Large amounts of national and transnational capital are currently being invested in mining projects located in the Atacama Desert, one of the driest deserts in the world. These projects require large quantities of water for their industrial processes. Water sources in the middle of this desert are extremely limited, despite many lakes, lagoons, salt lakes, and wetlands located on the Andean highlands, bordering its eastern side. Most of them are located in natural conservation areas or territories claimed by indigenous communities. Given the lack of superficial water, location of mining projects in northernmost Chilean regions are beginning to be increasingly located near ground resources and overlapping nature conservation areas, biodiversity protection sites, and communal lands claimed by indigenous peoples. At present, water withdrawal by mining companies has been favored by governments and legislation and supported by neoliberal mechanisms such as privatization and commodification of natural resources. On the opposing side, ecosystems and local communities have lost the battle, due to the increasing competition for water resources that is threatening the subsistence of living systems in this part of Chile.
that encourages the setting up of new sites which, in turn, require large amounts of water. For national and transnational mining companies and for the financing of the Chilean emerging economy, the production of minerals is a breakthrough opportunity that implies the exploitation of all available sources of water.

In 1981 the government’s military dictatorship led by General Pinochet (1973–1990), enacted a new Water Code to deal with water resources in Chile. Although metaphorically they remained public goods, in practice they were commoditized and privatized, generating a free market for water rights by allowing the sale thereof, without any involvement of the State in its allocation. In the continuation of a historical process of deprivation, many indigenous peoples and rural communities lost their water rights because they were legally or illegally claimed or bought by mining and drinking water companies. Water use rights were acquired in perpetuity and became the exclusive property of national and transnational private companies, while their former owners, communities of local and indigenous people, had to leave their lands, unable to survive without water on the marginal lands of the Atacama Desert.

FIG. 1. Mining investments, wildlife conservation areas, and groundwater withdrawals in the Atacama Desert in 2010.

Located, especially in the areas around or in endorheic basins, on highlands, along the outlets of exorheic lakes, or in upwelling lowlands (Figure 1). To do this, national and international mining companies have traditionally appropriated water sources and more recently, they have acquired and bought in the market, the right of use of these waters from the indigenous and peasant communities. Sometimes, they have obtained these rights through the payment of compensation to local communities, for damages caused to wetlands and salt lakes that are used for irrigation and grassland purposes. Other times they have tried to get additional water rights by installing new wells, or through the regularization of illegal loggings. In many cases, water extraction has taken place over areas claimed by indigenous communities, or which are part of the national system of wildlife protected areas.

The amount of water which is required for cooper extraction, processing, production and final disposal vary according to the kind of ore (oxide or sulphur) and geographical aspects, and could be estimated between 38.5 and 193.3 m³/ton of fine cooper, depending on available technologies and volume of production. According to Gossjean et al., water should be considered a fossil or non-renewable resource since most of it was stored in the ground around 18,000 years BP (before present) when rainfall was 300 or 400% over present figures and an optimum climate favored vegetation covers and ground recharge.

In 2008, the Department of Scientific and Technological Research of the Chilean Catholic University (DICTUC) calculated an Andean highlands water balance based on

<table>
<thead>
<tr>
<th>Years</th>
<th>Urban Population</th>
<th>Urban %</th>
<th>Rural Population</th>
<th>Rural %</th>
<th>Total Population</th>
<th>Total %</th>
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<td>1940</td>
<td>55909</td>
<td>53.7</td>
<td>48188</td>
<td>46.3</td>
<td>104079</td>
<td>100</td>
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<tr>
<td>1952</td>
<td>63967</td>
<td>62.2</td>
<td>38622</td>
<td>37.8</td>
<td>102789</td>
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<tr>
<td>1960</td>
<td>98260</td>
<td>79.7</td>
<td>25004</td>
<td>20.3</td>
<td>123264</td>
<td>100</td>
</tr>
<tr>
<td>1970</td>
<td>157274</td>
<td>90.0</td>
<td>17416</td>
<td>10.0</td>
<td>174710</td>
<td>100</td>
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<tr>
<td>1982</td>
<td>257846</td>
<td>93.72</td>
<td>17298</td>
<td>6.28</td>
<td>275144</td>
<td>100</td>
</tr>
<tr>
<td>1992</td>
<td>318925</td>
<td>93.92</td>
<td>20654</td>
<td>6.08</td>
<td>339579</td>
<td>100</td>
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<tr>
<td>2002</td>
<td>403138</td>
<td>94.07</td>
<td>25456</td>
<td>5.93</td>
<td>428594</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Censos de Población y Vivienda. Instituto Nacional de Estadística. Santiago, Chile.

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6Instituto de Asuntos Públicos, Centro de Análisis de Políticas Públicas, Informe País: Estado del Medio Ambiente en Chile 2008 (Universidad de Chile, 2010).


8Gustavo Lagos, Eficiencia del uso del agua en la minería del cobre (Centro de Estudios Públicos 1997).


10Department of Scientific and Technological Research of the Chilean Catholic University (DICTUC), Levantamiento hidrogeológico para el desarrollo de nuevas fuentes de agua en áreas prioritarias de la Zona Norte de Chile, Regiones XV, I, II y III. Informe Final Parte I: Hidrografía Regional del Altiplano de Chile. (Dec. 2008).
Marching development in the Atacama Desert

Table 2. Water Balance (in liters per second) in Northern Chile Selected Watersheds

<table>
<thead>
<tr>
<th>Salar del Huasco</th>
<th>Northern Group (*)</th>
<th>Southern Group (**)</th>
<th>Salar de Pedernales</th>
<th>Salar de Maricunga</th>
</tr>
</thead>
<tbody>
<tr>
<td>DICTUC this study</td>
<td>DICTUC this study</td>
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<td>DICTUC this study</td>
<td>DICTUC this study</td>
</tr>
</tbody>
</table>

Inputs
- Precipitation: 1158.7, 1158.7, 704.7, 704.7
- From other basins: 308.7, 308.7, 1831.4, 1831.4
- Total: 1469.6, 1469.6, 2182.2, 2182.2

Outputs
- Evaporation: 757, 757, 632.1, 632.1
- Water withdrawals: 118.1, 387, 317.1, 233
- To other basins: 130, 130, 65.5, 65.5
- Total: 875.1, 1019.1, 317.1, 2182.2
- Water balance (IN-OUT): 283.6, 726, -314.4, -412

(*) Salar Punta Negra and Salar de Aguas Calientes 2.
(**) Laguna Tuyajto, Pampa Colorada, and Pampa Las Tecas.
Source: Dirección General de Aguas de Chile.

Pilot watersheds, including inputs provided by precipitation and upstream sources and outputs, such as evaporation, water withdrawals, and flows that go to other basins. Such data could be found as public information at the General Water Direction (DGA) and has been argued by several organizations, researchers, and our own studies. Salar de Huasco, located in the Tarapacá region today shows a positive balance, mainly due to the inexistence of water extraction and it recently being declared a national park in 2008. There are some relevant differences in the amount of water withdrawals between public information and our own estimations. For example, we obtained negative balances in the Northern Group and higher values of negative figures at the Southern Group of watersheds, and especially at Maricunga and Pedernales salty lakes (Table 2).

Thus, the boom in mining development that Chile experiences, has generated huge economic gains to the State and national and foreign companies, but at the same time, degradation of ecosystems and the forced migration of populations of villages and settlements which cannot subsist with such scarce and erratic water supply. However, the current stage of water crisis triggered by mining is not the only reason to explain the abandonment of rural areas, which has been recorded since the early twentieth century (Table 1). Other reasons for this migration have been the lack of jobs and facilities, and the increasing interest of communities in educating their children in nearby cities. Ethnic exclusion and the absence of public policies that promote the liability of rural towns and settlements have affected territorial equity, and clearly involved the State in the occurrence of socio-environmental injustices.

MINING DEVELOPMENT IN THE ATACAMA DESERT

Paradoxically, the extremely arid Atacama Desert is a region that concentrates large reserves of metallic and non-metallic minerals. During the nineteenth and early twentieth centuries, the exploitation of nitrate meant the emergence of many towns around the reservoirs, destruction of vegetation (fuel used) and drying of multiple sources of water. The replacement of natural salts by chemical ones, involved the abandonment of all of these landscapes and the consequence was the formation of ghost towns which have remained abandoned until today. Currently, these places concentrate some of the world’s most important reserves of copper, gold, silver, molybdenum, and lithium, which have attracted large amounts of national and foreign economic investments. According to the U.S. Geological Survey, Chile owns 30% of world copper reserves.

Quantity and quality of Chilean mines and large investments have meant that national production has increased from 2 to 5.4 million metric tons between 1992 and 2009, and that its exports represented 38.5% of total


14Jose Arelano, “Codelco in the copper industry” (presented at CRU/CESCO Ninth World Copper Conference, Corporación Nacional del Cobre, Apr 2010).
in 2003 and 53.5% in 2009. A representation of such investments made in 2010 is presented in Figure 2. Practically almost all large mining companies in the world (with capital from Canada, Chile, Australia, UK, Japan, USA, Switzerland, etc.) are developing their projects in Northern Chile in order to meet growing market demands worldwide, clearly impacted by the industrialization of China, which has raised the price of a pound of copper to about five dollars (five years ago, a pound was less than a dollar).

Figures 1 and 3 show that one of the most significant interventions to confront the exhaustion, scarcity and irregularity of surface waters sources is the increasing opening of groundwater wells. Some of them are directly related to the presence of wetlands, and in, or around nature conservation areas, such as national parks, nature reserves, and priority sites for biodiversity protection. Other ground sources are situated along lowland areas of water upwelling, and many of them are part of communal territories claimed by indigenous peoples, leading in many cases to growing conflicts that challenge the environmental institutions and scientific knowledge of the area.

Nowadays, among the most critical areas we can mention Pampa del Tamarugal aquifer, located in the lowlands vicinity of Pozo Almonte, the uppermost section of Loa River watershed, and the higher basin of the Copiapó River (Figure 1). To the right of the map the use of groundwater properly extracted from highlands and from the rest of the regional territories is shown. As indicated, the Antofagasta region spends more than 8,000 l/s of groundwater extracted from the highland plateau on mining activities. Tarapacá and Atacama regions, highland plateaus, are also the main regions for mining, while water taken from the rest of their territories can, especially in the case of the latter region, be used in agriculture, services, and tourism.

Figure 2 presents economic investment projects which were implemented in 2010 in the four regions in which the Chilean Atacama Desert is located: Arica and Tarapacá (left), Antofagasta (center) and Atacama (right). In the Arica region, mining investments are, at present, very few, and, according to governmental and private company representatives, this is due to lack of water and because the main sources are considered to be public lands for the protection of nature and are territories claimed by Aymara communities. Currently, mining companies and the regional government are intending to disaffect 40,000 ha. of such areas in order to facilitate the establishment and expansion of mining operations in the Lauca National Park and Surire national reserve.

15ProChile, Análisis de las exportaciones chilenas del año 2009 (Dirección General de Relaciones Económicas Internacionales Boletin, 2010).

The Tarapacá region (capital city Iquique) concentrated major mining investments in the 1990s and, as a result, it faced severe conflicts between international entrepreneurs and local communities in relation to the possession of water rights and because of the negative ecological impacts caused by the drainage of wetlands, such as Lagunillas and Salar de Coposa. These still unsolved conflicts clearly showed the social and political insufficiency of legal and institutional mechanisms and procedures and could be understood as the preface of future, more complex, and generalized conflicts in the area. Mining activities have significantly reduced water availability to communities of farmers and pastoralists, forcing people to leave almost their entire crop areas, grasslands, and livestock circuits, and emigrate mainly to nearby sprawl cities (Arica, Iquique, Pica, Alto Hospicio, and Pozo Almonte).

Antofagasta region, on the other hand, has experienced the largest amount of mining investment during the past three decades. It has involved the extraction of surface and ground water from salt lakes, wetlands, and rivers located at the Andean highlands (Figures 2 and 3). While the upper basin of the Loa River (the only river that flows into the Pacific Ocean and does not disappear while crossing the desert) has been, and currently is, the subject of many surface and groundwater withdrawals. Some parts of the upper section still remain as an area of nature conservation, where numerous wetlands survive as national parks and reserves or as priority sites for biodiversity conservation. However, decertification could again be considered a matter of time, given increasing pressures that confront Licancabur and Tatio National Park (where the major geysers in the country are found) or communal territories claimed by Atacameños indigenous people.

Groundwater withdrawals located in the upper basin of the Loa River, are, on the other hand, challenging the conservation of salt lakes like Aloncha, Carcote, and Ascotán; another critical condition could also be observed in the high concentration of wells in the regional southern part, affecting Huachalaje, Miniques, and Miscanti lagoons, and Tara, Aguas Calientes, El Laco, Punta Negra, Agua Negra, and Pajonales salt lakes. These examples confirm that the problem is becoming very difficult to solve under present legislation, and institutional, environmental, and sustainability development issues of overlapping areas of wetlands, biodiversity protection sites, indigenous and rural communities’ claimed lands, and extraction of surface and ground water. Collisions are apparent everywhere, especially in the Loa River upper basin, in Salar de Atacama, and around Los Flamencos and Llullaillaco National Parks.

A third cluster of large economic mining associated investments are increasingly located in the Atacama region, moving towards the south, right on the search site for sources of water. One of the areas of greatest interest at present is located in the Copiapó River upper basin, which drains into the Paipote creek and commits the salt lakes of Pedernales and Maricunga, and Laguna Verde, near the mining town of El Salvador (Figure 1). While it is the least populated region which forms the Atacama Desert, the population is concentrated in the river valleys...
that originate in the Andes; this means that agricultural, urban, and industrial activities would be severely affected by the extraction or pollution of the rivers. In this case, the main conflicts have been generated with indigenous communities, such as the Coya people, who inhabit the upper basin of Copiapó, and the people called Alto-Huasquinos, who are located in the upper valley of Huasco, and with farmers in the irrigated lands of the middle sections of fertile valleys that specialize in export products.

CONCLUSIONS

Chilean society should reflect on what it has done and will do in the short and long terms in relation to the survival of unique ecosystems such as wetlands of the Andean highlands bordering the Atacama Desert. They should also make a decision about settlements and territories historically occupied by indigenous and rural communities in these landscapes. These decisions have to involve discussions about whether or not remaining natural areas, such as wetlands, lakes, and lagoons in the region of Arica, at the East of Calama, to the South of Antofagasta and at the highest section of the Copiapó Valley, should be conserved or not. The discussion must necessarily be around the environmental sustainability of highlands and must consider not only the economic benefits associated with mining activities, but also a socio-environmental evaluation of who the winners and losers of these interventions have been up to the present date. Similarly, they should be clear about the social and cultural needs to preserve the settlements and territories of indigenous peoples, preventing its complete disappearance in the short term.

Chile urgently needs to implement laws and regulations related to land resources management to solve increasingly territorial collisions. Real preventive ecological and social assessments are required in regional and communal development planning, and strategical environmental assessments should be applied to such complex situations similar to those observed in the Atacama Desert.

Conservation of unique ecosystems and cultural landscapes located in the Andean highlands seem to be a major obligation priority that should be shared by the various social actors in the country. Public policies have to overcome exclusion and environmental injustices that have historically predominated in the occupation of these territories. The Water Code has commoditized and privatized hydric resources, producing negative effects from social and ecological points of view. This Code must be replaced by mechanisms and procedures that explicitly consider equity and social justice in the distribution of resources to properly assess environmental and social costs and benefits resulting from their assignment and to return the State’s rights and institutional resources to administer the territories of the country under the umbrella of sustainability. Forty years of extreme liberalism applied to the development of these regions have left too many losses. If the pertaining political changes are not implemented as soon as possible, without any doubt we are going to repeat the desolation and abandonment characterizing the ghost towns that remained after the nitrate mining boom.

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