water

MDPI

*Article*

# Governing Water Resource Allocation: Water User Association Characteristics and the Role of the State

**Alejandra Engler [1,2,*], Oscar Melo [1,2,3], Francisca Rodríguez [2], Bárbara Peñafiel [2] and Roberto Jara-Rojas [2,4]**

1 Department of Agricultural Economics, Pontificia Universidad Católica de Chile, Santiago 8320000, Chile; omelo@uc.cl
2 Center for the Socioeconomic Impact of Environmental Policies (CESIEP—Núcleo Milenio), Santiago 8320000, Chile; frodrig1@uc.cl (F.R.); bpenafie@uc.cl (B.P.); rjara@utalca.cl (R.J.-R.)
3 Water Law and Management Center, Pontificia Universidad Católica de Chile, Santiago 8320000, Chile
4 Department of Agricultural Economics, Universidad de Talca, Talca 3460000, Chile
* Correspondence: mengler@uc.cl

**Abstract:** Water, as a common pool resource, is threatened by the possibility of overextraction generating a negative economic impact, conflicts among users, and greater income inequality. Scholars have discussed different governance approaches to deal with this threat, including centralized governance and self-governance, and lately, special attention has been paid to the interactions between formal institutions (the state) and local water user associations and how this promotes self-governance. The aim of this paper was to examine the adoption of Ostrom's design principles present in the legal norms dictated in the Chilean Water Code by water user associations and to analyze the roles of their size, community homogeneity, and perceived water stress on adopting legal norms. The results showed that water communities generally follow the rules established in the Water Code, but the voting system, distribution of water, and fee payment are adjusted in small and homogenous water user associations. We can also conclude that a cornerstone in the system is implementing graduated sanctions, as water users see the tools provided by the Water Code as ineffective.

**Keywords:** water resources; governance system; water user communities



**Citation:** Engler, A.; Melo, O.; Rodríguez, F.; Peñafiel, B.; Jara-Rojas, R. Governing Water Resource Allocation: Water User Association Characteristics and the Role of the State. *Water* **2021**, *13*, 2436. https://doi.org/10.3390/w13172436

Academic Editor: Thomas M. Missimer

Received: 2 July 2021
Accepted: 28 August 2021
Published: 4 September 2021



## 1. Introduction

Precipitation reductions due to climate change, along with population growth, are increasing the gap between water demand and supply, posing dramatic challenges to water management [1–3]. In this scenario, water as a common pool resource (CPR) is threatened by the possibility of overextraction, which would not only jeopardize the sustainability of the resource but also generate a negative economic impact, conflicts among users, and greater income inequality [4–6]. It is therefore urgent to identify governance structures capable of facing such challenges [7–10].

In the last decades, scholars have discussed alternative governance approaches to deal with the "tragedy of the commons" [11]: a centralized governance, where the public authority dictates how to distribute water, self-governance, where the community creates its own rules and norms to provide a distribution system [12–15], or hybrid systems, with the involvement of formal institutions detailing a set of rules for self-governed communities [8,9,16]. It has been argued that predominantly top-down water governance structures (mainly led by the state) fail to produce effective and timely solutions to increasingly uncertain scenarios, whereas self-governance provides the flexibility to adjust the management of common resources to the community's needs [9,13,17–20]. As stated by Ostrom, autonomous and self-organized governance systems may perform better at regulating small common pool resources than a centralized system [21]. In explaining the success of self-governed communities, Ostrom [22] depicted a set of eight design principles (DPs) (see Table 1) that provide the foundation to understand how communities can take

collective action in managing common resources. However, it has also been acknowledged that self-governance systems have pitfalls. On the one hand, in the presence of power asymmetries, communities may not be inclusive and may just replicate the existing local power inequalities [23,24]. On the other hand, scholars have also highlighted that the effectiveness or success of self-governed common resources depends on the community characteristics, such as size, community homogeneity, economic endowment, social and cultural aspects, and leadership [8,9,25–29], and on external factors such as the political and social context, physical infrastructure, definition of property rights, and policy interventions [30–33]. As for community characteristics, for example, Luo et al. [9] and Arvanitides et al. [25] showed that smaller communities can create opportunities for interactions that, in turn, facilitate agreements and monitoring, thus increasing the chances for the community to engage in collective action. Conversely, the effect of community homogeneity on collective actions has not reached a consensus. Luo et al. [9] analyzed the interaction between the size and heterogeneity of communities in the performance of collective action, discovering that small/heterogenous communities perform well (measured by user perception), while large/heterogenous communities do not, and in the case of middle-sized communities, the effect of homogeneity is not clear.

**Table 1.** Design principles (DPs) for a successful self-governed CPR institution.

| Design Principles | Description |
| --- | --- |
| Principle 1: clearly defined boundaries | Individuals or households who have rights to withdraw resource units from the CPR must be dearly defined, as must the boundaries of the CPR itself. |
| Principle 2: congruence between appropriation and provision rules and local conditions | Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, material, and/or money. |
| Principle 3: collective-choice arrangements | Most individuals affected by the operational rules can participate in modifying the operational rules. |
| Principle 4: monitoring | Monitors, who actively audit CPR conditions and appropriator behavior, are accountable to the appropriators or are the appropriators. |
| Principle 5: graduated sanctions | Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, by officials accountable to these appropriators, or by both. |
| Principle 6: conflict resolution mechanisms | Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials. |
| Principle 7: minimal recognition of rights to organize | The rights of appropriators to devise their own institutions are not challenged by external governmental authorities. |
| Principle 8: nested enterprises (for CPRs that are parts of larger systems) | Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises. |

Note(s): Source: Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. (p. 90).

The advantages and shortcomings of self-governed systems have led to increasing the attention towards hybrid systems, where formal institutions (the state) interact with local communities enhancing collective action and promoting self-governance [13,16,34–38].

Hybrid systems may also include water markets that benefit from the interaction of government and local, self-governed communities to enhance water transactions [39]. Nabiafjadi [16] argued that, although there is a need for the decentralized administration of water distribution, providing local organizations more power, it is still necessary to have an accountable board that controls other actors' performances. In addition, the state provides resources to invest in large infrastructure projects and new technologies that enable better water management [36]. Furthermore, Hanemann argued that self-governance systems are viable when the physical infrastructure already exists, highlighting the relevance of governmental intervention [40].

Although the literature provides ample evidence of the benefits of self-governance in a public–private scheme for water resource management, a less-explored angle of research is how state regulations linked to water management can contribute to the implementation of Ostrom's DPs within communities. The aim of this paper is twofold. First, we examine the adoption of the DP present in the legal norms dictated in the Chilean Water Code by Water User Associations (WUAs). Second, we analyze the role of WUA size, community homogeneity, and perceived water stress on adopting legal norms. In Chile, water allocation is determined by the Chilean Water Code of 1981, which defines water resources as a public good and grants their use to private users through tradable water user rights, whose property is protected by the Constitution. The Water Code also establishes a decentralized nested self-governance structure for water distribution organized with three levels of private associations—Surveillance Boards (Junta de Vigilancia), Channel Associations (Asociación de Canalistas), and the WUA (Comunidades de Agua)—that manage the water allocation to final users, according to a private market of water shares. At the local level, the WUA manages the distribution of water along the channel. Along with private organizations, the state, represented by the General Water Directorate (Dirección General de Aguas), is the institution in charge of overseeing the adequate implementation of the law and keeping a record of the water organizations and granted water rights, among other responsibilities. Hence, they provide a framework combining a nested governance system with private water property rights.

Understanding how WUAs apply and adapt the norms stated by the Water Code and how it relates to structural factors of the communities can provide insights for practitioners and policymakers on how the institutional context can enhance the collective action in pursuing sustainable water management. To achieve our objectives, we used Ostrom's [22] eight design principles (DPs) for a successful self-governed CPR institution as a framework for the fieldwork and compared the legal rules established in the Water Code with its adoption by the WUA.

This paper proceeds as follows. Section 2 describes the Chilean water distribution system. Section 3 develops a brief literature review of self-governed common resources, Ostrom DPs, and collective actions. Section 4 presents the materials and methods of the study. Section 5 explains the main results. Section 6 discusses the main results, and Section 7 gives the conclusion.

## 2. Irrigation Water Allocation in Chile

The Chilean Water Code of 1981 establishes that water is a public resource; however, its use is granted to private entities (natural or legal) through transferable water use rights. Water rights ownerships are not tied to the land and can be freely traded [41], but changing the point of water extraction requires approval by the General Water Directorate (Dirección General de Aguas, DGA) and a public consultation regarding the possible effects on other users. The same law establishes the governance system that defines a nested design of private organizations in charge of the allocation of water. These organizations oversee the management of the shared resources from rivers, channels, aquifers, or reservoirs and act as independent and decentralized organizations [42,43] structured in three levels of associations: Surveillance Boards (Junta de Vigilancia), Channel Associations (Asociación de Canalistas), and WUAs (Comunidades de Agua). Surveillance Boards can be composed

by individual users, Channel Associations, and WUAs, with the mission of managing and preserving water resources, planning, and allocating water to channel WUAs according to their water shares. Channel Associations and WUAs are responsible for the secondary irrigation infrastructure, and their main tasks are to plan and schedule the water distribution to final users according to their shares (measured in $m^3$/sec), maintain the channel, and develop collective infrastructure projects that can benefit the community. Although regulated by the Water Code of 1981, the collective use of water is self-governed by the WUA [44]. For that purpose, the Water Code establishes a generic statute that regulates each organization level. It states their operational limits and functions and, for the WUAs, determines their administrative procedures, such as user meetings, directory composition, fee payment, penalties, and conflict resolution mechanisms. Water users may adapt this statute according to their own circumstances, as long as it does not contradict the stipulations of the Water Code. The Chilean State, through the DGA and the Judicial System, provides the framework for settling water rights conflicts that may arise among users [42].

## 3. Ostrom Design Principles and Collective Action

According to Hardin in his famed paper "The Tragedy of the Commons", common pool resources (CPR) can experience exhaustion of the resource due to overuse, as each individual seeks to maximize gains without accounting for their effects on others [11]. Ostrom [22] defined CPRs as "a natural or man-made resource system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use." [22] This has been a common argument favoring privatization or state appropriation of the commons; however, the "tragedy" is not inevitable, and empirical evidence has provided numerous examples of commons enduring—and even thriving—instead of being misused or overused [22,45–48]. Ostrom [22] analyzed "long enduring, self-organized, and self-governed common-pool resources (CPRs)" by performing in-depth studies of a series of CPRs and the strategies to manage their use, concluding that, although the rules within these systems varied widely, there are similarities that can be extracted from these case studies. These findings were summarized in eight design principles (DPs) for a successful self-governed CPR institution, as defined by Ostrom (summarized in Table 1). Over time, several studies have used Ostrom's DPs to understand the conditions under which self-governed CPRs, specifically water resources, fisheries, and forestry, perform successfully, e.g., [13,30–32,49–51].

The success of self-governed communities and collective action can be measured in the sustainability and productivity of the common resources, conflict-free communities, lack of freeriding, participation, and the existence of accountability to their own crafted rules [30,33,37]; in the literature, this has been tied to the presence or absence of DPs [30,32,49]. However, DPs cannot be seen in isolation. Although the presence of DPs has been used as an indicator of successful resource management [30–32,49], they represent only some of the characteristics explaining the self-governance system. DPs respond to generalized propositions that can be understood as necessary conditions. However, they are not sufficient in explaining the effectiveness of resource management or collective action [30,34,49]. According to Baggio [30], the "clearly defined boundaries" and, more specifically, biophysical boundaries appear as the most relevant DP, along with the congruence between local conditions and the extraction and provision of rules. Hanemann [40] went further in pointing out that the constraint in managing common resources is capital, as it provides the means for developing the infrastructure that allows collective action. Additionally, successful irrigation management does not only depend on "human-made infrastructures" but, also, the biophysical infrastructure (e.g., structural characteristics of the channel, etc.). Naiga [32] found that, according to water users, the effective application of sanctions and conflict resolution mechanisms are the most relevant DPs to guarantee the success of self-governance.

Not only the biophysical infrastructure is relevant when analyzing water management systems; several studies have emphasized the social and political context, cultural aspects,

participation of women, and educational level (to name the most cited) that have not been considered as part of the DPs, despite their relevance [13,27,31,32,34,52].

Similarly, studies have indicated that state rules and co-management strategies can enhance self-governance [13,34,53], and in this sense, nested systems (principle 8) can contribute to reducing conflicts among users. The state provides financial and technological means, as well as a set of rules that support the development of users' autonomy in enhancing self-governance irrigation water management [13,36]. Co-management using participatory approaches involving organizations, governmental institutions, and water users to set up priorities and plans is also a necessary condition to foster an effective governance structure, as it allows for coordination and cooperation, improved acceptance of the decisions, and fewer conflicts among stakeholders [18,19,28,34]. In this sense, a participatory co-management framework can be seen as a social learning process, where formal and informal institutions should have the flexibility to adapt their rules [34]. In addition, to be able to face climate challenges, retaining a flexible legal body that regulates the governance of the water management system is paramount, as the rate of changes at the operational level of water management occur faster than changes at the constitutional level [10].

## 4. Material and Methods

### *4.1. Materials*

The study area was in the Valparaiso, Libertador Bernardo O'Higgins, and Maule regions in Central Chile, characterized by a Mediterranean climate suitable for growing a diverse portfolio of agricultural products, such as fruit production and horticulture, vineyards, and industrial crops. These regions are responsible for most of the agricultural production and exports of the country, contributing to 44.1% of the total agricultural GDP of the country [54]. The area comprises 70% of Chile's total avocado-growing area, 41% of citrus, 85% of apple, 36% of berries, and 52% of vineyards, which are among the biggest agricultural exports in Chile. It also accounts for 67% of Chile's maize production [55].

We selected 32 WUAs from five basins, distributed from north to south of Central Chile: Petorca, (3), Aconcagua (5), Cachapoal (9), Longaví (6), and Maule (9). The WUAs were selected randomly within each basin using the lists provided by the Surveillance Boards. For each WUA selected, the president was contacted and interviewed. When a president was not available or willing to being interviewed, we replaced him/her using the same random procedure. The basins presented different scenarios in terms of the water availability, and the highest water deficit was projected for the central macrozone of Chile, where Petorca and Aconcagua are located. It is estimated that, by the year 2025, the deficit will be –2844 $mm/m^3$ $year^{-1}$, while the regions of O'Higgins (Cachapoal) and Maule (Maule and Longaví) have a projected water surplus of 12,688 $mm/m^3$ $year^{-1}$ [56]. An in-depth semi-structured questionnaire was administered in-person to the president of each WUA. Additionally, 11 interviews with qualified respondents, such as the presidents of the Monitoring Boards and Channel Associations, were conducted to further understand the institutional arrangements and nuances of the systems. Qualified informants were purposely selected to cover representatives of different organizations and institutions that integrate the nested structure of the water governance system. Thus, a total of 43 interviews were conducted in the five basins. The decision to interview presidents of the WUAs was made, because they are the most knowledgeable about how their communities operate and, thus, are able to provide a comprehensive overview of WUA functioning. The same questionnaire (described in Section 4.2) was used in both interviews, but in the case of the qualified informants, more emphasis was placed on the questions related to the nestedness principle. Interviews were conducted by water basins during three periods: 9–14 October 2018 (Maule and Longaví), 23–27 October 2018 (Petorca and Aconcagua), and 10–15 December 2018 (Cachapoal). The interviews were recorded, and the results were transcribed, codified, and analyzed using Nvivo 12 software.

### 4.2. Methods

In this study, we aimed to provide evidence regarding the applicability and adaptation of DPs by WUAs under state regulation that provide a set of self-governance rules in the context of a private nested system for water distribution. As explained in Section 2, the Water Code allows the transfer of privately owned water use rights, thus permitting the market to reallocate water, but also defines the existence, functions, and attributions of private organizations in charge of the distribution of water—namely, the Surveillance Boards, Channel Associations, and WUAs. For convenience in constructing the questionnaire and analysis of the results, we aggregated the eight DPs described in Table 1 into four tiers as follows: tier 1 represents the boundaries of the system and corresponds to the 1st principle related to clearly defined boundaries; tier 2 focuses on the rules and arrangements and aggregates the 2nd, 3rd, and 7th principles; tier 3 relates to rule enforcement reflected in principles 4, 5, and 6; and tier 4 is the 8th principle (nestedness) that refers to the resource governance system (see Table 2). Likewise, Wang et al. presented a similar aggregation that allows for an integrated view of DPs [57].

**Table 2.** Four-tier groupings of Ostrom's design principles for enduring CPRs.

| Tier | Principle |
|---|---|
| 1. Boundaries | Principle 1: clearly defined boundaries |
| 2. Rules and arrangements | Principle 2: congruence between appropriation and provision rules and local conditions |
| | Principle 3: collective-choice arrangements |
| | Principle 7: minimal recognition of rights to organize |
| 3. Rule enforcement | Principle 4: monitoringPrinciple 5: graduated sanctions |
| | Principle 6: conflict resolution mechanisms |
| 4. Resource governance system | Principle 8: nestedness |

Note(s): Source: Adapted from Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action.

The questionnaire was structured in sections following the eight principles depicted in Table 2. Section 1 was related to the general identification of the interviewee. Section 2 corresponded to principle 1 ("clearly defined boundaries") and included questions about the formalization of water rights and mechanisms used for the distribution of water within the WUA. Section 3 was related to "characteristics of the rules of the WUA", which included principles 2, 3, and 7. It included questions on the rules regarding the election of the directives, maintenance of the irrigation system, overall rules of the WUA, and how decisions are made and implemented. Section 4 corresponded to questions on "enforcement", which included principles 4–6. The questions included how water distribution and the overall rules of the WUA are monitored, which sanctions are in place, and which actions are sanctionable, as well as the conflict resolution mechanisms. Principle 8 was reflected in questions regarding cooperation and confidence with the Surveillance Board and Channel Associations, such as if these organizations have any role in making rules and sanctions or if they provide financial or management assistance. The questionnaire also included questions related to the structure of the community and water scarcity perceptions. Additionally, we added questions related to the role of the state and the aid it provides to the WUA. The guiding questions of each section are presented in Appendix A.

## 5. Results

We organized this section into subsections by tiers of the DPs, as described in Section 3. Tiers 1–3 were analyzed by size, composition, and water scarcity, and tier 4 provided a general description of the nestedness principle (8th principle). Finally, we discuss conflicts

within the communities and their relationship with the key arrangements of the governance principles. Following this, a description of the criteria used to classify WUAs as small, medium, and large, as well as their siting in homogenous and heterogenous communities, is presented.

We first classified the WUAs according to their size, user homogeneity, and water scarcity perceptions. We categorized their sizes as small, medium, or large by dividing the sample approximately into thirds, using to the number of users reported by the presidents. The sizes were classified as follows: small $\leq$ 59, medium 60–200, and large $\geq$ 201. The community homogeneity and heterogeneity were determined based on self-reported information from the presidents interviewed about the concentration of water shares among users. Our sample of WUAs had a larger proportion of heterogenous users (Table 3). The water scarcity perception was measured by directly asking the interviewees about their perceptions. As expected, more respondents perceived water scarcity to be high in the northern basins; in Petorca, 100% of respondents perceived water scarcity as high, 60% in Aconcagua, and less in the southern basin of Longaví, where only 17% of respondents perceived the water scarcity as high (Table 4).

**Table 3.** Size and homogeneity of the water communities (number of water communities).

| Group Size/Composition | Homogenous | Heterogenous |
|---|---|---|
| Small | 3 | 7 |
| Medium | 5 | 5 |
| Large | 2 | 7 |
| Total | 10 | 19 |

Note: Three WUAs were not classified, because their sizes or compositions could not be identified by the information provided in the interview.

**Table 4.** Water scarcity perception by basin.

| Basin | Water Scarcity Perception as a Percentage of Responses | | |
|---|---|---|---|
| | Low | Medium | High |
| Petorca | 0% | 0% | 100% |
| Aconcagua | 0% | 40% | 60% |
| Cachapoal | 33% | 44% | 22% |
| Maule | 25% | 63% | 13% |
| Longaví | 67% | 17% | 17% |

### 5.1. Tier 1: Boundaries

The first self-governance principle is related directly to the legal constitution of the water communities at the General Water Directorate (DGA), which requires that the number of users and their corresponding water rights be specified. According to the Water Code, in the same legal act, the WUA needs to establish their statutes, which might be those proposed by the Code or may be adapted by the WUA and require the approval of the users in a special assembly. The interviewees stated that the WUAs were all legally established, and 78% used the statute proposed by the Water Code. Most of the users registered their water rights at the DGA; however, in six cases out of 32, the presidents recognized that some of the users have not completed this legal formalization, the main reasons being that inheritance and subdivision of the property rights make the legal proceedings difficult.

Not only is it important to clarify the ownership of the water rights but, also, the physical means of distribution. There were two alternative distribution systems used by interviewees: dividing frame, which allows for a more exact measurements of the water assigned to each user, and gates that are used by establishing shifts, which allow for more flexibility of transitory arrangements among users but provide less accurate distribution. In practice, the water distributed is usually delivered to each user based on the proportions of the actual flows.

According to our results, the size of the community is correlated with the type of distribution system. In Table 5, a clear difference can be seen among communities in the use of dividing frames. In small WUAs, the use of dividing frames is nonexistent, or they are only used in some parts of the channel (none/some), while large WUAs use them along most or all of the channel (all/majority). This can be explained by the complexity of managing larger communities and economies of scale fostering, in this case, a higher investment in the distribution system. Unexpectedly, the community homogeneity and water scarcity perception did not show a pattern in the use of frames.

**Table 5.** Relationship between dividing frames and WUA size, community homogeneity, and level of water scarcity.

| **(a)** | | |
|---|---|---|
| **Size** | **Use of Dividing Frames** | |
| | **All/Majority** | **None/Some** |
| Small | 91% | 9% |
| Medium | 42% | 58% |
| Large | 29% | 71% |
| **(b)** | | |
| **Composition** | **Use of Dividing Frames** | |
| | **All/Majority** | **None/Some** |
| Homogeneous | 45% | 55% |
| Heterogeneous | 42% | 58% |
| **(c)** | | |
| **Water Scarcity** | **Use of Dividing Frames** | |
| | **All/Majority** | **None/Some** |
| Low | 44% | 56% |
| Medium | 58% | 42% |
| High | 50% | 50% |
| Percentages below 40% | Percentages between 40% and 60% | Percentages above 60% |

### *5.2. Tier 2: Rules and Arrangements*

The Chilean Water Code requires WUAs to establish a statute that provides permanent rules for the management and allocation of water. The generic statute provided in the Water Code establishes that users should attend the annual assembly and co-finance maintenance and common investments in accordance with water shares and sets up voting rules in which votes are weighted by water shares and decisions are adopted by absolute majority.

Our results showed that 79% of the WUAs follow the generic statute, because it provides a complete set of rules. Among those that have adopted a modified version of the statutes, the most common changes are regarding specifying sanctions, dates for channel cleansing, fines for not attending meetings, water allocation arrangements, and the voting system (either "de jure" or "de facto"). In the interview, President #29 mentioned: " . . . we pay our fees per shift [water distribution system] . . . we all pay the same for maintenance expenses and then we share equally [the water], regardless if one has 6 or 18 water rights, users pay the same and get the same. We have 24-h shifts; we have been doing this since several years ago". According to this comment, it appears that this arrangement results in simplicity and fairness in the distribution of water.

On the other hand, the size and composition of the WUAs seem to be directly related to the voting system. Table 6 shows that small and homogenous WUAs tend to count the vote per person instead of using water rights shares, as proposed by the Code. The figure also shows that water scarcity appears not to be relevant to adjusting the rules inside the community.

**Table 6.** Relationship between the voting system and WUA size, community homogeneity, and level of water scarcity in agricultural areas in Chile.

| (a) | | |
|---|---|---|
| **Size** | **Voting System** | |
| | **Per Person** | **Per Share** |
| Small | 71% | 29% |
| Medium | 75% | 25% |
| Large | 17% | 83% |
| **(b)** | | |
| **Composition** | **Voting System** | |
| | **Per Person** | **Per Share** |
| Homogeneous | 63% | 38% |
| Heterogeneous | 57% | 43% |
| **(c)** | | |
| **Water Scarcity** | **Voting System** | |
| | **Per Person** | **Per Share** |
| Low | 50% | 50% |
| Medium | 56% | 44% |
| High | 40% | 60% |
| Percentages below 40% | Percentages between 40% and 60% | Percentages above 60% |

A problem present in every WUA, regardless of size, degree of homogeneity, or water scarcity, is the poor participation of users in community meetings and in voting. This situation reflects the low interest of the users in participating and engaging in management activities. This is a common situation, and it is the same reason the presidents and board of directors of WUAs tend to stay in their positions for long periods and are frequently re-elected.

### *5.3. Tier 3: Rule Enforcement*

The Water Code establishes that the role of monitoring the water distribution is fulfilled by the wardens (Celador). In particular, wardens ensure the fair and correct distribution of the water and report to the president any anomalies or disruptions that occur within the WUAs.

The case study revealed that the use/presence of wardens is directly related to the size of the community, as it can be seen in Table 7 that large WUAs have a permanent warden, while, in small and medium WUAs, this is less common. Regarding water scarcity, there is no evident pattern related to the use of wardens, although the perception of water scarcity tends to lead to the use of wardens throughout the year. The decision to not use wardens was typically justified by the belief that they are ineffective, and President #22 expressed this with the following comment: "we do not have wardens in my water community, the Cuñado channel had a warden but there are too many kilometers to watch and there were too many water pumps [a stealing device] . . . then we have learned to take care for ourselves . . . when I see a water pump I ask the perpetrator immediately to remove it . . . the wardens are only for critical years." Another reason is that small WUAs cannot afford the cost of hiring a permanent warden, as President #3 expressed: "we do not have wardens because there is not enough money. We use shifts, and users are informed in advance when their shift finishes and it is the neighbor's turn . . . . I [the president] check once in a while; this is my function".

**Table 7.** Relationship between use of wardens and WUA size, organization form, and perception of water scarcity.

| (a) | | | |
|---|---|---|---|
| **Size** | **Use of Wardens** | | |
| | **Never** | **Occasional** | **Always** |
| Small | 45% | 9% | 36% |
| Medium | 33% | 8% | 58% |
| Large | 0% | 0% | 100% |
| **(b)** | | | |
| **Composition** | **Use of Wardens** | | |
| | **Never** | **Occasional** | **Always** |
| Homogeneous | 36% | 9% | 3% |
| Heterogeneous | 24% | 6% | 71% |
| **(c)** | | | |
| **Water scarcity** | **Use of Wardens** | | |
| | **Never** | **Occasional** | **Always** |
| Low | 33% | 11% | 56% |
| Medium | 25% | 8% | 58% |
| High | 20% | 0% | 80% |
| Percentages below 40% | Percentages between 40% and 60% | | Percentages above 60% |

The Chilean Water Code establishes sanctions for the nonpayment of established fees, as well as for the illegal extraction of water. The Code also allows for establishing additional (or modified) sanctions according to the realities and needs of the WUA.

In this study, we analyzed the number of sanctions applied by the community and found no clear relationship between the size and/or composition of the WUA and the sanctions each WUA established, nor did we find a relationship between the water scarcity and sanctions (Table 8). A relevant issue regarding sanctions is that many communities report difficulties enforcing them despite their regulation in the statutes. For example, in WUAs where flow dividers are not available, cutting off water for one user would leave downstream users without water. As one of the interviewees mentioned: "[users] have to pay a fee . . . many do not pay and this is my worst problem, because I cannot cut the water for one user without cutting downstream users as well, because I do not have flow dividers" (President #1). In this case, the physical infrastructure does not allow for an effective sanction. There are also cases where power asymmetries inside the community make it difficult to apply sanctions in practice. For example, President #15 pointed out: "there are no fines here, because if we apply fines large producers ignore them; therefore, we decided to not apply them to anybody".

As for the types of sanctions, the statute establishes gradual sanctions that begin with verbal reprimands and progress to fines, cutting-off the water supply, and, finally, legal enforcement. However, the use of external bodies and institutions in conflict resolution are rare (i.e., local courts or police intervention). As President #26 states: "They cannot be punished because we would need to turn over the thief to the authorities, and normally nothing happens". Instead, verbal reprimands and social norms are more frequent and, to a lesser extent, the imposition of fines. For example, President #25 mentioned: "we do not impose fines, there is only social punishment from other users". President #10 commented on the matter: "We have in the statute a fine of 150 UTM, but we use 'diplomatic channels'". In some cases, the interviewees stated that they did not use sanctions, because the level of conflict is nonexistent or very low (18% of the sample).

**Table 8.** Relationship between sanctions and size, composition, and water scarcity.

| (a) | | | | | |
|---|---|---|---|---|---|
| **Size** | **Graduated Sanctions** | | | | |
| | **None** | **Verbal Reprimand** | **Cutting Water** | **Fine** | **Legal Action** |
| Small | 6% | 45% | 18% | 9% | 9% |
| Medium | 9% | 21% | 21% | 21% | 21% |
| Large | 3% | 29% | 14% | 14% | 29% |
| **(b)** | | | | | |
| **Water Scarcity** | **Graduated Sanctions** | | | | |
| | **None** | **Verbal Reprimand** | **Cutting Water** | **Fine** | **Legal Action** |
| Low | 0% | 41% | 18% | 24% | 18% |
| Medium | 9% | 29% | 14% | 29% | 29% |
| High | 9% | 50% | 13% | 25% | 13% |
| **(c)** | | | | | |
| **Composition** | **Graduated Sanctions** | | | | |
| | **None** | **Verbal Reprimand** | **Cutting Water** | **Fine** | **Legal Action** |
| Homogeneous | 0% | 26% | 16% | 32% | 26% |
| Heterogeneous | 13% | 25% | 25% | 25% | 25% |
| Percentages below 40% | Percentages between 40% and 60% | | | Percentages above 60% | |

### *5.4. Tier 4: Nestedness*

Ostrom's 8th principle recognizes that large systems such as water distribution cannot be managed locally and need a nested interconnected system where hierarchies are organized from the most local to intermediate and national levels. The Chilean system reflects this organizational structure, recognizing in the Water Code different management layers, with three levels of interconnected private organizations: the Surveillance Boards, Channel Associations (that are nonmandatory), and WUAs, as presented in Section 3. The government participates in the following three organizations that help manage water resources: the Hydraulic Infrastructure Directorate (DOH) provides resources for implementing large-scale infrastructure projects, with the aim of preserving and making more efficient the use of water resources, and the General Water Directorate (DGA) and National Irrigation Commission (CNR) implement governmental policies to secure water availability, increase the irrigation surface, and strengthen the self-governance capacity of water communities.

The Channel Association's group of WUAs obtain water from the same hydraulic infrastructure, and multiple interviewees indicate this allows for smaller WUAs to join efforts in developing improvement projects. For example, President #30 mentioned that: "The channel association that gathers several WUAs in Petorca pushed to assure part of the available water of the Las Palmas reservoir be for our associates of the water". A representative of a Channel Association (Informant #3) described their duties as: " . . . we advise our associates on how to professionalize the management of the community; we are outside organizations that provide wardens, aid the community management, and provide machinery for channel maintenance. The communities' boards are the links to the association".

The Surveillance Boards are in charge of distributing water to the WUAs, according to their water property rights and water availability. According to the presidents interviewed, there is an overall level of satisfaction with the Surveillance Boards, as indicated by President #27: "The Surveillance Board is a transparent organization, well dedicated to their duties; they have a good disposition in responding to our queries. . . . if we a have a legal question they have lawyers that guide us". In some cases, Surveillance Boards provide assistance to small communities that lack financial resources and knowledge. As an example, the Petorca Surveillance Board was crucial in organizing the water communities of the

Petorca River, as President #32 stated: "The Surveillance Board helped us to organize our communities along the Petorca river. We did not know that we had water rights, but now the community not only knows that we have water rights, but also how to maintain them". The Boards also link communities with governmental institutions such as CNRs and DOHs, allowing water users to benefit from the programs and resources that those institutions provide, such us training, educational programs, and the empowerment of communities.

In periods of high water scarcity, the state is allowed to decree areas of water scarcity (Decreto de Escasez Hídirca). These decrees allow the DGA to intervene in areas of high shortfalls by redistributing water among communities and providing economic resources to aid farmers and local residents. In practice, DGA delegates by redistributing them among channels to the Surveillance Boards. A president of a Surveillance Board (Informant #2) added: " ... if this location was decreed an area of water scarcity, it would allow the Surveillance Board to intervene, but the DGA will not do it because the communities know better how to regulate the distribution of water".

Regarding national organizations, especially CNRs, communities recognize that they do help, especially with funding for infrastructure and programs for the regularization of water rights or education. Interviewee #31 said: "The CNR came to help us to legalize our water rights; they provided us with a report about refining rights", and interviewee #1 added: "The CNR implemented a program to help us learn about safeguarding water". However, some believe that national organizations do not provide enough help. Other organizations that were mentioned include the Institute for Agricultural Development (INDAP) and universities. The INDAP is a service under the Ministry of Agriculture, whose objective is to "promote the economic, social, and technological development of small agricultural producers and peasants, in order to contribute to increasing their business, organizational, and commercial capacity, improving their integration into the rural development process, and optimizing at the same time the use of productive resources" [58]. As stated, only communities constituted by small producers can benefit from INDAP programs.

### 5.5. Conflicts, Water Scarcity Perceptions, and Size of the WUA

Besides the efficient and fair distribution of common resources, successful governance should be able to reduce conflicts inside the community. According to our results, 78% of the sample declared that internal conflicts exist in the WUAs; however, only seven cases reported a medium-to-high perception of conflict, and there was no pattern regarding sizes of the WUAs and the perception of water scarcity (Table 9). Regarding external conflicts, 50% appeared to have them, and the most frequent were with hydroelectric companies, the mining sector, and the villages located along the channel.

**Table 9.** Relationship between conflicts, size of the WUA, and water scarcity perceptions.

| (a) | | |
|---|---|---|
| **Size** | **Conflict Level** | |
| | **Low** | **Medium/high** |
| Small | 79% | 11% |
| Medium | 78% | 22% |
| Large | 67% | 33% |
| **(b)** | | |
| **Water Scarcity** | **Conflict Level** | |
| | **Low** | **Medium/high** |
| Small | 100% | 0% |
| Medium | 75% | 25% |
| Large | 71% | 38% |
| Percentages below 40% | Percentages between 40% and 60% | Percentages above 60% |

There are two characteristics related to the DPs presented in the previous sections that are worth mentioning: the use of flow dividers and wardens, as shown in Table 10. In the first case, a higher level of conflicts was associated with a higher use of flow dividers. However, we believe that this relationship is mediated by the size of the community, since the use of flow dividers is more likely for larger communities. This is also the case for the use of year-round wardens, which appears to be positively related to a higher level of perceived conflicts.

**Table 10.** Relationship between conflicts, the use of flow dividers, and the use of wardens.

| **(a)** | | |
|---|---|---|
| **Conflict Level** | **Use of Dividing Frames** | |
| | **None/Some** | **All/Majority** |
| Small | 61% | 39% |
| Medium/high | 13% | 88% |

| **(b)** | | | |
|---|---|---|---|
| **Conflict Level** | **Use of Dividing Frames** | | |
| | **Never** | **Occasional** | **Always** |
| Small | 33% | 8% | 58% |
| Medium/high | 14% | 0% | 86% |
| Percentages below 40% | Percentages between 40% and 60% | | Percentages above 60% |

## 6. Discussion

The results of the study show that, overall, the rules for WUAs established in the Water Code offer them a framework that provides a comprehensive set of regulations that cover all the DPs defined by Ostrom [22] including the nested structure of private organizations and public institutions that allows for an integrated organization of the water allocation system. We observed that most of the associations follow the organizational rules established in the Water Code, but we also found that structural characteristics generate "de facto" adjustments in some rules according to own realities. It is important to notice that these adjustments, although not in the generic statutes, are allowed by the legislation. Our findings related to the nestedness principle support the conclusions of previous works that the state rules can promote self-governance and co-management between state and users grouped into private organizations [13,34], yet these guidelines also need to provide flexibility for context-dependent adjustments [6,24,34,59].

The size of the WUA is the dominant factor explaining differences in the implementation of the Water Code rules, followed by community homogeneity, in which small and homogenous communities tend to make adjustments. This result is in line with Arvanitides [25] and Luo [9], who observed that size and community homogeneity/heterogeneity are strong drivers of arrangements fostering collective action [9,25]. The voting system is a good example of the rule adjustments. The Water Code establishes that the water shares owned by each user should be proportional to the vote, giving more power to those who own more shares, yet most of small and homogenous WUAs use the one person, one vote system. The same is true for the distribution of water and fee payments. In these cases, we can see that these adaptive adjustments are utilized considering simplicity and practicality—or, in other words, because they are more cost-effective. Ostrom and other scholars have highlighted that smaller and more homogenous communities are more likely to achieve self-governance [60–62].

Monitoring is another aspect that differs among communities according to size, as larger WUAs tend to use wardens permanently, while small and medium WUAs use them mostly during critical times. This may be explained by the lack of resources of small WUAs to support hiring a warden throughout the year, but another possibility is that a self-monitoring system among users may be sufficient, since according to the interviewees,

a dialogue between affected users is one of the most utilized and effective ways to solve conflicts. Regarding sanctions, we found that implementing effective graduated sanctions encountered difficulties. As expressed in our interviews, this is due to the lack of effective enforcement tools available to WUAs. A recurring comment from the presidents interviewed was that legal processes take too long and do not resolve conflicts quickly enough, and judges are often not specialized in the complexities of the topic. Hence, a cornerstone to achieve a successful system is the availability of effective sanctioning tools. This requires an adaptive capacity by the state, government agencies, and nongovernmental water organizations [23,59]. Likewise, power differences between WUA members play a role in applying sanctions and providing fair treatment for all users. This could be a drawback of local governance, as the voice of the most powerful might determine relationships in the WUA [23]. Leadership and social capital are seen as crucial in establishing a dialogue for conflict resolution, which was one of the common practices in this case. Strengthening the leadership could constitute a powerful tool [29,63], as this can establish goals, coordination activities, monitoring, dispute resolution, and sanctions [64,65].

The legal body that governs water allocation should also take into account the challenges that communities face with other economic sectors or villages. In this sense, higher levels in the nested governance system should have tools to resolve conflicts before they escalate or go to court. An adapted hierarchical level that integrates monitoring committees from all sectors, with legal recognition and with a participatory approach, may lead to lower transaction costs and more efficient solutions for water allocation. Several authors have pointed out that participatory approaches and coordination among organizations, in which the state provides the knowledge transfer, control over the actors' performances, investments, and technologies without imposing rules at the local level, can benefit tailored arrangements of self-governance [9,17,19,38,66].

It is also relevant to note that a nest of public and private institutions is also needed for the long-term sustainability of resource development and an integrated perspective of social and biophysical issues [17]. It is not only important to invest in infrastructure, but this also needs to be accompanied by strengthened social relations and a more effective flow of information within nested institutions. Dedicating more effort to education regarding water organization and creating social networks may aid in the reduction of potential conflicts when water availability is low [38].

In light of this discussion, we can raise three issues that should be considered when designing public policies to enhance CPR management. First, the differences in structural characteristics call for flexible legal rules for WUAs that will allow the design of their own self-governance structures. We found differences among communities related to size and homogeneity in the water distribution and voting systems, the use of wardens, and water distribution mechanisms (i.e., flow dividers versus gates). We believe the adoption of community arrangements is tied to size and homogeneity in response to the no one-size-fits-all approach that legal rules should consider [67]. Second, the nested structure provides a framework to organize the water distribution basin for the final users, but as highlighted by several informants, the nestedness should consider more coordination among water users undertaking different economic activities; at the moment, this appears to be a weak link. Third, when promoting self-governance in a nested structure of private organizations, it is necessary to create the capacity to professionalize water distribution management. We found that a key for the success of this structure is to empower and educate WUAs and their directives. This aspect has been raised by several authors that consider social capital, cultural aspects, and leadership as key factors in fostering collective action and self-governance.

## 7. Conclusions

This article explored how WUA characteristics are related to the use of the legal rules established in the Water Code in their organizational arrangements. For this purpose, we used the Ostrom governance of the endurance CPR model [22] as a framework to analyze the Chilean case of water allocation governance. The Chilean Water Code establishes a series of articles that rule the governance structure of WUAs, with a proposed statute that WUAs generally use. These WUAs are at the lowest level of the hierarchy; they distribute water to the final users along the channel. We found that the WUAs follow the rules established in the Water Code, but their sizes and compositions define different arrangements among users. In particular, the voting system, distribution of water, and fee payment are adjusted in small and homogenous WUAs; they are on a per-person basis rather than based on users' water shares. We can also conclude that a cornerstone in the system is implementing graduated sanctions, as water users see the tools provided by the Water Code as ineffective.

Our results shed light on the dominant factors in the governance of water allocation, and the role of the relative strengths and weaknesses of the state rules in Chile. This notwithstanding, we need to highlight some limitations of our study. First, the point of view of the president of a community is not always the same view of the users; hence, a study on the intrinsic motivations and social capital of the final users would allow us to understand what drives specific collective actions and adaptive governance. Second, a question that is still open is what constitutes a "good" allocation of water; to answer this, we need to understand what users consider to be fair. Finally, further empirical research is needed to understand how leadership, social capital, and cultural capital affect the collective action and adaptive governance of water resources.

**Author Contributions:** Conceptualization, A.E., F.R., O.M., R.J.-R.; methodology, A.E., F.R., B.P.; data analysis, A.E., F.R., B.P.; writing—original draft preparation; A.E., F.R, O.M., R.J.-R.; writing—review and editing, A.E., F.R., O.M., visualization, A.E., F.R., O.M.; project administration, A.E., funding acquisition, A.E. All authors have read and agreed to the published version of the manuscript.

**Funding:** This work was supported by the FONDECYT program, Chile, through Project Grant Number 1180556.

**Institutional Review Board Statement:** The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of University of Talca.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Data available upon request due to restrictions regarding the privacy of the respondents.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A. Guiding Questions per Section

| Section | Guiding Questions |
| --- | --- |
| Section 1: identification | Basic questions describing the interviewee and his/her community. |
| Section 2: "clearly defined boundaries" | What is the status of water rights within your community?<br>How is the distribution of water shifts/amount of water defined each year? What information is used for this?<br>Are there distribution problems/conflicts?<br>Which physical mechanisms are used for water distribution? |
| Section 3 "characteristics of the rules of the community" | How does the internal regulation of the community work? Who participates in its elaboration/update?<br>What does this regulation consist of and in which cases does it apply?<br>How is the directive elected? Who participates?<br>How are the irrigation systems maintained/cleaned?<br>Do you consider that the existing legal system (both external and internal) adequately responds to the needs of the community you preside over? |
| Section 4: "enforcement" | How does the monitoring of the rules of the community work?<br>What kind of conflicts does the person in charge of monitoring encounter?<br>Which sanctions exist in your community?<br>How are conflicts resolved? Are sanctions applied/respected? |

## References


1. Gosling, S.N.; Arnell, N.W. A Global Assessment of the Impact of Climate Change on Water Scarcity. *Clim. Chang.* **2016**, *134*, 371–385. [CrossRef]
2. *IPCC Climate Change 2014*; Synthesis Report. Versión Inglés; IPCC: Geneva, Switzerland, 2014; ISBN 9789291691432.
3. Boretti, A.; Rosa, L. Reassessing the Projections of the World Water Development Report. *NPJ Clean Water* **2019**, *2*, 15. [CrossRef]
4. Crate, S.; Nuttall, M. *Anthropology and Climate Change: From Actions to Transformations*; Crate, S., Nuttall, M., Eds.; Routledge Taylor and Francis: New York, NY, USA, 2009.
5. Ponce, R.; Parrado, R. Climate Change, Water Scarcity on Agriculture and the Economy-Wide: Impacts in the LAC Region. *Ser. Work. Pap.* **2015**. [CrossRef]
6. Castro, P.; Mouro, C. Psycho-Social Processes in Dealing with Legal Innovation in the Community: Insights from Biodiversity Conservation. *Am. J. Community Psychol.* **2011**, *47*, 362–373. [CrossRef]
7. Milupi, I.D.; Somers, M.J.; Ferguson, W. A Review of Community-Based Natural Resource Management. *Appl. Ecol. Environ. Res.* **2017**, *15*, 1121–1143. [CrossRef]
8. Menestrey Schwieger, D.A. When Design Principles Do Not Apply: The Role of Individual Commitment and "Voluntarism" in Maintaining Communal Water Supply in Northern Kunene, Namibia. *Hum. Organ.* **2020**, *79*, 216–225. [CrossRef]
9. Luo, F.; Tian, M.; Sun, C. Analysis of the Correlation between Group Heterogeneity and the Self-Governance Performance of Small-Scale Water Conservancy Facilities: Based on the Threshold Model of the Number of Water User Households. *Irrig. Drain.* **2019**, *68*, 690–701. [CrossRef]
10. May, C.K. Institutional Panarchy: Adaptations in Socio-Hydrological Governance of the South Dakota Prairie Pothole Region, USA. *J. Environ. Manag.* **2021**, *293*, 112851. [CrossRef] [PubMed]
11. Hardin, G. The Tragedy of the Commons. *Science* **1968**, *162*, 1243–1248.
12. Meinzen-Dick, R. Beyond Panaceas in Water Institutions. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 15200–15205. [CrossRef]
13. Sarker, A.; Ikeda, T.; Abe, T.; Inoue, K. Design Principles for Managing Coastal Fisheries Commons in Present-Day Japan. *Ecol. Econ.* **2015**, *117*, 32–38. [CrossRef]
14. Barnaud, C.; Corbera, E.; Muradian, R.; Salliou, N.; Sirami, C.; Vialatte, A.; Choisis, J.P.; Dendoncker, N.; Mathevet, R.; Moreau, C.; et al. Ecosystem Services, Social Interdependencies, and Collective Action: A Conceptual Framework. *Ecol. Soc.* **2018**, *23*, 15. [CrossRef]
15. Liu, Z.; Rommel, J.; Feng, S. Does It Pay to Participate in Decision-Making? Survey Evidence on Land Co-Management in Jiangsu Province, China. *Ecol. Econ.* **2018**, *143*, 199–209. [CrossRef]
16. Nabiafjadi, S.; Sharifzadeh, M.; Ahmadvand, M. Social Network Analysis for Identifying Actors Engaged in Water Governance: An Endorheic Basin Case in the Middle East. *J. Environ. Manag.* **2021**, *288*, 112376. [CrossRef] [PubMed]

17. Dörre, A.; Goibnazarov, C. Small-Scale Irrigation Self-Governance in a Mountain Region of Tajikistan. *Mt. Res. Dev.* **2018**, *38*, 104–113. [CrossRef]
18. Deitch, M.J.; Gancel, H.N.; Croteau, A.C.; Caffrey, J.M.; Scheffel, W.; Underwood, B.; Muller, J.W.; Boudreau, D.; Cantrell, C.G.; Posner, M.J.; et al. Adaptive Management as a Foundational Framework for Developing Collaborative Estuary Management Programs. *J. Environ. Manag.* **2021**, *295*, 113107. [CrossRef] [PubMed]
19. Chilima, J.S.; Blakley, J.; Diaz, H.P.; Bharadwaj, L. Understanding Water Use Conflicts to Advance Collaborative Planning: Lessons Learned from Lake Diefenbaker, Canada. *Water* **2021**, *13*, 1756. [CrossRef]
20. Chandrasekara, S.S.K.; Chandrasekara, S.K.; Gamini, P.H.S.; Obeysekera, J.; Manthrithilake, H.; Kwon, H.H.; Vithanage, M. A Review on Water Governance in Sri Lanka: The Lessons Learnt for Future Water Policy Formulation. *Water Policy* **2021**, *23*, 255–273. [CrossRef]
21. Ostrom, E. Coping with Tragedies of The Commons. *Annu. Rev. Political Sci.* **1999**, *2*, 493–535. [CrossRef]
22. Ostrom, E. *Governing the Commons*; Cambridge University Press: Cambridge, UK, 1990. [CrossRef]
23. Chaffin, B.C.; Gosnell, H.; Cosens, B.A. A Decade of Adaptive Governance Scholarship: Synthesis and Future Directions. *Ecol. Soc.* **2014**, *19*, 56. [CrossRef]
24. Armitage, D. Governance and the Commons in a Multi-Level World. *Int. J. Commons* **2007**, *2*, 7. [CrossRef]
25. Arvanitidis, P.A.; Nasioka, F.; Dimogianni, S. Water Resource Management in Larisa: A "Tragedy of the Commons?". In *Sustainable Water Use and Management*; Leal Filho, W., Sümer, V., Eds.; Green Energy and Technology; Springer International Publishing: Cham, Switzerland, 2015; pp. 65–89.
26. Skurray, J.H. The Scope for Collective Action in a Large Groundwater Basin: An Institutional Analysis of Aquifer Governance in Western Australia. *Ecol. Econ.* **2015**, *114*, 128–140. [CrossRef]
27. Yu, H.H.; Edmunds, M.; Lora-Wainwright, A.; Thomas, D. Governance of the Irrigation Commons under Integrated Water Resources Management—A Comparative Study in Contemporary Rural China. *Environ. Sci. Policy* **2016**, *55*, 65–74. [CrossRef]
28. di Vaio, A.; Trujillo, L.; D'Amore, G.; Palladino, R. Water Governance Models for Meeting Sustainable Development Goals: A Structured Literature Review. *Util. Policy* **2021**, *72*, 101255. [CrossRef]
29. Correa, H.; Blanco-Wells, G.; Barrena, J.; Tacón, A. Self-Organizing Processes in Urban Green Commons. The Case of the Angachilla Wetland, Valdivia-Chile. *Int. J. Commons* **2018**, *12*, 573–595. [CrossRef]
30. Baggio, J.A.; Barnett, A.; Perez-Ibarra, I.; Brady, U.; Ratajczyk, E.; Rollins, N.; Rubios, C.; Shin, H.C.; David, J.Y.; Aggarwal, R.; et al. The Puzzle of Good Governance: Putting the Pieces Together through the Lens of Ostroms Design Principles. CSID. 2016. Available online: https://complexity.asu.edu/sites/default/files/papers/csid_wp_2014-008.pdf (accessed on 20 April 2021).
31. Bastakoti, R.C.; Shivakoti, G.P. Context and Institutions in Irrigation Management: Applicability of Design Principles in Nepal and Thailand. In Proceedings of the Workshop Water and Design Principles, Indiana University, Bloomington, IN, USA, 3–6 June 2009.
32. Naiga, R. Conditions for Successful Community-Based Water Management: Perspectives from Rural Uganda. *Int. J. Rural Manag.* **2018**, *14*, 110–135. [CrossRef]
33. Bisung, E. Community Based Collective Action for Safe Water in Rural Sub-Saharan Africa. *Water Secur.* **2021**, *13*, 100088. [CrossRef]
34. Trimble, M.; Berkes, F. Towards Adaptive Co-Management of Small-Scale Fisheries in Uruguay and Brazil: Lessons from Using Ostrom's Design Principles. *Marit. Stud.* **2015**, *14*, 14. [CrossRef]
35. Agrawal, A.; Brown, D.G.; Rao, G.; Riolo, R.; Robinson, D.T.; Bommarito, M. Interactions between Organizations and Networks in Common-Pool Resource Governance. *Environ. Sci. Policy* **2013**, *25*, 138–146. [CrossRef]
36. Oates, N.; Hisberg, A.; Rodríguez Ros, J.; Solomon, H.; Ludi, E.; Marlet, S.; Jamin, J.Y. The Implications of State Intervention for Self-Governed Irrigation Schemes: Insights from Tigray, Ethiopia. *Irrig. Drain.* **2020**, *69*, 88–99. [CrossRef]
37. Chopra, A.; Ramachandran, P. Understanding Water Institutions and Their Impact on the Performance of the Water Sector in India. *Water Policy* **2021**, *23*, 466–486. [CrossRef]
38. Finger, R.; Borer, A. Cooperative Management of a Traditional Irrigation System in the Swiss Alps. *Soc. Sci.* **2013**, *2*, 1–19. [CrossRef]
39. Svensson, J.; Wang, Y.; Garrick, D.; Dai, X. How Does Hybrid Environmental Governance Work? Examining Water Rights Trading in China (2000–2019). *J. Environ. Manag.* **2021**, *288*, 112333. [CrossRef] [PubMed]
40. Hanemann, M. Property Rights and Sustainable Irrigation-A Developed World Perspective. *Agric. Water Manag.* **2014**, *145*, 5–22. [CrossRef]
41. Ministerio de Justicia, C. DFL 1122 Fija Texto Del Código de Aguas. 1981. Available online: https://www.bcn.cl/leychile/navegar?idNorma=5605 (accessed on 27 August 2021).
42. Herrera, M.; Candia, C.; Rivera, D.; Aitken, D.; Brieba, D.; Boettiger, C.; Donoso, G.; Godoy-Faúndez, A. Understanding Water Disputes in Chile with Text and Data Mining Tools. *Water Int.* **2019**, *44*, 302–320. [CrossRef]
43. Retamal, R.; Melo, O.; Arumí, J.L.; Parra, O. Chile: Environmental, Political and Social Issues. In *Chile: Environmental, Political and Social Issues*; Rivera, D., Ed.; Nova Publishers: New York, NY, USA, 2012; pp. 33–68.
44. Rivera, D.; Godoy-Faúndez, A.; Lillo, M.; Alvez, A.; Delgado, V.; Gonzalo-Martín, C.; Menasalvas, E.; Costumero, R.; García-Pedrero, Á. Legal Disputes as a Proxy for Regional Conflicts over Water Rights in Chile. *J. Hydrol.* **2016**, *535*, 36–45. [CrossRef]

45. Bollier, D.; Helfrich, S. *Patterns of Commoning*; Bollier, D., Helfrich, S., Eds.; The Commons Strategies Group: Amherst, MA, USA, 2015.
46. Buck, S.J. No Tragedy of the Commons. *Environ. Ethics* **1985**, *7*, 49–61. [CrossRef]
47. van Rensselaer, P. The Tragedy of the Sahel Commons. *Science* **1974**, *185*, 813.
48. Vreja, L.; Balan, S.; Mavrodin, C. Sustainability and the Tragedy of the Commons. A New Perspective. *Int. Conf. Compet. Agro-Food Environ. Econ. Proc.* **2016**, *5*, 176–187. Available online: https://ideas.repec.org/a/aes/icafee/v5y2016p176-187.html (accessed on 21 April 2021).
49. Cox, M.; Arnold, G.; Tomás, S.V. A Review of Design Principles for Community-Based Natural Resource Management. *Ecol. Soc.* **2010**, *15*, 38. [CrossRef]
50. Wilson, D.S.; Ostrom, E.; Cox, M.E. Generalizing the Core Design Principles for the Efficacy of Groups. *J. Econ. Behav. Organ.* **2013**, *90*, S21–S32. [CrossRef]
51. Saeed, A.R.; McDermott, C.; Boyd, E. Are REDD+ Community Forest Projects Following the Principles for Collective Action, as Proposed by Ostrom? *Int. J. Commons* **2017**, *11*, 572–596. [CrossRef]
52. Singleton, B.E. What's Missing from Ostrom? Combining Design Principles with the Theory of Sociocultural Viability. *Environ. Politics* **2017**, *26*, 994–1014. [CrossRef]
53. Muchara, B.; Ortmann, G.; Wale, E.; Mudhara, M. Collective Action and Participation in Irrigation Water Management: A Case Study of Mooi River Irrigation Scheme in KwaZulu-Natal Province, South Africa. *Water SA* **2014**, *40*, 699. [CrossRef]
54. ODEPA. Estadísticas Productivas 2017. Available online: https://www.odepa.gob.cl/estadisticas-del-sector/estadisticas-productivas (accessed on 12 May 2021).
55. ODEPA. Estadisticas Productivas 2019. Available online: https://www.odepa.gob.cl/estadisticas-del-sector/estadisticas-productivas (accessed on 19 April 2021).
56. Valdés-Pineda, R.; Pizarro, R.; García-Chevesich, P.; Valdés, J.B.; Olivares, C.; Vera, M.; Balocchi, F.; Pérez, F.; Vallejos, C.; Fuentes, R.; et al. Water Governance in Chile: Availability, Management and Climate Change. *J. Hydrol.* **2014**, *519*, 2538–2567. [CrossRef]
57. Wang, Y.; Zhang, M.; Kang, J. How Does Context Affect Self-Governance? Examining Ostrom's Design Principles in China. *Int. J. Commons* **2019**, *13*, 660–704. [CrossRef]
58. INDAP. Qué Es INDAP. Available online: https://www.indap.gob.cl/indap/qué-es-indap (accessed on 17 May 2021).
59. Arnold, C.; Gunderson, L. Adaptive Law and Resilience. *Environ. Law Rep.* **2013**, 10426–10443.
60. Agrawal, A. Sustainable Governance of Common-Pool Resources: Context, Methods, and Politics. *Annu. Rev. Anthropol.* **2003**, *32*, 243–262. [CrossRef]
61. Agrawal, A. Common Property Institutions and Sustainable Governance of Resources. *World Dev.* **2001**, *29*, 1649–1672. [CrossRef]
62. Ostrom, E. Polycentric Systems for Coping with Collective Action and Global Environmental Change. *Glob. Environ. Chang.* **2010**, *20*, 550–557. [CrossRef]
63. Chaudhry, A.M. Improving On-Farm Water Use Efficiency: Role of Collective Action in Irrigation Management. *Water Resour. Econ.* **2018**, *22*, 4–18. [CrossRef]
64. Glowacki, L.; von Rueden, C. Leadership Solves Collective Action Problems in Small-Scale Societies. *Philos. Trans. R. Soc. B Biol. Sci.* **2015**, *370*, 20150010. [CrossRef] [PubMed]
65. Wang, Y.; Wu, J. An Empirical Examination on the Role of Water User Associations for Irrigation Management in Rural China. *Water Resour. Res.* **2018**, *54*, 9791–9811. [CrossRef]
66. Dell'Angelo, J.; Mccord, P.F.; Gower, D.; Carpenter, S.; Caylor, K.K.; Evans, T.P. Community Water Governance on Mount Kenya: An Assessment Based on Ostrom's Design Principles of Natural Resource Management. *Mt. Res. Dev.* **2016**, *36*, 102–115. [CrossRef]
67. Delgado-Serrano, M.M.; Ramos, P.A.; Lasso Zapata, E. Using Ostrom's DPs as Fuzzy Sets to Analyse How Water Policies Challenge Community-Based Water Governance in Colombia. *Water* **2017**, *9*, 535. [CrossRef]