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Assessing the Impacts on Income and Employment

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Abstract[*]

Climate change is a pressing issue, affecting the lives of all people across the world. However, poorer and excluded communities are usually more affected, especially in low-income countries. Among them, women but particularly indigenous groups in rural areas seem to bear the bulk of the impacts produced by climate change and its many manifestations. We study the relationship between droughts and incomes and labor market outcomes in Chile over the period 1990-2017, focusing in particular on indigenous women. Our results show that overall indigenous women are the group most severely affected by droughts, decreasing their income, their probability of working in agriculture, and increasing their likelihood of working as an unpaid family worker or being out of the labor force. Results are robust to the use of different variables to measure droughts and to different econometric specifications. Our study corroborates the existence of marked heterogenous effects of climate change on different population groups and the vulnerability of indigenous communities to these shocks.

JEL classifications: E24, I31, J16, Q54
Keywords: Droughts, Climate change, Women, Indigenous groups, Water scarcity, Chile

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All data used are publicly available from their original sources. CASEN surveys are available in http://observatorio.ministeriodesarrollosocial.gob.cl/encuesta-casen, Population Census are available from https://www.ine.gob.cl/estadisticas/sociales/censos-de-poblacion-y-vivienda/censo-de-poblacion-y-vivienda, Agricultural Census are available from https://www.ine.gob.cl/estadisticas/economia/agricultura-agroindustria-y-pesca/censos-agropecuarios, and climate-related data are available from https://www.cr2.cl/bases-de-datos/ and from https://snia.mop.gob.cl/BNAConsultas/reportes.
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1. Introduction

Climate change is one of the most pressing global problems, involving sociocultural and institutional changes (Barnes and Dove, 2015). Vulnerability to climate change in local communities is increasing around the world and is projected to increase further in coming decades. This vulnerability is also related to the reproduction and increase of several inequalities (IPCC, 2014). Poorer communities are the ones who experience its impacts the most, suffering the increase in temperatures, the loss of biodiversity, droughts, and water scarcity, among other detrimental impacts. This is because these vulnerable groups are also largely excluded from the decision-making processes that affect their territories. Within these groups, women and indigenous peoples have been highlighted in recent literature for being the most affected by climate change, especially in rural contexts (Brugnach et al., 2017).

In the case of women, recent research on climate change has shown severe effects on employment, income, and increased vulnerability. Indigenous peoples, on the other hand, have experienced colonization processes that pushed a large part of the population to lands that are highly vulnerable to climate change, concentrating most of the cultivable land in non-indigenous hands. This is particularly marked in predominantly agricultural economies, where phenomena such as desertification, water scarcity and loss of biodiversity have had a strong impact on indigenous economies, increasing their levels of vulnerability and pushing these populations to the urban margins (Tsosie, 2007; Sobrevila, 2008). These effects become particularly relevant when we look at the condition of historical vulnerability that rural and indigenous women have had in Latin America, and in the Chilean case specifically (Denton, 2002; Pearse, 2017).

In Chile, one of the most relevant problems of climate change today is water scarcity and its devastating effects on the population, especially rural inhabitants. During the last decade, Chile has faced one of the longest and most extensive droughts in its history, which has impacted the replenishment of aquifers, basins, and general water availability (Cr2, 2015). The increase in frequency and intensity of droughts across the globe over the last decades has been linked directly to climate change (IPCC, 2022). In Chile, the consequences of this prolonged drought are compounded by a governance system that conceives water as a commodity, with a high concentration of water rights in a few hands, and where irrigation associated with agriculture and forestry accounts for 73 percent of consumptive water use, resulting in a strong linkage between agro-industrial exploitation and water scarcity.

Research on climate change and economic outcomes indicates that weather shocks, such as changes in temperature, rainfall, and windstorms, affect agricultural and industrial output, labor productivity, health, and conflict, among other variables (Dell et al., 2014). However, the literature on rainfall shocks, including drought and water scarcity, has focused primarily on their aggregate impacts on agricultural activities and in rural areas. Results have shown that rainfall variability decreases agricultural output (Damania et al., 2020), agricultural wages (Mueller and Osgood, 2009; Mueller and Quisumbing, 2011), and local tax revenues (Sanoh, 2015), and it increases food prices and vulnerability to poverty (Hill and Porter, 2017). Rainfall shocks also increase outmigration (Baez et al., 2017) and farm households' labor supply in non-agricultural sectors, with diversification of activities operating as a mitigation and adaptation strategy (Branco and Féres, 2021). Water scarcity, defined as large sustained dry events, has also affected urban areas, decreasing employment, hourly wages, hours worked, and labor incomes, mainly through adverse impacts on health and productivity (Desbureaux and Rodella, 2019).

Moreover, rainfall shocks can have long-term impacts on economic outcomes and wellbeing, as exposure to rainfall shocks in early childhood affects education and health later in life (Dinkelman, 2017; Shah and Steinberg, 2017); while increased drought frequency has long-term negative impacts on employment and wages in the agricultural, manufacturing and service sectors (Bastos et al., 2013).

As mentioned, the impacts of rainfall shocks may be heterogeneous among socioeconomic groups, and stronger for groups that are more likely to be exposed to shocks, and less able to cope with them. Exploring heterogeneous impacts by gender, Mahajan (2017) studies the effect of rainfall shocks on agricultural wages and finds that low rainfall increases the gender wage gap in agriculture. Feeny et al. (2021) find that rainfall shocks experienced in early childhood decrease the probability of formal sector employment for adult women but not for men, because they lower girls' educational attainment. On average, women appear to be less able than men to diversify into non-farm, non-agricultural activities (Afridi et al., 2022), but this varies with women's socioeconomic status and stage in the life cycle, with younger women with higher incomes and education levels being more likely to diversify away from agriculture (Huynh and Resurrección, 2014).

On the other hand, indigenous people appear to be more vulnerable to rainfall shocks and water scarcity compared to the rest of the population because they are more likely to be exposed

and are less able to adopt mitigation and adaptation strategies (Islam and Winkel, 2017). In particular, rainfall shocks have been associated with a decrease in education expenditure and school enrollment, and an increase in child labor among indigenous households (Nordman et al., 2022; Pham, 2022). Quandt (2019) and Azong and Kelso (2021) are among the few studies that adopt an intersectional approach to explore the differential impact of rainfall shocks on indigenous women. In Cameroon, Azong and Kelso (2021) find that women are more vulnerable to rainfall shocks regardless of their ethnicity, because of socioeconomic and cultural discrimination. Meanwhile, Quandt (2019) finds differing perceptions of livelihood resilience between genders and members of different ethnic groups in Kenya. Results show that perceptions of livelihood resilience are lower among women, but significant heterogeneity exists at the intersection of gender and ethnicity. In turn, perceptions affect the adoption of adaptation strategies. Finally, for the case of Chile, recent qualitative research has shown that changes in water availability and governance particularly impact the daily lives of Mapuche women (Bravo and Fragkou, 2019).

Thus, the labor market impacts of rainfall shocks, including droughts and water scarcity, depend in part on the sectoral composition of the local production structure, and on people's access to adaptation strategies, which varies across socioeconomic groups. However, evidence on heterogeneous impacts is still scarce, especially for the Latin American context, and at the intersection of gender and ethnicity. This paper seeks to contribute to the literature on the relationship between climate change and inequality. To the best of our knowledge, this is the first study to analyze, for the case of Chile, the differential impacts of droughts on women, indigenous people, and indigenous women using an econometric approach. We use individual-level information for the period 1990-2017, a fixed-effect model at the municipality level and different measures of drought to account for the fact that most of the effect could be concentrated only in the hardest-hit municipalities. Our main results corroborate the hypothesis that indigenous women are the most affected by droughts in terms of income and employment status. Each one standard deviation increase in the continuous measure of droughts reduces autonomous income of indigenous women by 0.14 percent in the country as a whole and by 0.314 percent in the south of Chile, where Mapuche communities tend to concentrate. However, using a dichotomous measure that strictly identifies areas suffering from a drought increases this percentage to 4.81 percent in absolute value for the south of the country. Similarly, as drought increases, the likelihood of working in agriculture decreases by 0.11 percent, and the likelihood of working as an unpaid family

worker or of being out of the labor force increases by 0.03 percent and 0.114 percent, respectively. Again, using a dichotomous measure identifying areas under drought increases these effects significantly (to -1.6% and 2.27% in the cases of the probability of working in agriculture and of being out of the labor force), suggesting that hard-hit areas are the ones in which these impacts are concentrated.

The rest of the paper is organized as follows. Section 2 provides a brief context on water governance in Chile, to understand how that governance affects indigenous and other vulnerable groups' access to water. Section 3 describes the data and methods used, and Section 4 presents the main results. Section 5 concludes and presents some policy recommendations.

2. Water Governance in Chile

The concentration of water use for irrigation and the strong linkage between agro-industrial exploitation and water scarcity is the result of the politics of water in Chile. The current water governance system is the product of a long historical process, where governments have played different roles in water management, the generation of technical knowledge, and associated infrastructure, which have deeply affected some groups of the population more than others. In 1981, through the DFL-1122 decree, the current Water Code was established, recognizing water resources as public goods, but paradoxically giving at the same time rights in perpetuity over them to the private sector.

Water rights were initially given for free and permanently to private individuals and companies, which, until 2005, were exempt from taxes and not required to use this water for productive activities. The allocation of water rights did not consider their historical uses, causing severe impacts on the indigenous communities that had been depending on them (Bravo and Fragkou, 2019). Within this context, when water rights were established (during Pinochet's dictatorship in the 1980s), indigenous communities lacked access to information about changes in water property and the inscription of water rights, and therefore were basically excluded from the process. This change in water allocation also included the ownership of groundwater, which has been also privatized: as an example, in the north of Chile, a great part of water rights was registered by the mining industry, which currently owns 95 percent of groundwater rights (Castillo, 2016).

Towards the end of the 1980s, a water market was established, which allowed renting and selling of water property rights among private actors with no Government intervention. The return

to democracy in 1990, after Pinochet's dictatorship, did not mean any substantial change in laws regarding water rights. The Water Code was only modified in 2005, and more recently in 2022, but without altering the fundamentals of the water governance system (Peña et al. 2019).[1]

Water governance since the 1980s has been extremely relevant for the configuration of the agro-export sector, concentrating water rights in more profitable areas. However, not only were water rights allocated under a market system, but the irrigation infrastructure was also concentrated in few hands. The main actor in this process, with a key role in the current configuration of the agro-export business, was the National Irrigation Commission (CNR, in Spanish), created in 1985.

In this context, the only public policy for drought management in Chile is the Water Scarcity Decree, a legal instrument created to operate during short periods of time, which, among other features, authorizes water extraction in rural areas in extreme drought conditions. According to Article N° 314 of the Water Code, this instrument gives the General Direction of Water (DGA in Spanish) the power to allocate and redistribute water resources with the purpose of "authorizing underground and surface water extraction without requiring the possession of water entitlements or limiting the volume of extraction to local ecological conditions" (MOP S/F). However, as rainfall continued to decrease over the last couple of decades, the Decree has been consistently renewed over a long period of time, especially in areas focused on agricultural activity. In turn, this has led to the overuse of water basins, generating severe water sustainability problems which affect the most vulnerable and poorer local communities (Budds, 2012).

Water governance is closely related to the political-economic momentum (Romero Aravena et al., 2018). Therefore, the problem that emerges from water management is above all a "hydrosocial" issue that accounts for processes of water commodification, through hydropolitical dynamics (Ulloa and Romero-Toledo 2018; Budds, 2012; Damonte et al., 2020). In the Chilean context, water scarcity has much more to do with social aspects that determine how, why and by whom water is being used, than by hydroclimatic factors (Budds, 2012). In this context, the situation of indigenous peoples in relation to droughts must be understood within the framework of a governance that has gradually left these groups without regular access to water, concentrating

[1] As main changes, the priority of human right in the use of water and the need for effective use of water is introduced. These modifications affect only the new rights (6 percent of the water in Chile), while the rights already granted remained intact.

these property rights in agro-industry sector. This significantly reduces their ability to adapt to the crisis and build resilient communities, particularly affecting indigenous women: drought can lead to increased unpaid and unrecognized care work for women at home (see Appendix 2).

3. Data and Methods

Our main data sources are the Survey of Socioeconomic Characterization (CASEN, from its name in Spanish), a cross-sectional multipurpose household survey collected at two- to three- years intervals between 1990 to 2017. CASEN, which is a representative at the regional level for every year considered, provides socioeconomic and demographic information for households. and allows us to analyze individual-level data on employment status and income. Our main sample consists of working adults between the ages of 18 and 65 who are not currently studying. With respect to our main outcomes of interest, we first analyze income using autonomous income, defined as total income minus public and private transfers; and autonomous income from agriculture, which includes agricultural wages as well as income from self-employed activities related to crops, livestock, forestry and fishing. We then analyze the following set of labor market outcomes: being unemployed, estimated for the sample in the labor force; working in agriculture and working as an unpaid family worker, each estimated for the sub-sample that is working; and being out of the labor force, estimated for the full sample of 18 to 65 years old who are not studying.

We measure drought using two definitions. First, we use a continuous measure of droughts computed as a standardized index of precipitation or water flow depending on the area considered. Here, positive values identify areas with larger levels of precipitation or water flow, and therefore non-drought areas. To make our results more easily interpretable, we have multiplied the index by -1, thus in our results an increase in the index represents an increase in the measure of drought. Second, we use the technical criterion adopted by the General Direction of Water (DGA in Spanish), which is defined at the basin level, but can be easily assigned to municipalities, considering the municipalities located within each basin. According to this definition, a basin—and therefore a municipality—is experiencing drought if the cumulated precipitations or water flow, depending on the area of the country, is below a threshold of -0.84 in a standardized index of precipitations or water flow, respectively (see DGA's Resolution 1674 of 2012).[2] We believe the

[2] See resolutions in: https://dga.mop.gob.cl/legistlacionynormas/resoluciones/Resoluciones/1674_2012.pdf

continuous measure can provide us with a more general view of the impact of an increase in droughts on income and employment (similar to an extensive margin of the effect), while the dichotomous measure of droughts only considers areas under a severe drought as "treated," and therefore informs on the magnitude of the effect in the most affected areas (similar to the intensive margin). We present both results for the main estimates.

Our focus is on analyzing heterogenous impacts of droughts for women compared to men, indigenous population compared to non-indigenous groups, and especially indigenous women compared with the rest of the population. We estimate individual-level regressions using data from CASEN, considering individuals who identify themselves as belonging to an indigenous group, and women. Our baseline regression is

$$y_{ijt} = \beta T_{it} + \gamma W_{ji} + \rho I_{ji} + Z_{jit}\vartheta + \emptyset_i + \tau_t + \mu_{jit} \quad (1)$$

where y_{jit} is the outcome of interest, *Tit* is a either continuous or dummy variable indicating the presence of drought in municipality i at time t, W_{ji} is a dummy variable with value 1 when the individual j is a woman (0 when is a man), I_{ji} is a dummy variable with value 1 when the individual belongs to an indigenous group (0 otherwise) and Z_{jit} is a vector of other individual-level characteristics, such as age, marital status, level of education, occupation and sector of employment. Finally, $\emptyset_i$ is a municipality fixed effect, to control for time-invariant unobserved heterogeneity, and τ_t is a time trend. After estimating this baseline model, we add interaction terms between drought, gender, and belonging to an indigenous group, to estimate the differential impact of droughts on women, indigenous groups, and indigenous women, as in equation (2):

$$y_{ijt} = \beta T_{it} W_{ji} I_{ji} + Z_{jit}\vartheta + \emptyset_i + \tau_t + \mu_{jit} \quad (2)$$

All regressions are estimated using robust standard errors. Additional estimates using region by year fixed effects and clustered standard errors at the municipality level yield similar results. Our estimates are computed for the country as a whole and for northern and southern areas of the country, for which the CASEN survey is highly representative. Our estimates do not include weights, but estimations including individual probability weights yield similar results and are available upon request. Finally, since we are interested in several outcomes and only have one "treatment," we have conducted a multiple hypothesis testing using the Romano-Wolf test (Clarke et al. 2019). The test results, which are also available upon request, showed that our estimates are still valid and significant even after adjusting with the aforementioned test.

Our identifying assumption is that conditional on all observed variables and on time-invariant municipal level unobserved variables, the spatial distribution of droughts is as good as random. We believe that this is a reasonable assumption when droughts are measured by the volume of precipitations. The use of region by year fixed effects in robustness checks further controls for time-varying unobserved variables operating at regional level. However, when droughts are measured by water flow, we cannot rule out the existence of time-varying unobserved factors simultaneously affecting local (municipal) levels of droughts as well as incomes and labor market outcomes. For this reason, our results should be interpreted as conditional correlations rather than causal impacts.

4. Results

4.1. Autonomous Income

Table 1 presents the baseline results of the relationship between droughts and autonomous income for workers in all industries and for people working in the agricultural sector specifically (both as wage workers and as self-employed, including employers), estimated for the whole country, the northern region (from Tarapacá to Coquimbo) and the southern region (Maule to Los Lagos). We then interact the variable of interest (drought) with a dummy variable that indicates whether the individual is a woman (Table 2) or belongs to an indigenous group (Table 3). Table 4 interacts both, showing results for indigenous women.

Our baseline results indicate that, on average, droughts have no significant relationship with total incomes or on agricultural incomes for the country as a whole or in the south. Contrary to what we expected, in the north it seems that agricultural workers are somehow benefiting from droughts, although the effect is small (less than 0.2 percent with every standard deviation change in the index). However, this might be a result of the relatively small sample considered and the fact that the north of the country does not have an important agricultural industry, in contrast to the central and southern parts of the country, where the effect is zero on average.

As expected, schooling level increases income, between 5 percent and 9 percent, while women, indigenous groups and people living in rural areas have significantly lower income compared to men, non-indigenous people and people living in an urban area, respectively.

Table 1. Overall Effects of Droughts on Autonomous Income (in logs)

	Whole Country		North		South	
	All	Ag. Workers	All	Ag. Workers	All	Ag. Workers
Drought	5.24e-05	-4.47e-05	0.000216	0.00198***	-7.36e-05	-0.000145
	(0.000124)	(0.000279)	(0.000253)	(0.000715)	(0.000189)	(0.000393)
Schooling (years)	0.0901***	0.0597***	0.0821***	0.0469***	0.0896***	0.0649***
	(0.000222)	(0.000499)	(0.000525)	(0.00127)	(0.000332)	(0.000710)
Age (years)	0.0137***	0.00917***	0.0125***	0.00816***	0.0132***	0.00932***
	(6.33e-05)	(0.000139)	(0.000140)	(0.000352)	(9.81e-05)	(0.000199)
Married = 1	-0.124***	-0.158***	-0.133***	-0.134***	-0.129***	-0.186***
	(0.00146)	(0.00312)	(0.00327)	(0.00779)	(0.00227)	(0.00454)
Mining = 1	0.447***		0.443***		0.390***	
	(0.00387)		(0.00613)		(0.0148)	
Manufacturing = 1	-0.000551		0.0122		-0.00498	
	(0.00278)		(0.00810)		(0.00391)	
Services = 1	0.0762***		0.0851***		0.0717***	
	(0.00197)		(0.00494)		(0.00289)	
Self-employed = 1	-0.810***	-0.929***	-0.701***	-0.672***	-0.842***	-0.998***
	(0.00637)	(0.0152)	(0.0146)	(0.0368)	(0.00979)	(0.0210)
Salaried = 1	-0.840***	-1.073***	-0.723***	-0.896***	-0.843***	-1.067***
	(0.00613)	(0.0148)	(0.0141)	(0.0361)	(0.00946)	(0.0207)
Military = 1	-0.439***		-0.274***		-0.411***	
	(0.00785)		(0.0186)		(0.0127)	
Domestic Work = 1	-1.197***		-1.116***		-1.201***	
	(0.00695)		(0.0167)		(0.0107)	
Rural = 1	0.00543***	-0.0442***	-0.0293***	-0.0899***	0.00316	-0.0467***
	(0.00178)	(0.00310)	(0.00460)	(0.00849)	(0.00257)	(0.00460)
Woman = 1	-0.285***	-0.274***	-0.289***	-0.200***	-0.285***	-0.330***
	(0.00159)	(0.00394)	(0.00354)	(0.00902)	(0.00250)	(0.00625)
Indigenous = 1	-0.0619***	-0.105***	-0.0407***	-0.0377***	-0.0749***	-0.118***
	(0.00239)	(0.00505)	(0.00513)	(0.0131)	(0.00324)	(0.00605)
Constant	11.31***	11.90***	11.26***	11.80***	11.17***	11.64***
	(0.0102)	(0.0282)	(0.0214)	(0.0522)	(0.0149)	(0.0342)
Observations	1,095,255	257,775	198,042	34,478	499,295	145,621
R-squared	0.439	0.345	0.440	0.365	0.392	0.318

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 2 shows that in general, women's incomes are around 30 percent lower than men's, on average. Living in a municipality that experiences drought significantly decreases incomes in the South. Meanwhile, women living in municipalities with a drought do not appear to be significantly worse off, and, contrary to what we expected, experience very small increases incomes in the south (0.09 percent).

Table 2. Effects of Droughts on Autonomous Income (in logs): Heterogenous Effects by Gender

	Chile	North	South
Drought	-0.000125	0.000197	-0.000398*
	(0.000140)	(0.000289)	(0.000211)
Women = 1	-0.285***	-0.289***	-0.285***
	(0.00159)	(0.00357)	(0.00250)
Drought*Woman	0.000470**	5.18e-05	0.000894***
	(0.000187)	(0.000412)	(0.000277)
Schooling (years)	0.0901***	0.0821***	0.0896***
	(0.000222)	(0.000525)	(0.000332)
Age (years)	0.0137***	0.0125***	0.0132***
	(6.33e-05)	(0.000140)	(9.81e-05)
Married = 1	-0.124***	-0.133***	-0.129***
	(0.00146)	(0.00327)	(0.00227)
Mining = 1	0.447***	0.443***	0.391***
	(0.00387)	(0.00613)	(0.0148)
Manufacturing = 1	-0.000443	0.0123	-0.00471
	(0.00278)	(0.00810)	(0.00391)
Services = 1	0.0763***	0.0851***	0.0720***
	(0.00197)	(0.00494)	(0.00289)
Self-employed = 1	-0.810***	-0.701***	-0.842***
	(0.00637)	(0.0146)	(0.00979)
Salaried = 1	-0.840***	-0.723***	-0.843***
	(0.00613)	(0.0141)	(0.00946)
Military = 1	-0.439***	-0.274***	-0.411***
	(0.00785)	(0.0186)	(0.0127)
Domestic Work (Employed) = 1	-1.197***	-1.116***	-1.201***
	(0.00695)	(0.0167)	(0.0107)
Rural = 1	0.00544***	-0.0293***	0.00322
	(0.00178)	(0.00460)	(0.00257)
Indigenous = 1	-0.0619***	-0.0407***	-0.0749***
	(0.00239)	(0.00513)	(0.00324)
Constant	11.31***	11.26***	11.17***
	(0.0102)	(0.0214)	(0.0149)
Observations	1,095,255	198,042	499,295
R-squared	0.439	0.440	0.392

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Results for the differential effect of droughts for indigenous groups (Table 3) show that they have significantly lower incomes than their non-indigenous counterparts. Droughts are associated with a slight increase in the average incomes of indigenous groups, but the results seem to be driven by the central area of the country, while no significant effect appears in the north or the south.

Table 3. Effects of Droughts on Autonomous Income (in logs): Heterogenous Effects among Indigenous and Non-indigenous Groups

	Chile	North	South
Drought	-8.07e-05	0.000214	-0.000154
	(0.000128)	(0.000263)	(0.000195)
Indigenous = 1	-0.0615***	-0.0407***	-0.0743***
	(0.00239)	(0.00516)	(0.00326)
Drought*Indigenous	0.00125***	1.70e-05	0.000654
	(0.000324)	(0.000657)	(0.000409)
Schooling (years)	0.0901***	0.0821***	0.0896***
	(0.000222)	(0.000525)	(0.000332)
Age (years)	0.0137***	0.0125***	0.0132***
	(6.33e-05)	(0.000140)	(9.81e-05)
Married = 1	-0.124***	-0.133***	-0.129***
	(0.00146)	(0.00327)	(0.00227)
Mining = 1	0.447***	0.443***	0.390***
	(0.00387)	(0.00613)	(0.0147)
Manufacturing = 1	-0.000540	0.0122	-0.00499
	(0.00278)	(0.00810)	(0.00391)
Services = 1	0.0762***	0.0851***	0.0717***
	(0.00197)	(0.00494)	(0.00289)
Self-employed = 1	-0.810***	-0.701***	-0.842***
	(0.00637)	(0.0146)	(0.00979)
Salaried = 1	-0.840***	-0.723***	-0.843***
	(0.00613)	(0.0141)	(0.00946)
Military = 1	-0.439***	-0.274***	-0.411***
	(0.00785)	(0.0186)	(0.0127)
Domestic Work (Employed) = 1	-1.197***	-1.116***	-1.201***
	(0.00695)	(0.0167)	(0.0107)
Rural = 1	0.00542***	-0.0293***	0.00311
	(0.00178)	(0.00460)	(0.00257)
Woman = 1	-0.285***	-0.289***	-0.285***
	(0.00159)	(0.00354)	(0.00250)
Constant	11.31***	11.26***	11.17***
	(0.0102)	(0.0214)	(0.0149)
Observations	1,095,255	198,042	499,295
R-squared	0.439	0.440	0.392

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Now moving to our main results, Table 4 shows that indigenous women are the group most affected by droughts in terms of income, reducing their income up to 0.3 percent in the south of the country for each standard deviation increase in the index, controlling for the overall effect of droughts, and the average income penalty both women and indigenous groups experience in the economy. The magnitude of the effect is smaller in the country as a whole (0.14 percent) and close to zero in the north of the country (with a point estimate of 0.05 percent).

Table 4. Effects of Droughts on Autonomous Income (in logs): Heterogenous Effects among Indigenous Women

	Chile	North	South
Drought	-0.000298**	0.000200	-0.000625***
	(0.000145)	(0.000302)	(0.000219)
Women = 1	-0.288***	-0.299***	-0.287***
	(0.00165)	(0.00380)	(0.00263)
Indigenous = 1	-0.0701***	-0.0694***	-0.0784***
	(0.00286)	(0.00635)	(0.00379)
Woman*Indigenous	0.0236***	0.0680***	0.0128*
	(0.00465)	(0.00959)	(0.00656)
Drought*Woman	0.000592***	6.52e-05	0.00130***
	(0.000196)	(0.000439)	(0.000294)
Drought*Indigenous	0.00174***	0.000206	0.00173***
	(0.000391)	(0.000811)	(0.000485)
Drought*Woman*Indigenous	-0.00142**	-0.000537	-0.00314***
	(0.000662)	(0.00128)	(0.000863)
Schooling (years)	0.0901***	0.0822***	0.0896***
	(0.000222)	(0.000525)	(0.000332)
Age (years)	0.0137***	0.0125***	0.0132***
	(6.33e-05)	(0.000140)	(9.81e-05)
Married = 1	-0.124***	-0.134***	-0.129***
	(0.00146)	(0.00327)	(0.00227)
Mining = 1	0.447***	0.443***	0.390***
	(0.00387)	(0.00613)	(0.0148)
Manufacturing = 1	-0.000731	0.0121	-0.00497
	(0.00278)	(0.00810)	(0.00391)
Services = 1	0.0761***	0.0854***	0.0719***
	(0.00197)	(0.00494)	(0.00289)
Self-employed = 1	-0.810***	-0.701***	-0.841***
	(0.00637)	(0.0146)	(0.00979)
Salaried = 1	-0.840***	-0.723***	-0.843***
	(0.00613)	(0.0141)	(0.00946)
Military = 1	-0.439***	-0.275***	-0.411***
	(0.00785)	(0.0186)	(0.0127)
Domestic Work (Employed) = 1	-1.196***	-1.113***	-1.200***
	(0.00695)	(0.0167)	(0.0107)
Rural = 1	0.00557***	-0.0288***	0.00323
	(0.00178)	(0.00460)	(0.00257)
Constant	11.31***	11.27***	11.17***
	(0.0102)	(0.0214)	(0.0149)
Observations	1,095,255	198,042	499,295
R-squared	0.439	0.441	0.392

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

4.2. Labor Market Outcomes

We now examine the relationship between droughts and labor market outcomes, focusing again on indigenous women. We report results for the linear probability of working in agriculture (Table 5), working as an unpaid family worker (Table 6), being unemployed (Table 7), and being out of the labor force (Table 8).

While women are always less likely than men to work in agriculture, results from Table 5 show that indigenous workers are more likely to work in that economic sector. While droughts lower the likelihood of working in agriculture in general, the decrease in participation in agriculture because of droughts appears to be stronger for indigenous women, with point estimates ranging from 0.11 percent for country-level results to 0.224 percent for the south. As expected, years of schooling decrease the probability of working in agriculture, while living in a rural area increases it.

Table 5. Effects of Droughts on Labor Market Status: Working in Agriculture

	Chile	North	South
Drought	-0.000744***	-0.00102***	-0.000600***
	(7.50e-05)	(0.000144)	(0.000118)
Women = 1	-0.0989***	-0.0728***	-0.129***
	(0.000704)	(0.00152)	(0.00114)
Indigenous = 1	0.0481***	0.0415***	0.0507***
	(0.00157)	(0.00327)	(0.00211)
Woman*Indigenous	-0.0522***	0.0185***	-0.0701***
	(0.00223)	(0.00453)	(0.00316)
Drought*Woman	0.00252***	0.00215***	0.00305***
	(8.89e-05)	(0.000183)	(0.000138)
Drought*Indigenous	0.000618***	0.000725*	0.000667**
	(0.000212)	(0.000427)	(0.000269)
Drought*Woman*Indigenous	-0.00106***	-0.00140**	-0.00224***
	(0.000314)	(0.000591)	(0.000418)
Schooling (years)	-0.0220***	-0.0183***	-0.0230***
	(9.80e-05)	(0.000227)	(0.000149)
Age (years)	-0.000913***	-0.000703***	-0.000857***
	(2.94e-05)	(6.24e-05)	(4.67e-05)
Married = 1	0.00997***	0.00849***	0.00785***
	(0.000709)	(0.00151)	(0.00112)
Rural = 1	0.304***	0.303***	0.327***
	(0.00104)	(0.00268)	(0.00143)
Constant	0.394***	0.350***	0.432***
	(0.00343)	(0.00747)	(0.00527)
Observations	1,127,391	203,488	516,537
R-squared	0.325	0.303	0.340

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 6 shows that droughts increase the probability of working as an unpaid family worker, especially for indigenous women, although the magnitude of the coefficient is small in all cases. Each standard deviation increase in the drought index increases the likelihood of working as an unpaid family worker by 0.03 percent for the country as a whole and 0.06 percent in the north of the country. With respect to the probability of being unemployed, Table 7 shows that women, especially indigenous women, are always more likely to be unemployed, regardless of whether or not they live in a drought area, and droughts do not seem to increase this gap.

Table 6. Effects of Droughts on Labor Market Status: Working as an Unpaid Family Worker

	Chile	North	South
Drought	0.000217***	0.000222***	0.000246***
	(1.75e-05)	(3.91e-05)	(2.77e-05)
Women = 1	0.0104***	0.0117***	0.0119***
	(0.000238)	(0.000623)	(0.000394)
Indigenous = 1	0.00308***	0.00332***	0.00344***
	(0.000421)	(0.000961)	(0.000589)
Woman*Indigenous	0.00190**	0.00535***	0.000921
	(0.000815)	(0.00183)	(0.00117)
Drought*Woman	-0.000313***	-0.000359***	-0.000277***
	(2.73e-05)	(6.41e-05)	(4.23e-05)
Drought*Indigenous	-0.000366***	-0.000196	-0.000465***
	(6.35e-05)	(0.000125)	(8.26e-05)
Drought*Woman*Indigenous	0.000334***	0.000699***	0.000105
	(0.000119)	(0.000247)	(0.000155)
Schooling (years)	-0.000504***	-0.000717***	-0.000534***
	(2.47e-05)	(7.21e-05)	(3.78e-05)
Age (years)	-0.000132***	-0.000203***	-0.000174***
	(8.22e-06)	(2.00e-05)	(1.33e-05)
Married = 1	0.00157***	0.00148***	0.00378***
	(0.000202)	(0.000505)	(0.000337)
Rural = 1	0.00890***	0.0149***	0.0106***
	(0.000262)	(0.000856)	(0.000366)
Constant	0.0265***	0.0356***	0.0219***
	(0.00127)	(0.00303)	(0.00169)
Observations	1,132,552	204,948	518,363
R-squared	0.013	0.017	0.015

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 7. Effects of Droughts on Labor Market Status: Being Unemployed

	Chile	North	South
Drought	-9.52e-05*	0.000136	-0.000294***
	(5.22e-05)	(0.000116)	(7.83e-05)
Women = 1	0.0228***	0.0114***	0.0278***
	(0.000569)	(0.00134)	(0.000907)
Indigenous = 1	0.000906	0.000570	-0.00116
	(0.00101)	(0.00231)	(0.00134)
Woman*Indigenous	0.00560***	-0.00381	0.0107***
	(0.00170)	(0.00344)	(0.00240)
Drought*Woman	-0.000283***	-0.000301*	-0.000214**
	(7.33e-05)	(0.000174)	(0.000108)
Drought*Indigenous	-0.000114	0.000898***	-0.000425***
	(0.000136)	(0.000315)	(0.000165)
Drought*Woman*Indigenous	0.000157	-0.000427	0.000418
	(0.000241)	(0.000478)	(0.000313)
Schooling (years)	-0.00308***	-0.00274***	-0.00373***
	(6.59e-05)	(0.000158)	(0.000101)
Age (years)	-0.00304***	-0.00311***	-0.00327***
	(2.23e-05)	(5.13e-05)	(3.42e-05)
Married = 1	0.0404***	0.0411***	0.0428***
	(0.000528)	(0.00121)	(0.000820)
Rural = 1	-0.0234***	-0.0269***	-0.0251***
	(0.000606)	(0.00155)	(0.000879)
Constant	0.172***	0.183***	0.187***
	(0.00268)	(0.00532)	(0.00381)
Observations	1,231,875	222,662	568,631
R-squared	0.041	0.038	0.046

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Finally, droughts might affect people's participation in the labor force. Traditional gender norms, assigning unpaid domestic labor to women, continue to be prevalent in Chile, especially in rural areas and among indigenous communities. Droughts tend to increase the time required to collect water and associated activities, which are typically carried out by women. Thus, by increasing demand for domestic labor, droughts might decrease women's labor force participation. An emerging hypothesis from the qualitative research that was part of this research focuses on these phenomena (see Appendix 2). We test this hypothesis in Table 8. As expected, results indicate that women are always more likely to be out of the labor force, and that droughts significantly

increase this probability, especially for indigenous women: The estimated effect of droughts for indigenous women is 0.11 percent for Chile, 0.29 percent for the north and 0.2 percent for the south.

Table 8. Effects of Droughts on Labor Market Status: Being out of the Labor Force

	Chile	North	South
Drought	0.00125***	0.00104***	0.00129***
	(6.88e-05)	(0.000147)	(0.000102)
Women = 1	0.363***	0.375***	0.387***
	(0.000666)	(0.00158)	(0.000988)
Indigenous = 1	-0.0164***	0.0316***	-0.0280***
	(0.00135)	(0.00314)	(0.00175)
Woman*Indigenous	0.00917***	-0.0964***	0.0388***
	(0.00195)	(0.00456)	(0.00249)
Drought*Woman	-0.00255***	-0.00241***	-0.00245***
	(8.81e-05)	(0.000208)	(0.000125)
Drought*Indigenous	-0.000606***	-0.00115***	-0.00107***
	(0.000183)	(0.000408)	(0.000224)
Drought*Woman*Indigenous	0.00114***	0.00292***	0.00201***
	(0.000275)	(0.000619)	(0.000335)
Schooling (years)	-0.0184***	-0.0176***	-0.0192***
	(8.87e-05)	(0.000222)	(0.000127)
Age (years)	-0.00317***	-0.00423***	-0.00283***
	(2.78e-05)	(6.45e-05)	(4.03e-05)
Married = 1	0.0221***	0.00737***	0.0288***
	(0.000680)	(0.00158)	(0.000993)
Rural = 1	0.0297***	-0.00413**	0.0475***
	(0.000782)	(0.00206)	(0.00106)
Constant	0.472***	0.517***	0.432***
	(0.00374)	(0.00708)	(0.00498)
Observations	1,913,033	342,251	919,349
R-squared	0.179	0.173	0.199

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

4.4. Robustness Checks

We conducted several robustness checks on the main results. First, we replaced the continuous measure of drought with a dichotomous one, to identify more severely affected areas. Second, we use region by year fixed-effects instead of municipality fixed-effects, to control time-varying unobservables that may be simultaneously affecting droughts and income and labor market

outcomes. Third, we evaluate whether our results are driven by a large portion of the sample being from the Metropolitan Region of Santiago (MRS), where agriculture and droughts in general would have a potentially smaller impact on income and employment. To do this we estimated the main regressions excluding the MRS from the sample. Results from all robustness checks are presented in the Appendix. Results for the dichotomous measurement of drought are similar to those estimated using the continuous outcome, but the estimated coefficients are larger: among indigenous women living in areas suffering from droughts, incomes decreased by 3 percent when the metropolitan region of Santiago is excluded, and by 4.8 percent in the south of Chile.

In terms of labor market outcomes, the magnitude of the point estimates increases but they are similar in terms of significance. Using the dichotomous measure, results show that, for indigenous women, living in areas suffering droughts reduces the likelihood of working in agriculture by 1.6 percent and increases the likelihood of being out of the labor force by 2.3 percent.

Our second set of estimates using region by year FE, yield basically the same results obtained before. In particular, an increase in droughts is associated with a reduction in the chances of working in agriculture (for the country as a whole) and with an increase in the chances of being out of the labor force, especially in the south of the country.

Finally, our results change little when we exclude the MRS, and overall, it seems to be more informative to analyze differences between the north and south with respect to the whole country, given their different geographical and productive characteristics, than just excluding the MRS from the full sample.

5. Conclusions

Chile is facing a longstanding and severe drought that has caused several impacts over different outcomes, but that has mainly affected water availability for human consumption, especially for vulnerable populations. While an important part of the problem comes directly from climate change, for the specific case of Chile, it is possible to assert that water governance plays an important role in increasing the severity of the droughts, and amplifies its effects for rural inhabitants, women, and especially indigenous groups.

This paper analyzed the relationship of droughts with several measures of income and labor market outcomes at the individual level, focusing on women and indigenous groups, with the

hypothesis that both groups are more affected in terms of income and labor market outcomes compared to men and non-indigenous groups, respectively; and that indigenous women are the most affected group.

Overall, our results suggest that indigenous women are indeed the group most severely affected by droughts. First, droughts decrease indigenous women's probability of working in agriculture. In principle, this might be part of a process of diversification of household income sources and lead to better paid jobs, as we can see from the qualitative research (see Appendix 2). However, our results also indicate that droughts cause a larger decrease in income among indigenous women compared to other groups, suggesting that their diversification away from agriculture is not going towards higher-income activities. Indigenous women in Chile, on average, have significantly lower labor force participation, incomes, and years of schooling compared to both indigenous men and non-indigenous women. Droughts appear to exacerbate this gap, increasing inequality and indigenous women's vulnerability, and adaptation and mitigation policies should consider these heterogeneities in exposure and vulnerability to the impacts of droughts and other climate change related events. An important element of this vulnerability involves an increase in unpaid work, documented as an emerging hypothesis from the qualitative research that is part of this research (see Appendix 2). This phenomenon will be a crucial element that needs to be addressed in future research about gender, indigenous people and drought public policy.

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Appendix 1. Tables

Table A1. Variables Used in the Sample

Variable	Observations	Mean	Std. Dev.	Min	Max
Autonomous income (logs)	1,505,352	12.08	1.15	1.39	18.25
Years of Schooling	2,268,083	9.88	4.22	0	23
Age	2,279,300	38.91	13.58	18	65
Indigenous = 1	1,921,275	0.12	0.32	0	1
Women = 1	2,279,300	0.52	0.50	0	1
Married = 1	2,279,104	0.42	0.49	0	1
Works in Agriculture = 1	1,332,151	0.25	0.43	0	1
Rural = 1	2,279,300	0.32	0.47	0	1
Unpaid Family Worker = 1	1,338,469	0.01	0.10	0	1
Unemployed = 1	1,392,536	0.08	0.27	0	1
Out of the labor force = 1	2,176,471	0.36	0.48	0	1
Drought = 1	2,279,300	0.10	0.30	0	1

Table A2. Means across Areas, According to the Presence of a Drought

	Chile		Excluding MRS	
Variable	No drought	Drought	No drought	Drought
Autonomous income (logs)	12.06	12.28	12.03	12.25
Years of Schooling	9.80	10.55	9.69	10.46
Age	38.85	39.44	38.97	39.50
Indigenous (%)	11.72	32.17	12.78	10.93
Women (%)	51.65	49.97	51.56	52.54
Married (%)	41.72	49.31	41.43	44.21
Works in Agriculture (%)	24.64	43.09	26.37	21.02
Rural (%)	32.49	46.84	34.18	28.98
Unpaid Family Worker (%)	1.05	10.19	1.12	0.93
Unemployed (%)	8.05	27.20	8.13	8.24
Out of the labor force (%)	36.02	48.01	36.81	35.15
Observations	2,050,196	229,104	1,816,634	216,206

Table A3. Effects of Droughts on Autonomous Income (in logs): Heterogenous Effects among Indigenous Women, Using Dichotomous Measure of Droughts

	Chile	North	South
Drought = 1	-0.0141***	-0.00374	-0.0229***
	(0.00314)	(0.00708)	(0.00468)
Women = 1	-0.290***	-0.300***	-0.291***
	(0.00174)	(0.00399)	(0.00280)
Indigenous = 1	-0.0725***	-0.0652***	-0.0816***
	(0.00298)	(0.00655)	(0.00396)
Woman*Indigenous	0.0269***	0.0693***	0.0207***
	(0.00488)	(0.00998)	(0.00692)
Drought*Woman	0.0181***	0.0124	0.0289***
	(0.00467)	(0.0102)	(0.00693)
Drought*Indigenous	0.0155	-0.0459**	0.0144
	(0.00942)	(0.0203)	(0.0117)
Drought*Woman*Indigenous	-0.0251	-0.0124	-0.0481**
	(0.0159)	(0.0318)	(0.0207)
Schooling (years)	0.0901***	0.0823***	0.0896***
	(0.000222)	(0.000525)	(0.000332)
Age (years)	0.0137***	0.0125***	0.0132***
	(6.33e-05)	(0.000140)	(9.81e-05)
Married = 1	-0.124***	-0.134***	-0.129***
	(0.00146)	(0.00327)	(0.00227)
Mining = 1	0.446***	0.443***	0.390***
	(0.00387)	(0.00613)	(0.0148)
Manufacturing = 1	-0.000748	0.0123	-0.00509
	(0.00278)	(0.00810)	(0.00391)
Services = 1	0.0761***	0.0857***	0.0717***
	(0.00197)	(0.00494)	(0.00289)
Self-employed = 1	-0.810***	-0.701***	-0.841***
	(0.00637)	(0.0146)	(0.00979)
Salaried = 1	-0.840***	-0.723***	-0.843***
	(0.00613)	(0.0141)	(0.00946)
Military = 1	-0.439***	-0.275***	-0.411***
	(0.00785)	(0.0186)	(0.0127)
Domestic Work (Employed) = 1	-1.196***	-1.113***	-1.201***
	(0.00695)	(0.0167)	(0.0107)
Rural = 1	0.00561***	-0.0289***	0.00330
	(0.00178)	(0.00460)	(0.00257)
Constant	11.32***	11.27***	11.18***
	(0.0102)	(0.0214)	(0.0149)
Observations	1,095,255	198,042	499,295
R-squared	0.439	0.441	0.392

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A4. Effects of Droughts on Autonomous Income (in logs): Heterogenous Effects among Indigenous Women, Results for Chile without the MRS (compared to the results presented in the paper)

	Chile	Excl. MRS	North	South
Drought	-0.000298**	-0.000506***	0.000200	-0.000625***
	(0.000145)	(0.000151)	(0.000302)	(0.000219)
Women = 1	-0.288***	-0.288***	-0.299***	-0.287***
	(0.00165)	(0.00176)	(0.00380)	(0.00263)
Indigenous = 1	-0.0701***	-0.0721***	-0.0694***	-0.0784***
	(0.00286)	(0.00292)	(0.00635)	(0.00379)
Woman*Indigenous	0.0236***	0.0265***	0.0680***	0.0128*
	(0.00465)	(0.00476)	(0.00959)	(0.00656)
Drought*Woman	0.000592***	0.000875***	6.52e-05	0.00130***
	(0.000196)	(0.000209)	(0.000439)	(0.000294)
Drought*Indigenous	0.00174***	0.00197***	0.000206	0.00173***
	(0.000391)	(0.000400)	(0.000811)	(0.000485)
Drought*Woman*Indigenous	-0.00142**	-0.00183***	-0.000537	-0.00314***
	(0.000662)	(0.000680)	(0.00128)	(0.000863)
Schooling (years)	0.0901***	0.0880***	0.0822***	0.0896***
	(0.000222)	(0.000234)	(0.000525)	(0.000332)
Age (years)	0.0137***	0.0133***	0.0125***	0.0132***
	(6.33e-05)	(6.69e-05)	(0.000140)	(9.81e-05)
Married = 1	-0.124***	-0.123***	-0.134***	-0.129***
	(0.00146)	(0.00155)	(0.00327)	(0.00227)
Mining = 1	0.447***	0.448***	0.443***	0.390***
	(0.00387)	(0.00400)	(0.00613)	(0.0148)
Manufacturing = 1	-0.000731	-0.00471	0.0121	-0.00497
	(0.00278)	(0.00295)	(0.00810)	(0.00391)
Services = 1	0.0761***	0.0734***	0.0854***	0.0719***
	(0.00197)	(0.00206)	(0.00494)	(0.00289)
Self-employed = 1	-0.810***	-0.793***	-0.701***	-0.841***
	(0.00637)	(0.00678)	(0.0146)	(0.00979)
Salaried = 1	-0.840***	-0.819***	-0.723***	-0.843***
	(0.00613)	(0.00653)	(0.0141)	(0.00946)
Military = 1	-0.439***	-0.392***	-0.275***	-0.411***
	(0.00785)	(0.00825)	(0.0186)	(0.0127)
Domestic Work (Employed) = 1	-1.196***	-1.195***	-1.113***	-1.200***
	(0.00695)	(0.00745)	(0.0167)	(0.0107)
Rural = 1	0.00557***	-0.00370**	-0.0288***	0.00323
	(0.00178)	(0.00186)	(0.00460)	(0.00257)
Constant	11.31***	11.32***	11.27***	11.17***
	(0.0102)	(0.0106)	(0.0214)	(0.0149)
Observations	1,095,255	978,203	198,042	499,295
R-squared	0.439	0.425	0.441	0.392

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A5. Effects of Droughts on Labor Market Status: Chile, Using Dichotomous Measure of Droughts

	Agriculture	Unpaid	Unemployed	Out of labor
Drought = 1	-0.0140***	0.00372***	0.000708	0.0235***
	(0.00162)	(0.000334)	(0.00111)	(0.00152)
Women = 1	-0.105***	0.0112***	0.0237***	0.370***
	(0.000749)	(0.000258)	(0.000601)	(0.000700)
Indigenous = 1	0.0476***	0.00324***	0.00114	-0.0139***
	(0.00164)	(0.000442)	(0.00105)	(0.00141)
Woman*Indigenous	-0.0487***	0.00133	0.00519***	0.00506**
	(0.00235)	(0.000863)	(0.00179)	(0.00205)
Drought*Woman	0.0478***	-0.00589***	-0.00651***	-0.0528***
	(0.00209)	(0.000556)	(0.00173)	(0.00217)
Drought*Indigenous	-0.00410	0.000674	-0.00109	-0.0167***
	(0.00506)	(0.00147)	(0.00324)	(0.00438)
Drought*Woman*Indigenous	-0.0160**	0.00256	0.00192	0.0227***
	(0.00730)	(0.00269)	(0.00560)	(0.00668)
Schooling (years)	-0.0220***	-0.000504***	-0.00308***	-0.0184***
	(9.80e-05)	(2.47e-05)	(6.59e-05)	(8.87e-05)
Age (years)	-0.000913***	-0.000132***	-0.00304***	-0.00317***
	(2.94e-05)	(8.22e-06)	(2.23e-05)	(2.78e-05)
Married = 1	0.00997***	0.00158***	0.0404***	0.0220***
	(0.000709)	(0.000202)	(0.000528)	(0.000680)
Rural = 1	0.304***	0.00890***	-0.0235***	0.0297***
	(0.00104)	(0.000262)	(0.000606)	(0.000782)
Constant	0.396***	0.0260***	0.171***	0.469***
	(0.00344)	(0.00126)	(0.00269)	(0.00375)
Observations	1,127,391	1,132,552	1,231,875	1,913,033
R-squared	0.325	0.013	0.041	0.179

Note: All regressions include municipality fixed effects and a time trend. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 2. Qualitative Research

In addition to our quantitative analysis, which to some extent constitutes our main source of information, we add a qualitative study to capture perceptions regarding water scarcity for indigenous women. The main contribution of this phase is to link the differences in labor market outcomes encountered in the quantitative section, with perceptions and to provide a more comprehensive picture of the phenomena of water scarcity associated with the within-municipality location of groups and other potentially ignored variables at the local level. This phase follows a comparative case selection strategy to ground research in concrete local settings, to ensure an adequate variety of biocultural and institutional configurations.

We carried out a qualitative study of two cases: Pitrufquén in the south of Chile (Mapuche communities) and Alto Loa in the north (Lickanantay and Aymara communities), both with a high percentage of the rural indigenous population. A purposive qualitative sample of 14 indigenous women was used in each case, using the semi-structured format. The interview addressed four main topics: perceptions of water scarcity in general, perceptions of its differentiated effects on Indigenous Peoples; perceptions of its differentiated effects on women; and finally, strategies for adaptation and management of water scarcity at a local level.

The qualitative nature of the research implies that the methodological design is based on a comprehensive and pertinence criterion, and not on a statistical representativity one. The sampling is made considering every component deemed relevant for the problem at hand. In this case, a sampling technique focused on "model cases," where the heterogeneity within the cases can be represented. According to this, participants are selected according to the following attributes: gender (focus on indigenous women), belonging to Indigenous People and main occupation (50 percent farmers, 50 percent other activities). The results below are based on these case studies.

A.1 Pitrufquén

The district of Pitrufquén is located in the Araucanía Region of Southern Chile. In this district, 33.91 percent of the population belongs to the Mapuche People. The research was carried out in the context of long-standing conflict over demands for autonomy and territory by these Indigenous people. This conflict has become particularly intense in the last five years. The situation of the Indigenous communities that were part of this study is marked by three elements, all products of the colonization process and all the basis of the demands of the indigenous movement: i) the

predominance of small plots (less than 5 hectares, but the majority smaller than half a hectare), ii) the lack of regularization of the community land titles, and iii) Indigenous communities' lack of water rights and irrigation infrastructure. Despite this, and given the climate of the region, the water shortage phenomenon is no more than a decade old. It began with the megadrought (2010), and its effects are concentrated in the spring and summer. In these seasons, the weekly drinking water supply for most Indigenous communities in this area is delivered by water trucks.

Observations in the field and interviews show that agriculture is an important productive activity for women's households. However, given the size of the properties and the water rights situation, agriculture is not the main household income. Normally, the primary income comes from the salaries of men—husbands, sons, or grandsons – who work in a range of activities outside the communities: construction and electricity, seasonal work on non-indigenous farms, or forestry lands, among others. However, even though agriculture is not considered the main source of income for the household, with some exceptions, Indigenous women continue to prioritize this activity as a supplementary income and for self-consumption, just as their mothers and grandmothers did. This work centers on the vegetable garden or small greenhouses and focuses on the cultivation of vegetables. In addition, these women also work in silviculture and small-scale livestock farming.

Most of the women interviewed use their production for self-consumption, which helps to reduce food expenses. However, there are also cases of women who produce for commercial purposes in local markets. Among their products are fruits, vegetables, and eggs for sale, in addition to homemade products such as jams, cakes, and knitted goods. They are sold at local markets, through family or friend networks, or informally in public spaces. Funds made this way are considered supplementary income for the household. In all cases, these agricultural activities have been supported by state programs that complement the achievement of certain objectives (for example, a greenhouse). The resources or inputs are small and provided by programs such as INDAP, CONADI, PDTI, and Programa Orígenes–CONADI, to name the most important. The projects financed this way mentioned most frequently are greenhouses, irrigation systems, or rainwater collectors.

The inhabitants of Pitrufquén are supplied with drinking water by the local water company, the system of Rural Drinking Water Associations (Asociaciones de Agua Potable Rural, APR), wells, rainwater collectors and, especially in the summer, from water trucks. Although the

Araucanía region is characterized by a vast network of canals, these are not state-owned and are found on the properties of non-indigenous owners. These landowners historically developed this infrastructure during the German, Croatian, and Italian colonization processes, creating an unequal distribution of water resources between Indigenous communities and non-indigenous landowners. In rural areas, households also have wells, a non-potable water source whose availability is related to climatic variations and the amount of rainfall.

Therefore, the perception of water scarcity has been marked by the decrease in rainfall over the last five years. However, more important is the decrease in the water in the APR system, the drying-up of wells on properties and the decrease in the flow of the Toltén River, which is the main watercourse in the area. For those who get their water through the APRs, the increase in water consumption due to the increase in the resident population and the reduction of supply associated with the shortage has implied that families must resort to other sources and strategies. These include buying water or getting used to water cuts and reorganizing their consumption and activities such as bathing and washing clothes and dishes. Those who have their own well rely on the water trucks in the summer for supply, which according to interviewees, significantly modifies their daily routine. They go to the river to bathe and wash instead of doing so at home, they stop cultivating or reduce the size of their vegetable garden to adapt to the amount of water available, or, once or twice a week, they must fetch water from the river, located some 5 kilometers or more from their land. Although the interviewees do not recognize a differentiated effect in terms of gender, these changes in routine are faced only by the women in the household, significantly increasing their unpaid workload: “So, that’s how it is, as I was telling you, the municipality comes and fills the water tank, the one you can see outside, which is tiny, the drinking water one. And in summer, I have to go to my mum’s house to wash and fetch water; they dug a deep well. So, in the last two years our well has dried up. But my mother’s hasn’t” (Interviewee n°5, woman, Technician in Special Education. November 2022). Another area of perception is the decrease in the flow of the Toltén River. The reduction in the available flow is perceptible in both urban and rural areas, making it difficult to access it and therefore making the related uses of it also more difficult (fetching water, washing clothes, recreational uses).

The perception of the differentiated effects on Indigenous people is marked by a long-standing conflict that places territory and its resources at the center. The interviewees pointed out that as a result of the land situation of the Mapuche people, none of them had water rights, whether

of individual or collective origin. This coincides with the land restitution policy of the National Corporation for Indigenous Development (Corporación Nacional de Desarrollo Indígena, CONADI) which is one of the main tools that has been used to try to resolve the conflict in the area. The policy considers the state purchase of land but does not include the purchase of associated water rights. Not having water rights poses limitations for cultivating the land and the construction and regulation of wells, which add to the existing difficulties in accessing the APR system. At the same time, there is a recognition of the lack of infrastructure to improve water access and use in Indigenous communities, for example, canalization, deep wells, and irrigation systems, especially when compared to large non-indigenous landowners in the area. According to the interviewees, this means that agricultural activities cannot provide a stable and sufficient income for the household. Consequently, young people of both sexes, and men in general, have to look for complementary activities or migrate to urban areas.

Regarding the perception of gender-differentiated effects, most of the women interviewed reported overseeing domestic and agricultural work in their households. Among these tasks are those that use water, such as washing, cleaning, irrigating, cooking, and looking after the children, animals, and the vegetable garden. Given that it is the women who carry out these tasks, they are the ones who perceive, face, and adapt their households to the effects of water scarcity in the area. The interviewees report that they must reorganize water consumption in their homes and reduce overall consumption. This implies that "You have to bathe the old-fashioned way. Use just what is necessary. And when there is a little drinking water, put it in a tank. And leave the water stored there. That way you have it for consumption, lunch, and all those things. Prioritizing is the only way" (Interviewee n° 1, female Indigenous smallholder, November 2022). This reorganization directly affects the unpaid workload of Indigenous women. On the other hand, another issue highlighted by the interviewees is the limited water available for irrigating their vegetable gardens due to the water drop in the wells that happens in the summer months. This implies that crops are limited, or greenhouses are abandoned with direct consequences on income from two sides: on the one hand, there are no sales of these products, one of the household's complementary incomes. On the other hand, households must buy fresh foods at the market they used to produce themselves, which implies an additional expense for the homes: "For example, I produce all the vegetables, do you understand? And I've had to reduce my production, especially between November and March, so to speak, because water is very scarce, the water in the streams reduces, and the wells go down.

We have the APR system here, but we're not authorized to use drinking water for irrigating crops when there is little water in the summer" (Interviewee n° 15, female Indigenous smallholder, November 2022).

Finally, the data collected in the fieldwork, both from observation and in the interviews, show an interesting aspect in the study of the daily management of the effects of water scarcity, which could constitute strategies that could contribute to public policy for adaptation and mitigation of climate change in the Indigenous population. The role of Indigenous women stands out in this management, as they are the ones who most frequently develop strategies for the rationalization of water use and/or the use of nearby sources. These include the reuse of water, the adaption of kitchen sinks and washing machines for the reuse of water in greenhouses and vegetable gardens, the installation of rainwater collectors, and the installation of domestic irrigation systems in vegetable gardens.

A.2 Alto Loa

The towns of Alto Loa are located in the Loa Province of the Antofagasta Region, in the northern mountainous area of the region. In this region, 8.6 percent of the population belongs to Indigenous peoples, most notably the Likan Antai and Quechua peoples. The situation of the Indigenous communities in this area is marked by three elements. First, they are communities found in an arid environment, where water scarcity is marked by the decrease in the water flow of the last decade. Previously, piping and contamination of rivers due to mining activity were the cause of scarcity; The second element is the presence of community lands and water rights, which although scarce have been duly regularized. Some are in the process of recovery through purchases made by the State in the framework of Indigenous Law 19. Finally, there is some irrigation and canalization infrastructure typical of pre-Hispanic Andean cultures. This, together with targeted financing in the area through specific programs for small indigenous agriculture, has allowed better use of water in a context of extreme scarcity.

Our research findings, both from interviews and observation, show that agriculture is an important productive activity for the communities of Alto Loa that complements high-altitude grazing. However, it has become a complementary activity to others due to the sustained scarcity of water that has been aggravated by the piping and contamination of rivers. Most of the households of the people interviewed have income from tourism, small businesses, and jobs in the

mining circuit, although not necessarily in specific mining operations. Agriculture plays a relevant role for local older women, for whom this activity provides the main source of household income and has cultural value. This relevance seems to decline in the homes of young and adult women, where the principal income comes from activities linked to commerce and tourism, work carried out by the women and their partners. In these cases, they maintain plots in community lands and seasonal residences. This is primarily due to the lack of educational establishments in the highland towns, which forces families to move with their children to the regional capital city Calama.

Agricultural activity is carried out on small farms focused on growing vegetables, mainly carrots and lettuce, but quinoa and corn are also grown. Agriculture and grazing are both for self-consumption and sale. Principal products and by-products include vegetables, cereals for livestock feed, baked goods and pastries, and wool. These products are traded by individuals in the markets and streets of Calama.

The inhabitants of Alto Loa are supplied with drinking water through the system of Rural Drinking Water Associations (Asociaciones de Agua Potable Rural, APR), tanks, water trucks, and wells. These associations were established no more than fifteen years ago, following an episode of contamination of the Loa River. This event prompted the municipalities to solve the problem of the communities directly served by this water basin. The APR system has a plant in the town of Lasana, located in the highest area. The supply from this plant is intermittent due to the lack of water and maintenance and the increase in population in an area of extreme scarcity. This has meant that the towns in the lower part of the basin, such as Chiu Chiu, have water supply problems, going without water for days or during specific periods.

To find solutions to this problem, local stakeholders, including neighborhood associations, municipalities, and the main mining company in the area, CODELCO, have established an alliance for the provision of tanks located in community areas and homes and water trucks that distribute and sell water.

In this context, the perception of water scarcity is marked by two elements: first, by the decrease in the flow of the Loa River, the primary source of water in the area and, indeed, the longest river in the national territory. In the agricultural sector, the reduced flow of this river is perceived as the main reason for the difficulties in irrigating and maintaining crops affecting their size and quality. As a result, crops have ceased to have the value they had, and trading them has become difficult. Our interviewees point out that on a day-to-day basis, this has been resolved

through the farmers organizing under a shift system. Unlike in other territories, this system functions without regard to water rights but rather in terms of equitable resource distribution according to availability. This implies that farmers must adjust the area they cultivate to the available water, leaving some parts of their land uncultivated. In addition, the decrease in available water has impacted the cultivation methods, changing them according to the interviewees. Thus, the introduction of greenhouses as a technique is beginning to spread in the area: they allow crops to be grown in a smaller area with less water and to replace vegetables with quinoa and corn, which are adapted to arid climates. One of the interviewees said. "We are making changes in the crop. We are also moving away from, reducing our sowing of carrots. Changing to corn. These little things mean you don't need so much water. For example, 3 to 4 days after sowing carrots, you must water them at least 4 days later so they don't dry up. On the other hand, with corn, you can water it after 8 days; these are the little things that we've been changing" (Interviewee n°7, woman, farmer, January 2023).

Secondly, the perception is also marked by the lack of water available in the APR system and the repercussions this has on inhabitants' daily lives. As one of the interviewees points out: "We have to wait for the water, sometimes around 5 in the morning. I have a small house in town, there as it's further downhill, sometimes the water arrives, a little arrives. There's been a great need for water this year: it's dried up several days. We haven't had water since before November; we've had no water for more than a month, but we still have to pay for it" (Interviewee n°10, woman, farmer. January 2023). The people interviewed point out that this poses difficulties for carrying out domestic and care work, as well as those chores linked to agricultural production. In the domestic sphere, the interruption of the water service for hours or days implies problems, in particular for cleaning and feeding.

The perception of the effects of water scarcity on Indigenous peoples is marked by the conflict over territory and its resources that affects all of the country's Native Peoples. In this context, the land distribution policy implemented by National Corporation for Indigenous Development, CONADI, has involved the purchase of land and water rights in this area. In particular, the women interviewed reported having individual or collective water rights. However, possessing these rights does not seem to solve the difficulties in accessing the required water; they remain due to the sustained drop in water flow.

Regarding the differentiated effects in terms of gender, the female interviewees perceive that it is women mainly who adapt practices linked to the domestic and care work mentioned earlier. This results in an increase in their unpaid work and daily difficulties which prevents them from inserting themselves in other areas that could provide them with income, such as working with artisan cooperatives, preparing food for mining companies, and working in commerce and tourism. Among those effects perceived as particularly difficult are the rationing of water for cleaning and food, its storage in containers to cover periods when the service is cut off, its transport from nearby tributaries, and the purchase of water. As one interviewee, the owner of a small tourist restaurant, pointed out: "We buy water only for the restaurant, for the bathroom. They charge me $25,000 Chilean pesos to put it in the tank. We need water for washing the dishes, for the bathrooms, so we have to order it to be delivered to fill the tank" (Interviewee n°3, woman, micro-entrepreneur in tourism. January 2023).

In the case of women engaged in agricultural production, adapting to the effects of scarcity also involves transporting water from the main tributaries and organizing themselves under a shift system. This means a significant increase in the women's workload: they need to modify the watercourses to allow for storage and/or carry out irrigation in the very early hours of the morning, a task particularly difficult for older women. Regarding this, one of our interviewees said, "We receive water from the canal. When there is water, we have water, but when there is not so much, we have to irrigate at night or fill a retention pond, and with that, we can irrigate" (Interviewee n°9, woman, farmer. January 2023).

The problems associated with water have motivated the women from the towns in the area and others who have migrated from them to organize. Among the most important leading organizations are the Loa Women's Network and the Coordinating Committee for the Defense of Loa River and Mother Earth. This latter group has also had significant participation from women. This is noteworthy, given the Andean authorities are strongly masculinized. However, Indigenous women have played a central role in the organization and demands regarding water scarcity, thus making the conflict visible.

B. Conclusions

Despite the fundamental differences in ecosystems, worldview, and agricultural production systems, the findings in both cases have some general elements. We would like to highlight these factors here to contribute to a reflection on water scarcity, women, and Indigenous peoples. First, Indigenous women perceive the effects of water scarcity on their agricultural activities and, consequently, their family income, either due to reduced crops for self-consumption or for supplementary household income. Despite this, they do not consider this reduction in agricultural activity as a critical element when evaluating their household income since most of their income comes from other activities, either their own or from other members of the household. As a result of this same decrease in the resource, Indigenous families have been gradually abandoning farming as their main activity. Secondly, although they do not perceive differentiated effects on women, the interviewees recognize a transversal increase in the domestic burden and paid work that is mainly assumed by the women in the household. This point is particularly relevant because it prevents the women from developing other occupations and/or activities that could strengthen their income and autonomy. The importance of the women is also shown in their role in the community and protest activities related to water: they lead these activities despite the fact that normally Indigenous authorities tend to be masculinized. On this point, those who carry out the tasks of adaptation to scarcity are primarily women. Therefore, when designing policies for mitigation and adaptation to climate change with cultural relevance in the future, it is important to recognize that water scarcity impacts women to a greater extent and that they occupy leadership roles in these scenarios.