 doi:10.20944/preprints202009.0612.v1

Article

Water privatization and inequality: Gini coefficient for water resources in Chile

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Abstract: This document makes a comprehensive analysis of the inequality of the water market in Chile, measured by the Gini coefficient method. The situation of water rights in Chile is of particular interest because it is a completely privatized system, where rights are traded in the market and therefore water is presented as a commodity. This privatization of water in Chile occurred as part of the process of neoliberalization since the 1981 Water Code. The results of this study indicate that both the concentration and the inequality in the distribution of water rights is very high. It proposes a profound revision of applying a mercantile logic to a scarce basic resource for life such as water and exploring the importance of its role as a national good for public use.

Keywords: Water; Gini coefficient; concentration; privatization; Chile.

1. Introduction

As part of the Chilean process of neoliberalization, in 1981 the water code was created, and this scarce good began to be commercialized, generating negotiable property rights. In general, the creation of a water market can be based on the privatization of rights, institutionally controlled business cycles, pricing according to availability, and determining its free disposal as a fundamental human right for subsistence [1]. In all these cases and in the face of the climate emergency, water scarcity is a challenge in the management of the resource that must be adapted to the current planetary crisis [2-3]. It is for this reason that it is relevant to critically review those cases in which water resource management instruments have not been adapted to the climate crisis. This occurs in the Chilean case, which takes on greater relevance in the face of resistance from democratic authorities for recognizing the importance of adapting the regulation of the water domain to current times. On January 7, 2020, the Senate of the Republic has decided to reject the consecration of water as a national good of public use [4], despite the fact that Chile faces a severe drought [5] and that international literature raises the urgency of rethinking the models of governance over natural resources [6]. This article presents evidence on how the Chilean case can illustrate the complexity of creating a market through the privatization of water rights for consumptive purposes, which leads to a high concentration of ownership of a good without substitutes, generating speculative scenarios with the commercialization of property and significant inequality in access to water. Consumptive purposes imply that water is not returned to its original course, i.e. water is consumed.

When a water market is proposed, it is important to understand that this is one of the particularities of the Chilean reality, where in 1981 water rights are privatized and with it the values and mechanisms to exchange water for money establish a market that sets its prices by the law of supply and demand. For Rutgerd Boelens [7], in the study of water rights it is key to identify the affordability of the resource for the users, determining how the owner of the water rights exercises his power by controlling a scarce resource basic for the development of life. Boelens proposes that

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power relations will define the distribution of water resources, but its discussion also restructures power relations in the joint society. In the international specialized literature there is consensus that the water market should not operate like any other type of tradable good and requires democratic and institutionalized regulations. In some cases, the development of a water market can improve the efficiency in the distribution of water resources [8], but in case of a weak regulatory institutionality it can generate speculative frameworks that end up reducing the population's access to water [9-11].

The present article seeks to contribute to the discussion of the effects of generating a water market in a situation of water scarcity, from the review of its distribution and sustainability, taking the case of water rights in Chile. Specifically, it studies the inequality of water distribution in Chile as measured by the Gini index. To frame the problem of water in Chile, the article presents a general framework of the origin and scope of water management in Chile, from its first regulations to the creation of a market through its privatization in 1981. The data for the study and the methods used are then discussed. The source of the information analyzed is based on secondary data obtained from the General Water Directorate of the Ministry of Public Works. These data are georeferenced and the inequality of the allocation of this resource for its consumptive use is studied, that is, for waters that are extracted without reincorporation into the channels. The method used is a geo-localized Gini index to review the distribution of the resource spatially. The results argue that privatization optimizes the distribution of the water resource. The proposal is to open the discussion based on specialized international literature in order to rethink how to manage water resources in Chile from the institutional and public policy point of view, considering the important drought that the country faces and in view of the climate emergency.

Historical review of the formation of the water market in Chile

In 1819, Bernardo O'Higgins, the architect of Chile's independence, drafted a supreme decree to determine how water should be used, based on a metric configuration of the irrigators, clearly establishing how water should be marketed and assigning responsibility for the correct use of the resource to the controllers of the intakes. Already in 1857, water resources will be nominated as national public goods. In view of the emergence of drought episodes, in 1872 several regulations sought to generate mechanisms to manage water in the event of alterations in annual rainfall and focused on rural agricultural productivity. These were the first approaches to regulating water use in Chile, without a market as such but rather with a system of concessions for use for specific productive purposes.

It was in 1927 that a water code proper was drawn up, within the framework of the civil code, with 476 articles covering a large part of the provisions relating to water resource management and enshrining it as a national good for public use, where the State would be governing the modes of allocating the use of the resource for activities other than human consumption. This project will have a set of revisions in 1928, 1930, until the final configuration of the 1936 water code, where the concession of the use of the resource is consecrated as part of the State's roles. The water code will take a more definitive and consensual form at the level of parliament in 1951, the year in which the role of the State is specified, establishing that it is the President of the Republic who will approve applications for water use rights. Then, under the government of Eduardo Frei Montalva and in the midst of the search for improving the functioning of the agricultural world, in 1967, a new water code was created that emphasized the public domain of water resources. Under this code, the exploitation will be defined according to a rationalized rate by the central planning agencies, thus defining the volume of maximum use flows [12]. In this first review, it is seen that Chile historically privileged the understanding that water was a national good of public use whose fair distribution should be supervised by the government authority (by the president of the Republic himself), with a rationality typical of a protagonist State in the national productive life from a centralized planning approach. With neoliberalism, the paradigm changes completely. The State reduces its participation

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in the regulation of productive activities, and in matters of public interest markets are created such as social security, education, health and water, among others.

The neoliberalization of public goods in the case of water will take its form in the 1981 Water Code. With the framework provided by the Constitution of the Republic promulgated in 1980, the property regime will be the focus of this new mechanism for regulating water resources. Thus, the management of this resource will be oriented towards the possibilities of its commercialization and acquisition, without State regulation. The State, on the other hand, will play a role in assigning use rights, but without the effective capacity to control such uses, much less the markets for water use transactions between private parties. With this, water in Chile becomes a commodity [13]. For Humberto Peña [14], the main characteristics of the Chilean water code can be identified by the following aspects:

- Transfer of water management from the State as a public good to the market as a commodity.
- The enshrining of original water rights to generate ownership.
- The work of inspection and conflict resolution among private parties is organized, placing this role in the government.
- Strategic planning for water resource management is generated with a focus on its productive role without sufficient emphasis on the sustainability of its use.

From these transformations, the territory as a whole enters a process of privatization for commercial purposes. For Carl Bauer, the separation of water rights from land rights would be another problematic factor since water tributaries crossing a land will not have a direct commercial relationship with the landowner. This will account for the overlap of property rights on the same land. The use of water will not have much territorial weight, but will be valuable as an economic resource, so its basic role for the development of life is subjugated to its commercial efficiency. Making water a commodity with the 1981 Water Code also marks the emergence of a water market that in those years followed the recommendations of the Inter-American Development Bank and the World Bank [15]. The main objective argued by the promoters of these reforms was the need to manage water scarcity. For this, the water policies proposed that the access and coverage would be achieved in a better way if the -until then, public management of the water resource passed to private hands, in search of increasing the efficiency and improving the management, favoring competitiveness in the sector eliminating barriers for international companies and reducing the regulations, and assuring a 10.3% profitability [16-18]. It is the fundamental argument of neoliberalism [19].

For Bauer [20], the freedom to buy and sell water rights has led to the revaluation of water resources in certain areas, but the negative effects are related to the normative rigidity of the constitutional and legal framework of the Water Codes. This makes it difficult for regulations to be adapted to the diverse uses of water and the nature of the flows themselves, which eventually leads to the aforementioned potential conflicts over water between companies and communities; or to lead to the reduction of efficient management of the resource due to inadequate exploitation despite scarce conditions. In a productive and short term logic, water privatization with a focus on productive activities does not consider the common good but rather aspires to the economic return of such activities, thus neglecting the ecological role of water resources since the productive processes have other objectives related to income and commercial efficiency of businesses.

In 2005, a transformation to the Water Code was introduced. Although the water market was not disarticulated, a monetary tax was generated on the non-exploitation of water resources by those who held the corresponding water rights, seeking to avoid speculation with the water rights. According to Humberto Peña and Pablo Jaeger [20], the objective of avoiding speculation and

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monopolistic frameworks was to generate a greater balance between the productive role of water and social needs, in addition to adding sustainability criteria to water resource management. However, it will be Peña himself, the writer of the reform, who will later recognize that this reform was made in an adverse political climate, of difficult progress because the Constitution facilitates the hindering of progressive reforms, favorable to the conservative political forces that in Chile tend to prioritize the market over the social function of water [21]. In other words, the reforms were limited without managing to resolve the conflicts related to the sustainability of the water market, preserving its characteristics and vices that tend to concentrate the resource and unequal access to it.

2. Materials and Methods

The data set used for this study comes from the national databases of water rights registered with the General Water Directorate of the Ministry of Public Works of the Government of Chile, where original rights and applications for water rights are identified according to Article 122 of the Water Code. The database corresponds to the National Consolidated Rights, dated January 20, 2020. In particular, we have applied the study to consumptive water rights, that is, those assigned so that water is consumed without returning to its original course. Even so, in the presentation of the results, the global water rights are presented, against the consumptive rights [22].

However, it should be reported that the original database presented a low number of data consistency problems, so a thorough review of the information had to be carried out. In this process of cleaning up the database, inconsistent information had to be removed. In short, for the national consolidated, out of a total of 131,124 cases, only 97.62% were used (128.015 permits), given that the rest encountered problems of various kinds, including typing errors, records without data on the volume of water transferred and units of measurement that cannot be converted into volumes of water, as is the case with the so-called shares or irrigators, which are measures proportional to the flows of a given course, information that is not entirely clear for the calculation of the Gini Coefficient on the resource. The corrected table is attached as a complementary database annex to this publication and has also been sent to the Ministry of Public Works for correction.

Based on the above, it was decided to work with 97.62% of the data already processed, with which different spatial concentration analyses were carried out, starting with the spatialization of the water resource capture points (Figure 1). From the data set, several analyses were executed. Specifically, (i) distribution according to the right of the resource, (ii) nature of origin, (iii) volume of water extracted and finally (iv) an analysis of how concentrated the water resource is based on its Gini coefficient, on a national, zonal and regional scale.

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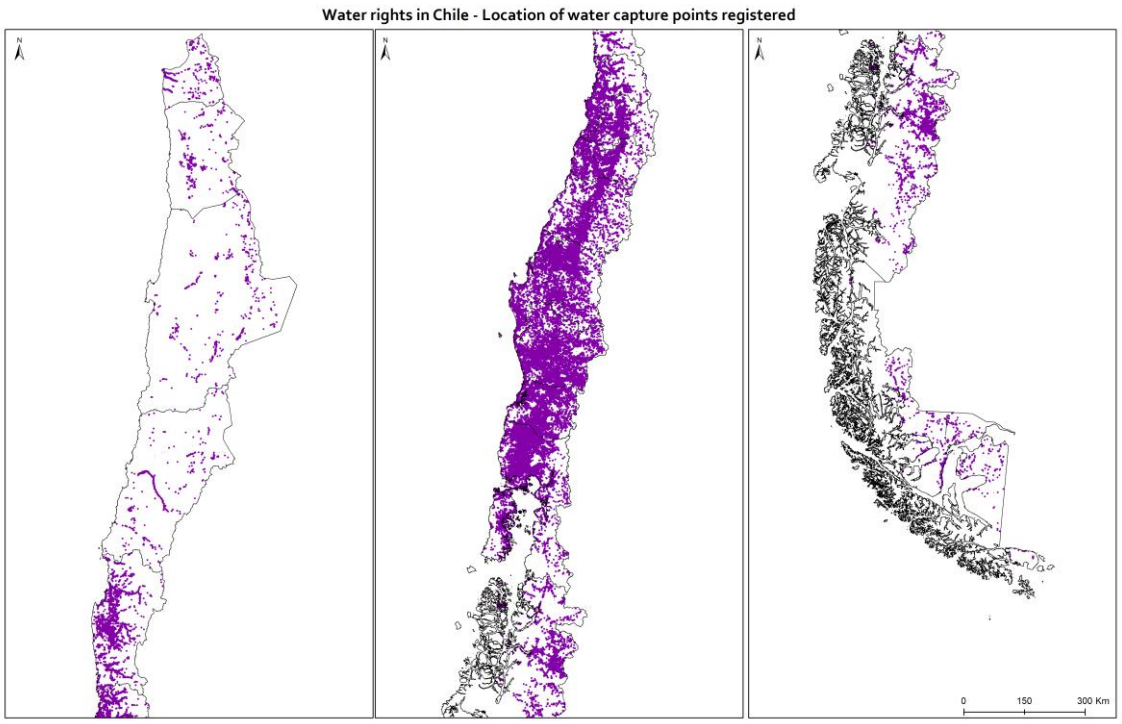

Figure 1. Location of water capture points registered as rights at the General Water Directorate of the Ministry of Public Works. Source: drawn up by the authors based on data from the D.G.A.

To analyse this data, a study of unequal access to water rights is carried out using the Gini coefficient. The Gini coefficient is a method for measuring levels of inequality in the distribution of a certain factor in a given population. It is usually used to measure income inequality, as suggested by its creator, Corado Gini. The result of the calculation ranges from 0 (total equality) to 1 (total inequality). Its interpretation is simple, which is key in this study that seeks to review the problem of water rights in Chile so that its discussion is taken up by different disciplines, from human rights approaches to market studies. In particular, we have classified the rights to consumptive water according to the volume of water assigned for each user registered with the General Water Directorate, in order to have clarity on the levels of inequality in the allocation of water resources.

Then, based on the distribution patterns of water rights, we will be able to review which actors concentrate the greatest amount of liters per second and how these results are interpreted in light of the water crisis the country is experiencing.

To obtain the Gini coefficient, the following calculation was made:

$$Gini = 1 - \sum_{k=1}^{n-1} (X_{k+1} - X_k)(Y_{k+1} - Y_k)$$

Where, X corresponds to the cumulative proportion of the variable stakeholders owning water rights included in this study, while Y corresponds to the cumulative proportion of water volume measured by Litres / Seconds.

3. Results

For a general description of the sample, out of a total of 131,124 permits granted and registered in the original database, 128,015 (97.62% of the total) are identified. In this database, 54.1% of the permits were for groundwater and 45.9% for surface water. Of the total number of permits, those corresponding to consumptive water are studied, whose flow estimate is 4,293,280 lts/sec. As

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indicated in Figure 2, most of the non-consumptive permits are located near the mountain range in the central-southern zone of the country (Regions of Valparaíso, Metropolitana, O'higgins, Maule, Ñuble, Biobio, Araucanía, Los Ríos and Los Lagos), while the consumptive ones are distributed throughout the national territory.

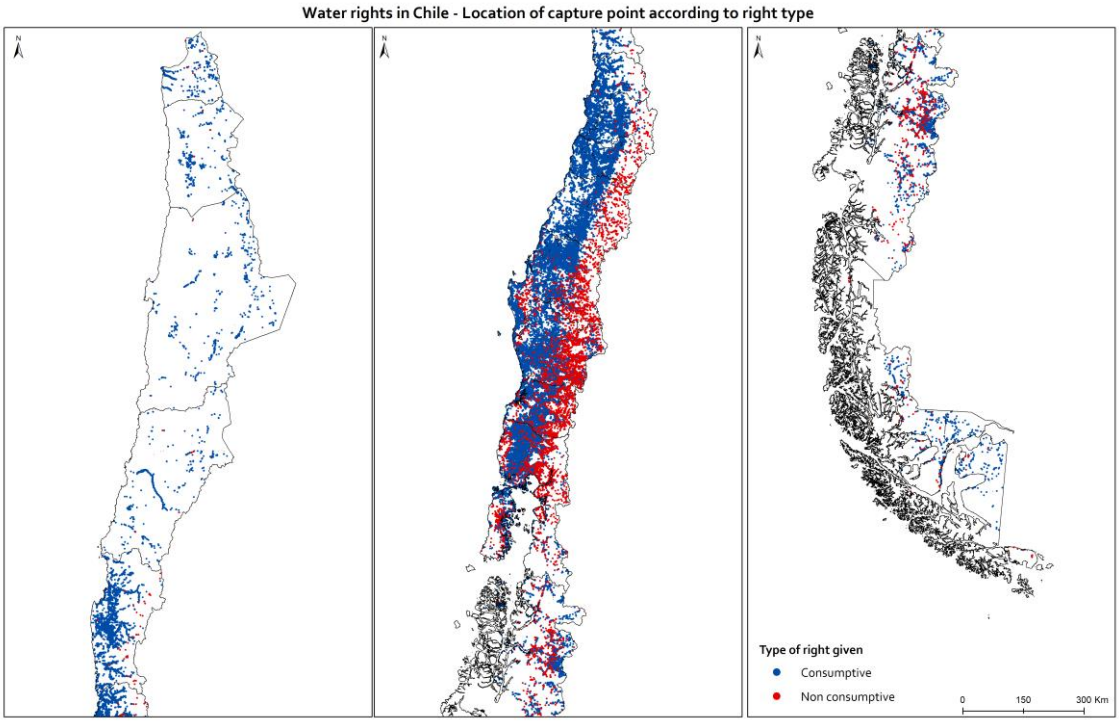

Figure 2. National map with the permits according to consumptive or non-consumptive right type. Source: Compiled by the authors based on information from the DGA.

When quantifying the value of the water market for surface consumption rights, it is estimated that it corresponds to a market of USD 45,868,679. One of the problems found in the study is that the General Water Directorate holds 57.4% of the permits without information on the owners or the destination of use given to these water rights. For this reason, we present the concentration of water rights, incorporating those actors for whom we do not have data (Table 1) and a table of consumptive rights considering only those where the uses given to the water are identified (Table 2).

Table 1. Consumptive water rights by use, including "No data" cases. Source: Author's elaboration based on DGA data.

Consumptive rights of water			
Water use	**Lts./sec.**		**%**
	Recount	**Add up**	**Of the total**
NO DATA	73.591	2.465.931	57,4%
Drink/Domestic Use/Sanitation	13.008	352.034	8,2%
Hydroelectric Energy	40	5.746	0,1%
Other Uses	1.983	95.927	2,2%
For Observation and Analysis	3	2	0,0%
Fish Farming	332	21.858	0,5%
Irrigation	24.524	1.296.526	30,2%
Silvo-Agropecuario	127	1.223	0,0%
Industrial use	380	26.915	0,6%
Medical Use	4	67	0,0%
Mining use	479	27.05	0,6%
Total	**114.471**	**4.293.280**	

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Table 2. Consumptive water rights by use, excluding "No data" cases. Source: Author's elaboration based on DGA data.

Consumptive rights of water			
Water use	**Lts./sec.**		**%**
	Recount	**Add up**	**Of the total**
Drink/Domestic Use/Sanitation	13.008	352.034	19,3%
Hydroelectric Energy	40	5.746	0,3%
Other Uses	1.983	95.927	5,2%
For Observation and Analysis	3	2	0,0%
Fish Farming	332	21.858	1,2%
Irrigation	24.524	1.296.526	71,0%
Silvo-Agropecuario	127	1.223	0,1%
Industrial use	380	26.915	1,5%
Medical Use	4	67	0,0%
Mining use	479	27.050	1,5%
Total	**40.880**	**1.827.348**	

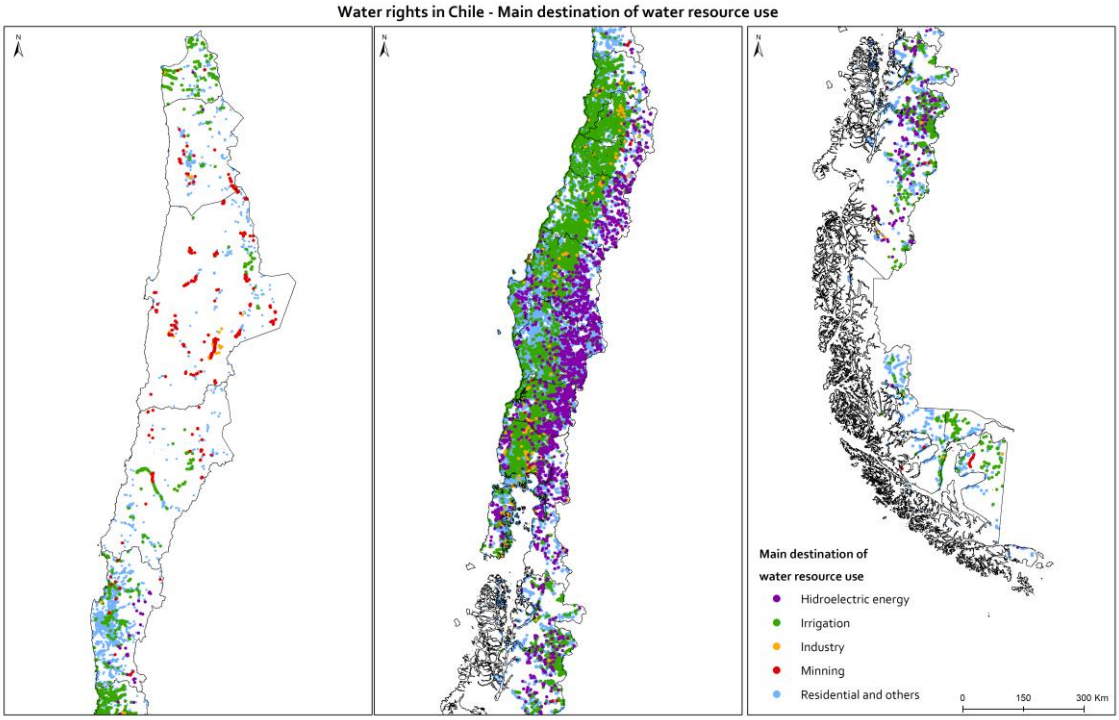

Figure 3. Water rights according to main destination of water resource use. Source: Author's elaboration according to DGA data.

One of the main reviews is to detect that irrigation as a consumptive activity and at the same time productive, registers 71% of the volume of water transferred for productive use with clear identification of use. The use of water for irrigation in Chile is equivalent to the annual consumption of 243 million homes, similar to the number of homes in India or 10 times the United Kingdom (Figure 3). This result makes it necessary to review whether this water consumption has a similar contribution to the treasury through production taxes, when only 2.75% of annual sales are concentrated, representing only 6.27% of companies in Chile and contributing through income tax from agricultural activities, only 0.46% of the fiscal budget (0.11% of GDP). Then, it is also important to review the volume of privatized water distributed in regions, where Maule (14.69%), O'Higgins (14.04%) and the Metropolitan Region (13.52%) concentrate a great part of the total national consumption flow (Table 3). This initial descriptive review allows us to recognize the general profile of consumptive water rights in Chile (Figure 4) and the importance of studying their levels of inequality and concentration.

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Table 3. Spatial distribution of permits in the territory by political-administrative regions. Source: Compiled by the authors on the basis of DGA data.

Region	Recount	Add up	Of the total
Arica y Parinacota	2.281	20.996	0,49%
Tarapacá	1.708	37.273	0,87%
Antofagasta	1.022	25.840	0,60%
Atacama	1.592	41.040	0,96%
Coquimbo	11.891	149.198	3,48%
Valparaíso	13.958	410.540	9,56%
Metropolitana	9.575	580.271	13,52%
O'Higgins	8.744	602.980	14,04%
Maule	9.022	630.651	14,69%
Ñuble	7.639	161.216	3,76%
Biobío	6.909	333.580	7,77%
Araucanía	14.915	465.402	10,84%
De Los Ríos	8.166	161.737	3,77%
De Los Lagos	10.932	287.634	6,70%
Aysén	4.704	230.327	5,36%
Magallanes	1.413	154.596	3,60%
Total country	**114.471**	**4.293.280**	

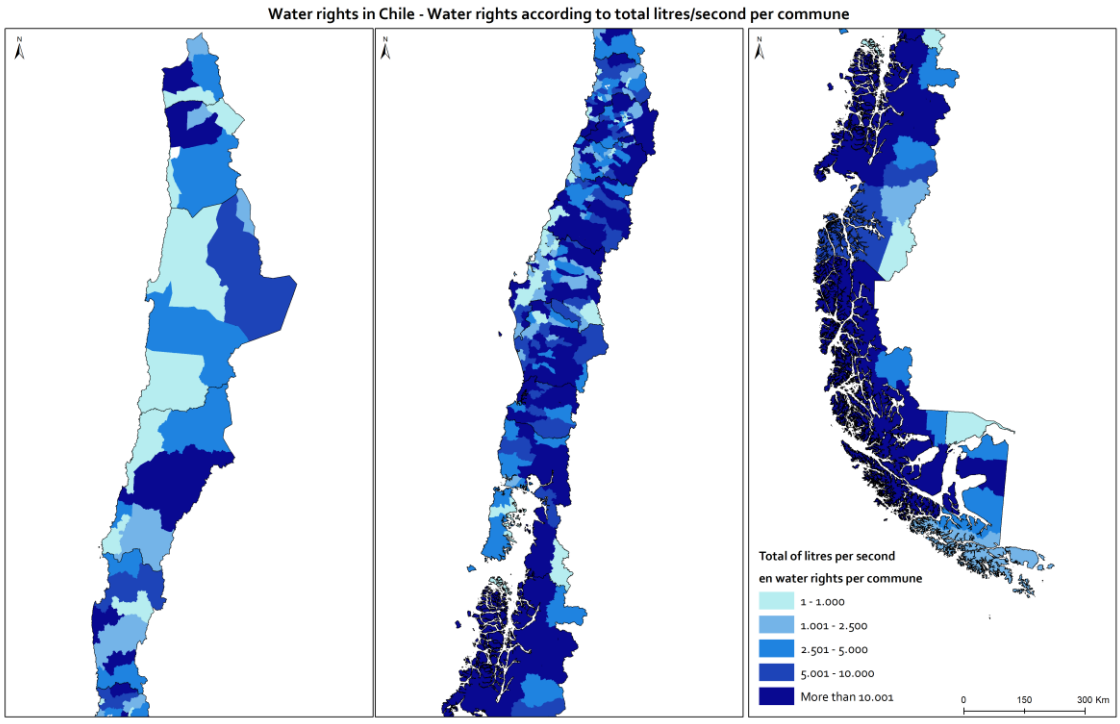

Figure 4. Water rights according to total litres/second per commune. Source: Own elaboration from DGA data.

The Gini coefficient for all permits at the national level is 0.9999585 and in the specific case of surface consumption rights, this reaches a value of 0.9537 (Table 4). At first glance, the level of inequality is abysmal, and the concentration is very high. In this study, 1% of the registered actors own 79.02% of the total volume of water available in the system, which in turn makes up only 4.3%

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of the existing water property rights. In other words, very high inequality and very high concentration of water resources.

Table 4. Study of the Gini Coefficient at the national level for the total and for the specific of superficial consumer rights. Source: Prepared by the authors.

Gini Coefficient for All Rights	
Total Rights	128.015
Total Owners	63.864
Flow rate (lts./sec.)	4.865.684.475
Gini Coefficient	0.999585
Gini Coefficient for Surface Consumer Rights	
Total Rights	55.853
Total Owners	29.001
Flow rate (lts./sec.)	3.369.691
Gini Coefficient	0.9537

The distribution of water rights in all regions of Chile has a very high inequality (Table 5), fluctuating between 0.8309 (Atacama Region) and 0.9721 (O'Higgins and Ñuble Regions). The most unequal areas correspond to the central sector of the country, where there is greater population and agricultural development, which is reflected in regions such as O'Higgins, Maule and Metropolitan, which although they have fewer water rights delivered (4,726 rights) equivalent to 10.6% of the national total, each right has in proportion more liters/second than the rest of the nation, equivalent to 42.9% of the national total. In other words, the highest consumption of liters/second occurs in the central valley, in areas with a high preponderance of agricultural activities that demand irrigation, such as vineyards, avocados, berries and fruits in general.

Surface water consumption rights					
Region	No rights	Sum of lt/sec	National Percentage Rights	National Percentage Lt/sec	Gini Index
Arica y Parinacota	336	16.944	0,8%	0,5%	0,8993
Tarapacá	285	30.596	0,6%	0,9%	0,9499
Antofagasta	446	11.554	1,0%	0,3%	0,8980
Atacama	212	11.672	0,5%	0,3%	0,8309
Coquimbo	695	58.671	1,6%	1,7%	0,9329
Valparaiso	2.213	173.222	4,9%	5,1%	0,9569
Metropolitan	1.562	385.058	3,5%	11,4%	0,9716
O'Higgins	1.213	515.841	2,7%	15,3%	0,9721
Maule	1.951	545.045	4,4%	16,2%	0,9598
Ñuble	2.312	127.003	5,2%	3,8%	0,9721
Bio Bio	3.888	315.563	8,7%	9,4%	0,9535
Araucanía	10.121	441.378	22,6%	13,1%	0,9152
De Los Rios	6.482	135.056	14,5%	4,0%	0,8671
De Los Lagos	7.693	218.361	17,2%	6,5%	0,9115
Aysen	4.346	229.828	9,7%	6,8%	0,9704
Magallanes	974	153.899	2,2%	4,6%	0,8993
Total country	**44.729**	**3.369.692**	**100,0%**	**100,0%**	**0,954**

4. Discussion

Speculation occurs when decisions are made about certain actions without enough evidence about what is believed to generate optimal results for everyone in the future. A speculative process results from the search for rewards with a strong element of chance. Certainly, speculation has no scientific basis since it is driven by belief rather than evidence. From this definition, in Chile, there is a process of speculation with water, given that its consumption would indicate that more water is consumed than is naturally regenerated. To illustrate this problem with an analogy, it is to consume the water believing that the glaciers will not run out. Without going any further, the mere fact that runoff is much lower than productive consumption generates a high concern, where the sustainability of the water resource is compromised in the future. Without regulatory mechanisms appropriate to the Chilean reality, the water market and its speculative characteristic is dangerous for the subsistence of Chile. This needs to be remedied through public policy and structural transformations to property management in Chile.

On the one hand, the World Bank proposes that water markets should be formalized and more transparent, which leads to significant price dispersion, unclear operating costs and significant information asymmetries among market participants. The latter could lead to the development of inequitable economic activities in relation to the exchange processes. Recently, the Organization for Economic Cooperation and Development (OECD) has proposed that Chile increase its tax collection by increasing (or creating) taxes on the exploitation of natural resources (such as water) in order to finance new social and infrastructure projects needed to advance development.

Several authors specify that the water market is more important in areas where the resource is scarcer [23-26]. However, this is in contradiction with much of the literature that raises critical views of water resource distribution. To understand the notions of the water market, then, we can conclude that water privatization is far from being a socially just way of distributing resources in a society that, in addition, presents high levels of inequality and segregation.

Author Contributions: Conceptualisation, Francisco Vergara-Perucich; methodology, Juan Correa-Parra; validation, Juan Correa-Parra, Carlos Aguirre-Nuñez and Francisco Vergara-Perucich; formal analysis, Juan Correa-Parra, Carlos Aguirre-Nuñez and Francisco Vergara-Perucich; investigation, Juan Correa-Parra; resources, Juan Correa-Parra; data curation, Juan Correa-Parra and Francisco Vergara-Perucich; writing—original draft preparation, Francisco Vergara-Perucich; writing—review and editing, Juan Correa-Parra, Carlos Aguirre-Nuñez and Francisco Vergara-Perucich; visualisation, Juan Correa-Parra; funding acquisition, Francisco Vergara-Perucich. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by ANID, grant number FONDECYT 11180569.

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

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