

Article

Mining, Urban Growth, and Agrarian Changes in the Atacama Desert: The Case of the Calama Oasis in Northern Chile

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Abstract: Since the mid-twentieth century, Latin American rural territories have undergone significant transformations. One of the leading causes is the expansion of large-scale operations that exploit natural resources for world market exportation with low processing. In this paper, we study the changes in agricultural activities, livestock, and land use in the Calama oasis (the Atacama Desert, northern Chile) in relation to the growth of large-scale copper mining and other chained processes (urbanization and increased demand for water resources); based on a mixed methodology combining descriptive statistics, archival and bibliographic review, ethnography, and spatial analysis. We present the results through a historical reconstruction of the analyzed dimensions and their relationships, accounting for contradictory dynamics in time and space. We identify how mining and urban growth promote some agricultural and livestock activities under certain economic and political conditions, while in other contexts, these activities have been severely weakened, seeing increasing urbanization of rural land, rural-urban pluriactivity, and a growing deagrarianization.

Keywords: extractivism; capitalist periphery; rurality; urbanization; rural-urban pluriactivity; deagrarianization; depeasantization; rural proletarianization; south-central Andes



Citation: Calderón-Seguel, M.; Prieto, M.; Meseguer-Ruiz, O.; Viñales, F.; Hidalgo, P.; Esper, E. Mining, Urban Growth, and Agrarian Changes in the Atacama Desert: The Case of the Calama Oasis in Northern Chile. *Land* **2021**, *10*, 1262. <https://doi.org/10.3390/land10111262>

Academic Editors: Carmen Delgado Viñas and María L. Gómez-Moreno

Received: 27 October 2021

Accepted: 17 November 2021

Published: 19 November 2021

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1. Introduction

Since the mid-20th century, global capitalism, national development policies, and widespread urban growth have driven a diverse array of significant environmental, economic, political, and cultural transformations in a significant part of the planet's rural zones [1–4]. In Latin America, agricultural systems and rural land use have undergone considerable modifications, caused by major transnational capital investment, the weakening of smallholder agriculture, rural pluriactivity, urban growth, the overextraction of natural resources, and greater urban–rural interaction, among other things [5–10].

To understand the changes that have occurred in Latin America's rural areas over an extended period of time, it is important to consider that, historically, the continent's participation in the global economy has been based upon the widespread exportation of largely unprocessed natural resources, or extractivism [11–17]. Theoretically, extractivism is a pattern of accumulation that develops in the peripheral areas of global capitalism. As a worldwide economic system, capitalism has historically been organized on the basis of relations between central and peripheral areas. The centers are the preponderant spaces of accumulation, dominating the world market and the production of complex goods

with advanced technology. The peripheries export mainly raw materials and foodstuffs to the centers, transferring surplus labor and natural resources [18–22]. Extractivism, as a pattern of accumulation, is expressed in different types of extractive activities. Extractive operations of all kinds, whether forestry or agricultural monocropping, industrial livestock production and fishing, aquaculture, hydrocarbon extraction, mining, and natural resource-based energy production, are situated in—and directly affect—rural zones. Consequently, these activities have become a determining factor in how rural zones are socially and spatially configured, as well as how they have varied over time and space. In fact, in its development, extractivism has generated different struggles in rural areas between large companies, states, indigenous peoples, and rural communities, among other actors, for the control of the territories and the use of their natural resources [11,23–30].

Among such extractive activities, mining is one of the most historically prevalent industries in Latin America and is particularly well-developed in the Andean area [11,27,28,31–36]. Most studies addressing mining and rurality in the Andes have emphasized the overextraction and destruction of natural resources and changes to the way of life of Andean peasants and other rural inhabitants caused by deagrarianization, rural–urban pluriactivity, migration, and others, focusing on the conflictive dynamics that have arisen as extraction has intensified in recent decades [26,29,30,37–39].

Such investigations have provided valuable empirical and theoretical data on the processes occurring in recent decades; however, by examining studies that address the links between mining and Andean rural zones over a more extended period of time [32,40–42], highly contradictory trends can be observed. Today, the depletion and destruction of natural resources and accelerated changes to ways of life are the norms; yet, in other times and places, the processes driven by mining (e.g., urban growth, mining camps, and company towns) have invigorated certain agricultural activities, while at the same time weakening others. In this sense, further research that considers these relationships from a historical perspective is required to arrive at a more comprehensive understanding of how mining extractivism has led to current circumstances in rural Andean zones.

In this paper, we will consider the growth of large-scale copper mining in the Atacama Desert from the early 20th century to the present, and its connections with the agricultural transformations in neighboring zones, as a case study. Specifically, we will examine the Calama oasis, located in the Loa River basin in Northern Chile. This case study is extremely important for understanding rural transformations related to extractivism. Chile has been the world's leading producer of copper since the early 20th century [43,44]. The Loa River basin, in particular, is home to one of the largest copper-producing hubs on the planet [45]. It includes Chuquicamata, which for most of the 20th century was the world's largest copper mine [44,46]. The development of large-scale mining has driven intense urban growth, and the demand for water resources for mining, industrial, and urban consumption has increased notably [47–50]. The oases, wetlands, and tributaries of the Loa River basin have been inhabited since pre-Hispanic times by indigenous Andean groups engaged in agricultural and herding activities. While these groups' ways of life have undergone significant changes since the dawn of the colonial period, the development of large-scale copper mining and urban growth have accelerated several transformations and endowed rural spaces with new characteristics [51–55].

This article seeks to provide an understanding, through a case study, of the connections between extractivism and rural territories of the capitalist periphery during the 20th and 21st centuries. Below, we describe the case study area, then outline the research methodology. We continue with the presentation of the results in two sections: a description of the expansion of large-scale copper mining and its links to urban growth and access to water resources, and an account of the dynamics of agricultural, livestock, and land uses changes, from the early 20th century to the present, and explain how this relates to the processes addressed in the previous section. We close the article with a discussion and conclusion.

2. Case Study

The Calama oasis is situated at 2200 m above sea level (m.a.s.l.) in the Loa River basin of the hyper-arid Atacama Desert [56]. Precipitation there is extremely low, bordering on zero under 2500 m.a.s.l.; it concentrates at higher altitudes in the summer months and rises with altitude from west to east [57]. Because of this, different types of climates have been identified along the entire length of the Loa River [58], as well as a variety of ecosystem tiers, defined by the physical characteristics of their environment, the presence of water resources, and the predominant flora and fauna [59]. The Calama oasis lies within one of the basin's riparian ecosystems—areas of transition between aquatic ecosystems and the absolute desert that occur between sea level and 3000 m.a.s.l. These ecosystems depend on rivers and other watercourses to shape wetlands, oases, and ravines, which themselves sustain diverse, biodiversity-rich ecosystems. Since pre-Hispanic times, numerous interconnected human settlements have arisen around these ecosystems, and their inhabitants have engaged in agricultural activities up to the present day (in addition to the herding activities carried out in puna ecosystems above 3500 m.a.s.l.) [53,55,60,61].

In terms of political administration, the area under study was part of Bolivia until the end of the War of the Pacific (1879–1884), before being annexed by the State of Chile. At present, the area lies within the municipality of Calama, in El Loa Province, within the Antofagasta Region. Since the early 20th century, large-scale copper mining has been conducted in the area surrounding the Calama oasis, which has driven major territorial transformations, as this article attests to throughout. Figure 1 shows the location of the present-day city of Calama and the vegetative cover at the oasis, as well as the city's proximity to the main mining deposits, tailing ponds, and waste heaps.

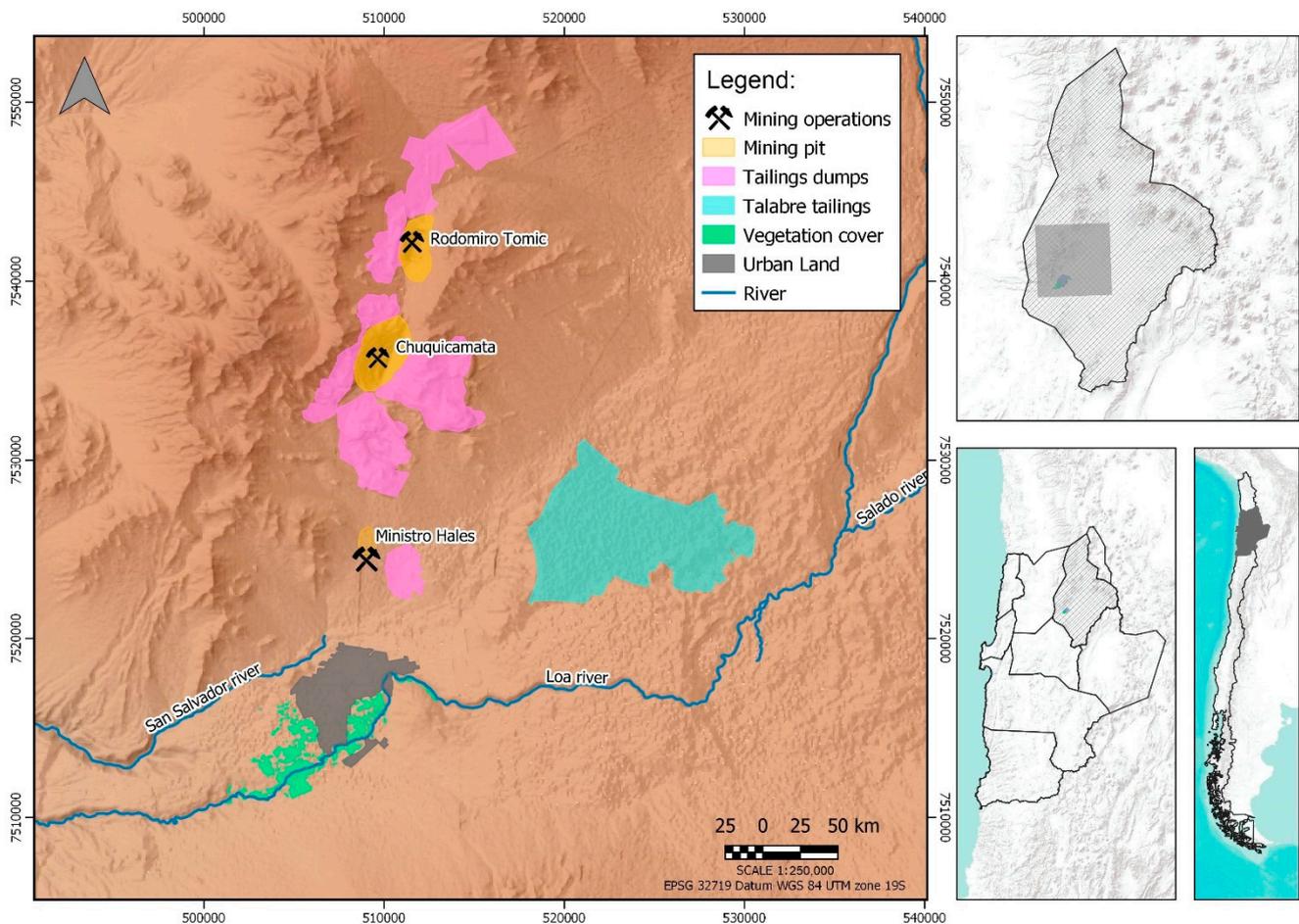


Figure 1. Location of the Calama oasis, Calama commune, Antofagasta Region, Chile, with the closest mining operations.

With regard to population, the 2017 census [62] counted 160,091 people residing in the case study area (158,487 in the city of Calama and 1604 in the rural zones of the oasis). In other words, the census reported that 97% of the total population of the municipality (165,731) resided within the case study area. In the municipality, 25% of the population (39,724 people) self-identified as indigenous, and 37,662 people said they lived in the city of Calama (95% of the indigenous population).

3. Methods

The study adopted a mixed research design that combined descriptive statistics, archival review, and bibliographical sources with ethnographic work and spatial analysis using geographic information systems. The data were grouped according to the main dimensions of interest and presented as a processual historical reconstruction, in which the different aspects were gradually concatenated.

The statistical data were used to highlight the quantitative growth of copper production in mines relevant to the case study, as well as the expansion of the urban population in the zone. Information on the mining production was compiled from the databases of the state-run Chilean Copper Commission (Comisión Chilena del Cobre, COCHILCO), where production for each copper deposit was obtained for the 1960 to 2019 period. Information on the urban population was obtained from government population and housing censuses conducted between 1907 and 2017. The information was processed through a univariate descriptive analysis of frequency distributions that enabled us to assemble time series [63].

Archive and bibliographical sources were used to support the historical reconstruction of the different dimensions analyzed and are thus present throughout the article. Press files from the local newspaper, *El Mercurio de Calama*, were collected from the Chilean National Library for the 1968–1973 period. Furthermore, a search for bibliographical sources was conducted in different institutional repositories and the main databases of scientific journals. The data were analyzed according to central themes and coded using qualitative analysis software.

The ethnographic data aided in the historical reconstruction of the different dimensions of analysis, primarily to illuminate the agricultural transformations in the case study, based on the subjects' own experiences. The fieldwork was conducted between 2016 and 2019 in different field campaigns. Data-collection methods included participant- and nonparticipant observation, semi-structured interviews, and open-ended conversations. Fourteen semi-structured interviews were conducted with farmers (four men and ten women) and six with informants from public services and mining companies (five men and one woman). We include the ethnographic interview guideline (in Spanish) as Supplementary Material (Table S1). The data were analyzed based on the central themes and coding with qualitative analysis software.

Subsequently, agrarian transformations in the Calama oasis and the city's expansion were represented spatially, with changes in land use shown by quantifying urban growth and the reduction of vegetation cover (farmed crops and "vegas"—high Andean wetlands used for grazing animals). Analysis of the change in vegetation cover was conducted by comparing 1955 Aerservice overflight images taken by the Chilean Military Geographical Institute (Instituto Geográfico Militar, IGM) with Landsat satellite images from 1986, 1996, 2006, and 2016. With regard to the urban area, a 2010 vector layer obtained from the government website Chile Geospatial Data Infrastructure (Infraestructura de Datos Geoespaciales de Chile, IDE) was used and compared with our own vectorization of the urban radius from 2019 and with remote-sensing images [64].

Figure 2 shows a workflow diagram of the methodological design and its execution:

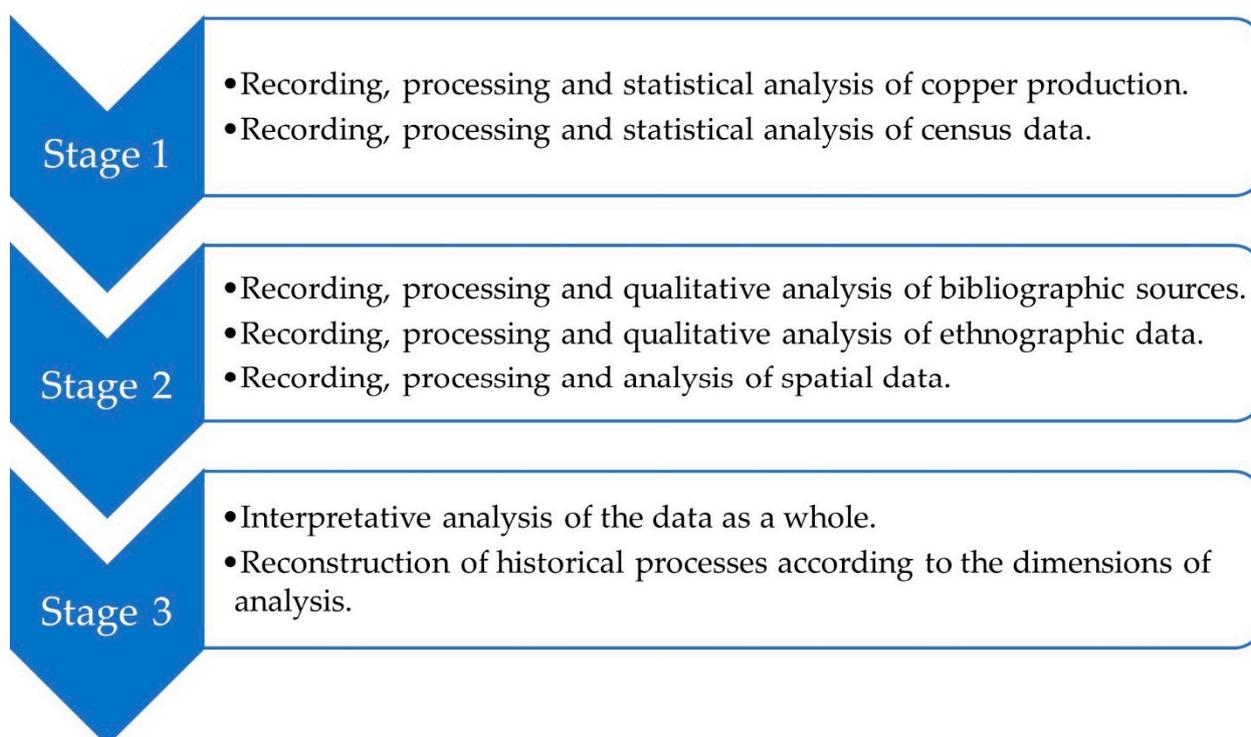


Figure 2. Workflow diagram of data recording, processing, and analysis activities.

4. The Expansion of Large-Scale Copper Mining, Urban Growth, and Access to Water Resources

This first results section characterizes the development of large-scale copper mining, which is the predominant extractive activity in the study case. This is followed by a description of the urban growth resulting from the copper expansion and then the changes in the access forms to water resources that have driven large-scale mining and urbanization. Both urban growth and transformations in water access are the two most essential processes derived from the expansion of extractivism and are crucial to understanding the changes in agricultural and livestock activities and land use in the Calama oasis.

4.1. Development of Large-Scale Copper Mining

In 1915, 20 km from what was then the town of Calama, the US-owned Chile Exploration Company (Chilex) opened the Chuquicamata copper mine. Before then, the area had been mined by individual miners, called *pirquineros*, and small and medium-sized companies. In addition to opening up the deposit, Chilex built a series of infrastructure works, including a copper oxide treatment plant, an internal railway line to transport the ore, a thermoelectric plant on the coast and a transmission line to the mine, an ore processing plant, a camp to house 15,000 miners and their families, and a network of intakes and pipes for extracting water from the upper reaches of the Loa River basin and transporting it to the mining operations and camp. When it opened, Chuquicamata became the largest copper extraction operation in Chile, and indeed the world, and remained so for most of the 20th century [44,46,65].

During the first half of the 20th century, Chuquicamata's production grew steadily, and by the end of the 1950s, it accounted for 57% of all copper extracted in Chile [66]. From 1950 to 1970, modernization projects were implemented in the large-scale copper mining industry in Chile and throughout the world [67]. In Chuquicamata, a new sulfur plant was opened, along with a modern housing development for workers, many industrial processes were automated, and machinery was updated. In addition, a new refinery was opened, and new water intakes and infrastructure were built, alongside other innovations [47,49,67].

The mine also introduced new workforce management policies, which included moving some of its workforce to the city of Calama [67]. This modernization process occurred at a time of internal upheaval in Chile that included intense labor disputes at different mines and an environment of intense public debate around the international control of Chile's large-scale copper mining sector [44,46,67].

Despite the above-mentioned initiatives, production did not increase as much as expected. The large-scale copper mining industry, and Chuquicamata in particular, remained at the center of public debate in Chile. Between 1966 and 1969, during the administration of Christian Democratic President Eduardo Frei Montalva (1964–1970), the Chilean State acquired a majority interest in the country's large-scale copper mining sector. Subsequently, in 1971, the government of socialist President Salvador Allende Gossens (1970–1973) nationalized the industry, placing all operations under the ownership of the state-owned National Copper Corporation (Corporación Nacional de Cobre, CODELCO) [44,46,67]. As the leading operation in the country, Chuquicamata played a strategic role in the political project of Allende's government [68,69].

In 1973, a military coup ushered in the civil–military dictatorship led by Augusto Pinochet (1973–1989). The regime implemented a series of neoliberal policies that included the privatization of natural resources, public enterprises, and essential services, as well as the liberalization of markets and the movement of capital [70–72]. Nevertheless, aware of the role that large-scale mining played in the national economy and the revenue it generated for the functioning of the Chilean State, particularly its Armed Forces, Pinochet did not privatize the large mines that had been nationalized in 1971. The regime limited itself to designing the institutional framework that ultimately enabled the expansion of large-scale private mining from 1990 onward under successive democratic neoliberal governments [73,74]. As such, Chuquicamata remains the property of the Chilean State to this day.

Prior to 1990, Chuquicamata was the only large-scale copper mine in the Loa River basin. It was later joined by the state-owned Radomiro Tomic (1995) and Ministro Hales (2013) mines and the public–private El Abra (1996), all situated in the municipality of Calama. These new investments intensified copper extraction in the area, with the production of the mineral rising from 681,000 metric tons (MT) in 1990 to 885,000 MT in 2019. Production peaked in 2004 at 1.2 million MT [75].

An important aspect for understanding the territorial processes associated with copper mining expansion over time is that, regardless of the political orientation of any given administration, in operational terms, management of the mines has focused on constantly increasing production [76–78]. While accelerations and slowdowns have occurred at different times in the evolution of copper production in the Loa River basin throughout the 1960–2019 period (Figure 3), the overall trend shows an increase in extractive capacity, most notably in the 1975–1990 and 1995–2005 cycles.

4.2. Urban Growth

While small and medium-scale mining activity in the Chuquicamata area prior to 1915 had drawn workers from other parts of Chile [65] and Bolivia [79], the scale of the Chilex operation significantly increased the urban population of the Antofagasta Region [47,80]. It must also be considered that the construction of a camp for 15,000 people rapidly reconfigured the demographics and functioning of the territory [81].

The camp's population grew steadily from the beginning of mining operations at Chuquicamata until the mid-20th century (Figure 4), before the number of residents stabilized at around 24,000 in the 1952–1960 inter-census period. From then onwards, the population gradually decreased until the 2002 census. It should be noted that the camp was closed in 2007, and its population relocated to Calama, owing to the expansion of productive operations [81]. Meanwhile, the population of the city of Calama also rose with the opening of Chilex operations, but at a different pace than the camp. The city's population increased slowly until the 1940s, at which time it began to rise much more

sharply; it has continued to do so up to the present. The 2017 census reported 158,487 people living in the city.

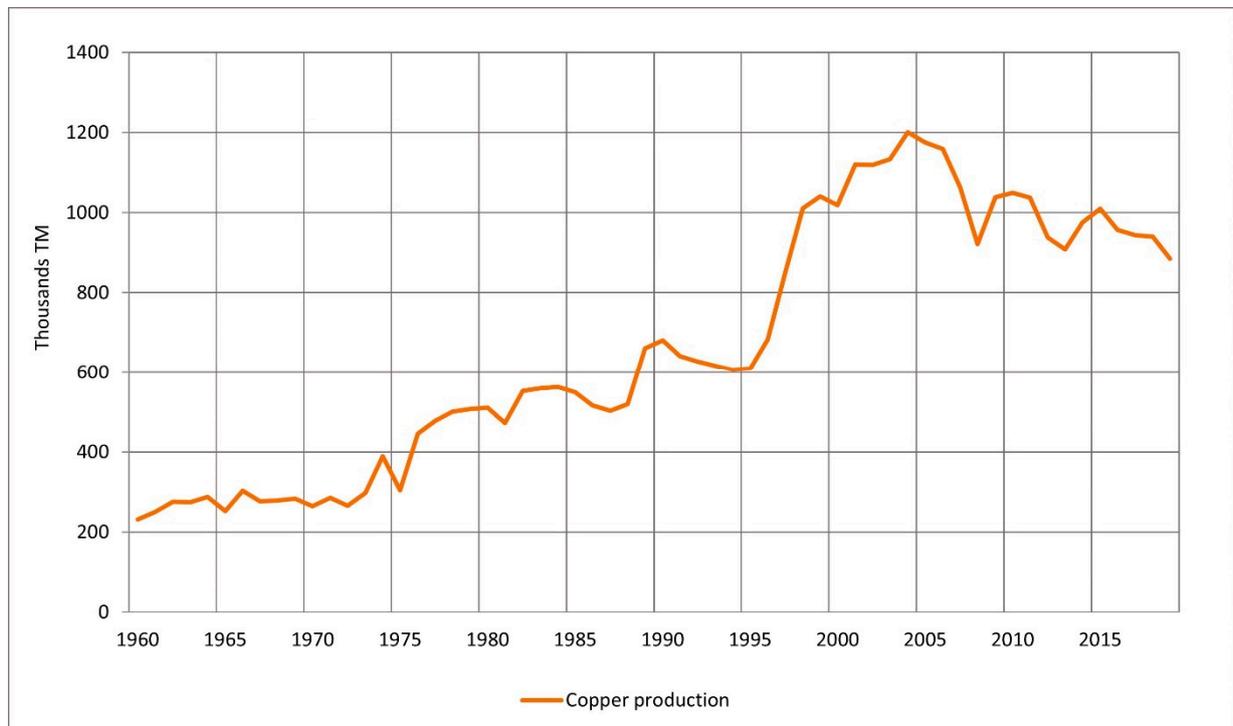


Figure 3. Production of large copper mining in the Loa River basin in thousands TM.

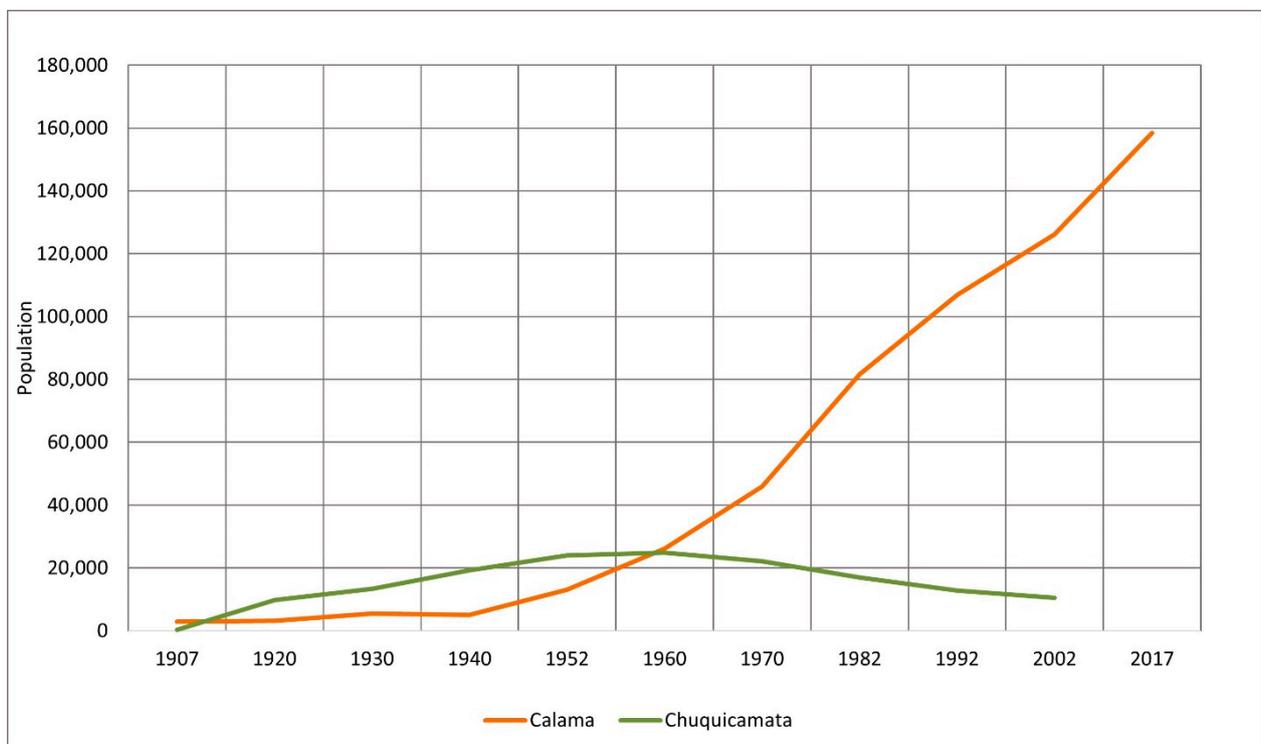


Figure 4. Population growth in the cities of Calama and Chuquicamata.

Calama has experienced two periods of urban growth, both linked directly to corporate policies introduced at the Chuquicamata mine. The corporate modernization and

productive expansion policies that were favored from 1950 to 1970 included moving workers and their families to Calama and limiting the population of the camp. By 1970, 32% of the Chuquicamata workforce resided in Calama [67], where the company had built several housing developments for its workers and their families [81–84].

Another factor in Calama's growth was not linked directly to mining but caused by the attractive employment opportunities in sectors of the economy associated with mining expansion and urban growth. A significant proportion of new migrants have been relatively unskilled individuals working in low-paying jobs, and many have erected their own homes informally on the outskirts of the city, in areas without essential services [85–88].

In light of the social problems and impacts on quality of life associated with the above, the Chilean State has instituted several programs related to housing regularization, formal construction, essential service installation, and urbanization in general. From the 1960s to the 1980s, these programs essentially relied on government action and pressure from residents [89,90]. From the 1990s to the present, however, urban growth projects have sought to implement public services in collaboration with large-scale public and private mining concerns in the area [91,92]. Nevertheless, critiques about the poor quality of life in the city, and the impact copper mining has had on it, have been at the center of social mobilizations in recent years [93].

Lastly, growth in the city of Calama, whether through state action or corporate policy, has extended the city into nearby agricultural lands and vegas [64,94–96]. At certain moments, this has led to disputes among farmers, authorities, and other stakeholders [97–99]. According to our ethnographic records, this situation is ongoing, with housing development prioritized over agricultural development and care of the vegas in the Calama oasis. In the opinion of those interviewed, this has been one of the leading causes of the deagrarianization process in recent decades.

4.3. *The Access to Water Resources*

Since the late 19th century, the demand for water from the Loa River has grown considerably with the expansion of the nitrate industry in the region, the building of the Antofagasta–Bolivia railway, and the growing demand for drinking water for mining camps and cities [48,100]. Water resource extraction and the privatization of water rights rose sharply from 1915 onward with the development of large-scale copper mining and the accompanying urban expansion; complex systems of intakes, pipes, and storage ponds were also built along the basin [47–50,101].

Due to increasing demand, between 1888 and 1920, a series of local-regional regulatory instruments were developed to govern the ownership and usage of water from the Loa River [100,102]. When the Chilean State began enacting national water codes (in 1951, 1967, and 1981), water management came under the purview of these laws. In both local-regional and national regulations, agricultural and livestock activities in general, and smallholder agriculture in particular, have been negatively impacted [50,103,104].

The 1920 regulation prioritized the nitrate industry, the railway, urban consumption, and the copper industry; at the same time, irrigation was allocated less water than it was using. The studies underpinning the regulation [102] estimated that Calama's irrigation canals captured an average 3 L/s per hectare (ha), which was used for irrigating crops and vegas. Nevertheless, some argued that watering the vegas was a waste of resources [102]; this ignored their role in grazing livestock, which was primarily carried out by indigenous peasants. The regulation ultimately authorized 1.5 to 2 L/s per ha for the irrigation of crops and expressly prohibited the irrigation of vegas. In contrast, 500 L/s was reserved for potable water and the railway, 400 L/s for nitrate production, and 300 L/s for industrial use and ore processing.

The national water codes of 1951 and 1967 granted the Chilean State significant regulatory powers, with the 1967 code strengthening its expropriation authority over all private water rights [105]. Under the new regulations, new water rights in the Loa River basin were allocated for large-scale copper mining and urban consumption, and water extraction

increased with new intakes, pipes, holding ponds, and a very large reservoir [47,50,101]. During these years, Calama's farmers complained to the authorities that the works were impairing their irrigation capacity in the oasis and threatening agricultural activity [106]. Nevertheless, as the following section shows, at the same time—and perhaps in an attempt to counteract the above-described effects—the State implemented several agricultural development projects in the area under study.

The Water Code of 1981 was one of several neoliberal policies implemented by the Pinochet-led dictatorship (1973–1989) [105,107]. Essentially, it strengthened private ownership of water resources and sought to establish a market for water rights by separating the ownership of land from the ownership of water. The Code was implemented in the Loa River basin between 1982 and 1984, granting individual private ownership to farmers in the basin's main agricultural sectors, including the Calama oasis (the other localities were Quillagua, Chiu Chiu, and Lasana) [50,108,109]. The goal was to define specific ownership rights for farmers, thereby freeing up surplus water for mining and potable uses. In fact, the report supporting the regulation of water rights explicitly stated that the priorities for allocation were, in the first place, potable water, followed by the extractive industry, and, thirdly, irrigation [110]. Furthermore, the report argued that the irrigation of vegas should be restricted [108,109]. This is a common practice in the Andes, but states have usually kept it hidden [111]. Thus, when farmers' individual water rights were registered, less water was recorded than was actually used. Technical and administrative staff did not count the irrigation of fallow lands or vegas and employed deception and other tricks (telling farmers that irrigation water would have to be paid for in the future), as well as confusion (farmers had no way of translating their traditional irrigation practices into liters per second) and fear (as this occurred during the dictatorship, some farmers reported that they would not have been able to oppose the policy) [50,108,109].

The Ley Indígena (Indigenous Law) of 1993 (19,253) enabled indigenous associations and communities, as well as indigenous individuals, to register water rights in their own name and use funds provided under the law to purchase them on the market. In this way, the farmers of the Calama oasis have been able to recover or retain some of the water they were legally dispossessed of when the 1981 code was implemented [112]. However, because of the multiple surface and groundwater rights granted to the mining industry and potable water companies since the Water Code has been in force, in 2000, Chile's National Water Authority (Dirección General de Agua, DGA) declared the surface water of the Loa River exhausted [113].

In retrospect, the dynamic described has generated different episodes of water dis-possession and disputes since the emergence of large-scale copper mining to the present, with the involvement of several main stakeholders—indigenous farmers and irrigators in the Loa basin, Chile's large-scale copper mining companies, potable water companies, and the Chilean State [50,52,54,104]. One of the first water disputes documented in relation to Chuquicamata occurred near Calama before 1920 when a landowner in the city accused Chilex of building a pipe to steal water that he owned. Only after the court ruled against the company did it stop extracting water [114].

5. Agrarian Change and Deagrarianization

This second section of results characterizes the agricultural, livestock, and land-use changes in the Calama oasis. It is shown how these transformations are directly connected to the expansion of extractivism and its derived dynamics, presented in the previous section.

5.1. Agricultural and Livestock Activities before the Development of Large-Scale Copper Mining

During the colonial period (16th–18th century), the Calama oasis maintained an agrarian structure that, with some changes over time, remained essentially the same until the early years of the 20th century [48,61,115,116]. Overall, there were two main economic sectors in the area, which coexisted and had dealings with one another. On the one hand,

were the large-scale farming estates that occupied the most arable lands. They focused on growing alfalfa to be sold as forage and leased space for grazing livestock (mainly cattle in transit). The owners of these lands had removed themselves from direct production and thus required day laborers. They also had business and mining investments in the region and constituted a local bourgeoisie with multiple interests. Their operations had ties with agricultural markets and the circulation of merchandise in general. This kind of operation was under the control of the non-Indigenous population: first, Spanish colonial agents; then, beginning in the early 19th century, citizens of the newly-formed nations of Bolivia, Chile, and Argentina, as well as immigrants from other European and Asian countries (e.g., Spain, Croatia, Syria). In contrast, the other type of operation present in the Calama oasis corresponded to smallholdings situated on the land further from town; they had less potential for commercial agriculture because of the size of the farms and the presence of vegas. These farmers grew alfalfa and corn and grazed sheep, llamas, goats, and, to a lesser extent, cattle on the vegas. They consumed what they produced and occasionally sold or traded with other indigenous farmers or groups. The family provided the workforce, and some members also found work as salaried workers (full or part-time) on the larger agricultural estates, in businesses, or in the area's mining activities.

Ten years before Chilex launched its operation, Risopatrón [117] wrote that Calama's commercial agriculture had great growth potential, as there was enough demand for agricultural products at the borax mines of Ascotán and the small mining operations of El Abra and Chuquicamata. In 1913, just two years before Chilex began operations, Bowman [118] noted that there was significant agricultural activity at the Calama oasis, oriented mainly toward the production of alfalfa as forage for the livestock used for hauling (mules) or food (cattle) at the nitrate mines. In fact, he highlighted Calama as the principal forage production center in northern Chile.

In addition to the above, some sources indicate that, before Chilex began its operations, the indigenous peasant population of the Loa River basin increasingly participated in the labor market: as salaried employees in the mining industry, working at higher altitudes (sulfur, borax, and other mines) [119], in small-and medium-scale copper operations that were working the Chuquicamata deposit, and in the Caracoles silver mine (near Calama). This meant that agricultural and livestock-raising activities were already becoming less critical for indigenous subsistence [61,116].

5.2. The First Half of the 20th Century: Urban-Extractive Food Markets and Agricultural and Livestock Dynamism

With large-scale copper mining occurring from 1915 onward, and the nitrate industry in crisis throughout the 1920s [120], the agricultural activities of the Calama oasis became more progressively linked with copper mining in the area and its attendant urban growth. These have become the main factors in explaining its development to date.

In the 1920s, the agricultural system was simultaneously connected to the declining nitrate industry and the expanding large-scale copper mining sector. At the end of that decade, some agricultural dynamics linked to nitrate operations and their markets remained. Rudolph [48] mentions 1780 ha under cultivation, primarily planted to alfalfa, and cattle, in transit from Argentina to the nitrate offices, grazing on the extensive pasturelands; there is also mention of sheep and llamas, which would have provided meat and wool to the local population, grazing on the vegas. The author also notes that care of the crops and herding were tasks that fell primarily to women. Based on this information, we can infer that the male indigenous population was mainly employed in non-agricultural occupations, such as mining or associated activities. At the time, the main hub that attracted workers and offered employment was the Chuquicamata mine, which employed 8000 workers, who, along with their families, accounted for the 18,000 people living at the camp.

From the 1930s to the end of the 1960s, driven by the demand for food from growing urban centers (the Chuquicamata camp and city of Calama), land ownership at the oasis became concentrated. Sanhueza and Gundermann [116] report that, from the late 1920s, the number of small family-run farms further from town and those pasturing their herds

on the vegas dropped. At the same time, more and more land became privatized, and the large estates producing alfalfa and raising cattle and sheep expanded in size, selling their products in the city of Calama and the Chuquicamata camp. These so-called “fincas” dominated the rural space of the Calama oasis until the early 1970s [121]. Their existence explains why the area planted to alfalfa increased by more than 1000 ha in Loa Province between 1935 and 1964 [51]. Their links with local urban markets enlivened these operations, and their base of paid labor made them an employment hub for indigenous migrants from rural towns in the Loa interior (such as Ayquina, Turi, Cupo, Caspana, Toconce, and others) who came to the city of Calama. According to some informants, for those who did not have the contacts or knowledge to enable them to obtain higher-paid employment in the mines or in the city, working on the fincas was one of the more feasible options. To carry out their agricultural and livestock activities, the fincas combined salaried employment (seasonal and year-round) with traditional work relationships that did not involve the payment of a wage [51].

Our ethnographic records and other sources [90] reveal that family-run farming activities continued in places further from the city, albeit in a lesser fashion. Based on the interviews conducted, we identified two crucial differences in how they operated in relation to the previous period: (a) farmers hired themselves out more (to fincas, urban employment, and mining), and (b) the diminishing use of the vegas for grazing, owing to a lack of labor and fewer water resources available to irrigate these seasonal wetlands.

In summary, while, on the one hand, Calama’s population had been growing since the 1940s, on the other, agricultural activity on the fincas and the persistence of family-based agriculture from the 1930s to the late 1960s kept the land around the city predominantly in agricultural use (Figure 5).



Figure 5. Aerial view of Calama in 1966. Source: National Historical Museum Collection (Author: Anonymous).

5.3. *The Second Half of the 20th Century to the Present: Changes in the Agricultural and Livestock System and the Deagrarianization*

The land ownership structure that has been described above changed significantly from the late 1960s onwards. At the local level, it should be noted that agricultural activity on the fincas slowed down as alfalfa sales dropped significantly, along with the demand for forage for livestock [122]. The cattle that had been imported from Argentina were being replaced by imports of butchered meat [123], which weakened the underlying economic dynamic of the fincas.

At the national level, it is important to consider that an Agrarian Reform (Law 16,640) was enacted between 1967 and 1973 in Chile. The law sought to liquidate large agricultural estates owned by landlords and redistribute the land to the peasantry, in addition to modernizing agricultural and livestock production and overcoming the marginalization and poverty that affected the country's rural peasants and laborers. To accomplish this, the government introduced organization and training programs for peasants, invested in equipment and technology, and provided technical assistance. Large holdings were also expropriated, and the Asentamientos Campesinos (peasants' settlements) were formed (a transitory institution formed after an expropriation that functioned as a collective production unit managed by peasants with government assistance) [124].

In the study area, during Frei Montalva's administration (1964–1970), different initiatives were put forward that sought to organize and train peasants, improve irrigation infrastructure, formalize the ownership of small operations, and provide technical and financial assistance and technological support [123,125–127]. During the administration of Allende Gossens (1970–1973), in addition to projects concordant with previous initiatives [88,95,128–130], the largest fincas in the rural areas of the oasis were expropriated [131]. The government argued that the expropriation was justified, as productive activities on the estates had virtually stopped [132].

After the 1973 coup, the dictatorship ushered in a nationwide neoliberal counter-reform that instituted a series of measures, such as the restitution of expropriated properties, the division, sale, and auction of 'settlements' as individual parcels, the liberalization of the land market, and the creation of a water market. This fostered the emergence of small and medium-sized agricultural enterprises and large, high-tech capitalist operations linked to the global market [124,133]. In the Calama oasis, however, the counter-reform acquired a different expression. According to our ethnographic records and other sources [90,134], the peasant 'settlements' were indeed broken down into individual parcels; however, in general, the fincas were not reconstituted, nor were the large agribusinesses formed as planned. We argue that owing to the crisis that had been occurring in the alfalfa market before the Agrarian Reform and the limitations on introducing other crops in the area in question due to the salinity of the water [121,135], those who had owned the fincas moved their capital to other sectors of the economy. When they were given new land or regained possession of their former estates, they sold them to housing developers. Even before expropriations began, owners of the fincas had already been selling their land to developers [94]. Several informants spoke of places in the city of Calama that had formerly been part of the fincas and were now urbanized.

In the 1980s, state investment and development in peasant agriculture decreased. Although there were different initiatives in the Calama oasis [90], those interviewed perceived that state support was reduced and insufficient. Thus, during this time of intense mining expansion, limited access to irrigation water, increased urban encroachment, and lower public investment supporting peasant agriculture, the family smallholdings that had resulted from the parceling of settlements became fewer in the process of deagrarianization that can still be observed today. While, in the 1920s, an estimated 1780 ha of land were under cultivation in the area [48,102], by the end of the 1970s, that area had dropped to just 1112 ha [110], and, by 2006, to 418 ha [135].

As the fieldwork for this case study confirmed, in agreement with Mondaca and Ogalde [90], since 1990, public investment in programs serving peasants in Calama has in-

creased (in the form of loans, subsidies, training, provision of inputs and equipment, animal sanitization, improvements to irrigation infrastructure, and support for non-agricultural enterprises). Organizations participating in the implementation of these programs include the Agricultural Development Institute (Instituto de Desarrollo Agropecuario, INDAP), the Agricultural and Livestock Service (Servicio Agrícola y Ganadero, SAG), and the National Irrigation Commission (Comisión Nacional de Riego, CNR). Chile's National Indigenous Development Corporation (Corporación Nacional de Desarrollo Indígena, CONADI) has also provided funding for the acquisition of water rights and for improving irrigation infrastructure. These activities have occurred in a context in which the historic inhabitants of the oasis have been forming indigenous communities and associations within the framework of the Indigenous Law of 1993 (19,253). These new entities coexist and intersect with older organizations such as neighborhood associations, farmer and irrigator associations, sports clubs, women's centers, and others [90,99,112,136]. These projects have revitalized some agricultural activities and irrigation in certain parts of the oasis; however, they have not affected the forces exerting pressure to deagrarianize, and thus the process continues.

Areas with vegetation cover steadily diminished as the city expanded. From 1961 to 2016, the urban footprint increased by 1549 ha, while vegetation cover fell by 2753 ha (Figure 6). This is because the city has directly encroached upon those areas and because of the abandonment of agricultural activities and the limited irrigation of the vegas.

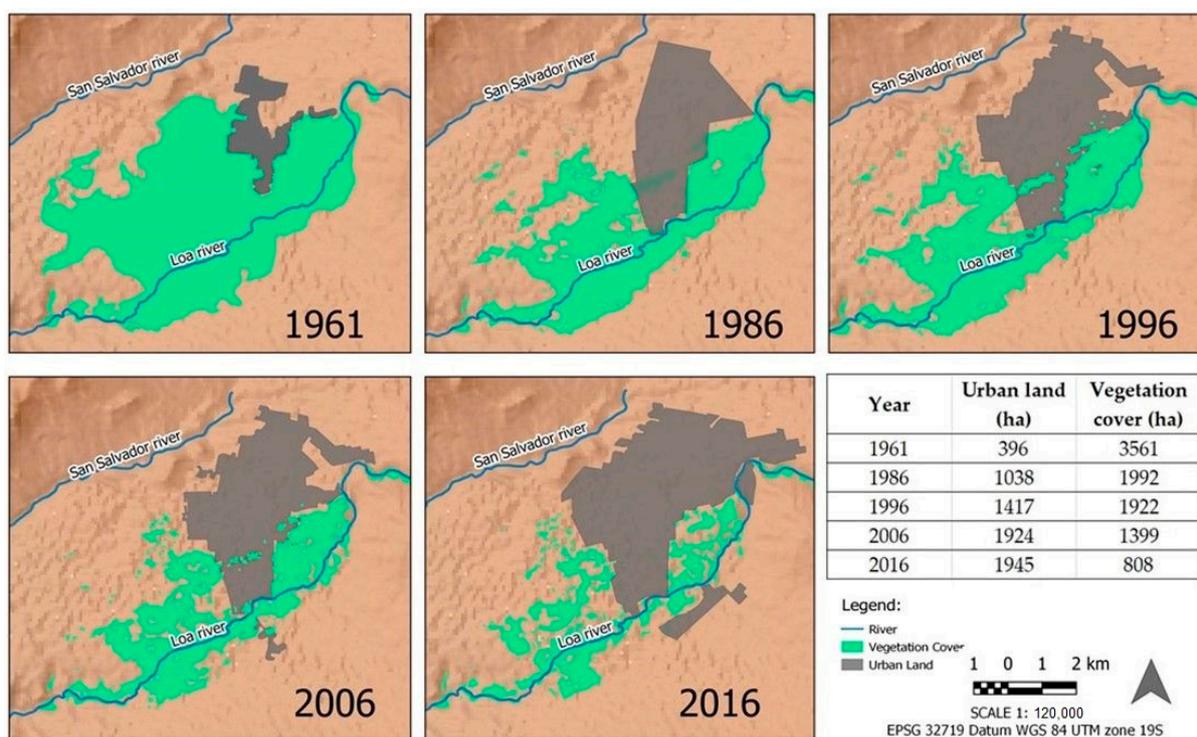


Figure 6. Evolution of urban land and vegetation cover in the Calama oasis (1961–2016).

During the ethnographic work conducted, researchers recorded that there are still some smallholder family farms operating in the Calama oasis today that grow alfalfa and corn (for family use and sale) and raise livestock (for family use and occasional sale). Sheep are the main livestock, although there are also goats, llamas, some horses, and smaller animals (pigs and rabbits) present. Families provide the labor for all of these agricultural and livestock activities. In regard to livestock, the vegas are no longer used for grazing; animals are instead rotated among corrals. This is because of the limited workforce available, the small number of animals, and the poor nutritional quality of vegetation in the vegas. It should be noted that many family members engaging in farming activities do not do so full time, especially the younger generations, who are inclined to seek out salaried

work or self-employment in cities (construction, service, retail, etc.) and, to a lesser degree, in industry or mining operations. In fact, for some families living in rural areas, agricultural and livestock activities play a marginal or even nonexistent role in their livelihood.

As for the sale of agricultural products, our ethnographic data shows that alfalfa is sold directly from the farms to other peasant farmers in the area of study or those in other rural areas of the Loa interior. Some farmers sell alfalfa to the Calama Rodeo Club. Corn is often sold directly from the farm as well, in small quantities to intermediaries. Occasionally, an entire field of corn is sold to a single buyer who will arrive with laborers to harvest the crop.

The general perception among interviewees is that agriculture has been diminishing over time and is presently extremely precarious. According to testimonials based on interviewee experiences, the following processes have been causing this situation:

- Urban sprawl into farmlands and vegas, as well as non-agricultural use of rural spaces, the latter by longstanding property owners who have stopped practicing agriculture and new owners who purchased their properties for other purposes (e.g., auto-mechanic shops, parking, tourism).
- Fragmentation of agricultural lands through inheritance, which makes it difficult to practice certain activities because of the extremely small plots.
- The younger generation's relative lack of interest in farming and raising livestock, as they can obtain higher income from salaried employment or as independent workers in the city, in industry, or the mines. At the same time, family operations cannot afford to hire outside help.
- Lower quality and quantity of water resources owing to urban expansion and mining growth, which drives higher water extraction, causes water pollution, and concentrates water rights outside of the agricultural sector.
- Little regulation or state control of mining, water use, land use planning, and urban growth, in parallel with inadequate support for peasant agriculture.

6. Discussion and Conclusions

The results presented here show how the Calama oasis is a paradigmatic study case for understanding the transformations occurring in rural territories near extractive operations of global importance. The area has undergone a series of agricultural, livestock, and land-use changes related to urbanization and the privatization of natural resources. The dynamics in question do not follow a unilinear trend over time but vary historically and are explained by the confluence of processes at different levels (macro–micro, global–local) and by the intersection of ecological, economic, political, and cultural dimensions. In the same way that it is possible to observe common trends in other rural territories and spaces affected by extractivism, there are specific dynamics that can only be understood in relation to the particular history of the study case. Therefore, research on these issues should be guided by theoretical frameworks and methodological approaches that seek to understand the different scales and dimensions of analysis that interact in a particular space.

The case study shows the links that have existed between extractivism and the growth of urban centers in Latin America [137], and particularly of the close connection between mining and urban expansion in the southcentral Andes [138,139]. The urbanization of the Calama oasis has been driven by three mechanisms: (a) corporate policies focused on increased production, which involves city growth; (b) informal growth of the city perimeter due to unplanned settlement by people attracted there; and (c) urbanization promoted by the State with the aim of regularizing and installing essential services in peripheral zones of the city that developed informally.

The growth of the mining industry in the Loa River basin, and the expansion of the city of Calama and other regional urban centers, led to a higher demand for water resources and labor over time. In this regard, as observed in other parts of the Andes [26,29,30,37–39], mining extractivism has driven territorial transformations that are accompanied by the dispossession and destruction of natural resources, the proletarianization of urban and

mining occupations, and intense transformations in the ways of life of peasants and other rural inhabitants. Thus, significant changes in land use occurred in the rural spaces of the Calama oasis, tending in recent decades towards the urbanization of the rural space, urban–rural pluriactivity, and a deagrarianized way of life.

Nevertheless, analysis of the agricultural dynamics of the case study area from a long-term perspective shows that, along with the above processes, and as in other parts of the southcentral Andes [32,40], at certain times, the mining industry, its camps, and cities have strengthened the position of stakeholders in the agricultural system by creating demand for their products. In the Calama oasis, it was primarily the large landowners operating extensive alfalfa-producing estates who wasted no time moving their capital to other sectors of the economy when profitability dropped.

The indigenous peasantry, despite receiving state support at certain times, has become progressively weakened. During specific periods, supportive public actions and the farmers' own appeals competed with other public policies in force at the same time—the ongoing support for copper extraction, the privatization of water resources, the limits on irrigation, and the promotion of urban growth—to lessen their potential impacts. Despite all of this, however, the peasants are virtually the only actors today that are sustaining the now-diminished agricultural activities at the oasis. While these activities continue to play a role in providing livelihoods, they also endure because they are entangled with the farmers' traditional land-based way of life. We can thus see the intersection of different scales of economic and political processes in how certain forms of land use are configured and vary over time, from the international context to national policies and the dynamics unique to the territory and its inhabitants. Despite the intense deagrarianization of recent decades, the urban–agrarian linkage is still present in certain parts of the study area (Figure 7).



Figure 7. Agricultural lands adjoining urban lands in Calama in 2019. Source: the authors.

Finally, the data analyzed show that any government policies applied locally that seek to halt deagrarianization and promote agricultural and livestock activities will have a limited scope because the fundamental processes that are negatively affecting these activities correspond to national and global economic and political factors. In this sense, Chile currently has a unique opportunity to try to turn these aspects around. During the years 2021 and 2022, a popularly elected body will discuss a new constitution. Among the central issues of public debate, extractivism and the management of natural resources have occupied a prominent role. Thus, if the new institutional framework establishes effective power mechanisms for local populations to define the development strategies of their territories and the use of their natural resources, it is feasible that subsequent public policies of local scope will increase the degree of their effectiveness in a new, more favorable economic and political context.

Supplementary Materials: The following are available online at <https://www.mdpi.com/article/10.3390/land10111262/s1>, Table S1: Ethnographic interview guideline (in Spanish).

Author Contributions: Conceptualization, M.C.-S. and M.P.; methodology, M.C.-S., F.V. and M.P.; validation, M.C.-S., M.P. and O.M.-R.; formal analysis, M.C.-S. and F.V.; investigation, M.C.-S., F.V., P.H. and E.E.; resources, M.P.; data curation, M.C.-S. and F.V.; writing—original draft preparation, M.C.-S.; writing—review and editing, M.C.-S., M.P. and O.M.-R.; visualization, M.C.-S. and F.V.; supervision, M.P. and M.C.-S.; project administration, M.P.; funding acquisition, M.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Universidad de Tarapacá, Proyecto UTA Mayor N° 5798-21.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of Universidad de Tarapacá (protocol code 12/2020, approved 4 May 2020).

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

Data Availability Statement: The copper production data are available in COCHILCO at www.cochilco.cl, accessed 4 April 2016 and 2 March 2020. Population data were obtained in person from the Documentation Center of the National Institute of Statistics in Santiago, Chile. Some population data are available at www.ine.cl, accessed 19 January 2018. The ethnographic data are not publicly available due to ethical restrictions. The archival data are not publicly available due to copyright restrictions. Some geospatial data are not publicly available due to copyright restrictions, while others are available in IDE at www.ide.cl, accessed 1 March 2021.

Acknowledgments: We acknowledge support from Agencia Nacional de Investigación y Desarrollo (ANID), Fondecyt 1201527. M.C.-S. acknowledge support from Agencia Nacional de Investigación y Desarrollo/Scholarship Program/Doctorado Nacional 2019–21190475. F.V. acknowledge support from Agencia Nacional de Investigación y Desarrollo/Scholarship Program/Doctorado Nacional 2021–21211935. M.P. and M.C.-S. thank the Center for Intercultural and Indigenous Research (ANID, Fondap 15110006). The authors thank the informants interviewed.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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