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# The Political Ecology of Water Governance and Migration in Chile

## La ecología política de la gobernanza hídrica y la migración en Chile

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Abstract

Rural communities in north-central Chile have faced decades-long conflicts over water resources. Although local socio-environmental dynamics have received considerable attention, the related mobility patterns remain underexplored. This study examines the relationship between drought conditions, water governance arrangements, and internal migration flows to and from the province of Petorca. A mixed-methods approach is employed, integrating long-term precipitation anomalies based on Standardised Precipitation Indices (1983-2019), census-based net migration data (1982-2017), and eight semi-structured interviews with local activists, policymakers, and water management experts. Quantitative findings indicate that intensified drought does not lead to increased out-migration; rather, a negative correlation exists between drought and net migration in the province. Interview data highlight the roles of systemic constraints and place attachment in shaping (im)mobility among rural communities, as well as the influx of external actors associated with agribusiness expansion. The study demonstrates how socio-environmental changes, power inequalities, and resource governance influence mobility outcomes in water-stressed regions.

*Las comunidades rurales del centro-norte de Chile enfrentan persistentes conflictos relacionados con el acceso y la gestión de los recursos hídricos. Aunque las dinámicas socioambientales locales han sido ampliamente estudiadas, los patrones de movilidad local siguen poco explorados. Este estudio examina la relación entre sequía, gobernanza hídrica y flujos migratorios en la provincia de Petorca. Utilizando un enfoque metodológico mixto, se combinan anomalías de precipitación a largo plazo según los Índices Estandarizados de Precipitación (1983-2019), datos censales de migración neta (1982-2017) y ocho entrevistas semiestructuradas con activistas locales, responsables de políticas públicas y expertos en gestión hídrica. Los resultados cuantitativos demuestran que existe una correlación negativa entre la sequía y la migración neta. Las entrevistas profundizan en cómo las limitaciones sistémicas, el apego al lugar y la llegada de nuevos actores ligados a la agroindustria inciden en la (im)movilidad local. El estudio destaca que los cambios socioambientales, las desigualdades de poder y la gobernanza hídrica son factores centrales en la movilidad dentro de regiones afectadas por el estrés hídrico.*

Environmental migration; rurality; political ecology; Chile; water governance

*Migración ambiental; ruralidad; ecología política; Chile; gobernanza hídrica*

Key words

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## 1. Introduction

Over the past two decades, extensive scholarship has documented the political economy of water governance, agribusiness expansion, and socio-environmental conflict in Chile (i.e., see Anríquez & Melo, 2018; Bolados García, 2016; Correa-Parra et al., 2020). However, less is known about how these processes shape internal migration and (im)mobility in water-stressed rural territories. While few studies have examined how institutional contexts, privatisation, and rural dispossession may influence decisions to stay, leave, move or return to affected areas (see Escribano Miralles & Piñeiro, 2017; and Wiegel, 2023), empirical accounts of environmental migration remain limited across the country.

This article addresses this gap by examining how drought conditions and water governance arrangements relate to migration patterns in the rural province of Petorca, in Chile's Valparaíso Region. Marked by prolonged drought, export-oriented agribusiness, and intense water conflicts, Petorca has become a focal point for debates and activism on equitable water governance, environmental justice, and rural livelihoods in Chile (Muñoz et al., 2020; Quiroz Sandivari, 2025). The study aims to identify whether and how water scarcity shapes (im)mobility and to examine how power-laden rural dynamics may influence migration under prolonged water stress.

To address this question, the study adopts a mixed-methods approach combining hydroclimatic indicators, census-based migration data, and interviews with local activists, policymakers, and experts. This design enables empirical evidence of how mobility and immobility manifest and are experienced, interpreted, and negotiated locally.

The analysis draws on the political ecology of migration (Radel et al., 2018), complemented by insights from socio-metabolism thinking (Foster, 1999; Roose & Panez, 2020) and hydro-social theory (Linton & Budds, 2014; Parsons & Chann, 2019). Together, these perspectives support examinations of how ecological stress, exacerbated by economic structures and unequal power relations, intersect and shape mobility outcomes in Petorca.

Moving beyond cause-effect narratives of environmental mobility, this article contributes to the field of political ecology of migration by investigating how hydroclimatic variability, local manifestations of power (Carr, 2005), and (im)mobility experiences intersect in rural Chile.

## 2. Context: The Development of Chilean Water Governance

### 2.1. The National Framework

Stretching for six thousand kilometres along the West coast of South America, squeezed between the ocean and the Andes, continental Chile presents unusual and highly diverse geography and climatic profiles. Its territory spans semi-arid regions in the north, Mediterranean in the centre, oceanic in the south, and mountain cold in the Cordillera. This configuration is also reflected in distinct political, economic, social, and ecological framework, especially regarding water governance.

Water availability in the country is a major topic of discussion and concern. While Chile ranks among Latin American countries with the highest access to safely managed drinking water (Correa-Parra et al., 2020), it has profoundly diverse water accessibility patterns. Per capita water availability ranges from 510 $m^3$/year in the desertic north to over 2 million $m^3$/year in the southern regions (Anríquez & Melo, 2018). The country is also highly vulnerable to climate variability, with frequent extreme hydrological events posing severe risks to agriculture and rural livelihoods (Garreaud et al., 2020; Muñoz et al., 2020). However, the geomorphological and geographical contexts are not the only factors in unequal water distribution and access in Chile.

Chile presents a unique water governance regime, rooted in neoliberal privatisation of water use. Water has historically played a strategic role in the national economy, both for domestic markets and exports (Bauer, 1997). While water-use rights have existed since the colonial period, they were formalised and expanded during the Pinochet dictatorship (1973-1990) through three landmark legal texts: the 1979 Decree Law 2,603, the 1980 Constitution, and the 1981 Water Code (Budds, 2004, 2013). These reforms detached water-use rights from land ownership, allowing them to be freely bought, sold, mortgaged, and traded. The legal framework prioritised market efficiency over water's fundamental role in sustaining life, generating enduring social, political, and environmental tensions (Guerrero Rojas & Fragkou, 2021; Ríos Brehm & Quiroz, 1995).

Water privatisation has been a widely contested initiative in Chile. Neoliberal economists viewed privatisation as having positive implications for the country, especially for national economic development (Harberger, 1993; Keech, 2004). It favoured the expansion of private initiatives across sectors such as mining, forestry, hydroelectric power generation, and agriculture, driving economic growth (OECD, 2021). However, from 1990s and throughout Chile's re-democratisation, inefficiencies associated with the adoption of the 1981 Water Code became increasingly evident (Engler et al., 2021). At the same time, several *Free Trade Agreements* (FTAs) promoting agricultural export (Carter & Barham, 1996) intensified pressures on water resources, contributing to the proliferation of small and medium-scale conflicts for water access and use (Bolados García, 2016; Roose & Panez, 2020).

This economic model further weakened already disadvantaged small farmers in rural areas. Water-use rights serve as an indirect mechanism to ensure land tenure and productivity. Reduced access to these titles meant shrinking economic and political power. This impacted people's income, increasing propensity to indebtedness or land sales, and limited their ability to defend their interests in water disputes (Bauer, 1998). Over time, this dynamic contributed to an oligopolistic system of water use dominated by large agribusiness owners, fur-

ther restricting access for small farmers and local populations. These processes intensified tensions between rural communities, political administrators, and private companies nationwide (Fragkou et al., 2022; Panez Pinto et al., 2017).

The 1980 Constitution and the 1981 Water Code remain in force today and continue to define the Chilean development model by regulating water access, use, trade, and management (Budds & O'Reilly, 2023). The contemporary application of this legislation has been particularly consequential for agricultural production and the dynamics among the actors involved in this sector, including rural communities, small landowners, farmers, and water users' association (Suárez Delucchi, 2024), as well as big agribusinesses and supply chains at a national and international level (Madariaga et al., 2021). Representing one of the country's economic engines, today's rural agricultural practices reflect the long shadow of neoliberalism in contemporary Chile.

Due to Chile's unique geomorphological configuration, the way water privatisation policies impacted the population and territories is not uniform across the country. Especially in areas with low population density and high degrees of resource extractivism, communities are experiencing a cumulative impact of increased temperatures, poor rainfall regimes, resources overexploitation, and a tense socio-cultural context (Garreaud et al., 2020, 2025). The situation is becoming increasingly alarming due to the severity of conflicts unravelling in these areas. Within these contexts, patterns of mobility have begun to attract scholarly and policy attention (Escribano Miralles & Piñeiro, 2017). Although available evidence remains limited, existing studies suggest that the deep intertwining between socio-economic, political, environmental, as well as personal and household level determinants contributes to mobility dynamics in rural Chile (Wiegel, 2023).

## 2.2. The Province of Petorca

The province of Petorca, located in the Valparaíso Region, is a notable example of the convergence of water scarcity and socio-environmental conflicts in rural Chile. Over the last few decades, the territory has undergone intense socio-economic and environmental transformations, leading to a reconfiguration of its demographic, social, and economic structures (Roose, 2020).

The province's hydrology is defined by two main watersheds: La Ligua (1980 $km^2$) and Petorca (1986 $km^2$) rivers. Both rivers have similar physical-geographical characteristics, originate in the Andes, and flow into the Pacific Ocean. Unlike upper Andean rivers, their flow depends on seasonal precipitation. This is unique if compared to most Chilean watersheds, which get about 70% of their water from thawing (Panez Pinto et al., 2017). This trait increases the vulnerability of the basins in terms of ground and surface water availability (Duran-Llacer et al., 2020).

Petorca is the province of the Valparaíso Region with the highest rurality (INE, 2021). Traditional rural activities, such as *haciendas*, small-scale mining, and artisanal textile production, have largely been replaced since the 1990s by fruit-export agribusinesses. This economic shift coincided with Chile's agrarian reform under Frei Montalva (1967) and Allende (1970-73), followed by Pinochet's privatisation of land and water under the 1981 Water Code, which decoupled water rights from land ownership and facilitated the rise of commercial agriculture (Budds, 2004; Gwynne & Meneses, 1994).

Over the decades, intensive agriculture, especially avocado and citrus cultivation, became major economic activities in the province (Madariaga et al., 2021). The province's attractiveness can be explained by new advancement in irrigation technologies such as wells drilling, and the availability of unused, rain-fed land on the slopes of the valleys with optimal climate for fruit cultivation. Supported by microcredit, government subsidies, and increased allocation of surface and groundwater, the valleys of Petorca and La Ligua soon became vastly populated by these crops (Ibid.).

Fruit plantations require irrigation year-round (Madariaga et al., 2021). Given that these valleys are prone to seasonal declines in water availability, fruit production led to increased allocation of groundwater-use rights and extraction from acquifers (Duran-Llacer et al., 2020; Sommaruga & Eldridge, 2021). Since 1994, the General Water Directorate (DGA)—the agency that oversees the allocation of water rights—has registered a large increase in the applications for new water-use rights, exceeding the availability of water resources. Between the second half of the 1990s and the first half of the 2000s, both Petorca and La Ligua were declared "restriction areas" (in 1996 and 2004, respectively), halting the granting of new permanent water rights in these basins. New rights were processed and added to a waiting list, awaiting allocation when hydrological models' estimation for water availability in the watersheds allowed it.

Since 2004, the socio-environmental situation in the province of Petorca drastically declined. In the last fifteen years, an anomalously long drying event, the so-called central Chilean megadrought (MD) began raising concerns among the government, experts, local population, and investors. The MD (2010-present) is the driest recorded period in the last 700 years, severely affecting local water supply (Muñoz et al., 2020; Garreaud et al., 2025). The convergence of reduced precipitation and unsustainable water extraction, particularly for intensive agriculture, has created a deep socio-environmental crisis.

The socio-economic impacts of water scarcity are evident at a local level, especially in the agricultural labour market. Reduced water availability forced small farmers to cut crop areas, decreasing employment and pushing residents to look for job opportunities in other, more affluent industries in coastal areas and larger cities (Panez Pinto et al., 2017). While local inhabitants and small farmers face environmental and economic marginalisation, agribusinesses with sufficient resources maintain production, creating an economic imbalance where those with economic power maintain control land and water (Baland & Robinson, 2008; Muñoz et al., 2020). The intense socio-environmental changes and overall decline quality of life in recent decades may influence local migration trends (Fragkou et al., 2022; Wiegel, 2023).

The case of Petorca is particularly prominent in academia and public discourse. The sharp decline in water availability, combined with economic pressures, environmental stress, and community resistance, has been highlighted by nearly two decades of local and national engagement in struggles to protect of the right to water (Instituto Nacional de Derechos Humanos, 2020). Over time, this created an impasse between institutional action and community resistance. Chilean institutions perpetuated discourses on "meteorological drought," *de facto* silencing broader socio-economic factors and often downplaying state and corporate responsibility, favouring short-term mitigation strategies like emergency water provision and limited interventions on the hydraulic infrastructure (Fragkou et al., 2022; Guerrero Rojas & Fragkou, 2021; Panez Pinto et al., 2017).

In contrast, local organisations in Petorca played a central role in catalysing a nationwide movement advocating for water as a human right, most notably the *Movement for Defence of*

*the Water Access, Land, and Environment Protection* (MODATIMA). These mobilisations, together with broader socio-environmental movements, contributed to debates that culminated in the 2022 constitutional referendum proposing a redefinition of Chile's development and water governance model (Paz Acevedo, 2024). Although this proposal was ultimately rejected, the conversations leading up to it created a fertile ground for a renewed convergence of interests for imagining alternatives to the current neoliberal model (Budds & O'Reilly, 2023).

Within this context, the province of Petorca provides a critical empirical setting for examining how prolonged water scarcity and contested governance arrangements shape everyday livelihoods and mobility decisions, making it particularly relevant for analysing patterns of migration and immobility under conditions of sustained water struggles.

## 3. Theoretical Framework: For a Political Ecology of Migration in Water Stressed Territories

Over the past four decades, research on environmental migration has moved away from deterministic interpretations that framed environmental change as a direct cause of displacement, towards approaches that conceptualise migration as a multi-causal and socially mediated process (Khavarian-Garmsir et al., 2023). Early formulations treated environmental degradation as an external shock producing migration as a largely uniform outcome, isolating environmental factors from individual, socio-economic and political drivers (El-Hinnawi, 1985).

Recent scholarship has challenged this view, showing that migration decisions rarely respond solely to environmental stress, particularly for slow-onset events such as drought. Instead, environmental pressures are understood to interact with and compound the impacts of water governance arrangements, power relations, household structures, and individual agency, producing varied patterns of mobility and immobility (Abel et al., 2019; Adger et al., 2020; McLeman, 2017). Following this line of inquiry, this study adopts a relational understanding of migration, reading it as a process embedded in historical and contemporary, structural and contextual power relations.

To identify which factors contribute to mobility outcomes and how, this study draws on political ecology as its primary theoretical framework. Political ecology foregrounds how socio-environmental relations are shaped by power and institutions, and how access to resources is unevenly distributed across social groups (Benjaminsen & Svarstad, 2021; Robbins, 2012). Within this field, emerging debates on the political ecology of migration recently started to approach human mobility as a key component of power relations and institutional histories. According to this reading, some actors are able to mobilise resources to relocate or adapt, while others experience constrained or forced immobility due to dispossession, loss of livelihoods, or political marginalisation (Carr, 2005; Radel et al., 2018). This perspective is relevant for the present study as it shifts the focus away from biophysical scarcity alone to the institutional and local-scale arrangements that determine who can move, who must stay, and under what conditions.

To account for the material dimensions of the constraints identified through a political ecology lens, the analysis draws on socio-metabolic perspectives (Roose & Panez, 2020). Rooted in Marxist thought and developed by Alfred Schmidt (1962), socio-metabolism directs attention to the material exchanges between society and nature. It examines flows of energy and matter and guides analysis towards ruptures or *socio-metabolic rifts* created by extractive mod-

els of capitalist production (Foster, 1999; Napoletano et al., 2018). In water-stressed agrarian contexts such as rural central Chile, ruptures can appear as restructured land tenure systems, intensified water extractivism for commercial use, and redefined labour regimes. These transformations directly affect livelihoods and shape the material conditions that enable or limit migration decisions, linking macro-level political-economic processes to household-level experiences of scarcity and precarity (Seow, 2018).

Hydro-social theory further refines this framework, centring water governance as a key mediator of mobility and immobility. Hydro-social theory conceptualises water as a co-produced socio-material resource rather than a purely natural one (Linton & Budds, 2014; Wesselink et al., 2017). From this perspective, scarcity is not only the result of hydrometeorological conditions but is produced through governance regimes, water privatisation systems, and extraction practices. This allows us to trace how these processes reconfigure who can access water and thereby who can remain, leave, or gain access to resources in a territory. In this sense, migration in water-stressed regions is not simply a reaction to scarcity; it becomes a constituent component of hydro-social systems, contributing to material flows. As such, migration can redistribute access to water, transform local water management practices, and reproduce or challenge existing inequalities (Parsons & Chann, 2019).

These perspectives provide a focused framework for analysing migration under conditions of scarcity, enabling it to be examined as an integral component of territorial socio-environmental relations rather than a deterministic outcome of prolonged stress.

## 4. Methodology: Mixed methods to study complexity

Given the multi-scalar nature of local water conflicts and the limited empirical attention to mobility patterns in Petorca, this study employs a mixed-methods design to capture both long-term structural patterns and locally situated experiences of migration and immobility. This article integrates hydroclimatic and demographic trends with the experiences and perceptions of activists, experts, and policymakers in the province of Petorca (Kasirye, 2021; Mik-Meyer, 2020). Statistical descriptions and correlation analysis of environmental stress and migratory trends identified patterns of relation, while semi-structured interviews revealed contested meanings of local water governance structures, social hierarchies, histories of migration, and decision-making processes. Together, these methods allowed the investigation of migration as a complex process of ongoing negotiations embedded within local socio-ecological systems.

### 4.1. Quantitative data and analysis

To characterise long-term drought conditions and their temporal relationship with internal migration, the quantitative analysis draws on hydroclimatic and demographic data at a province-wide scale. Hydroclimatic data were retrieved from the open-access Catchment Attributes and MEteorology for Large-sample Studies dataset (CAMELS-CL; Alvarez-Garreton et al., 2018). Three precipitation products (CR2MET, CHIRPS, MSWEP) were selected to account for methodological differences between gauge-based and satellite-derived estimates. Analysis focused on data from four catchments located within the Petorca and La Ligua watersheds (two catchments per watershed), covering 1983-2019.

Annual mean precipitation values were calculated for each catchment and transformed into five-year rolling Standardised Precipitation Indices (SPI) to characterise long-term meteorological drought. SPIs enable comparison across catchments and precipitation products by normalising precipitation anomalies relative to historical conditions, capturing trends in drought persistence and intensity.

Demographic data on internal migration were drawn from the national population censuses conducted by the National Institute of Statistics (INE) in 1982, 1992, 2002, and 2017. These censuses constitute the most comprehensive and consistent source of internal migration data available in Chile (Harnecker & Mallea, 2023; Rowe et al., 2017). Net migration rates were calculated at municipal and provincial scales.

Descriptive statistics summarised long-term trends in SPI values and migration balances. Bivariate correlation analysis (Pearson's *r*) explored associations between precipitation anomalies and net migration over time. Given the limited number of temporal observations and the coarse spatial resolution of census data, correlation results are interpreted cautiously and used as indicative patterns rather than causal evidence.

While the quantitative analysis identifies broad temporal patterns between drought and migration, it does not capture how these dynamics are experienced, interpreted, or negotiated at the local level. This limitation motivates a complementary qualitative approach.

## 4.2. Qualitative Data Collection and Analysis

Building on quantitative analysis, the qualitative component was designed to examine how water scarcity, governance arrangements, and mobility processes are experienced and interpreted by actors directly engaged with water-related conflicts in the province of Petorca.

Eight semi-structured interviews were conducted between December 2022 and March 2023. The sample included policy-related actors (n=2), activists (n=2), and experts, researchers and technical actors (n=4). For analytical purposes, participants were categorised by their primary area of engagement (current role) at the time of the interview (e.g. activist, policymaker, expert). Several participants occupied overlapping roles. Table 1 summarises the primary and secondary areas of engagement of the interview participants, reflecting the multiple roles they occupy within water governance in the province.

**Table 1. Participants areas of engagement**

| Participant ID | Primary area of engagement | Secondary area(s) of engagement |
|---|---|---|
| Participant 1 | Policymaker (public administration) | Water governance; just transition advocacy |
| Participant 2 | Policymaker (water management) | Human and water rights advocacy; environmental activism |
| Participant 3 | Environmental activist | Academic research (sociology) |
| Participant 4 | Academic expert (human geography) | Agrarian development; environmental activism |
| Participant 5 | Academic expert (migration studies) | Community engagement for rural livelihoods |

| Participant ID | Primary area of engagement | Secondary area(s) of engagement |
|---|---|---|
| Participant 6 | Technical expert (water engineering in APRs) | Agroecological practices; environmental activism |
| Participant 7 | Environmental activist | Environmental education |
| Participant 8 | Technical expert (water management) | Environmental activism; human rights advocacy |

Participants were selected based on their direct involvement in water-related governance, activism, policymaking, research, or community management in the province. Recruitment used professional networks and referral sampling, focusing on individuals with sustained engagement in water-related issues. The qualitative sample prioritised analytical relevance and diversity of perspectives. Although the sample size was limited by remote interviews, thematic saturation was reached for core issues, including water governance arrangements, experiences of drought, and dynamics of mobility and immobility in the province.

Interviews were conducted online in Spanish or English, lasted 40 to 70 minutes, and followed a flexible guide addressing perceptions of water scarcity, governance arrangements, experiences of mobility and immobility, and coping or resistance strategies. All participants received information about the study's aims and provided informed consent before participation.

Interviews were recorded via audio recording or note-taking, transcribed *verbatim* and analysed using NVivo 14. Thematic analysis was employed. Coding proceeded in two stages: first, open coding to identify recurring concepts and narratives; second, axial coding to organise codes into broader analytical categories related to governance, material constraints, and mobility outcomes. Analytical categories were developed iteratively through engagement with the data and the research questions, allowing qualitative findings to inform the interpretation of quantitative patterns.

## 4.3. Integration of Quantitative and Qualitative Evidence

Understanding mobility under conditions of environmental stress requires analytical approaches that capture both structural patterns and the processes through which these patterns are produced and experienced (Kasirye, 2021). In this study, quantitative indicators of drought and migration provide a cross-temporal account of mobility and local environmental dynamics. These data alone cannot explain whether and how similar environmental conditions produce divergent mobility outcomes. Qualitative accounts offered insight into meanings, constraints, and decision-making processes. Data from interviews may limit the ability to situate these experiences within longer-term temporal and spatial trends. Integrating quantitative and qualitative components does not establish causal attribution, but interrogate the modes and conditions under which environmental stress translates into mobility or immobility in the selected case study (Carling, 2024).

Integration of quantitative and qualitative components occurred at several stages of the research process. Initially, quantitative analysis guided the design and refinement of the qualitative inquiry by identifying periods and contexts where correlations between drought and migration were weak, absent, or counterintuitive. Integration was then implemented during the analysis of quantitative trends and qualitative narratives. Quantitative results established a

temporal and spatial baseline of drought intensity and net migration patterns, while interview material was analysed to assess convergence and divergence with these trends.

Divergences between quantitative and qualitative findings were analysed through iterative comparison to identify institutional, material, and social factors not captured by precipitation indices or census data. When findings converged, qualitative evidence supported the interpretation of quantitative patterns, such as increased mobility toward the province as selective in-migration. When findings diverged, interviews clarified the limitations of correlation-based analysis by providing details on the direction, duration, and character of migration experiences. This integrative strategy enhances analytical depth while maintaining transparency about the distinct contributions and limitations of each data source.

## 4.4. Ethics and reflexivity

Given Petorca's prominence as a heavily investigated case study in academic scholarship and media coverage, the research was undertaken with heightened attention to the ethics of conducting work in potentially over-researched communities and territories (Kelly, 2021). This involved prioritising participant well-being, avoiding duplication of prior interviews, and minimising burden on local actors. Identifying details were anonymised to protect privacy.

## 4.5. Methodological Limitations

As with much research on environmental migration that combines climatic indicators, demographic data, and qualitative inquiry, this mixed-methods design involves trade-offs among coverage, resolution, and interpretive depth (Kasirye, 2021; Mik-Meyer, 2020). The environmental analysis relies on precipitation-based Standardised Precipitation Indices, which are widely used to characterise meteorological drought but do not capture groundwater depletion, extraction pressures, or governance-mediated scarcity central to hydro-social dynamics (Alvarez-Garreton et al., 2018; Linton & Budds, 2014). Likewise, census-based migration data are the most consistent longitudinal source in Chile, yet their decadal periodicity limits observation of short-term, circular, or informal mobility and provides limited information on the socio-demographic characteristics of movers (Rowe et al., 2017; Harnecker & Mallea, 2023).

The qualitative component is based on a purposive, ta sample of actors engaged in water governance, activism, and technical expertise. This approach aligns with qualitative designs that prioritise analytical relevance over representativeness in highly politicised and extensively researched contexts (Kelly, 2021; Mik-Meyer, 2020). However, the underrepresentation of other experiences, such as those of seasonal agricultural workers, small-scale farmers with limited organisational ties, or younger migrants, is acknowledged. The use of online interviews also limited the researcher's ability to build rapport and make place-based observations.

Differences in temporal resolution and spatial scale between precipitation indices, census data, and interview narratives constrain the degree of formal integration between quantitative and qualitative components, a challenge frequently noted in mixed-methods research on complex socio-environmental processes (Kasirye, 2021). Observed divergences—such as cases where intensified drought corresponds with reduced out-migration—therefore require interpretative rather than statistical reconciliation. Although triangulation strengthens analytical robustness, causal inference remains limited.

Acknowledging these constraints, the study offers a transparent and analytically grounded account of mobility dynamics in a water-stressed territory. The findings reflect the specific hydro-institutional context of the province of Petorca and are not statistically generalisable. However, they provide analytical insights into how environmental stress, governance arrangements, and material inequalities shape mobility and immobility in a water-scarce context. Raw quantitative outputs and thematic coding summaries are provided as Supplementary Information (SI) to support transparency and reproducibility.

## 5. Results: The Local Ecology of Power—Scarcity, Asymmetries, and Migration

The assessment of migration dynamics in areas of severe scarcity, privatisation regimes and prolonged socio-environmental conflict required a mixed-methods approach able to account for the complexity of the dynamics at play. This section presents the results of this approach, organised as follows: the first section (5.1) reports the results of correlation analysis between long-term precipitation anomalies and net migration trends; the second section (5.2) presents the results of thematic analysis of interview data, documenting participants' elaboration of socio-environmental, economic, and political drivers to (im)mobility from and towards the province.

### 5.1. Drought-Migration Correlation Analysis

Quantitative results on precipitation anomalies and net migration in the province of Petorca set a baseline for contextualising accounts of (im)mobility. Precipitation data (CR2MET, CHIRPS, MSWEP, derived from CAMEL-CL) for four catchments in the Petorca and La Ligua watersheds were aggregated to annual means (1983-2019) and expressed as five-year rolling Standardised Precipitation Indices (SPIs). Migration data derive from national censuses (INE, 1982-2017).

Across all products, SPIs indicate an increase in the frequency and persistence of multi-year dry spells since the 1980s, with a marked intensification after 2008 (see figures S1-S3 in SI). Product differences affect the timing and peak severity identified in the catchments, but the broad pattern of prolonged dry conditions is consistent across datasets. Provincial net migration remained negative across censuses (more people left than arrived), although municipalities such as the coastal areas of Papudo and, more recently, Zapallar—subject to leisure tourism and intensified construction works—registered positive in-migration.

Correlation analysis between SPI values and net outgoing migration produced mixed patterns. In figure 5, the Pearson correlation coefficient between net migration at a provincial level and the three SPIs in the four catchments considered is presented.

CR2MET-based SPI values show negative correlations in the La Ligua river basin (Rio La Ligua 1, r = -0,99; Rio La Ligua 2, r = -0,97). In La Ligua watershed, correlation coefficients present overall consistent values for all the three precipitation products from which SPIs have been calculated. Correlation coefficients are negative across precipitation products in this watershed. Conversely, in the Petorca river basin the drying trend sees little to no correlation in its upper part (Rio Petorca 1, r = -0,08), while an almost perfect correlation in the lower area

(Rio Petorca 2, r = 0,8). Despite the high positive correlation coefficient, the p-value referred to the catchment Rio Petorca 2 indicate that this correlation is not statistically significant.

**Figure 1. Correlation analysis between net migration and SPIs for the three considered precipitation products**

| | Rio Petorca 1 | Rio Petorca 2 | Rio La Ligua 1 | Rio La Ligua 2 |
|---|---|---|---|---|
| **CR2MET** | -0.080759 (0.92) | 0,82865 (0.172) | -0,99052** (0.01) | -0,96737** (0.033) |
| **CHIRPS** | -0.53601 (0.464) | -0,51959 (0.481) | -0,61362 (0.387) | -0,61216 (0.338) |
| **MSWEP** | -0,97461** (0.026) | -0,98538** (0.015) | -0,9978*** (0.003) | -0,955** (0.045) |

The Pearson correlation coefficient r indicates: a positive correlation when 1>r>0; no correlation when r=0; a negative correlation when 0>r>-1. Values of r equal to 1 and -1 indicate respectively a perfect positive correlation and a perfect negative correlation. Personal elaboration based on SPI values and net migration data (author's elaboration based on INE 1982, 1992, 2002, 2017) through Excel correlation analysis tool. P-values are in parenthesis. ***p<.01, **p<.05, *p<.1

Correlation coefficient for the two satellite-based precipitation products shows a consistent negative relation throughout the four catchments between SPIs and net outgoing migration. CHIRPS-derived SPIs showed moderate negative correlations in all catchments (-0,52>r>-0,61), while MSWEP-derived SPIs recorded strong, stable negative correlation that remain stable throughout the four catchments (r ≈ -0.97).

Quantitative evidence shows a province-wide intensification of drought conditions over the past four decades, with multi-year dry spells increasingly frequent and persistent. Migration patterns remain dominated by net population loss, though with localised exceptions such as Papudo and Zapallar. Correlation analysis indicates that in three catchments out of four, severe drought correlates with lower rates of outmigration. These results are reported alongside qualitative findings presented below.

## 5.2. (Im)mobility, Water Governance, and Power in Petorca

Interviewees discussed migration and immobility in Petorca through the factors shaping everyday life and community dynamics in the province. Three themes structure the qualitative materials: (i) factors compounding vulnerability to scarcity and migration pressures; (ii) selective migration under a regime of "paltocracía;" and (iii) patterns of immobility and return migration.

### 5.2.1. Compounded vulnerability to scarcity and migration pressures

In line with quantitative results, participants consistently described water scarcity in Petorca as extending beyond meteorological drought and contextualised their experiences within the institutional arrangement of water governance in the province.

Participants highlighted a perceived disconnect between the recognition of climate change impacts and institutional responses to water scarcity, with several interviewees described water privatisation as limiting local access and collective decision-making over water use. One local activist pointed to what they described as a dual dynamic, whereby drought is acknowledged as part of global climate change but also resulting from privatised resources management and inaction of political and institutional actors, viewed as failing to protect local water cycles and

community water needs (Participant 3, January 2023). Likewise, an officer of the Ministry of Energy argued that in the country the water issues is not new and that "one of the main causes related to this lack of water or going down in the water availability [levels] is related to an incorrect management from our institutions" (Participant 1, December 2022). Congruently, a local policymaker and activist observed how "the ownership of the water stops democratic solutions from being possible because the water has owners. So, [to change things] you should expropriate it or pay compensation, and so on. Water property does not allow water democracy" (Participant 2, January 2023).

Water access constraints for local communities were at the centre of participants' responses. In several accounts, the physical uncertainty of underground reserves intensified structural inequalities in access to water (i.e., Participant 2, January 2023). Participants noted that landowners had no use rights to access surface waters nor technical knowledge to know whether their land presented underground reservoirs to use, *de facto* restraining their ability to use local water resources (Ibid.).

Likewise, reliance on emergency water delivery was repeatedly problematised by participants. As explained by Participant 6, in Petorca there are 25 Rural Drinking Water committees (Agua Potable Rural, APRs). These organisations, granting water access for domestic consumption to local communities, were identified during interviews as "the most vulnerable" to water scarcity and increasingly dependent on emergency water provision (e.g., Participants 3, 4, and 6). A local activist for water rights explained that APRs had historically relied on direct access to springs and wells for domestic and agricultural water use, however "once the springs dried up, [the APRs] were forced to ask [support for water supplies] to the municipality, and the municipality stepped in through ONEMI—which is like the government's emergency system under the Ministry of the Interior" (Participant 3, January 2023). Currently, 11 out of 25 APRs rely on deliveries from emergency water trucks to grant access to drinkable water for the local population (Ibid.).

Participants linked difficulties in securing safe and reliable water infrastructure to public investment criteria. Explained in the words of a policymaker,

> this suffering from drought and lack of water intersects with the inequality caused by the Water Code and the Constitution. But it's also like these areas are left behind because the state doesn't take care of them or invest in them, since they're considered behind due to the small rural population. Petorca is the largest municipality in the Valparaíso region, and it has a significant population dispersion. Projects end up being more expensive, and because one lives out there, you don't have water, since the state won't guarantee your human right to water. (Participant 1, December 2022)

A second participant further illustrated the "inefficiency" of the current emergency approach, underlining how "the Ministry of the Interior spends around seven or ten billion pesos a year to supply the province of Petorca [with water]. With that same money, we could have built proper, safe, high-quality systems for secure water capture" (Participant 3, January 2023).

Several participants described this politically and institutionally produced water scarcity as exerting cumulative pressures on daily life over time. One interviewee illustrated how decisions over water use affected the local population, arguing that

> [O]nly water rights holders have the exclusivity to decide what is done with water when we all need water. Then it is undemocratic and derives from privatization rather than

> from the decisions of water users' organizations and canal associations. Decisions are made based on property, not on the needs of the land, of food, of health. The effects are suicides, depression, migration, right? A kind of grief. Why? Because you don't have water to irrigate, you don't have water to survive, you don't have water for human consumption—and in the end, the decisions are made by the big landowners. (Participant 2, January 2023)

The repercussions of a decade-long emergency approach to the crisis of the local hydrological system were embedded in participants' narratives of loss and migration. Emotional distress, social disintegration, and mental health impacts associated with the loss of water for irrigation and consumption were frequently addressed as feelings widely experienced in the community (Participant 3, January 2023; Participant 6, March 2023). In line with this, when Participant 5 was asked to revisit personal experiences and conversations in the rural villages of the province, it was also recalled that

> [...] people said, "my neighbours are going away because the water was not enough," or "my cousins have goats, but they can't be all the year here because there's no water. Because of that all the mountains are without flowers or grass that the goats can eat so maybe they went to the south." It is like [...] all the families now talk about it, and it is like "I know this, I know that. I know that person." It is happening a lot. Something is happening after all these ten years and many more of drought. (Participant 5, February 2023)

Several interviewees linked water scarcity to constrained employment opportunities in accounts of migration from Petorca. For example, participant 1 identified trends of labour mobility towards other areas of the country. In their account, people in rural areas "are seeing climate migration in this sense. Particularly related to water, of course it is a problem. [People in Petorca] are moving to other areas because they do not have water for consumption nor for their [livelihoods]" (Participant 1, December 2022). Employment loss was described in relation to reduced water availability in the province, linking it to indebtedness and internal migration patterns motivated by job opportunities in the construction and hospitality sectors of areas of touristic interests, such as the coastal areas of the province and more affluent areas of the country (Participant 4, February 2023).

Finally, perception of what life could look like elsewhere also appeared as a factor shaping mobility decisions. According to Participant 6, especially among the younger generations in Petorca, "there is a prevailing cultural perception that life outside the countryside is far better than rural life," contributing to aspiration of mobility towards larger urban centres for both study and work-related opportunities (March 2023).

### 5.2.2. Selective migration under a regime of "paltocracía"

Contributing to the accounts of vulnerability and departure, several interviewees noted how a trend that is frequently unspoken is that of selective in-migration to areas of the province associated with export-oriented agriculture. In these accounts, interviewees linked land acquisition processes to perceived declines in land value and to pressures to relocate, describing a sequence in which residents are left with no other option than to leave their land and new owners move in to benefit of the newly available resources (Participants 2 and 3, January 2023).

All participants formulated explicit arguments on the impacts of state-sponsored agribusiness for export in compounding the water crisis in Petorca. For instance, it was observed that "[Valparaíso is] the region with the highest number of environmental conflicts in the whole country. We're facing the mega-drought, the lack of water availability, but also the business side of water" (Participant 2, January 2023). Likewise, several participants refrained from the narrative of changing climate as the only driver of scarcity in the province, offering an invitation to see scarcity as produced also through political decision making and economic strategies (Participant 4, February 2023). The complex interplay of contributing factors was frequently at the centre of interviews, with a strong focus on the role of industries and governmental agencies, as addressed above.

Avocado production and its impacts on local small-scale agriculture were prominently featured in conversations over water struggles in Petorca. These accounts describe perceived economic barriers to changing land- and water-use practices under conditions of scarcity. Participants discussed at large the sustained profitability of pursuing avocado monocrops for export given the favourable climate and soil conditions, including the lack of local pests, as well as state incentives (Participant 6, March 2023). In parallel, interviewees highlighted the hardships local farmers faced in creating and maintaining alternatives to this plantation-like mode of production (Participants 2 and 3, January 2023). For example, according to Participant 6, attempts to transitioning to an agroecological practice were perceived as unviable, "because, for the market, it is not profitable" (March 2023).

> This dynamic was framed through the concept of *paltocracía*, a neologism proposed by a local policy maker and activist, combining the words *palta* (avocado) and *democracy* (Participant 2, January 2023). The term was used in the interview to denote the quasi-oligarchic control over land and water by the small ground of big agribusiness owners and holders of water use right. The interviewee described this arrangement as one in which "those who own the land also own the water or want to grab the water-use rights. They make all the decisions, and they don't make them based on what people actually need" (Participant 2, January 2023).

During data collection, it was discussed also how such a system was made viable through limited state oversight and regulation enforcement for what concerned intensive agricultural practices. For example, it was noted that "the state is not able to control how many avocado trees are being planted around and how many are drying up the aquifers even more" (Participant 3, January 2023), creating a fertile ground for a regime of *paltocracía* to deeply root in the territory. Furthermore, some participants framed the local impacts of agribusiness in terms of human rights violation and injustice, explicitly attributing responsibility to industries and state actors for inequitable access to resources and its human costs (Participant 8, March 2023).

Access to water was repeatedly described as closely connected to unjust land tenure security distribution and constrained possibilities of livelihood continuity. Interviewees also referred to situations in which the competition for, restriction or loss of water use rights was perceived as undermining the capacity to retain land, translating into land devaluation and loss and shaping who could arrive and remain, and who was compelled to leave. As one participant indicated,

> There's a lot of land that is losing value because there is no water. When people lose their livelihood, they must go out to look for work elsewhere and often they lose their lands for auction. It's like losing their land for not paying contributions. Because *there is* water

> available, but there is a great inequality in access to water. If they take your water, they take away your land. And I feel like that's forced migration, not land abandonment. (Participant 2, January 2023)

Regardless of outwards trends of mobility of local inhabitants, the population in some parts of the province of Petorca continues to grow, as indicated both by official statistics and interviewees. Participant 3 identified that in the time period between 2021 and 2023,

> In the municipality of La Ligua, [trends of migration of external actors have been] very severe. Today, 38,000 people are residing in the area. Before this demographic explosion, there were 30,000 inhabitants in the entire area of the municipality. [...] Of course, many of these people have no connection to this place, like for example having family members or a social network here. (January 2023)

The same participant explained this trend through illegal land allotments (loteos brujos). This practice involves land units subdivided below the minimum legal standard, sold for cheap to external actors, and used by the latter to drill wells to extract and sell water, further depleting aquifers. In this sense, allocating land that local inhabitants could not cultivate or live on anymore contributed to produce an even more severe abuse of water commodification, severely straining local communities (Participant 3, January 2023).

### 5.2.3. Patterns of immobility and return migration

Interviewees described migration in Petorca as a gradual and uneven process, involving pressured departures, new arrivals, but also a strong attachment to place contributing to both people staying and returning to their lands.

Beside constrained material conditions, emotional attachment to land, family histories, and community ties repeatedly emerged as a strong driver for people's decisions to stay. As one participant explained, "I see so many people holding on to their land even though they no longer have any water, because there's a family heritage at stake" (Participant 2, January 2023).

The resistance to leaving rural areas despite deteriorating conditions represented a reoccurring node of analysis of mobility dynamics in Petorca. According to Participant 4, water scarcity and related conflicts affected the territory in economic terms, but also socially, demographically, and politically, playing a role in the process of deciding whether to stay or leave. Regardless of difficult and deteriorating conditions to make a living, "it is not easy to leave the land that you have grown on. You have this emotional attachment to the place" (Participant 4, February 2023).

Connection to the territory of origin and its community was read as a driver for return mobility trends. As Participant 6 observed, "lately, I've also met people who moved back to the countryside, who are the ones who have migrated [in the past]" (March 2023). Interviewees reported instances of people returning to the province of Petorca, particularly among younger individuals who had previously migrated in search of education or employment opportunities in larger urban centres (Participant 3, January 2023). These experiences were described as limited in scale but recurrent enough to be recognised by participants as part of local mobility dynamics. According to Participant 6, return migration was also often associated with

engagement in agroecological practices, participation in community initiatives, and involvement in local activism related to water access and environmental issues.

## 6. Discussion: Asymmetric Mobilities in the Province of Petorca

The case of Petorca demonstrates that human mobility is shaped by more than just climate, with policy, economic, and socio-environmental factors combining to create uneven mobility patterns. Earlier studies addressed hydroclimatic stress, water commodification, and institutional responses for water access in the province (Muñoz et al., 2020; Panez Pinto et al., 2017) but paid less attention to migration dynamics. This paper extends previous research by examining how these factors influence local migration trends. In doing so, it shows that analysing mobility can provide a more nuanced understanding of the impacts of unequal water distribution in rural Chile.

This study finds that (im)mobility dynamics in Petorca are influenced by the same factors driving water scarcity. The migration-water relationship is primarily shaped by the effects of neoliberal governance and its shortcomings, rather than by climate alone. A hydro-social perspective is essential to understand how water availability, accessibility, and quality influence policymaking, the economy, and socio-cultural outcomes, including migration.

Migration under scarcity is closely tied to water privatisation, which alters local labour markets and relationships with the territory. As Wiegel (2023) observed in Chilean *Norte Chico*, these arrangements do not cause immediate displacement but create cumulative pressures that gradually change perceptions of opportunity and reduce people's ability to stay or leave. Experiences of loss can strengthen attachment to place, encouraging continued presence and engagement. These experiences also shape collective responses to emotional and existential concerns, encouraging local sense-making of environmental degradation, displacement, and dispossession (cf. literature on solastalgia, e.g., Askland & Bunn, 2018; Rafa et al., 2025). For example, some individuals return to the areas where they grew up. Although limited in scale, return migration, especially among young adults, was described as able to bring new resources and skills for community revitalisation, capacity building, and improved local governance, including water management (International Organisation of Migration, 2019). Combined with existing conditions, water scarcity in Petorca can drive both mobility and immobility, making it difficult to distinguish between voluntary and involuntary mobility related decision making (Bergmann & Martin, 2023; Robins et al., 2024).

The political ecology of migration approach facilitated connecting existing research on water exploitation (e.g., Budds, 2004; Guerrero Rojas & Fragkou, 2021; Quiroz Sandivari, 2025) to novel data on local migration in rural Chile. The persistence of export-oriented agrarian production under worsening environmental conditions reinforces inequalities in water and land distribution. In this system, water-use rights function as both productive assets and legal anchors for land ownership. Losing these rights can lead to land devaluation and increasing economic instability for small-scale farmers. Conversely, secure water rights and land tenure enable external actors to enter and benefit from water-scarce territories. This dynamic disrupts local socio-metabolic relationships, as incoming flows support productivity for external markets at the expense of internal socio-ecological reproduction. Resource competition leads to a dual migration response: local communities experience forced out-migration or restrict-

ed immobility, while external actors benefit from easier in-migration. Alongside immobility and return migration, this process turns environmental migration into a gradual, power-driven restructuring of population and capital, which communities resist through revitalisation efforts.

Using a composite framework for the study of mobility under scarcity in the province of Petorca offers a new approach to researching environmental migration in water-stressed regions. Slow-onset events, such as the central Chilean MD, do not operate in a vacuum to generate mobility outcomes. Rather, their impacts depend on pre-existing conditions of vulnerability or receptivity, acting as a risk or opportunity multiplier. For this reason, it is crucial for scholars in the field of environmental migration to integrate diverse data through multiple methods and apply relevant theories to understand the complexity of factors that underpins (im)mobility and social security during prolonged environmental transformations.

The study's findings challenge linear narratives of environmental migration in adaptation and rural development policies, highlighting risks such as inaction and maladaptive solutions (e.g., overreliance on emergency water delivery in Petorca; see also Khavarian-Garmsir et al., 2025). As Weigel (2023) concludes in her work, ignoring the conditions under which existing (im)mobility decisions are taken allows resource-rich industries to retain power, widening the social gap highlighted in this research and making it more difficult for rural communities to pursue a "good life" without losing their territories (p. 8).

## 7. Conclusions

This study has examined how historically embedded and contextually specific water governance arrangements contribute to determining who remains, who is compelled to leave, and who is permitted to enter the territory during periods of prolonged water scarcity in the province of Petorca. By integrating the political ecology of migration with socio-metabolic and hydro-social readings, the analysis offers a power-sensitive perspective on the ways in which local political, economic, and socio-ecological tensions shape population dynamics and migration experiences. Addressing migration in this context requires policy interventions that recognise water governance as a central mechanism shaping labour opportunities, living conditions, and mobility decisions. Failure to address the institutional structures that control resources' access and their distribution risks perpetuating the conditions that produce distressed and unequal (im)mobility experiences.

Future research employing a political ecology of migration perspective should continue operate across multiple scales, linking local manifestations of power in migration experiences to their broader historical and systemic determinants. Additionally, such research could examine the influence of resistance movements and bottom-up community management strategies on local interpretations of environmental change, as well as their interactions with national resource management policies. Incorporating more detailed quantitative analyses would enable the evaluation of a wider array of variables not addressed in the present study, such as datasets on water availability, water rights allocation, and independently collected demographic information at both provincial and national levels, including aggregated data on age, gender, and reasons for movement. Comparative approaches could further be used to contrast experiences across regions affected by similar dynamics or policies. Collectively, these insights have the potential of contributing more robust evidence to inform policymaking, promoting more equitable, just, and adaptive long-term interventions in rural areas.

## Data access statement

The analysed quantitative data used in this research may be requested directly from the corresponding author, provided that the request is well-founded and justified. Interview transcripts and recordings collected for this study are not publicly available due to confidentiality restrictions.

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## References

Abel, G. J., Brottrager, M., Crespo Cuaresma, J., & Muttarak, R. (2019). Climate, conflict and forced migration. *Global Environmental Change*, *54*, 239-249. https://doi.org/10.1016/j.gloenvcha.2018.12.003

Adger, W. N., Crépin, A.-S., Folke, C., Ospina, D., Chapin, F. S., Segerson, K., Seto, K. C., Anderies, J. M., Barrett, S., Bennett, E. M., Daily, G., Elmqvist, T., Fischer, J., Kautsky, N., Levin, S. A., Shogren, J. F., Van Den Bergh, J., Walker, B., & Wilen, J. (2020). Urbanization, Migration, and Adaptation to Climate Change. *One Earth*, *3*(4), 396-399. https://doi.org/10.1016/j.oneear.2020.09.016

Alvarez-Garreton, C., Mendoza, P. A., Boisier, J. P., Addor, N., Galleguillos, M., Zambrano-Bigiarini, M., Lara, A., Puelma, C., Cortes, G., Garreaud, R., McPhee, J., & Ayala, A. (2018). The CAMELS-CL dataset: Catchment attributes and meteorology for large sample studies – Chile dataset. *Hydrology and Earth System Sciences*, *22*(11), 5817-5846. https://doi.org/10.5194/hess-22-5817-2018

Anríquez, G., & Melo, O. (2018). The Socio-Economic Context of Chilean Water Consumption and Water Markets Growth: 1985-2015. In *Water Policy in Chile* (pp. 53-63). Springer, Cham. https://doi.org/10.1007/978-3-319-76702-4_4

Askland, H. H., & Bunn, M. (2018). Lived experiences of environmental change: Solastalgia, power and place. *Emotion, Space and Society*, *27*, 16-22. https://doi.org/10.1016/j.emospa.2018.02.003

Baland, J.-M., & Robinson, J. A. (2008). Land and Power: Theory and Evidence from Chile. *American Economic Review*, *98*(5), 1737-1765. https://doi.org/10.1257/aer.98.5.1737

Bauer, C. J. (1997). Bringing water markets down to earth: The political economy of water rights in Chile, 1976-1995. *World Development*, *25*(5), 639-656. https://doi.org/10.1016/S0305-750X(96)00128-3

Bauer, C. J. (1998). *Against the Current: Privatization, Water Markets, and the State in Chile*. Kluwer Academic Publishers. https://doi.org/10.1007/978-1-4615-6403-4

Benjaminsen, T. A., & Svarstad, H. (2021). *Political Ecology: A Critical Engagement with Global Environmental Issues*. Springer International Publishing. https://doi.org/10.1007/978-3-030-56036-2

Bolados García, P. (2016). Conflictos socio-ambientales/territoriales y el surgimiento de identidades post neoliberales (Valparaíso-Chile). *Izquierdas*, *31*, 102-129. https://doi.org/10.4067/S0718-50492016000600102

Budds, J. (2004). Power, Nature and Neoliberalism: The Political Ecology of Water in Chile. *Singapore Journal of Tropical Geography*, *25*(3), 322-342. https://doi.org/10.1111/j.0129-7619.2004.00189.x

Budds, J. (2013). Water, Power, and the Production of Neoliberalism in Chile, 1973-2005. *Environment and Planning D: Society and Space*, *31*(2), 301-318. https://doi.org/10.1068/d9511

Budds, J., & O'Reilly, K. (2023). Reforming Water Governance in Chile: A Hydrosocial Relations Perspective. *Journal of Latin American Geography*, *22*(3), 151-159. https://doi.org/10.1353/lag.2023.a915672

Carling, J. (2024). Mixed methods: Bridging the qualitative–quantitative divide in migration research. In *How to Do Migration Research* (pp. 33-40). Edward Elgar Publishing. https://doi.org/10.4337/9781035306855.00011

Carr, E. R. (2005). Placing the Environment in Migration: Environment, Economy, and Power in Ghana's Central Region. *Environment and Planning A: Economy and Space*, *37*(5), 925-946. https://doi.org/10.1068/a3754

Carter, M. R., & Barham, B. L. (1996). Level Playing Fields and Laissez Faire: Postliberal Development Strategy in Inegalitarian Agrarian Economies. *World Development*, *24*(7), 1133-1149. https://ideas.repec.org/a/eee/wdevel/v24y1996i7p1133-1149.html

Correa-Parra, J., Vergara-Perucich, J. F., & Aguirre-Nuñez, C. (2020). Water Privatization and Inequality: Gini Coefficient for Water Resources in Chile. *Water*, *12*(12), 3369. https://doi.org/10.3390/w12123369

Duran-Llacer, I., Munizaga, J., Arumí, J. L., Ruybal, C., Aguayo, M., Sáez-Carrillo, K., Arriagada, L., & Rojas, O. (2020). Lessons to Be Learned: Groundwater Depletion in Chile's Ligua and Petorca Watersheds through an Interdisciplinary Approach. *Water*, *12*(9), 2446. https://doi.org/10.3390/w12092446

El-Hinnawi, E. (1985). *Environmental refugees*. United Nations Environment Program (UNEP). https://digitallibrary.un.org/record/121267?ln=en&v=pdf

Engler, A., Melo, O., Rodríguez, F., Peñafiel, B., & Jara-Rojas, R. (2021). Governing Water Resource Allocation: Water User Association Characteristics and the Role of the State. *Water*, *13*(17), 2436. https://doi.org/10.3390/w13172436

Escribano Miralles, P., & Piñeiro, J. (2017). *Mapeo sobre Migración, Medio Ambiente y Cambio Climático en América del Sur*. International Organisation of Migration

(IOM). https://environmentalmigration.iom.int/sites/g/files/tmzbdl1411/files/documents/mapeo-sobre-migracion-medio-ambiente-y-cambio-climatico-en-america-del-sur_csm.pdf

Foster, J. B. (1999). Marx's Theory of Metabolic Rift: Classical Foundations for Environmental Sociology. *American Journal of Sociology*, *105*(2), 366-405. https://doi.org/10.1086/210315

Fragkou, M.-C., Monsalve-Tapia, T., Pereira-Roa, V., & Bolados-Arratia, M. (2022). Abastecimiento de agua potable por camiones aljibe durante la megasequía. Un análisis hidrosocial de la provincia de Petorca, Chile. *EURE (Santiago)*, *48*(145), 1-22. https://doi.org/10.7764/eure.48.145.04

Garreaud, R., Boisier, J. P., Álvarez-Garreton, C., Christie, D., Carrasco-Escaff, T., Vergara, I., Chávez, R. O., Aldunce, P., Camus, P., Suazo-Álvarez, M., Masiokas, M., Castro, G., Muñoz, A., Zambrano-Bigiarini, M., Fuster, R., & Godoy, L. (2025). *Hyperdroughts in central Chile: Drivers, Impacts and Projections* [Preprint]. https://doi.org/10.5194/egusphere-2025-517

Garreaud, R. D., Boisier, J. P., Rondanelli, R., Montecinos, A., Sepúlveda, H. H., & Veloso-Aguila, D. (2020). The Central Chile Mega Drought (2010-2018): A climate dynamics perspective. *International Journal of Climatology*, *40*(1), 421-439. https://doi.org/10.1002/joc.6219

Guerrero Rojas, R. A., & Fragkou, M. C. (2021). ¿Infraestructura ante la crisis hídrica? Políticas de Estado en los ríos Petorca y La Ligua. *Cuadernos médico sociales*, *61*(1), 61-71. https://doi.org/10.56116/cms.v61.n1.2021.26

Gwynne, R., & Meneses, C. (eds.) (1994). *Climate change and sustainable development in the Norte Chico, Chile: Land, water and the commercialisation of agriculture*. [s.l.]: University of Birmingham, University of Oxford. https://bibliotecadigital.infor.cl/handle/20.500.12220/5642

Harberger, A. C. (1993). Secrets of Success: A Handful of Heroes. *American Economic Review*, *83*(2), 343-350. https://ideas.repec.org/a/aea/aecrev/v83y1993i2p343-50.html

Harnecker, B., & Mallea, F. (2023). Measuring irregular migration in Chile: The use of data linkage methods. *International Journal of Population Data Science*, *8*(2). https://doi.org/10.23889/ijpds.v8i2.2188

Instituto Nacional de Derechos Humanos. (2020). *orme Misión de Observación. Provincia de Petorca*. https://bibliotecadigital.indh.cl/server/api/core/bitstreams/4f4aef23-5985-42d1-bf2b-43870b7fa1c2/content

INE. (2021). Censo Nacional Agropecuario, Año Agrícola 2020-2021. *Dirección de Estadística y Censos. Chile, Santiago*. https://www.ine.gob.cl/censoagropecuario

International Organisation of Migration. (2019). IOM, Experts Gather on Environmental Migration, Climate-Resilient Reintegration of Returning Migrants. https://mena.iom.int/news/iom-experts-gather-environmental-migration-climate-resilient-reintegration-returning-migrants

Kasirye, F. (2021). An overview of mixed and multi method research. *Advance*, *1-8*. https://doi.org/10.31124/advance.14681643.V1

Keech, W. (2004). *Democracy, Dictatorship and Economic Performance in Chile*. *Econometric Society 2004 Latin American Meetings*, *332*, 1-53. https://ideas.repec.org//p/ecm/latm04/332.html

Kelly, G. (2021). Researching Over-Researched Societies. In R. Mac Ginty, R. Brett & B. Vogel (eds.), *The Companion to Peace and Conflict Fieldwork* (pp. 47-63). Cham: Palgrave Macmillan. https://doi.org/10.1007/978-3-030-46433-2_4

Khavarian-Garmsir, A. R., Hajian Hossein Abadi, M., Sadeghi, A., Rahimi, D., & Asadzadeh, A. (2024). Trends and future research in climate migration: A bibliometric analysis of forty years. *Environmental Hazards*, *23*(3), 241-264. https://doi.org/10.1080/17477891.2023.2265928

Linton, J., & Budds, J. (2014). The hydrosocial cycle: Defining and mobilizing a relational-dialectical approach to water. *Geoforum*, *57*, 170-180. https://doi.org/10.1016/j.geoforum.2013.10.008

Madariaga, A., Maillet, A., & Rozas, J. (2021). Multilevel business power in environmental politics: The avocado boom and water scarcity in Chile. *Environmental Politics*, *30*(7), 1174-1195. https://doi.org/10.1080/09644016.2021.1892981

McLeman, R. A. (2017). On the Origins of Environmental Migration. *Fordham Environmental Law Review*, *20*(2), 403-426. https://ir.lawnet.fordham.edu/cgi/viewcontent.cgi?article=1658&context=elr

Mik-Meyer, N. (2020). Multimethod qualitative research. In D. Silverman (ed.), *Qualitative Research* (pp. 357-374). SAGE Publications. https://www.mik-meyer.com/wp-content/uploads/2025/02/Multimethod_qualitative_research.pdf

Muñoz, A. A., Klock-Barría, K., Alvarez-Garreton, C., Aguilera-Betti, I., González-Reyes, Á., Lastra, J. A., Chávez, R. O., Barría, P., Christie, D., Rojas-Badilla, M., & LeQuesne, C. (2020). Water Crisis in Petorca Basin, Chile: The Combined Effects of a Mega-Drought and Water Management. *Water*, *12*(3), 648. https://doi.org/10.3390/w12030648

Napoletano, B. M., Urquijo, P. S., Paneque-Gálvez, J., Clark, B., York, R., Franch-Pardo, I., Méndez-Lemus, Y., & Vieyra, A. (2018). Has (even Marxist) political ecology really transcended the metabolic rift? *Geoforum*, *92*, 92-95. https://doi.org/10.1016/j.geoforum.2018.04.008

OECD. (2021). *OECD Economic Surveys: Chile 2021*. OECD Publishing. https://doi.org/10.1787/79b39420-en

Panez Pinto, A., Faúndez Vergara, R., & Mansilla Quiñones, C. (2017). Politización de la crisis hídrica en Chile: Análisis del conflicto por el agua en la provincia de Petorca. *Agua y territorio = Water and Landscape*, *10*, 131-148. https://doi.org/10.17561/at.10.3614

Parsons, L., & Chann, S. (2019). Mobilising hydrosocial power: Climate perception, migration and the small scale geography of water in Cambodia. *Political Geography*, *75*, 102055. https://doi.org/10.1016/j.polgeo.2019.102055

Paz Acevedo, R. (2024). Toward a Constitution of Care: Lessons from the Chilean Constitutional Process of 2021-2022. *Latin American Legal Studies*, *12*(1), 279-325. https://doi.org/10.15691/0719-9112Vol12n1a7

Quiroz Sandivari, N. P. (2025). Extractivismos y resistencias en la comuna de Petorca, Chile. Despojo y construcción de experiencias de gestión comunitaria en la producción del espacio. *Quid 16. Revista del Área de Estudios Urbanos*, *24*, 3. https://doi.org/10.62174/quid16.i24_a404

Radel, C., Schmook, B., Carte, L., & Mardero, S. (2018). Toward a Political Ecology of Migration: Land, Labor Migration, and Climate Change in Northwestern Nicaragua. *World Development*, *108*, 263-273. https://doi.org/10.1016/j.worlddev.2017.04.023

Rafa, A., Griffiths, M., & Way, R. (2025). Empirical research review on solastalgia: Place, people and policy pathways for addressing environmental distress. *People and Nature*, *7*(5), 1811-1825. https://doi.org/10.1002/pan3.70090

Ríos Brehm, M., & Quiroz, J. (with IBRD) (1995). *The market for water rights in Chile: Major issues*. The World Bank. https://digitallibrary.un.org/record/194827

Robbins, P. (2012). *Political Ecology. A Critical Introduction*. John Wiley & Sons Ltd.

Roose, I. (2020). *Flows of Chilean Water Governance: Social Innovations in Defiance of Mistrust and Fragmented Institutions*. Nomos, Baden-Baden. https://doi.org/10.5771/9783748910190

Roose, I., & Panez, A. (2020). Social Innovations as A Response to Dispossession: Community Water Management in View of Socio-Metabolic Rift in Chile. *Water*, *12*(2), 566. https://doi.org/10.3390/w12020566

Rowe, F., Casado-Díaz, J. M., & Martínez-Bernabéu, L. (2017). Functional Labour Market Areas for Chile. *Region*, *4*(3), R7-R9. https://doi.org/10.18335/region.v4i3.199

Schmidt, A. (1962). *The Concept of Nature in the Theory of Marx*. European Publishing House.

Seow, V. (2018). The Metabolism of Modern Migration. *Transfers*, *8*(3), 123-129. https://doi.org/10.3167/TRANS.2018.080309

Sommaruga, R., & Eldridge, H. M. (2021). Avocado Production: Water Footprint and Socio-economic Implications. *EuroChoices*, *20*(2), 48-53. https://doi.org/10.1111/1746-692X.12289

Suárez Delucchi, A. A. (2024). Unpacking "community water management" in rural Chile: An institutional ethnography. *Journal of Rural Studies*, *110*, 103345. https://doi.org/10.1016/j.jrurstud.2024.103345

Wesselink, A., Kooy, M., & Warner, J. (2017). Socio-hydrology and hydrosocial analysis: Toward dialogues across disciplines. *WIREs Water*, *4*(2), 1196. https://doi.org/10.1002/wat2.1196

Wiegel, H. (2023). Complicating the tale of "first climate migrants": Resource-dependent livelihoods, drought and labour mobilities in semi-arid Chile. *Geoforum*, *138*, 103663. https://doi.org/10.1016/j.geoforum.2022.11.005