the local level. This shows how technical restrictions are politicized and lead to water scarcity. Infrastructures are “socio-material arrangements” (Avelino et al., 2016: 559), reflecting contingent power relations. Everyday practices are not included within the decision-making process for water supply systems although local actors manage these through CAPR. Rather, their design and implementation based on existing place-disconnected regulations mirror contingent power relations (Feindt & Weiland, 2018).

Gupta et al. (2013) have argued that managing a water body without considering and connecting with local spatial planning may be impossible. Our results underscore this argument, as the disconnection between different scales and the lack of involvement of local actors in planning processes has exacerbated water scarcity in the municipality of Panguipulli. This is also directly related to the divergent perceptions of water availability that are common in the area. Water is imagined as abundant not only by the tourists stemming from more water-scarce areas in Northern Chile, but also by the local population who provide tourist services, such as cabins and rafting, and whose water use practices have been anchored in unlimited access to water resources for many years.

Technical responses conceived at national and regional levels, such as increasing prices for domestic water supply, may not lead to the desired effects, as enforcing payment is difficult in areas where everybody knows each other and the infrastructure is managed by local communities. In addition, financial resources are allocated at the

national and regional scale, addressing water insecurities through a technical approach. Dialogue and direct participation of involved actors in water access and use at the local scale are not financially supported, making it difficult to address water conflicts at this scale. Furthermore, the participative processes give rise to disruptions within the social structures at the local level, impeding an effective engagement of local actors in water governance when resources become limited. Local actors with limited financial resources withdraw from water supply networks and do not engage in decision-making, but rather opt for partly private water supply options, such as wells, or governmental programs that are not linked to drinking water supply, and do not require payment. However, the occurrence of sabotage actions among local residents has resulted in shortages within these systems.

Such uncoordinated and individually made decisions at a micro scale can lead to adverse effects surfacing as water shortages in water rich areas. These shortages are not necessarily linked to a lack of ownership of water rights, which are then, ultimately, no guarantee for access to water. Neither is access to water guaranteed through urban water supply systems by private companies nor through CAPR systems due to infrastructural constraints. While pollution of water due to lack of adequate sewerage and extensions of existing systems are not tackled, water insecurities are faced.

Hence, how and by whom decisions about water access and use are being made are pivotal factors generating water scarcity. Such a conceptual perspective on water insecurities has proven beneficial in highlighting the complexities of water governance and underscoring the adverse and unexpected effects caused by insufficient decision-making. Formal rules need to be connected to social conditions and habits to be effective and enforceable (Bridge & Perreault, 2009; Lenz & Glückler, 2016). In this regard, one size fits all-regulations have been shown to produce water shortages and conflicts rather than facilitating a shared objective at a particular geographical scale and within a given social context (Glückler et al., 2019).

10. Conclusion

Water scarcity “is not only a physical and management, but a social problem” (Fragkou et al., 2023: 91; Bravo & Fragkou, 2019; Oppliger et al., 2019). This becomes even more evident through our analysis in a water rich area. Water insecurities are produced not only through power imbalances and inequalities (Fragkou et al., 2023: 94), but also through disagreements between local actors and external influences on social cohesion. Securing water is, as Jepson et al. (2017: 60) have articulated, “as much about utilitarian needs as [about ensuring] cultural reproduction, collective values, and identity in relation to the waterscape.” Thus, our case study illustrates how water crises are socioculturally constructed and relational as they connect different actors, scales, materialities and economic dynamics. However, not all residents in Panguipulli are equally affected: While some refill their swimming pools daily for tourists, others receive limited amounts of water for domestic use through water trucks. Also, the differences in infrastructure lead to different water qualities for households. While some receive surface water through superficial open pipes, others have access through a buried pipe system making the water safer. Therefore, governing water insecurities requires addressing these multiple factors in a holistic manner.

Our results have shown that water insecurities in regions regarded as water-rich from a *physical* perspective are distributed unequally and heavily rely on infrastructure, financial resources and participation in decision-making processes concerning water distribution, its intended use, and the entities responsible for its allocation. These findings contribute to ongoing debates in geography and political ecology by underscoring the context-specificities of water governance. Furthermore, we contribute to moving the water security debate beyond the utilitarian focus on water supply (Jepson et al., 2017) by evidencing how diverse types of social relations with water that are anchored in

different ontologies and traditions generate water (in)securities. However, further in-depth studies of other water-abundant regions are urgently needed to gain deeper insights into socio-culturally constructed water scarcity and water crises in these areas. Such research may contribute to an understanding of the entanglements of different actors and context-laden factors challenging water governance at the local level. Identifying commonalities among different cases in the production of water scarcities may allow to group challenges faced by communities in water-abundant areas. This could contribute to a more comprehensive understanding of water-related challenges and may also help to identify entry points for adaptation against the background of potential further water stress under current climate change scenarios.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used DeepLWrite and Grammarly in order to correct for spelling and grammar. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

CRedit authorship contribution statement

Johanna Höhl: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Juliane Dame:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Angélica Videla-Oyarzo:** Methodology, Data curation, Conceptualization.

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Data availability

The data that has been used is confidential.

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