Ministerio del Medio Ambiente

Gobierno de Chile

STATE OF THE ENVIRONMENT REPORT

2016

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2016

Ministry of the Environment 2016
GOVERNMENT OF CHILE

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Gobierno de Chile

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CONTENT

FOREWORD

Over the last few years, Chile's economic growth has positioned it as the country with the highest income per capita in the region, tripling the value from three decades ago when the main economic reforms began. This has had a direct impact on the lives of people, significantly reducing the percentage of the population living in poverty, among other benefits. However, economic growth has also had negative consequences, particularly in the environmental sphere.

The efforts to reconcile economic growth with environmental sustainability have boosted, over the last years, the implementation of substantial reforms to the Environmental Institutional Framework. Since 2010, Chile has deployed a new Environmental Institutional Framework focused on the creation of a Ministry of the Environment, an Environmental Assessment Service, a Superintendency of the Environment and the Environmental Courts. This new institutional framework has improved the State's capacity to respond to the multiple environmental challenges faced by our country.

And we have responded. The Government has given continuity to State policies related to the environment that have enabled substantial progress to be made in environmental management. The implementation of a Strategy of Decontamination Plans that will significantly reduce air pollution in Chile's main cities is one among other outstanding advances achieved by the current government.

Along with that, green taxes were introduced in Chile for the first time, including the first CO_2 tax in South America; a Climate Action Plan was prepared that enables us to comply with our international commitments in terms of the reduction of greenhouse gases; a National Biodiversity Strategy was prepared; and a Law was passed to Promote Recycling and Extended Producer Responsibility, which will allow for a new approach to waste management in the country.

In addition to this, the largest marine protected area of the Southeast Pacific was created, the Nazca-Desventuradas Marine Park; the first Environmental and Social Recovery Program (PRAS by its acronym in Spanish) was prepared for the communes of Quintero, Puchuncaví, Huasco and Coronel; the National Environmental Accounts Plan was approved; and the National Program for Sustainable Consumption and Production was prepared, among other important policies and actions.

There is still much to be done, however. This second State of the Environment Report presents to the country, in a clear and transparent manner, the progress achieved in environmental matters over the last few years, while also explicitly exposing the environmental issues we yet need to solve. This is the only way we will be able to move forward with public environmental policies that solve the real problems of Chileans and achieve a sustainable economic development.

We hope that this new report will not only serve as a guide of our progress and challenges, but also as a dissemination and environmental education tool for teachers and students, and that it will promote responsible and effective citizen engagement.

Pablo Badenier Martinez
Former Minister of the Environment (March 2014-March 2017)

FOREWORD

In order to consolidate the protection of the environment and make progress towards green growth, it is essential to have adequate information that will allow us to perform an accurate diagnosis to prepare the best public policies and provide citizens with the best possibilities to participate in these processes.

A true democracy must guarantee informed participation when making environmental decisions, because that not only improves the quality of life of the communities and future generations, but also substantially contributes to environmental equity.

Furthermore, public and transparent information on this matter gives greater legitimacy to our country's environmental management system, helps anticipate and prevent environmental conflicts, and facilitates a more efficient management of projects and programs, whether public or private, thus increasing the level of protection of natural resources and environmental heritage.

In 2014, at the beginning of her administration, President Michelle Bachelet commissioned us with the task of advancing towards a sustainable development with environmental equity, that harmonizes economic growth with the demands and quality of life of the communities. And we have made substantial progress in this task over these years.

This is reflected in this State of the Environment Report. We see significant progress in air quality in the cities, deeper commitments from us in terms of climate action, advances in indigenous and gender issues related with environmental matters, the passing of a new Law on Recycling, and a significant increase in the protection of our natural heritage.

But, certainly, we still have a long way to go in order to consolidate a green growth model. We know that water, air and soil pollution is still a problem for many communities in our country. Its inhabitants demand response and solutions to these issues with greater frequency.

The information contained in this second State of the Environment Report will provide the basis to advance towards the sustainable development we want for our country, with a better quality of life for its inhabitants, not only for the Ministry of the Environment, but also for the different State agencies. Today, in a scenario where climate change is the main problem affecting us worldwide, it is essential to incorporate the environmental variable into all public policies to adapt to this new scenario.

This is also true for the private sector, for which this document provides relevant information to incorporate into their own projects. The State plays a key role in guiding the way towards green growth, but it requires committed businesses to help lead this change. Finally, as I have mentioned before, it is also essential for citizens.

Marcelo Mena Carrasco
Minister of the Environment

INTRODUCTION

The Second State of the Environment Report is an important tool to monitor the state of the different environmental components, as well as the public actions and policies being implemented to address the issues that affect us. As established by Law 19.300, it is a document published every four years, based on information validated by the diverse public agencies with competence on environmental matters.

This Second Report is made up of 17 chapters, which, in addition to including the main environmental components, address new topics in response to the countries characteristics and singularities, such as the challenges it faces to attain the goal of sustainable development. Likewise, a table has been incorporated with the main goals set by the country, which are linked to environmental objectives established at the international level.

- Drivers
- Gender and Environment
- Native Peoples
- Environmental Institutional Framework
- Environmental Management Tools
- Green Growth
- Air
- Climate Change
- Ozone Layer
- Environmental Noise
- Skies for Astronomical Observation
- Land
- Waste
- Green Urban Infrastructure
- Biodiversity
- Water
- Natural Events and Environmental Disasters

The information contained in this report was provided by different public agencies that make up the Inter-Institutional Committee on Environmental Information, which seeks to coordinate the public sector's efforts regarding environmental information.

In addition to the contribution made by the different public agencies with competence on environmental matters, this report received inputs from scientists, academic institutions and private companies, all of which helped in a concrete way to achieve the necessary synergy between public policy and the diverse social sectors.

Methodology

The Second State of the Environment Report was prepared based on the GEO (Global Environmental Outlook) methodology of the United Nations Environment Programme (UNEP). The aim of this integrated environmental assessment is to incorporate different stakeholders in order to generate a participative process.

The GEO methodology is, at the same time, a process that analyzes environmental changes, their causes, impacts and response policies. It provides information for decision makers and supports early warning efforts. The GEO is also a communication process aimed at raising awareness on environmental issues, providing options for action.

The UNEP Regional Office for Latin America and the Caribbean provided assistance to learn and implement the GEO methodology. As part of this process, training sessions were held for employees who are part of the Inter-Institutional Committee on Environmental Information as well as for different stakeholders who were convened by the Ministry of the Environment.

Although the country does not have information that will allow it to address all aspects included in the methodology, it is an approach that helps reveal information gaps and aspects that need to be strengthened in order to have a better understanding of the environmental issues faced by the country, their consequences for the population, and to prepare public policies that will enable safeguarding the quality of the environment and the health of the population.

This report is comprised of more than 200 indicators, which have been structured based on the Driving Forces-Pressure-State-Impact-Response model, with the aim of showing the cause-effect relationships between the environment and human activities, which explain the current situation of the different environmental components.

In this report, indicators are provided regarding:

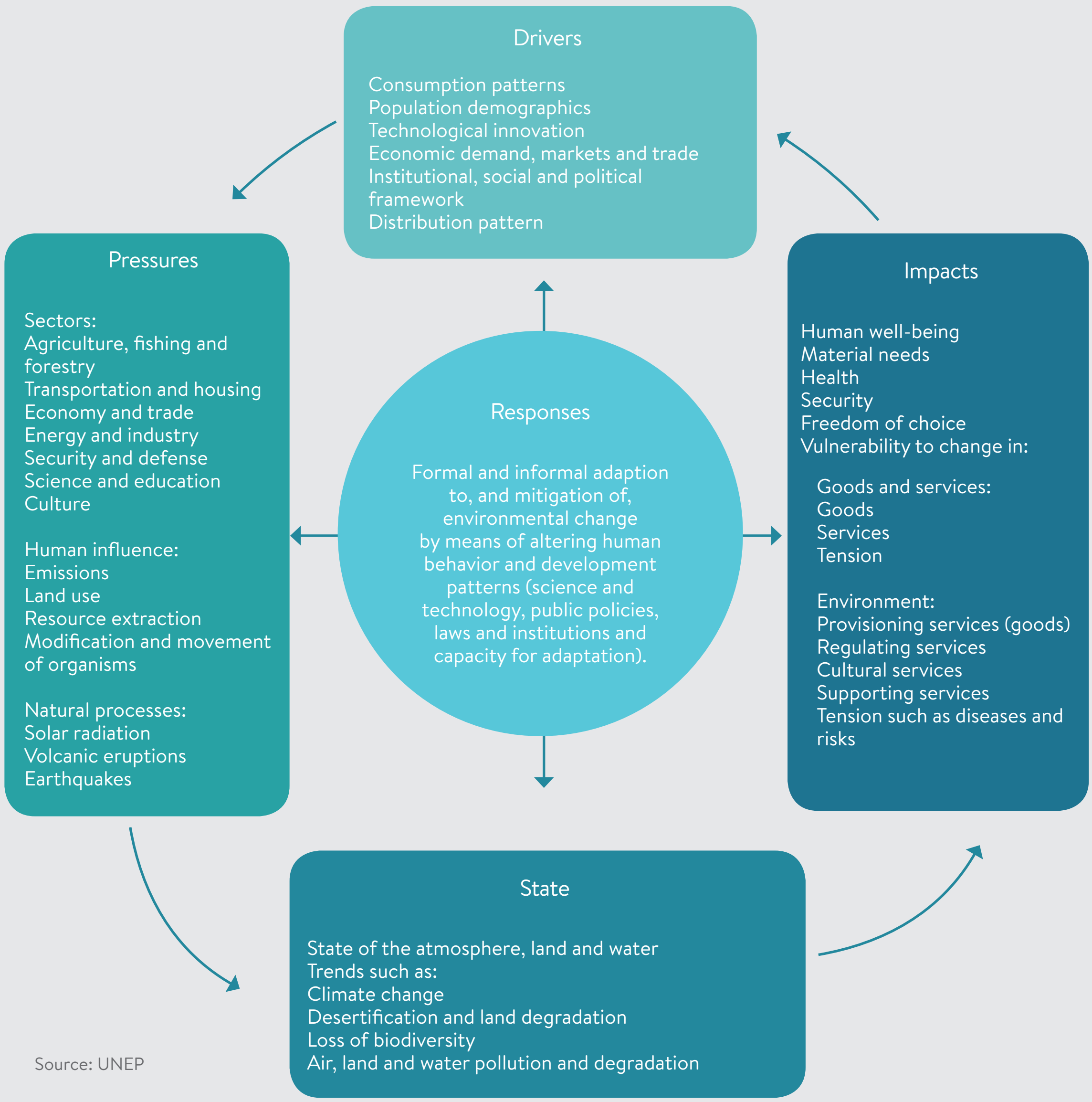
DRIVING FORCES: They refer to the indirect factors or variables behind the more specific pressures that affect the environment.

PRESSURES: They refer to direct factors or variables that affect the state of the environmental components, either individually or collectively.

STATE: It refers to the situation in which environmental components are in, as a result of drivers and pressures.

IMPACT: The state of the environmental components is tied to different types of impacts, both on people's quality of life or health and on the ecosystem services provided by the environment.

RESPONSES: They refer to the actions carried out by both the authorities and society at large, whether they are aimed at reducing environmental impacts or adapting to them. These actions will affect the state of the environmental components, as well as the pressures and drivers.


Drivers
Consumption patterns
Population demographics
Technological innovation
Economic demand, markets and trade
Institutional, social and political framework
Distribution pattern
Pressures
Sectors:
Agriculture, fishing and forestry
Transportation and housing
Economy and trade
Energy and industry
Security and defense
Science and education
Culture
Human influence:
Emissions
Land use
Resource extraction
Modification and movement of organisms
Natural processes:
Solar radiation
Volcanic eruptions
Earthquakes
Responses
Formal and informal adaption to, and mitigation of, environmental change by means of altering human behavior and development patterns (science and technology, public policies, laws and institutions and capacity for adaptation).
Impacts
Human well-being
Material needs
Health
Security
Freedom of choice
Vulnerability to change in:
Goods and services:
Goods
Services
Tension
Environment:
Provisioning services (goods)
Regulating services
Cultural services
Supporting services
Tension such as diseases and risks
State
State of the atmosphere, land and water
Trends such as:
Climate change
Desertification and land degradation
Loss of biodiversity
Air, land and water pollution and degradation

Source: UNEP

ACKNOWLEDGEMENTS

The Second State of the Environment Report was prepared within the framework of the GEO 6 (Global Environmental Outlook) Integrated Environmental Assessments process led by the United Nations Environment Programme (UNEP).

The Ministry of the Environment (MMA by its acronym in Spanish) thanks the Regional Office for Latin America and the Caribbean of the United Nations Environment Programme for the training provided to the Inter-Institutional Committee on Environmental Information in the application of the methodology for Integrated Environmental Assessments and for the technical assistance given to the Department of Environmental Information of the Division of Information and Environmental Economics of the MMA for the preparation of this report.

Eastern Santiago | JOSÉ GERSTLE

CHAP **01**

DRIVERS

CONTENT

INTRODUCTION

This chapter describes demographic, social and economic variables and indicators, which enable learning about the current situation and analyzing the main changes occurred over the last few years in the country. At the same time, they constitute some of the main drivers that impact the environment.

From the environmental perspective, the impacts of demographic growth are mainly reflected in the increase of the demand for land, natural resources and energy. Although population increase is a key variable for analyzing the pressures on natural systems, other background information must also be analyzed related to its distribution, migratory patterns as well as social and economic backgrounds, which determine the behaviors of the population and their relation with the territories that they inhabit.

On the other hand, the productive activity, as well as the consumption of energy and the vehicle fleet, are indicators that show the pressures on the different components of the environment.

1 • NATIONAL AREA

The total area of the country is 2,006,066 km^2, which are divided into 15 regions. The regions with the greatest areas are the Magallanes and Chilean Antarctic Region (68.9 percent of the total national area), Antofagasta Region (6.3 percent of the total national area) and Aysén Region (5.4 percent of the total national area), which together represent 80.6 percent of the total national area. The region with the smallest area is the Santiago Metropolitan Region with 15,403 km^2, which represents 0.77 percent of the total national area[1].

[1] *National Statistics Institute (INE by its acronym in Spanish) and 2002 Census.*

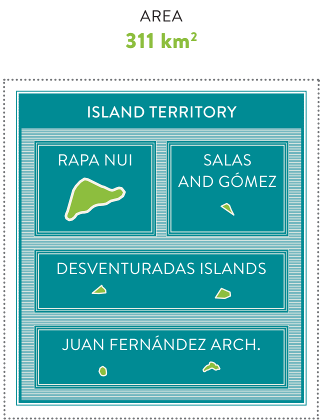
Silhouettes | FRANCISCO DONOSO

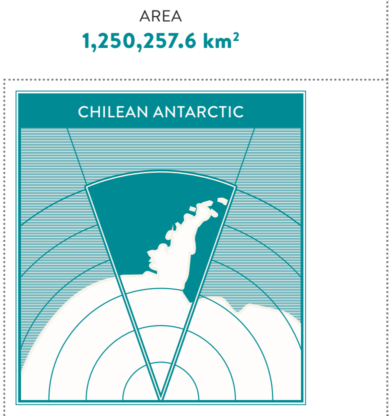
TABLE 01

NATIONAL AREA BY REGION (km²)

REGION	AREA (km²)
Arica and Parinacota	16,873
Tarapacá	42,226
Antofagasta	126,049
Atacama	75,176
Coquimbo	40,580
Valparaíso	16,393
Santiago Metropolitan Region	15,403
O'Higgins	16,387
Maule	30,269
Biobío	37,069
Araucanía	31,842
Los Ríos	18,430
Los Lagos	48,584
Aysén	108,494
Magallanes and Chilean Antarctica	1,382,291
TOTAL	2,006,066

Source: INE, 2007.





2 • COUNTRY POPULATION

2.1 General Population

The total estimated population for 2015 was 18,006,407 inhabitants. It is mostly concentrated in the The Santiago Metropolitan Region, with approximately 7,314,176 inhabitants, representing 41 percent of the national population[2].

The evolution of the country's population between 2000 and 2015 is illustrated in **Figure 01**, highlighting a constant and sustained growth. This increase, compared to that of other countries of the region, such as Argentina, Brazil and Colombia, is even higher, since the population growth rate of those countries has diminished, or has remained stable throughout the last few years[3].

2.2 National Population by Age Group and Gender

In 2015, the population was composed of 51 percent women and 49 percent men. Out of the total, most of the population was within the age group ranging from 20 to 50 years (51 percent). On the other hand, the elderly represented 10 percent of the population and were mainly made up of women (75 percent). When analyzing the population aged over 80, the results were similar, women represented 65 percent of the total[4] (INE, 2016).

Figure 02 presents the structure of the national population by age group and gender.

2.3 Urban/Rural Population

The urban/rural composition of the population is a factor that can significantly influence the use of natural resources and the demands for services and infrastructure.

During the 20th century, the Chilean population suffered an accelerated urbanization and territorial redistribution process, transforming a society marked by its rural character into a predominantly urban one. During the decade of the 1930s, for the first time, the rural population stopped growing and the urban population accelerated its growth, expanding the city towards agricultural lands (MINVU, 2004). This change process was reflected on the results of the Population Census of 1940, in which the official figures reveal a greater number of inhabitants in urban areas, surpassing the rural population with 52.5 percent of the population versus 47.5 percent.

This was the beginning of the acceleration of the urbanization process in the country, which was intensified during the decades of the 1960s and 1970s, outlining the structure of the country in that direction.

At present, according to official figures, 87 percent of the total Chilean population lives in urban areas (15,729,803 people). As shown in **Table 02**, the Antofagasta Region presents the greatest urban population index with 98 percent, followed by the Santiago Metropolitan Region with 97 percent based on its total population. On the contrary, the national population that currently lives in rural areas only represents 13 percent of the total and is mainly concentrated in the Maule and Araucanía Regions, which present rural indexes of 32 percent.

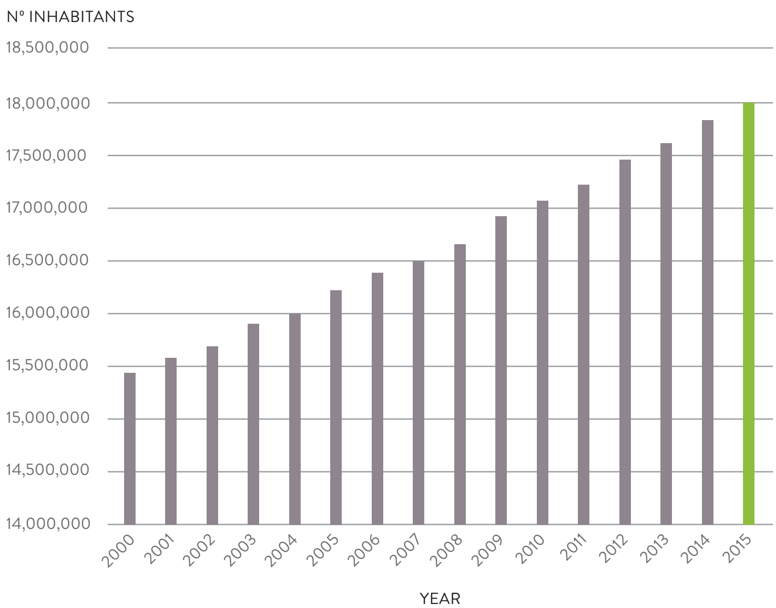
[2] Projections by the INE based on the 2002 Census.

[3] According to data from the World Bank, the population growth rate, between 2011 and 2014, has remained at 1.0 for Argentina and has diminished from 1.0 to 0.9 for Brazil and Colombia. Chile presents a constant rate of 1.0.

[4] National Statistics Institute (INE by its acronym in Spanish). Communes: Update of the 2002-2012 population and projections for 2013-2020.

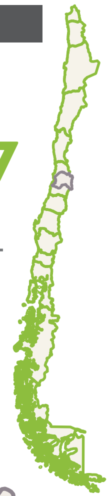
FIGURE 01

EVOLUTION OF THE TOTAL POPULATION IN THE COUNTRY



Source: INE, 2016.

ESTIMATED POPULATION



By 2015 in Chile

18,006,407
INHABITANTS

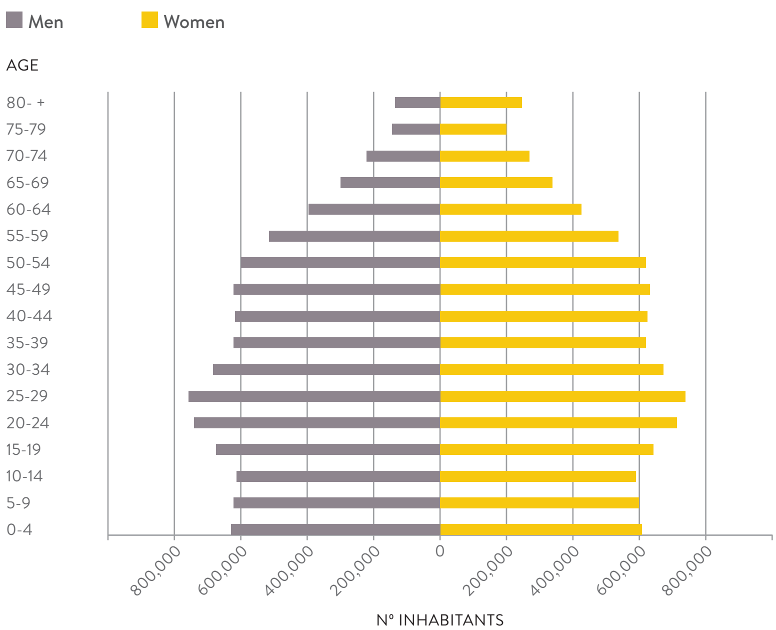
In the Santiago Metropolitan Region

7,314,176
INHABITANTS

SMR 41%

FIGURE 02

NATIONAL POPULATION BY AGE GROUP AND GENDER, 2015



Source: INE, 2016.

BY 2015

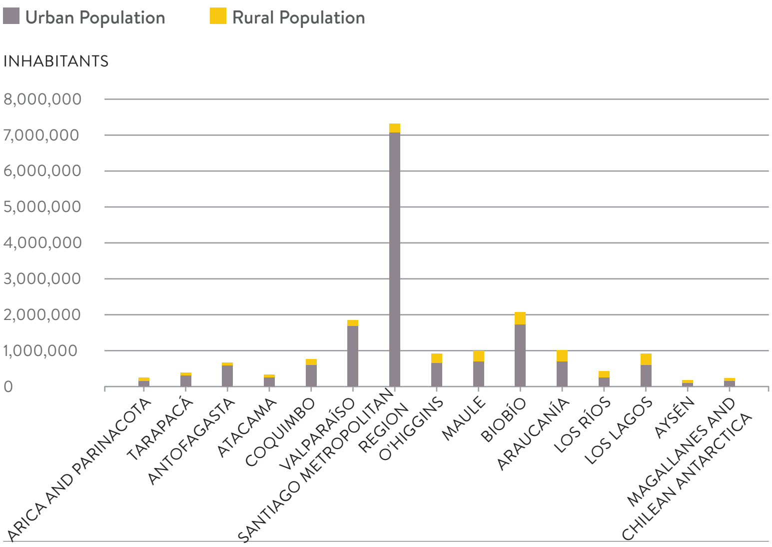
51% ♀
WOMEN

49% ♂
MEN

Productive Activity | JOSÉ GERSTLE

FIGURE 03

URBAN/RURAL DISTRIBUTION OF THE POPULATION BY REGION



Source: MMA, 2015 based on data from the INE, Chile. Population projections and estimates by sex and age (1990-2020).

TABLE 02

URBAN/RURAL POPULATION OF CHILE BY REGION					
REGION	**TOTAL**	**URBAN**	%	**RURAL**	%
Arica and Parinacota	239,126	223,630	93.52	15,496	6.48
Tarapacá	336,769	322,133	95.65	14,636	4.35
Antofagasta	622,640	609,380	97.87	13,260	2.13
Atacama	312,486	287,448	91.99	25,038	8.01
Coquimbo	771,085	622,218	80.69	148,867	19.31
Valparaíso	1,825,757	1,675,701	91.78	150,056	8.22
Santiago Metropolitan Region	7,314,176	7,092,988	96.98	221,188	3.02
O'Higgins	918,751	659,675	71.80	259,076	28.20
Maule	1,042,989	708,228	67.90	334,761	32.10
Biobío	2,114,286	1,744,051	82.49	370,235	17.51
Araucanía	989,798	676,429	68.34	313,369	31.66
Los Ríos	404,432	278,957	68.98	125,475	31.02
Los Lagos	841,123	587,646	69.86	253,477	30.14
Aysén	108,328	88,518	81.71	19,810	18.29
Magallanes and Chilean Antarctica	164,661	152,801	92.80	11,860	7.20
TOTAL	18,006,407	15,729,803	87.36	2,276,604	12.64

Source: INE, 2016.

City | VICTORIA CÁRCAMO

The urbanization rate in our country (87 percent) is high in comparison to the global rate (51 percent). However, it is similar to that of other countries in Latin America and the Caribbean (79 percent) and OECD member countries (77 percent) (MINVU, 2013).

The concentration of the population in urban settlements can facilitate economic and social development, as well as offer opportunities to mitigate the negative effects of consumption and production on the environment. However, accelerated, and unplanned, urban growth threatens sustainable development when the required infrastructure is not adequately developed, or when policies do not target environmental protection and ensure that the benefits of living in the city are equally distributed.

GLOBAL URBAN POPULATION

01

Urbanization processes have become a global scale phenomenon, with uneven and different paces and pathways, but all of them lead to a same complex and diverse reality: the construction of a planet of cities.

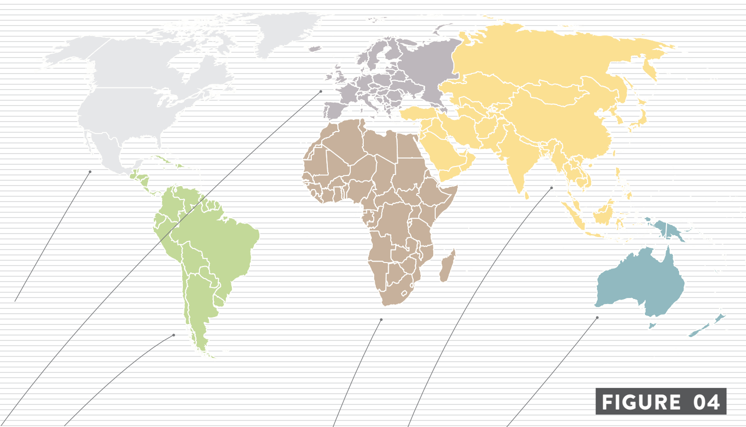


FIGURE 04

GLOBAL URBAN POPULATION, 1950, 2010, 2050

1950

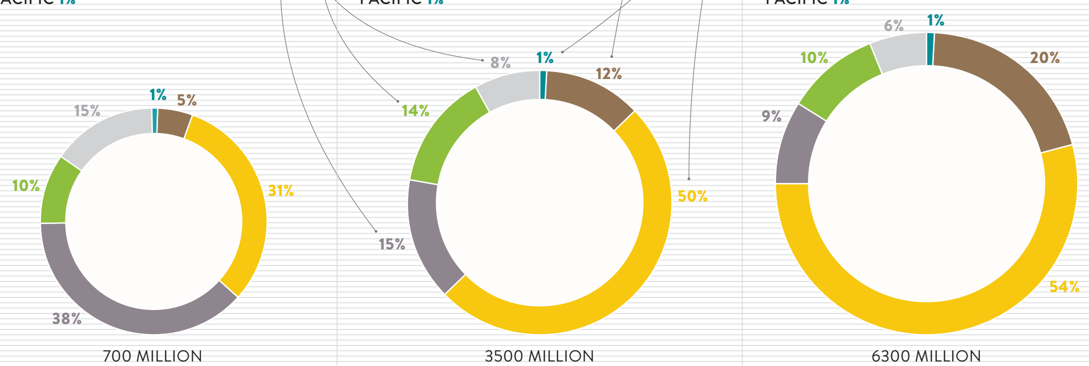
EUROPE 38%
ASIA 31%
NORTH AMERICA 15%
LATIN AMERICA AND THE CARIBBEAN 10%
AFRICA 5%
PACIFIC 1%

2010

ASIA 50%
EUROPE 15%
LATIN AMERICA AND THE CARIBBEAN 14%
AFRICA 12%
NORTH AMERICA 8%
PACIFIC 1%

2050 (FORECAST)

ASIA 54%
AFRICA 20%
LATIN AMERICA AND THE CARIBBEAN 10%
EUROPE 9%
NORTH AMERICA 6%
PACIFIC 1%



Source: UNICEF, 2012.

2.4 Migrant Population

One of the demographic phenomena increasingly experienced by the country is the rise of immigrant population. By 2014, it was estimated that this population reached 2.3 percent of the total (**Figure 05**).

Over the past 15 years, permanent residency permits for foreigners have increased fivefold. These new residents come mainly from South American countries such as Peru, Argentina, Colombia and Bolivia (**Figure 06**).

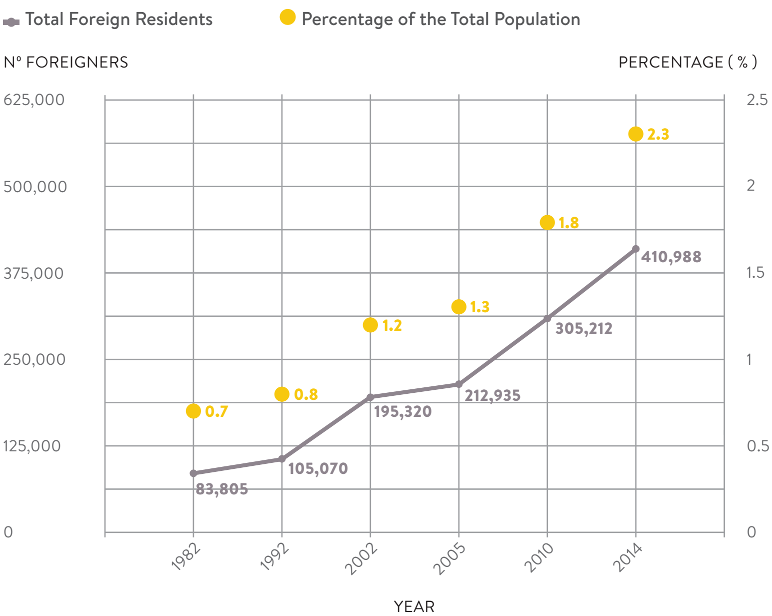
The immigrant population is characterized by a greater presence of women, close to 53 percent (Ministerio del Interior y Seguridad Pública, 2016), and a strong concentration in the Santiago Metropolitan Region and the northern regions (**Figure 07**). Nevertheless, their insertion into the work force has been precarious, with 1 out of every 4 immigrants living in poverty and 24 percent of them in overcrowded conditions (Ministerio de Desarrollo Social, 2013).

MIGRANT POPULATION TO DATE

PERU	ARGENTINA	BOLIVIA	COLOMBIA	ECUADOR
130,329	66,899	36,036	25,038	19,133

FIGURE 05

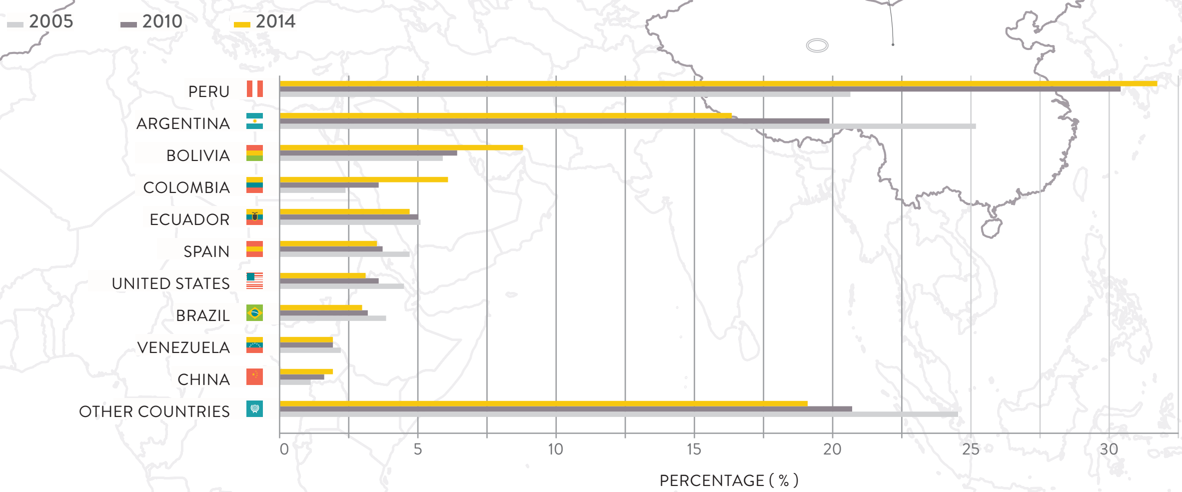
ESTIMATE OF FOREIGN RESIDENTS IN CHILE, 1982-2014



Source: Ministerio del Interior y Seguridad Pública, 2016.

FIGURE 06

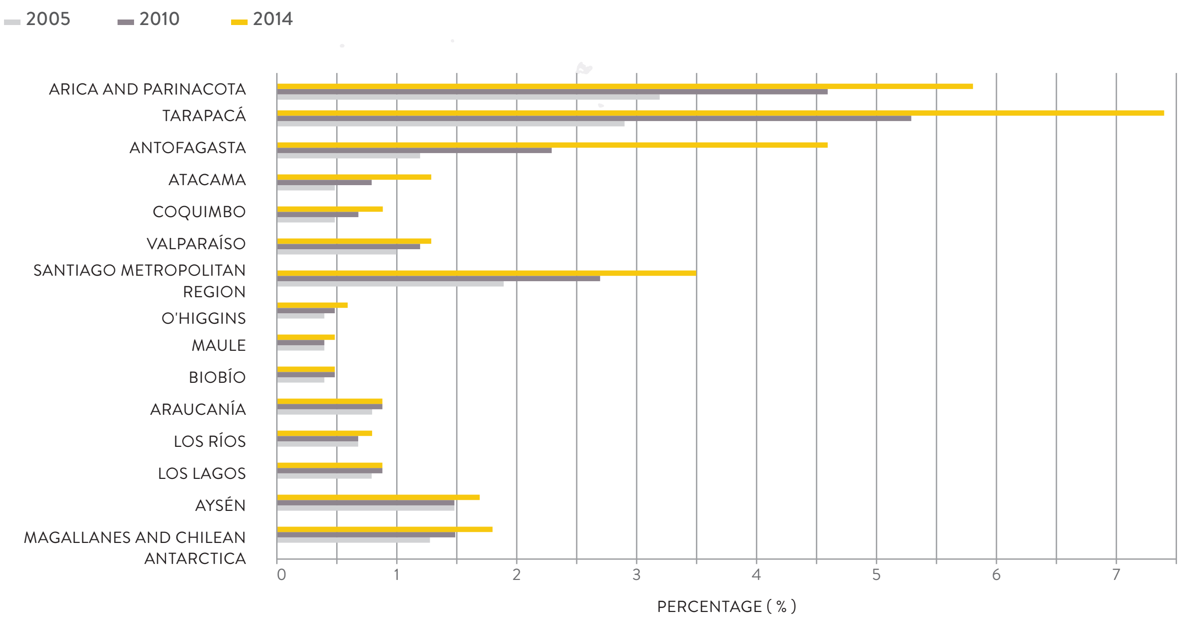
MIGRATION IN CHILE: THE 10 LARGEST IMMIGRANT COMMUNITIES, 2005-2014



Source: Ministerio del Interior y Seguridad Pública, 2016.

FIGURE 07

MIGRATION IN CHILE: DOMESTIC PERCENTAGE OF IMMIGRANTS BY REGION, 2005-2014



Source: Ministerio del Interior y Seguridad Pública, 2016.

2.5 Floating Population

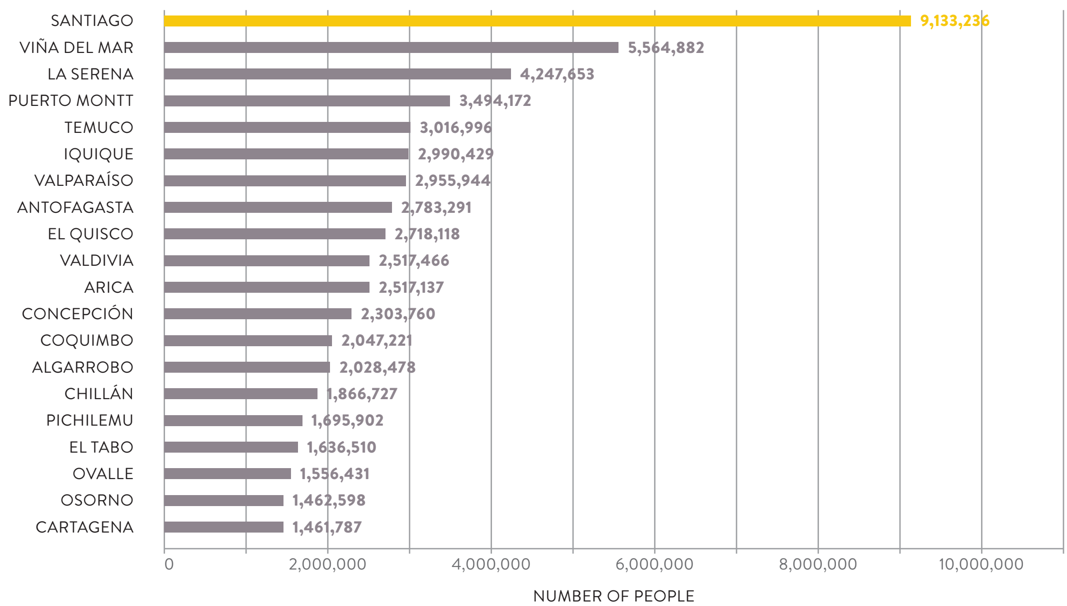
The sudden increase of the population in a given season of the year, called floating population, can have negative consequences on the environment. Because of that, it is relevant to learn how many people visit a city or commune without being residents and during which times of the year they do so. The floating population is established by adding the people who, without being usual residents, are in a city, whether they are lodging in a tourism accommodation, the house of a relative, a second home, a rented house or apartment, or simply visiting for the day.

The cities with the largest floating population are called tourism communes. This classification is developed by the National Tourism Service (Sernatur by its acronym in Spanish) and it is used as one of the criteria for the distribution of the Common Municipal Fund (FCM by its acronym in Spanish), which represents the main source of funding for municipalities.

The commune with the largest floating population in the country is Santiago. Other cities with high floating populations are generally those located along the coast, which concentrate their greatest population during the summer season.

FIGURE 08

TWENTY COMMUNES WITH THE LARGEST FLOATING TOURIST POPULATION, 2013



Source: Servicio Nacional de Turismo, 2013.

3 • SOCIAL AND ECONOMIC BACKGROUND

The average monthly household income, for 2015, at the national level, is CLP $832,072. The Santiago Metropolitan Region has the highest average income with CLP $1,063,000, while the Araucanía Region, with CLP $551,000, has the lowest [6].

Despite the sustained growth in income, the level of poverty is high. In 2015, 19.1 percent of the population lives below the poverty line[7]. This calculation was made by using a new methodology that not only considers household income, as was done until then, but also other factors such as education, work, social security and housing. This is referred to as multidimensional poverty[8]. Likewise, by adding a new dimension, which includes the surroundings and networks, the percentage of the population living in poverty reaches 20.9 percent.

On the other hand, the Gross Domestic Product (GDP) of the country has experienced sustained growth (**Figure 09**). In 2015, the GDP per capita reached USD $22,197 PPP dollars per year[9]. The economic activity that contributes the most at the national level is financial and business services, with approximately 19 percent, but there are areas where other activities are more prominent, such as in the northern area, where mining prevails. The greatest mining activity is concentrated in the Antofagasta Region, representing 61 percent of its GDP.

FIGURE 09

COMPARISON OF GDP, POVERTY, GINI AND HDI VARIATIONS

Source: **GDP:** Organisation for Economic Co-operation and Development, 2015 data; **HDI:** United Nations Development Programme (UNDP), available for 2014; **GINI**: CASEN Reports, until 2015; **Extreme Poverty**: CASEN Reports, 2015; **Poverty**: CASEN Reports, until 2015; **INE**: Population projections, 2002 Census.

[6] *Ministerio de Desarrollo Social (CASEN) 2015. Evolution and distribution of household incomes 2006-2015.*

[7] *Ibid.*

[8] *Ibid.*

[9] *GDP per capita based on Purchasing Power Parities (PPP). Data available at OECD Stat. http://stats.oecd.org*

Nevertheless, the growth of the country has not brought about an improvement in the distribution of wealth. Chile shows high and persistent inequality rates. However, according to the results of the 2015 CASEN Survey, regarding the Gini coefficient [10], it is observed that there is a "moderate and statistically significant [reduction] of inequality in the overall -generated by households- as well as monetary -household plus State subsidies- incomes" (Ministerio de Desarrollo Social, 2015) [11].

On the other hand, if we consider other indicators, such as the 2015 Human Development Index (HDI), created by the United Nations Development Programme (UNDP), Chile obtains an index of 0.832, one of the highest in Latin America. It is also observed that there is a continuous improvement in this index. Although this is a good indicator for measuring human development, when the inequality variable is considered the score drops to 0.672, which once again shows that inequality is one of the main issues for the development of the country.

[10] *The Gini coefficient is a measurement of income inequality among individuals within a region, for a given period. It takes values between 0 and 1, where 0 indicates that all individuals have identical incomes and 1 indicates that all the income goes to only one person. The Gini index is the Gini coefficient expressed as a percentage, and it is equal to the Gini coefficient multiplied by 100.*

[11] *Ministerio de Desarrollo Social. Encuesta de Caracterización Socioeconómica Nacional (CASEN). Evolución y distribución del ingreso de los hogares 2006-2015 (National Socioeconomic Characterization Survey (CASEN by its acronym in Spanish). Household Income Evolution and Distribution 2006-2015).*

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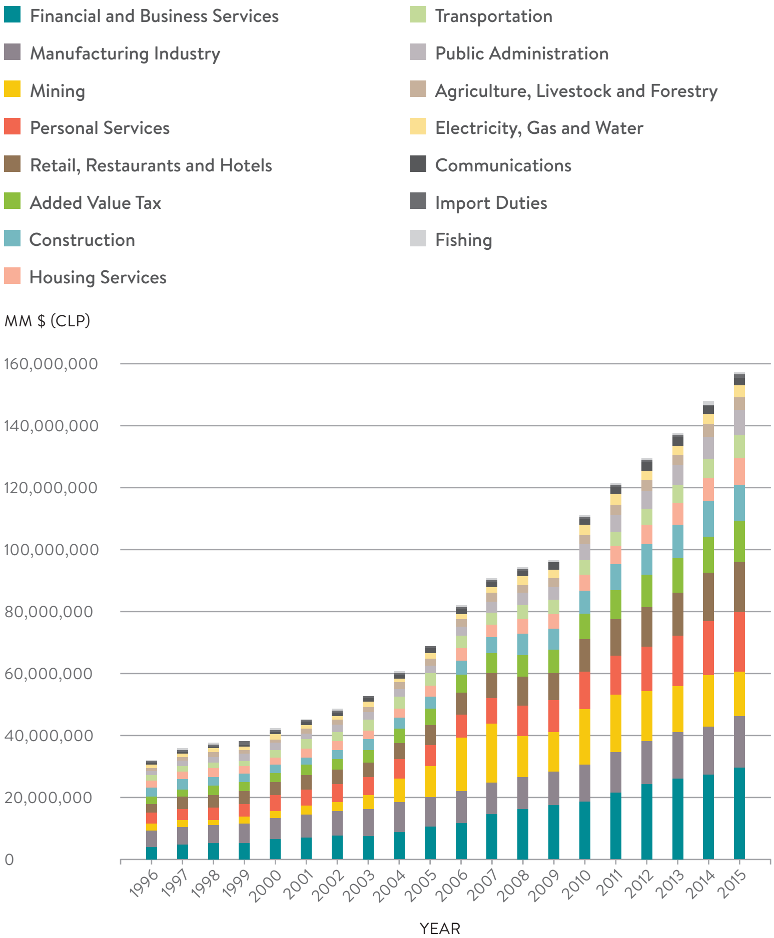
ⓘ HDI

The Human Development Index is a social statistical indicator created by the United Nations Development Programme (UNDP), which is made up of the integration of 3 main parameters:
(i) long and healthy life,
(ii) knowledge
(iii) a decent standard of living
These parameters are measured with information about life expectancy at birth, literacy rate, years of mandatory schooling for education, gross education rate, combined for elementary education, secondary education and higher education, and the GDP per capita (PPP) of each of the countries in which the index will be applied (MMA, 2011).

FIGURE 10

GROSS DOMESTIC PRODUCT BY TYPE OF ECONOMIC ACTIVITY
spliced data series, 2008 reference (million CLP)



Source: MMA, based on data from INE, 1998-2015.

The productive activity that represents the largest percentage of the GDP is financial and business services sector, with 19 percent (maintaining the leading position since 2005), followed by the manufacturing industry, with 11 percent, and mining, with 9 percent, as shown in **Figure 10**.

PERCENTAGE OF GDP

Financial and Business Services

19%

Manufacturing Industry

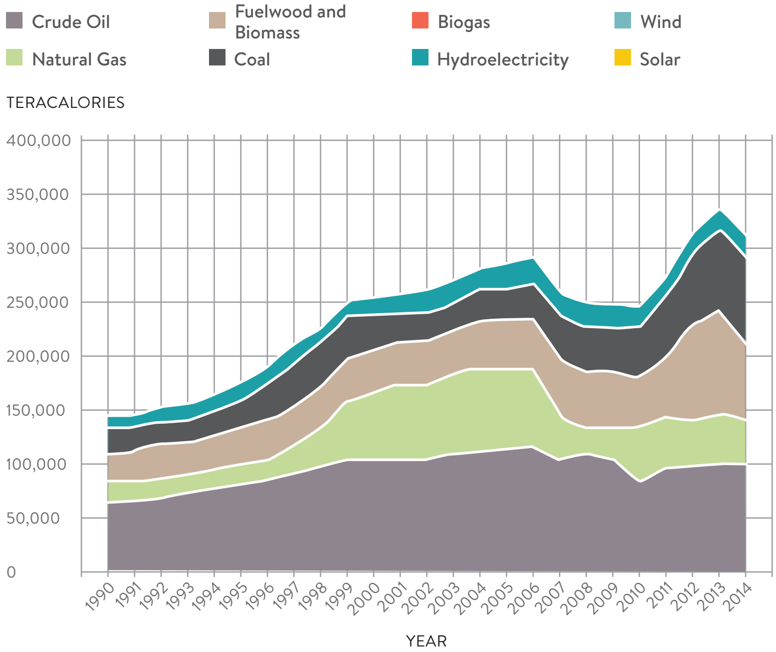
11%

Mining

9%

FIGURE 11

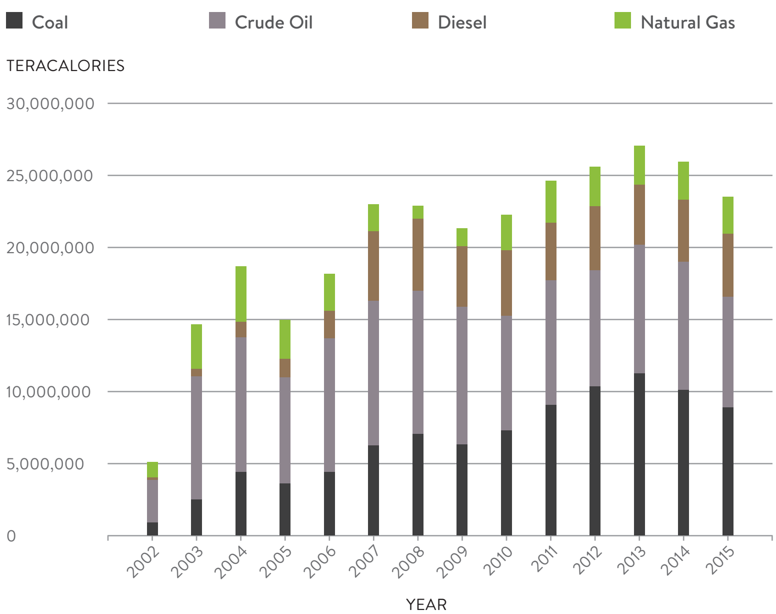
EVOLUTION OF GROSS PRIMARY ENERGY CONSUMPTION



Source: Balance Energético. Balance Nacional de Energía. http://energiaabierta.cne.cl

FIGURE 12

HYDROCARBON IMPORTS



Source: Balance Energético. Balance Nacional de Energía. http://energiaabierta.cne.cl

In terms of primary energy consumption, in 2014 it was 6 percent less than in 2013. Following the historical trend, crude oil is at the top of the list of the most consumed primary energy sources, followed by coal and fuelwood and biomass. Approximately 95 percent of the oil consumed is imported (Ministerio de Energía, n.d).

Although renewable energies have a minority share of gross consumption, it is important to highlight the constant growth experienced by wind energy, which has gone from 477 teracalories in 2013 to 1,230 in 2014, representing an increase of 157 percent.

HYDROCARBONS

95%

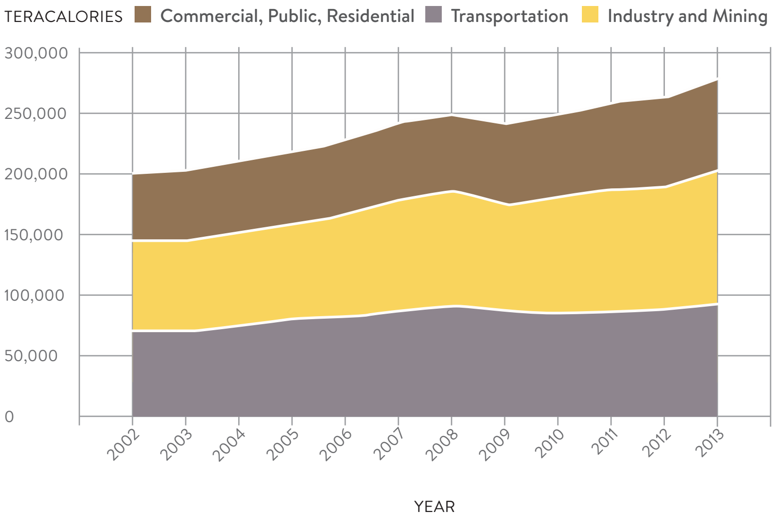
of the oil consumed is imported.

In 2015, the share of coal imports was

38%

FIGURE 13

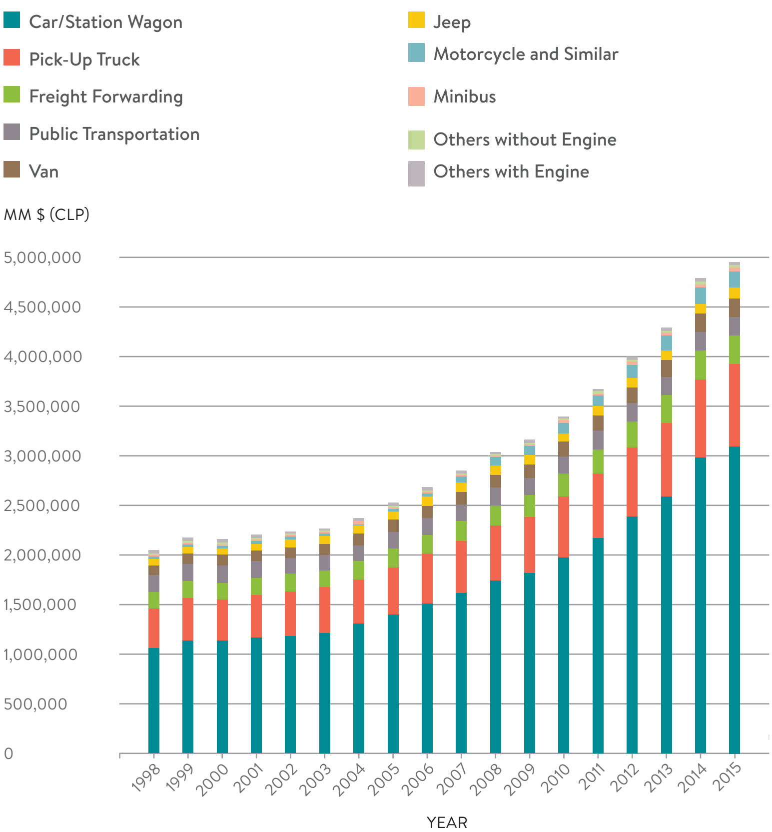
ENERGY CONSUMPTION VARIATION BETWEEN 2002 AND 2013



Source: Balance Energético. Balance Nacional de Energía.
http://energiaabierta.cne.cl

FIGURE 14

EVOLUTION OF THE VEHICLE FLEET



Source: MMA, based on data from INE 1998-2015

When analyzing the data by productive sector, it is observed that, in 2013, the largest energy consumption is concentrated in industry and mining (39 percent), followed by transportation (34 percent), and by commercial, public and residential consumption in third place (27 percent).

Meanwhile, the vehicle fleet shows a sustained increase, of approximately 4 percent in comparison to 2014. The cars and station wagons category has a share of nearly 60 percent of the fleet at the national level.

VEHICLE FLEET

Total national vehicle fleet by 2015

4,751,130
UNITS

Cars/Station Wagons

61.4%

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Weaver, Achao | KARINA BAHAMONDE

CHAP **02**

GENDER AND ENVIRONMENT

CONTENT

INTRODUCTION

Why talk about gender and the environment? Why should the environment be looked upon from the gender perspective or approach? In order to answer these questions, it is essential to consider the gender concept, which refers to social, cultural, and political components, to roles that have been learned, defined and valued in a society. In this regard, it refers to the difference, the inequality that, throughout history, has existed between men and women in different areas.

This chapter shows the current relevance of gender equality to achieve sustainable development, as well as the progress made by Chile in this field.

1 • BACKGROUND INFORMATION

The gender perspective or approach deals with the relationship between the masculine and feminine, the social construction it is based upon, and reveals the cultural differences underlying this relation framework. In this context, the relevance of talking about gender and environment arises, especially in countries in which, despite the knowledge and reflection achieved in this topic, there are still inequalities that affect women negatively, limiting, in this case, their necessary contribution to sustainable development.

The gender approach does not mean assigning women a special relation with the environment[1] or a greater responsibility, it rather highlights the gender role within these social patters, the inequalities and the consequences they have on the relation with the environment, as well as on building sustainable development. Issues such as access, use and ownership of resources, for example, are relevant and have consequences on environmental matters, especially among the poorest population. In this regard, the gender perspective in sustainable development involves the development of structural policies that will enable equating the position of women to achieve the development of their capacities, as well as to participate in spaces of power and decision making.

At present, gender equality is no longer a fight put up by a small group. On the contrary, it is an issue considered as strategic for society. As pointed out by the World Bank (2012), gender equality is necessary because it is a goal and a tool for development.

According to UN Women (ONU Mujeres, n.d.), the United Nations organization for Gender Equality and the Empowerment of Women, "the gender equality and women's empowerment mandate is universally agreed on by Member States and encompasses all areas of peace, development and human rights. The mandates on gender equality derive from the United Nations Charter, which unequivocally reaffirmed the equal rights of men and women."

In order to promote the application of this mandate and move forward in "gender mainstreaming" in societies, UN Women refers to the Fourth World Conference on Women (1995), which endorsed gender mainstreaming as a "critical and strategic approach for achieving gender equality commitments." As a result of the agreements achieved in this Conference, the UN Economic and Social Council (ECOSOC) defined gender mainstreaming, in 1997, as "...the process of assessing the implications for women and men of any planned action, including

GENDER EQUALITY

The gender perspective in sustainable development involves the development of structural policies that will enable **equating the position of women to achieve the development of their capacities, as well as to participate in spaces of power and decision making.**

"Striving for gender equality is a key element of a sustainability vision in which **each member of society respects others and plays a role that enables her or him to realize her or his full potential" (UNESCO, 2016).**

[1] The ecofeminism movement, which developed over the '70s and '80s, stated that women had a special relationship with the environment.

legislation, policies or programmes, in all areas and at all levels."

Although, for environmental matters, there are no global measurements that allow for an assessment to be made of the impacts of gender inequality, there is an index developed by the World Economic Forum that measures the gender gap based on four pillars: Economic Participation and Opportunity, Educational Attainment, Health and Survival and Political Empowerment. According to the 2015 Report, the gender gap, in comparison to 2006, when the measurements began, has not been closed and, despite the progress made, issues such as economic participation and political empowerment show the slowest advances. In the case of economic opportunities, it is estimated that it would take approximately 113 years to close the gap.

01

GENDER EQUALITY

Gender equality implies that all human beings, both men and women, are free to develop their personal skills and to make choices without being limited by stereotypes, rigid gender roles or prejudices. It encompasses equal rights, responsibilities and opportunities for men and women, girls and boys, considering the specific interests, aspirations and needs of men and women, which must be valued and favored in the same manner (UN Women, n.d.).

Gender equality, as a goal, often requires policies based on affirmative action towards women. As stated by Cristina Maoño[2] (n.d.), "because of the existing inequalities between them, giving the same treatment to women and men is not enough to achieve equality goals; it is rather the opposite, an equal treatment in a context of inequality can contribute to perpetuate the original lack of equality."

Creation of the Ministry of Women | KARINA BAHAMONDE

[2] Cristina Maoño has participated in the elaboration of various concepts related to gender, women and development agencies.

2 • UNITED NATIONS AGREEMENTS REGARDING THE LINKS BETWEEN GENDER AND ENVIRONMENT, SUSTAINABLE DEVELOPMENT AND GREEN ECONOMY

The United Nations Conference on the Human Environment, held in Stockholm (Sweden) in 1972, focused on environmental degradation and transfrontier pollution, did not specifically mention women. However, it can be deduced that the term "man" covered both men and women. The Declaration establishes that: "Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations."

Twenty years later, the United Nations Conference on Environment and Development (UNCED), also known as the "Earth Summit", held in Rio de Janeiro (Brazil) in 1992, focused on human socioeconomic activities and their negative impact on the environment, as well as the influence of the environment on socioeconomic activities. Regarding the links between women and environment, Principle 20 (out of 27) states that: "Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development."

Later on, the Johannesburg Declaration on Sustainable Development, adopted in 2002 during the World Summit on Sustainable Development, underscored more emphatically the cross-cutting nature of the participation of women in all fields of development. The declaration, titled "From our origins to the future", states in number 20 that: "We are committed to ensuring that women's empowerment, emancipation and gender equality are integrated in all the activities encompassed within Agenda 21, the Millennium development goals and the Plan of Implementation of the Summit."

On the other hand, the document "The future we want", which resulted from the United Nations Conference on Sustainable Development, held in Rio de Janeiro in 2012 (Rio+20), briefly points out the importance of women in the green economy context and dedicates a specific chapter to the challenge related to "Gender equality and women's empowerment". While the States Parties of the document recognize that progress on gender equality has been made, they also highlight that the potential of women to engage in, contribute to and benefit from sustainable development as leaders, participants and

Working for the environment | KARINA BAHAMONDE agents of change has not been fully realized, owing to, inter alia, "persistent social, economic and political inequalities."

It is worth noting that, on the one hand, the United Nations conferences on sustainable development have highlighted the importance of the active participation of women in the pathway towards sustainable development. On the other hand, the United Nations conferences aimed at promoting gender equality and women's empowerment incorporated the environment as an issue of particular concern. This was clear during the Fourth World Conference on Women, held in Beijing, China, which adopted the Declaration and Platform for Action. Said platform contains broad commitments related to "12 critical areas of concern", which include "women and environment". The three strategic objectives, together with a series of measures to be implemented, are the following:

- **Strategic objective K.1.:** Involve women actively in environmental decision-making at all levels.

- **Strategic objective K.2.:** Integrate gender concerns and perspectives in policies and programs for sustainable development.

- **Strategic objective K.3.:** Strengthen or establish mechanisms at the national, regional and international levels to assess the impact of development and environmental policies on women.

In the context of the 2030 Agenda for Sustainable Development, which includes 17 Sustainable Development Goals (SDGs), UN Women states that "the achievement of full human potential and of sustainable development is not possible if one half of humanity continues to be denied its full human rights and opportunities," adding that "the agenda includes a transformative stand-alone goal on gender equality and the empowerment of women and girls as well as gender-sensitive targets in 11 other goals" (ONU Mujeres, 2015).

But, at the same time, the signature and ratification of the United Nations agreements related to gender and environment, sustainable development and green economy, adopted over the last two decades, lack indicators that will allow for the supervision of the implementation of the commitments at the country level. As the International Union for Conservation of Nature (IUCN, 2013) points out, governments have come together to establish international mandates ensuring that gender equality and women's empowerment are central to environmental decision making and sustainable development. However, the lack of mechanisms to monitor and measure government progress has contributed to little or no implementation of these international agreements. In order to remedy the absence of indicators, the IUCN is developing (with support from the Swiss Government) a project aimed at establishing specific indicators for "Environment and Gender".

On the other hand, the United Nations Environment Programme (UNEP) is developing, within the framework of the Global Environment Outlook (GEO), disaggregated indicators by sex for 12 environmental issues, such as resource efficiency, sustainable consumption and production, energy, biodiversity, climate change, and green economy, including decent employment (UNEP, n.d.).

3 • PROGRESS AND CHALLENGES AIMED AT GENDER EQUALITY IN CHILE

With the return to democracy, in 1990, the gender equality topic was incorporated as a public policy issue. In fact, the National Service for Women (SERNAM by its acronym in Spanish) was created in January 1991 with the mission of "promoting equality, autonomy, equity, no discrimination and a life free of violence within society for women in all their diversity, as well as the implementation of policies, plans and programs that will mainstream gender equity in a cross-cutting manner throughout the State" (SERNAM, n.d.).

The institutions in this field have been recently reinforced with the creation of the Ministry of Women and Gender Equity (Law 20.820), which replaces the current SERNAM. For President Bachelet -who was the first woman in Chile to become President of the Republic-, gender equality is an integral and cross-cutting issue, a perspective that was strengthened during her period as director of UN Women (2010-2014).

The plans, programs, legal reforms and initiatives that have been implemented since the '90s to reduce inequality gaps in the country include: The Equal Opportunity Plans for Women and Men; the Government's Gender Agenda; the Women and Work Program, the Women Heads of Household Program; the law that categorizes femicide; and the reform to the election system that guarantees that women and men have a minimum of 40 percent and a maximum of 60 percent share in the list of candidates to Congress. On the other hand, the Council of Ministers for Gender Equality incorporated into the institutional framework the contribution of people in charge of gender in each of the ministries, agencies, ministry regional secretariats and public enterprises.

In 2000, Chile signed the Millennium Declaration, which included among its objectives the promotion of gender equality and women's autonomy. According to the Fourth Country Report (2014), Chile reached the goal of equal access to all levels of education. Likewise, the report records that, during the first trimester of 2014, a rate of 48.5 percent of female participation in the labor force was reached, which, although considered to be progress in the country, is below the 52 percent average for Latin America.

Regarding participation in Congress, out of a total of 158 seats only 25 are held by women, divided into 19 in the House of Representatives (holding 120 seats) and 6 in the Senate (holding 38 seats). Thus, women's representation in Congress reaches only 15.8 percent, while the goal was 40 percent. According to the report, this percentage reveals the existing gender inequality in the country, where 50.5 percent of the population is made up of women.

Despite the efforts made and progress achieved so far, there are still significant challenges. According to *The Global Gender Gap Report* by the World Economic Forum, which measures gender-based gaps in access to economic opportunities, education, health and political empowerment, Chile still has a long way to go. Furthermore, the country has not been able to maintain the achievements attained. In 2012, Chile ranked 87 in this index, dropping to position 91 in 2013. Noteworthy progress was made in 2014, placing the country in position 66 out of a total of 142 countries. However, in 2015 it dropped once more and ranked 73 among 145 countries.

Meanwhile, the Gender Equality Observatory for Latin America and the Caribbean of the Economic Commission for Latin America and the Caribbean (ECLAC) has been working since 2009 with indicators for the three dimensions of women autonomy: economic autonomy; physical autonomy; and autonomy in decision making. These three dimensions enable the monitoring and analysis of the situation in terms of gender equality (CEPAL, 2012).

MINISTRY OF WOMEN AND GENDER EQUITY

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Economic Autonomy

According to the 2013 Casen Survey results for Gender, in terms of poverty situation by incomes and sex, poor women surpass poor men: 15 percent versus 13.7 percent. Likewise, the percentage of people living in extreme poverty according to income is higher for women (4.8 percent) than men (4.2 percent). On the other hand, the percentage of women heads of households (households made up only by women with children) was 37.9 percent in 2013. Meanwhile, among households with multidimensional poverty (including education, health, work and social security and housing), the percentage for women heads of households reached 16.4 percent, while for men the percentage was 15.8 percent.

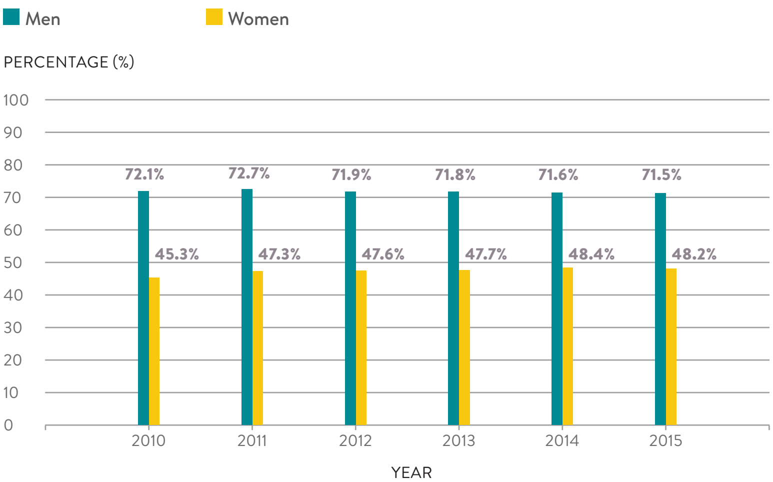
Another aspect of the scarce economic autonomy is the low participation of women in the labor market, which undermines women worldwide and is also negative in terms of the country's growth and competitiveness. Within the framework of the OECD, data from 2009 revealed that 47 percent of women in Chile were employed, while the OECD average was 62 percent (INE, January 2015, p.14).

Figure 01 shows how the low female labor share rate has improved since 2010, but there is still a significant gap between men and women. Specifically, in 2014 the rate for women was 48.4 percent, while the rate for men reached 71.6 percent. Hence, the gap is equal to 23.2 percent.

The salary gap between men and women was 26.6 percent on average, according to the 2013 Casen Survey on Gender. The results of the New Supplementary Income Survey (NESI by its acronym in Spanish) conducted by the INE indicate that the income of women increased from an average of CLP $354,681 in 2013 to CLP $382,253 in 2014, while the average work income of men grew from CLP $531,034 in 2013 to $543,996 in 2014.

FIGURE 01

SHARE RATES



Source: INE, n.d. National Employment Survey, 2010-2015.

It is worth mentioning that women's unpaid work practically prevents them from having access to social services. In this context, it has been pointed out that several studies "focus on work for the market, excluding a significant number of activities aimed at individual, family and social well-being", which in turn renders "a partial vision of work" that does not take into account the broad diversity of types of work, both paid and unpaid" (Aguirre, R. and Ferrari, F., 2014).

Physical Autonomy

Physical autonomy mainly encompasses violence against women, sexual and reproductive rights, maternal mortality and teenage pregnancy.

According to data from the Gender Equality Observatory for Latin America and the Caribbean (OIG by its acronym in Spanish), in 2013 and 2014 women's deaths at the hands of their intimate partner or former partner reached 40 victims in Chile. It is important to point out that Law 20.480, which categorized femicide in 2010 (modifying the Domestic Violence Law), recognizes as such only the murder of a woman who had an emotional tie with the killer. That is, it does not consider other murders motivated by gender, which would make the number of victims even higher.

Regarding sexual and reproductive rights, the decriminalization of abortion for three reasons is currently being discussed: rape, non-viability of the fetus and risk of death for the mother. Maternal mortality has significantly dropped and the rate of birth among teenagers between 15 and 19 years old was 46.3 for every one thousand women in 2013, with the rate being higher among the vulnerable sectors of Chilean society.

Autonomy in Decision Making

Autonomy in decision making refers to the number of women in positions of power, which reflects, overall, a low share.

As previously mentioned, Michelle Bachelet has been the first woman to become President of the Republic. This fact, together with the parity of her first cabinet, has been considered a "historic milestone".

Regarding Congress, only 15.8 percent of legislators are women (25 out of 158). Female mayors reach 12.2 percent, compared to 87.8 percent of male mayors, and female city council members reach 24.8 percent versus 75.2 percent of male city council members. As for women's participation in the highest court of justice, the Supreme Court, data reveal a 25 percent share (CEPAL, 2012).

A similar situation is observed among large private companies in Chile, which are "marked by a strong underrepresentation of women in managerial and high executive positions" (Pizarro and Guerra, 2010). In this regard, the data indicate that Chile has a 24 percent share of women in executive positions, which is lower than the 28 percent average for Latin America (Pizarro and Guerra, 2010).

DECISION MAKING

Autonomy in decision making refers to the number of women in positions of power, which reflects, overall, a low share.

In Congress

15.8%

WOMEN (25 OUT OF 158)

4 • GENDER AND ENVIRONMENT IN CHILE - AN APPROACH

Chile has not yet begun to discuss the mainstreaming of a gender perspective in specific issues dealing with the environment, such as transportation, recycling, sustainable procurement, food, clothing, etc.

On the other hand, neither has the environment been considered in public policies aimed at gender equity, as can be observed in the main areas of concern of the National Service for Women (SERNAM). Overall, the programs, plans, and strategies dealing with sustainability, in which the environment is only one of its three pillars, have not incorporated the gender aspect. This is evident, for example, in the National Strategy for Green Growth, the National Program for Sustainable Consumption and Production, the National Plan for Sustainable Tourism, and the Strategy for Sustainable Construction.

The upcoming update of the National Strategy for Green Growth, as well as the formulation and implementation of national goals and indicators within the framework of the Sustainable Development Goals (SDGs), will provide a good opportunity to consider mechanisms and tools that will enable making progress towards greater equity between women and men in the context of sustainable development, taking into account environmental and social criteria.

SDG Goal 5 aims to "achieve gender equality and empower all women and girls." Considering the 17 SDGs, approximately 10 of them are directly related to the environment, such as: sustainable agriculture: sustainable water management and sanitation; accessible and sustainable energy; sustained, inclusive and sustainable economic growth and, along with it, decent employment for all; inclusive and sustainable industrialization; sustainable cities; sustainable consumption and production patterns; climate change; sustainable use of oceans and marine resources; and sustainable use of terrestrial ecosystems.

All of these topics allow for incorporating the gender perspective, as well as the active participation of women in decision making and in the formulation of policies and programs in favor of sustainable development.

One issue of particular concern in Chile is the lack of "environmental equity" in the country, which refers to the fact that the socioeconomic vulnerable sectors are the ones with greater exposure to pollution (air, landfills, among others), or which have scarce green areas, for example. As revealed by the data, indicated in section three, there are more women than men living in extreme poverty. Therefore, it can be deduced that women are more affected than men by an insufficient environmental equity, which has negative impacts on their health and quality of life.

ⓘ **Environmental Equity**

"Inequity is also expressed in the environment. Environmental degradation and pollution affect more severely the quality of life of the most vulnerable population . We have the duty to change this reality. Sustainability demands not only balancing economic growth and environmental protection, but also to do so with social equity. This will be the axis of our administration: achieving greater environmental equity."

Source: *Chile de todos. Programa de Gobierno, Michelle Bachelet 2014-2018 (Chile for All. 2014-2018* Government Program, Michelle Bachelet), p. 126

5 • SOME INITIATIVES THAT PROMOTE THE LINKS BETWEEN GENDER AND ENVIRONMENT

Although the country must make progress in the development and implementation of the links between gender and environment and, more specifically, in terms of sustainable development, there are some public initiatives that contribute to promote this nexus.

5.1 Promotion of Female Entrepreneurship

In order to improve the access and permanence of women in the labor market, the government has created several programs targeted at promoting female entrepreneurship. Although the economic resources, training and technical assistance of the programs are aimed at a broad array of trades and activities in general, some of them are directly related to the environment.

The "*Más Capaz Mujer Emprendedora*" ("More Capable Woman Entrepreneur") Program, executed by the National Training and Employment Service (SENCE by its acronym in Spanish) has several agreements with other public agencies, such as, for example, the National Fishing and Aquaculture Service (Sernapesca by its acronym in Spanish), which fosters female entrepreneurship in the artisanal fishing sector.

The "*Concurso Mujer Empresaria Turística*" ("Woman Tourism Entrepreneur Competition") was created as a result of an alliance between the SERNAM, Sernatur and BancoEstado, emphasizing sustainability, which is understood as "activities that make an optimal use of natural resources, respect the socio-cultural authenticity of host communities and ensure viable long-term economic development" (Sernatur, 2015).

Meanwhile, by means of an agreement signed between the National Institute for Agriculture and Livestock Development (INDAP by its acronym in Spanish), a dependency of the Ministry of Agriculture, and the Foundation for the Promotion and Development of Women (Prodemu by its acronym in Spanish), there is an education and training program for women farmers. The program, which lasts three years, includes fostering activities linked to forestry, agriculture and livestock production, rural tourism or handicrafts with an environmental sustainability approach.

There are other government programs particularly aimed at promoting female entrepreneurship, but the environment and sustainable development are not part of their specific objectives. However, they constitute an axis that could be explicitly incorporated in the future.

Thus, for example, through BancoEstado's "*Crece Mujer Emprendedora*" ("Grow Female Entrepreneur") program, the government seeks to foster female entrepreneurship with the aim of increasing the labor share of women while at the same time contributing to the economy.

The Technical Cooperation Service (Sercotec by its acronym in Spanish), through its "*Capital Abeja*" ("Bee Capital") call for projects, exclusively promotes initiatives by female entrepreneurs and small and microenterprises throughout the country. The Chilean Economic Development Agency (CORFO by its acronym in Spanish), within the framework of its Start-Up Chile program, offers one aimed at women, since one of the selection criteria requires that the project be led by a woman.

Juan Fernández Island | CHARIF TALA

02

GENDER AND ENVIRONMENT IN THE JUAN FERNANDEZ ARCHIPELAGO

The Corporation for the Defense of Human Rights of Boys, Girls and Teenagers, based on Gender and Family, with support from the GEF/ MMA/UNDP Project “Strengthening National Frameworks for Invasive Alien Species (IAS) Governance: Piloting in Juan Fernandez Archipelago,” carries out a project called “Applying Environmental Education with a Gender Approach in Robinson Crusoe Island: Conservation of Endemic Species and Control of Invasive Species within the framework of the GEF/ MMA/UNDP IAS JFA Project”.

The project tries to “apply integrated environmental education mainly targeted at the female community, allowing them to improve their community competencies on environmental management, strengthening care, development and respect towards them as a relevant subject in order to then transfer that to the natural environment. The aim is that the community will be part of the education process, generating a dynamic learning relationship that will result in activities to manage Invasive Alien Species.

First of all, it focused on people and on learning about their psychosocial circumstances, in order to then move on to environmental issues. Thus, between February and April 2014, on Alejandro Selkirk Island, the corporation held the first activity with the general objective of “improving the community competencies of women and children on environmental management, strengthening the care, development and respect for the environmental surroundings of Alejandro Selkirk.” The main objective was to achieve the environmental education of women and children on endemic plants and alien invasive plants, and the importance of eradicating the latter.

Through the learning and awareness of children and mothers, the purpose was to pass what they had learned on to their families and the community as a whole. The families live on Alejandro Selkirk island only during the summer season to ensure their livelihoods by means of lobster fishing and then they return Robinson Crusoe island.

Regarding the role of women in Juan Fernández, the corporation indicates that “female participation has been scarce, which has held back personal and organizational development processes, because they have joined late.”

The results of this project will be useful for the design and development of other initiatives focused on gender and the environment.

5.2 Environmental Protection Fund

The Environmental Protection Fund (FPA by its acronym in Spanish) is managed by the Ministry of the Environment (MMA by its acronym in Spanish) and it is the first and only environmental call for projects of the State of Chile.

Applications for the FPA are open to a broad array of community organizations, NGOs, women organizations, sports clubs, foundations, agricultural communities, indigenous associations, etc. According to FPA data, over the last years the interest of women in coordinating projects related to the environment and sustainable development has increased.

As shown in the following graph, between 2009 and 2012, the project leaders were mostly men, while between 2013 and 2015, most of the projects were led by women. It is worth noting that in 2015 there were 110 FPA projects managed by women, while only 72 were executed by men.

Regarding the distribution of the subject lines of the projects coordinated by women between 2009 and 2015, 63 percent were linked to topics related to climate change (which includes waste and environmental education projects), 19 percent to biodiversity, and 18 percent to energy efficiency.

FIGURE 02

COORDINATION OF EXECUTED PROJECTS BY GENDER (2009-2015)

Source: Authors' own elaboration based on the MMA's FPA, 2015.

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Soria Mamani in Enquelga | NICOLAS LAGOS

CHAP **03**

NATIVE PEOPLES

CONTENT

INTRODUCTION

This chapter addresses indigenous issues, emphasizing on the relation of native peoples recognized by the State of Chile with the environment and territory. It is an initial effort to address this issue as part of a State of the Environment Report, based on the GEO criteria and recommendations of the United Nations Environment Programme, UNEP.

1 • BACKGROUND INFORMATION

Indigenous peoples are those that *"...are regarded as indigenous on account of their descent from the populations which inhabited the country, or a geographical region to which the country belongs, at the time of conquest or colonization or the establishment of present state boundaries and who, irrespective of their legal status, retain some or all of their own social, economic, cultural and political institutions"* [1].

"The State recognizes as the main indigenous ethnicities of Chile the Mapuche, Aymara, Rapa Nui or people from Easter Island, the Atacameña (Lican Antai), Quechua, Colla, and Diaguita communities in the north of the country, and the Kawésqar or Alacalufe and Yámana or Yagán communities in the southernmost channels. The State values their existence because they are an essential part of the roots of the Chilean Nation, as well as their integrity and development, in accordance to their traditions and values" [2].

1.1 Indigenous Peoples and the Environment

The relation between indigenous peoples and the environment is more than a dialectic relation; independent and inseparable, the existence of one cannot be conceived without the other. The Organization of American States (OAS) observes that the indigenous peoples who have survived continue to rule themselves by traditions and customs that are compatible with the ecosystem that surrounds them. At present, people belonging to these ethnicities live both in urban areas as well as in remote rural areas, maintaining traditional lifestyles.

[1] *Article 1.1 letter b of the Convention concerning Indigenous and Tribal Peoples in Independent Countries, passed by Supreme Decree N°236, dated 4 October 2008, of the Ministry of Foreign Affairs.*

[2] *Paragraph two, Article 1 of Law19.253, which establishes regulations regarding the protection, promotion and development of indigenous peoples and creates the National Indigenous Development Corporation (CONADI by its acronym in Spanish).*

Sunset in the Atacama Desert | LEYLA MUSLEH

TABLE 01

INDIGENOUS PEOPLES AND THE ENVIRONMENT

AYMARAS

Arica and Parinacota / Tarapacá Regions *

Nature is sacred to the Aymara and man is an integral part of it. The territory inhabited by this ethnicity conserves multiple areas: *High-Andean plateaus*, *coast* and *Andean foothills*, which creates a heterogenous economic, social, and political organization. Camelid livestock developed in the High-Andean plateaus with llamas and alpacas, introducing lamb later on in the Puna. Albeit at a small scale, there are also high-altitude agriculture and orchards in farms, on stream terraces and oases, sowing species for self-consumption, such as quinoa and potato. The Aymara worldview is articulated on three biogeographical elements that are closely related to the ecological surroundings. *Alajpacha -symbolized by the sun-*, represents all that is intangible and energy. Akapacha represents the Earth, the place of mediation, exchange, the environment we inhabit. *Manqhapacha*, the water, the creator of life, is represented by the streams.

The Aymara peoples have had to face the loss of the ancient waters due to the Water Code (DFL N° 1.222). Information provided by the Foundation for Communication, Training and Farm Culture (FUCOA by its acronym in Spanish) of the Ministry of Agriculture, reveals that in 1981 this situation hindered the development of their agricultural activities, causing ecological impacts and boosting the migration of their inhabitants.

QUECHUAS

Tarapacá / Antofagasta Region*

It has been identified that the Quechua communities reveal cultural differences depending on their location, which to a great extent determines their level of economic and social integration. There are two main ones that inhabit the Loa province: the Quechua Community of Ollagüe, located in the basins of the Carcote and Ascotán salt flats and the Quechua Community San Pedro Station, which occupied the basin of the San Pedro or Inalcaliri river, a place they had to abandon due to the extraction of water for mining. The creation of the Quechua Indigenous Communities, in the Pozo Almonte commune, has been brought about by the agriculture in the ravines. The Quechua Community of Ollagüe has preferably developed livestock and agriculture, as well as gathering.

The Quechua communities of the Tarapacá Region are characterized by the development of agriculture at the bottom of the ravines in the foothills of the Andes mountain range, such as Quipisca and Miñi Miñe, and the oasis at Mamiña. The connection of these people with nature can also be observed in its deities. The most ancient ones are the Mallkus and T'all, masculine and feminine spirits of sacred hills. The Pachamama occupies a fundamental place, it personifies the divine land. The last one is the Amaru, a serpent that symbolizes the water courses.

ATACAMEÑOS

Antofagasta Region*

The Atacameños believe that nature benefits or punishes a person, and even an entire community, if it is not treated with respect. Their main representations developed in relation to the payment to the hills and to the Pachamama, and the water rituals. Each Atacameña community has one or more guardian hills, male (Mallku) and female (T'alla). Hills are also important for livestock reproduction in the atacameña communities, which are grouped in small towns and ayllus, the ancient socio-territorial organization with compartmentalized population, in agricultural and irrigated lands. Within each community's territory there are areas for collecting fertilizer and peat for agriculture, fuelwood, vegetable fibers, medicinal herbs and also for dyes (MOP, 2012 p.24). In addition, they extract construction materials and minerals such as salt, gypsum, scouring powder, onyx, pumice stones, red stones, and clay for pottery and cosmetics. At present, their main economic activities are shepherding, agriculture, mining and tourism. Chaxa Lagoon, in the Atacama Salt Flat, is co-managed by the Atacameña Community of Toconao and the National Forestry Corporation.

** The location of each native people is merely referential.*

CONTINUES ▶

COLLAS

Atacama Region*

The material and spiritual culture of the Colla people is in line with the Andean way of life and worldview, with Mother Earth or *Pachamama* being one of the main deities to which payment and fertility rituals are dedicated. One way is through the *apachetas* (rock mounts), which are types of altars that symbolize their connection with nature. The Collas have a dispersed population system, occupying water courses and fertile plains at the bottom of valleys and ravines. The rest of the territory is used for seasonal shepherding, through the settlement of pens and shepherding posts. The main economic activity of these people is livestock, characterized by migration and nomadism as articulating axes. In addition, they practice agriculture, mostly growing lucerne, and small-scale mining.

DIAGUITAS

Atacama Region*

Due to their contact with other populations, these people developed complex irrigation techniques for agriculture and domesticated llama and alpaca cattle. The most outstanding communities are those living closer to the mountain range, in Alto del Carmen. Some deities of the Diaguitas are also related to the powers of nature: The *Pachamama* is the mother of Earth, the *Llastay* is the god of the llama, vicuña, and guanaco herds as well as the condor, which protects the local wildlife. The Inti is the sun god, *Mayumama* the goddess of water and the *Mamquilla* -which represents the moon- is the goddess protecting crops during the harvest season.

According to the National Indigenous Development Corporation (CONADI by its acronym in Spanish), the ethnic name of the Diaguitas is currently advocated and used as ethnic identity by numerous indigenous families in Copiapó and Huasco and by other locations in the Elqui and Limarí valleys. In order to identify themselves and adhere to their condition of native peoples, these people rely on their family and local history, their last names and lineages, and on the land they have historically occupied.

RAPA NUI

Valparaíso Region*

The Rapa Nui or Easter Islanders are located in Easter Island or Rapa Nui -as it is called by its inhabitants- whose meaning is "large island", being the most isolated inhabited place in the planet. This society has experimented profound transformations related to the overexploitation of the environment. At present, public-private alliances have reduced the conflict of waste accumulation, which posed the threat of the nesting of the *Aedes aegipty* mosquito, a Dengue vector.

The ancestors of the Rapa Nui worshiped the Make Make god. It was said that *Make Make* was superior to all other deities, that he was the creator of all things and embodied the fertilizing strength of nature.

The "Isla de Pascua" Tourism National Park was created in 1966, with nearly 7,000 hectares (approximately 42 percent of the island). In 1972, the park was handed over to the National Forestry Corporation (CONAF), incorporating it into the National Wild State Protected Areas System. In 1995, the island was declared World Heritaga Site by the UNESCO, ratifying its character of "unique worldwide cultural phenomenon." At present, the development of tourism is the basis of the economy of several Rapa Nui families.

Over the last few years, the need to join willpower to achieve the adequate use and management of the island's natural and cultural resources has become evident, considering its size and carrying capacity. Likewise, there are public-private initiatives for the ecologic recovery of the island, such as the project to re-introduce the *toromiro*.

** The location of each native people is merely referential.*

CONTINUES ▶

MAPUCHES

Biobío / Araucanía / Los Ríos / Los Lagos Regions*

The Mapuche worldview is very rich. There are four great gods that represent the four elements: the *Kuze* -elderly woman- represents the land and has the power to give life to people; it is represented united to the Fucha -elderly man-, who represents water and has the power to manage people. On the other hand, we have *Ülcha* -the young woman- who represents air and has to power of giving life to the land; and *Weche* -the young man- who represents fire and has the power of managing the land.

A ritual of great importance is the *nguillatún*, carried out as a prayer for climate, sowing and spiritual matters. It is held at a special site, *nguillatue*. The Mapuche people's religion is rooted in the forces of nature, plants cannot be absent from each ritual, such as the *Canelo* (Cinnamon Tree), the *Pehuén* or *Araucaria* (Monkey Puzzle Tree), and the *Laurel* or *Tihue* (Bay). Herb specialists and *meicas* help cure lesser illnesses with roots, trunks, plants and medicinal herbs they call *lawen*. Over the last few years, intercultural medicine has been incorporated into the plans of the Ministry of Health.

The territorial space inhabited by the Mapuche, the *Nagmapu*, is not only the place or habitat of humans, animals and plants, but also of spiritual beings and its geography reaches sacred dimensions, especially around water bodies or courses. The large majority of the communities use their lands and territories for self-subsistence agriculture and livestock activities. In the larger territories, the forest is exploited for energy, construction materials, timber sales and for collecting seeds or herbs, in addition to animal grazing. In the case of the *Lafquenche* Mapuche, they maintain the same agriculture-livestock economy and some coastal communities concentrate on fishing and collection of resources along the shores. In Chiloé, fishing and collection of resources along the shores is an ancient activity of the *Huilliche* communities. At present, most of the Mapuche population lives in the main urban centers of the country. The main consensual initiatives between the State and the Mapuche organizations have been developed in the cultural arena. On the other hand, family-run tourism has been strengthened with State resources.

KAWÉSQAR

Magallanes Region*

The historical legacy of these people consists of their particular knowledge of nature and navigation systems. Their notion of territory is not linked to the land, but to the sea and free navigation. Today, the main source of work for the Kawesqar and their descendants are handicrafts, artisanal fishing and the collection of shellfish. The ban on the capture and extraction of species such as the huemul (South Andean Deer), the South American Fur Seal and the *Ciprés de Las Guaitecas* (Guaitecas Cypress) has limited their activities, despite the fact that special permits have been granted to them. The richness of plants and wildlife, infinite fjords and glaciers and the ethnohistorical importance led a large part of the Kawesqar territory to be declared a natural reserve.

YÁMANA OR YAGÁN

Magallanes Region*

The Yámana believed in a Supreme Being, creator of all that exists. According to anthropologist Martín Gusinde, depending on the circumstances, there were different names to refer to this omnipotent being, but *Watauineiwa* was the most common one. They also had a worldview populated by lesser spirits, who personified the forces of nature, animals and other environmental phenomena. The Yámana or Yagán organized themselves into family nuclei, without having a single person with more authority over others and their food was based on whatever they could obtain from the sea. In older times, there were five territorial and marine settlement units on the sea shore, known as *Wakimaala*, located in the Beagle Channel from *Yendegaia* up to Puerto Róbalo, including Ambarino Island, the Murria Channel and Hoste Island. In addition to them, were *Utamaala*, east of Puerto Williams and the Gable Island up to the Picton, Nueva and Lenox islands. Other settlements were *Inalumaala*, in the Beagle Channel, from the Divide point up to Brecknock; *Yeskumaala*, located in the Cape Horn archipelago; and *Ilalumaala*, from Cook Bay up to the false Cape Horn.

In 2005, Cape Horn was declared a Biosphere Reserve, covering 4,884,274 hectares that encompasses marine and terrestrial areas. The Reserve is a great national and international tourism attraction and covers the entire Yagán territory. In 2006, the Cape Horn commune was designated an Indigenous Development Area (ADI by its acronym in Spanish) [3].

[3] *The ADI are "...territorial areas in which the State administration agencies will target their actions to benefit the harmonious development of the indigenous peoples and their communities" (Article 26, Law 19.253).* ** The location of each native people is merely referential.*

TABLE 02

REFERENTIAL DISTRIBUTION OF INDIGENOUS PEOPLES

INDIGENOUS PEOPLE	REGION	PROVINCE	COMMUNE
Aymara	Arica and Parinacota	Arica, Parinacota	Camarones, Putre, General Lagos
	Tarapacá	Iquique	Camiña, Colchane, Huara, Pica, Pozo Almonte
Quechua	Tarapacá	Iquique	Pozo Almonte
	Antofagasta	El Loa	Ollagüe, Calama
Atacameño	Antofagasta	El Loa	Calama, San Pedro de Atacama
Colla	Atacama	Copiapó	Copiapó, Tierra Amarilla
Diaguita	Atacama	Huasco	Alto del Carmen
Rapa Nui	Valparaíso	Isla de Pascua	Isla de Pascua
Mapuche	Biobío	Biobío	Alto Biobío, Santa Bárbara
	Biobío	Arauco	Cañete, Contulmo, Los Álamos, Tirúa
	Araucanía	Malleco	Angol, Collipulli, Curacautín, Ercilla, Lonquimay, Los Sauces, Lumaco, Purén, Renaico, Traiguén, Victoria.
		Cautín	Carahue, Cunco, Curarrehue, Freire, Galvarino, Gorbea, Lautaro, Loncoche, Melipeuco, Nueva Imperial, Padre Las Casas, Perquenco, Pitrufquén, Pucón, Puerto Saavedra, Temuco, Teodoro Schmidt, Toltén, Vilcún, Villarrica
	Los Ríos	Valdivia, Ranco	Lanco, Mafil, Mariquina, Panguipulli, Valdivia, Futrono, La Unión, Lago Ranco, Río Bueno
	Los Lagos	Osorno	Osorno, Puerto Octay, San Juan de La Costa, San Pablo, Río Negro, Purranque y Puyehue
		Chiloé	Ancud, Quemchi, Castro, Chonchi, Quellón, Dalcahue y Queilén
Kawésqar	Magallanes	Última Esperanza	Puerto Natales
Yámana	Magallanes	Magallanes and Chilean Antarctica	Punta Arenas, Puerto Williams

Source: CONADI

2 • DEMOGRAPHIC CHARACTERISTICS

The indigenous population reaches **692,191 people, which represents 4.6 percent of the total Chilean population (INE, 2002).** Their historical distribution is maintained at the national level, but there is a strong presence of the Mapuche people throughout the entire territory, concentrated in the central and southern regions of the country (**Figure 01**).

The Mapuche population represents **87.3 percent of the total indigenous inhabitants**, followed by the Atacameño people, with 24 percent, and the Aymara people, with 7 percent (**INE, 2002**).

Iquique, Huayca | MMA

2002 CENSUS

4.6%

of the total Chilean population is of indigenous descent

Equal to

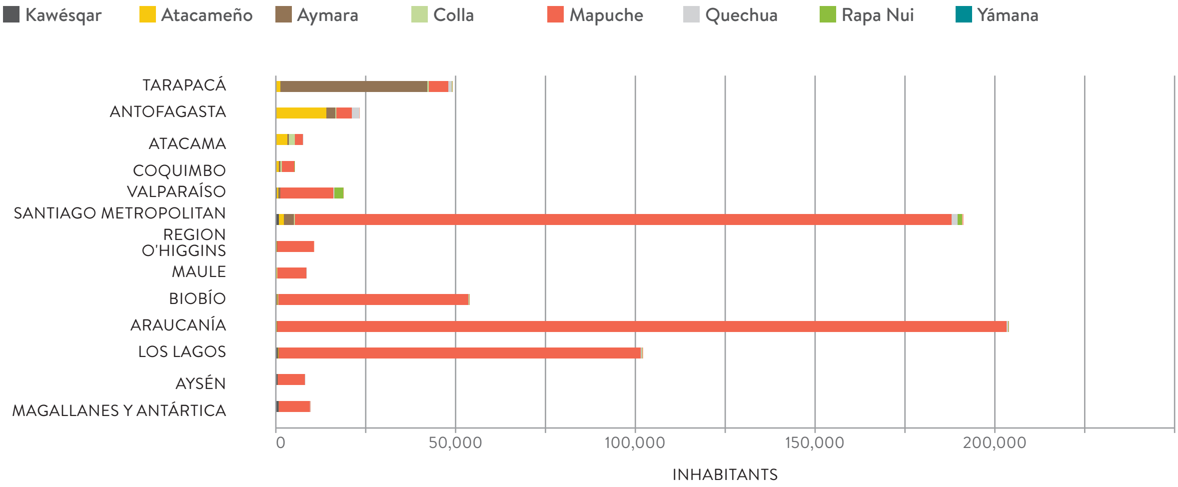
692,191
INHABITANTS

Of the total indigenous population, the Mapuche people represent

87.3%

FIGURE 01

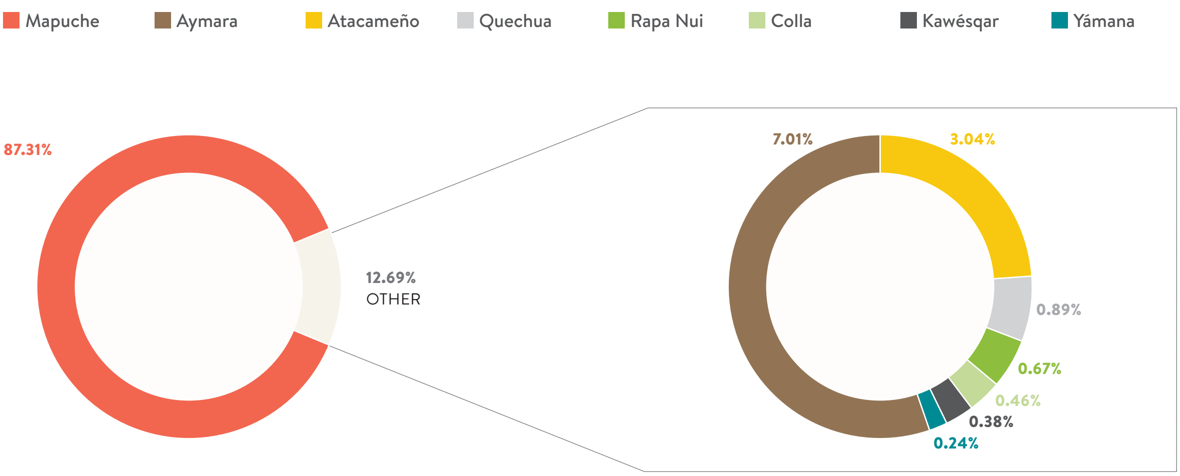
DISTRIBUTION OF INDIGENOUS POPULATION BY REGION AND ETHNICITY [4] [5]



Source: INE, 2002.

FIGURE 02

PERCENTAGE GRAPH OF THE DISTRIBUTION OF INDIGENOUS PEOPLES [6]



Source: INE, 2002.

[4] *It is important to consider that, for the 2012 Census, Chile had thirteen administrative regions. Because of that, this figure does not show the Arica and Parinacota and the Los Ríos regions.*

[5] *The graph was made based on the information available for the eight indigenous peoples considered in the 2002 Census. The Diaguita people were not included in that Census.*

[6] *The graph was made based on the information available for the eight indigenous peoples considered in the 2002 Census. The Diaguita people were not included in that Census.*

3 • INDIGENOUS DEVELOPMENT AREAS AND NATIONAL WILD STATE PROTECTED AREAS

Indigenous Development Areas (ADI by their acronym in Spanish) are created by Supreme Decree issued by the Ministry of Social Development, in accordance to article 26 of Law19.253. This legislation defines ADI as *"territorial areas in which the State administration agencies will target their actions to benefit the harmonious development of the indigenous peoples and their communities."*

Law19.253 establishes that "the Ministry of Planning and Cooperation (now Ministry of Social Development), by proposal of the National Indigenous Development Corporation (CONADI by its acronym in Spanish), may create Indigenous Development Areas, which are *"territorial areas in which the State administration agencies will target their actions to benefit the harmonious development of the indigenous peoples and their communities."*

In order to establish them, the following criteria must be fulfilled:

- **a)** They must be territorial areas in which indigenous ethnicities have lived since ancient times.
- **b)** They must have a high density of indigenous population.
- **c)** There must be lands owned by indigenous communities or individuals.
- **d)** They must be *ecologically homogenous.*
- **e)** They must *rely on natural* resources for the balance of these territories, such as the management of watersheds, rivers, river banks, plants and wildlife.

A significant part of the territories inhabited by indigenous peoples are located within the boundaries of the National Wild State Protected Areas System (SNASPE by its acronym in Spanish). Of the total area covered by the SNASPE, approximately 14.5 million hectares (19 percent of Chile's continental territory), 10 percent is inhabited by indigenous peoples.

These areas of environmental value provide ecosystem services that enable local development (water supply, grasslands for livestock, tourism attractions, cultural values), constitute relevant habitats for biodiversity (shelter, food, reproduction) and operate as first-line biological corridors for the altitudinal and regional migration of species, mainly birds.

The area shared by the National Wild State Protected Areas System and the Indigenous Development Areas can be observed below (**Map 01**).

ADI / SNASPE

The **ADI** are defined as "territorial areas in which the State administration agencies will target their actions to **benefit the harmonious development of the indigenous peoples and their communities."**

Of the total area covered by the **SNASPE**, approximately 14.5 million hectares (19 percent of Chile's continental territory), **10 percent is inhabited by indigenous peoples**.

TABLE 03

AREA SHARED BY THE NATIONAL WILD STATE PROTECTED AREAS SYSTEM AND THE INDIGENOUS DEVELOPMENT AREAS

INDIGENOUS PEOPLE	REGION	ADI	SNASPE
Aymara	Arica and Parinacota	Alto andino	Lauca National Park Las Vicuñas National Reserve Salar de Surire Natural Monument
	Tarapacá	Jiwasa Oraje	Volcán Isluga National Park
Quechua	Tarapacá	Jiwasa Oraje	Volcán Isluga National Park
	Antofagasta	Alto el Loa	-
Atacameño	Antofagasta	Alto el Loa	-
		Atacama La Grande	Los Flamencos National Reserve
Colla	Atacama	-	-
Diaguita	Atacama	-	-
Rapa Nui	Valparaíso	Te Pito o Te Henua	Rapa Nui National Park
Mapuche (Pehuenche)	Biobío	Alto Bio Bio	Ralco National Reserve
	Mulchen	Alto Bio Bio	Ralco National Reserve
Mapuche (Lafquemche)	Biobío	Lleu Lleu	-
Mapuche	Araucanía	Puel Nahuelbuta (Purén, Lumaco, Traiguén, Los sauces)	-
		Puel Nahuelbuta (Galvarino and Chol Chol)	-
		Lago Budi (Pto Saavedra and Teodoro Schmidt)	-
		Ercilla	-
Mapuche (Huilliche)	Los Ríos	-	-
	Los Lagos	-	-
Kawésqar	Magallanes and Chilean Antarctica	-	-
Yámana	Magallanes and Chilean Antarctica	Cabo de Hornos (In process)	Alberto D' Agostini National Park Yendegaia National Park Cabo de Hornos National Park

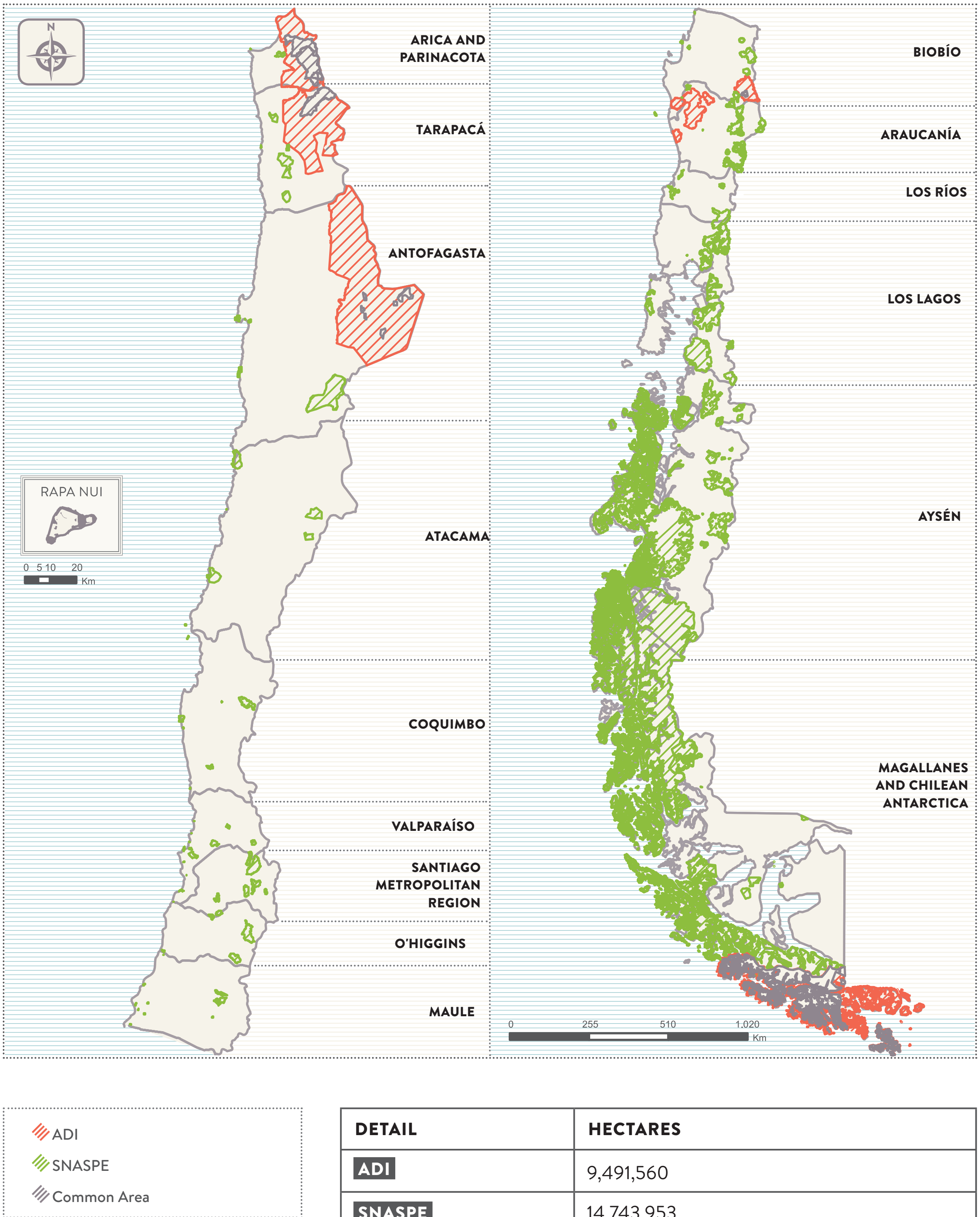
Source: CONADI, CONAF (SNASPE)

* *CONAF considers National Parks, National Reserves and Natural Monuments as part of the SNASPE.*

Article 35 of Law19.253 establishes that “in the management of wild protected areas located within indigenous development areas, the participation of existing communities will be considered.” One example is Los Flamencos National Reserve, in the Antofagasta Region, whose management includes the participation of Atacameños indigenous communities through an associative model that enables, among other things, the implementation of ecotourism projects (Donoso, 2015).

MAP 01

AREA SHARED BY THE ADI AND THE SNASPE



Source: CONADI

DETAIL	HECTARES
ADI	9,491,560
SNASPE	14,743,953
Common Area	1,432,712.07

4 • PRESSURES

"The land, the territory and the natural resources are of great importance" for indigenous peoples. They maintain a special relationship with nature, with a strong spiritual component. Because they depend on their natural resources and ecosystems for their survival and well-being, indigenous communities, mainly in rural areas, have a deep knowledge of their ecological surroundings and natural resources and have adopted complex methods and techniques to manage their habitat in a sustainable manner (Donoso, 2015).

This gains even more relevance considering that a large part of the territories traditionally inhabited by indigenous populations coincide with areas rich in natural resources, and, thus, are suitable for the extraction of these resources. Therefore, it is essential for the trend to increase investment in sectors such as energy and mining to consider future demands for natural resources, the available sources and efficient use strategies within the framework of the sustainability of the territory (CED, 2011).

4.1 Productive Activities

One of the environmental management tools to prevent or mitigate environmental impacts of the activities carried out in the country is the Environmental Impact Assessment System (SEIA by its acronym in Spanish), which is managed by the Environmental Assessment Service (SEA by its acronym in Spanish).

Article 85 of the SEIA Regulation indicates that "regardless of what is established in article 83 of the regulation, whenever the project or activity generates or presents any of the effects, characteristics or circumstances indicated in articles 7, 8 and 10 of this regulation, to the extent that it directly affects one or more human groups belonging to indigenous peoples the service (Environmental Assessment Service) will have to, in accordance to the second paragraph of Article 4 of the Law, design and develop a consultation process in good faith, that includes appropriate mechanisms according to the socio-cultural characteristics inherent to each people and through its representing institutions, so that they can participate in an informed manner and have the possibility of exerting influence during the environmental evaluation process. Likewise, the service will establish the mechanisms for these groups to participate during the evaluation process of clarifications, rectifications and/or expansions that the Environmental Impact Study can be the object of."

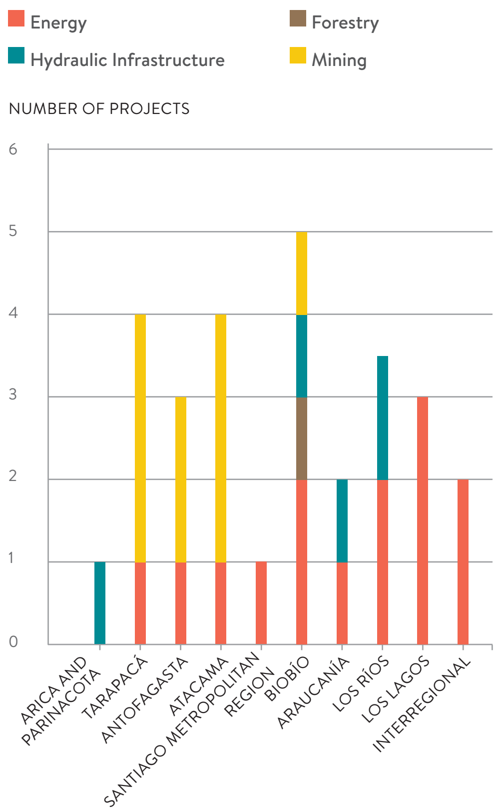
Since 2013 until the preparation of this report, 29 indigenous consultation processes have been initiated. Of these, 14 are closed, 14 are active and 1 was withdrawn by the owner. **Figure 03** details the indigenous consultations by region and productive sector.

INDIGENOUS TERRITORY

It is essential for the trend to increase investment in **sectors such as energy and mining to consider future demands for natural resources**, the available sources and efficient use strategies within the framework of the sustainability of the territory (CED, 2011).

FIGURE 03

PROJECTS WITH AN INDIGENOUS CONSULTATION PROCESS



Source: SEA, 2015.

KÜTRALKURA GEOPARK [7], THE CONNECTION BETWEEN NATURE AND SOCIETY [8]

01

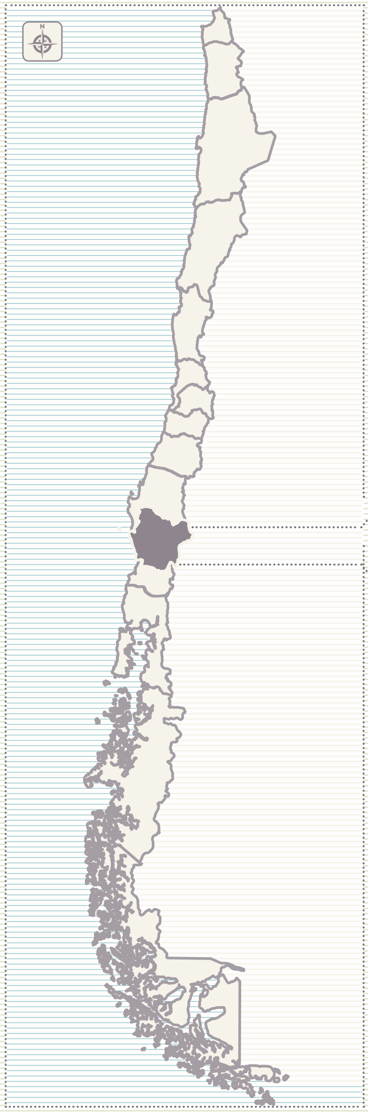
A geopark is a territory that encompasses a set of sites whose natural, environmental, ecological and cultural characteristics are representative of its geological history. These places are of high scientific, education, landscape, cultural or recreational interest and may be strategically used for the benefit of the communities that inhabit these territories, mainly through geotourism.

Geoparks seek to highlight the connection between nature and society, promoting tourism and educational activities that incorporate geodiversity, biodiversity and the local cultural. At the international level, there is a Global Geoparks Network, fostered by the United Nations Educational, Scientific and Cultural Organization (UNESCO), which promotes the creation of geoparks.

In Chile, specifically in the Araucanía Region, there is a pilot project boosted by the National Geology and Mining Service of Chile (Sernageomin), called Kütralkura Geopark, which aims to become the first of its type in the country. Its main objective is to support the sustainable development of the communities that are part of it, promoting a harmonious coexistence with the environment.

Kütralkura covers nearly 8,100 km^2 in the southern part of the Andes Mountain Range and encompasses the Melipeuco, Curacautín, Lonquimay and Vilcún communes. It includes six protected areas, five volcanoes and a large geodiversity, with different types of landscapes and a geological history that spans for 250 million years. At its core are the Conguillío National Park and the Llaima volcano, one of the most active in Chile and South America. In addition, Kütralkura Geopark integrates the northern area of the Araucarias Biosphere Reserve, which has a significant world-renowned biodiversity. Its inhabitants include several Mapuche-Pehuenche communities (Schilling et al., 2013 pp 13-14).

CHILE



[7] *Kütralkura: Mapuche word that means "Stone of fire".*

[8] *All information about this geopark was obtained from the Sernageomin Geotourism Guide.*

CONTINUES ▶

MAP 02

GEOGRAPHICAL LOCATION OF KÜTRALKURA GEOPARK

OUTSTANDING PLACES

Kütralkura Geopark | SNASPE | Water Bodies | Volcanoes

Source: Authors' own elaboration, based on data from Shilling et al., 2013.

5 • RESPONSES

Legal Framework

Twenty-two years after the entry into force of Law 19.253 or Indigenous Law, a new milestone was achieved on the road traveled by the country over the last decades to advance in the recognition of native peoples. Indeed, in 2016, a draft bill was sent to Congress creating the Ministry of Indigenous Peoples, the National Council and the Indigenous Peoples Councils, all of them initiatives that were consulted with representatives of the nine indigenous peoples recognized by the State[9].

The main aspects of the current regulation in Chile are detailed below:

LAW 19.253 OR "INDIGENOUS LAW"

This law, passed in 1993, establishes regulation about the protection, promotion and development of indigenous peoples, based on: The recognition of cultural and ethnic diversity; the legal recognition of the communities; the promotion of participation; affirmative action; the protection and expansion of indigenous lands; the targeting of State resources for development; the creation of the Indigenous Lands and Waters Fund; conciliation and arbitrage; the recognition, respect and protection of indigenous cultures; the development of a bilingual inter-cultural education system; self-identification mechanisms for urban indigenous peoples and migrants; and the recognition of the unique characteristics of indigenous peoples.

In other matters, the Indigenous Law created the National Indigenous Development Corporation (CONADI by its acronym in Spanish), the institution in charge of promoting, coordinating and executing the State's actions in favor of the integrated development of indigenous individuals and communities in the economic, social and cultural spheres, as well as fostering their participation in national life. The regulations dealing with lands, communities and indigenous associations are important.

LAW19.300

General Environmental Framework. Law19.300 on the General Environmental Framework of 1994 (modified by Law20.417 of 2010) establishes that "State agencies, in the exercise of their environmental competences, and in the application of environmental management tools, must tend towards the adequate conservation, development and strengthening of the social and cultural identity, languages, institutions and traditions of the indigenous peoples, communities and individuals, in accordance to what is set forth in the law and in the international conventions ratified by Chile that are currently in force" [10].

LAW20.249

On the Coastal and Marine Space of Native Peoples or "Lafquenche Law" of 2008. This law creates the "Coastal and Marine Space of Native Peoples", thus establishing a mechanism for indigenous communities who have historically inhabited the sea shore and prove their traditional use of it to access the use of a defined marine space whose management will preferably be handed over to an association of communities.

[9] *Bulletin N° 10.525-06 of the Senate and N° 10526-06 of the House of Representatives, the National Congress informed on the reception of the draft bills to create the Ministry and the Peoples Council, respectively, were signed on January 11, 2016 by President Michelle Bachelet.*

[10] *Paragraph two, Article 4.*

On the other hand, Chile has signed international declarations and conventions, including the following:

UNITED NATIONS DECLARATION

United Nations Declaration on the Rights of Indigenous Peoples (2007). Although it is a recommendation and, hence, not strictly binding, its signing has been a clear indication that the international community is committing to protecting the individual and collective rights of indigenous peoples.

This declaration establishes the individual and collective rights of indigenous peoples, particularly their right to culture, identity, language, employment, health and education. It also bans their discrimination and promotes their full and effective participation in matters that concern them, including their right to continue being different and to pursue their own idea of economic and social development.

ILO CONVENTION N°169

Concerning Indigenous and Tribal Peoples in Independent Countries. This convention is an international treaty adopted in Geneva on June 27, 1989. To date, the convention has been ratified by 22 countries. Chile ratified it in September 2008 and it entered into force in 2009 [11]. It was passed through Supreme Decree N°236, dated October 2, 2008, by the Ministry of Foreign Affairs.

The Convention "is based on respect for the cultures and ways of life of indigenous peoples and recognizes their right to land and natural resources and to define their own priorities for development. The Convention aims at overcoming discriminatory practices affecting these peoples and enabling them to participate in decision-making that affects their lives. Therefore, the fundamental principles of consultation and participation constitute the cornerstone of the Convention. Furthermore, the Convention covers a wide range of issues pertaining to indigenous peoples, including employment and vocational training, education, health and social security, customary law, traditional institutions, languages, religious beliefs and cross-border cooperation" [12].

5.1 Environmental Impact Assessment System

The Presidential Advisory Commission for the Evaluation of the Environmental Impact Assessment System (CAPE-SEIA by its acronym in Spanish) [13], created in 2015 to boost this mechanism from both the regulatory and social legitimacy perspectives, was tasked with addressing the consultation to indigenous peoples as part of the SEIA. Within this framework, it proposed to strengthen citizen engagement, among other measures, by means of technical assistance and reducing information asymmetries.

[11] *http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C169*

[12] *Page 1 of the document "Understanding the Indigenous and Tribal People Convention, 1989 (No. 169). Handbook for ILO Tripartite Constituents" - Geneva, 2013. Available at: http://www.ilo.org/wcmsp5/groups/public/@ed_norm/@normes/documents/publication/wcms_205225.pdf*

[13] *Available at: http://comision-seia.mma.gob.cl/wp-content/uploads/2015/04/Decreto-20-Comision.pdf*

6 • STATE INITIATIVES

The response of the Chilean State regarding indigenous peoples has not only focused on developing a legal framework, but also on creating a series of programs and initiatives that include them as beneficiaries.

6.1 Indigenous Environmental Protection Competition

The Environmental Protection Fund (FPA by its acronym in Spanish), managed by the Ministry of the Environment, includes among its lines of funding a specific competition for indigenous peoples.

The Indigenous Environmental Protection and Management competition aims at supporting indigenous associations and communities through the implementation of demonstrative experiences and activities that contribute to improving the environmental quality of their territory, raising greater awareness and valuing their surroundings, promoting environmental education and citizen engagement. The scopes or thematic lines that provide the framework for the competition's projects are the following:

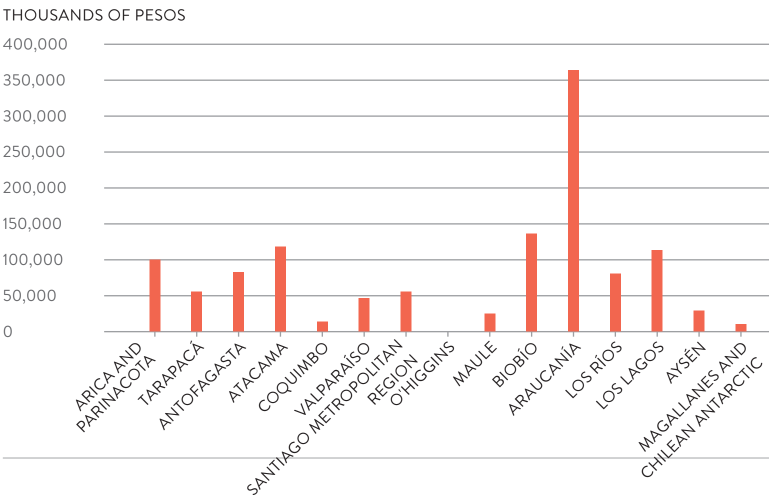
- ▶ Energy efficiency and Non-Conventional Renewable Energy (NCRE).
- ▶ Sustainable management of natural resources.
- ▶ Productive activities in harmony with sustainable development.
- ▶ Waste management and recovery of areas.

As part of this line of work, there is a collaboration agreement between the Ministry of the Environment (MMA by its acronym in Spanish) and the National Indigenous Development Corporation (CONADI by its acronym in Spanish) in order to develop joint actions that will enable implementing the Indigenous Environmental Protection and Management competition.

The support provided by the CONADI is aimed at funding initiatives submitted by indigenous communities, while the MMA provides the funds for initiatives executed by indigenous associations. The funding amounts range between CLP $5 and 10 million.

FIGURE 04

RESOURCES BY REGION 2012-2016



Source: Department of Environmental Protection Fund, Ministry of the Environment, 2016.

This agreement strengthened the competition, increasing the number of funded projects. Thus, 8 projects were funded in 2011, 50 in 2012, 34 in 2013, and 36 in 2014, while 32 projects were selected in 2015.

The main topics of the awarded funds include sustainable productive activities, natural resource management, biodiversity conservation, waste management, recovery of areas, energy efficiency and non-conventional renewable energy.

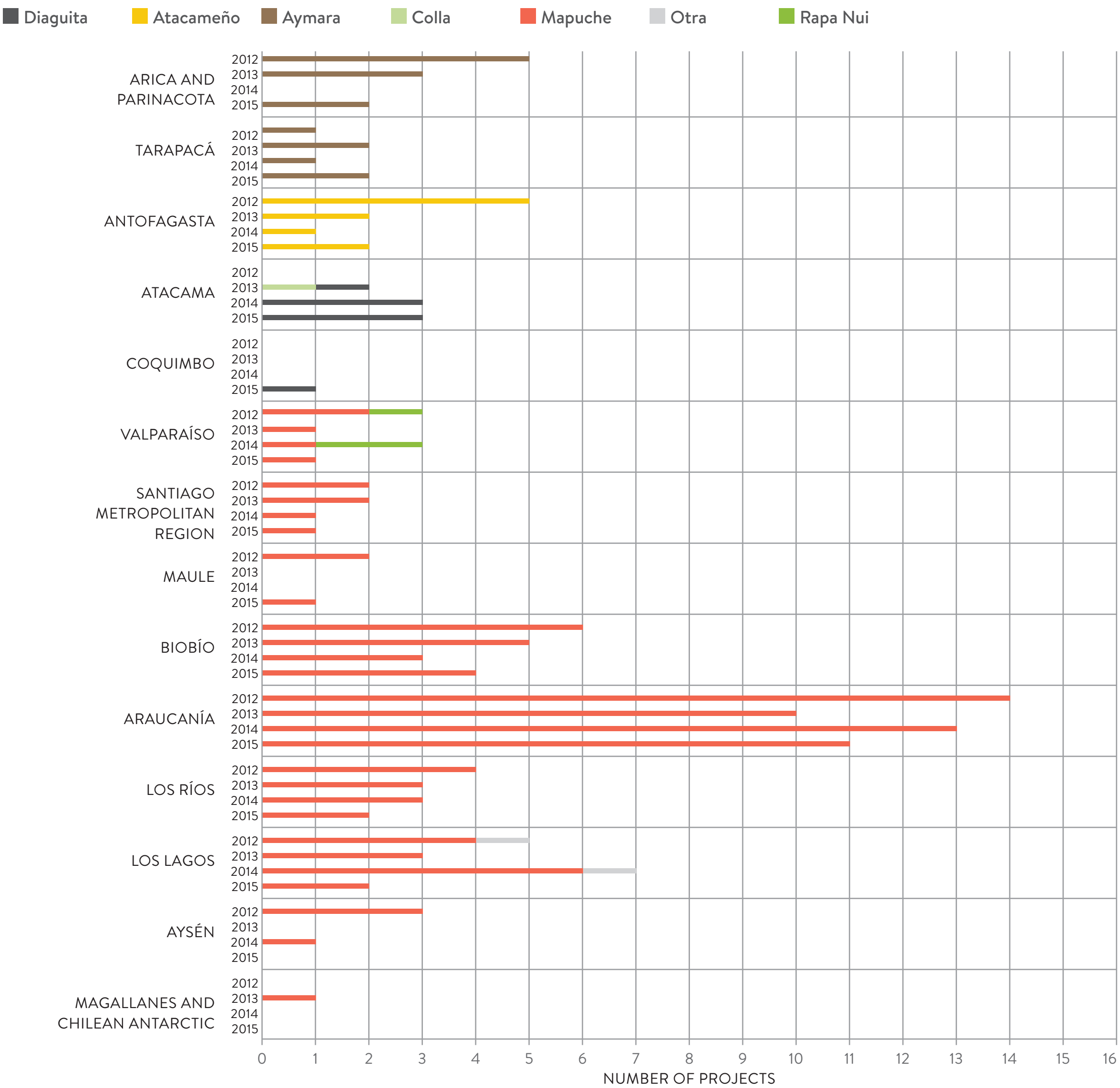
Based on data provided by the CONADI, it can be said that the funds distributed to associations in 2015 reached CLP $65 million, while the funds allocated to communities were CLP $177 million.

COLLABORATION AGREEMENT

This agreement strengthened the competition, increasing the number of funded projects. Thus, 8 projects were funded in 2011, 50 in 2012, 34 in 2013, and 36 in 2014, while 32 projects were selected in 2015.

FIGURE 05

NUMBER OF PROJECTS APPROVED AT THE REGIONAL LEVEL, BY INDIGENOUS PEOPLE



Source: Department of Environmental Protection Fund, Ministry of the Environment, 2015.

6.2 Entrepreneurship

Between 2010 and 2015, the Chilean Economic Development Agency (CORFO by its acronym in Spanish) has approved 108 initiatives worth CLP $4,547 million aimed at improving the competitiveness and productive and/or tourism diversification of indigenous peoples, by means of promoting investment, innovation and entrepreneurship.

6.3 Indigenous Territorial Development Program

The Indigenous Territorial Development Program (PDTI by its acronym in Spanish) is a technical advice program of the National Institute for Agriculture and Livestock Development (INDAP by its acronym in Spanish) aimed at the most vulnerable indigenous farmers and their families.

Table 04 shows the resources allocated to advice and investment in different regions of the country. **Table 05** provides information on the number of beneficiaries of the program for the 2012-2014 period.

6.4 Land Grants

Chile is among the countries that grant less percentage of its territory to its indigenous population in Latin America and the Caribbean (**Figure 06**). Because of that, a series of plicies and programs have been created with the aim of providing lands. At present, the Political Constitution of Chile makes no reference to the land rights of indigenous peoples, but Law 19.253 establishes mechanisms to remedy this situation through the National Indigenous Development Corporation (CONADI by its acronym in Spanish) (Article 20 of the Indigenous Law).

Land Purchases according to Article 20, Letter A of the Indigenous Law
It is a direct State subsidy, managed by the National Indigenous Development Corporation (CONADI by its acronym in Spanish), free of restitution charges and mainly targeted at purchasing non-indigenous lands, preferably by indigenous families with no land or who do not have enough land area and by communities or their members who do not have enough land area. Each year, the Corporation holds a public competition or open call for applications in the Biobío, La Araucanía, Los Lagos and Magallanes and Chilean Antarctic regions.

Subsidy for Application Article 20 Letter B of the Indigenous Law
As pointed out by the CONADI, this subsidy allows "financing mechanisms that will enable solving land issues, especially those arising from the compliance with judicial or extra-judicial resolutions or transactions related to indigenous lands in which there are solutions over indigenous lands or lands transferred to indigenous people, stemming from or recognized through granted land titles [títulos de merced and títulos de comisario] or other cessions or assignments made by the State in favor of indigenous peoples."

Between 1944 and 2013, CLP $205,159.5 million have been granted, covering 144,078 hectares (see **Figure 07**).

SUBSIDIES AND LANDS

Chile is among the countries that grant less percentage of its territory to its indigenous population in Latin America and the Caribbean. Law 19.253 establishes mechanisms to remedy this situation through the National Indigenous Development Corporation (CONADI by its acronym in Spanish) (Article 20 of the Indigenous Law).

205,159.5
MILLION CLP

have been granted between 1994 and 2013

and an area of

144,078
HECTARES

TABLE 04

RESOURCES ALLOCATED TO ADVICE AND INVESTMENT 2012-2014 PERIOD				
REGION	**2012 ($CPL)**	**2013($CPL)**	**2014($CPL)**	**OVERALL TOTAL**
Arica and Parinacota	41,300,238	18,278,000	38,295,476	97,873,714
Tarapacá	97,002,421	23,717,088	45,617,269	166,336,778
Antofagasta	199,750,825	233,021,577	395,853,796	828,626,198
Valparaíso	40,460,651	36,141,832	16,218,658	92,821,141
Biobío	1,705,406,739	1,719,355,991	1,661,994,837	5,086,757,567
La Araucanía	11,141,745,033	10,907,908,836	16,510,645,521	38,560,299,390
Los Ríos	1,041,430,315	1,171,570,893	1,510,522,670	3,723,523,878
Los Lagos	1,866,745,235	2,202,779,604	2,304,667,278	6,374,192,117
Aysén	34,922,435	24,518,938	39,029,214	98,470,587
OVERALL TOTAL	16,168,763,892	16,337,292,759	22,522,844,719	**55,028,901,370**

Source: INDAP, 2015.

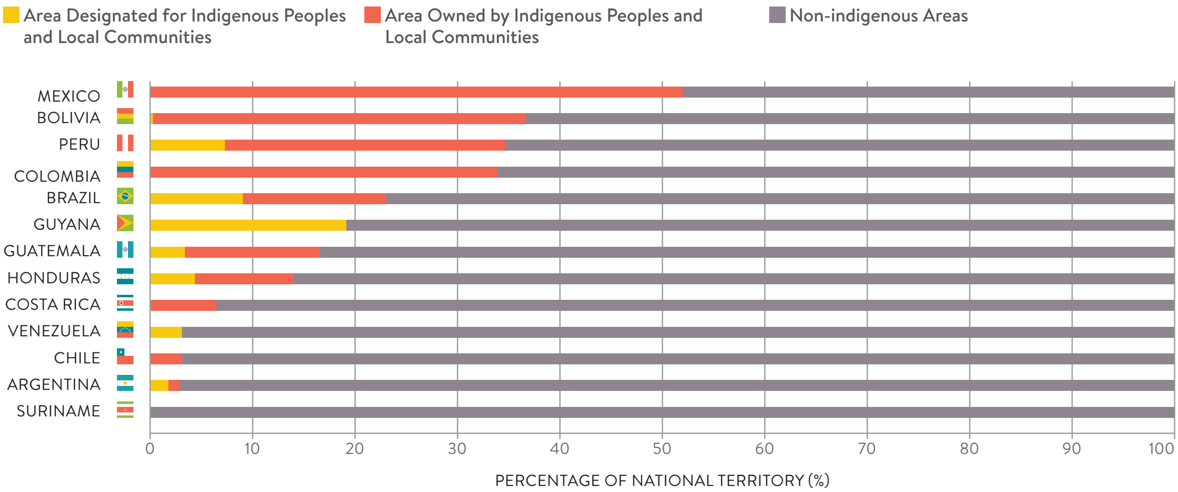
TABLE 05

NUMBER OF BENEFICIARIES PDTI PROGRAM 2012-2014 PERIOD				
REGIONS	**2012**	**2013**	**2014**	**OVERALL TOTAL**
Arica and Parinacota	73	39	96	208
Tarapacá	255	74	155	484
Antofagasta	429	474	499	1,402
Valparaíso	103	96	84	283
Biobío	3,902	4,472	4,996	13,370
Araucanía	45,375	43,277	48,533	137,185
Los Ríos	4,395	5,559	5,691	15,645
Los Lagos	7,331	7,331	6,557	21,219
Aysén	86	78	85	249
OVERALL TOTAL	61,949	61,400	66,696	**190,045**

Source: INDAP, 2015.

FIGURE 06

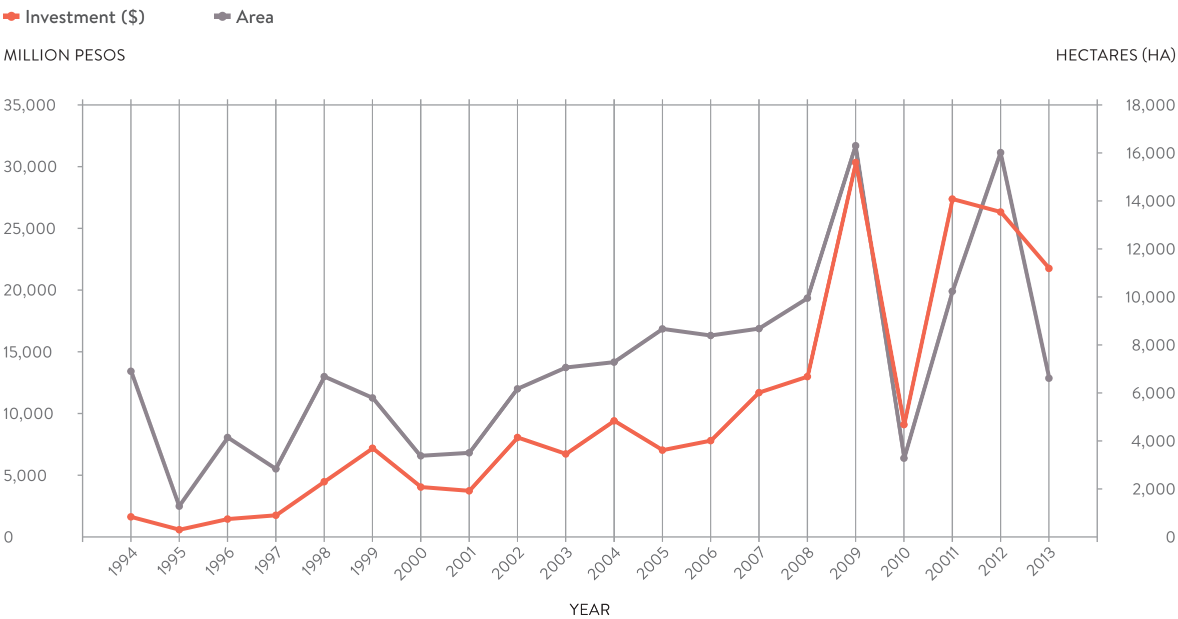
PERCENTAGE OF NATIONAL TERRITORIES SET ASIDE FOR INDIGENOUS POPULATION in Latin America and the Caribbean



Source: Who owns the World's land? A global baseline of formally recognized indigenous and community land rights, Rights and Resources Initiative, 2015.

FIGURE 07

INVESTMENT AND AREA GRANTED THROUGH THE SUBSIDY for Application Article 20 Letter B of the Indigenous Law (1994 – 2013)



Source: CONADI, 2015.

02

INDIGENOUS CONSULTATION ON THE DRAFT BILL THAT CREATES THE BIODIVERSITY AND PROTECTED AREAS SERVICE AND THE NATIONAL PROTECTED AREAS SYSTEM

Within the framework of the discussion of the draft bill that creates the Biodiversity and Protected Areas Service (SBAP by its acronym in Spanish) and the National Protected Areas System (SNAP by its acronym in Spanish), the Ministry of the Environment is conducting an indigenous consultation process in accordance to what is set forth in Article 6 N°1 letter a) and N°2 of the International Labor Organization Convention N°169 concerning Indigenous and Tribal Peoples in Independent Countries, hereinafter ILO Convention N°169, currently in force in our country since 2009. [14]

It is worth mentioning that it is a participation mechanism based on the dialogue between the State and the indigenous peoples, but it is foremost a right of the indigenous peoples and a duty of the State that, as established by ILO Convention N°169, arises each time legislative or administrative measures are adopted that can directly affect them.

Process and Stages of the MMA Indigenous Consultation

The process is being developed throughout the entire country, with all indigenous peoples, through their representing organizations. In order to conduct it, the adequate conditions have been generated in order to safeguard the informed participation of the organizations representing indigenous peoples, convening them to participate in all stages of the process through diverse mechanisms, such as: Radio spots; publications in national and local circulation dailies; giving preference to direct invitations and calls to participate; hiring consultants for the discussion phase; and ensuring meeting and participation conditions, among other aspects.

The consultation process considers the inherent characteristics of each people, through appropriate socio-cultural procedures, in a setting of equality and good faith, in order to reach an agreement regarding the matters being consulted, applying the necessary flexibility to guarantee the participation of indigenous peoples.

The stages defined to carry out this process are the following:

Process Planning: It is aimed at determining the organizations that will participate and the methodology jointly defined with the participating stakeholders. **Delivery of Information:** It is aimed at providing all background information, including the reasons that justify the process, the nature of the measures being consulted and their scope and implications. Internal **Debate:** It is a stage of the indigenous peoples on their own and the objective is for them to analyze, study and define their stances by debating and reaching internal consensus regarding the measure under consultation, so that they can intervene and be prepared for the dialogue phase. **Dialogue:** It is aimed at seeking agreements and, once the debate phase has concluded, it is expected that during this phase agreements will be reached regarding the matters being consulted. **Systematization:** Communication of the results and end of the process, which will enable introducing amendments to the draft bill in relation to the demands and interests of indigenous peoples in these matters.

Nevado Tres Cruces | JORGE HERRERO

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CHAP **04**

ENVIRONMENTAL INSTITUTIONAL FRAMEWORK

CONTENT

INTRODUCTION

Environmental policy must involve three fields of action: pollution control, sustainable management of natural resources and conservation of the natural heritage for ecological or cultural reasons (Andrews, 1999, p.4). In this context, the environmental institutional framework is the legal and organizational structure that must establish the "game rules" through which environmental management is regulated.

In 1980, Chile defined, as a constitutional guarantee, the right to live in a pollution-free environment and established that it was the duty of the State to safeguard this right (Political Constitution, Art. 19. N°8), but it was not until 1994, with the enactment of the General Environmental Framework Law, that the State organized the specific institutional structure to implement this principle.

Thus, the environmental policy and the responsibilities of the services with competence in the area are mainly regulated through Law 19.300 and Law 20.417, passed in 2010, which creates a new environmental institutional framework made up by the Ministry of the Environment (MMA by its acronym in Spanish) and its agencies[1]. The latter possess a series of responsibilities.

The highest-level environmental policies are informed, debated and coordinated by the ministries with responsibility on environmental issues. These make up the Council of Ministers for Sustainability, presided by the MMA, who is responsible for developing and implementing the environmental policies[2].

This institutional structure, of fragmented and shared environmental responsibilities, has undergone an important evolution in the past few years. The following sections describe the current environmental institutional framework along with its evolution through time.

1 • THE ENVIRONMENTAL INSTITUTIONAL FRAMEWORK EMERGES

The current environmental institutional framework originates as a response to the increasing number of environmental problems observed in the country, more specifically the atmospheric pollution of Santiago and the degradation of the native forests, as well as the concerns that the governmental coalition, which confronted the dictatorship, had on this topic[3].

The proposal is reflected in the General Environmental Framework Law, enacted and published in 1994 as a result of a critical assessment of the experiences in other countries of the region and a diagnosis of the feasibility of creating a centralized institutional structure, through the Ministry of the Environment.

[1] Environmental Assessment Service (SEA by its acronym in Spanish) and the Superintendency for the Environment (SMA by its acronym in Spanish).

[2] The Council of Ministers is made up of the ministers of Environment; Agriculture; Finance; Health; Economy, Development and Tourism; Energy; Public Works; Housing and Urban Planning; Transportation and Communications; Mining; and Social Development.

[3] The Coalition of Parties Pro Democracy was a coalition of 17 political parties which included the Green Party and the Party for Democracy (PPD by its acronym in Spanish), which had the environment among their program pillars.

ENVIRONMENTAL POLICY

The environmental policy and the responsibilities of the services with competence in the area are mainly regulated through Law 19.300 and Law 20.417, passed in 2010.

In addition to the environmental management model, the law defined a series of new environmental management tools, among which the Environmental Impact Assessment System (SEIA by its acronym in Spanish) stands out.

Island of Chiloe | MARTA HERNANDEZ

In order to provide further context, President Patricio Aylwin explained in a presidential communication of 1992 -which was submitted together with the draft bill-, that “if there is a matter in which the competences are distributed throughout the public sector, that is the environment. There is practically no ministry or service that does not include, to some degree, competences related with environmental issues, understanding them as variables of natural resource management and of facing pollution phenomena”. This is the reason why Chile chose an institutional model where the environmental competences of the different ministries and sectoral services were recognized through a coordination structure known as National Environment Commission (CONAMA by its acronym in Spanish).

The General Environmental Framework Law not only proposes a new environmental institutional framework, identifying and defining six principles that guide environmental policy, but it also recognized that the existing competences and attributions on environmental matters were insufficient to implement modern environmental management. As a result, in addition to the environmental management model, the Law defined a series of new environmental management tools, among which the Environmental Impact Assessment System (SEIA by its acronym in Spanish) stands out. These three elements -the institutional framework, the guiding principles and the environmental management tools- are the core and new aspects of the General Environmental Framework Law.

01

PRINCIPLES OF ENVIRONMENTAL POLICY

The presidential message that created the environmental institutional framework recognizes six guiding principles for environmental policy. These principles provide consistency and meaning to the institutional framework and the environmental management tools.

Prevention: Recognizes that it is necessary to avoid or prevent before environmental problems are caused.

Polluter Pays: Recognizes that whoever pollutes is responsible for taking on the associated costs of the necessary investments to avoid pollution.

Gradualism: Recognizes that it is necessary to seek a mechanism so that individuals can slowly adjust to more strict standards.

Responsibility: Recognizes that those that generate environmental damages are responsible for compensating the victims for the damage that was generated and restore the environment.

Participation: Recognizes that the engagement of those affected by environmental issues is key to ensure an adequate protection.

Efficiency: Recognizes the need to achieve the objectives with a minimum cost and favor environmental management tools that ensure the best allocation of resources.

Source: Authors’ own elaboration based on Law 19.300.

2 • THE ENVIRONMENTAL INSTITUTIONAL FRAMEWORK IN FORCE

As a result of the 2010 reform (Law 20.417), the environmental institutional framework of Chile is structured through three services: the Ministry of the Environment, in charge of developing and regulating environmental policy; the Environmental Assessment Service (SEA by its acronym in Spanish), in charge of implementing the Environmental Assessment System; and the Superintendency for the Environment (SMA by its acronym in Spanish), in charge of supervising the environmental management tools. It also recognizes the intersectoral nature of environmental policies with the creation of a Council of Ministers for Sustainability as a way of integrating environmental policies and regulations, but without governmental authority nor leadership over the Ministry of the Environment.

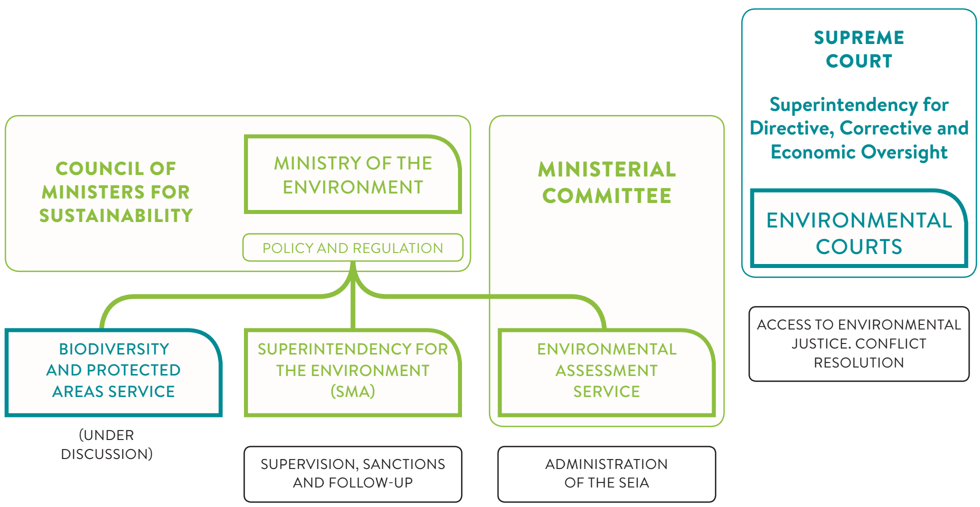
These institutions were complemented in 2012 with the creation of the environmental courts, of a special nature, which have competence to review the actions of the Superintendency for the Environment, the administrative actions of environmental nature with a general scope and the lawsuits for environmental damage (Law 20.600).

In addition, the National Congress is discussing -since 2011- the creation of a Biodiversity and Protected Areas Service, with the explicit objective of reforming the institutional framework with the purpose of bringing together in just one institution, under the auspices of the Ministry of the Environment, the responsibilities for regulating, protecting and conserving biodiversity.

The new institutional framework model will complete the environmental reform and will allow the implementation of the international commitments made by Chile. Its roles will include the management of a National Protected Areas System (SNAP by its acronym in Spanish), the execution of plans and programs to preserve the biodiversity of the country, the implementation of inventories for species and ecosystems and the restoration of those that are degraded, among other matters.

FIGURE 01

ENVIRONMENTAL INSTITUTIONAL FRAMEWORK



Source: Authors' own elaboration based on Law 19.300.

02

ROLES OF THE MINISTRY OF THE ENVIRONMENT AND THE COUNCIL OF MINISTERS FOR SUSTAINABILITY

ROLES OF THE MINISTRY[4]	Its specific roles are detailed under article 70 of the Law:
PROPOSING POLICIES	A Proposing environmental policies and periodically reporting on their progress and achievements. B Plans, programs, regulations and supervising the National Wild State Protected Areas System (SNASPE by its acronym in Spanish), which includes marine parks and reserves, as well as nature sanctuaries, and supervising the management of privately owned protected areas. C Plans, programs, regulations and supervising the Multiple-Use Coastal Marine Protected Areas (AMCP-MU by their acronym in Spanish). D Developing regulations, plans and programs on the topics of waste and contaminated soils, as well as chemical product risk evaluation, genetically-modified organisms (GMOs) and other substances that can affect the environment, in addition to the authority of other public institutions on sanitary matters. E Developing plans, programs and action plans on climate change. While exercising this competence, the Ministry must collaborate with different State agencies at the national, regional and local levels, with the aim of being able to determine their effects, as well as establishing the necessary adaptation and mitigation measures. F Developing plans, programs and actions that establish the basic criteria and preventive measures to strengthen the recovery and conservation of water and genetic resources, flora, fauna, landscapes, ecosystems, and natural spaces, especially those that are fragile and degraded, contributing to the compliance of international biodiversity conservation agreements.
COLLABORATING	G With sectoral ministries in the definition of environmental criteria that must be incorporated into the development of their plans and policies, Strategic Environmental Assessments (SEA) and planning processes, as well as into those of the services that are among their dependencies or related to them. H With competent institutions in the development of environmental policies for the sustainable management, use and exploitation of renewable natural resources and water. I With competent authorities at the national, regional and local levels for drafting, approving and developing environmental education, outreach and dissemination programs aimed at generating national awareness on environmental protection, sustainable development, nature preservation, environmental heritage conservation and the promotion of responsible citizen participation in these matters.

[4] *Created through the enactment of Law 20.417, which modified Law 19.300 General Environmental Framework Law.*

CONTINUES ▶

02

DEVELOPING	J Carrying out studies and programs for biodiversity research, protection and conservation, as well as managing and updating a biodiversity database. K Conducting the necessary studies and collecting all information available to determine the country's environmental baseline, as well as preparing environmental accounts, including the environmental assets and liabilities and studies on the carrying capacity of the country's environmental basins. L State of the Environment Reports, every four years, at the national, regional and local levels. However, once a year consolidated reports on the environmental situation at the national and regional levels must be issued. These reports will include data on the quality of the environment, as well as an executive summary than can be understood by the general public.
ENSURE	M The compliance with international conventions that Chile is a party of, dealing with the environment, and acting as administrative, scientific or technical counterpart for said conventions, without disregarding the role of the Ministry of Foreign Relations. When the mentioned conventions include, in addition to environmental matters, other sectoral competencies, the Ministry of the Environment shall integrate those sectors as a part of their administrative, scientific or technical counterparts.
PARTICIPATING	N In the creation of sectoral environmental budgets, promoting their consistency with the national environmental policy. While exercising this authority, management indicators associated to budgets can be established, in agreement with the sectoral ministry. With that aim, it will be necessary to have the approval of the Budget Directorate. Ñ In the procedure for the Strategic Environmental Assessment (SEA) of policies and plans promoted by different State agencies in accordance to this Law.
COORDINATING	O The process of establishing environmental quality and emission standards, as well as prevention and/or decontamination plans, determining the programs for their compliance.
INTERPRETING	P Providing an administrative interpretation of environmental quality and emission regulations, prevention and/or decontamination plans, based on prior reports by the institutions with competence on the specific matter and the Superintendency for the Environment (SMA). The Ministry of the Environment may request the head of each service and institution with competence on environmental matters, reports on the criteria used by the corresponding sectoral institution in the application of the regulations and plans indicated in the preceding paragraph, as well as on the doubts or difficulties for interpretation that could have arisen and the deviations or distortions that could have been detected. The Ministry could also standardize the application criteria and clarify the meaning and scope of the environmental quality and emission regulations, when observing discrepancies or errors in their interpretation.

CONTINUES ▶

02

MANAGING	Q The Pollutant Release and Transfer Register (PRTR), which will record and systematize, by source or group of sources from a same facility, the nature, flow and concentration of pollutant emissions that are subject to an emission regulation and the nature, volume and destination of the solid waste generated as indicated in the regulation. Also, in the cases and manner established by the regulation, the registry will systematize and estimate the type, flow and concentration, both total and by source, of the emissions that are not subject to a regulation in force. To that end, the Ministry will request the corresponding State services and institutions to provide general information on the productive activities, commodities, productive processes, technology, production volumes and any other data available and useful to carry out the estimates. The estimated emissions referred to in this paragraph will be unnamed and shall indicate the modeling methodology used. R The information of the air, water and soil quality monitoring programs provided by the competent institutions, when applicable.
ESTABLISHING	S A public information system on the compliance and application of the environmental regulations of a general nature in force, including a complete and updated registry of said regulation, which must be of free access and available through electronic means. T Collaboration agreements with regional governments and municipalities aimed at adopting the necessary measures to ensure the integrity, conservation and restoration of the regional and local environment, as well as environmental education, and citizen engagement. When those agreements include the transfer of resources, they should have the authorization of the Ministry of Finance.
GENERATING	U Collecting precise technical and scientific information to prevent pollution and ensure environmental quality, especially in relation to technologies, production, waste management and transfer, air pollution and environmental impact.
FINANCING	V Projects and activities aimed at environmental protection, sustainable development, preserving nature, conserving environmental heritage, environmental education and citizen engagement.
CARRYING OUT	W Promoting technical training and knowledge updating of governmental personnel in relation with the roles commissioned to the Ministry, which could also be granted to individuals.
CREATING	X Presiding operational committees and subcommittees made up of representatives of the ministries, agencies and other institutions with competences for studies, consultations, analysis, communication and coordination on matters related to the environment.

CONTINUES ▶

02

PROMOTING	Y Facilitating citizen engagement when preparing policies and plans, as well as environmental quality and emission standards in the SEA process of the policies and plans of the sectoral ministries.
ASSUMING	Z All other roles and authority that the law commissions to the Ministry.
ROLES OF THE COUNCIL OF MINISTERS FOR SUSTAINABILITY[5]	**The Council of Ministers for Sustainability is presided by the Minister of the Environment and integrated by the ministers of Agriculture; Finance; Health; Economy, Development and Tourism; Energy; Public Works; Housing and Urban Planning; Transportation and Telecommunications; Mining; and Social Development.**
PROPOSING TO THE PRESIDENT OF THE REPUBLIC	A Policies for the sustainable management, use and exploitation of renewable natural resources. B Sustainability criteria that must be incorporated into the development of policies and planning processes of the ministries, as well as those of the agencies that depend on or are related to them. C The creation of State Protected Areas, which include marine parks and reserves, as well as nature sanctuaries and Multiple-Use Coastal Marine Protected Areas (AMCP-MU by their acronym in Spanish). D Sectoral policies that must be submitted to the strategic environmental assessment.
RULE ON	E The criteria and mechanisms that will be the basis to implement citizen engagement for Environmental Impact Declarations, referred to in Article 26 of Law 19.300, General Environmental Framework Law. F The draft bills and administrative acts proposed to the President of the Republic, from any ministry, that include regulations of environmental nature specified under article 70.

[5] *Created through the enactment of Law 20.417, which modified Law 19.300 General Environmental Framework Law.*

Source: Authors' own elaboration based on Law 19.300.

3 • ENVIRONMENTAL MANAGEMENT TOOLS: A NEW PARADIGM

Environmental management tools are the set of policies, standards, taxes, grants, regulations, activities or programs available to the State to comply with environmental policy objectives. They can be characterized differently. One way of identifying them is based on the type of actions that they promote. Thus, environmental management tools can be defined based on three categories. These are:

(i) Regulatory (also known as command and control): They are divided into tools of direct regulation or of an administrative nature. This type of tool requires by law some kind of behavior, activity or action. It can also prohibit a behavior, require a technology or establish a standard. The compliance of this type of tool requires supervision to enforce the law. Some examples of these types of tools include emission standards, quality standards, permits and technological standards, among others.

(ii) Incentives or economic tools: This type of tool generates an incentive, which is typically monetary, for the compliance of an action. Some examples of these types of tools are the tradable emission permits, taxes, grants and other charges.

(iii) Moral persuasion: This type of tool tries to change behavior by convincing economic agents through the generation of information or education regarding the environmental impacts of their actions. Some examples of these types of tools are: access to information, environmental education, eco-labeling and environmental awards, among others.

Which instrument or what combination of them should be applied depends on several factors. Without a doubt, the main factor is linked to the feasibility of implementing a tool in a specific situation. From the technical point of view, the most relevant criteria are:

(i) Effectiveness: If it complies with the policy objectives.
(ii) Efficiency: If it complies with the objectives at a minimum cost.
(iii) Equality: If the costs of the implementation do not have a disproportionate impact on some group of society.

Chile's environmental institutional framework identifies and defines a series of regulation tools that are specific to environmental policy. These are presented in **Table 01**.

Over the last 20 years, the environmental policy has almost exclusively focused on regulations, preferably environmental management tools. However, the 2014 tax reform opened up the possibility of introducing new tools, since the application of two taxes with explicitly environmental objectives has been approved. These are a tax to the first purchase of automobiles based on NOx emissions and the application of an emissions tax to local and global pollutants from stationary sources that have kilns or turbines.

The environmental management tools chapter will go into greater detail about these tools and their implementation.

TABLE 01

ENVIRONMENTAL REGULATORY TOOLS	
TYPES OF TOOLS	**Legal Definition (General Environmental Framework Law)**
1 Direct regulation tools are based on the enactment of rules or standards and on the threat of sanctions to change the behavior of economic agents.	Quality Standards *(Paragraph 4, Heading II, Law 19.300)* Emission Standards *(Paragraph 5, Heading II, Law 19.300)* Management, Prevention and Decontamination Plans *(Paragraph 6, Heading II, Law 19.300)*
2 Administrative tools are also regulations and consist of the granting of licenses, permits and other ways of acquiring the right to use natural resources established in different legislations.	Environmental Impact Assessment System *(Paragraph 2, Heading II, Law 19.300)* On the Strategic Environmental Assessment *(Paragraph 1 bis, Heading II, Law 19.300)*
3 Economic tools incentivize optimal social behaviors by changing the allocation of resources through the pricing system.	Tradable emission permits, taxes to emissions or fees for users, which consider the environmental cost implicit in the production or use of certain goods or services and other tools to promote environmental improvement or restoration actions. *(Article 47, Paragraph 6, Heading II, Law 19.300)*
4 Education, research, technical assistance and environmental information make up the fourth category.	Education and Research *(Paragraph 1, Heading II, Law 19.300)* Citizen Engagement *(Paragraph 3, Heading II, Law 19.300)* Environmental Information *(Paragraph 3 bis, Heading II, Law 19.300)*
5 Justice	Complaint Procedures *(Paragraph 7, Heading II, Law 19.300)* Citizen Engagement *(Paragraph 3, Heading II, Law 19.300)* Environmental Information *(Paragraph 3 bis, Heading II, Law 19.300)*

Source: Authors' own elaboration, based on Law 19.300.

4 • SECTORAL ENVIRONMENTAL INSTITUTIONAL FRAMEWORK

The public sector environmental management is understood as the set of actions carried out by the institutions that make up the State administration, with the aim of coordinating and giving consistency to the decisions made and the tasks performed.

In this regard, Law 19.300 provides explicit authority to the Ministry of the Environment and the Council of Ministries for Sustainability so that State policies are implemented in a coordinated and integrated manner. Thus, the Ministry of the Environment is in charge of collaborating with sectoral ministries in the preparation of environmental criteria that must incorporated into the formulation of their policies and plans, strategic environmental assessments and planning processes, as well as those of their depending agencies.

Likewise, the Ministry of the Environment must collaborate with the competent agencies in the development of environmental policies for the sustainable management, use and exploitation of renewable natural resources and water, as well as in the determination of the effects and the establishments of the necessary climate change adaptation and mitigation measures at the national, regional and local levels.

The types of actions executed by the different agencies deal with:

- Environmental planning
- Regulations
- Environmental control
- Environmental education
- Provision of environmental services
- Restoration of environmental damage

Table 02 shows the most relevant services for environmental management and their responsibilities.

PUBLIC SECTOR ENVIRONMENTAL MANAGEMENT

Set of actions carried out by the institutions that make up the State administration, with the aim of coordinating and giving consistency to the decisions made and the tasks performed.

Law 19.300 provides explicit authority to the Ministry of the Environment and the Council of Ministries for Sustainability so that State policies are implemented in a coordinated and integrated manner.

TABLE 02

PUBLIC SECTOR RESPONSIBILITIES IN ENVIRONMENTAL MATTERS	
INSTITUTIONS	
MINISTRY OF TRANSPORTATION AND TELECOMMUNICATIONS (MTT by its acronym in Spanish)	Its main function is to propose the national policies regarding transportation and telecommunications, exercising the leadership and control of their implementation, overseeing public and private companies operating means of transportation and communications within the country, coordinating and promoting the development of these activities and supervising the compliance with pertinent laws, regulations and standards. The ministry is made up of the Under Secretariat of Transportations, the Under Secretariat of Telecommunications and the Civic Aeronautical Board (JAC by its acronym in Spanish).
MINISTRY OF HOUSING AND URBAN PLANNING (MINVU by its acronym in Spanish)	It is the institution in charge of developing the national housing and urban planning policy and of linking the ministry's action with that of other State secretariats, organizations, national or foreign public or private institutions, through an adequate inter-ministerial and international coordination.

CONTINUES ▶

TABLE 02

MINISTRY OF SOCIAL DEVELOPMENT (MDS by its acronym in Spanish)	It must contribute to the design and application of policies, plans and programs related to social development, particularly those aimed at eradicating poverty and providing social protection to vulnerable people or groups, promoting social mobility and integration. Likewise, it must oversee the coordination, consistency and coherence of policies, plans and programs related to social development at the national and regional levels and evaluate pre-investment studies of investment projects requesting State funding to determine their social profitability, so that they respond to the strategies and policies for economic and social growth and development determined for the country.
MINISTRY OF ENERGY (MINERGÍA by its acronym in Spanish)	It is the institution responsable for preparing and coordinating, in a transparent and participative manner, the different plans, policies and regulations for the development of the country's energy sector, thus ensuring that everyone can have access to energy in a secure manner and at reasonable prices.
NATIONAL STATISTICS INSTITUTE (INE by its acronym in Spanish)	It is the organization in charge of producing, compiling and publishing the country's official statistics. It generates price, labor, income and expenditure, economy, social, demographic, life, environment and census statistics.
MINISTRY OF EDUCATION (MINEDUC by its acronym in Spanish)	It is in charge of fostering the development of education at all levels, through a democratic humanistic education of excellence and open to the world at all education levels, stimulating scientific and technological research, artistic creation and the protection and increase of the nation's cultural heritage. In addition, it must safeguard the rights of all students, both in public and private establishments.
MINISTRY OF AGRICULTURE (MINAGRI by its acronym in Spanish)	It is the institution in charge of promoting, guiding and coordinating forestry, agriculture and livestock activities in the country, increasing national production, the conservation, protection and growth of renewable natural resources and the improvement of the population's food conditions.
UNDER SECRETARIAT OF FISHING (SUBPESCA by its acronym in Spanish)	It proposes the fishing policy and the way it is to be applied. It also leads and coordinates activities carried out by the State in relation to the fishing sector.
NATIONAL FISHING SERVICE (SERNAPESCA by its acronym in Spanish)	It is in charge of executing the national fishing policy, the regulations and the supervision of their compliance. Likewise, it must safeguard the due application of laws and regulations on fishing, ocean hunting and other ways of exploiting hydrobiological resources.
NATIONAL TOURISM SERVICE (SERNATUR by its acronym in Spanish)	It is responsible for promoting and disseminating the development of tourism activities in Chile. This service has offices in all regions of the country and is a dependency of the Ministry of Economy, Development and Tourism.

CONTINUES ▶

TABLE 02

GENERAL DIRECTORATE OF WATER (DGA by its acronym in Spanish)	It must plan development of water resources in natural sources in order to make recommendations on its use, research and measure the resource, safeguard water and oversee the work of user organizations. It is a dependency of the Ministry of Public Works.
SUPERINTENDENCY OF SANITATION SERVICES (SISS by its acronym in Spanish)	It must study, propose and control the compliance with technical regulations on design, construction and use of sanitation services and water resources linked to sanitation concessions (regulated by Supreme Decree 609/98), along with participating in studies of legislation associated with them as well as in the Environmental Impact Assessment System. In addition, it must report on the granting of concessions, their extension or modification and apply sanctions to sanitation service providers who breach current legislation.
NATIONAL FORESTRY CORPORATION (CONAF by its acronym in Spanish)	It must contribute to the conservation, increase, management and use of the country's forest resources. To that end, it must participate in the preparation and execution of national or regional forestry development plans and in the management and development of the State's forest heritage. It must also ensure the adequate management and use of forests established directly or indirectly by the Corporation, prepare and execute national and regional protection and conservation plans of the country's forest resources. It is a dependency of the Ministry of Agriculture.
AGRICULTURE AND LIVESTOCK SERVICE (SAG by its acronym in Spanish)	Its role is to contribute to the development of forestry, agriculture and livestock in the country by protecting, maintaining and increasing the health of animals and vegetables, as well as controlling their sanitary conditions and that of their products, subproducts and byproducts that may be the cause or vectors of diseases or plagues that might affect these resources. It is a dependency of the Ministry of Agriculture.
MINISTRY OF HEALTH (MINSAL by its acronym in Spanish)	Its objective is to ensure the right of all citizens to health protection. It is in charge of ensuring that all environmental factors, elements or agents that affect the health, safety and well-being of the population be eliminated or controlled. At the regional level, its Regional Secretariats (SEREMIs by their acronym in Spanish) participate in the Assessment Commissions, particularly in matters related to environmental impact assessment. The most relevant agencies that report to the Ministry and that are related to the environment are Health Services. There is at least one of them in each of the regions of the country and they all have Departments of the Environment. The roles of these services include executing integrated development, promotion and protection actions dealing with people and the environment, as well as health recovery and the rehabilitation of sick people. Likewise, they must comply with the policies, regulations, plans, programs and directives issued by the Ministry and to the regional policies, plans and programs. It is important to highlight that Law 19.937, published on February 24, 2004 modified decree having the force of Law2.763, of 1979, indicating that the supervision of the provisions contained in the Health Code and other complementary laws, regulations and standards, as well as the sanction to breaches in matters such as the hygiene and safety of the environmental and the work place, food products, among others, will be carried out by the corresponding Regional Secretariat, regardless of the competence legally assigned to other institutions.

CONTINUES ▶

TABLE 02

NATIONAL GEOLOGY AND MINING SERVICE OF CHILE (SERNAGEOMIN by its acronym in Spanish)	This institution advices the Minister of Mining in matters related to disseminating information on the existence, development and conservation of the country's mineral resources, as well as on the geological factors that condition the storage, runoff and conservation of underground water, vapors and gases in the national territory; providing, coordinating, motivating and conducting studies and research on ocean geology aimed at learning about the seabed mineral resources. It also proposes the passing of legislation aimed at improving the safety conditions of mining activities, in accordance with technical and scientific progress, demands information on training programs and courses and informs workers who are part of the extractive industry.
NATIONAL MONUMENTS COUNCIL (CMN by its acronym in Spanish)	It is a dependency of the Ministry of Education. One of its roles is to authorize construction or excavation works, or any other activity that may alter the natural state of areas declared "nature sanctuaries". It does not have regional offices.
NATIONAL INDIGENOUS DEVELOPMENT CORPORATION (CONADI by its acronym in Spanish)	It is a dependency of the Ministry of Social Development and is in charge of promoting the adequate use of indigenous lands; safeguarding for their balance and for the economic and social development of its inhabitants through the Indigenous Development Fund; and, in special cases, requesting the declaration of "Indigenous Development Area." In addition, it must ensure the preservation and dissemination of the archaeological, historical and cultural heritage of indigenous peoples and promote studies and research on the matter.
UNDER SECRETARIAT OF TRANSPORTATION, OF THE MINISTRY OF TRANSPORTATION AND TELECOMMUNICATIONS	It is in charge of determining the requirements that must be met by facilities that test the road worthiness of vehicles, as well as the technical procedures that must be followed in these tests and the maximum levels of pollutant emissions allowed.

5 • MUNICIPAL ENVIRONMENTAL MANAGEMENT

The General Environmental Framework Law grants certain authority to municipalities in environmental matters. After the legal modification of 2010, the role of local governments in this area was strengthened. Regarding supervision, municipalities receive citizen complaints for non-compliance with environmental legislation, which must be reported to the Superintendency of the Environment to process them (Art. 65 Law 19.300).

In order to complete the picture of municipal authority in environmental matters, it is necessary to consider the Organic Constitutional Law on Municipalities, which regulates them in general and establishes among their unique roles several that are related to the environment. Some outstanding ones are:

- ▶ The application of provisions on public transportation and traffic and on construction and urban development within the commune, in accordance with the laws and standards of the corresponding ministry.
- ▶ Urban planning and regulation of the commune and the preparation of the Communal Master Plan and of the Communal Development Plan, whose application must be in line with the regional and national plans.
- ▶ Communal cleaning and decoration (with the modification to Law 19.300, this unit is modified and it becomes environment, cleaning and decoration).
- ▶ Proposing and executing measures aimed at carrying out actions and programs related to the environment.
- ▶ Applying environmental legislation in the commune within their competence.
- ▶ Preparing the draft bill for environmental ordinance. In order for it to be approved, the Municipal Council may always request a report to the Ministry of the Environment.

Local Environmental Management has significantly evolved over the last few years, both from the institutional and the cultural perspectives. One of the main changes was the process of improving the environmental institutional framework based on Law 20.417, which establishes new roles for the municipal environmental management, such as the proposal and execution of measures related to the environment; the application of environmental legislation; and the preparation of the draft bill for environmental ordinance. This involves important challenges for the decentralization of environmental management, making it necessary to build capacities within the municipalities.

The Ministry of the Environment has supported local environmental management through the creation of the Environmental Certification System for Municipalities (SCAM by its acronym in Spanish).

Although municipalities have developed an institutional framework in line with the new challenges, they still have serious difficulties in several matters that are mainly linked to structural issues of environmental management. Nevertheless, the progress achieved over the last few years has been remarkable (UC Políticas Públicas, 2015).

6 • INTERNATIONAL COMMITMENTS

Chile actively participates in the international agenda for sustainable development and, in this context, attends several meetings and forums, becoming a party to most of the multilateral environmental agreements established since 1990. The main ones are detailed in **Table 03**. In addition, given the interest among institutions with competence on environmental matters, and with the aim of targeting cooperation within a framework that is in line with mutual interests and priorities, specific sectoral instruments have been put in place such as memoranda of understanding and declarations of intentions.

Since 2012, Chile leads a regional process to deepen the implementation of Principle 10 of the 1992 Rio Declaration on Environment and Development. Indeed, following the Rio+20 summit, the governments of Chile, Costa Rica, Dominican Republic, Ecuador, Jamaica, Mexico, Panama, Paraguay, Peru and Uruguay endorsed the "Declaration on the application of Principle 10 of the Rio Declaration on Environment and Development," in which they manifested their commitment to make progress towards reaching a regional agreement on access to information, public participation and justice regarding environmental issues, all of them established in Principle 10 of the 1992 Rio Declaration on Environment and Development.

At present, more than 23 countries participate in this process: Chile; Costa Rica; Dominican Republic; Ecuador; Jamaica; Mexico; Panama; Paraguay; Peru; Uruguay; Antigua and Barbuda; Argentina; Bolivia; Brazil; Colombia; Salvador; Grenada; Guatemala; Honduras; Saint Vincent and the Grenadines; Trinidad and Tobago; Saint Kitts and Nevis; and Dominica.

Following the Fourth Meeting of the Focal Points appointed by the Governments of the Signatory Countries, held in Santiago, Chile in November 2014, the countries began the negotiating phase of this instrument[6]. The Negotiating Committee includes the participation of interested public through their own and novel modalities for this process.

On the other hand, with the aim of making progress on the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda and its 169 goals in the three dimensions - economic, social and environmental – the National Council was formed in 2016 to implement this agenda, which was adopted in September 2015 during the 70th session of the General Assembly of the United Nations. This constitutes "plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom."

This National Council will be presided over by the Ministry of Foreign Affairs and will also include the following ministries: Economy, Development and Tourism; Social Development; and Environment. Its main roles will be to: Advise the President of the Republic on the implementation and monitoring of the 2030 Agenda; provide a space for coordination in the implementation and monitoring of the agenda and the SDGs at the national level, in accordance with the processes and meetings held at the international and regional levels; and providing a space for coordinating with the pertinent organizations, be they governmental, international organizations, non-governmental organizations, private sector and/or civil society, in technical aspects linked to the national stance regarding the Agenda and the Sustainable Development Goals.

[6] *All information regarding the process is available on the ECLAC website, which – as technical secretariat – has set up for this regional negotiation for strengthening environmental democracy. https://www.cepal.org/en/subsidiary-bodies/meeting-negotiating-committee-principle-10-latin-america-and-caribbean*

6.1 Organisation for Economic Co-operation and Development (OECD)

The OECD Environment Directorate is made up of the Environmental Policies Committee and the Chemicals Committee, which oversee the work of a series of groups in matters such as: Biodiversity, water and ecosystems; climate; investment and development; environmental information; environmental performance; integration of economic and environmental policies; as well as productivity of resources and waste, chemicals, pesticides and biotechnology.

The environmental performance assessments are one of the most important inputs this organization provides for its member countries. These reviews cover a large number of thematic areas, seeking to support States in the compliance of their national and international environmental objectives, sharing best practices, providing specific recommendations and, overall, motivating greater transparency in environmental management.

The first Environmental Performance Assessment was conducted by the OECD for Chile in 2005, and it was of a voluntary nature, since our country was not yet a full member of the organization. Its second assessment ended in 2016 and involved a process of approximately 18 months, which included: Information being provided by Chile; an OECD mission that met with several public and private stakeholders (NGOs, experts, academia, international organizations, business owners and workers); a presentation at the OECD Headquarters (Paris) that gave way to the approval of the conclusions and the 54 recommendations that were publicly announced on July 21, 2016[7].

OECD ENVIRONMENTAL PERFORMANCE REVIEW: CHILE

The first Environmental Performance Assessment was conducted by the OECD for Chile in 2005, and it was of a voluntary nature, since our country was not yet a full member of the organization. **Its second assessment ended in 2016 and involved a process of approximately 18 months, which included: Information being provided by Chile; an OECD** mission that met with several public and private stakeholders (NGOs, experts, academia, international organizations, business owners and workers); a presentation at the OECD Headquarters (Paris) **that gave way to the approval of the conclusions and the 54 recommendations** that were publicly announced on July 21, 2016.

6.2 Global Environment Facility (GEF)

The GEF (Global Environment Facility) is the financial mechanism for several conventions. It is a fund that co-finances projects with global environmental benefits and supports environmental change by addressing and solving underlying causes of environmental degradation in an associative manner with all stakeholders. It promotes innovative and replicable activities at the national and global scales and promotes a cost-benefit effect.

The focal point institution in Chile is the Ministry of the Environment. Since the GEF's inception, 25 years ago, Chile has implemented 60 projects in different thematic areas[8].

6.3 Pacific Alliance

Over the last few years, the member countries of the Pacific Alliance have sought not only to deepen regional integration in economic matters, creating attractive markets to achieve greater competitiveness at the international level, but also to strengthen and solidify their adherence to sustainable development and to green growth policies.

One example is that the technical teams and environmental authorities of the member countries have met on several occasions, particularly during 2016. On March 30 of that same year, the ministers of environment of the Alliance countries met in Cartagena de Indias, Colombia, and agreed upon a Declaration toward a Green Growth Platform. The declaration acknowledges that there can be no economic growth without safeguarding the environment and it was decided to promote the creation of a work space especially set aside for this topic.

[7]The digital versions, in English and Spanish, can be accessed on the website: www.mma.gob.cl

[8]The detailed information is available on the GEF website: www.thegef.org

In particular, the countries highlighted their commitment to a "Green Growth strategy that ensures a sustainable, equitable and inclusive economic development." The ministers committed to carry out actions "to ensure the conservation of biodiversity and ecosystem services and to address climate change." Finally, they stressed their intention of strengthening the environmental institutional framework and its management tools, including "appropriate information access, gender-equality, public participation in decision making and access to justice in environmental matters."

Along this same line, the Technical Group on Environment and Green Growth, was highlighted in the Presidential Declaration of Puerto Varas, on July 1, 2016. This initiative, and its subsequent action plan, seek to attune economic growth with national policies aimed at protecting natural resources and the environment. The next step in this path is the definition and implementation of an action plan with its diverse activities.

6.4 Environmental Provisions in Trade Agreements

All Free Trade Agreements negotiations that Chile has been a part of have followed the trend of proposing the incorporation of the environmental topic. As a result, there are environmental provisions in most of the current commercial agreements, under modalities such as: Articles in Cooperation Chapters (European Union, Australia, Turkey, Malaysia, Thailand); Environment Chapters (Colombia, United States, Hong Kong); parallel Environmental Cooperation Agreements (Canada, United States, Panama, P4[9], China, Costa Rica) or Preambles (South Korea, EFTA[10], Vietnam)[11].

[9] Brunei Darussalam, Chile, New Zealand and Singapore
[10] Iceland, Norway, Switzerland and the Principality of Liechtenstein
[11] For further information, visit https://www.direcon.gob.cl/acuerdos-comerciales/

Sunset Cape Froward | JORGE HERREROS

TABLE 03

MULTILATERAL ENVIRONMENTAL AGREEMENTS	
INTERNATIONAL AGREEMENT	
CONVENTION ON THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES	The Convention came into force in 1982 as part of the Antarctic Treaty System. When established, the priority was to consider the serious consequences of the increase of krill catches in the Southern Ocean on krill populations and on marine fauna, especially birds, seals and fish that mostly rely on krill for food.
STOCKHOLM CONVENTION	It is aimed at protecting human health, giving authority to signatory parties to take legal, administrative and/or regulation tools measures that they consider necessary to reduce or eliminate releases from the production or intentional use of Persistent Organic Pollutants (POPs), chemical substances used as pesticides by industries, or that are produced unintentionally as a result of certain human activities (combustion or incineration processes, among others).
BASEL CONVENTION	The Basel Convention is a global environmental treaty that strictly regulates the transboundary movement of hazardous wastes and sets out obligations to the Parties to ensure their rational environmental management, particularly of their disposal.
CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS	The Convention is aimed at conserving terrestrial, aquatic and bird migratory species throughout their range of distribution. This convention is an international treaty of the United Nations Environment Programme.
MONTREAL PROTOCOL	The Montreal Protocol on Substances that Deplete the Ozone Layer is an international treaty aimed at protecting the ozone layer by controlling the production of substances that degrade it.
ROTTERDAM CONVENTION	It is aimed at promoting shared responsibility and efforts from the parties in the international trade sphere of certain hazardous chemical products in order to protect human health and the environment in case of potential damage.
CONVENTION FOR THE CONSERVATION OF ANTARCTIC SEALS	This Convention is applied to the seas south of 60 degrees South Latitude and covers the following species: Southern Elephant Seal (*Mirounga leonina*), Leopard seal (*Hydrurga leptonyx*), Weddell Seal (*Leptonychotes weddelli*), Crabeater Seal (*Lobodon carcinophagus*), Ross Seal (*Ommatophoca rossi*), Southern Fur Seals (*Arctocephalus spp*).

CONTINUES ▶

TABLE 03

CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA (CITES)	It is an international treaty between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.
ANTARCTIC TREATY	It was subscribed in Washington on January 1st, 1959, and entered into force on June 23, 1961. The signatory countries (Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the former Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America) signed this agreement with the belief that a Treaty ensuring the use of Antarctica for peaceful purposes only and the continuance of international harmony in Antarctica will further the purposes and principles embodied in the Charter of the United Nations.
INTERNATIONAL CONVENTION FOR THE REGULATION OF WHALING	It seeks to establish a system of international regulation for the whale fisheries to ensure proper and effective conservation and development of whale stocks based on the principles embodied in the provisions of the International Agreement for the Regulation of Whaling, signed in London on June 8th, 1937, and the protocols to that Agreement signed in London on June 24th, 1938, and November 26th, 1945
CONVENTION ON BIOLOGICAL DIVERSITY (CBD)	Its aim is the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the use of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.
CONVENTION ON WETLANDS OF INTERNATIONAL IMPORTANCE ESPECIALLY AS WATERFOWL HABITAT (RAMSAR)	It is a treaty between governments used as a framework for national action and international cooperation for the conservation and rational use of wetlands and their resources. Today, there are 169 Signatory Parties in the Convention and 2,224 wetlands, covering a total area of 214.3 million hectares designated to be included in the List of Ramsar Wetlands of International Importance.
UN CONVENTION TO COMBAT DESERTIFICATION (UNCCD)	It is aimed at combating desertification and mitigating the effects of droughts in affected countries, especially in Africa, by adopting efficient measures at all levels, supported by international cooperation and association agreements, within the framework of an integrated approach according to Program 21, in order to contribute to achieving the sustainable development of affected areas.
UN FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)	It is aimed at reinforcing public awareness, on a global scale, of the problems related to climate change.

7 • ASSESSMENT AND SUPPORT TOOLS

As part of the improvement of the regulatory design, the General Environmental Framework Law, in Article 32, includes a procedure by stages for passing environmental quality standards. This procedure includes scientific analysis, citizen engagement, and technical and economic analysis. This last stage has focused on the ex-ante cost-benefit analysis of regulatory tools in order to ensure the social profitability of the proposed standards.

The Cost-Benefit Analysis (CBA) is a tool whose objective is to provide information to improve decision making. It basically consists of identifying and estimating the positive and negative impacts associated with a project or alternative (alternatives to reducing emissions, for example) to then contrast them and compare the net social benefit generated by each of them. The purest application of a CBA assumes that the largest part of the relevant costs and benefits can be expressed as money. Nevertheless, when applying this method to environmental policies there is a series of restrictions related to the estimate of both costs and benefits. Hence, in many cases it is not possible to press all components of the analysis in monetary units, obtaining only a quantification or description of the different effects of the policy. In the case of Chile, this analysis is called General Social and Economic Impact Analysis (AGIES by its acronym in Spanish) and it includes an assessment of the economic and social impact of the proposed standards.

Likewise, the "Regulation for passing environmental quality and emission standards" (Supreme Decree 38/2012) and the "Regulation for passing prevention and decontamination plans" (Supreme Decree 39/2012), indicate that, for all sectors involved[12], the AGIES should:

- Identify and quantify, whenever applicable, the associated risks.
- Assess the costs involved in the compliance of the draft bill of the environmental quality or emissions standard.
- Identify and, whenever applicable, quantify the benefits involved in the compliance with these standards.

The AGIES are a very significant tool in the design of environmental regulations. However, the final decision of implementing or not a regulatory standard does not exclusively depend on this tool, since, on the one hand, not all costs and benefits related to the implementation of a regulatory instrument can be quantified and, on the other hand, there may be other factors that elude such type of analysis.

[12] *The document explicitly mentions that the impact analysis must be made for the population, ecosystems or species directly affected or protected, for the owners of the regulated resources or activities and for the State.*

Baker River Delta | MANUEL VALLEJOS

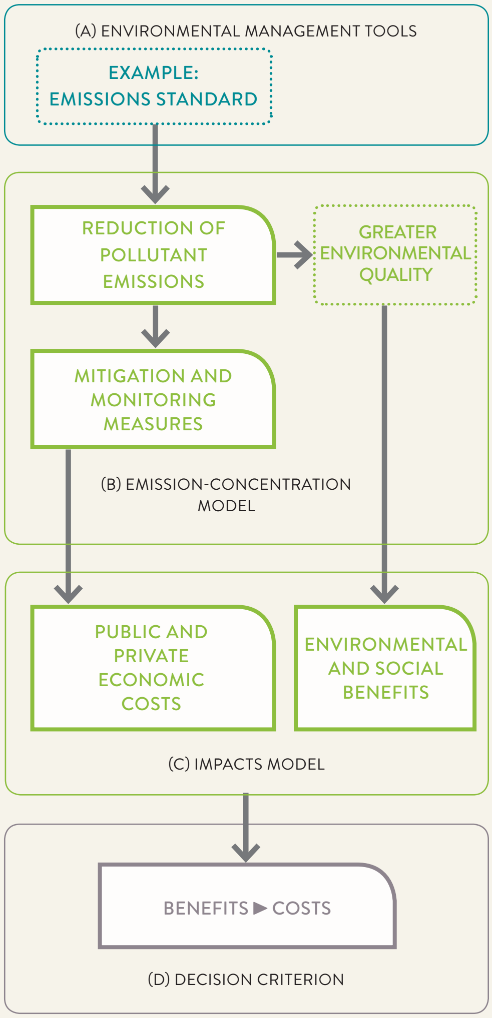
03

AGIES

The General Social and Economic Impact Analysis (AGIES by its acronym in Spanish) is a tool mandated in the regulations for passing standards and environmental decontamination and prevention plans (Supreme Decree 38/2012 and Supreme Decree 39/2012 of the Ministry of the Environment, Supreme Decree 93/1995), which aims at providing information regarding environmental, economic and social aspects in the participation processes and committees as part of the process of passing standards (operations, consultation and Ministers for Sustainability). Thus, it is intended to address all dimensions or axes of sustainability in State policies.

Overall, the AGIES attempts to link all actions promoted by the State (standards, plans, programs, economic instruments, etc.) with the changes they generate on the environment, regulated sector and the population, in order to make a qualitative and quantitative estimate of the positive and negative impacts of the environmental regulation.

(► **See flowchart**).



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CHAP **05**

ENVIRONMENTAL MANAGEMENT TOOLS

CONTENT

INTRODUCTION

Environmental management tools are public policy tools that, through regulations, incentives or mechanisms that motivate the actions or behaviors of agents, enable contributing to the protection of the environment, as well as to prevent, mitigate or reduce environmental issues.

The environmental management tools included in Law 19.300 are: Education and research; the Environmental Impact Assessment System; standards for environmental quality, nature preservation and environmental heritage conservation and emissions; management, prevention and decontamination plans; and citizen engagement. Nevertheless, as the country makes progress and deepens its management in environmental matters, new tools have been introduced that, along with addressing relevant issues for environmental management, respond to international demands and commitments.

1 • BACKGROUND INFORMATION

In 2005, the Environmental Performance Assessment conducted by the Organisation for Economic Co-operation and Development (OECD), acknowledged the importance and the country's progress regarding the implementation of environmental management tools, but made several recommendations to deepen the implementation of some of them as well as to develop new ones.

Specifically, the OECD recommended developing and strengthening regulatory frameworks, along with their supervision and compliance; assessing the introduction of new economic instruments; and integrating environmental considerations into the tools and State policy. Likewise, it recommended deepening principles such as "the polluter pays" and the provision of environmental information to support decision making.

Some of these recommendations were reflected in the 2010 modification to Law 19.300. Thus, through Law 20.417 new tools were incorporated, such as the Strategic Environmental Assessment and the access to environmental information. Likewise, the Ministry of the Environment was created, with roles that complement the usefulness and work of all other environmental management tools.

In addition, since 2014 the Ministry of the Environment began working on deepening the regulatory framework for emissions and quality and introducing new economic instruments that contribute to reducing pollution, both from air emissions as well as from waste generation. In this regard, one significant advancement to improve air quality and safeguard people's health was the publication of the Emission Standards for Thermoelectric Power Plants (Decree N°13/2011) and for Copper Smelters and Arsenic Emissions Sources (Decree N°28/2013).

Likewise, the Ministry of the Environment has also worked on waste management, through the Framework Law for Waste Management, Extended Producer Responsibility and Promotion of Recycling, Law 20.290, which seeks to address waste management in an integrated manner. Furthermore, the 2014 Tax Reform (Law 20.780) approved the implementation of environmental taxes for the first time in Chile.

2 • TOOLS ESTABLISHED BY LAW 19.300

2.1 Quality and Emission Standards

Environmental standards are tools of a regulatory nature aimed at establishing the allowed limits for the emission and concentration of pollutants, in order to protect the health and quality of life of people and the environment.

Law 19.300 sets the emission and quality standards; whose objective is to prevent and control the concentration of pollutants in the environment.

Quality standards may be primary or secondary. Primary ones are intended to protect the health of the population, while secondary ones are aimed at protecting and conserving the environment by establishing allowed concentration values and periods. If the limits set by environmental quality standards are surpassed in a specific location, it must be declared a saturated area. If the concentration of pollutants ranges between 80 and 100 percent of the value indicated in the standard, it must be declared a latent area[1].

On the other hand, **emission standards** establish the maximum amount of pollutants that can be released into the atmosphere or water by emission sources. Its objective may be to prevent pollution or to provide a means for restoring air or water quality levels when these have exceeded. In this case, emission standards may constitute responses to mitigate or solve quality problems (**Table 01**).

Supreme Decree N°38/12 of the Ministry of the Environment establishes the process for passing environmental standards, which includes the stages and timeframes for their preparation and review. The stages included are the creation of a expanded operations committee, the preparation of a draft bill for the standard, a public consultation phase, the formulation of the definitive bill, the approval by the Council of Ministers for Sustainability, signature by the authorities, acknowledgment by the Office of the General Comptroller of the Republic, and finally its publication in the Official Gazette, when it enters into force. The general flowchart is shown in **Figure 01**.

By 2015, Chile has emission and quality standards for air and water. The air component includes standards to control noise, light pollution and the emission of foul smells from pulp mills.

ENVIRONMENTAL STANDARDS

They are tools of a regulatory nature aimed at establishing the allowed limits for the emission and concentration of pollutants, in order to **protect the health and quality of life of people and the environment.**

By 2015, Chile has emission and quality standards for air and water. The air component includes standards to control noise, light pollution and the emission of foul smells from pulp mills.

ⓘ Public Table: Progress of Regulatory Processes[2]
The Regulation for Passing Environmental Quality and Emission Standards (Supreme Decree N°38/2012 MMA) establishes in Article 9 that: *"The Ministry will create a public table to report on the matter and status of the different files on standards, their timeframes and pending processes, indicating the date on which the process was initiated. A copy of said table will be available on the Ministry's website."* The public table can be found in the banner of Transparent Government of the ministry's website.

1 The declaration of a latent or saturated area is made based on measurements validated by the competent services, according to the parameters established in both the primary and secondary environmental quality standards.

[2] *The public table is also established for Prevention and Decontamination Plans, according to Supreme Decree N°39/12 MMA – Regulation for Passing Prevention and Decontamination Plans.*

TABLE 01

TYPES OF ENVIRONMENTAL STANDARDS	
PRIMARY ENVIRONMENTAL QUALITY STANDARD	It establishes the values for maximum concentrations and periods or minimum permissible periods of elements, compounds, substances, chemical or biological byproducts, energies, radiations, vibrations, noise or a combination of them, whose presence or absence in the environment may represent a risk to human life or health.
SECONDARY ENVIRONMENTAL QUALITY STANDARD	It establishes the values for maximum concentrations and periods or minimum permissible periods of substances, elements, energy or a combination of them, whose presence or absence in the environment may represent a risk to the protection and conservation of the environment or for the preservation of nature.
EMISSION STANDARDS	They establish the maximum amount allowed for a pollutant, measured in the effluent of the emission source.

Source: Department of Standards of the MMA, 2016.

01

THE ENVIRONMENTAL REGULATION PROGRAM

Article 10 of the regulation for Passing Environmental Quality and Emissions Standards (Supreme Decree N°38/2012 MMA) establishes the definition of an environmental regulation program, which must be passed at least every two years and contain the sustainability criteria and program priorities for policies, plans and programs for passing environmental quality and emission standards, as well as other environmental management tools. The first environmental regulation program (2016-2017) was established by Exempt Resolution N°0177 of the Ministry of the Environment, dated March 10, 2016.

The management for air and climate change will focus on the National Strategy for Prevention and/or Air Decontamination Plans, as well as the 2017-2022 National Climate Change Plan, and on the sectoral adaptation plans. The program defines the preparation of three new emission standards - power generators, boilers, and off-the-road machinery- as well as regulations for controlling and managing smells.

For biodiversity, management will be guided by the 2015-2030 National Biodiversity Conservation Strategy and a National Action Plan. In addition, regarding species recovery, conservation and management plans, the creation of protected areas and the development of management plans for marine protected areas will continue. For water resources, the priority is aimed at protecting hydrographic basins. To that end, secondary environmental quality standards will be prepared for five watersheds in the country.

The work on waste, soils and environmental risk is focused on developing and updating policies, plans and tools that will improve adequate waste management, reduce risks associated with handling chemical substances and allow making progress in managing soils with potential presence of pollutants.

2.2 Management, Prevention and/or Decontamination Plans

2.2.1 Management Plans

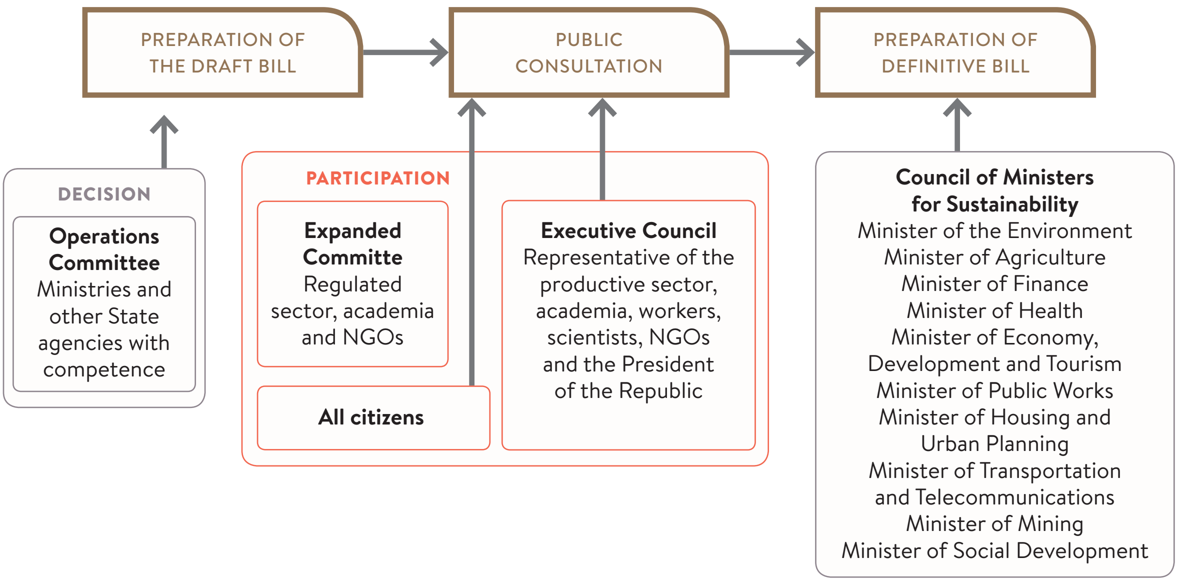
Management plans are aimed at regulating the use or exploitation of natural resources in a specific area. Law 19.300 establishes that the Ministry of the Environment, along with the service in charge of regulating the use of the resources, whenever necessary, may require a management plan that could include topics such as soil and landscape conservation, streamflow management and species protection.

2.2.2 Prevention and/or Air Decontamination Plans

According to Law 19.300, the implementation of a prevention and/or decontamination plan will be carried out whenever a place has been declared a latent or saturated area, due to the non-compliance of the limits established by the environmental quality standards, in order to determine actions that will enable the recovery of the place's environmental conditions.

FIGURE 01

DECISION AND PARTICIPATION BODIES DURING THE PREPARATION OR REVIEW OF STANDARDS AND PLANS



Source: Department of Standards of the MMA, 2016.

TABLE 02

OBJECTIVE AND AREA OF IMPLEMENTATION		
TOOL	**AREA OF IMPLEMENTATION**	**OBJECTIVE**
Primary Environmental Quality Standard	Latent Area	To avoid the exceedance of one or more primary or secondary environmental quality standards in a specific place.
Air Prevention Plan	Saturated Area	To recover the levels indicated in the primary and/or secondary environmental quality standards.

At present, in Chile there are 15 prevention and decontamination plans in force.
For further details, see the Air chapter.

2.3 Education and Research

According to Law 19.300, environmental education is an interdisciplinary process aimed at developing abilities and attitudes that will enable a harmonious coexistence between humans, their culture and their bio-physical surrounding. In this context, since 2003 the Ministry of the Environment, along with the Ministry of Education, CONAF and the UNESCO, implements the National Certification System for Educational Facilities (SNCAE by its acronym in Spanish).

The SNCAE is a volunteer program that all educational facilities in the country can apply for, as long as they are recognized by the Ministry of Education, if they offer pre-school, elementary or high school education. It also includes schools for special education and technical-professional high schools.

This system seeks to set up an environmental education standard and has three levels of certification (basic, medium and excellence), which verify the incorporation of environmental education. Certification in each level is achieved according to the percentage of compliance of the indicators established in a self-diagnosis environmental matrix.

Starting in 2011, the number of educational facilities with current certification has experienced a sustained increase, particularly the ratio of facilities at the excellence level. This reveals the work done by the education communities to make progress in incorporating environmental topics.

Figure 02 shows the increase of facilities at the excellence level, which went from 15 percent of certified facilities in 2011 to 33 percent of the total certified facilities in 2015.

With the 2015 process already ended, the National Certification System for Educational Facilities has 1,182 facilities with current environmental certification distributed throughout the country, as shown in **Figure 03**.

To learn more about the progress and background of the educational facilities undergoing a certification process, the information is available in the environmental education portal of the MMA. Likewise, the SNCAE has its own website (http://scp.mma.gob.cl/), where visitors can access the documents and actions that enabled the certification of each educational facility in the country.

SNCAE

Facilities at the excellence level of the total certified facilities in 2015

▲33%

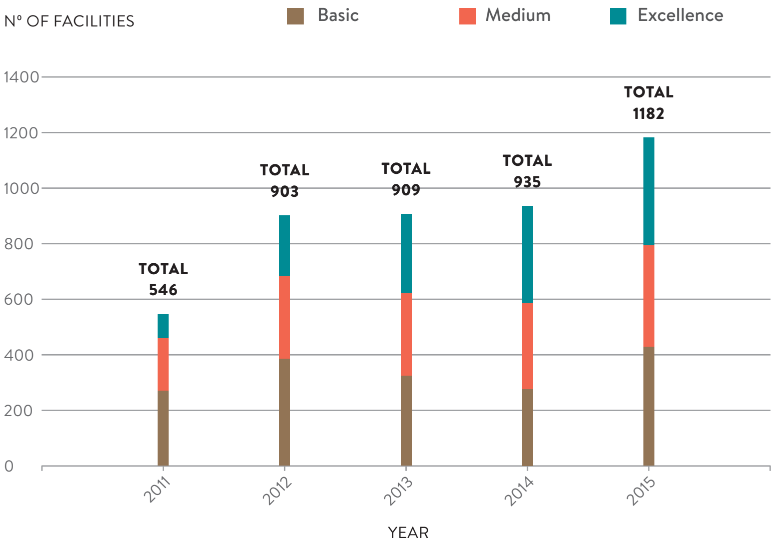
Facilities with current environmental certification, distributed throughout the country in 2015

1,182 **CERTIFIED**

Education | NICOLÁS LAGOS

FIGURE 02

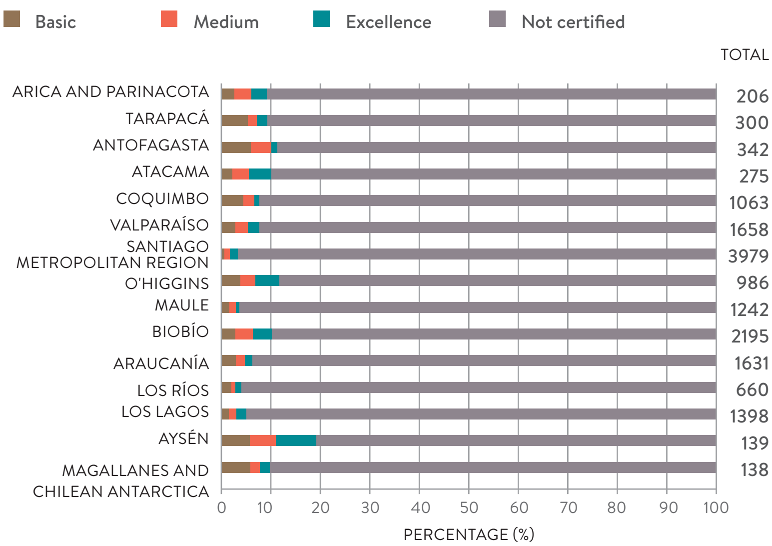
NUMBER OF FACILITIES WITH CURRENT CERTIFICATION
by year and level



Source: Department of Environmental Education of the MMA, 2016.

FIGURE 03

PERCENTAGE OF CERTIFIED FACILITIES
by type of certification, valid in 2015



Source: Department of Environmental Education of the MMA, 2016.

System of Environmental Certification of Municipalities

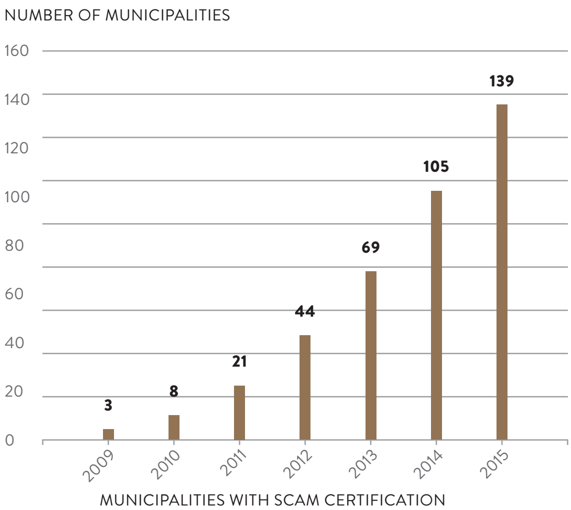
After the modification of Law 19.300, in 2010, local environmental management is part of the organizational structure of the Ministry of the Environment, strengthening the work carried out until then through the System of Environmental Certification of Municipalities (SCAM by its acronym in Spanish). This system, created in 2008, is a useful tool for supporting environmental education as well as for contributing to improve environmental management of municipalities.

It is worth pointing out that, also in 2008, a diagnosis was conducted to learn about the situation of municipalities in terms of environmental management. The diagnosis revealed that 37 percent of the 327 municipalities that participated in the study had a "unit in charge of environmental matters" (CONAMA 2008). In this context, it was necessary to strengthen the incorporation of the environmental dimension as part of the institutional organization and to build capacities to strengthen and promote local environmental management.

Although initially the SCAM began with only three municipalities, their participation has grown exponentially, reaching, by 2015, 156 municipalities at some stage or process within the system. As a result of these efforts, as shown in **Figure 04**, 139 municipalities have a valid environmental certification by 2015.

FIGURE 04

NUMBER OF MUNICIPALITIES WITH CURRENT CERTIFICATION PER YEAR



Source: Department of Local Environmental Management of the MMA, 2016.

02

CERTIFICATION PROCESS AND STAGES

The SCAM is made up of three levels: Basic (6 months); Intermediate (11 months) and Excellence (11 months). These three levels are stages of the certification procedures so that municipalities can achieve the necessary capacities for local management in accordance to the country's institutional framework and international expectations.

Basic Certification Level

- Municipal and communal environmental diagnosis
- Environmental strategy
- Municipal and Communal Environmental Committee
- Annual agreement

Intermediate Certification Level

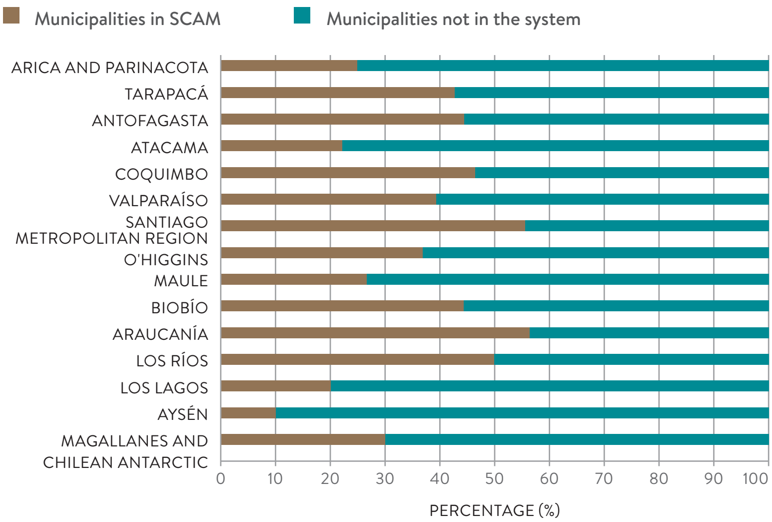
- Execution of the lines established in the previous process
- Design of plans and execution of pilot projects in areas such as waste and water and energy efficiency
- Staff training

Excellence Certification Level

- Execution of the plans and/or projects prepared during the previous stage
- Consolidation of the operations of the Municipal and Communal Environmental Committee
- Adequate operation of the recycling and water and energy saving systems. The municipality must have an approved, in force and operational municipal ordinance and an environmental participation system, as well as a commitment for auditing to maintain its certification level.

FIGURE 05

PERCENTAGE OF MUNICIPALITIES WITH ENVIRONMENTAL CERTIFICATION
at the regional level by 2015



Source: Department of Local Environmental Management of the MMA, 2016.

Diagnosis of Local Environmental Management

The 2010 reform to the environmental institutional framework demands new obligations for municipalities. The main ones include the creation of a Department of Environment, Hygiene and Decoration, the preparation of a draft bill for an environmental ordinance, the ruling within the Environmental Impact Assessment System, the collection of reports of non-compliance with environmental standards and the collaboration in education and citizen engagement matters.

In this context, and given that the country's environmental management requires collaboration from the local institutions, in 2014 the Ministry of the Environment developed a project aimed at learning about the degree of progress in local environmental management and strengthening staff capacities to support and improve the collection of local environmental information[3].

The diagnosis was based on a survey that had already been administered in 2008. Some questions were improved and new ones were included. The instrument was administered at the national level and the response rate reached 90 percent (MMA, 2016).

One of the main results of the study is that 70 percent of surveyed municipalities has an environmental unit or someone in charge of environmental matters, which represents significant progress in comparison to 2008, when this was true for only 37 percent of the municipalities (CONAMA, 2008).

Regarding the generation of environmental information, the majority of the municipalities does not have environmental indicators. The indicators mostly used are the ones dealing with energy consumption within the municipality (28 percent), the generation of municipal waste (28 percent), and the consumption of water and animal control (26 percent). On the other hand, the least used indicators are the carbon footprint (2 percent), the rate of composting (6 percent) and the per capita environmental budget (8 percent) (MMA, 2016).

[3] The project was commissioned to and executed by the Center for Public Policies of the Catholic University of Chile.

Environmental Protection Fund

The Environmental Protection Fund (FPA by its acronym in Spanish), managed by the Ministry of the Environment through a public competition, supports and funds projects or activities aimed at protecting or restoring the environment, promoting sustainable development, preserving nature, and conserving environmental heritage (Law 19.300, Article 66).

The competition is open to individuals or public or private legal entities, such as neighborhood boards, sports clubs, parent centers, cultural and environmental organizations, indigenous communities and associations, non-governmental organizations, research centers and universities.

After 19 years of implementation, the FPA has funded over 2,600 projects, with an investment of more than CLP $13,000 million that has benefited communities throughout the country.

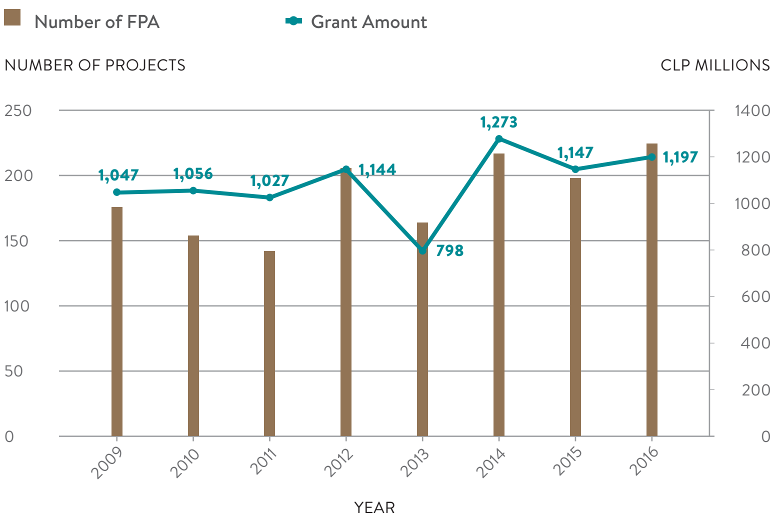
During the 2016 competition, 225 initiatives were approved, representing a 22 percent increase in comparison to 2015 and an investment that exceeds CLP $1,197 million.

The competitions for 2016 focused on Local Environmental Management and Indigenous Environmental Protection and Management. The Local Environmental Management competition is divided into more specific topics such as waste management and recovery of areas, climate change and environmental decontamination, biodiversity conservation, energy efficiency and non-conventional renewable energies and territorial environmental equity (targeted PRAS territories Huasco, Puchuncaví–Quintero and Coronel).

Figure 06 shows the number of approved projects and the corresponding amounts, from 2009 until 2016.

FIGURE 06

NUMBER OF ENVIRONMENTAL PROTECTION FUND (FPA BY ITS ACRONYM IN SPANISH) PROJECTS AND GRANT AMOUNT



Source: Department of Environmental Protection Fund of the MMA, 2016.

2.4 Environmental Impact Assessment System

The Environmental Impact Assessment System (SEIA by its acronym in Spanish), in force since 1997, is one of the country's main tools to prevent environmental degradation. This tool seeks to integrate the environmental variable into the design and execution of productive projects and activities carried out in Chile. Thus, through an Environmental Impact Declaration (DIA by its acronym in Spanish) or an Environmental Impact Study (EIA by its acronym in Spanish)[4], the aim is to assess that those activities comply with current environmental regulations.

The SEIA is managed by the Environmental Assessment Service (SEA by its acronym in Spanish). This service also coordinates the State agencies involved in the assessment process, in order to obtain permits or rulings.

Although Article 10 of Law 19.300 defines the projects that must be submitted to the Environmental Impact Assessment System, it is also possible to submit them voluntarily.

Citizen engagement is a significant part of the environmental assessment process, along with the participation of the competent agencies and local governments.

The Regulations for the SEA[5] establish the mechanisms, timeframes and implementation for citizen engagement, depending on whether it is an Environmental Impact Study or Declaration. For either case, Law 19.300 establishes that any interested individual may have access to the content of the project undergoing the assessment, except for any information of a confidential nature.

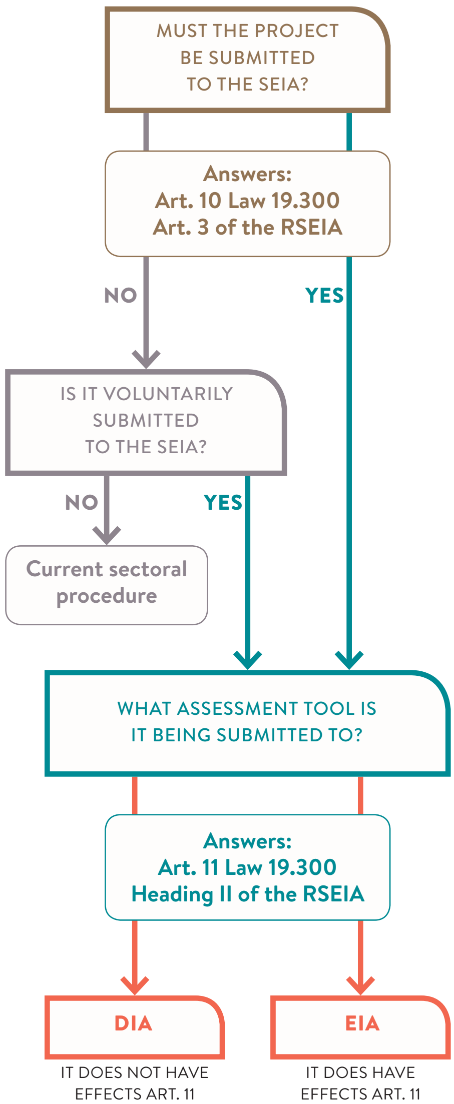
Definitions According to Law 19.300

Environmental Impact: Disturbance of the environment caused directly or indirectly by a project or activity in a specific area.

Environmental Impact Declaration (DIA by its acronym in Spanish): Document that describes an intended activity or project, or the changes that will be made to it, submitted under oath by the corresponding owner, whose content allows the competent institution to assess whether its environmental impact complies with the current environmental legislation.

Environmental Impact Study (EIA by its acronym in Spanish): Document that describes in detail the characteristics of an intended project or activity or its changes. It must provide justified background information in order to predict, identify and interpret its environmental impact and describe the action or actions that will be executed to prevent or minimize its significantly adverse effects.

ASSESSMENT TOOLS (DIA/EIA)



Source: Environmental Assessment Service, 2016.

[4] *Article 10 lists which activities must undergo an environmental impact assessment. Likewise, Article 11 of Law 19.300 establishes the effects, characteristics or circumstances that define whether a project or activity must submit an environmental impact study.*

[5] *The Regulations for the SEIA are available in Spanish in the following link: http://www.sea.gob.cl/sites/default/files/migration_ files/dto-40_12-ago-2013.pdf*

TABLE 03

DIFFERENCES IN THE ASSESSMENT PROCEDURES BETWEEN A DIA AND AN EIA		
MATTER	DIA	EIA
Assessment Deadline	60 days	120 days
Deadline Extension	30 days	60 days
Citizen Engagement	Only if the project generates environmental burdens and citizen engagement is requested.	Always
Indigenous Consultation	Not applicable	Applicable whenever there is a significant impact on indigenous peoples[6]
Complaint Appeal	To the Executive Director of the SEA	To the Ministerial Committee

Source: Environmental Assessment Service, 2016.

[6]*The significant impacts are established in the Regulations for the SEIA.*

03

PRESIDENTIAL ADVISORY COMMISSION FOR THE REFORM OF THE ENVIRONMENTAL IMPACT ASSESSMENT SYSTEM

After 18 years of operations of the SEIA, and in response to the greater demands and challenges faced by the country in environmental issues, President Michelle Bachelet created the Presidential Advisory Commission for the Reform of the Environmental Impact Assessment System, whose objectives were to strengthen the authority of the Environmental Assessment Service (SEA by its acronym in Spanish), to contribute to improving the social legitimacy of projects and to assess and improve the system's legal framework. All of this was done with the aim of adjusting the system to the changes experienced by the country as a result of economic growth, sociocultural changes, new international demands and commitments, and the objective of achieving sustainable development.

The final report of the commission, submitted to President Bachelet in July 2016, contains 25 proposals and recommendations, which include topics associated with the submission criteria and evaluation tools, the procedures and contents of the assessment, the participation of public agencies with competence on environmental matters, environmental permits, citizen engagement, public consultation and the tools linked to the Environmental Qualification Resolution (RCA by its acronym in Spanish).

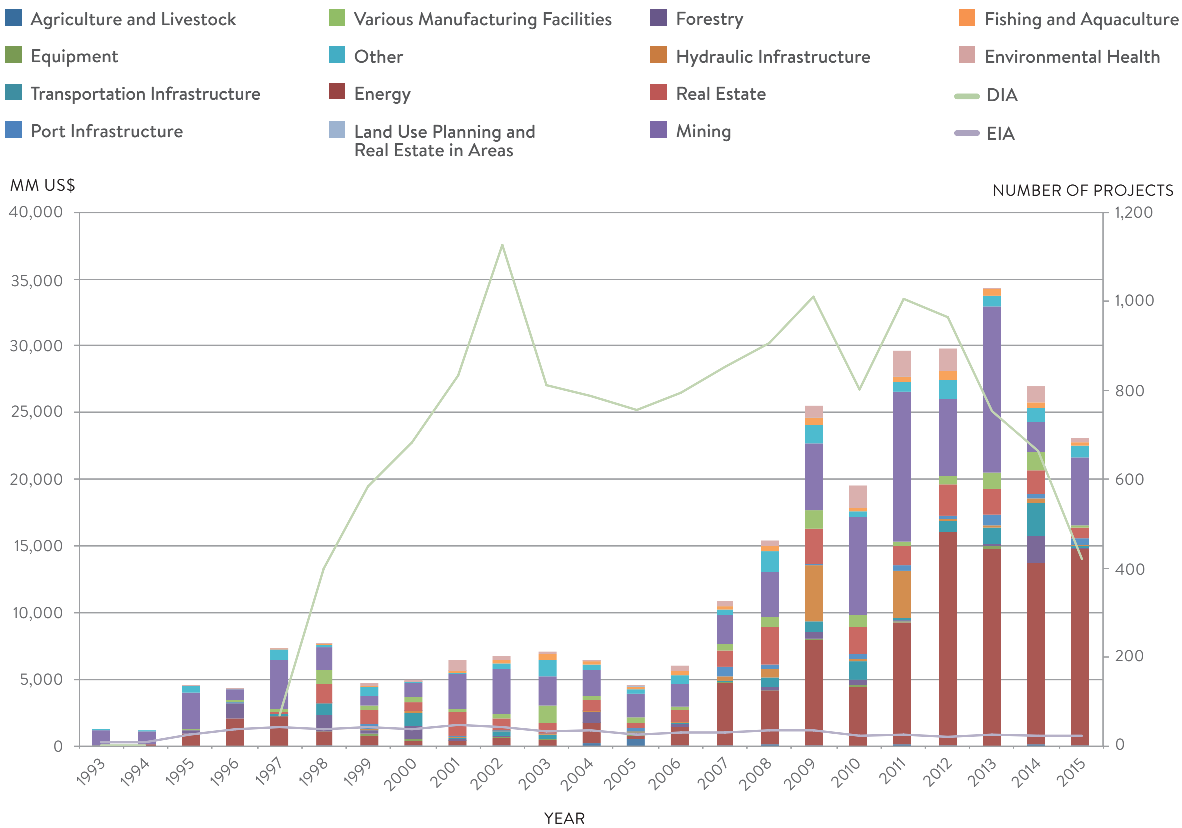
The proposals include the creation of an assessment mechanism for strategic projects, that seeks to address more effectively the assessment of projects whose impacts may bring about significant changes to the territories.

Likewise, they propose an early engagement process, prior to the submission of the project to the SEIA, in order to create dialogue and reach an understanding between the owners and the communities. The intention of this phase is for the parties to get to know each other and make their stances transparent, in order to contribute to improving information asymmetries. This procedure would be voluntary, but once it has been accepted by the owner, its execution will be mandatory.

Between 1997 and 2015, 620 Environmental Impact Studies and over 14,000 Environmental Impact Declarations have been approved, representing an investment amount of approximately USD $290,000 million.

FIGURE 07

AMOUNT OF EXPECTED INVESTMENT IN PROJECTS APPROVED THROUGH THE SEIA
and number of projects by sector

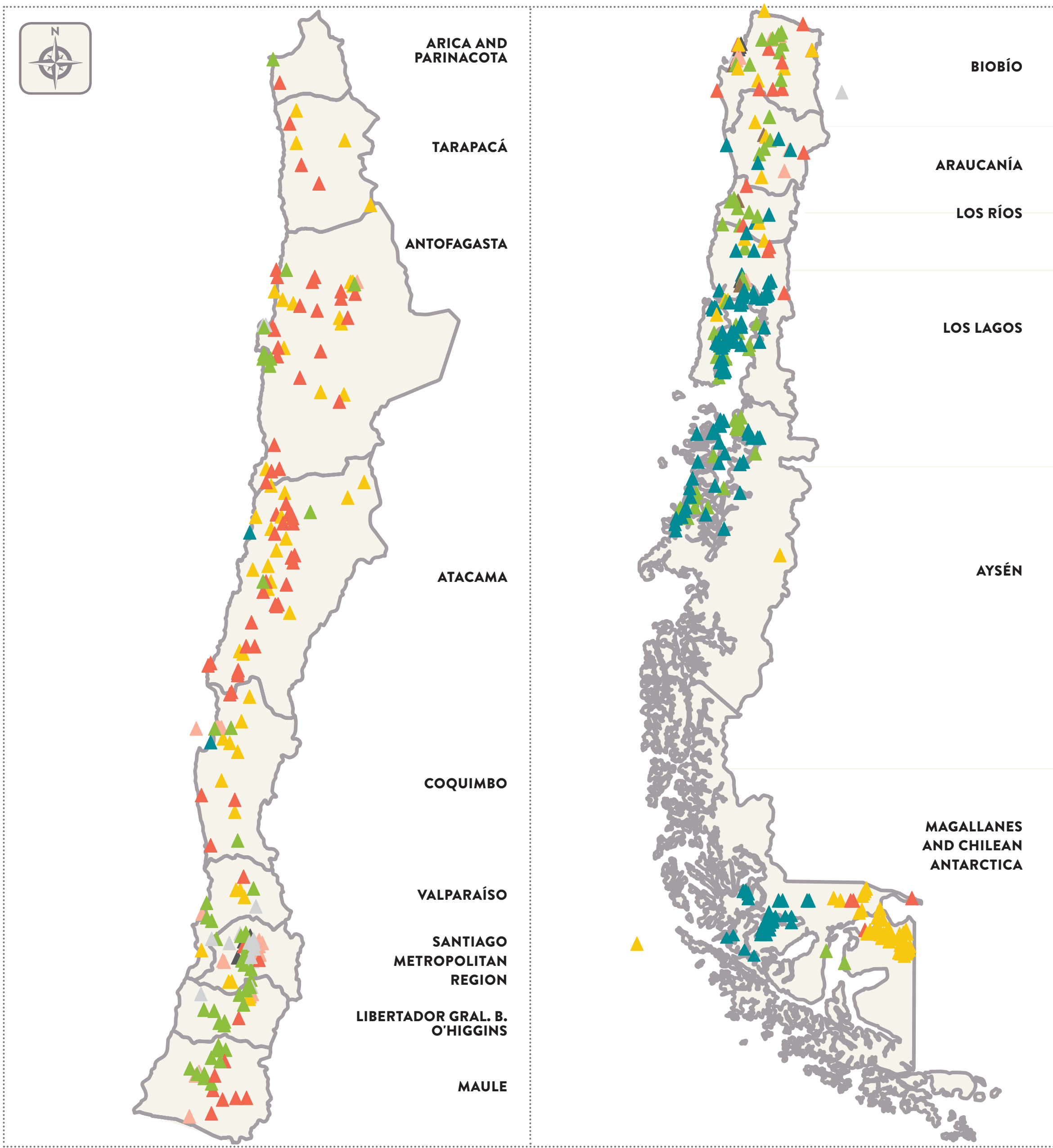


Source: Environmental Assessment Service, 2016.

Los Lagos Region | SOLEDAD GAJARDO

MAP 01

DISTRIBUTION OF PROJECTS APPROVED IN 2015



APPROVED PROJECTS

- Energy
- Forestry
- Fishing and Aquaculture
- Transportation Infrastructure
- Various Manufacturing Facilities
- Mining
- Environmental Health
- Real Estate

Source: Environmental Assessment Service, 2016.

2.5 Citizen Engagement

Citizen engagement is considered a core element of environmental management. Law 19.300 establishes it as an essential component of Environmental Impact Assessment and, since 2011, with the enactment of Law 20.500 on Citizen Associations and Participation in Public Management, all public agencies must incorporate public engagement into their work. In this context, the mechanisms and opportunities available until then have been expanded to include citizens in public management.

Since 2011, the Ministry of the Environment has a General Standard for Citizen Engagement (Exempt Resolution N° 962/2011), which was updated in 2015 by Exempt Resolution N° 601/2015, which includes new mechanisms and acknowledges others already in existence, such as public hearings, citizen meetings, participative dialogues, committees, public-private gatherings or working groups, as well as the creation of the MMA's Participation Committee and the Early Citizen Engagement Program.

The standard defines that citizen engagement is a right that can be demanded and that the ministry must safeguard, while at the same time it is a civic responsibility of individuals. Likewise, it establishes that, in order to achieve citizen inclusion, actions are required based on the rights approach.

Other citizen engagement mechanisms already in existence are access to environmental information, citizen consultations, civil society councils and participative public reports (**Table 04**).

Citizen consultation has been the most broadly used mechanism in environmental management, since it has been part of the processes for passing standards and plans, as well as of environmental impact assessments, since the environmental institutional framework was created. However, new methodologies have gradually been incorporated, such as dialogues and town meetings, and enabled motivating the interest and participation of more people throughout the country.

Regarding the Environmental Impact Assessment System (SEIA by its acronym in Spanish), both Law 19.300 and the Regulations for the SEIA establish citizen engagement as part of the assessment process. According to the Regulations, citizen engagement encompasses the rights to access and have knowledge of the physical or digital file of the assessment, make observations and obtaining justified responses to them.

In the case of Environmental Impact Assessments (EIA by their acronym in Spanish), the law establishes that the owner of the project must publish a summary of the EIA in the Official Gazette and in a regional- or national-circulation daily, whichever applies. In addition, individuals or legal entities may obtain information of the content of the EIA, except for the background information related to intentions or procedures that can be patented. Individuals or legal entities may make observations to the EIA within a 60-day deadline starting from the date on which the summary was published.

Regarding Environmental Impact Declarations (DIA by their acronym in Spanish), the Environmental Assessment Service must publish a monthly list of declarations submitted for processing. Interested parties may access the content of the DIA. The regional offices or the executive director of the SEA, as applicable, may decide to carry out a citizen engagement process for a 20-day timeframe, for projects or activities that generate environmental burdens for the communities located in the area where the project's environmental impacts will occur.

The observations must be considered in the project's assessment process. If the observations are not adequately weighted, whomever submitted them may file a complaint to the higher authority within a 30-day deadline and this authority must rule on the complaint within the 60 days following its submission.

TABLE 04

CITIZEN ENGAGEMENT MECHANISMS IMPLEMENTED IN ENVIRONMENTAL MATTERS	
MECHANISM	**TOOL**
Public Consultations	Processes for passing Quality and Emission Standards.
	Procedures and stages for passing Prevention and Decontamination Plans.
	Process for classifying species according to their conservation status.
	Other processes of a voluntary nature.
	Of the Ministry of the Environment and Regional Consulting Councils of the MMA.
Consulting Councils	Carried out at the central and regional levels.
Public Report	Presidential Advisory Commission for the Environmental Impact Assessment System.
Citizen Meetings	In-person attendance.
Access to Environmental Information	Websites.
	Conferences.
	Seminars.
	Dissemination materials.

Source: Authors' own elaboration.

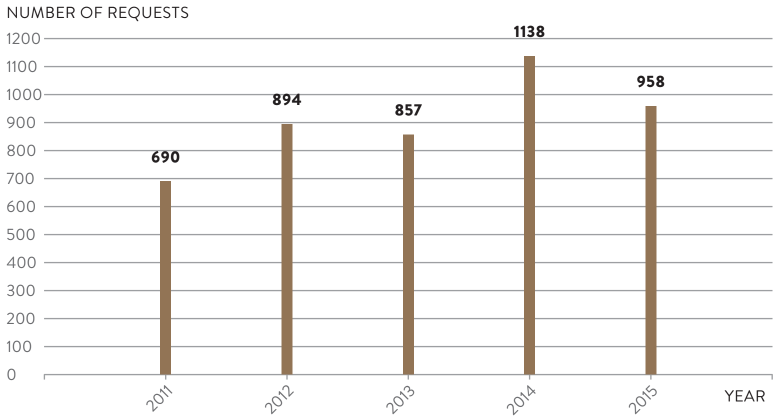
Citizen engagement | MMA

2.6 Access to Environmental Information

Since the reform of Law 19.300, in 2010, access to environmental information is an environmental management tool as well as a right. Access to information is defined as the capacity of citizens to obtain environmental information held by public authorities. Said access is obtained through the public mechanisms that institutions use for making information available, either in a proactive manner or at the demand or request for information to the institution.

FIGURE 08

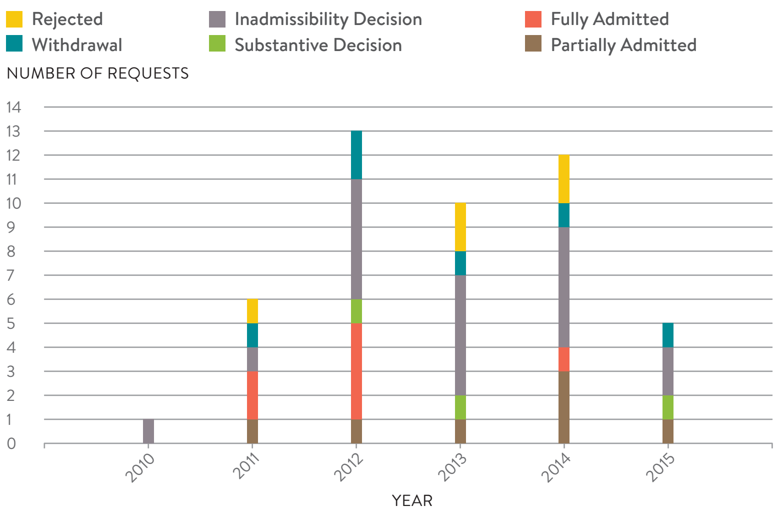
NUMBER OF REQUESTS TO ACCESS PUBLIC INFORMATION ON ENVIRONMENTAL TOPICS, BY YEAR



Source: Citizen Service and Archive Office, MMA, 2015.

FIGURE 09

NUMBER OF REDRESS COMPLAINTS[7] FILED TO THE COUNCIL FOR TRANSPARENCY REGARDING ENVIRONMENTAL TOPICS



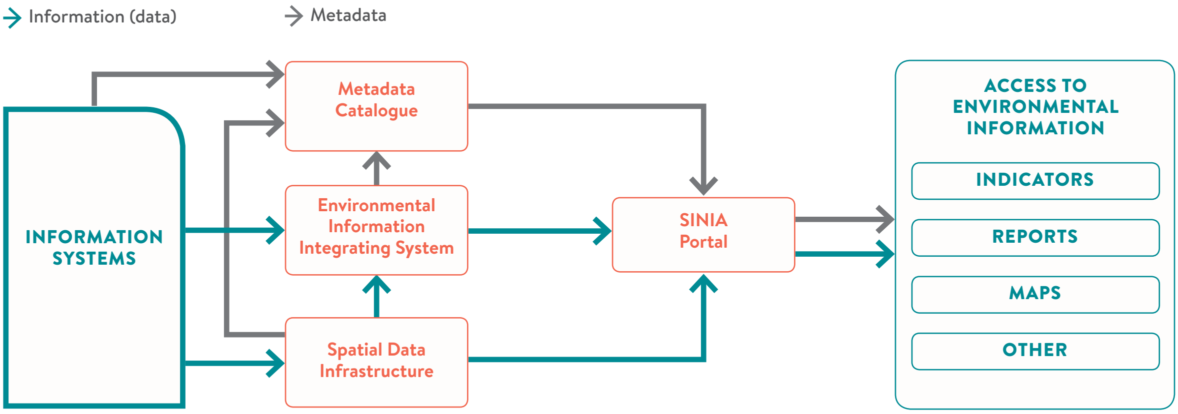
Source: Citizen Service and Archive Office, MMA, 2015.

[7]A redress complaint is filed when the requesting party considers that he or she has been denied access to public information by a State agency.

The National Environmental Information System (SINIA by its acronym in Spanish), managed by the Ministry of the Environment, is one of the main mechanisms for making environmental information available in a timely manner, with the possibility of it being accessed and downloaded by anyone interested in it. To that end, the system integrates several components that allow inputting and obtaining information, such as documents as well as georeferences or statistics (**Figure 10**).

FIGURE 10

STRUCTURE OF THE SINIA



Source: Department of Environmental Information, MMA, 2016.

Likewise, this State of the Environment Report (IEMA by its acronym in Spanish), along with the Annual State of the Environment Reports (REMA by their acronym in Spanish) allow bringing environmental information closer to the people and maintain updated indicators that enable monitoring the environmental situation in the country.

2.7 Strategic Environmental Assessment

Strategic Environmental Assessment (EAE by its acronym in Spanish) is a new environmental management tool, as established by the 2010 modification of Law 19.300, and its aim is to incorporate environmental considerations into strategic decision-making processes, such as policies, plans and land use instruments, under a sustainability approach.

Starting on November 4, 2015, when its Regulation entered into force, the EAE is a formal and regulated process in terms of procedures and deadlines.

According to Law 19.300, "policies and plans of a general regulatory nature will be submitted to the EAE, as well as their substantial modifications, with significant consequences on the environment or sustainability, by decision of the President of the Republic in response to proposals made by the Council of Ministers for Sustainability." Likewise, master plans, urban development plans, shoreline zoning, regional land use plans and integrated watershed management plans must always be submitted to the EAE.

By 2015, 278 planning instruments have been prepared with the EAE. Of these, a total of 116 instruments have already finalized their assessment process and 162 are being developed.

The results achieved with the application of the EAE enable identifying relevant environmental aspects for the harmonious coexistence between different activities carried out in the territory, as well as identifying the conditions for a more sustainable development.

One of the outstanding examples in terms of the design of policies that incorporate environmental considerations was the country's Energy Policy for 2050, which was submitted to the EAE by initiative of the Ministry of Energy. This process took place in 2015 and was successfully completed, since the result was a policy with high participation and consensus and designed with sustainability criteria.

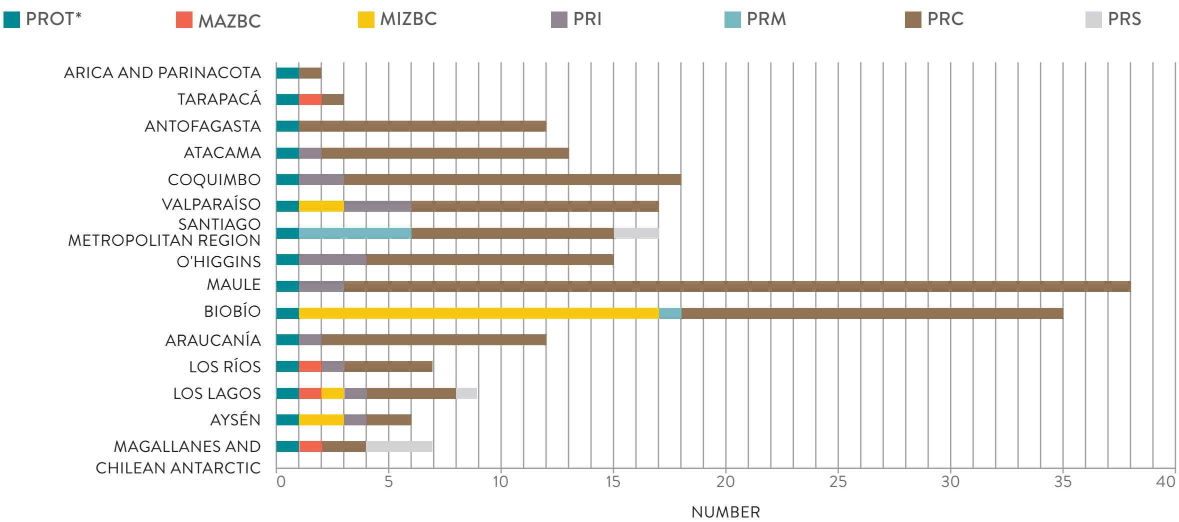
In order to support the application of the EAE, the Ministry of the Environment prepared the Guidelines for Using the Strategic Environmental Assessment in Chile, which can be downloaded from the website of the Ministry of the Environment.

The benefits of implementing a Strategic Environmental Assessment include the following:

- It enables designing and generating conditions for more sustainable decisions, from the perspective of an integrated, participative and early analysis.
- It supports the incorporation of dimensions such as air pollution, noise levels, climate change adaptation measures, natural surroundings, waste management and disaster risk.
- It contributes to the challenge of ensuring that different land use planning instruments and public policies are cohesive and complementary to other tools such as decontamination plans, plans to recover degraded areas or the Climate Change Action Plan, as well as all other sectoral plans that deal with environmental matters.

FIGURE 11

NUMBER AND TYPE OF PROJECTS SUBMITTED TO STRATEGIC ENVIRONMENTAL EVALUATION BY 2015



*PROT: Regional Plan for Land-Use Planning
*MAZBC: Shoreline Macrozoning
*MIZBC: Shoreline Microzoning
*PRI: Inter-commune Master Plan
*PRM: Metropolitan Master Plan
*PRC: Commune Master Plan
*PRS: Sectional Master Plan

Source: Office for Strategic Environmental Assessment, MMA, 2016.

3• ECONOMIC INSTRUMENTS

Economic instruments for environmental management are economic actions or measures carried out by the authority to motivate behaviors in society that favor environmental objectives. Although environmental management in Chile has essentially operated with regulatory tools, Law 19.300 mentions these types of instruments as part of the prevention and decontamination plans (Art. 45).

In this context, the tax reform passed in 2014 (Law 20.780), for the first time explicitly includes environmental taxes that apply for emissions into the atmosphere from stationary sources of sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM) and carbon dioxide (CO_2). This tax will start to be implemented starting on January 1, 2017. The reform also includes taxes to the first sale of light vehicles based on the potential NOx emissions, in force since December 29, 2014.

On the other hand, on May 17, 2016 President Michelle Bachelet passed the Framework Law for Waste Management, Extended Producer Responsibility and Promotion of Recycling, which seeks to contribute to reducing waste by promoting its reuse and recycling, with incentives for their valuation.

Likewise, the country has initiated the implementation of other economic instruments such as subsidies in the implementation of measures in decontamination plans, particularly regarding air.

3.1 Environmental Taxes

Environmental taxes, or Pigovian taxes, are environmental management tools that modify price signals in order to motivate a socially efficient behavior of economic agents (Pigou, 1947).

Although the production of goods (i.e. electricity) creates externalities, it also generates social benefits such as employment and income, among others. Consequently, the aim is not to eliminate the activity, but to achieve a social balance. Indeed, taxes contribute to that.

In the Chilean case, Law 20.780 sets a USD $5.00 tax per tonne of CO_2. This tax is consistent with international commitments and global trends. Regarding local pollutants (PM, NOx and SO_2), the design of the tax estimates the social cost based on the difference in the carrying capacity of ecosystems and the exposed population, which makes this a pioneer instrument in this matter. The latter is translated into a tax per tonne that varies according to the pollutant and the commune.

In terms of stationary sources, the tax is applied to facilities whose sources are made up of boilers and turbines which, together, represent a thermal power greater or equal to 50 MWt (thermal megawatts).

In the case of the tax to automobiles, the tax is applied to the sale of vehicles according to their urban performance and NOx emissions (work vehicles are excluded). Its aim is to decentivize the use of less efficient vehicles and internalize the social cost of NOx emissions, given that mobile sources emit nearly 30 percent of the national total of this pollutant.

The establishment of taxes will complement the environmental management tools proposed and executed by the Ministry of the Environment. Taxes to stationary sources will complement the Recovery Programs for Environmentally Vulnerable Territories in the communes of Puchuncaví, Quintero, Coronel and Huasco, which have sources subject to the tax, as well as the ongoing decontamination plans in the communes of Tocopilla, Rancagua, Codegua, Graneros, San Vicente, Mostazal and Renca, where there are sources subject to the tax. These taxes will also complement the updating of the Air Decontamination Plan of the Santiago Metropolitan Region and the Decontamination Plan for the city of Valdivia.

TABLE 05

TAX COLLECTION FROM VEHICLES, 2015

MONTH	MONTHLY COLLECTION (CLP)	OBSERVED DOLLAR (PESOS PER DOLLAR)*	TOTAL USD
January	1,308,021,817	620.91	**2,106,621**
February	1,971,128,959	623.62	**3,160,785**
March	2,442,828,311	628.5	**3,886,759**
April	2,683,339,136	614.73	**4,365,069**
May	2,619,450,753	607.6	**4,311,143**
June	2,837,019,480	629.99	**4,503,277**
July	2,900,782,599	650.14	**4,461,781**
August	2,896,838,190	688.12	**4,209,786**
September	4,501,854,543	691.73	**6,508,109**
October	1,960,196,605	685.31	**2,860,306**
November	4,390,610,796	704	**6,236,663**
December	2,423,515,518	704.24	**3,441,320**
Annual	32,935,586,707	-	**50,051,623**

Source: General Treasury of the Republic.

** Monthly observed dollar according to the Central Bank, accessed March 23, 2016.*

3.2 Santiago and Metropolitan Region Compensations System

Environmental compensation measures are an alternative mechanism to an adverse effect that cannot be mitigated or repaired. Such measures include the replacement of natural resources or environmental elements affected by others of similar characteristics, class, nature, quality and function. Within the framework of the review of the Air Prevention and Decontamination Plan (PDDA by its acronym in Spanish) (Supreme Decree 66/2009 of the Ministry General Secretariat of the Presidency) created an emissions compensation system. New projects and activities and their modifications, which enter the area regulated by the PDDA at any stage and involve an increase of the baseline emissions situation, exceeding the values presented in the following **Table**, must compensate their emissions by 150 percent.

TABLE 06

PERMISSIBLE LIMITS ACCORDING TO ARTICLE 98 OF SUPREME DECREE N°66/2009	
POLLUTANT	**MAXIMUM EMISSION (TONNE/YEAR)**
PM_{10}	2.5
NOx	8
SOx	50

Emissions Compensation Programs (PCE by their acronym in Spanish) are evaluated by the Regional Secretariat of the Ministry of the Environment for the Santiago Metropolitan Region. The values to be compensated, as well as the deadlines for submitting such programs, are established in the Environmental Qualification Resolution (RCA by its acronym in Spanish) that results from the submission of a project or activity to the Environmental Impact Assessment System and they are 60 days for PM_{10} and 90 days for NOx, respectively.

Compensation Criteria

The compensation measure is chosen by the owner of the project and the geographical area for this instrument in the entire Santiago Metropolitan Region. In order for the measure to be accepted, it must comply with several criteria:

1. **Comparable:** Emissions to be compensated must be comparable in terms of composition and granulometry characteristics.
2. **Realistic:** That it entails an effective reduction of emissions.
3. **Quantifiable:** That there is a method that will enable measuring such reductions.
4. **Additional:** That the measure proposed by the owner does not respond to other obligations, or that it is not an action that must be carried out any way.
5. **Permanent:** That the reduction remains for the period that the project is forced to reduce emissions.
6. **Demandable:** The commitments made by the owner must be formally signed.

Compensation Alternatives

The commonly presented compensation alternatives are:

- Scrapping by retiring vehicles (to compensate PM_{10} from combustion, NOx and SOx).
- Buying emissions from stationary sources.
- Paving of roads.
- Creation and maintenance of green areas.
- Conservation and recovery of natural areas.

Between 2012 and April 2015, 86 PCE were submitted, of which 67 were approved. The typology of projects that has been most broadly used to compensate for PM_{10} is paving (66 percent), followed by forestation or maintenance of green areas (18 percent).

3.3 Subsidies for Housing Thermal Refurbishment

In 2009, a thermal subsidy was created (modification of Supreme Decree 255 of the Ministry of Housing and Urban Planning). The aim of this subsidy is to support the most vulnerable families in the thermal refurbishment of their homes and also so that beneficiary families may save money on heating, increase their comfort and eliminate risk due to interior humidity and condensation problems.

Initially, this subsidy benefitted housing located between the O'Higgins and Magallanes and Chilean Antarctic regions. Starting in 2014, its coverage was expanded to include housing located between the Coquimbo and Magallanes and Chilean Antarctic regions.

The subsidy includes providing between 100 and 130 Development Units[8] (UF by their acronym in Spanish), according to the location of the housing. It is estimated that approximately 1 million UF (USD $35 million) are provided in subsidies each year at the national level.

This subsidy has a social and an environmental objective. Along with improving the quality of life of benefited families, it is estimated that greater thermal refurbishment will reduce the demand for fuel for heating by up to 30 percent (MINVU, 2016). Thus, this subsidy is in line with the 2020 National Energy Efficiency Plan and it complements the measures and objectives of the air decontamination plans.

Between 2008 and 2014, 48,762 subsidies have been provided, representing an investment of 5,457,303 UF (**Figure 12**).

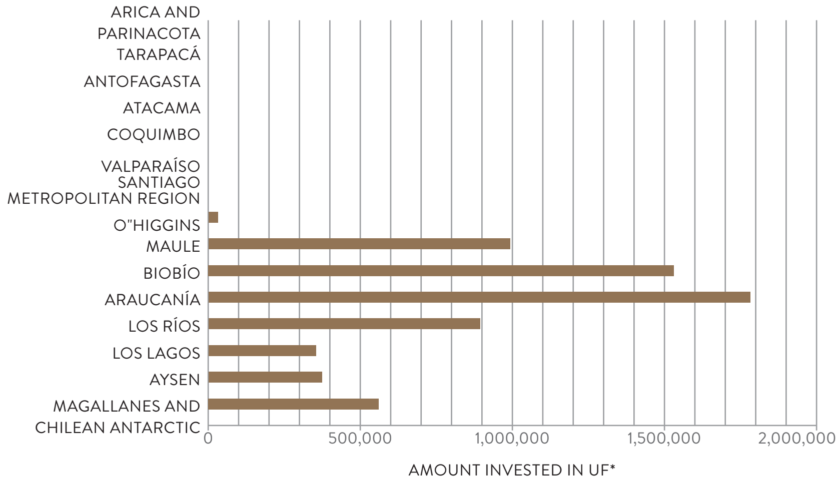
Another measure with environmental impact is the setup of solar collectors (Solar Thermal Systems). They are systems to save on heating of drinkable tap water. These were boosted by Law 20.365, which creates a tax exemption for construction companies that install these systems in new housing. In addition, said law included installing 1,500 collectors in already existing housing, which was implemented through the Household Wealth Protection Program (PPPF by its acronym in Spanish) between 2011 and 2012. Afterwards, the Ministry of Housing and Urban Planning continued to install them with its own funds. By October 2015, 13,364 collectors have been installed at the national level, representing an investment of 785,772 UF (USD $28 million) (**Figure 13**).

[8] *Accounting unit used in Chile, which is adjusted according to the Consumer Price Index.*

Coyhaique | KARINA BAHAMONDE

FIGURE 12

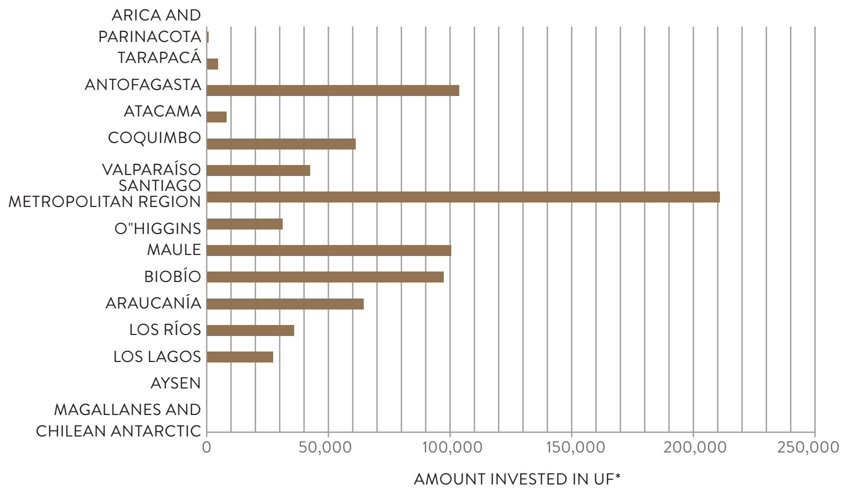
AMOUNT OF SUBSIDIES GRANTED FOR HOUSING THERMAL REFURBISHMENT BETWEEN 2008 AND 2014



Source: MINVU, 2015.

FIGURE 13

AMOUNT OF INVESTMENT IN SOLAR THERMAL COLLECTORS BETWEEN 2011 AND 2015



Source: MINVU, 2015.

** Data up to October 2015*

3.4 Environmental and Social Recovery Program

The Environmental and Social Recovery Programs (PRAS by their acronym in Spanish) aim at achieving environmental equity, which is one of the axes that guides the current environmental management. These programs seek to improve the quality of life of the population living in territories that have experienced significant environmental burden throughout the years. This is done by means of structural solutions intended to transform these territories into vigorous and modern areas in the medium and long terms, enabling to show that a sustainable coexistence is possible between industrial activities, environmental care and quality of life.

These programs consist of an integrated and multisectoral intervention led by the Under Secretariat of the Environment, with participation of other State agencies, the productive sector and, essentially, citizens.

The starting point of the program is the dialogue among different stakeholders in order to define the mechanisms that will enable to ensure citizens of the territories that they will live in an environment free of pollution and, at the same time, establish the priorities for environmental and social recovery, as well as the gradualism of their implementation.

To attain these objectives, it includes the creation of a Council for Environmental and Social Recovery (CRAS by its acronym in Spanish) for each territory, to be made up of State agencies, civil society and the business sector. Its aim is to contribute to the participative preparation process of the program, during its design, validation and follow up stages.

The main characteristics of the territories where the PRAS are being implemented are detailed below.

Territories

HUASCO

Location: Northern Chile, Atacama Region. **Area:** 1,601.4 km^2. **Population:** 7,945 inhabitants. The agreement aimed at creating the Council for Environmental and Social Recovery of the Huasco commune was signed on July 10, 2015 by 24 Council members and it has been formalized by Resolution N°773, dated August 5, 2015. It is made up of nine civil society representatives, corresponding to 37.5 percent; nine public sector representatives, corresponding to 37.5 percent; and six company representatives, corresponding to 25 percent of council members.

WORK METHODOLOGY OF THE PRAS

ACTIVITY 1:
DEFINITION / SHARED DIAGNOSIS

- Desired shared state
- Identifying gaps
- Identifying obstacles
- Identifying responsible and related stakeholders
- Evaluation of the status of the investment portfolio

ACTIVITY 2:
DESIGN AND IDENTIFICATION OF SOLUTION OPTIONS

- Exploring and identifying solutions
- Assessing feasibility based on the priorities of the shared evaluation
- Identifying information gaps
- Observations, suggestions and validation by the CRAS
- Preparation of the draft bill for the PRAS

ACTIVITY 3:
CITIZEN CONSULTATION

- Citizen consultation of the draft bill for PRAS, through an in-person workshop and a website

ACTIVITY 4:
PREPARATION OF THE DEFINITIVE PRAS

- Revision and adjustment of initiatives and projects based on citizen suggestions and observations
- Observations, suggestions and validation by the CRAS
- Final PRAS

Source: Office for Risk and Environmental Assessment.

QUINTERO-PUCHUNCAVÍ

Location: Central Chile, Valparaíso Region. **Area:** 301 km^2 in Puchuncaví + 148 km^2 in Quintero. **Population:** 12,956 inhabitants. It has a CRAS made up of 19 civil society representatives, corresponding to 73.1 percent; four public sector representatives, corresponding to 15.4 percent; and three industrial sector representatives, corresponding to 11.5 percent of council members. The agreement was approved by Resolution N° 890, dated August 19, 2015.

CORONEL

Location: Southern Chile, BIOBÍO Region. **Area:** 279 km^2. **Population:** 108,855 inhabitants. The CRAS agreement for Coronel is signed by 41 Council members and it was approved by Resolution N°1484, dated December 31, 2015. This Council is made up of 15 civil society and productive sector representatives, corresponding to 36.6 percent; 14 business productive sector representatives, corresponding to 34.1 percent; and 12 public sector representatives, corresponding to 29.3 percent of council members.

3.5 Law to Promote Recycling and Extended Producer Responsibility (EPR)

Extended Producer Responsibility (EPR) is an economic instrument originating in Europe that extends responsibility to producers for generated waste after the useful life of a product has come to an end. The OECD defines EPR as a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products.

Chile incorporated this concept into waste management and since 2016 has a law regulating it, Law 20.920. According to this legislation, producers of goods defined as priority (see chapter on Waste), will be in charge of managing and funding initiatives to reduce, reuse and value generated waste once the useful life of their products has ended.

Among other matters, the law establishes goals for collection and valuation, which will be set by the Ministry of the Environment according to the list of priority products. Thus, the law seeks two main objectives: On the one hand, it promotes the design of products with an increased useful life and potential for valuation and, on the other hand, it motivates reusing and valuing products once their useful life has come to an end. This enables internalizing the environmental externalities inherent to waste (soil and water pollution, foul smells, emissions, vectors), reducing final waste disposal, thus increasing the useful life of sanitary landfills, and formalizing the current recycling market in the country.

These types of instruments have an additional advantage as they contribute to creating green jobs, thus boosting the sustainable growth and development of the country.

It is worth pointing out that the development and implementation of this instrument is in line with the recommendations made in 2005 by the Organisation for Economic Co-operation and Development (OECD) regarding waste management. Likewise, the trend of the OECD countries is to broaden this approach (EPR) towards other goods, adjusting to the current context.

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Organic and sustainable apple orchard | EMILIO LÓPEZ

CHAP **06**

GREEN GROWTH

CONTENT

INTRODUCTION

A green growth strategy encompasses a series of actions that allow promoting the economic development of nations, ensuring that natural assets continue to provide environmental resources and services that the collective well-being of current and future generations relies upon. To that end, it is proposed to broaden the capacities to produce and consume goods and services without deteriorating the environmental supports for human life.

The basic approach of these strategies is that natural assets cannot be substituted indefinitely. Hence, policies formulated under this approach must enable natural assets to provide their entire economic potential and essential life-supporting services in a lasting manner.

According to the Organisation for Economic Co-operation and Development (OECD), green growth does not replace sustainable development, but rather should be considered a subset of it as a practical and flexible approach to make concrete and measurable progress in its economic, social and environmental pillars. At the same time, it has a prevention approach, since it reasserts the idea of conserving natural resources based on the type of economic growth that is being promoted, instead of implementing environmental protection or recovery measures after the productive activity has been carried out.

Because of this, the OECD has committed to developing policies that promote green growth. In this context, the OECD adopted a Declaration on Green Growth in 2009 with the signature of 30 member countries and four applicant countries, including Chile. After its incorporation into this organization in 2010, Chile reasserted its commitment by publishing a National Green Growth Strategy in 2013.

In order to implement it, a series of initiatives have been carried out aimed at decoupling economic growth from resource use. Some of the most significant initiatives in this matter include: (i) the approval of a tax reform that includes the introduction of taxes to externalities (Law 20.780, 2014); (ii) the implementation of an Air Decontamination Strategy, 2014-2018; (iii) Chile's Intended Nationally Determined Contributions (INDC) for the 2015 Paris Agreement on Climate Change (Government of Chile, 2015); (iv) 2050 Energy Policy (Ministry of Energy, 2015); (v) the Law for Promoting Recycling; (vi) the National Environmental Accounts Plan; and (vii) the National Sustainable Consumption and Production Program.

All these initiatives are indeed intended to implement the 2013 National Green Growth Strategy, so as to not only decouple growth from resource use, but also to achieve a more sustainable economic development.

1 • BACKGROUND INFORMATION

Chile's economic development model is structured based on three strategic axes. First, ensuring macroeconomic stability anchored in the structural surplus rule[1] and the autonomy of the Central Bank. Second, a globally open economy. Third, a primary exports model based on the exploitation and export of natural resources.

The development strategy has been relatively successful. Chile has a gross domestic product (GDP) at purchasing power parity (PPP) per capita[2] of USD $23,564 for 2015 and the International Monetary Fund (IMF) estimates that in 2016 it will surpass USD $24,000. This is the higher per capita income in the region and it triples the value from three decades ago, when the main economic reforms began. Economic growth has had a direct impact on people's lives, remarkably reducing the percentage of the population living in poverty. According to the CASEN Survey (2015), 11.7 percent of the population lives in poverty by income and 3.5 percent lives in extreme poverty.

[1] The structural surplus rule means that the estimate of the Central Government's incomes will be made adjusting it to the economic cycle and, consequently, authorizing public expenditures that are consistent with such incomes. This results in savings during times of expansion of economic activity, in order to be able to spend them when the economy contracts and fiscal incomes decrease.

[2] The GDP at purchasing power parity (PPP) is gross domestic product converted to international dollars using purchasing power parity rates and divided by total population. An international dollar has the same purchasing power over GDP as a U.S. dollar has in the United States.

Likewise, significant progress has been achieved in improving living conditions, with life expectancy reaching 80 years, infant mortality rate at 7.8 children per 1,000 live births, and an illiteracy rate lower than 1.5 percent of the population.

Despite the progress mentioned above, there is concern for two aspects inherent to Chile's recent economic growth. Great income inequality persists, which – although it has decreased slightly over the last few years- continues to be one of the most unequal in the world[3], and increasing levels of environmental degradation are observed.

DEVELOPMENT STRATEGY

Economic growth has had an impact in reducing the percentage of the population living in poverty. According to the CASEN Survey (2015), 11.7 percent of the population lives in poverty by income and 3.5 percent lives in extreme poverty.

There is concern for two aspects inherent to Chile's recent economic growth. Great income inequality persists and **increasing levels of environmental degradation are observed.**

Puelo | SEBASTIÁN PAUBLO

[3] *This inequality is reflected in the Gini coefficient, which reached approximately 0.48 according to the 2015 CASEN Survey.*

Wind power | KARINA BAHAMONDE

2 • ENVIRONMENTAL DEGRADATION

The economic growth achieved over the last 30 years has had significant environmental costs. The greatest environmental problems faced by the country are air pollution, soil degradation, waste management and treatment, threats to biodiversity and water depletion and pollution. These environmental impacts affect vulnerable sectors to a greater extent and that is precisely the challenge that has motivated the explicit commitment of the environmental policy with "environmental equity."

Multiple pressures cause the environmental problems observed in the country, but there is no doubt that unsustainable consumption and production patterns are a key factor. As countries develop, they tend to increase their level of consumption and production and, hence, their environmental impact. Consequently, it is essential to make progress in specific policies that can decouple the resource use from economic growth or to prepare guidelines for their sustainable use.

Therefore, in order to achieve sustainable development and a better quality of live, States must promote changes in these patterns through measures such as the creation of incentives to internalize environmental externalities and technological change, both of which would contribute to this purpose while also generating positive externalities such as innovation and improvements in productive processes. That is the final objective of a green growth strategy.

3 • 2013 GREEN GROWTH STRATEGY

Green growth can be defined as growth that is more efficient and resilient in its use of natural resources, without necessarily slowing down growth (World Bank, 2012). According to the OECD, it jointly addresses three key imperatives that are especially relevant for developing economies: (i) the continued inclusive economic growth needed by developing countries to reduce poverty and improve well-being; (ii) improved environmental management needed to tackle resource scarcities and climate change; and (iii) equity and inclusion, expanding the benefits of development to all those excluded by the current economic system.

Chile has initiated the process towards green growth, incorporating actions that generate incentives to achieve changes in consumption and production patterns in the context of sustainable development. In addition, it has promoted efforts in innovation, technologies and environmentally friendly productive processes. The 2013 National Green Growth Strategy includes three strategic axes: i) internalizing environmental externalities through the implementation of environmental management tools; ii) promoting the market for environmental goods and services; and iii) monitoring and measurement of the strategy. These strategic axes are complemented with specific objectives and actions which, together, will enable consolidating the active role of the State in terms of sustainability, taking on the responsibility of implementing necessary actions for protecting the environment in a preventive and corrective manner.

Table 01 shows in detail the strategic axes, objectives and lines of action proposed by the Green Growth Strategy.

TABLE 01

STRATEGIC AXES AND ACTION LINES OF THE NATIONAL GREEN GROWTH STRATEGY	
STRATEGIC AXES	**LINES OF ACTION**
A) IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT TOOLS	
Command and control tools	Strengthening the generation and use of emission standards.
	Promoting the development of Prevention and Decontamination Plans.
	Strengthening the development of Management Plans.
	Strengthening the design and management of Protected Areas.
	Strengthening the Environmental Impact Assessment System.
Economic and complementary instruments	Studying the reformulation of the specific fuel tax.
	Promoting the use of tradable emission permits.
	Promoting Extended Producer Responsibility.
	Developing and implementing Sustainable Public Procurement.
	Promoting environmental labeling.
	Strengthening environmental education.
	Promoting and expanding Clean Production Agreements.
	Promoting Corporate Social Responsibility.
	Promoting and expanding the use of NAMAs.
Sectoral sustainability strategies	Promoting sustainability strategies in tourism, construction and energy.
Regulatory best practices	Strengthening regulatory impact assessment.
	Implementing Strategic Environmental Assessment.
	Strengthening inter-ministerial coordination.
	Strengthening citizen engagement.
B) PROMOTION OF THE MARKET FOR ENVIRONMENTAL GOODS AND SERVICES	
Eco-innovation and entrepreneurship	Promoting environmental entrepreneurship.
	Boosting national capacities for environmental research and innovation.
Green jobs and training	Strengthening the creation of green jobs.
	Promoting appropriate training in environmental matters.

CONTINUES ▶

C) MONITORING AND MEASUREMENT OF THE STRATEGY	
Green growth indicators	Generating national and local indicators.
Indicators for citizen environmental behavior	Developing citizen environmental performance measurement instruments.
	Creating environmental accounts.
Well-being indicators	Strengthening the use of socioeconomic indicators.

Source: Authors' own elaboration, based on the National Green Growth Strategy, 2013.

Many of the management tools proposed in the Green Growth Strategy are currently being developed, such as:

Command and control tools:

i) Promoting the development of Prevention and Decontamination Plans: During 2014, the Ministry of the Environment launched the Air Decontamination Strategy (2014-2018), which includes the implementation of 14 decontamination plans to reduce emissions in areas declared as saturated or latent and the implementation of short-term measures in areas for which there are no plans but record high concentrations of particulate matter.

ii) Strengthening the design and management of protected areas: During 2014, a draft bill was sent to the National Congress to create the Biodiversity and Protected Areas Service.

iii) Strengthening the Environmental Impact Assessment System (SEIA by its acronym in Spanish): In August 2013, the new Regulation of the Environmental Impact Assessment System was published in the Official Gazette. After a long consultation process, the Presidential Advisory Commission for the evaluation of the SEIA published its final report.

Economic and complementary instruments

i) Promoting the use of tradable emission permits: Although a tradable emission permits system has not yet been set up, the tax reform Law 20.780 was approved in 2014, including in Article 8 the introduction of green taxes to emissions of CO_2, PM, NOx and SO_2 pollutants.

ii) Promoting Extended Producer Responsibility: The Law of Recycling and Extended Producer Responsibility was passed during 2016.

iii) Developing and implementing Sustainable Public Procurement: During 2016, ChileCompra published Directive N°25 “Recommendations for hiring goods and services incorporating environmental and energy efficiency criteria”, developed together with the Ministry of the Environment.

01

INITIATIVES THAT PROMOTE A GREEN GROWTH STRATEGY

(i) Tax reform that includes the introduction of taxes to externalities (Law 20.780, 2014)

Environmental pollution is considered a negative externality as its impact causes a decrease in the well-being of third parties. Environmental taxes, or Pigovian taxes, are aimed at having agents internalize the externalities they produce by means of a direct charge or tax to the emission generated by the economic activity (Pigou, 1947).

Law 20.780, passed in 2014[4], establishes two types of taxes. The first applies to carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NOx) and particulate matter (PM) emissions from stationary sources made up of boilers or turbines, which together add a thermal power equal to or greater than 50 thermal megawatts (Article 8). The second tax applies to the first sale of vehicles according to their urban performance and NOx emissions (Article 2).

(ii) Implementation of the 2014-2018 Air Decontamination Strategy and the regulations program (MMA, 2014)

It is estimated that air pollution in Chile is responsible for approximately 4,000 premature deaths. Hence, controlling pollution is one of the main challenges of the environmental authority. The work program in terms of air pollution control is presented in the 2014-2018 Air Decontamination Strategy (MMA, 2014)[5].

Its objectives are: i) establishing 14 new decontamination plans that present effective measures for reducing emissions in areas declared as saturated or latent in Chile, and ii) implementing short-term measures in areas for which there are no plans and high concentrations of particulate matter have been recorded.

The finalization of the plans and draft bills will contribute for Chile to have 20 plans in force by 2018, covering over 57 percent of the country's population, representing 87 percent of the people exposed to air pollution.

(iii) Intended Nationally Determined Contributions (INDC) for the 2015 Paris Agreement on Climate Change (MMA, 2015)

Chile is highly vulnerable to climate change impacts. Because of that, it has had a proactive stance to acquire voluntary commitments to mitigate Greenhouse Gases (GHG), as well in the international negotiations in this matter.

The most significant initiatives include the incentive for Non-Conventional Renewable Energies (NCRE) (Law 20.986)[6], which demands that, by 2025, 20 percent of the energy inputs into the system are sourced from NRCE. Another relevant initiative is the use of tools to mitigate GHG, such as Law 20.780.

Chile's Intended Nationally Determined Contributions (INDC) for the 2015 Paris Agreement on Climate Change are based on five pillars: i) mitigation; ii) adaptation; iii) construction and strengthening of capacities; iv) technology development and transfer; and v) funding[7].

(iv) 2050 Energy Policy (Ministry of Energy, 2015)

Ensuring Chile's economic growth demands as a necessary condition to have reliable, sustainable and inclusive energy at reasonable prices. To that end, the Government, through the Ministry of Energy, after a national consultation process, proposed the 2050 Energy Policy, structured on four pillars:

CONTINUES ►

01

1. Security and quality of the supply.
2. Energy as an engine for development.
3. Energy compatible with the environment.
4. Efficiency and energy education.

Four goals stand out as the most relevant ones: i) that renewable energies must represent 60 percent by 2035 and at least 70 percent of the electric power generation by 2050; ii) that the energy matrix achieves at least a 30 percent reduction in the intensity of GHG emissions by 2030; iii) that the large consumer sectors (mining, industries and transportation) make an efficient use of energy, with active energy management systems and the implementation of energy efficiency improvements; and iv) that all new buildings have OECD efficient building standards, as well as intelligent energy control and management systems.

(v) Law of Promotion of Recycling (2016)

The Law of Promotion of Recycling seeks that waste emanated by a series of goods commercialized in the domestic market be managed in the best possible manner, avoiding their disposal in sanitary landfills. To that end, the law promotes creating management systems as well as introducing economic and regulatory incentives.

This tool involves producers, business owners, consumers, and waste managers, forcing manufacturers of certain goods to organize and finance the management of waste derived from them. Producers or importers of "priority products" must take care of them once their useful life has come to an end, facilitating their return to the industries where they were manufactured or stored.

(vi) National Plan for Environmental Accounts

The Economic Environmental Accounts System (SCAE by its acronym in Spanish) is a second-generation satellite accounts system that incorporates a registry of the natural productive capital (environmental assets) and their change over time, expanding the accounting approach of the National Accounts System (SCN by its acronym in Spanish)[8]. The Integrated Environmental, Ecosystem and Economic Accounts System (SICAEE by its acronym in Spanish) is Chile's proposal for an integrated environmental information system, in accordance with the recommendation made by the United Nations (MMA, 2016), which will allow formulating sustainable development and green growth indicators. At present, the MMA is implementing the system through a National Plan for Environmental Accounts published in 2016.

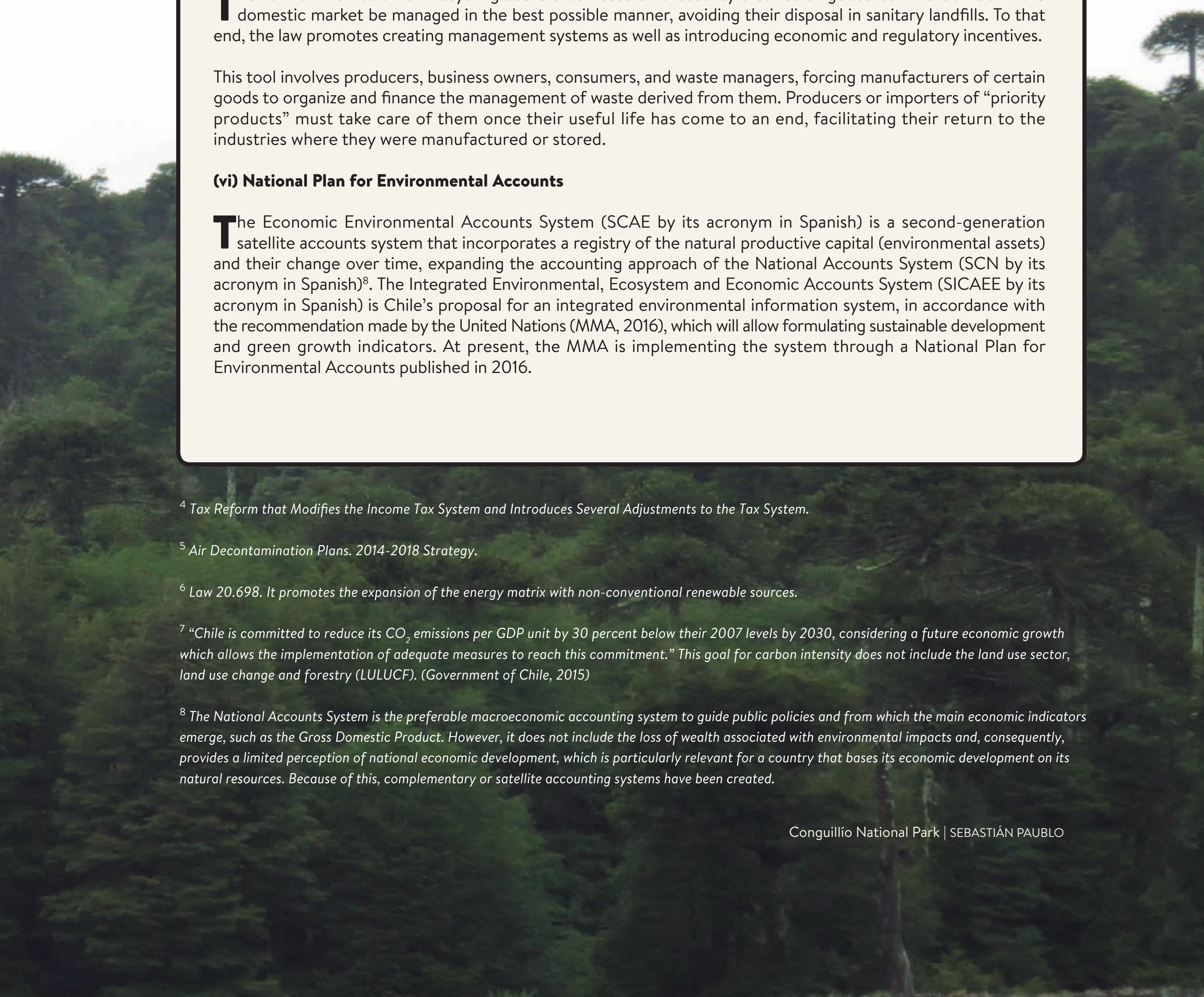
[4] *Tax Reform that Modifies the Income Tax System and Introduces Several Adjustments to the Tax System.*

[5] *Air Decontamination Plans. 2014-2018 Strategy.*

[6] *Law 20.698. It promotes the expansion of the energy matrix with non-conventional renewable sources.*

[7] *"Chile is committed to reduce its CO_2 emissions per GDP unit by 30 percent below their 2007 levels by 2030, considering a future economic growth which allows the implementation of adequate measures to reach this commitment." This goal for carbon intensity does not include the land use sector, land use change and forestry (LULUCF). (Government of Chile, 2015)*

[8] *The National Accounts System is the preferable macroeconomic accounting system to guide public policies and from which the main economic indicators emerge, such as the Gross Domestic Product. However, it does not include the loss of wealth associated with environmental impacts and, consequently, provides a limited perception of national economic development, which is particularly relevant for a country that bases its economic development on its natural resources. Because of this, complementary or satellite accounting systems have been created.*



Conguillío National Park | SEBASTIÁN PAUBLO

4 • BACKGROUND ON SUSTAINABLE CONSUMPTION AND PRODUCTION

The idea of advancing towards more sustainable consumption and production patterns arose in 1992, during the Earth Summit held in Rio de Janeiro, which recognized that achieving sustainable development would necessarily require changing productive practices and lifestyles. This idea was incorporated into Agenda 21 with the objective of shifting to "more sustainable patterns of production and consumption"[9]. Ten years later, during the Johannesburg World Summit on Sustainable Development, in 2002, the signatory countries of the Summit Declaration committed to implementing an "Action Plan" on "changing unsustainable patterns of consumption and production."

At the United Nations Conference on Sustainable Development (Rio+20), an action plan was proposed through the 10 Year Framework of Programmes on Sustainable Consumption and Production (10YFP). Furthermore, sustainable consumption and production are part of the Post-2015 Agenda for Sustainable Development, which includes it as one of the Sustainable Development Goals (SDGs).

The 10 Year Framework of Programmes on Sustainable Consumption and Production stems from the Implementation Plan approved during the Johannesburg World Summit on Sustainable Development, in 2002, and kick-started through the Marrakech Process, initiated in 2003. In order to achieve its objectives, each region and their respective countries began developing concrete strategies and actions.

In specific and operational terms, the 10YFP10 includes six work programs: i) Consumer information; ii) Sustainable lifestyles and education; iii) Sustainable public procurement; iv) Sustainable buildings and construction; v) Sustainable tourism, including ecotourism; and vi) Sustainable Food Systems. In this regard, over the last few years Chile has actively participated and is carrying out several initiatives, as will be discussed below in the section on the National Sustainable Consumption and Production Program.

4.1 Institutions for Sustainable Consumption and Production

Chile's international commitment within the 10YFP framework, along with the country's environmental, social and economic needs, has led to the creation of a specific institutional framework to promote initiatives related to sustainable consumption and production. Because of that, in March 2014 the MMA created the "Committee for Sustainable Consumption and Production" (CCPS by its acronym in Spanish), made up of more than 20 public agencies, mostly ministries.

The main objective of the CCPS was to create a National Sustainable Consumption and Production Program (PNCPS by its acronym in Spanish) in order to integrate and coordinate different national initiatives in these matters, as well as to create and implement a Sustainable Consumption and Production Action Plan (PACPS by its acronym in Spanish)[11] that will enable the continuity of initiatives already being implemented, promoting the development of new actions.

With the aim of including different sectors of society in a more concrete manner, the Consulting Committee on Sustainable Consumption and Production was created in April 2015, made up of representatives from the business sector, academia, NGOs, public enterprises and employees, and the MMA. The roles of this Committee are mainly to advise the CCPS regarding its functions and to present initiatives to promote more sustainable consumption and production patterns (MMA, 2015).

[9] *Agenda 21 is the action program to promote sustainable development throughout the world at the local, state, regional and global levels. This agenda includes four main thematic areas: economic and social dimensions; conservation and management of resources for development; strengthening the role of major groups; and means of implementation.*

[10] *10 Year Framework of Programmes on Sustainable Consumption and Production http://www.unep.org/10yfp/*

[11] *This plan was approved by the Council of Ministers for Sustainability on July 4, 2016.*

4.2 Sustainable Consumption and Production Initiatives in the Public Sector

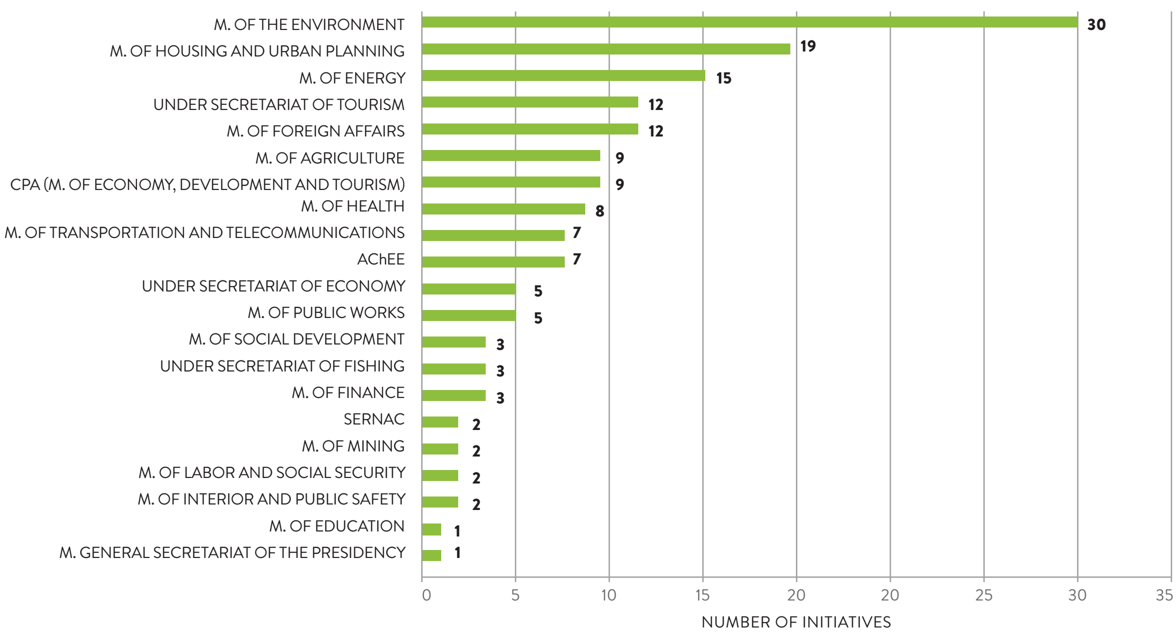
In order to develop the National Sustainable Consumption and Production Program, the CCPS participated in a diagnosis of the different sustainable consumption and production initiatives developed by the public sector to date. This allowed quantifying the initiatives and analyzing the main sectors addressed.

The diagnosis revealed the existence of 158 initiatives, of which more than half are tools and legislation (31 percent and 20 percent, respectively). It also showed the existence of programs (13 percent), action plans (9 percent), strategies (6 percent), institutional framework (6 percent), international agreements (6 percent) and policies (6 percent). The less frequent types of initiatives are projects, which represent only 3 percent of the total.

Most of the 158 initiatives developed by the public sector have been led by the Ministry of the Environment (30), the Ministry of Housing and Urban Planning (19), the Ministry of Energy (15), the Under Secretariat of Tourism (12) and the Ministry of Foreign Affairs (12). Together, these institutions have led 56 percent of the initiatives. The ministries with the lowest number of initiatives are the Ministry of Education and the Ministry General Secretariat of the Presidency, each of them with one initiative (**Figure 01**).

FIGURE 01

NUMBER OF SUSTAINABLE CONSUMPTION AND PRODUCTION INITIATIVES



Source: Authors' own elaboration, based on data from the National Sustainable Consumption and Production Program (2015).

Regarding the economic sectors with the greatest number of initiatives on sustainable consumption and production, the energy sector stands out with the largest number of tools developed (26). It is followed by the construction and agriculture sectors, each of them with 18 legislative initiatives. **Table 02** shows the details of this analysis.

TABLE 02

SUSTAINABLE CONSUMPTION AND PRODUCTION INITIATIVES DEVELOPED BY THE PUBLIC SECTOR, BROKEN DOWN BY ECONOMIC SECTOR

TYPE OF INITIATIVE	SECTOR					
	Transportation	Mining	Energy	Construction	Management within the Public Sector	Finance
International Agreement	2	1	4	4	2	1
Strategy	2	5	9	5	7	3
Policy	3	7	6	7	4	6
Standard	10	8	9	8	8	6
Action Plan	7	5	6	8	8	3
Program	7	5	13	9	8	3
Project	0	0	2	0	0	0
Tool	5	7	26	18	8	6
Institutional Framework	5	5	7	7	7	5

TYPE OF INITIATIVE	SECTOR					
	Agriculture	Industry	Tourism	Education	Public Procurement	Fishing
International Agreement	7	7	4	5	0	3
Strategy	5	7	6	5	2	4
Policy	7	7	7	7	2	7
Standard	9	18	5	5	1	5
Action Plan	5	6	3	7	1	4
Program	10	8	5	12	2	5
Project	1	0	1	3	0	0
Tool	18	14	17	12	4	6
Institutional Framework	6	5	5	6	3	7

Source: Authors' own elaboration, based on data provided by the National Sustainable Consumption and Production Program (2015).

It is important to highlight that many of the initiatives developed by public agencies, jointly address both sustainable consumption and production, while others are specifically focused on promoting sustainable consumption or production.

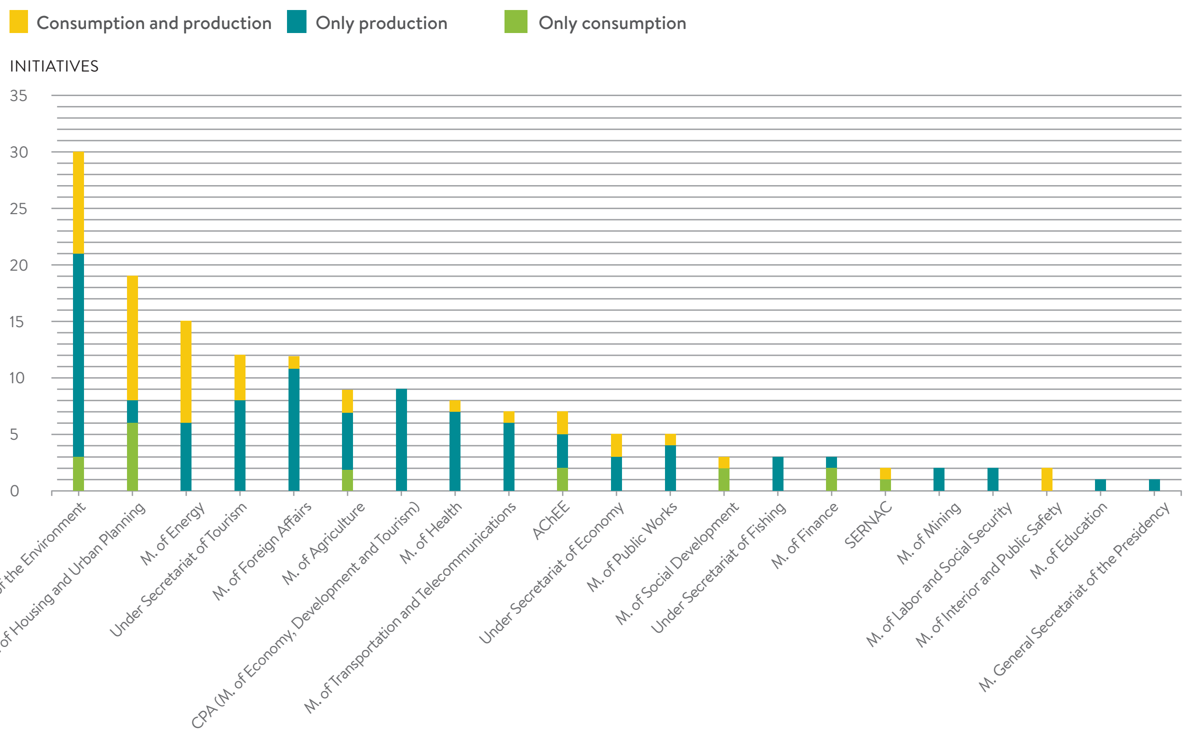
Most of the initiatives identified are currently being executed (126), while of the remaining 32 there are 13 in the planning stage and 19 that have been completed. Regarding the latter, 14 of them had post-completion follow up and the experiences were used to create new initiatives.

IDENTIFIED INITIATIVES

13	126	19
in the planning stage	**being executed**	**completed**

FIGURE 02

SUSTAINABLE CONSUMPTION AND PRODUCTION INITIATIVES BY THE PUBLIC SECTOR
by type of approach (consumption or production)



Source: Authors' own elaboration, based on data from the National Sustainable Consumption and Production Program (2015).

4.3 Main Sustainable Production Initiatives

In addition to the diagnosis on sustainable consumption and production initiatives carried out to prepare the PNCPS, there are several efforts by the public and private sectors to achieve a more sustainable production. Some of the most outstanding include the Clean Production Agreements (CPA), the Nationally Appropriate Mitigation Actions (NAMAs), and the Sustainability Reports prepared by companies.

Clean Production Agreements (CPA) are management tools that consist of "an agreement signed by a business sector, company(ies) and the institution(s) with competence on the matters of the agreement, whose objective is to apply Clean Production through specific goals and actions" (INN, 2003). CPA are promoted by the National Council for Clean Production (CPL by its acronym in Spanish), a public-private organization created under the auspices of the Ministry of Economy-CORFO, which fosters modernization and competitiveness of productive sectors by means of promoting clean production[12]. At present, there are nine sectors committed to CPAs with more than 6,000 companies participating[13].

Regarding the fight against climate change, the NAMAs are Nationally Appropriate Mitigation Actions that must be implemented by developing countries with the aim of contributing to the global reduction of emissions of greenhouse gases. These actions must meet the criteria of measurement, reporting and verification.

In August 2010, Chile declared to the United Nations its voluntary commitment to carry out Nationally Appropriate Mitigation Actions in order to achieve a 20 percent deviation below its increasing trajectory of emissions for the 2020 business-as-usual scenario, projected since 2007. By 2014, the country recorded nine of these actions, five of which are included in the NAMA Registry of the United Nations Framework Convention on Climate Change (UNFCCC), while the other four are being prepared (MMA, 2014). The institutions responsible for these NAMAs are: The National Council for Clean Production; the National Forestry Corporation; the Center for Renewable Energies; the Ministry of the Environment; the Ministry of Energy; the Ministry of Housing and Urban Planning; the Municipality of Santiago; the Agriculture and Livestock Research Institute; and the Agriculture and Livestock Service. The reductions expected from these NAMAs will help Chile comply with the voluntary commitment made to the United Nations Framework Convention on Climate Change. See chapter on Climate Change for further details.

In Chile there are still few companies that prepare Sustainability Reports. However, according to the data from the analysis performed by PricewaterhouseCoopers, the preparation of these reports has increased since 2000, when only one report was prepared, while in 2011 there were 77. Of these reports, 86 percent were prepared by large companies (large private companies and large government companies), 8 percent by SMEs and 6 percent by NGOs, State agencies and universities. Regarding the productive sectors, the mining industry holds the first place with 30 percent of the national publications, followed by the energy industry with 10 percent (PWC, 2014).

[12] *Clean production is a productive and environmental management strategy that enables increasing efficiency and productivity of companies and reducing costs, while also minimizing risks for human populations and the environment.*

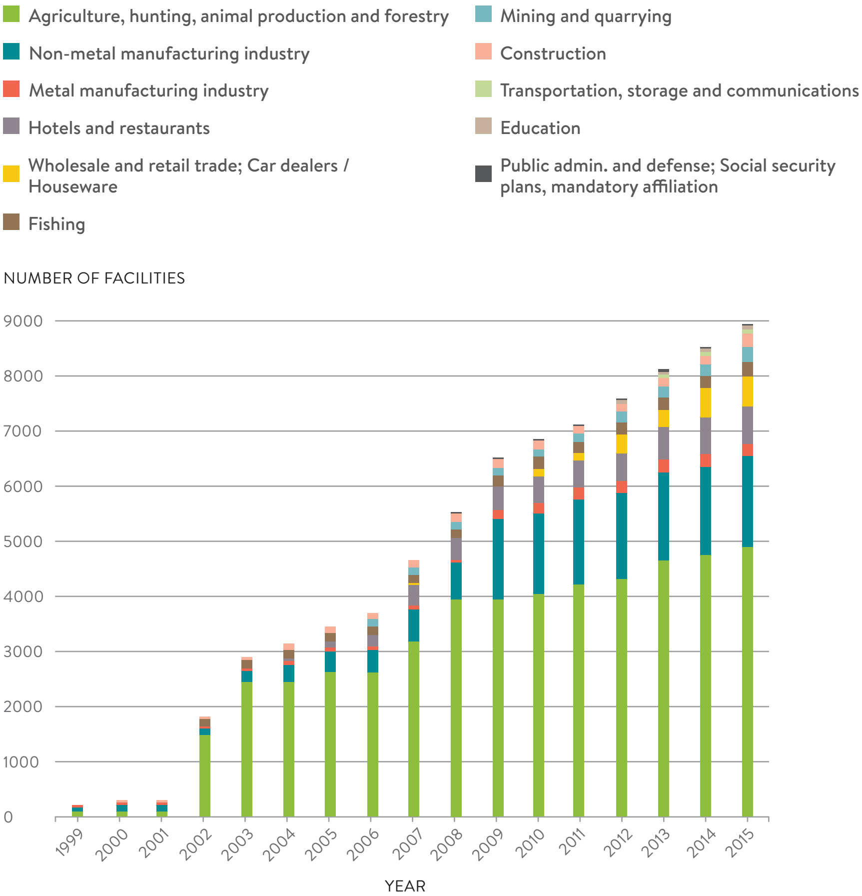
[13] *The committed sectors are: Agriculture, livestock, forestry and aquaculture; Mining extraction activities; Manufacturing industries; Construction, wholesalers and retailers; Transportation and storage of goods; Gastronomy and lodging sector; Public Administration and Education.*

The Social Responsibility Council for Sustainable Development, led by the Ministry of Economy, Development and Tourism, is the organization in charge of boosting and helping companies in matters of Corporate Social Responsibility and of preparing a State policy on the topic. The 2015-2018 Social Responsibility Action Plan was approved in 2015 and includes 17 specific measures and three general objectives: Strengthening existing corporate responsibility practices; development of new corporate responsibility practices; and monitoring and evaluation.

The outstanding specific measures include the support and integration of SMEs into the National Social Responsibility for Sustainable Development Strategy, the promotion of voluntary pre-investment agreements (prior to the submission to the Environmental Impact Assessment Service), and the formulation of a National Social Responsibility Policy (Ministry of Economy, Development and Tourism, 2015), among others (Ministry of Economy, Development and Tourism, 2015).

FIGURE 03

NUMBER OF FACILITIES WITH CPA BY ISIC CODE



Source: National Council for Clean Production, 2016.

4.4 Main Sustainable Consumption Initiatives: Citizens and State

The United Nations Environment Programme (UNEP, 2015) highlights the different processes to move independently towards sustainable consumption and production by pointing out that "achieving sustainable consumption patterns is more technically and politically complex than changing production patterns, because it raises important issues such as human values, equity and lifestyle choices. The sustainable consumption challenge has generated fewer policy initiatives than those seen on sustainable production."

This observation, or statement, is also valid for Chile, where actions aimed at achieving a more sustainable consumption are still relatively scarce[14]. There are several reasons to explain this slow progress. First, there is no unique approach and concept on sustainable consumption, causing confusing and bewilderment among consumers[15]. Second, the level of environmental concern and awareness expressed by society fluctuates[16]. Third, the overall perception that goods and services with greater sustainability attributes (or fewer impacts) have a higher price than traditional ones, which reduces the motivation of consumers to purchase them.

In this regard, the State -as a large purchaser-, by preferring sustainable products and services, can provide a powerful incentive for companies to incorporate sustainability criteria into their products or services (FOMIN, 2011) and stimulate consumers-citizens to guide their purchases by these types of products. It is also expected that, by setting the example, the State will foster innovation processes in companies, eco-businesses and green jobs.

The outstanding initiatives boosted by the public sector in terms of sustainable consumption include those carried out by the Ministry of Social Development (Choose a Healthy Life Program), the Ministry of Housing and Urban Planning (Live Sustainably Program, Green Areas Plan, Bikeways Plan, Housing Energy Certification Program), the Ministry of Finance (Socially Responsible Public Procurement Policy), and the National Tourism Service (Tourism Sustainability Seal), among others.

It is important to consider that the environmental attributes of goods and services of the initiatives to promote a more sustainable consumption must be verified by labels, seals or certifications, in order to inform consumers regarding the processes that enabled their production, as well as their main characteristics. At present, Chile lacks a national eco-labeling system and is in a situation of proliferation of certifications, seals and labels, many of which often lack national or international recognition, causing confusion among consumers.

[14] Although the use of concepts such as responsible consumption increases every day in company strategies, this increase is explained because companies want to adjust to the new standards and demands of the international and domestic markets (Universidad Diego Portales, 2012).

[15] At present, the concepts of sustainable consumption, ethical consumption, consumption with awareness and solidary consumption are used as synonyms.

[16] In the CEP Survey administered in November 2015, in response to the question "Which are the three problems the Government should dedicate greatest efforts to tackle?", the environment appears with 3 percent at the end of the list.

5 • THE NATIONAL SUSTAINABLE CONSUMPTION AND PRODUCTION PROGRAM

This program is the cornerstone of the Green Growth Strategy and is one of the main efforts of the Committee for Sustainable Consumption and Production.

Its aim is to be a tool that contributes to guiding the transition towards more sustainable consumption and production patterns, promoting the decoupling of the country's growth and development from environmental degradation. The program is structured on five principles and 12 lines of action, which will be implemented through an action plan divided into two stages (Stage 1: 2016-2020 and Stage 2: 2020-2025)[16].

The specific objectives of the program include:

1. Coordinating and aligning efforts of the public and private sectors to promote sustainable consumption and production patterns in the country.
2. Integrating sustainable consumption and production into the policies, plans, programs and strategies of the public sector.
3. Promoting a detailed analysis of the social, environmental and socioeconomic impacts in the generation of information and the management of goods and services throughout their life cycle.
4. Boosting green growth for Chile, strengthening strategic sectors and clean technologies.
5. Contributing to the compliance with international commitments on sustainable consumption and production.

The principles the program is based on are the following

1. Environmental equity, in terms of ensuring that environmental impacts do not affect in a disproportionate manner the most vulnerable sectors and communities of the country, while at the same time including them in decision-making processes.
2. Sustainability culture, focused on developing and strengthening a social, economic and environmental responsibility culture based on the incorporation of the sustainability concept into the nature of citizens as well as their way of thinking and acting.
3. Competitiveness and innovation, through the efficient management of resources and innovative solutions in Chilean companies.
4. Efficiency in the use of resources, based on better ways of satisfying human needs based on a more sustainable way of producing and consuming goods and services.
5. Governance and participation, understood as the extent of coordination, both public and external, required for its correct implementation.

5.1 Action Lines of the National Sustainable Consumption and Production Program

The program's structure is based on eight sectoral lines of action and four cross-cutting lines of action. This structure was designed thinking that the cross-cutting lines present elements that are common to the main lines, which will facilitate their alignment as well as the communication between the different initiatives, creating synergies and collaboration among lines of action.

The lines of action will be implemented gradually, through the two five-year action plans. Each line of action will have specific objectives and actions, in addition to having indicators that will enable monitoring and verifying their state of progress. These indicators will be assessed and included in the State of the Environment Report.

Sectoral lines of action:

- Sustainable construction
- Sustainable tourism
- Sustainable food systems
- Responsible industry
- Consumer information
- Sustainable lifestyles and education
- Sustainable cities
- Sustainability in the public sector

Cross-cutting lines of action:

- Sustainable smaller-sized companies
- Waste management
- Water management
- Clean energies and energy efficiency

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From the mountain| FRANCISCO DONOSO

CHAP **07**

AIR

CONTENT

INTRODUCTION

Air quality is one of the environmental issues that most directly affects the population. Despite the efforts and different tools used, there are areas in the country that still do not comply with the limits established in the current primary and secondary standards. In this context, and given the complexity of the issue, in 2014 the Ministry of the Environment began the preparation and implementation of a new Prevention and Decontamination Plans strategy for the 2014-2018 period, which seeks to improve air quality in the main urban areas of the country, thus incorporating a national approach to manage this issue.

1 • BACKGROUND INFORMATION

Several national and international studies have shown a link between the concentration level of pollutants such as particulate matter (PM), ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO) and nitrogen dioxide (NO_2) and the incidence of premature deaths and several cardiorespiratory diseases, in both children and adults. There is also evidence of environmental effects, such as visibility impairment, damage to materials and impacts on flora and fauna (**Table 01**).

TABLE 01

IMPACTS GENERATED BY PM, O_3, SO_2 AND NO_2

EFFECT	BRIEF DESCRIPTION
Damage to Human Health	Particles and compounds emitted into the air in certain concentrations can produce harmful effects on people's health, for instance, reduced pulmonary function, increased susceptibility to respiratory infections, premature deaths and cancer, among others.
Visibility Impairment	The presence of particles in the air reduces visibility, causing reduced well-being and quality of life.
Damage to Materials	The excess of air pollution may cause damage in building materials, altering their physical and chemical properties.
Damage to Aquatic Ecosystems	High concentrations of NO_2 and SO_2 can produce acid deposition in the water, modifying its composition and making the survival of aquatic species difficult.
Damage to Plants and Forests	Acid deposition in soils can modify the growth of plants and trees. Also, ozone and other particles may enter through the stomata of plants and damage their structure.

Source: MMA (2011 a).

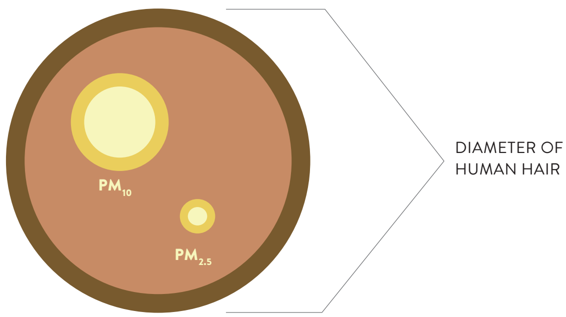
Particulate matter (PM) is the pollutant that has been more significantly associated to mortality and morbidity events in the population (Pope and Dockery, 2006). This pollutant is classified according to its aerodynamic diameter[1], the characteristic that determines the intensity of its impacts. Particles with diameters smaller than or equal to 10 microns are known as PM_{10} and particles with diameters smaller than or equal to 2.5 microns are known as $PM_{2.5}$. Thus, two fractions can be distinguished for PM_{10}: The coarse fraction, that is, between 2.5 and 10 microns of aerodynamic diameter, and the fine fraction, smaller than 2.5 microns of aerodynamic diameter.

It is worth noting that the $PM_{2.5}$ fraction is composed of particles that are small enough to penetrate through airways until they reach the lungs and alveoli, which increases the risk of premature mortality due to cardiopulmonary effects, in both short- and long-term exposures (CONAMA, 2010).

Regarding the PM_{10} coarse fraction, according to the United States Environmental Protection Agency (EPA), even though there is an apparent relation between short-term exposure and respiratory and cardiovascular effects, there is not enough evidence to verify potential effects from long-term exposure (EPA, 2009).

FIGURE 01

DIFFERENCES BETWEEN $PM_{2.5}$ AND PM_{10}



Source: Authors' own elaboration based on image from the EPA website.

[1] *Diameter of a hypothetical sphere with a density of 1g/cm³ having the same final sediment velocity, due to gravitational force, in calm air than that of the particle, under existing temperature, pressure and relative humidity conditions.*

2 • AIR QUALITY

In Chile, the first emission and quality standards were dictated in 1961 and 1978, respectively[2]. Since then, new studies and legislative review processes have been carried out resulting in Chile having more primary environmental quality standards[3] at the national level, which regulate the concentration in the air of six types of pollutants, identified as the main and most harmful ones for human health. These standards regulate maximum concentrations of particulate matter, both PM_{10} and $PM_{2.5}$, as well as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), tropospheric ozone (O_3), carbon monoxide (CO) and lead (Pb). **Table 02** presents a description of some of the current primary air quality standards in micrograms by cubic meter ($\mu g/m^3$).

The assessment of the state of air quality, according to the limits established in the primary standards, is based on the analysis of the data collected by the monitoring stations with population representation (EMRP, by its acronym in Spanish)[4]. In the country there are also private monitoring stations, most of which have been installed under the framework of the requirements established in the environmental qualification resolutions, as a monitoring mechanism of the impact of projects or decontamination plans, as is the case of the monitoring network of copper foundries.

Most of the air quality monitoring has preferably focused on PM_{10} particulate matter. However, with the entry into force of the $PM_{2.5}$ standard, in 2012, the monitoring coverage of this pollutant has significantly increased over the last few years, enabling the availability of a better indicator of the state of air quality.

According to the measurements, it is possible to see that the cities located in central and southern areas of our country present high concentration levels of $PM_{2.5}$, exceeding the 20 micrograms per cubic meter established as the maximum limit in the current annual standard. Cities in the northern area do not register such elevated annual levels of $PM_{2.5}$, because the main emission sources of particulate matter in that area are derived from processes of the mining industry, which has a higher contribution of coarse particulate matter (Kavouras, Koutrakis et al., 2001). Nonetheless, some cities with a greater presence of activities such as thermoelectricity generation or copper foundries show higher levels in comparison to other cities in the north that do not have such types of activities.

According to this background information, it is possible to estimate that, in Chile, at least 10 million people are exposed to an annual $PM_{2.5}$ average concentration higher than 20 micrograms per cubic meter.

[2] *Decree N° 144 of the Ministry of Health (1961) and Resolution N° 1215 of the Ministry of Health (1978).*

[3] *"Standard that establishes concentration limits and maximum and minimum permissible periods of elements, compounds, substances, chemical or biological byproducts, energies, radiations, vibrations, noise or a combination of them, whose presence or absence in the environment may represent a risk to human life or health." Article 2, letter n, Law 19.300.*

[4] *A monitoring station is classified as EMRP when it meets the technical characteristics of measurement and location that, for a specific air quality standard, ensures its measurements are representative.*

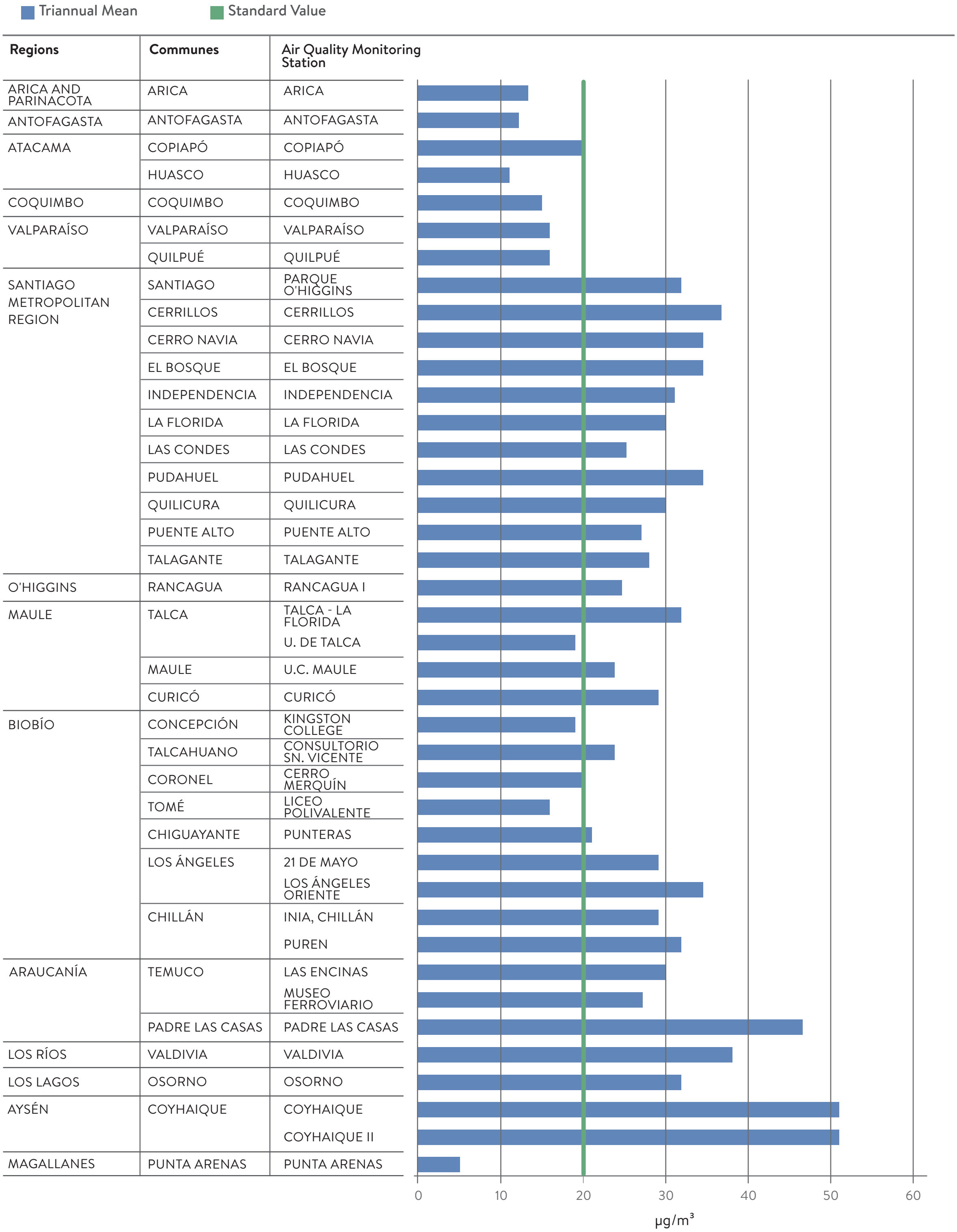
TABLE 02

CURRENT PRIMARY QUALITY STANDARDS				
POLLUTANT	**STANDARD VALUE**	**UNIT**	**METRIC**	**EXCEEDANCE**
O_3	120	µg/m^{3}N	8 hour running mean	Arithmetic mean of the 99th Percentile of the daily maximum 8 hour running means.
PM_{10}	50	µg/m^{3}N	Annual arithmetic mean	Triannual mean
	150		Daily arithmetic mean	98th Percentile of the daily concentrations.
$PM_{2.5}$	20	µg/m^{3}N	Annual arithmetic mean	Triannual mean
	50		Daily arithmetic mean	98th Percentile of the daily means.
SO_2	80	µg/m^{3}N	Annual arithmetic mean	Triannual mean
	250		Arithmetic mean of 24 hours	Triannual mean of the 99th Percentile of the daily concentrations.
CO	10.000	µg/m^{3}N	Arithmetic mean of 8 hours	Triannual mean of the 99th Percentile of the daily maximum 8 hour running means.
	30.000		Arithmetic mean of 1 hour	Triannual mean of the 99th Percentile of the daily maximum of 1-hour concentrations.
NO_2	100	µg/m^{3}N	Triennial arithmetic mean	Triannual mean
	400		Hourly arithmetic mean	Triannual mean of the 99th Percentile of the daily maximum of 1-hour concentrations.
Pb	0,5	µg/m^{3}N	Biennial arithmetic mean	Biannual mean

Source: Authors' own elaboration.

FIGURE 02

MEAN ANNUAL $PM_{2.5}$ CONCENTRATIONS AT THE NATIONAL LEVEL, 2015 PERIOD



Source: Department of Monitoring Networks. (*) Reference data.
Note: Annual means do not represent the level of compliance with the standard. Hence, they are for reference only.

According to this background information, and following the methodology proposed by the MMA (2011a), it is estimated that more than 3,700 people die prematurely each year due to cardiopulmonary diseases associated with chronic $PM_{2.5}$ exposure. This figure represents more than double the number of deaths in car accidents (CONASET, 2015). It is worth mentioning that this figure cannot be compared to that of the First State of the Environment Report 2011, since on this occasion the minimum inhalable concentration is restricted to that indicated by the World Health Organization (WHO), which is $10\mu g/m^3$.

TABLE 03

MORTALITY AND MORBIDITY ASSOCIATED WITH $PM_{2.5}$ EXPOSURE*

TYPE OF EVENT	EVENT	AGE GROUP	CASES
Premature Mortality	Cardiopulmonary	All	3,723
Hospital Admissions	Cardiovascular	All	1,709
	Chronic Obstructive Pulmonary Disease	18-64	231
	Pneumonia	All	1,049
	Asthma Attacks	All	152
Emergency Room Visits	Acute Bronchitis	All	108,100
Activity Restriction	Missed Workdays	All	870,756
	Days with Restricted Activity	All	3,861,706
	Days with Minor Restricted Activity	All	7,273,360

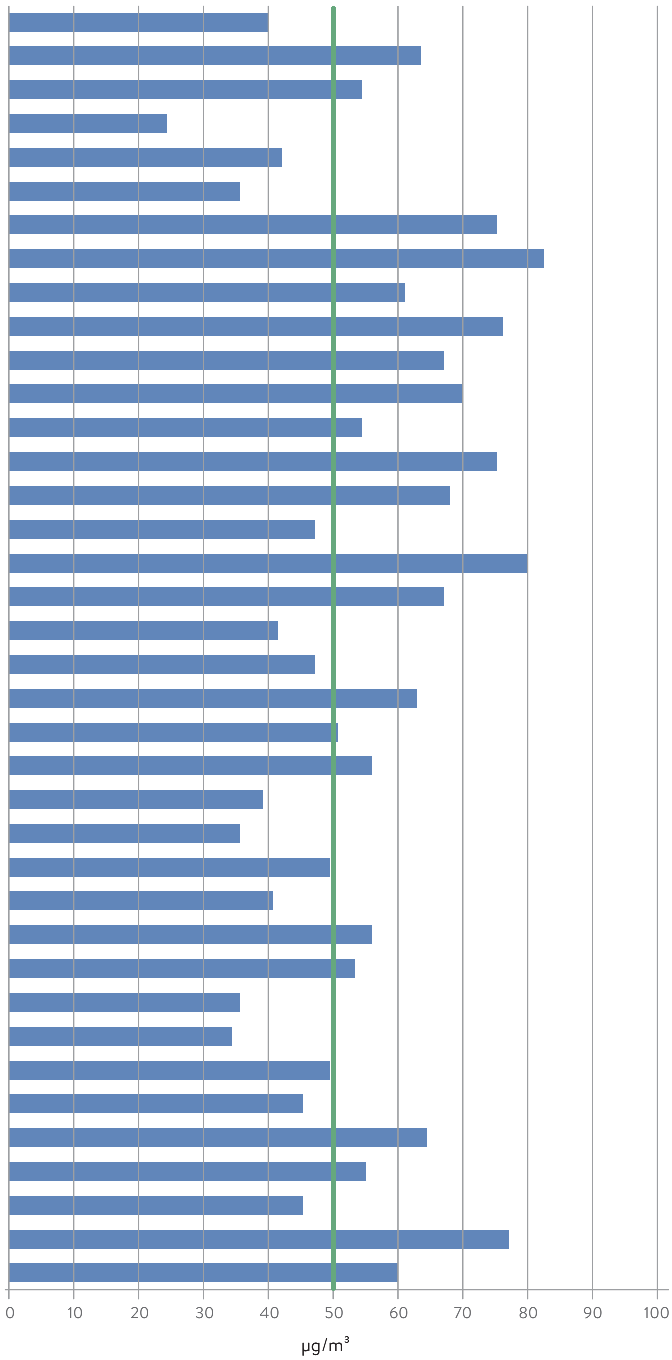
Source: Authors' own elaboration based on MMA (2015c) and GREENLABUC (2015).

FIGURE 03

ANNUAL PM_{10} MEAN FOR 2015 AT SELECTED STATIONS [μg/m³]

Triannual Mean   Standard Value

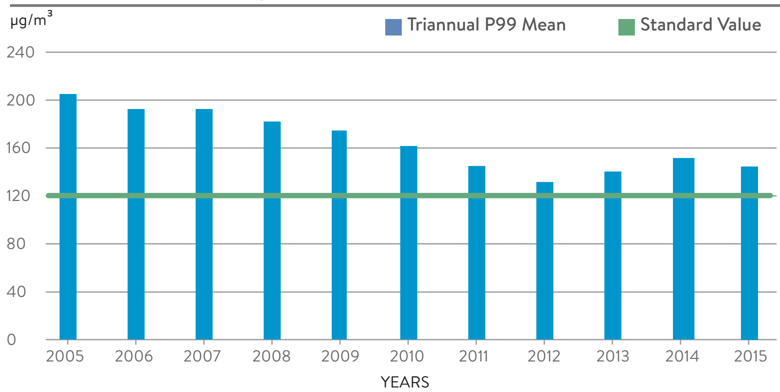
Regions	Communes	Air Quality Monitoring Station
ANTOFAGASTA	ANTOFAGASTA	ANTOFAGASTA
ATACAMA	COPIAPÓ	COPIAPÓ
COQUIMBO	ANDACOLLO	ANDACOLLO
	SALAMANCA	CUNCUMEN
VALPARAÍSO	QUILPUÉ	QUILPUÉ
	VIÑA DEL MAR	VIÑA DEL MAR
SANTIAGO METROPOLITAN REGION	SANTIAGO	PARQUE O'HIGGINS
	CERRILLOS	CERRILLOS
	CERRO NAVIA	CERRO NAVIA
	EL BOSQUE	EL BOSQUE
	INDEPENDENCIA	INDEPENDENCIA
	LA FLORIDA	LA FLORIDA
	LAS CONDES	LAS CONDES
	PUDAHUEL	PUDAHUEL
	PUENTE ALTO	PUENTE ALTO
	TALAGANTE	TALAGANTE
O'HIGGINS	RANCAGUA	RANCAGUA I
		RANCAGUA II
	RENGO	RENGO
	SAN FERNANDO	SAN FERNANDO
MAULE	TALCA	TALCA - LA FLORIDA
	CURICÓ	U. DE TALCA
		CURICÓ
	MAULE	U.C. MAULE
BIOBÍO	CHIGUAYANTE	PUNTERAS
	TALCAHUANO	CONSULTORIO SN. VICENTE
	CONCEPCIÓN	KINGSTON COLLEGE
	LOS ÁNGELES	21 DE MAYO
	CHILLÁN	PUREN
	CORONEL	CERRO MERQUÍN
	TOMÉ	LICEO POLIVALENTE
ARAUCANÍA	TEMUCO	LAS ENCINAS
	PADRE LAS CASAS	MUSEO FERROVIARIO
		PADRE LAS CASAS
LOS RÍOS	VALDIVIA	VALDIVIA
LOS LAGOS	OSORNO	OSORNO
AYSÉN	COYHAIQUE	COYHAIQUE
		COYHAIQUE II



Source: Department of Monitoring Networks. (*) Reference stations.
Note: Annual means do not represent the level of compliance with the standard. Hence, they are for reference only.

FIGURE 04

EVOLUTION OF THE MAXIMUM TRIANNUAL MEAN OF THE 99TH PERCENTILE OF THE RUNNING MEANS OF THE 8-HOUR CONCENTRATIONS OF O_3 IN THE METROPOLITAN REGION



Source: Department of Monitoring Networks.
Note: Annual means do not represent the level of compliance with the standard. Hence, they are for reference only.

Pollution in Santiago I KARINA BAHAMONDE

3 • POLLUTANT EMISSIONS

The concentrations of PM_{10}, SO_2, CO and NO_2 are mainly produced by direct emissions of these pollutants into the atmosphere, either from anthropogenic or natural sources. In turn, O_3 is formed in the troposphere, due to photochemically -initiated reactions between volatile organic compounds (VOCs), nitrate oxides (NOx) and other chemical compounds in the atmosphere (Jorquera, 2007).

On the other hand, $PM_{2.5}$ particulate matter is also produced by direct emissions. However, it is mostly formed by chemical reactions between gaseous pollutants, such as SOx and NOx and other atmospheric compounds. This type of $PM_{2.5}$ is known as secondary particulate matter. In this regard, it is important to highlight that particulate matter can be classified by the size and chemical composition of the particles, using their origin as criterion.

Secondary particulate matter is formed both by the condensation of gases cooled after their emission, which are added to already existing particles and combine themselves to form larger conglomerates, as well as by forming cloud or fog droplets, to which the condensed gases serve as nucleus.

Main emission sources of pollutants can be classified, according to their characteristics, as stationary, mobile and fugitive sources. Stationary sources are considered to be emissions generated by fuel burning in industrial and residential activities, to generate energy, heat or steam, and other industrial processes, such as copper smelting. They also include emissions generated by burning other fuels such as biomass, associated with residential heating.

Mobile sources correspond to emissions that come from exhaust gases, brakes and tire wear, from different means of transportation, such as cars, trucks, buses and motorcycles.

Fugitive sources are emissions that are not channeled through pipelines, chimneys, or other systems towards the exterior, such as emissions that come from paved and unpaved roads, as well as from construction and demolition, among others. The particulate matter associated with this type of source corresponds mainly to coarse particles, of which almost 90 percent are larger than 2.5 micrometers (μm) (Chow and Watson, 1998). Fugitive emissions also have a natural origin, due to dust or rock erosion suspensions by wind. Their emission rates strongly depend on meteorological parameters such as wind speed, environmental humidity and precipitation.

The following **table** shows a classification of sources that are generally used in the preparation of emission inventories in Chile.

FUGITIVE POLLUTION SOURCES

They are emissions that are not channeled through pipelines, chimneys, or other systems towards the exterior, such as emissions that come from paved and unpaved roads, as well as from construction and demolition, among others. The particulate matter associated with this type of source corresponds mainly to coarse particles, of which almost 90 percent are larger than 2.5 micrometers (μm) (Chow and Watson, 1998).

Fugitive emissions also have a natural origin, due to dust or rock erosion suspensions by wind. Their emission rates strongly depend on meteorological parameters such as wind speed, environmental humidity and precipitation.

TABLE 04

CLASSIFICATION OF EMISSION SOURCES			
TYPE	**POLLUTANTS**	**SUBTYPE**	**EXAMPLES OF ACTIVITIES**
Stationary Sources	PM_{10}, $PM_{2.5}$ SO_2, CO, COV and NOx	Area	Residential heating, agriculture burns and forest fires.
		Specific (Industry)	Electric generation, industrial processes such as combustion in steam-generating boilers and industrial furnaces, as well as other industrial processes such as copper smelting.
Mobile sources	PM_{10}, $PM_{2.5}$ NOx, CO, COV, SO_2	On-road	Buses, trucks, private and commercial vehicles, taxis, and motorcycles.
		Off-road	Construction or agriculture machinery, airport or port operations.
Fugitive Sources	PM_{10}	Natural	Resuspended Dust from: Wind Erosion [5] Marine Aerosol [6]
		Anthropogenic	Resuspended Dust from: Construction of buildings Unpaved roads

Source: Authors' own elaboration, based on Jorquera (2007).

To analyze pollutant emissions at a regional level, it is necessary to have accurate information about the location and emitted pollutants by different sources. Few cities in our country have a thoroughly detailed emission inventory and, in general, they are cities with a significant number of inhabitants or areas with mega industrial sources.

Tocopilla, Calama and Antofagasta stand out among the cities being monitored. They are also the capital cities of the three provinces that make up the Antofagasta Region: Tocopilla, El Loa and Antofagasta. Two of them have been declared PM_{10} saturated zones in 2007 and 2009.

Tocopilla was declared a PM_{10} saturated zone due to its annual concentration through Supreme Decree 50/2007 and due to its 24-hour concentration through Supreme Decree 74/2008, both by the Ministry General Secretariat of the Presidency. The most significant sources that contribute to PM_{10} emissions in this city include: Marine aerosol, wind erosion, thermoelectric power plants and the mining industry. In the case of $PM_{2.5}$, only four sources were identified, of which the most significant ones are thermoelectric power plants, which contribute 62 percent of emissions. Because of that, today there is a Decontamination Plan in place, which considers emission reduction measures related to these sources, as well as to the rusted minerals processing and agrochemical product storage industries.

[5] *Soil dust removal by the natural action of the wind when its speed surpasses a limit value. This phenomenon is favored by arid or semi-arid soils with scarce vegetation cover.*

[6] *An aerosol is a mixture of solid and liquid particles suspended in a gas. A marine aerosol is generated by the action of the wind on the ocean surface and it is characterized by having high concentrations of chloride, sulfate and sodium.*

In contrast to Tocopilla, where there is a significant contribution made by thermoelectric power plants to the emission of pollutants, in the city of Calama the pollution associated with $PM_{2.5}$ is determined by emanations in the productive processes of large mining, representing 54 percent of the contribution in the urban area and 75 percent in the rural area of the total emissions of fine PM. It is necessary to mention that the city of Calama stands out for generating the greatest amount of resources at the national level, due to copper mining, since the largest deposits –Chuquicamata and Radomiro Tomic– are located close to the city (CONAMA, 2008). Regarding PM_{10}, the greatest contribution comes from fugitive emissions caused by wind erosion and re-suspended dust due to vehicle traffic on unpaved roads.

On the other hand, although the city of Antofagasta is not in a saturated state, PM_{10} emissions mainly originate from the calcium contributed by the cement industry, followed by sodium, potassium, silicon and sulfur. Regarding the $PM_{2.5}$ composition, the predominant element is sulfur, which is present as sulfate. The contribution of mining industries in this city reaches between 44 and 48 percent of the total emissions, considering cement companies, non-metal plants and foundries (DICTUC, 2008).

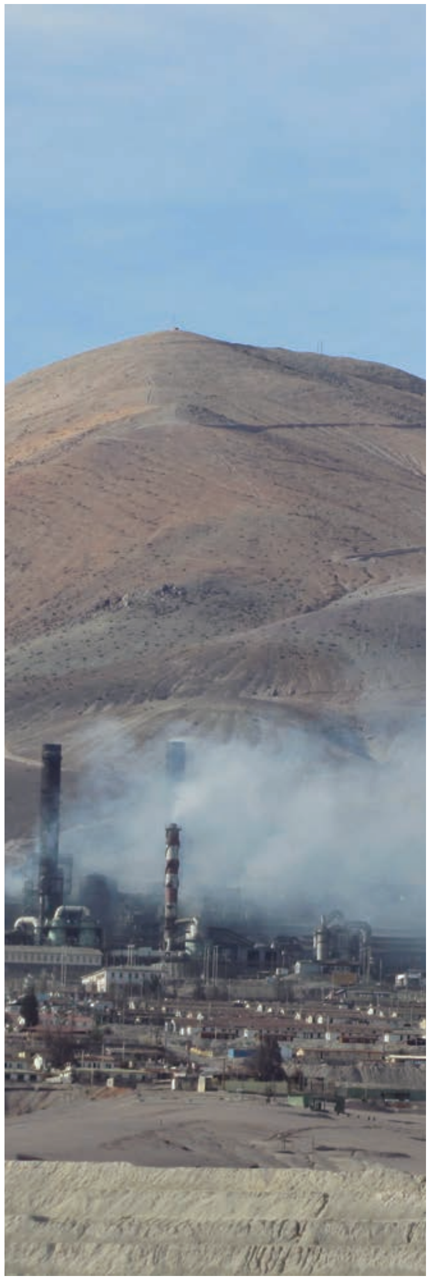
Another location in northern Chile that has been monitored because it is a saturated area is the commune of Andacollo, where PM_{10} analyses have been conducted. The chemical elements with greatest presence in the PM_{10} analyses are iron, sulfur, potassium and chloride, among which the predominant element is iron, contributing 45 percent to the total emissions (MMA, 2015a).

Regarding emissions inventories carried out in the area, it can be said that the greatest source of PM_{10} is the circulation of trucks in the two mining sites that contribute 69 percent of the commune's emissions (Municipalidad Andacollo, 2011). Based on that, on January 1, 2015 the Air Decontamination Plan entered into force for Andacollo and its surrounding sectors, establishing that mining companies must reduce their emissions by 65 percent within a two-and-a-half-year deadline starting on the date the plan entered into force.

In the Valparaíso region, the Concón, Quintero and Puchuncaví communes have consolidated as one of the main industrial areas in the country, considering industrial facilities, the activities carried out and the job creation associated with the great demand for labor (MMA, 2013). The main industries present in the area include thermoelectric power plants, oil refineries, chemical industries, liquid natural gas plants and copper foundries. This broad industrial activity focused in this area brought about negative externalities. Because of that, in 1993 it was declared a saturated area due to the high presence of sulfurous anhydride and particulate matter in the areas surrounding the Ventanas industrial compound, located in the Puchuncaví commune.

In 2015, according to measurements in the monitoring stations with population representation (EMRP by their acronym in Spanish) conducted by the Superintendency of the Environment, it was concluded that the $PM_{2.5}$ primary standard for annual concentration is being surpassed (Concón station measurements) and that the daily concentration is in a state of latency (Concón, Puchuncaví, La Greda and Quintero stations); and that the standard for particulate matter (PM_{10}), in terms of annual concentration, is in a state of latency (Concón, Quintero, La Greda), according to what is explicitly expressed in Supreme Decree 10/2015 of the Ministry of the Environment.

Regarding the Metropolitan Region, on October 4, 2016 a new Air Decontamination Plan was announced, titled Santiago Breathes, which will replace the current plan (Supreme Decree 66/2010 of the Ministry General Secretariat of the Presidency). In contrast to the old plan, it addresses the damage associated


Emission sources I FRANCISCO DONOSO

with $PM_{2.5}$ and includes measures such as the full ban on fuelwood heating, a new Transantiago fleet with emission levels similar to the strictest technology at the international level (Euro VI), the creation of legislation for off-road machinery and stricter legislation for the industrial sector that will enable reducing $PM_{2.5}$ emissions by 30 percent.

The central area of the valleys of the O'Higgins Region includes 17 communes and was declared a saturated zone due to breathable particulate matter (PM_{10}) based on Supreme Decree N°7/2009 of the Ministry General Secretariat of the Presidency. In that area, it was observed that during the fall-winter period the concentrations of $PM_{2.5}$ and PM_{10} increase due to the atmosphere's stability (low ventilation conditions) and the increase of seasonal emissions. A study conducted in Rancagua, Rengo and San Fernando revealed that the main $PM_{2.5}$ emission sources are biomass combustion (66 percent), secondary aerosols (11-20 percent) and wind erosion (22-27 percent). Regarding $PM_{2.5}$, Rancagua shows the greatest concentrations in comparison to Rengo and San Fernando. On the other hand, the results for PM_{10} are similar, because of the predominance of the fine fraction over the PM_{10} (MMA, 2011c).

In Talca, the percentage contribution to PM_{10} emissions as a result of residential fuelwood consumption is even greater than in the O'Higgins communes, reaching a contribution to 77 percent of emissions. Because of that, in March 2016 the Air Decontamination Plan for the Talca and Maule communes was published in the Official Gazette (Supreme Decree N°49/2015 of the Ministry of the Environment), which –just like the plans in the southern areas of the country– includes specific measures aimed at promoting the use of sustainable heating.

In the Biobío Region, Metropolitan Concepción has been declared a saturated area due to $PM_{2.5}$ fine particulate matter (Supreme Decree N° 15/2015 of the Ministry of the Environment). The communes that make up Metropolitan Concepción are Lota, Coronel, San Pedro de la Paz, Hualqui, Chiguayante, Concepción, Hualpén, Talcahuano, Penco and Tomé, where the most significant sources are the stationary ones and residential fuelwood combustion. Industrial activity is mainly made up of the development of the forestry, petrol-chemical, energy, fishing, agriculture and livestock and metal-mechanic sectors. In terms of the characteristics of $PM_{2.5}$, it was determined that organic aerosols contribute between 52 and 70 percent of fine particulate matter.

On the other hand, the communes of Chillán and Chillán Viejo, also located in the Biobío Region, are saturated areas due to $PM_{2.5}$ and PM_{10} daily concentrations since 2013. The Air Decontamination Plan declared through Supreme Decree N°48/2015 of the Ministry of the Environment established that the main emission sources of $PM_{2.5}$ and PM_{10} breathable particulate matter are residential fuelwood combustion, followed by industries, agricultural burns and wildfires and, finally, mobile sources.

In the Temuco and Padre Las Casas communes, a large part of the $PM_{2.5}$ pollution is due to emanations caused by the use of fuelwood for combustion in stoves and heaters, contributing approximately 90 percent of the emissions during the coldest months, when significant amounts of polycyclic aromatic hydrocarbons (PAH) are released into the atmosphere (Pozo et al.,2015). Temuco and Padre Las Casas are communes currently declared as saturated areas due to $PM_{2.5}$ and PM_{10} through Supreme Decree N° 35/2005 of the Ministry General Secretariat of the Presidency and Supreme Decree N° 2/2013 of the Ministry of the Environment. Because of this last declaration an Air Decontamination Plan was prepared, through Supreme Decree N° 8/2015 of the Ministry of the Environment, published on November 17, 2015, which is in force and being applied.

FUELWOOD EMISSIONS

In Talca, the percentage contribution to PM_{10} emissions as a result of residential fuelwood consumption reaches a contribution to

77%

OF EMISSIONS

The communes of Chillán and Chillán Viejo, located in the Biobío Region, are saturated areas due to $PM_{2.5}$ and PM_{10} daily concentrations since 2013.

Table 05 shows a summary of the composition of the main pollutants, based on chemical characterization studies, which affect the locations mentioned above and the percentage contributions of the main sources responsible for those emissions.

TABLE 05

CHEMICAL COMPOSITION OF POLLUTANTS BY LOCATION

LOCATION	POLLUTANT	SOURCES	COMPOSITION
Tocopilla	PM_{10}	Marine aerosol: 44.7% Specific External Combustion Sources: 28% Mining industry: 19% Wind erosion: 8%	• Large amounts of Cl, Na, S, Mg and Br: contributed by marine aerosol. • Na, Si, Al, Fe, Ca, K: geological dust. • Contributions of sulphur, V and Ni, Mg, Al, Si, K, Ca, associated with volatile ashes ->Thermal power stations.
	$PM_{2.5}$	Specific External Combustion Sources: 62% Marine Aerosol: 8% Wind erosion: 4%	• $PM_{2.5}$ is mainly composed of secondary sulfates.
Calama	PM_{10}	Unpaved streets: 34% Mining industry: 32% Mobile sources: 12% Wind erosion: 22%	• Trace elements were found that are typical of foundries, such as K, Cu, Zn, As, V, Ni and Mo.
	$PM_{2.5}$	Mining industry: 54% Mobile sources: 37% Unpaved streets: 9%	• Elemental Carbon (EC) associated with oil combustion. • K, Cu, Zn, As, V, Ni and Mo related to foundries.
Antofagasta	PM_{10}	Mining industry: 47% Wind erosion: 42% Unpaved streets: 10.6%	• The main element component is calcium. • It is followed by elements such as Na, K, Si and S and, to a lesser extent, by elements such as Cl, Al, Fe and Cu.
	$PM_{2.5}$	Mining industry: 44% Wind erosion: 50% Unpaved streets: 12%	• The main component is sulfur, as sulfate ion. • Secondary elements are Ca and total carbon, followed by nitrate ion, chloride ion, silicon, iron and copper originating from geological dust.
Andacollo	PM_{10}	The main emission source is truck traffic in the mining industry (70%).	• The predominant elements are: Fe, S and K, with percentages of 45%, 14%, 13%, respectively.

CONTINUES ►

TABLE 05

CHEMICAL COMPOSITION OF POLLUTANTS BY LOCATION			
LOCATION	**POLLUTANT**	**SOURCES**	**COMPOSITION**
Concón, Quinteros, Puchuncaví	$PM_{2.5}$	The mining industry in the area (foundries) and specific external combustion sources (thermal power plants) stand out. In addition, the petrol-chemical industries are a significant source of BTEX.	• Cu and Se are among the element components that were most frequently detected. • Toluene, ethylbenzene and xylene, especially in Concón.
Santiago Metropolitan Region	$PM_{2.5}$	Transportation: 19.5% Industrial sector: 15.3% Use of residential fuelwood: 38.5% Off-road machinery: 20%	• Organic carbon: 52% • Elemental carbon: 10% • Inorganic compounds: NO_3(15%), NH_4(14%), SO_4(5%), Cl (4%).
Rengo, Rancagua, San Fernando	$PM_{2.5}$	Biomass combustion: 66% Secondary aerosols: 11-20% Unpaved streets: 22-27%	• The organic fraction is similar for the three sites: 62% in Rengo and 70% in San Fernando and Rancagua. • Secondary aerosols contribute 25%. The remaining fractions present high similarity: C (4%), NH_4 (3%), NO_3 (7%), SO_4 (4%), and other elements (5-6%).
Talca and Maule	PM_{10}	Residential fuelwood combustion: 76.7% Stationary sources: 14.8 % Agricultural burns: 5.3% Mobile sources: 2.6%	•Without information about its composition.
Chillán	PM_{10}	Residential combustion: 86% Mobile sources: 7% Burns and wildfires: 3.9%	• Organic matter, geological material, nitrates and elemental carbon are the main components of PM_{10}.
Greater Concepción	$PM_{2.5}$	Fuelwood combustion for residential heating Specific sources (industries)	• Organic aerosols contribute between 52 and 70% to $PM_{2.5}$. The rest is divided into nitrates (5%), sulfates (4%), and Chlorides (2%) for the urban sector.
Temuco, Padre las casas	$PM_{2.5}$	Primary: Fuelwood combustion 30.4% Coal 5.1% Dust 2.3% Vegetable waste 0.7% Secondary: Inorganic 4.1% Organic 52.8% Undetermined: 3.6 %	• Marine aerosol: Na and Cl. • Dust: Al, Si, Ti and Fe oxides. • Fuelwood: contributes sugar (cellulose), organic acids (hemicellulose) and polycyclic aromatic hydrocarbons (PAH). • Mobile sources: Hopanes, elemental carbon, PAH.

The PRTR Report was considered in order to characterize and analyze PM_{10}, $PM_{2,5}$, NOx and SOx emissions, which includes declared information up to 2013. Based on this information, at the national level the measurements revealed approximately 436,209 metric tons per year of $PM_{2.5}$ in 2013, 218,899 metric tons per year of SOx in 2013 and 229,401 metric tons per year of NOx in 2013. The main emission sources at the national level are fuelwood burning for residential heating for $PM_{2.5}$, copper foundries and thermoelectric power plants for SOx and mobile sources and other industrial processes for NOx.

FIGURE 05

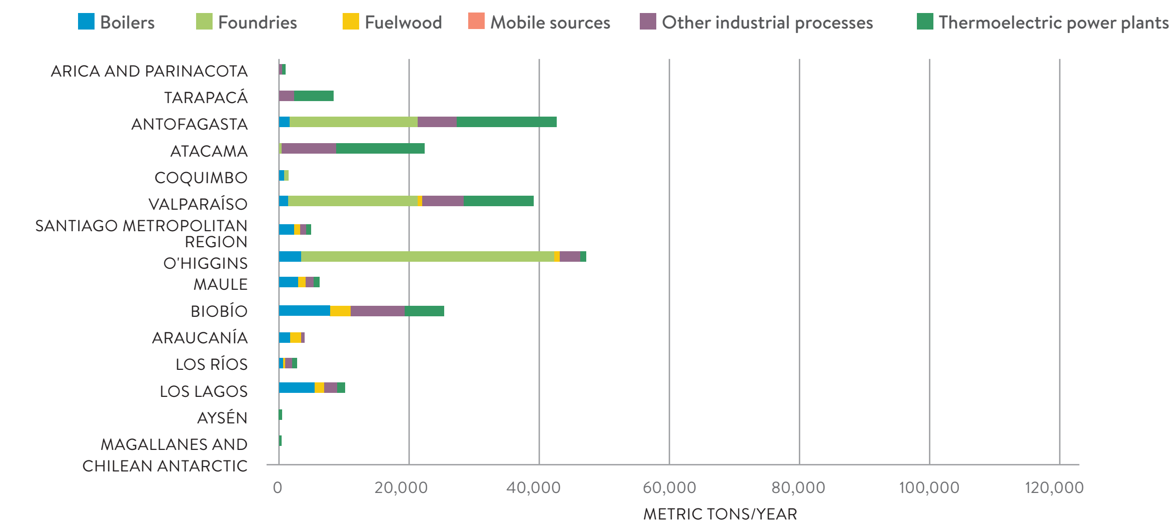
DISTRIBUTION BY TYPE OF SOURCE, 2013

Source: Authors' own elaboration based on MMA (2016a)

At the same time, an analysis was conducted by region. According to this analysis, the predominant sources in northern Chile are copper foundries and thermoelectric power plants, in the central area they are industrial, residential and mobile sources, and in the south they are residential heating with fuelwood.

FIGURE 06

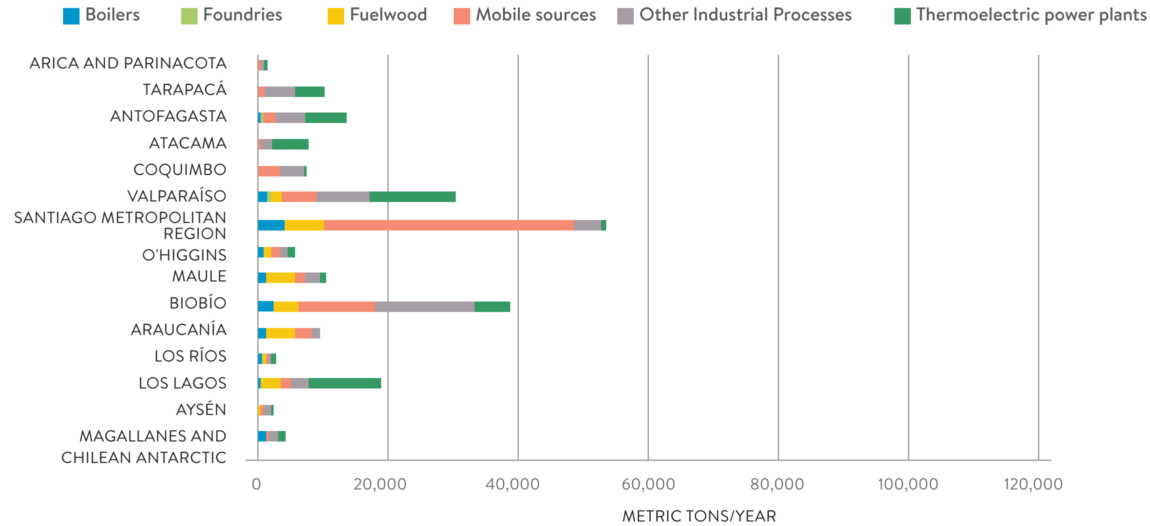
SO_2 EMISSIONS CHART BY REGION AND SECTOR, 2013



Source: Authors' own elaboration based on MMA (2016a)

FIGURE 07

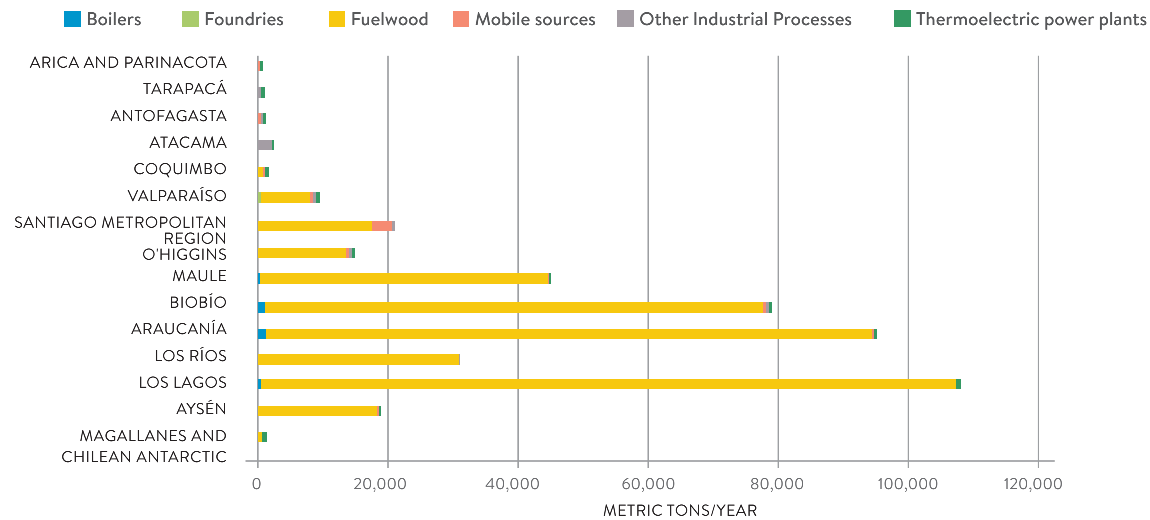
NOx EMISSIONS CHART BY REGION AND SECTOR, 2013



Source: Authors' own elaboration based on MMA (2016a)

FIGURE 08

$PM_{2.5}$ EMISSIONS BY REGION AND SECTOR, 2013



Source: Authors' own elaboration based on MMA (2016a)

01

PRTR ESTIMATE OF FUELWOOD COMBUSTION EMISSIONS

Residential fuelwood emissions were estimated using a top-down methodology, which included fuelwood consumption obtained from the 2006 CASEN survey and emission factors that incorporate variables such as humidity, type of artifact, bad operation and geographical area involved, which were revealed by the latest studies and inventories carried out in different regions and cities of the country by the ministries of Energy and Environment. In addition, it considered information from the Ministry of the Environment's heater replacement programs.

In order to develop the time series with annual emissions, population growth based on the projections made by the National Statistics Institute (INE by its acronym in Spanish) was considered. It is worth noting that emissions presented for residential fuelwood consumption may be overestimated, due to the error margin in the expansion of fuelwood consumption at the national level and the methodological considerations in the calculation of emissions, in addition to the lack of studies in some regions.

4 • 2014-2018 AIR DECONTAMINATION STRATEGY

Air contamination is one of Chile's main environmental issues, both due to its consequences for people's health as well as for the environment. Air quality is mostly affected by particulate matter. Because of that, the country currently measures this pollutant in 25 cities. The problem, which is more serious in the central and southern areas of the country, increases as cities become larger. Although decontamination plans are being developed, air quality exceeds the levels established in the quality standards, especially for $PM_{2.5}$.

In this context, the Ministry of the Environment prepared the 2014-2018 Air Decontamination Strategy, which seeks to address the pollution affecting the country, especially in the cities in southern Chile and in the Santiago Metropolitan Region.

The strategy defines two large lines of action. On the one hand, the implementation of decontamination plans that present effective measures for reducing emissions in the areas declared saturated or latent and, on the other hand, the implementation of short-term measures in places where there are no plans and where monitoring reveals high concentrations of particulate matter.

The strategy establishes the creation of 14 air decontamination plans in four years. Therefore, by 2018 the country will have 20 decontamination plans in force, which will benefit 87 percent of the population exposed to air pollution problems.

The strategy is complemented with the new national legislation that will continue to be improved. Emission standards, along with quality standards, are tools aimed at preventing and controlling the concentration of pollutants in the air. In cases where quality standards are surpassed, the law establishes other tools such as prevention or decontamination plans, whose elaboration begins once the decree declaring an area as latent or saturated has been issued[7]. At present, Chile has emission standards[8] for stationary and mobile sources, detailed in **Table 06**.

[7] *The prevention plan is a tool aimed at preventing the exceedance of one or more primary or secondary environmental quality standards in an area, while the decontamination plan seeks to recover the levels indicated in said standards in an area declared as saturated.*

[8] *According to Law 19.300, emission standards are those that "establish the maximum permissible amount of a pollutant measured at the effluent of the emission source."*

TABLE 06

CURRENT EMISSION STANDARDS, BY SOURCES

SOURCE	ACTIVITY	POLLUTANTS	SCOPE	SUPREME DECREE
Stationary Sources	Cooper foundries and Arsenic-Emitting Sources	PM, SO_2, As and Hg	National	SD N° 28/2013 MMA
	Kraft or Sulfate Pulp Production	TRS compounds	National	SD N° 37/2013 MMA
	Incineration and Co-incineration	PM, SO_2, NOx, TOC, CO, heavy metals, HCI, HF, benzene, dioxins and furans.	National	SD N° 29/2013 MMA
	Thermoelectric Power Plants	PM, SO_2, NOx, Hg	National	SD N° 13/2011 MMA
	Stationary Sources, Specific and Group Sources*	PM	Metropolitan Region	SD N° 4/1992 MINSAL
Residential Sources	Fuelwood heaters	PM	National	SD N° 39/2011 MMA
Mobile sources	Light and Medium Vehicles	CO, HC, NOx, Particles	Metropolitan Region, Regions V and VI	SD N° 54/1994 MTT
	Heavy Vehicles	CO, HC, NOx, PM	Metropolitan Region, Regions V, IV, VI, VII, VIII, IX and X	SD N° 55/1994 MTT
	Public Transportation Buses	CO, HCT, HCNM, CH_4, NOx and PM	Metropolitan Region	SD N° 130/2001 MTT
	Light Vehicles	Total HC, CO, NOx, Particles	Metropolitan Region, Regions V and VI	SD N° 211/1991 MTT
	Emissions Control in Technical Inspection Stations	NO, HC and CO	Metropolitan Region	SD N° 149/2006 MTT

MTT: Ministry of Transportations and Telecommunications; MMA: Ministry of the Environment; MINSAL: Ministry of Health.

*Stationary Source: Any source designed to operate in a fixed location, whose emissions are discharged through a duct or chimney. Those mounted on vehicles to facilitate their transportation are included.

Specific Stationary Source: Any stationary source whose volumetric flow emissions are higher or equal to a thousand cubic meters per hour (1,000 m^3/hr) under standard conditions, measured at full load.

Group Stationary Source: Any stationary source whose volumetric flow emissions are lower than a thousand cubic meters per hour (1,000 m^3/hr) under standard conditions, measured at full load.

Source: Authors' own elaboration

Just like the standards, prevention and decontamination plans have been essential for the environmental management of the air in Chile[9]. According to the Environmental Framework Law 19.300, the actions to be implemented under the Prevention and Decontamination Plans framework may include emission standards, tradable emission permits, emission taxes or fees to users, and other encouragement tools for actions to improve and restore the environment (Art. 47). **Table 07** shows the current state of decontamination plans.

[9] *The conditions for the use and preparation of these tools are established in Supreme Decree N° 39/2012 of the Ministry of the Environment, which approves the Regulation for Passing Prevention and Decontamination Plans.*

TABLE 07

CURRENT STATE OF DECONTAMINATION PLANS	
SITUATION	**LOCATION**
Plans In-Force	1. Tocopilla
	2. María Elena – Pedro de Valdivia
	3. Chuquicamata
	4. Potrerillos
	5. Paipote – Tierra Amarilla
	6. Puchuncaví and Quintero (Ventanas)
	7. Santiago Metropolitan
	8. Central Valley of the Libertador Bernardo O'Higgins Region
	9. Caletones
	10. Temuco and Padre las Casas
	11. Andacollo
	12. Talca - Maule (PM_{10})
	13. Chillán - Chillán Viejo
	14 Osorno
	15. Coyhaique (PM_{10})
Development of Definitive Project	1. Huasco
	2. Concón, Puchuncaví and Quintero (Ventanas)
	3. Valdivia
	4. Los Ángeles
	5. Santiago Metropolitan ($PM_{2.5}$) (*)
Draft projects	1. Greater Concepción
	2. Curicó
	3. Coyhaique ($PM_{2.5}$)

Source: MMA 2015a

(*) The Air Decontamination Plan has been approved by the Council of Ministers.

4.1 Management of Critical Episodes at the National Level

Critical air pollution episodes due to particulate matter, including both PM_{10} and $PM_{2.5}$, have historically been addressed in air decontamination plans through Critical Episodes Management Plans. These management plans establish measures to prevent and control emissions of particulate matter, with the objective of reducing the population's exposure to high concentrations of this pollutant, particularly in urban and urban-industrial areas.

The lack of decontamination plans in the main cities of the central and southern zones of Chile created the need to establish a coordination between the authorities of the Ministry of Health and the Ministry of the Environment. This led to the passing of Supreme Decree N° 11/2015 of the Ministry of Health on the condition of $PM_{2.5}$ Sanitary Warning between the Santiago Metropolitan and the Aysén regions. This decree enabled the implementation and supervision of measures to reduce the emission of pollutants, particularly in days when bad ventilation conditions were observed.

Within the framework of the exception decreed by the Ministry of Health, measures were established for declaring the state of air quality (warning, pre-emergency or environmental emergency) putting in place, according to the expected air quality, the following measures:

- Restriction of the use of fuelwood for heating in places where it is pertinent (households and/or communities). To that end, urban restriction polygonals will be established to enable reducing emissions during episodes (in pre-emergency and emergency).

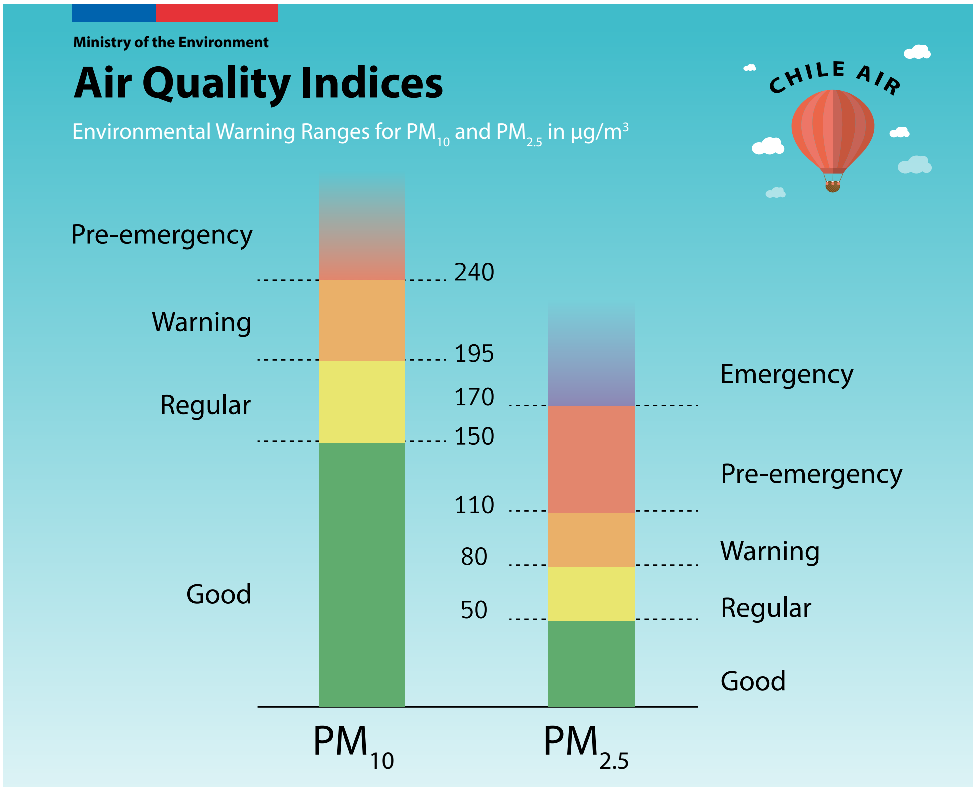
- Paralyzation of stationary sources. Based on the records of the sanitary authority and the establishment of an emission threshold, stationary sources with large emissions will be paralyzed (in pre-emergency and emergency).

- Informing the population of health risks. Recommendations will be made to limit practicing massive sports and outdoor activities and replacing physical education classes, in coordination with the Ministry of Education, for learning activities in the classroom at schools while high concentrations of pollutants are observed (in warning, pre-emergency and emergency).

- Multisectoral supervision program. Supervision of stationary sources that must be paralyzed will be strengthened, according to the restrictions established by the authority (in pre-emergency and emergency).

FIGURE 09

AIR QUALITY INDEX IN TERMS OF PARTICLES



Source: Department of Monitoring Networks, MMA.

02

THE CASE OF SANTIAGO

Air quality management in the Santiago Metropolitan Region began with the passing of Supreme Decree (SD) N° 131/1996 dated June 12th, 1996 of the Ministry General Secretariat of the Presidency (MINSEGPRES by its acronym in Spanish), which declared the area as saturated by particulate and gaseous pollutants. In this context, the first Air Prevention and Decontamination Plan for the Metropolitan Region (APDP) was implemented through Supreme Decree N°16/1998, whose objective was to achieve the compliance with primary air quality standards and was then updated and afterwards reformulated through Supreme Decree N °58/2003 and Supreme Decree N °66/2009, respectively, both of them issued by the MINSEGPRES. The current Decontamination Plan contains the air quality goals and measures aimed at controlling emissions from the main sources of pollution identified in the Santiago Metropolitan Region.

Although most of the pollution in this Region is essentially explained by human activities, it is important to take into account that its geographical and ventilation conditions expressed in the high levels of atmospheric stability, especially between the months of April and August, prevent an adequate removal of pollutants from the basin, favoring the increase in their concentration, the exceedance of standards and the occurrence of critical pollution episodes.

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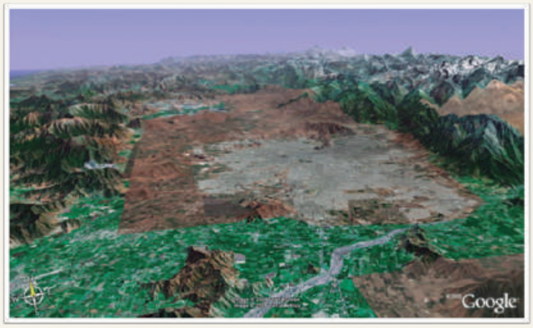


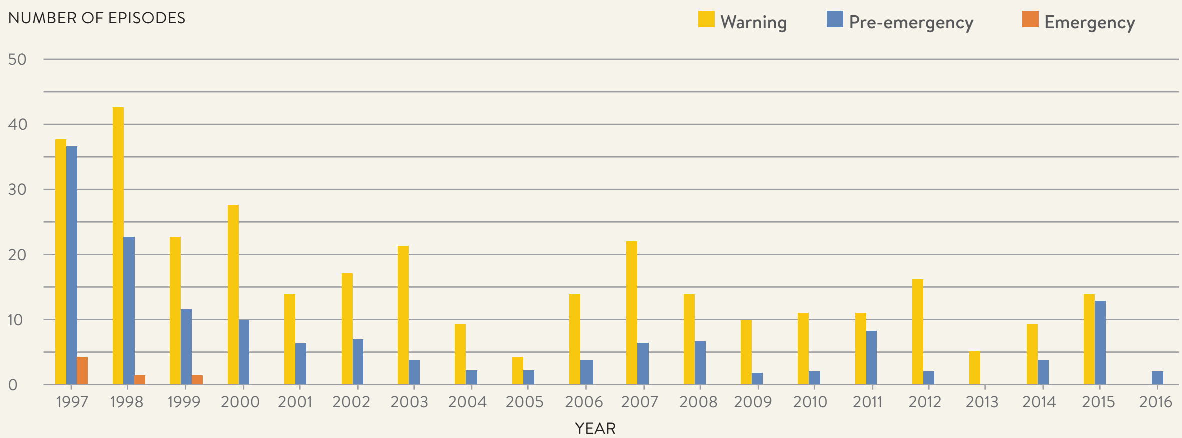
a) Schematic of the geography of the Santiago basin, where the Coastal and the Andes mountain ranges can be observed as well as the conurbation of the Greater Santiago.

b) View of Santiago showing the effect of morning stability associated with the radiation temperature inversion over the city.

The measures included in the APDP have helped to reduce, gradually and systematically, the high levels of pollution during the last decade, enabling to diminish the intensity and duration of PM_{10} critical episodes over time. Thus, in 1997 there were 38 warning days, 37 pre-emergency days and 4 environmental emergency days, while in 2016 there were only two pre-emergency events (see **Figure 10**). In the case of $PM_{2.5}$, as previously indicated, starting with the implementation of the sanitary warning measures - since 2015 – Critical Episodes Management is conducted for that pollutant, applying prevention measures during the April-August period. **Figure 11** shows that in 2016 there was a total of 42 critical episodes, which represented a reduction by 18 percent in comparison to 2015. This was possible despite the occurrence of environmental emergencies.

FIGURE 10

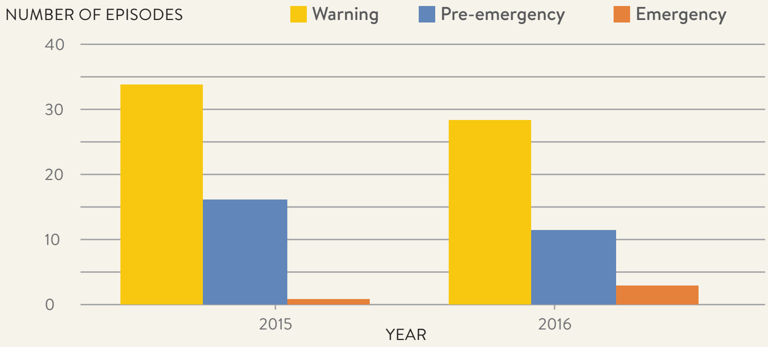
SUMMARY OF CRITICAL PM_{10} EPISODES IN THE METROPOLITAN REGION



Source: Department of Monitoring Networks, MMA.

FIGURE 11

NUMBER OF RECORDED $PM_{2.5}$ EPISODES, APRIL 1 – AUGUST 31, METROPOLITAN REGION

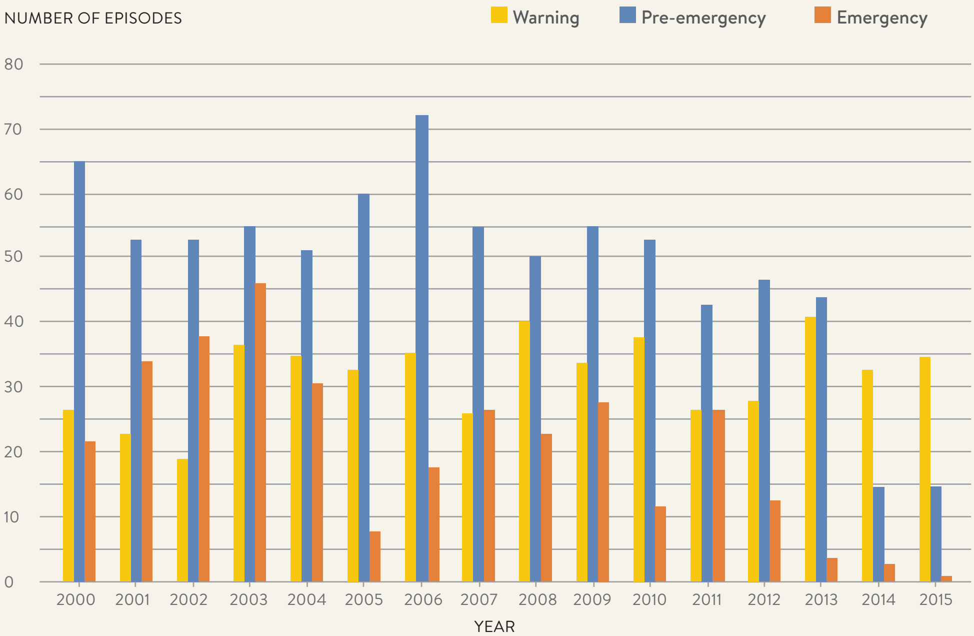


Source: Department of Monitoring Networks, MMA.

Regardless, the $PM_{2.5}$ emergencies declared do not represent a setback in air quality in the Santiago Metropolitan Region, but rather respond to a change in the standard that enabled taking contingency measures during episodes that had not been previously considered. According to the preliminary results of the study “Characterization of Fine and Coarse Particulate Matter in the Metropolitan Region”, which is ongoing, a re-construction has been made of $PM_{2.5}$ concentrations and, hence, of the potential pollution episodes from 2000 to 2015, as shown in Figure 12. The study correlates historical air quality measurements based on the new measurement standards, concluding the $PM_{2.5}$ critical episodes maintain a consistent reduction over time.

FIGURE 12

ESTIMATED NUMBER OF $PM_{2.5}$ EPISODES IN THE METROPOLITAN REGION

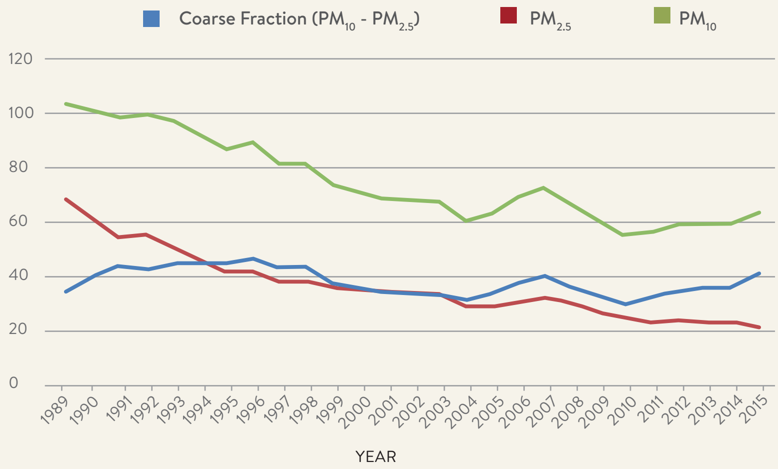


Source: Study of the Characteristics of Fine and Coarse Particulate Matter in the Metropolitan Region.

CONTINUES ▶

FIGURE 13

EVOLUTION OF BREATHABLE PARTICULATE MATTER. FINE AND COARSE FRACTION (1985-2015)



Source: Department of Monitoring Networks, MMA.

Although the primary air quality standard entered into force in 2012, $PM_{2.5}$ has been monitored in the Santiago Metropolitan Region since 1989, considering that this pollutant has the greatest impact on people's health. **Figure 13** shows the historical monitoring of particulate matter trends developed with the discreet gravimetric method, obtaining concentrations for both the $PM_{2.5}$ and the coarse fraction, which add up to the PM_{10}[10]. Monitoring has systematically been conducted in the Las Condes, Independencia and Santiago stations.

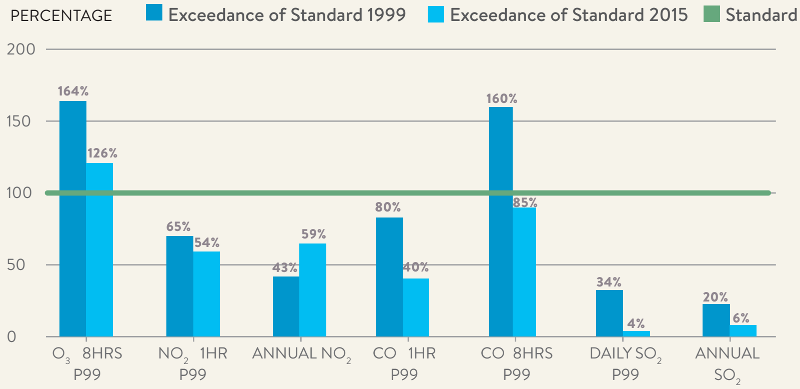
The results of this monitoring indicate that, during the entire period, the reduction of average concentrations of particulate matter are associated with the achieved decrease of $PM_{2.5}$, which presents an accumulated reduction of 68 percent (a reduction of 47 μg/m^3). This is explained because the Decontamination Plan for the Metropolitan Region (APDP) targeted the control of combustion processes.

Regarding the monitoring of gases, **Figure 14** shows a comparison of the compliance with the standard between 1999 and 2015 for the Metropolitan Region. Overall, a significant reduction is observed in the concentrations of ozone (O_3) and carbon monoxide (CO), which dropped 38 and 75 percent, respectively. Because of this, saturation due to ozone and latency due to CO are maintained.

[10] *The coarse fraction is the result of the subtraction between the PM_{10} and $PM_{2.5}$ concentrations.*

FIGURE 14

EXCEEDANCE OF TRIANNUAL STANDARD (%)



Source: Department of Decontamination Plans.

Santiago Breathes

Santiago Breathes is the new Air Decontamination Plan for the Metropolitan Region, which contains a series of measures to tackle air pollution in the city. It is mainly aimed at reducing fine particulate matter ($PM_{2.5}$).

The measures proposed for reducing pollution basically target the transportation, industry and residential sectors, in addition to other cross-cutting measures that establish better mechanisms for emissions compensation, supervision and the promotion of clean transportation such as bicycles and electric vehicles.

With its application, it is estimated that by 2026 the Santiago Breathes decontamination plan will establish sectoral reductions[11] of $PM_{2.5}$ concentrations of 95 percent for the residential sector, 47 percent for transportation, 48 percent for the off-road machinery subsector, 41 percent for the industrial sector, 7 percent for the agroindustry subsector, and a full reduction of emissions from agricultural burns, thus enabling the compliance with the annual and daily $PM_{2.5}$ standards for the period.

[11] *Reductions calculated in comparison to the 2026 baseline.*

FIGURE 15

EMISSIONS REDUCTION BY SECTOR BY 2026

Source: MMA

CONTINUES ▶

According to the General Social and Economic Impact Analysis (AGIES by its acronym in Spanish), the estimated net benefits for the Decontamination Plan for the Metropolitan Region are approximately USD $6,965 million at their current value, highlighting the contribution of the transportation sector (off-road and on-road machinery), whose set of measures would account for 61 percent of the total benefits, as well as 92 percent of the estimated costs.

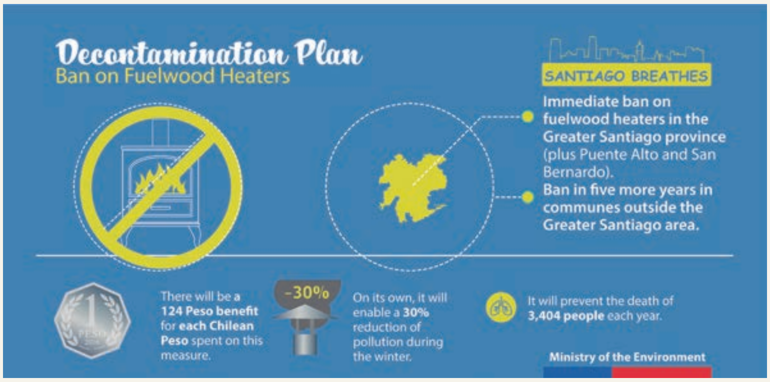
The main measures proposed for each sector include:

Residential Sector: The immediate ban of the use of heaters based on fuelwood in Greater Santiago (Santiago province and the Puente Alto and San Bernardo communes), and within a five-year timeframe – in case of non-compliance with quality standards – in communes outside Greater Santiago.

This sector has a significant cost-effectiveness index, since it is estimated each CLP $1 spent in its design and implementation will render a benefit of CLP $124. In addition, in isolation, it would enable reducing the $PM_{2.5}$ concentration by 30 percent by 2026, which would prevent the death of 3,404 people during the 2017-2026 period.

FIGURE 16

BAN ON FUELWOOD HEATERS



Source: MMA

The new provisions on the industry sector establish greater requirements for reducing emissions, along with an ongoing monitoring system for large sources, thus diminishing their $PM_{2.5}$ concentration by 41 percent by 2026, which would represent a 16 percent reduction of the total concentration of this pollutant in the Metropolitan Region by that same year.

The measures related to the transportation sector are structured according to their different classifications, also considering those linked to fuels.

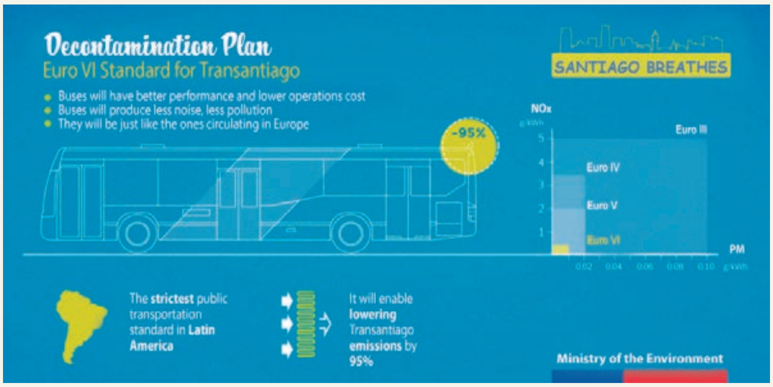
Some outstanding measures aimed at public transportation include the requirement of the Euro VI standard for the Transantiago fleet, in addition to a program for monitoring vehicle emissions in the bus system and incentives for the reduction of emissions and energy efficiency.

A low emission zone is established for the freight forwarding sector within the Metropolitan Region. At the same time, existing off-road machinery will face emissions reduction requirements, while a new legislation will condition the entrance of new equipment.

The most outstanding sectoral measures related to transportation in light and medium vehicles are the permanent restriction of two digits according to their manufacturing year for vehicles with a green seal during the most critical months for bad air quality (May to August), greater degree of requirements for controlling emissions in roadworthiness control plants, and different incentives for the purchase of hybrid and electric vehicles.

FIGURE 17

EURO VI STANDARD FOR TRANSANTIAGO



Source: MMA

In addition, other cross-cutting measures are established, such as the creation of a “Green Fund” for Santiago aimed at financing emissions compensation projects, along with the increase of 100 hectares of new green areas and vegetation mass surrounding the Santiago basin. There are also measures for educating the population on topics related to critical episodes and agricultural, forestry and residential burns, among others.

03

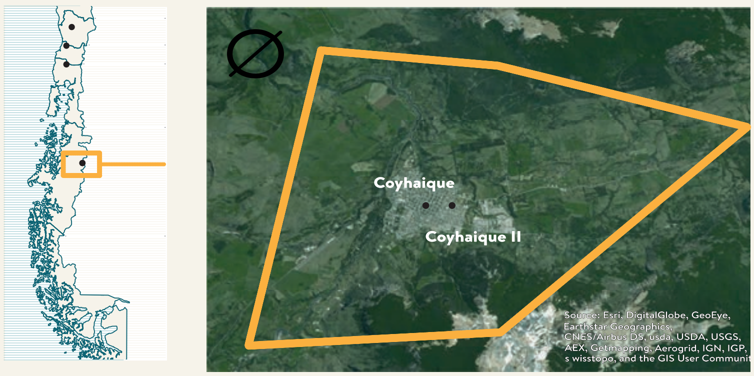
COYHAIQUE

The Coyhaique commune is located in the Aysén Region, in the southern zone of the country. The city is characterized by having a cold climate throughout most of the year. Since most of the housing built in Coyhaique does not have good thermal insulation, this generates a high demand for heating. Given that firewood is the cheapest fuel, its massive use causes high indices of air pollution, specifically of PM_{10} and $PM_{2.5}$. Within the city there are two stations monitoring air quality and meteorological parameters, the Coyhaique and Coyhaique II stations, which measure PM_{10} and $PM_{2.5}$.

In 2012, the area surrounding the city (see map) was declared an area saturated with PM_{10}, after broadly exceeding the daily and annual standards. Its high concentrations are among the highest in the world. The number of health warnings is also among the highest in the country, with 12 emergencies declared in 2015. Because of this problem, a new PM_{10} Air Decontamination Plan (ADP) was put in place on March 28, 2016.

FIGURE 18

MAP OF THE CITY OF COYHAIQUE. PM_{10} SATURATED AREA



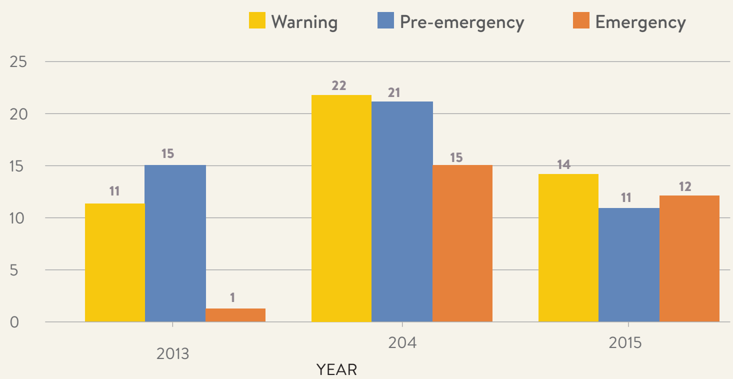
• Air quality station

Saturated or Latent Area

Source: MMA 2016c.

FIGURE 19

RECORDED PM_{10} EPISODES IN COYHAIQUE



Source: Department of Monitoring Networks, MMA.

This ADP considers at least 7,000 thermal refurbishment subsidies for housing in Coyhaique's saturated area and 10,000 replacements of fuelwood heaters for cleaner heating systems. In addition, a fuelwood collection and drying center will be set up harboring a volume of 100,000 m^3, representing a third of what is currently consumed in Coyhaique. To date, the Seremi of the Ministry of the Environment has carried out fuelwood heater replacement programs as shown in the following **table**.

TABLE 08

CHEMICAL COMPOSITION OF POLLUTANTS BY LOCATION

YEAR	FUELWOOD HEATERS	KEROSENE HEATERS	PELLET STOVES	FUELWOOD STOVES
2011 (Pilot)	300	0	0	
2012-2013	1,580	0	0	
2014-2015	182	122	0	
2014-2015 (Public Agencies)	0	0	170	
2014-2015				440
2016 (I Semester)	500	390	35	
Total	2,562	512	205	440
Total to date	3,719			

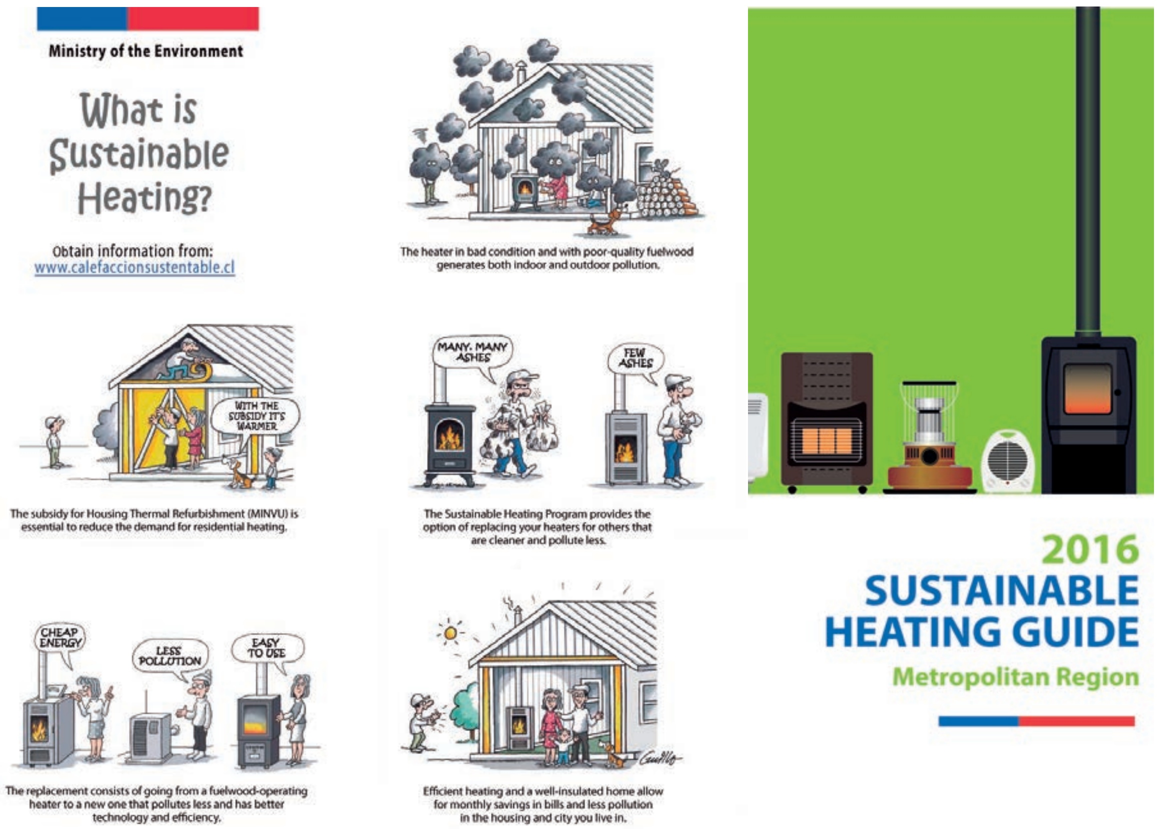
Source: Environment SEREMI Aysén Region

Houses with (right) and without (left) thermal refurbishment, Coyhaique | JIMENA SILVA

4.2 Sustainable Heating

The Sustainable Heating Guide is the first guide for people living in polluted areas in central and southern Chile that provides relevant information on heating, so that citizens can make informed decisions when purchasing or using the different available options. This guide informs about the main heating technologies available in the market, along with their essential characteristics, describing in a clear and friendly manner their advantages and disadvantages, from the environmental, practical and economic perspectives.

Thus, by providing information about the pollution produced by each option, both within the home and to the atmosphere, the guide shows the investment and operation costs of the different technologies with their corresponding fuels. Finally, a series of general and specific recommendations are provided on sustainable heating for each type of housing.



Source: MMA

4.3.1 Heater Replacement Program

The Heater Replacement Program is a structural measure in most of the air decontamination plans in the cities of central and southern Chile. Through it, beneficiaries can access a new heating system that is more efficient and less polluting when they hand in their old fuelwood heather and/or stove. The number of replacements established in each plan enables reaching the air quality standard in each city. The following **table** shows the number of replacements committed in each air decontamination plan.

TABLE 09

REPLACEMENTS COMMITTED IN EACH AIR DECONTAMINATION PLAN

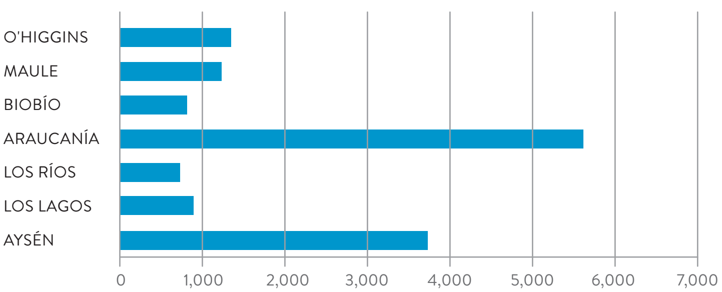
AIR DECONTAMINATION PLAN	TOTAL HEATERS TO BE CHANGED	NON-FUELWOOD HEATERS (PERCENTAGE OF THE TOTAL) [12]
17 Communes in the Central Valley of O´Higgins	12,000	
Talca and Maule	13,000	
Chillán and Chillán Viejo	20,000	10,000 (50%)
Temuco and Padre Las Casas	27,000	12,000 (44%)
Valdivia (*)	26,000	13,000 (50%)
Osorno	25,000	10,000 (40%)
Coyhaique	10,000	5,000 (50%)

Source: Office of Sustainable Heating and New Technologies, MMA.
(*) Valdivia's Air Decontamination Plan is not yet in-force.

The Heater Replacement Program has been implemented since 2011 and, to date, more than 12,000 homes have benefited from it in the Araucanía, Aysén, O´Higgins, Maule, Biobío, Los Ríos and Los Lagos regions. **Figure 20** shows the number of heaters that have been replaced in each region:

FIGURE 20

HEATER REPLACEMENTS SINCE 2011 TO DATE BY REGION



Source: Office of Sustainable Heating and New Technologies, MMA.

[12] *Heaters that do not use fuelwood as their primary supply.*

Since 2015, multi-option replacements have been implemented, allowing beneficiaries to choose the heating technology that is more suitable for their needs. The alternatives offered vary in each region and include pellet, kerosene, gas and fuelwood heaters that have been certified by the Superintendency of Electricity and Fuels (SEC by its acronym in Spanish).

PELLET STOVES

Pellets are small cylinders composed of compressed sawdust with very low humidity. Just like fuelwood, pellets are cheap fuel with great heating capacity but, in contrast to fuelwood, it produces much less pollutant emissions. These heaters have a thermostat, enabling them to control the temperature within the home, helping reduce fuel expenses.

FORCED DRAFT KEROSENE HEATER

These heaters, in contrast to the traditional kerosene heaters, have the great advantage of not emitting pollutants within the home. Hence, there is no need to open windows for ventilation and they are suitable for sleeping rooms. Since they do not use open flame, they do not represent a risk of burns and, due to their technology, they can control room temperature automatically, contributing to save on fuel.

GAS-FIRED FORCED-DRAFT HEATER

These gas heaters offered by the heater replacement program use forced draft. Hence, combustion gases are emitted outside the home and do not consume its indoor oxygen. Because of this, it is safe to use them in any room.

CERTIFIED FUELWOOD HEATERS

These fuelwood heaters have the Seal of the Superintendency of Electricity and Fuels, which means that they comply with the emission standard, which requires for them to be below 2.5 gr of PM per hour (MMA, 2012). Fuelwood is a cheap fuel and, therefore, accessible for most families.

Source: MMA 2016d

Regardless of the technology used, the replacement always goes hand-in-hand with training, so that the beneficiaries will learn how to use their heaters safely, saving on fuel and reducing emissions to a minimum in the case of fuelwood heaters.

4.3.2 Replacement Program in Non-Residential Buildings

In order to effectively achieve lower pollution levels, it is essential not only for housing to have more efficient and less polluting heating systems. Because of this, the Ministry of the Environment also replaces heaters and boilers in non-residential buildings such as schools, pre-schools, hospitals, etc.

This is the case of the Baquedano School in Coyhaique, where an old fuelwood boiler was replaced by two pellet boilers operating under Swiss technology, each of them with a capacity of 150 kW. This enabled not only to significantly reduce combustion emissions, but also to improve the quality of life of students and teachers by providing them with the necessary warmth to heat the entire school. The project will allow reducing energy consumption by 71 percent, while increasing the average temperature of the classrooms from 7°C to 18°C. This is a pilot project that will serve as a model in the future for other education and health facilities (Ernst Basler and Partner, 2015).

Coyhaique | EL DIVISADERO

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ANNEXES

SECONDARY AIR QUALITY STANDARDS

SUSPENDED PM	SUPREME DECREE	LOCATION	LEVEL	UNIT	METRICS	EXCEEDANCE
Iron in SUSPENDED PM	4/1992	Huasco River Basin	150	mg/m^2	Monthly Arithmetic Mean	Not allowed
Arica and Parinacota	4/1992	Huasco River Basin	30 (Sept., Oct., Nov., and first half of December). The rest of the year, 60.	mg/m^2	Monthly Arithmetic Mean	Not allowed
SUSPENDED PM	4/1992	Huasco River Basin	100	mg/m^2	Annual Arithmetic Mean	Not allowed
Iron in SUSPENDED PM	4/1992	Huasco River Basin	30	mg/m^2	Annual Arithmetic Mean	Not allowed
SO_2	185/1991	North	80	$\mu g/m^3$	Tri-Annual Arithmetic Mean	Not allowed
SO_2	185/1991	South	60	$\mu g/m^3$	Tri-Annual Arithmetic Mean	Not allowed
SO_2	185/1991	North	365	$\mu g/m^3$	Daily Arithmetic Mean	Percentile 99.7
SO_2	185/1991	South	260	$\mu g/m^3$	Daily Arithmetic Mean	Percentile 99.7
SO_2	185/1991	North	1000	$\mu g/m^3$	Hourly Arithmetic Mean	Not allowed
SO_2	185/1991	South	700	$\mu g/m^3$	Hourly Arithmetic Mean	Not allowed

ANNEXES

HEALTH EFFECTS OF SELECTED POLLUTANTS

TYPE OF EFFECT	EFFECT	EXPOSURE	POLLUTANT	CAUSE	AGE GROUP	SOURCE
Premature Mortality	Premature Mortality	Acute	$PM_{2.5}$, PM_{10}	Al	Al	Cifuentes et al. (2000)
			O_3	Al	Al	Bell et al. (2005)
		Chronic	$PM_{2.5}$	Cardiopulmonary	>30	Pope et al. (2004
Medical Actions	Hospital Admissions	Acute	$PM_{2.5}$	Heart Attacks	65+	Ito (2003)
			$PM_{2.5}$	Dysrhythmia	65+	Ito (2003)
			$PM_{2.5}$	Ischemic Heart Disease	65+	Ito (2003)
			$PM_{2.5}$	Chronic Lung Disease	18-64	Moolgavkar (2000)
			$PM_{2.5}$	Chronic Lung Disease	65+	Ito (2003)
			$PM_{2.5}$	Pneumonia	65+	Ito (2003)
			$PM_{2.5}$	Heart Illnesses	18-64	Moolgavkar (2000)
			$PM_{2.5}$		65+	Moolgavkar (2000)
			$PM_{2.5}$	Asthma	0-64	Sheppard (2003)
			O_3	Respiratory Diseases	65+	Schwartz (1995)
	Emergency Room Visits	Acute	$PM_{2.5}$	Asthma	0-17	Norris et al. (1999)
			O_3	Asthma	Al	Peel et al. (2005)

CONTINUES ▶

TYPE OF EFFECT	EFFECT	EXPOSURE	POLLUTANT	CAUSE	AGE GROUP	SOURCE
Activity Restriction	Loss of Productivity	Acute	O_3	Missed School Days	0-17	Gilliland et al. (2001)
			$PM_{2.5}$	Missed Workdays	18-64	Ostro (1987)
			$PM_{2.5}$	Restricted Activity Days	18-64	Ostro (1987)
			$PM_{2.5}$	Low Restricted Activity Days	18-64	Ostro and Rothschild (1989
			O_3	Low Restricted Activity Days	18-64	Ostro and Rothschild (1989
Medical Actions	Hospital Admissions	Acute	SO_2	Respiratory Diseases	65+	Schwartz et al. (2003)
			NO_2	Respiratory Diseases	65+	Fung et al. (2006)
	Emergency Room Visits	Acute	SO_2	Asthma	0-14	Wilson et al. (2007)
			SO_2	Asthma	65+	Wilson et al. (2007)
			NO_2	Asthma	75+	Villeneuve et al. (2007)
			NO_2	Cough	7-14	Schwartz et al. (1994)
	Loss of Productivity		NO_2	Missed School Days	4-12	O'Connor et al. (2008)

Source: DICTUC (2011)
$PM_{2.5}$ Episodes Recorded at the National Level. 2013-2015.

Serrano Glacier during the winter | VALERIA PIZARRO

CHAP **08**

CLIMATE CHANGE

CONTENT

INTRODUCTION

Climate change has become the greatest challenge faced by humanity. Chile is a country highly vulnerable to this phenomenon. Although the share of its national Greenhouse Gases (GHG) emissions are low at a global level, they are rapidly increasing. In 1994, the country signed the United Nations Framework Convention on Climate Change (UNFCCC) and in 2002, the Kyoto Protocol. In 2008, a National Climate Change Plan was launched for the 2008-2012 period, with measures for adapting to climate change, mitigating GHG emissions and building capacity. In 2014, the country published a National Plan for Adaptation to Climate Change and three sectoral adaptation plans have been approved. In 2015, Chile submitted its Intended Nationally Determined Contributions (INDC) for the Paris Climate Agreement. At present, a new National Climate Change Action Plan is being prepared for the 2017-2022 period, one of the goals of the current program of the Government of Chile.

Climate Change
According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

1 • BACKGROUND INFORMATION

Scientists agree that the climate change phenomenon is a fact and that it is mainly caused by human action. This is pointed out in the Fifth Assessment Report (AR5 2013/2014) by the Intergovernmental Panel on Climate Change (IPCC): "Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems (...) Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems."

Climate Change Mitigation
It is a "human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs)" (IPCC, 2014).

However, there are climate change adaptation options and through stringent mitigation activities, climate change impacts can be maintained at a manageable level, creating a clearer and more sustainable future. Furthermore, the IPPC assessment states that: "Since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen" (IPCC, 2014).

Climate Change Adaptation
"The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2014). Several adaptation options can be distinguished, including prevention and reaction, public and private, or autonomous and planned (IPCC, 2014).

There is also concern about climate change among the national population. According to data from the Second National Environment Survey[1] (2015), "a large part of the population agrees that this phenomenon will have concrete consequences in their daily lives (86 percent), stating that this issue is the main environmental challenge for this generation (82 percent)" (MMA, 2016a).

The responsibility for climate change is attributed to the emission of GHG. These gases are naturally present in the planet and allow its temperature to be warm enough for the development of life. However, human activity has increased them, mainly through the burning of fossil fuels and deforestation, thus causing a warming process.

In order to limit global warming to no more than 2°C in comparison to the pre-industrial era, the maximum threshold defined by the UNFCCC, significant reductions of GHG emissions are required, posing a great technological, economic, institutional and behavioral challenge.

[1] *The summary of the results of the Second National Environment Survey are available at: http://portal.mma.gob.cl/wp-content/uploads/2016/03/Segunda-Encuesta-Nacional-de-Medio-Ambiente.pdf*

During the COP21 (21st Conference of Parties), held in Paris in December 2015, a legally binding agreement was reached among the countries that are signatories of the UNFCCC to carry out national actions that will enable maintaining climate change below the agreed temperature threshold[2].

ⓘ Greenhouse Gases (GHG)
According to the IPCC, GHG are "gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)" (IPCC, 2014).

[2] The objectives of the Paris Climate Change Agreement are: Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change; (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

Pure nature | YANKO CARICEO

2 • STATE OF THE ENVIRONMENT AND IMPACTS IN CHILE THAT CAN BE ATTRIBUTED TO CLIMATE CHANGE

Chile has seven of the nine vulnerability characteristics identified by the UNFCCC: low-lying coastal areas; arid and semi-arid areas; forested areas; areas prone to natural disasters; areas liable to drought and desertification; areas of high urban atmospheric pollution; and mountainous ecosystems (MMA, 2011a). In addition, it has a variable and steep terrain, particularly in the Andes and Coastal mountain ranges; its rivers and water reservoirs are susceptible to being affected, especially in the continental ice caps; its oceans, which are a source for fishing, are also a key resource for the country.

The University of Chile conducted a study[3] that projected climate change impacts according to the IPCC's new CO_2 Representative Concentration Pathways (RCP), performing simulations for the most favorable scenario (RCP 2.6, which presents the lowest concentrations of CO_2 due to strong climate mitigation policies) and the least favorable (RCP 8.5, which projects the highest concentrations of CO_2). On the other hand, the Economic Commission for Latin America and the Caribbean (ECLAC)[4] studied the impacts of climate change in Chile, based on the projections of the HadCM3 global climate model prepared by the United Kingdom's Met Office, modelling according to the A2 and B2 emissions scenarios of the Special Report on Emissions Scenarios (GHG SRES). At the same time, the Meteorological Service of Chile (DMC by its acronym in Spanish), in compliance with the commitments made in the 2008-2012 National Climate Change Action Plan (PANCC I by its acronym in Spanish), performed climate modelling using the boundary conditions of the MIROC5 global model to provide input for the Weather Research and Forecasting[5] (WRF) regional model (MMA, 2014a). These studies provide similar conclusions that only differ in the level of intensity of potential future impacts.

Some of the main conclusions are presented below, also including complementary indicators prepared based on available public information regarding the state of the environment and projected impacts on climate variables, environmental components and several relevant sectors for the country.

2.1 Temperatures

2.1.1 Surface Air Temperature

The country has experienced warming inland in the northern, central and southern regions ranging from 0.2 to 1.1°C; cooling, from -0.2 to -0.5 °C, in the extreme southern areas (between latitudes 38° and 43°S); and cooling in the coastal areas of northern and central-southern Chile (between latitudes 17° and 41°S) of -0.2°C per decade (Falvey and Garreaud, 2009), which is in line with the cooling pattern of the Pacific ocean's surface temperatures due to the Pacific Decadal Oscillation (PDO) (Vuille et al., 2015).

The indicators of standardized anomalies in extreme annual temperatures[6] for the 1961-2015 period (**Figure 01**), seek to identify warming or cooling effects in one year in comparison to the normal temperatures period (1961-1990). The northern zone reveals a tendency to increase its minimum temperatures and to decrease its maximum temperatures for the overall period (although this general behavior is divided into a first warming period until the beginning of the 1980s and then a cooling period, with the exception of 2015 in which an increase was recorded). The central zone shows clearer trends in terms of warming, with increases (considering the complete time series) in both minimum and maximum temperatures. The insular zone does not present clear patterns (its minimum temperature shows first a warming period from 1961 to the mid-

TEMPERATURES

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[3] *Universidad de Chile. 2012. Estado del arte de modelos para la investigación del cambio global. Departamento de Geofísica, Santiago de Chile.*

[4] *ECLAC, 2012. La economía del cambio climático en Chile (The Economics of Climate Change in Chile – In Spanish). Naciones Unidas, Santiago de Chile, 134 pp. Retrieved from: http://repositorio.cepal.org/bitstream/ handle/11362/35372/S2012058_es.pdf?sequence=1*

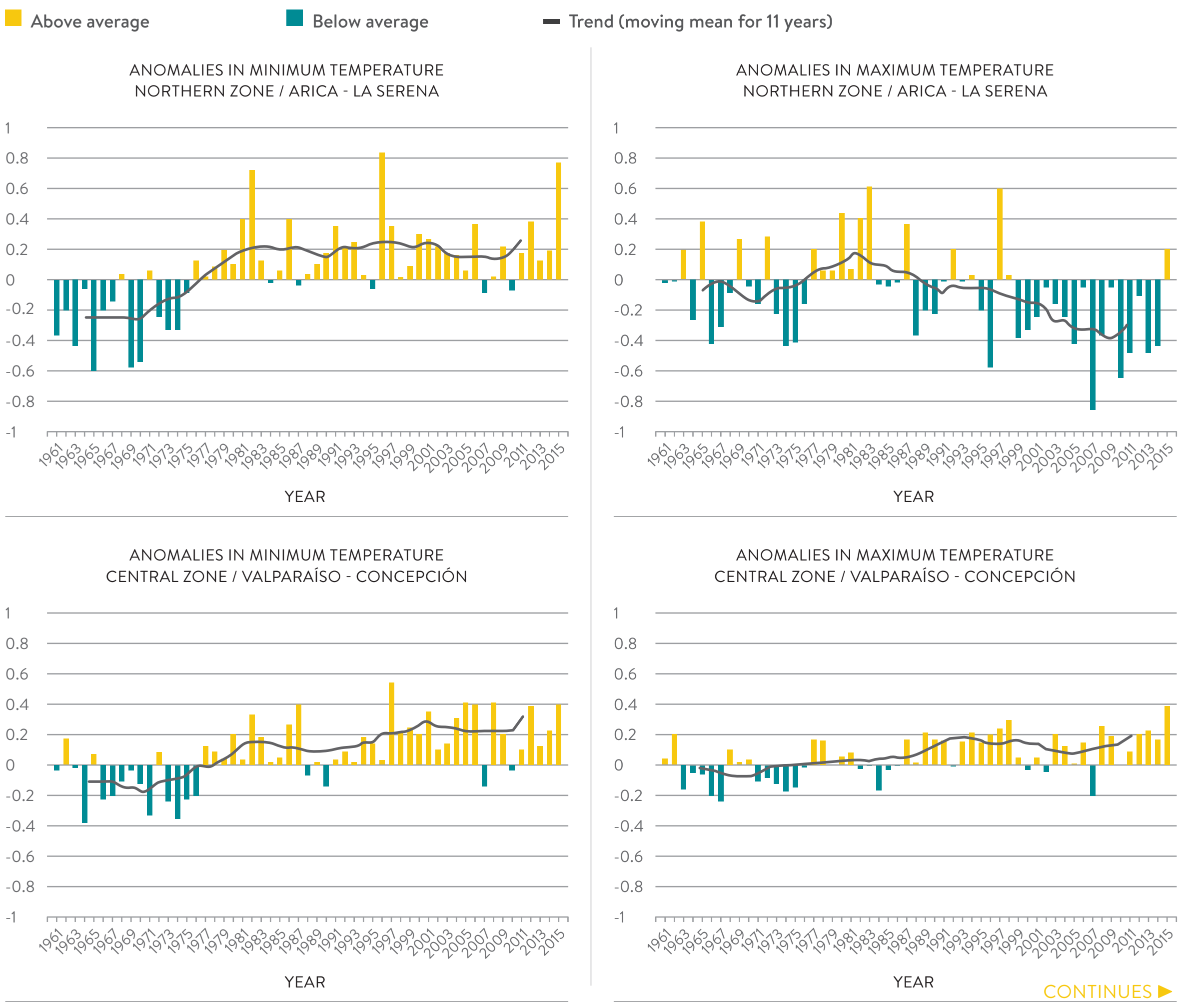
[5] *Dirección Meteorológica de Chile. 2014. Análisis de los Resultados Convenio Alta Dirección Pública, Director, Dirección Meteorológica de Chile, Objetivo N°3. DMC, Santiago de Chile.*

[6] *See definition in note to **Figure 01**.*

1980s and then a cooling period for the remaining years, while its maximum temperature shows an inverse behavior). The southern zone, besides the inter-annual variability, does not show a well-defined trend considering the entire series. However, over the last four years a warming tendency has been observed in both the minimum and maximum temperatures. A similar situation is observed in cities in the extreme southern zone, but with a clearer increase of maximum temperatures over the last 12 years.

FIGURE 01

STANDARDIZED ANOMALIES IN EXTREME ANNUAL SURFACE AIR TEMPERATURES (MINIMUM AND MAXIMUM) by zones of the country, 1961-2015 [6]



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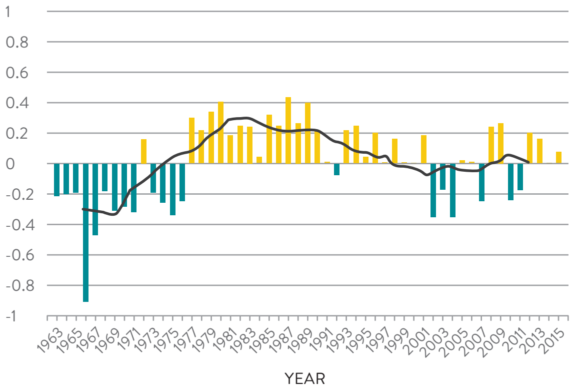
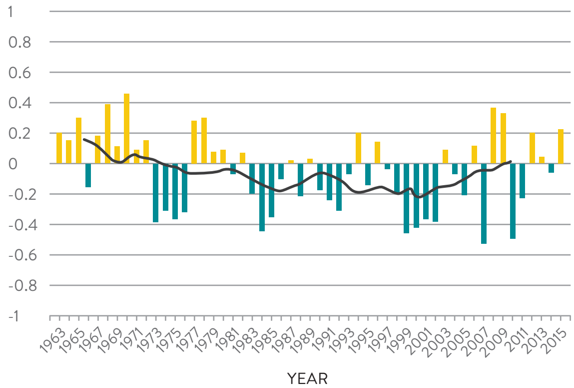
ANOMALIES IN MINIMUM TEMPERATURE
INSULAR ZONE / ARCHIPIÉLAGO DE JUAN FERNÁNDEZ

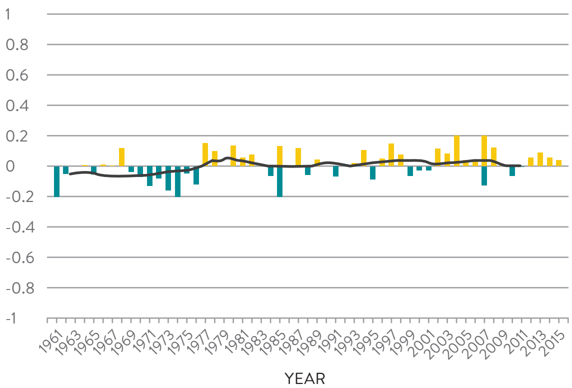


ANOMALIES IN MAXIMUM TEMPERATURE
INSULAR ZONE / ARCHIPIÉLAGO DE JUAN FERNÁNDEZ

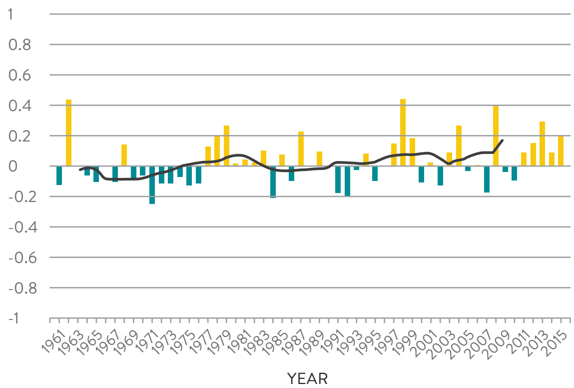


Above average Below average Trend (moving mean for 11 years)

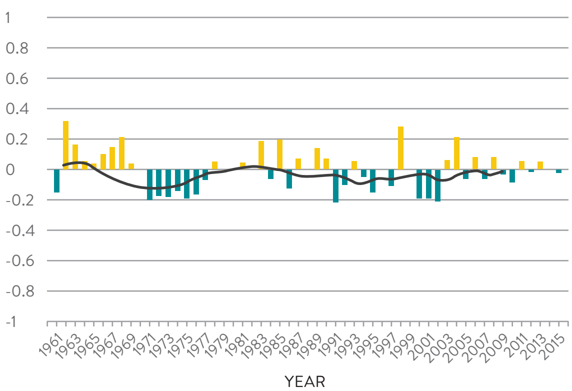
ANOMALIES IN MINIMUM TEMPERATURE
SOUTHERN ZONE / TEMUCO - PUERTO MONTT



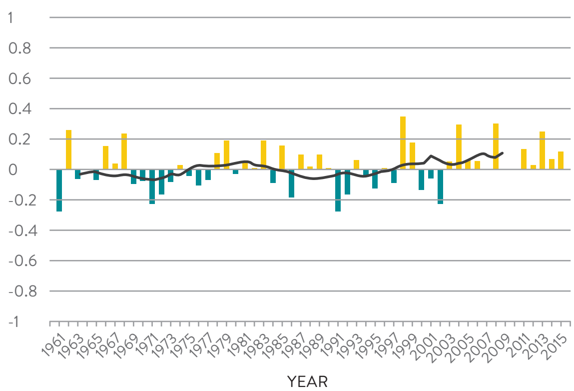
ANOMALIES IN MAXIMUM TEMPERATURE
SOUTHERN ZONE / TEMUCO - PUERTO MONTT



ANOMALIES IN MINIMUM TEMPERATURE
EXTREME SOUTHERN ZONE / COYHAIQUE - PUNTA ARENAS



ANOMALIES IN MAXIMUM TEMPERATURE
EXTREME SOUTHERN ZONE / COYHAIQUE - PUNTA ARENAS



Standardized anomalies are the difference in temperature (minimum or maximum) in comparison to their average during the normal period (1961-1990), divided by the standard deviation for that period, expressed in standardized units (adimensional). The ***Figure*** *shows the average of the anomalies in the monitoring stations grouped by country zones: Northern Coastal Zone (Arica, Iquique, Antofagasta and La Serena); Central Zone (Valparaíso, Santiago, Curicó, Chillán and Concepción); Insular Zone (Juan Fernandez Archipelago); Southern Zone (Temuco, Osorno, Valdivia and Puerto Montt); Extreme Southern Zone (Coyhaique, Balmaceda and Punta Arenas). The positive values (yellow bars) represent warming trends and negative ones (blue bars) represent cooling trends in comparison to the normal temperatures. The continuous line shows the trend as a moving mean for 11 years.*

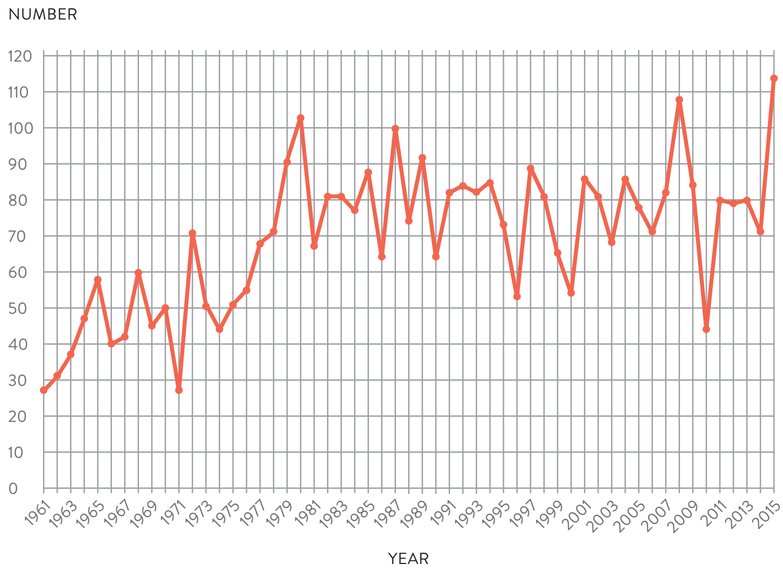
Source: Authors' own elaboration, based on data from the Meteorological Service of Chile (DMC by its acronym in Spanish).

Regarding extreme temperature events, it has been observed that warm nights have increased and cold nights have decreased from the Large North to the South (Coyhaique).

At an aggregate level, a significant increase is observed in the frequency of heat waves[7] for the 1961-2015 period (**Figure 02**), reaching a historical record in 2015. This behavior differs according to the zone of the country. In the northern, extreme southern and insular zones no evident trends are observed. However, in the central and southern zone there is a marked tendency towards the frequency of these events, as can be seen, for example, in the case of Santiago (**Figure 03**).

FIGURE 02

NUMBER OF HEAT WAVES AT THE NATIONAL LEVEL PER YEAR, 1961-2015



Note: A heat wave is defined as the thermal behavior of a region where temperatures above the 90 percent percentile (which is the 10 percent with the highest values) are recorded and/or forecast during three consecutive days for the meteorological station representative of a region (Meteorological Service of Chile)

Source: Authors' own elaboration based on data provided by the Meteorological Service of Chile.

In the case of cold waves[8], which can damage agricultural crops, among other impacts, it is observed that in some regions of the central zone of the country -Maule (Curicó) and Biobío (Chillán) regions- there has been a slight trend towards a decrease in the frequency of this phenomenon (**Figure 04**).

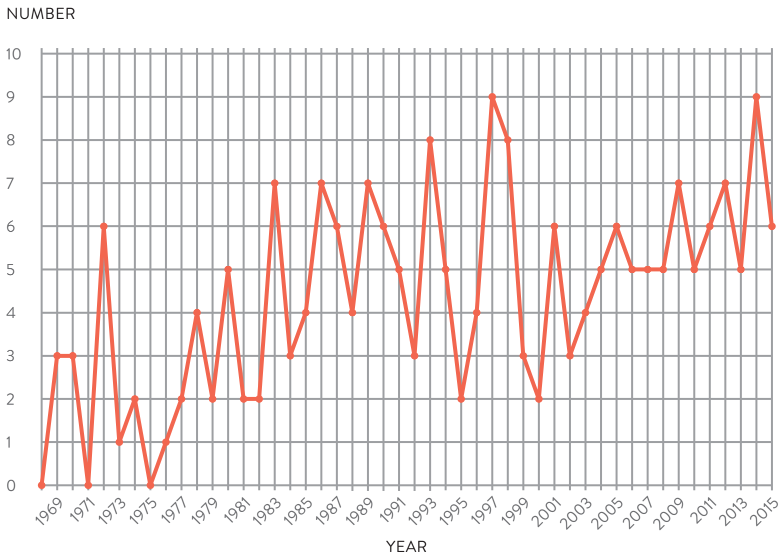
It has been projected that, in the future, there will be an increase in temperatures throughout the country, with the greatest rises in the northern zone. Towards 2030, there will be a 1.5°C increase in the Large North and the Andean Highlands and at least a 0.5°C increase in the southern and extreme southern zones, according to the most favorable scenario (RCP2.6), with increasing values for the 2031-2050 period. The outlook for the least favorable scenario (RCP2.8) follows the same pattern, but with greater intensity in the warming values (Universidad de Chile 2012 in MMA 2014a).

[7] *A heat wave is defined as an unusually warm and uncomfortable period. See calculation methodology in the note below **Figure 02**.*

[8] *Movement of very cold air masses (below 0°C), covering extensive areas of the territory.*

FIGURE 03

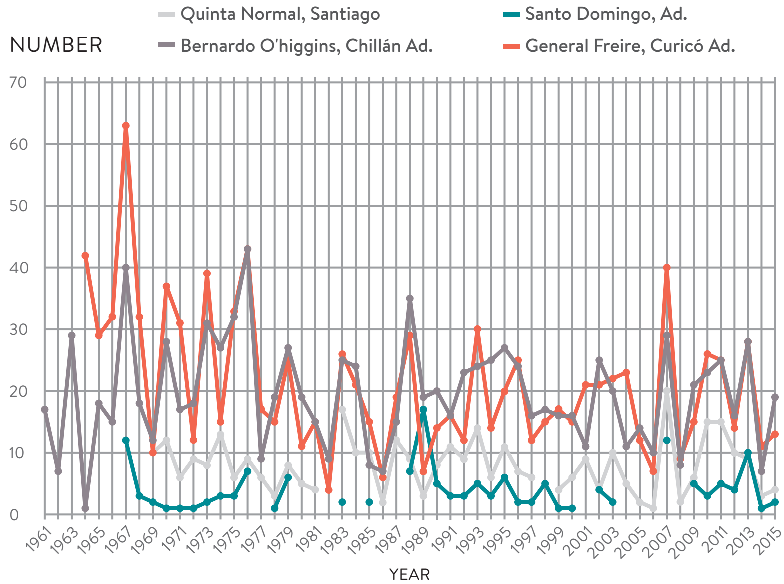
HEAT WAVES IN SANTIAGO
(Quinta Normal meteorological station), 1968-2015



Source: Authors' own elaboration based on data provided by the Meteorological Service of Chile.

FIGURE 04

NUMBER OF COLD WAVES IN THE CENTRAL ZONE OF THE COUNTRY, 1961-2015

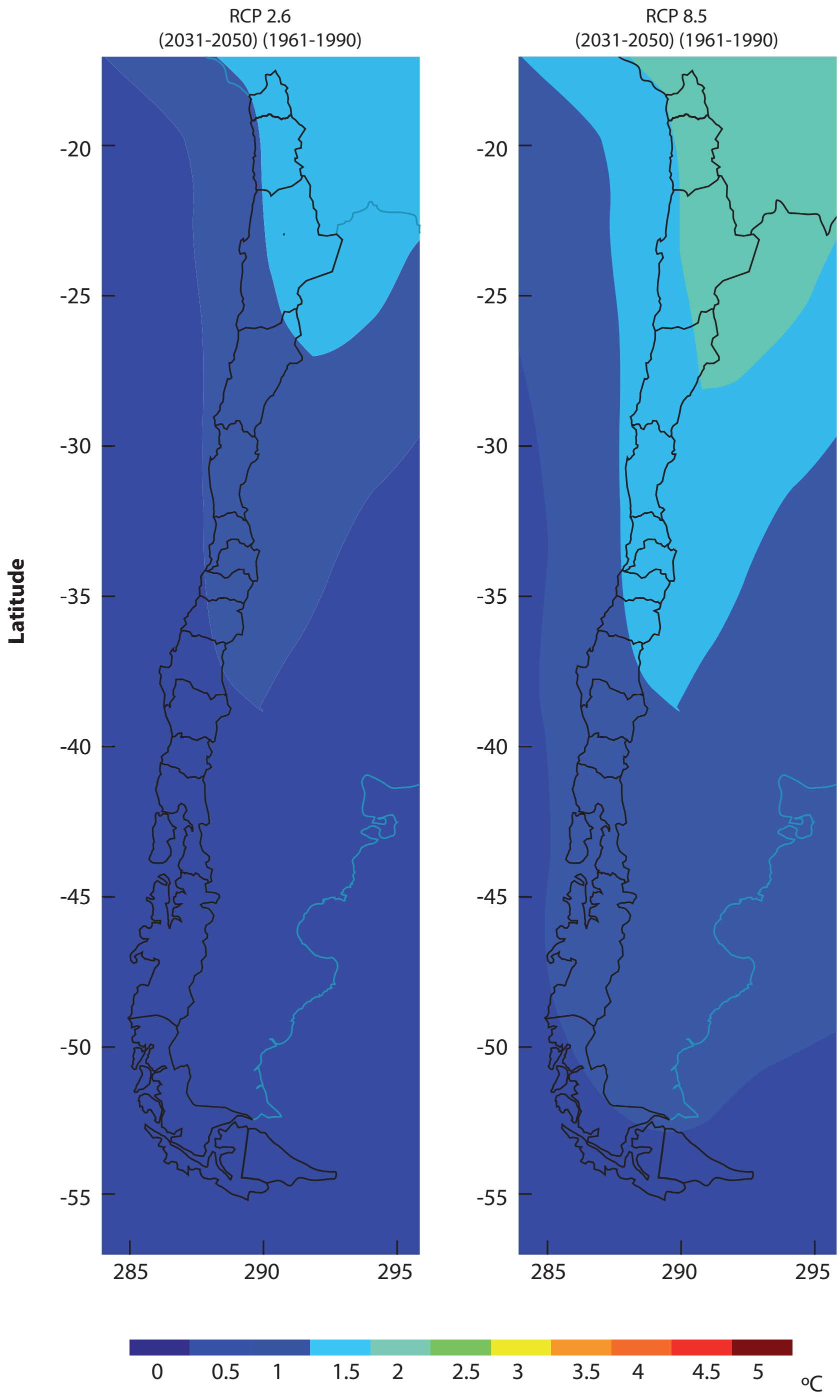


Source: Authors' own elaboration based on data provided by the Meteorological Service of Chile.

In addition, the Meteorological Service of Chile conducted a study to analyze in greater detail the climate change projections for different regions in Chile, with results indicating trends of increasing temperatures greater than those projected at a global scale. For example, the temperature in the central zone would rise to 4°C, with the maximum in Santiago being 2°C greater in 2050.

MAP 01

PROJECTION OF CHANGES IN AIR TEMPERATURE FOR THE 2031-2050 PERIOD IN COMPARISON TO THE 1961-1990 PERIOD, for the most favorable (RCP 2.6) and least favorable (RCP 8.5) scenarios



Source: MMA (2014a) based on University of Chile (2012).

2.1.2 Sea Surface Temperature

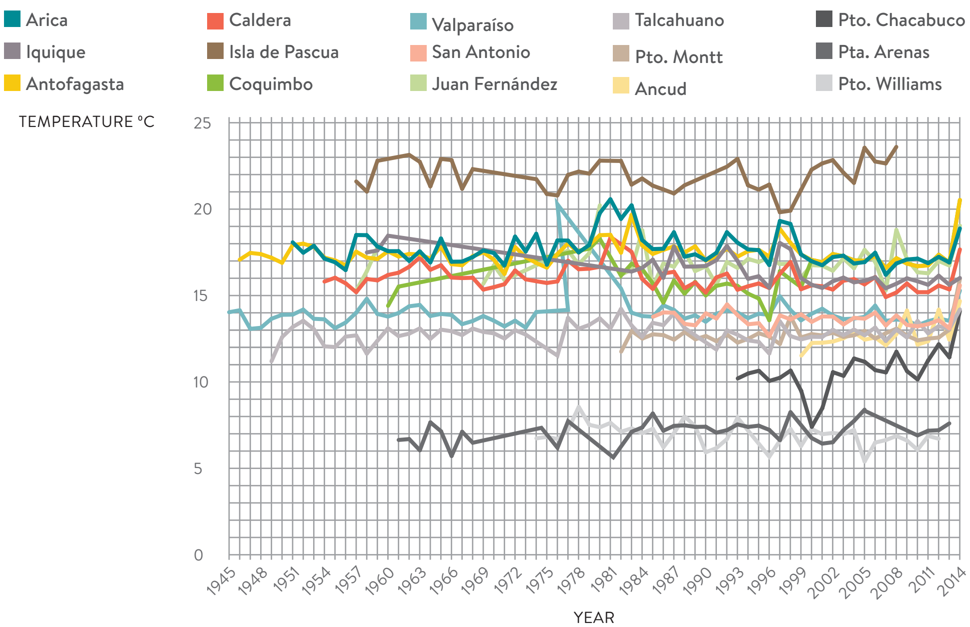
The average Sea Surface Temperature (SST) shows variable behavior for the 1945-2014 period. According to Falvey and Garreaud (in SUB-PESCA and MMA, 2015), cooling has been observed since the end of the 1970s, at approximately 0.1 to 0.2°C per decade. This is confirmed by satellite SST data, by observing a clear cooling in front of the central-southern and northern zones of Chile after 1979. However, on the other hand, when observing more recent years (since 2010), there has been an increase in SST, reaching record highs in 2014 in most monitoring stations.

The El Niño-La Niña Southern Oscillation (ENSO) is the most significant agent of inter-annual climate variability in the region and in the ocean conditions of marine ecosystems. The warm phase of ENSO is manifested with an increase in SST and a decrease of trade winds in the eastern Pacific Ocean. The inverse, or cold, phase, known as La Niña, presents colder SSTs than usual and an intensification of trade winds in the eastern Pacific Ocean. Both El Niño and La Niña affect biomass and the distribution of the main pelagic and demersal fishing resources differently. Between 1951 and 2015, there have been 36 ENSO events (20 El Niño and 16 La Niña), which, among other factors, have influenced the thermal regime of Chilean waters and the hydrobiological resources exploited. The El Niño phenomenon expected for 2015 was called "The Godzilla El Niño" due to its great intensity and potentially devastating impacts at a global level, even exceeding that of 1997.

There is no consensus regarding future projections for SST in Chile and neither is there a clear conclusion on how climate change will affect the frequency or magnitude of ENSO events and/or how they will impact the climate change trend (SUBPESCA and MMA, 2015).

FIGURE 05

AVERAGE SEA SURFACE TEMPERATURE, according to selected monitoring stations, 1945-2014



Source: Authors' own elaboration, based on data provided by the Chilean Navy Hydrographic and Oceanographic Service (SHOA by its acronym in Spanish)

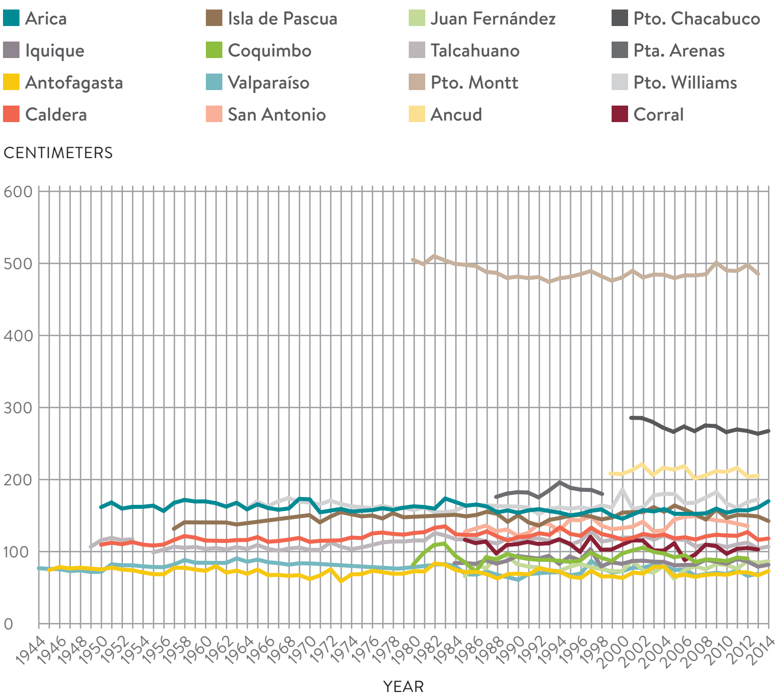
2.2 Sea Level and Surges

In Chile, the relative variation of mean sea level (MSL) in comparison to the ocean bottom is conditioned by the seismic activity of tectonic plates in the subduction zone between the Nazca Plate and the South American Plate. An analysis based on records going back 60 years in tide gauges of the SHOA's national network (Contreras-López et al., 2012) indicates that MSL change rates differ significantly throughout the country (**Figure 06**). In the northern zone, it is diminishing at rates reaching up to -1.4 mm/year (Arica), while in the central and southern zones it increases up to 2.2 mm/year (Puerto Williams). The place with the highest MSL increase rate is Easter Island (Isla de Pascua), with 3.2 mm/year. Predictions from one of the conservative climate change scenarios for 2100 indicate MSL increases between 0.2 and 0.3 m for different latitudes in the country; values that coincide with the increase rates estimated by the ECLAC (CEPAL, 2011) and the IPCC report (Magrin et al., 2014). Using numeric models, Albrecht and Shaffer (2016) project MSL increases in the Chilean coast ranging between 34 and 52 cm for the RCP 4.5 scenario and between 46 and 74 cm for the RCP 8.5 scenario by the end of the 21st century.

On the other hand, it is observed that the number of surges[9] recorded has increased from 13 to 45 in the 2011-2015 period (**Figure 07**) and it is projected that they will grow in number and intensity.

FIGURE 06

SEA LEVEL (ANNUAL AVERAGE), according to monitoring stations, 1944-2014

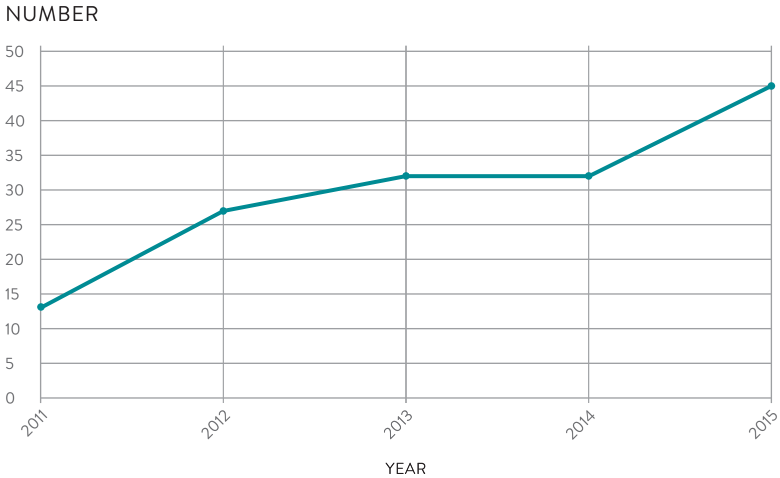


Source: Authors' own elaboration, based on data provided by the Chilean Navy Hydrographic and Oceanographic Service (SHOA by its acronym in Spanish)

[9] *A surge is defined as the alert due to long waves generally caused by a far-away storm. They are typically hundreds of meters long (SHOA, 2002).*

FIGURE 07

NUMBER OF SURGES IN THE COUNTRY, 2011-2015



Note: A surge is defined as the alert due to long waves generally caused by a far-away storm. They are typically hundreds of meters long (SHOA, 2002).

Source: Authors' own elaboration, based on data provided by the Chilean Navy Meteorological Service.

Flying away | FRANCISCO DONOSO

2.3 Rainfall and Drought

The behavior of precipitation during the 1969-2015 period differs among the zones of the country. In the northern zone (La Serena), there is high inter-annual variability in precipitation, with a slight tendency to increase (**Figure 08**). In the central zone (Santiago average), there is a slight tendency to decrease, over the last seven years (2009-2015) values below the normal average have been recorded. In the southern zone (Valdivia) there is a slight tendency to decrease. During the 2010-2015 period, the central-southern zone of the country (from Coquimbo to the Araucanía regions) recorded a rainfall deficit close to 30 percent (Boisier et al., 2016), with unprecedented time and space extensions of this record in the 20th century. The extreme southern zone (Punta Arenas) does not show a defined trend.

This analysis is in line with studies that indicate that the central-southern zone of the country has seen a statistically significant reduction in rainfall (Quintana and Aceituno, 2012; Schulz et al., 2012) and in the semi-arid zone precipitation have been characterized by successive rainy years and multi -annual droughts (Ortega et al., 2012).

By 2030, it is projected that precipitation will decrease between 5 and 15 percent for the northern-central-southern zone encompassing from the Copiapó to the Aysén river basins (latitude 27°S to 45°S). For the southern zone (latitude between 38°S and 42°S, approximately from the Biobío river basin to the southern border of the Los Lagos region), the decrease will be more significant (**Map 02**). For the 2031-2050 period, the decrease in precipitation in these areas would intensify, whereas in the extreme southern zone of the Magallanes and Chilean Antarctic Region it is projected that there will be a slight increase in precipitation in the least favorable scenario (scenario RCP 8.5) (MMA, 2014a).

Droughts[10] in the central zone of the country are a recurring phenomenon. According to the Climate and Resilience Science Center (CR2), in its "Report to the Nation. The 2010-2015 mega-drought: A lesson for the future", nearly one fourth of the years between 1940 and 2010 have presented drought, but mostly in an isolated manner. However, four multi-annual events have been recorded: 1945-1947, 1967-1969, 1988-1990 and the current one still underway (2010-2015), which has been denominated "mega-drought" because it has been the period with the longest duration and the greatest territorial extension (CR2, 2015). The report also indicates that "anthropic climate change is responsible for at least one fourth of the observed deficit, a fraction that is foreseen to increase in the future" and that "this factor will remain in the future, increasing the occurrence of droughts such as the current one and the aridification of the central and southern zones of Chile."

The prior analysis is in line with the study "The economy of climate change in Chile" (CEPAL, 2012), which projects a marked increase of drought events in the future, especially from the second half of the 21st century onwards, with end-of-the-century projections being ten times higher in 30 years.

RAINFALL AND DROUGHT

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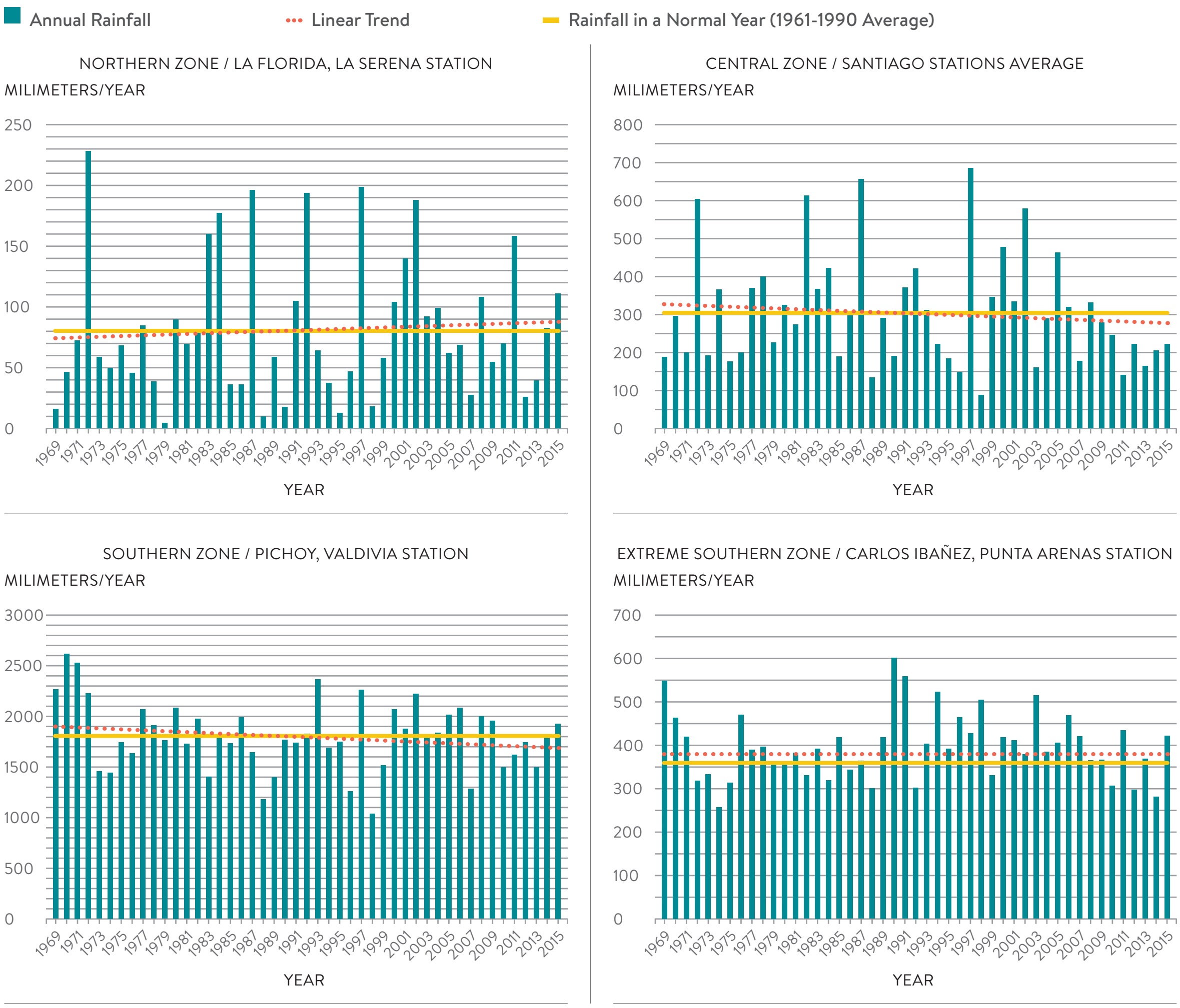
[10] *Drought is defined as a deficit in precipitation higher than 30 percent, calculated by comparing (dividing) the average annual total of the dry period with a long-term average.*

FIGURE 08

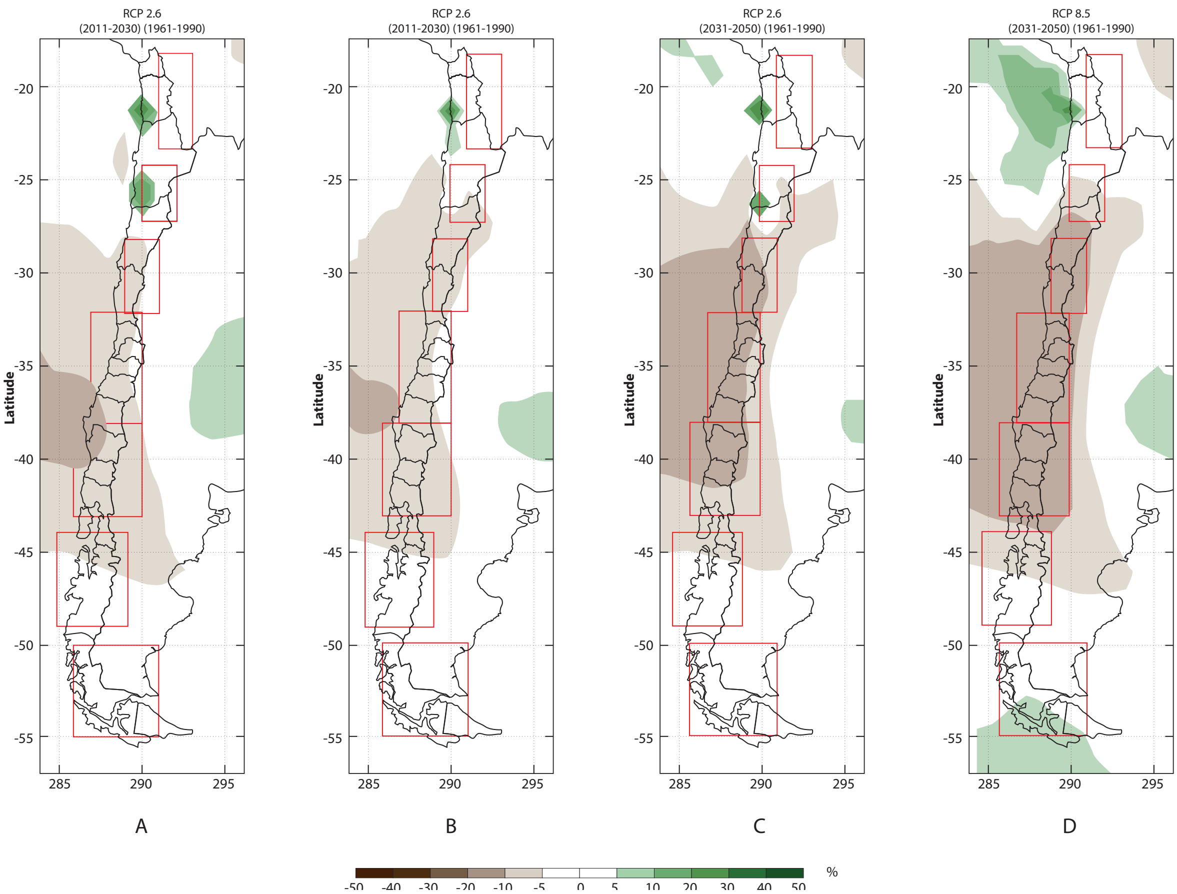
ANNUAL RAINFALL, IN SELECTED CITIES OF THE COUNTRY, 1969-2015



Note: Annual rainfall (bars), linear trend (segmented line) and rainfall during a normal year of the 1961-1990 period (continuous line), expressed in millimeters per year, by zone and city of the country: Northern Zone (La Serena); Central Zone (Santiago Average: Pudahuel, Tobalaba and Quinta Normal Stations); Southern Zone (Valdivia); Extreme Southern Zone (Punta Arenas).

MAP 02

PROJECTIONS OF PERCENTAGE CHANGE IN RAINFALL IN COMPARISON TO THE NORMAL PERIOD (1961-1990) FOR THE FOLLOWING SCENARIOS: A) RCP 2.6 2011-2030 period; B) RCP 8.5 2011-2030 period; C) RCP 2.6 2031-2050 period; and D) RCP 8.5 2031-2050 period



Source: Authors' own elaboration, based on data provided by the Meteorological Service of Chile (DMC by its acronym in Spanish).

Note: All brown tones indicate a decrease in precipitation and green tones, an increase.

2.4 Current and Projected Sectoral Impacts

Given the country's highly vulnerable condition to climate change, it is estimated that, in Chile, environmental, social and economic losses due to this phenomenon could be significant, reaching 1.1 percent of the GDP per year by 2100 (CEPAL, 2012, in MMA 2014a). Biodiversity, water resources, built infrastructure and economic sectors could be negatively affected during this century.

The projected impacts of climate change could be negative for economic activities such as mining, drinking water provision, agriculture and hydroelectricity in the northern and central zones of the country. However, there would be regions in the south that would benefit from increased productivity in some sectors such as forestry, agriculture and livestock (CEPAL, 2012).

The potential impacts of climate change are presented in greater detail below[11], with the projections for different sectors and resources of interest to the country.

2.4.1 Water Resources

2.4.1.1 Streamflows

The variation of annual average streamflows of the country's rivers (in comparison to their average for the normal period between 1961 and 1990) in the 1960-2015 series indicate a relatively regular cyclic change from 1960-2010, within a normal variability context (increase and decrease) given by macro-climatic phenomena (El Niño and La Niña effects). However, between 2010 and 2015, these patterns disappear.

Regarding water availability in hydrographic basins, **Figure 09** shows the average streamflows for the 1961-2010 periods and for future projected climate change periods[12] in the Illapel, Aconcagua, Teno and Cautín basins (CONAMA, 2010a) and in the Limarí, Maipo, Maule and Laja rivers (CEPAL, 2012). In the medium- and long-term, it is expected that there will be less water available in these basins. Between the baseline period (1960-2010) and the final projected period (2071-2099), it is expected that average streamflows will be reduced by 20 to 30 percent in the Cautín and Laja river basins, by 30 to 40 percent in the Maipo, Maule and Teno river basins, and by 50 to 80 percent in the Aconcagua, Limarí and Illapel river basins.

Studies commissioned by the General Directorate of Water (DGA by its acronym in Spanish) on water demand and future projections indicate that the current water gap for the regions, from Arica and Parinacota to the Santiago Metropolitan, is close to 3,800 million m^3/year and that it would rise to approximately 5,800 million m^3/year by 2025 (DGA, 2007a y 2007b).

In addition, an elevation of the zero-degree isotherm has been projected[13], which brings about a reduction in water reserves at the origin of snow and snow-rain basins and the increased risk of disaster during events of extreme precipitation and high temperatures, which significantly increase streamflows, potentially causing floods and landslides.

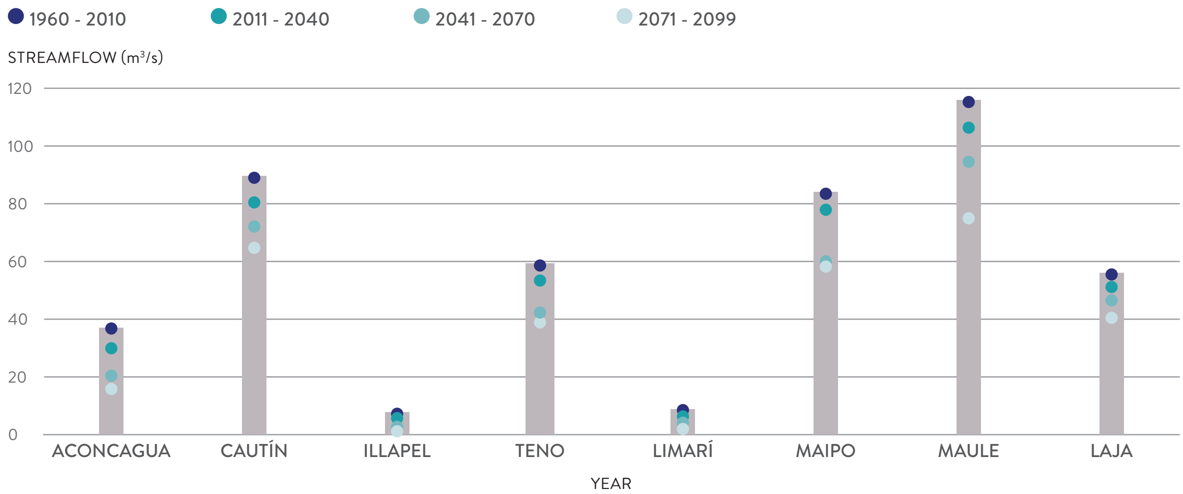
[11] *Described in the Adaptation Plan document.*

[12] *Within the future GHG emission scenarios defined by the IPCC, scenario A2, which is considered in this analysis, is characterized by a "dynamic international economy with an intensive use of fossil fuels, which creates an increase of GHG concentrations in the atmosphere with values much higher than the current ones, which in turn has an impact on the increase of temperature levels, changes in rainfall patterns, increase of the mean sea level and a greater frequency and intensity of extreme climatic phenomena" (CEPAL, 2012, p.9).*

[13] *"The zero-degree isotherm (0°C) is the height in comparison to the sea level, which separates solid precipitation (snow) from liquid precipitation (rain). The analysis and projection of the zero-degree isotherm is crucial for our country, since small variation in the height of the isotherm can make the difference between a flood and a regular rain without risk of landslides or avalanches in the Andean foothills" (DMC, 2015).*

FIGURE 09

STREAMFLOWS OF HYDROGRAPHIC BASINS OBSERVED AND PROJECTED UNDER CLIMATE CHANGE SCENARIO A2. Average for periods 1960-2010, 2011-2040, 2041-2070 and 2071-2099



Source: Authors' own elaboration, based on CONAMA (2010a) and CEPAL (2012).

Glaciers

Chile has one of the largest and most diverse reserves of glaciers in the world, representing 3.8 percent of the total area of the planet, excluding Antarctica and Greenland. The vast majority of glaciers in the country are undergoing a general area loss trend, due to a great extent to climate change impacts (temperatures and precipitation) (DGA, 2011). This is revealed by a report[14] prepared by the General Directorate of Water (DGA by its acronym in Spanish) published in 2011, which studied the variation in the area covered by 147 glaciers in the country (in their corresponding periods of available information), grouped in 70 montane centers classified into five glacier zones.

This report indicates that "negative variations have been recorded in the front and area of most glaciers in all glacier zones." For example, reductions of up to 83 percent of the glacier area have been observed in one case in the southern zone of the country (Nevados de Chillán, between 1975 and 2011) and reduction rates of up to 1.66 km^2 per year in the extreme southern zone (Greve Glacier, between 1976 and 2009) (**Figure 10**).

In the future, it is projected that there will be significant glacier retreat and loss of area, affecting water contribution during dry periods.

ICE CAPS

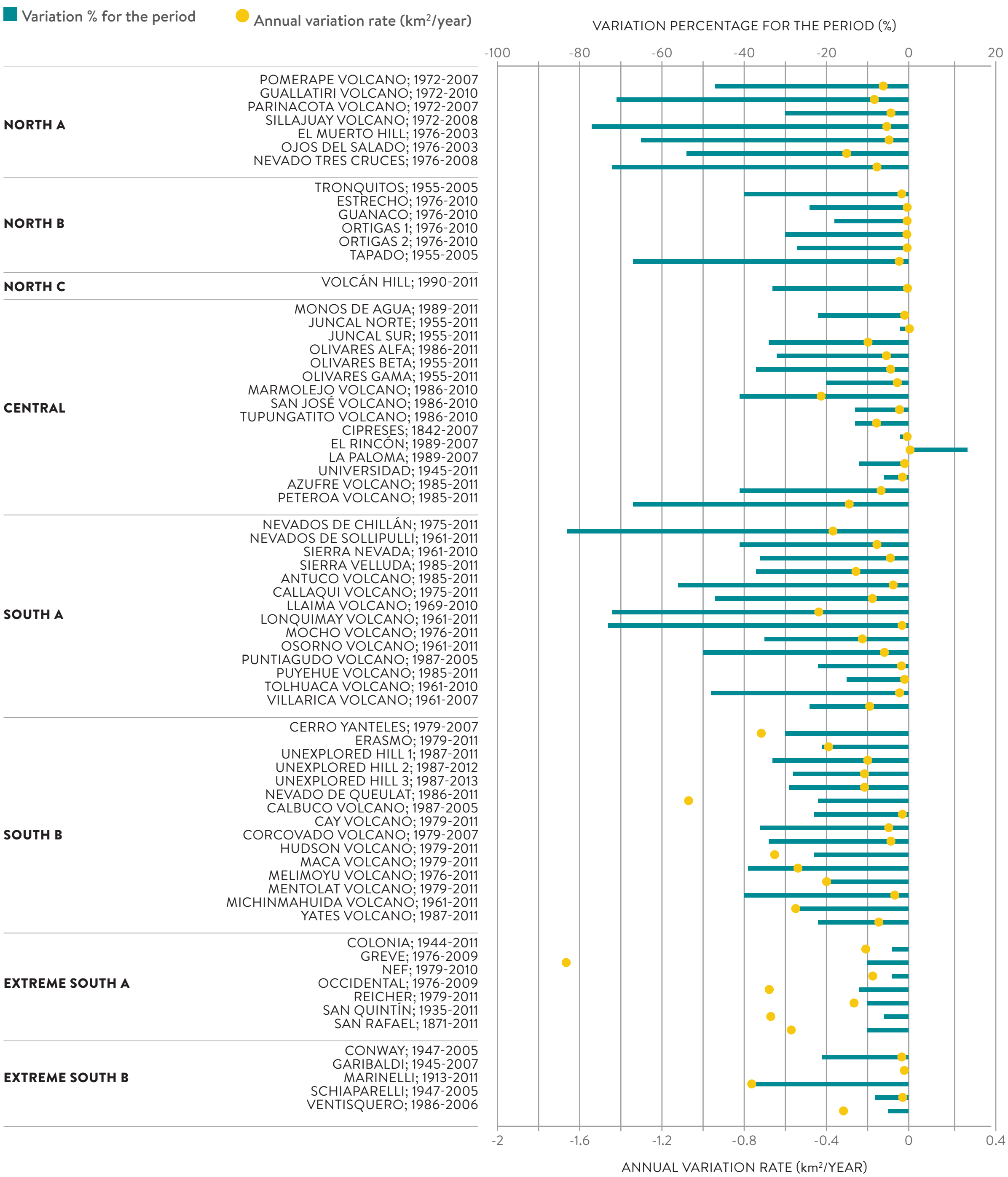
The vast majority of glaciers in the country are undergoing a general area loss trend, due to a great extent to climate change impacts (temperatures and precipitation) (DGA, 2011).

"Negative variations have been recorded in the front and area of most glaciers in all glacier zones." For example, reductions of up to 83 percent of the glacier area have been observed in one case in the southern zone of the country (Nevados de Chillán, between 1975 and 2011) and reduction rates of up to 1.66 km^2 per year in the extreme southern zone (Greve Glacier, between 1976 and 2009).

14 "Recent glacier variations in Chile, by main glacier zones", General Directorate of Water, Ministry of Public Works, 2011.

FIGURE 10

GLACIER AREA VARIATION



Note: The variation in glacier area is presented as a percentage (change in the area between the initial and final years of the different periods specified in the graph) and the annual area variation rate (km²/year), for 5 glacier zones and 70 montane centers that group 147 glaciers.

Source: Authors' own elaboration, based on data by the DGA.

2.4.2 Biodiversity

In terms of biodiversity, a significant loss is projected of the national genetic heritage, characterized by its high endemism.

By 2050, it is estimated that three vegetation floors will be the most affected, since the bio-climates associated with them seem to lose their configuration. These are the Andean temperate-antiboreal deciduous forest of Nothofagus pumilio and Maytenus disticha, in the Magallanes and Chilean Antarctic Region; coastal Mediterranean deciduous forest of Nothofagus macrocarpa and Ribes punctatum; and inland Mediterranean thorny forest of Acacia caven and Prosopis chilensis, both of them in the Valparaíso, Santiago Metropolitan and O'Higgins regions (MMA, 2014a).

Significant negative effects are foreseen in hotspot systems, such as High-Andean wetlands in the northern zone and endemic flora species classified as vulnerable or endangered.

2.4.3 Health

An increase is projected for some diseases already existing in the country, the entry conditions for new diseases and the augmented seriousness of the effect of certain environmental variables on people's health. In the central-southern zones of the country there could be a rise in diseases passed on by rodents and ticks (Hanta virus and rabies) and the development of vector-borne diseases - such as malaria and dengue fever, which are currently absent in Chile - would be favored in the Large North.

As a result of droughts and floods, water quality and availability as well as food would be reduced, with potential impacts on people's nutrition and quality of life and on the increased incidence of some noncommunicable diseases.

The rise in the frequency and intensity of heat waves will have negative impacts on the physical and mental health of the population.

2.4.4 Infrastructure

The increased frequency and intensity of extreme hydro-meteorological events would represent a risk to built infrastructure (road works, bridges, ports, water infrastructure, among others), with a significant impact on the services provided by them. Given that an increase in the intensity and frequency of surges is expected, this would pose a risk for the populations living along the shoreline.

2.4.5 Energy

The main projected impacts are related to the generation of hydroelectric power, which relies on the availability of river streamflows, which would be reduced. In the scenario of greatest GHG emissions[15], the Central Interconnected System's (SIC by its acronym in Spanish) potential for generating hydroelectric power would drop between 11 percent (2011-2040 period) and 22 percent (2071-2099 period), and by 10 and 16 percent for those same periods in the scenario of the lowest emissions[16] (CEPAL, 2012).

QUALITY OF LIFE

As a result of droughts and floods, water quality and availability as well as food would be reduced, with potential impacts on people's nutrition and quality of life and on the increased incidence of some noncommunicable diseases.

The rise in the frequency and intensity of heat waves will have negative impacts on the physical and mental health of the population.

[15] *Scenario A2.*

[16] *Scenario B2.*

2.4.6 Forestry, Agriculture and Livestock Sector

A relocation of agricultural crops towards the south is to be expected, along with a lower availability of water for irrigation in the central zone, generating changes in production and net income, which would be negative in the northern and central zones and positive in the southern and extreme southern zones. The most vulnerable population would be the one focused on inland and coastal rainfed agriculture between the Valparaíso and Biobío regions, farmers in the transverse valleys and livestock owners in the drylands.

2.4.7 Fishing and Aquaculture

National fish catch may be affected. Anchovy catch might increase if sea surface temperature (SST) is reduced by 0.02°C/year, but the opposite would happen if it rises by 0.034 or 0.025°C/year (Yáñez et al., 2014[17] in MMA, 2014a). If SST increases between 1.0 and 2.3°C by 2050, slight decreases would be expected (approximately 5 percent) in longline fishing catch of swordfish (Silva et al., 2015[18] in MMA, 2014a).

In aquaculture, the future sea level rise could affect culture centers, due to changes in the salinity of estuarine waters. In addition, it is possible that this effect might favor the incidence of plagues and/or diseases in those sites.

2.4.8 Tourism

The projection of a more tropical condition in the northern zone of the country may have positive effects in beach tourism. However, there would be also be negative impacts, given by the rise in the snow line (zero-degree isotherm), glacier melting, acceleration of reproductive cycles of different pests (i.e. mosquitos in the Large North; horseflies and large horseflies in the central and southern zones; algae such as the Didymo in the southern and extreme southern zones) and the incidence of extreme events. In the ice caps and glaciers of the extreme southern zone, it would entail negative effects on tourism in the area, which represents a significant portion of its economic activities (MMA, 2014a).

2.4.9 Cities

Temperature rise and rainfall decrease are particularly concerning, since they affect the areas where the greatest part of the country's population lives and where the demand for water resources will increase. Greater pressure is expected on several utilities: tap water supply; sewerage; energy systems; transportation; and health, especially among the population in the lower socio-economic strata (Proyecto CAS, 201219 in MMA, 2014a).

[17] *Yáñez E., M.A. Barbieri, F. Plaza and C. Silva. 2014 Climate Change and Fisheries in Chile. In: Mohamed Behnassi, Margaret Syomiti Muteng'e, Gopichandran Ramachandran & Kirit N. Shelat (Editors). Vulnerability of Agriculture, Water and Fisheries to Climate Change: Toward Sustainable Adaptation Strategies, Springer, Chapter 16, 259-270.*

[18] *Silva, C.; Yáñez, E.; Barbieri, MA.; Bernal, C. and Aranis, A. 2015. Forecasts of swordfish (Xiphias gladius) and common sardine (Strangomera bentincki) off Chile under the A2 IPCC climate change scenario. Progress in Oceanography 134: 343–355.*

[19] *Proyecto Clima Adaptación Santiago (Santiago Climate Adaptation Project, CAS by its acronym in Spanish). 2012. Plan de adaptación al cambio climático para la Región Metropolitana de Santiago de Chile (Santiago Metropolitan Region Climate Change Adaptation Plan). CAS, GORE and MMA, Santiago, Chile.*

3 • PRESSURE: GREENHOUSE GAS EMISSIONS IN CHILE

Chile's greenhouse gases (GHG) emissions are not globally significant. According to data from the World Resources Institute (WRI), which includes emissions of all GHG and all IPCC sectors, the country's share is only 0.24 percent[20] of global emissions and just 0.25 percent according to the International Energy Agency (which only considers CO_2 emissions from hydrocarbon combustion) (MMA, 2014b). However, national emissions have rapidly increased, a fact that is cause for concern and poses significant challenges for the country.

The UNFCCC established a set of objectives for reducing GHG. Stemming from the Kyoto Protocole (Third Meeting of the Framework Convention), reduction goals were set for six gases: carbon dioxide (CO_2); methane (CH_4); Nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6). The emissions and capture of these GHG are measured by countries in their national GHG inventories.

CO_2 emissions are mainly associated with the burning of fossil fuels, the production of cement and the extraction of minerals, while its sequestration is achieved through the photosynthesis process of the forests. CH_4 is largely linked to the decomposition of organic matter originating from agriculture and landfills; N_2O is, to a greater extent, produced by the use of fertilizers and the burning of fossil fuels. Fluoride gases (HFCs, PFCs and SF_6), on the other hand, are associated with industrial processes.

[20] *Data for 2012, excluding the forestry and other land use sector (FOLU) from the Agriculture, forestry and other land use sector (AFOLU).*

Pollution | FRANCISCO DONOSO

Puchuncaví, Ventanas | KARINA BAHAMONDE

01

NATIONAL GHG INVENTORY AND METHODOLOGY FOR ESTIMATING EMISSIONS AND SEQUESTRATION

Chile's National Greenhouse Gases Inventory (INGEI by its acronym in Spanish) was created following the 2006 IPCC guidelines for national greenhouses gases inventories. It encompasses the entire national territory (continental, insular and Antarctic) and includes CO_2, CH_4, N_2O, HFC and PFC and SF6, emissions, and CO_2 sequestration (due to the photosynthesis performed by forests).

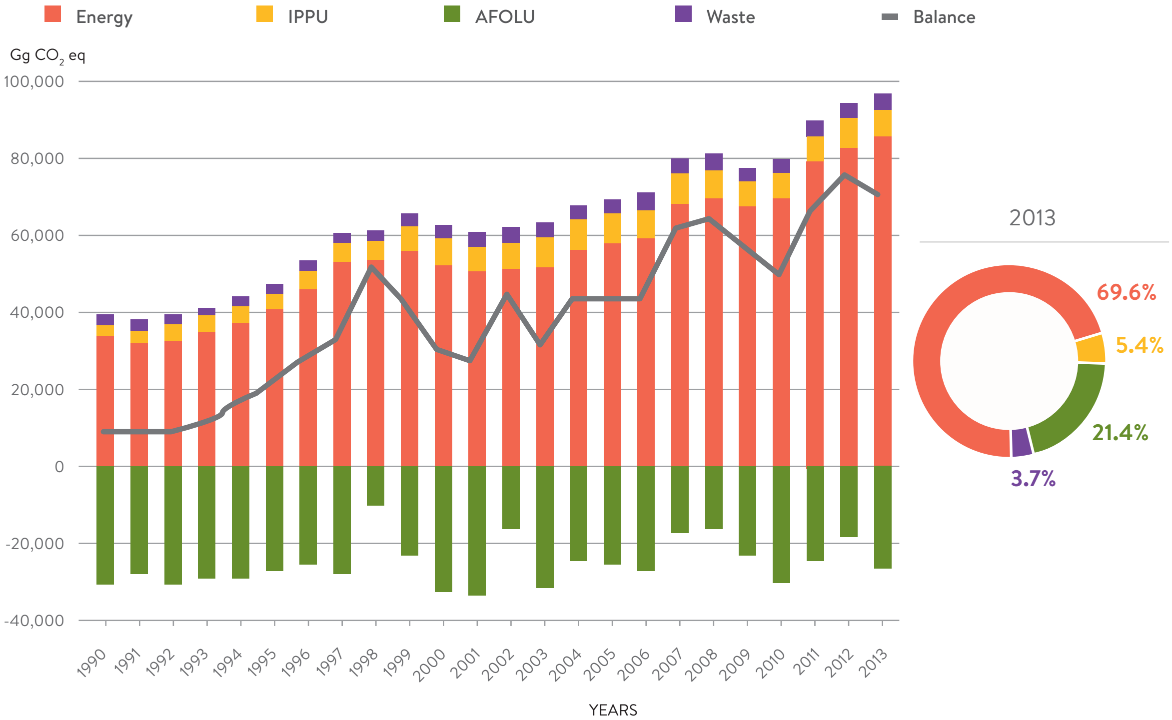
The country's economic sectors are grouped according to the four sectors defined by the IPCC, which share characteristics in terms of the processes that generate the GHG emissions or sequestration. These sectors are: Energy; Industrial Processes and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU); and Waste. All these sectors generate emissions, but the only one that performs CO_2 sequestration is AFOLU, due to the photosynthesis process of forests.

Chile's fourth INGEI is the most recent one prepared to date and includes a time series for the 1990-2013 period that updates and corrects previous inventories.

Source: Authors' own elaboration, based on data from the Department of Climate Change of the Ministry of Environment.

FIGURE 11

GREENHOUSE GASES (GHG) EMISSIONS AND SEQUESTRATION
by IPCC Sector and Balance 1990-2013



Source: Department of Climate Change of the Ministry of the Environment.

TABLE 01

GREENHOUSE GASES (GHG) EMISSIONS AND SEQUESTRATION IN Gg CO_2 EQ. BY IPCC SECTOR AND BALANCE 1990-2013

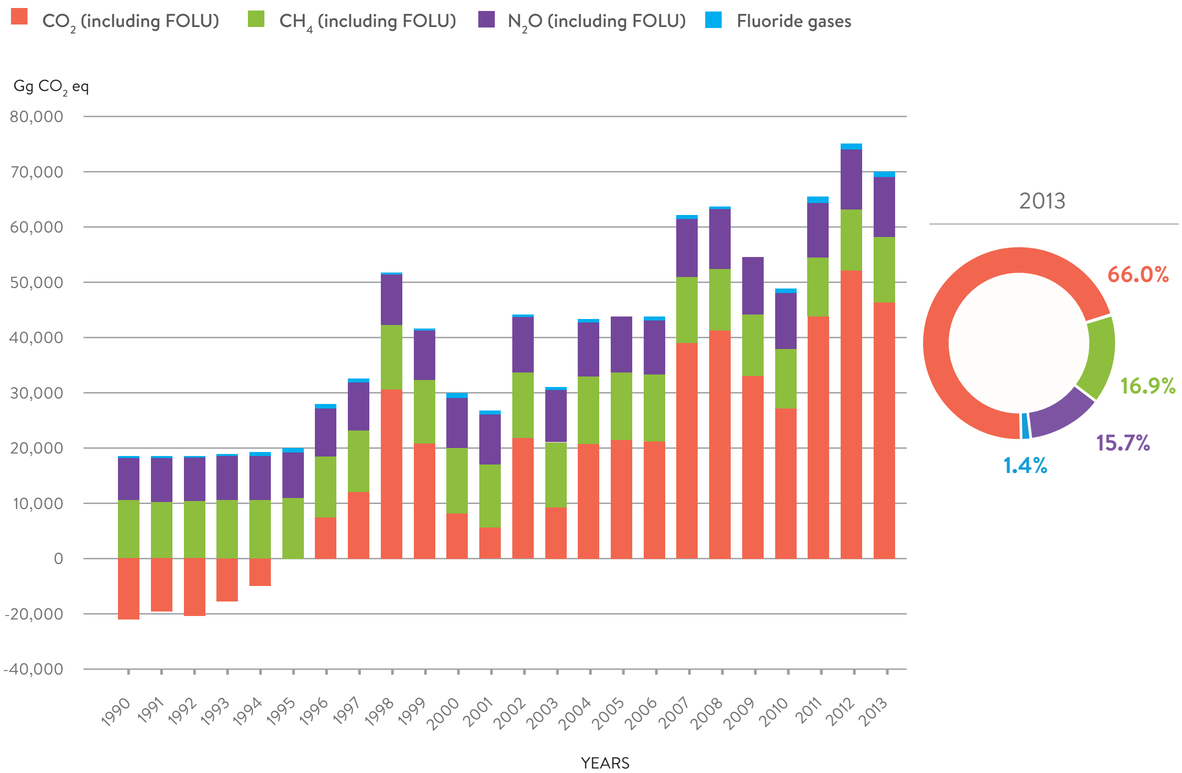
SECTOR	1990	2000	2010	2011	2012	2013
1. Energy	33,219.5	52,122.9	69,423.7	78,527.0	82,076.6	85,075.4
2. IPPU	3,127.5	6,449.6	6,008.1	6,868.3	7,214.9	6,619.4
3. AFOLU	-30,866.3	-32,819.2	-30,514.4	-24,339.9	-18,410.7	-26,119.2
Agriculture	12,633.5	13,580.7	12,879.8	12,741.7	13,285.0	13,735.2
FOLU	-43,499.8	-46,399.9	-43,394.2	-37,081.6	-31,695.8	-39,854.4
4. Waste	2,526.1	3,348.3	3,802.6	3,939.8	4,019.2	4,478.8
Balance (includes FOLU)	8,006.8	29,101.5	48,719.9	64,995.1	74,899.9	70,054.4
Total Emissions (excludes FOLU)	51,506.6	75,501.4	92,114.2	102,076.7	106,595.6	109,908.8

Source: Department of Climate Change of the Ministry of the Environment.

In 2013, the GHG balance (including FOLU) was dominated by CO_2 (66.0 percent), followed by CH_4 (16.9 percent) and N_20 (15.7 percent). Fluoride gases (HFCs, PFCs and SF_6) together reached 1.4 percent. It is worth highlighting that, between 1990 and 1994, the CO_2 balance corresponded to net sequestration, while later on the emission (net emission) has been persistently higher (**Figure 12**).

FIGURE 12

NET EMISSIONS BY TYPE OF GREENHOUSE GAS (GHG), 1990-2013



Source: Department of Climate Change of the Ministry of the Environment.

The energy sector is the main source of national GHG emissions, accounting for 85,075.4 Gg CO_2E in 2013, representing 77.4 percent of total GHG emissions that year. The sector's emissions increased by 156.1 percent between 1990 and 2013 and by 22.5 percent between 2010 and 2013.

The Industrial Processes and Product Use (IPPU) sector accounted for 6,619.4 Gg CO_2E in 2013, representing 6 percent of total GHG emissions that year. The sector's emissions increased by 111.7 percent between 1990 and 2013 and by 10.2 percent since 2010.

The Agriculture, Forestry and Other Land Use (AFOLU) is the only sector that absorbs CO_2, which makes it the most relevant because of its potential for mitigation in the country. In 2013, the GHG balance in the sector reached -26.119,2 Gg CO_2E, reducing its sequestration condition by 15.4 percent since 1990 and by 14.4 percent since 2010. Regarding GHG emissions and absorptions in absolute terms by category, 73.8 percent corresponds to land, followed by 15.5 percent corresponding to aggregated sources and non-CO_2 land emissions sources and, finally, 10.6 percent corresponding to livestock.

The waste sector accounted for 4,478.8 Gg CO_2E in 2013, representing 3.7 percent of total GHG emissions that year. The sector's GHG emissions increased by 77.3 percent between 1990 and 2013 and by 17.8 percent since 2010.

The country's GHG emissions are mostly linked to economic growth, which is based on an energy matrix mainly composed of fossil fuels, and to population growth. Between 1990 and 2010, total GHG emissions (excluding the FOLU sector) increased by approximately 83.5 percent, while the economy (Gross Domestic Product) almost tripled (with an increase of approximately 185 percent) and the national population experienced a growth of nearly 30 percent. Overall, throughout the period, the economy grew faster than emissions (relative decoupling[21]). An absolute decoupling of GHG emissions and GDP is only observed between 1999 and 2002, a brief period during which emissions decreased due to a greater availability of natural gas coming from Argentina. In comparison to population, GHG emissions have grown faster (**Figure 13**).

Because of the above-mentioned reasons, there is a downward trend in the intensity of GHG emissions (excluding FOLU) per GDP unit, dropping by approximately 36 percent between 1990 and 2010, reaching 0.29 tCO_2E/1000US[22] that last year. On the other hand, the intensity of per capita GHG emissions (excluding FOLU) shows an upward trend, increasing by nearly 41 percent between 1990 and 2010, reaching at the end of the period approximately 5.4 tCO_2E/person.

Using World Resources Institute (WRI)[23] statistics for total global GHG emissions (out of 178 countries with data) for 2012 (excluding the LULUCF sector), Chile would rank 50th, from greater to lower emissions, in terms of total GHG emissions. At the same time, it would place 146th in terms of GHG per GDP unit and 79th for per capita GHG emissions. This shows that the most favorable position is the one obtained for GHG per GDP emissions, followed by per capita GHG emissions and then by total GHG emissions.

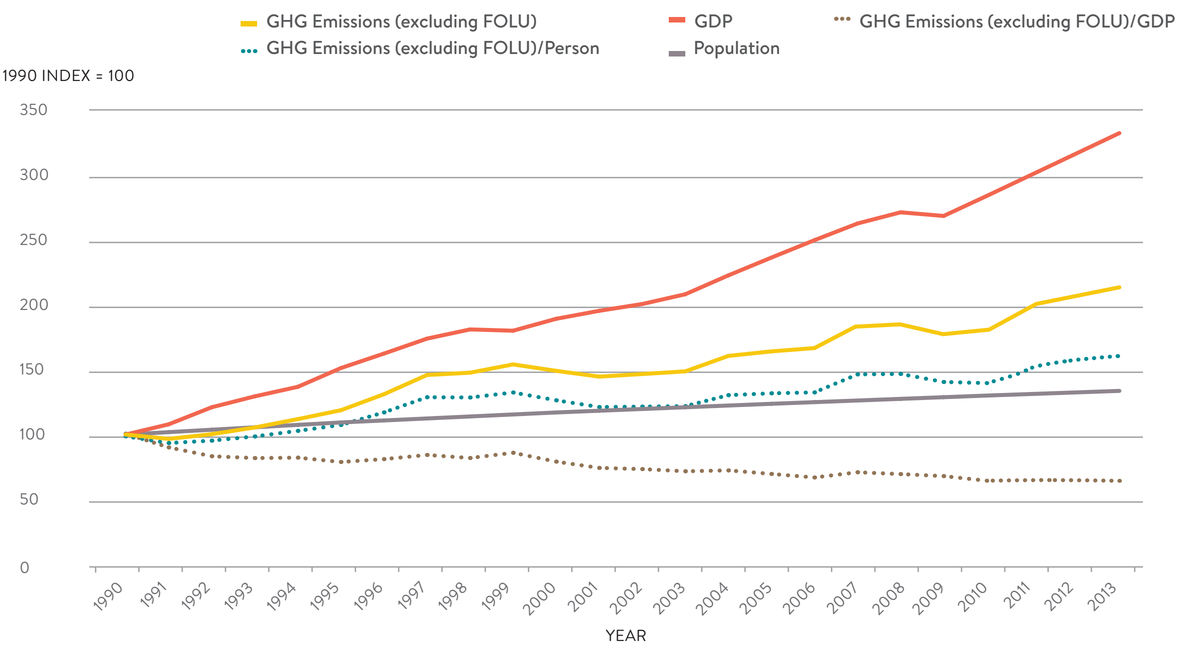
[21] The term decoupling refers to "breaking" the ties between "environmental damage" and "economic goods". It compares pressures on the environment to changes in relevant linked economic variables (drivers). Decoupling occurs when the growth rate of the relevant environmental variables is lower than the growth rate of its economic driver during a period. If an economic variable is growing (say GDP, for example), it is called "absolute decoupling" when the environmental variable has zero or negative growth, that is, the "pressure" on the environment is stable or diminishing. "Relative decoupling" occurs when the environmental variable is growing but at a slower rate than the economic variable.

[22] tCO_2-eq/1000USD = metric tons of CO_2 equivalent per thousand United States Dollars adjusted for purchasing power parity.

[23] http://cait.wri.org/login-main.php?log=7&postlogin=cait

FIGURE 13

NATIONAL GHG EMISSIONS (EXCLUDING FOLU), GDP AND POPULATION, 1990-2013



Source: MMA (emissions); OECD (GDP PPP) and INE (population).

Note: Only GHG emissions are included, excluding the LULUCF sector.

4 • CHILE'S RESPONSES TO CLIMATE CHANGE

4.1 National Climate Change Strategy and Action Plans

Chile ratified the United Nations Framework Convention on Climate Change in 1994 and became part of the Kyoto Protocol in 2002, joining 192 other countries that have made this commitment.

In 2006, Chile prepared a National Climate Change Strategy (ENCC by its acronym in Spanish). The ENCC established three priority axes to face this great challenge: 1) Adaptation; 2) Mitigation; and 3) Capacity building.

This strategic vision was reflected in the formulation of the first National Climate Change Action Plan for 2008-2012 (PANCC-I by its acronym in Spanish), which, considering the same axes as the ENCC, allowed the country to make progress setting the goal of developing sectoral and national adaptation and mitigation plans. Its implementation meant, for the first time in the country, allocating national financial resources and building technical capacity to move forward on the climate change issue.

In August 2010, the country voluntarily took on the challenge of taking part of global actions to mitigate worldwide GHG emissions, submitting to the Secretariat of the Convention Appendix II of the Copenhagen Agreement.

In 2014, the country published a National Plan for Climate Change Adaptation and by 2015 three sectoral adaptation plans have been approved[24].

One of the goals committed in President Michelle Bachelet's 2014-2018 Government Program was establishing a public policy instrument to integrate and guide national actions related to climate change.

In 2015, Chile presented its commitment to the Paris Climate Change Agreement during the Conference of the Parties (COP21), through the document Intended Nationally Determined Contribution (INDC). This national report establishes five essential pillars: 1) Mitigation; 2) Adaptation; 3) Building and strengthening capacities; 4) Development and technology transfer; 5) Funding. These pillars, in turn, include specific goals[25].

In order to fulfill the government's commitment, the Department of Climate Change of the Ministry of the Environment, in close coordination with other ministries and institutions with competence in this matter, including specialized academia, the private sector and citizens, prepared between 2014 and 2016 the draft project of the new National Climate Change Action Plan for 2017-2022 (PANCC-II by its acronym in Spanish), which also included a citizen engagement and public consultation process[26].

The general objective of the PANCC-II is to face the short- and medium-term challenges posed by the impact of climate change on the national territory and to ensure the implementation of the commitments made by Chile to the UNFCCC. It seeks to become the articulating instrument of a cross-cutting climate change policy for the country in the short and medium terms, by means of a guiding framework for all stakeholders. Four thematic axes, 15 specific objectives, 35 lines of action and 79 measures are distinguished in the plan. The four thematic axes are: 1) Adaptation; 2) Mitigation; 3) Means of implementation; and 4) Climate change management at the regional and communal levels. **Table 02** shows the corresponding general objectives for these axes.

The PANCC-II also includes 10 governing principles: common good; equity; sustainability; precaution; transparency; citizen engagement; cooperation and synergies; cost-effectiveness; flexibility; and consistency.

24 See details in the Adaptation section of this chapter.

25 The detailed INDC goals for each of its five pillars can be found in the corresponding sections presented below in this chapter.

26 http://portal.mma.gob.cl/plan-de-accion-nacional-de-cambio-climatico-2017-2022-pancc-ii/

TABLE 02

PANCC-II AXES AND GENERAL OBJECTIVES	
THEMATIC AXIS	**GENERAL OBJECTIVE**
Adaptation	Strengthening the country's capacity to adapt to climate change, gaining deeper knowledge of its impacts and the country's vulnerability, and generating actions that will enable minimizing negative effects and making the most of positive effects, promoting economic and social development and ensuring environmental sustainability, in line with the adaptation pillar of Chile's contribution to the UNFCCC.
Mitigation	Creating the enabling conditions for the implementation, compliance and follow-up of Chile's GHG emissions reduction commitments to the UNFCCC, consistently contributing to the country's sustainable development and to a low growth of carbon emissions.
Means of implementation	Implementing the cross-cutting elements that will complement the measures set forth in PANCC-II regarding institutional strengthening, technology transfer, capacity building and technical assistance, financing and international negotiations.
Climate change management at the regional and communal levels	Developing the elements that will enable setting the institutional and operational foundations, as well as the necessary capacities, to make progress in the management of climate change in the territory, through the regional and communal governments, and incorporating all stakeholders.

Source: MMA.

4.2 Institutional Framework

According to the General Environmental Framework Law 19.300, in its article 70, letter h "(...) the Ministry will especially be in charge of proposing policies and formulating the plans, programs, and actions plans dealing with climate change."

The Department of Climate Change (DCC), incorporated into the Division of Air Quality and Climate Change of the Ministry of the Environment, is in charge of proposing climate change policies27 and of coordinating the ministries and public agencies regarding climate change and it has been structured with the following lines of work: international negotiations; capacity building; adaptation; mitigation and GHG inventories; and institutional arrangements.

The Ministry of the Environment (MMA by its acronym in Spanish) considers the competences of other sectors, through the Council of Ministers for Sustainability (CMS by its acronym in Spanish). In 2014, this Council agreed to begin the process to be called Council of Ministers for Sustainability and Climate Change[27], to show the increasing importance of this phenomena for the institutional framework, and to add the Ministry of Foreign Affairs, due to its role in international negotiations.

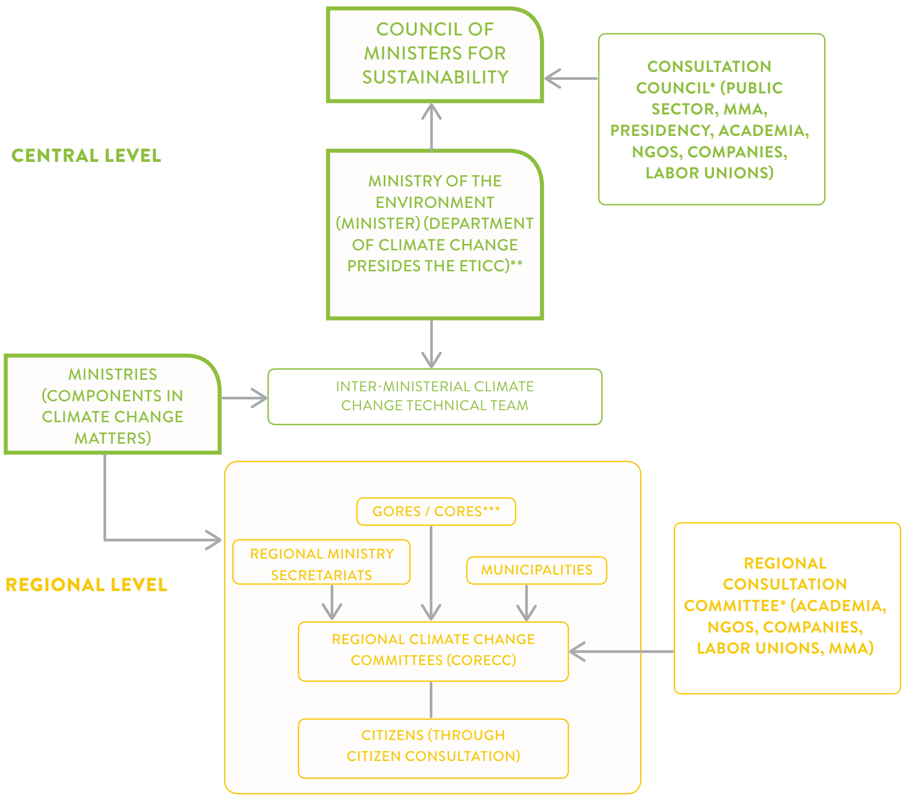
[27] *Currently being processed.*

The National Plan for Climate Change Adaptation, approved by the CMS in December 2014, established the need to strengthen the institutional framework for climate change, proposing an operational structure for implementing the plan, with an inter-sectoral and territorial approach, headed by the CMS and incorporating the Inter-Ministerial Technical Team on Climate Change (ETICC by its acronym in Spanish) and the Regional Climate Change Committees (CORECC by their acronym in Spanish)[28].

[28] *The CORECC must promote the incorporation of the climate change issue into regional public policies, seeking consistency and potential synergies with national policies, Regional Development Strategies and regional sectoral policies and activities. In addition, they must promote the search for regional resources to carry out the measures and actions and to quantify impacts, mitigation, adaptation and capacity building at the regional level.*

FIGURE 14

INSTITUTIONAL FRAMEWORK FOR PREPARING, IMPLEMENTING AND MONITORING PANCC-II ACTIVITIES



** Law 20.417 (Law on the Environment)*
*** Integrated by the focal points of the ministries with competence in climate change matters.*
**** Regional Governments (GORES) / Regional Councils (CORES)*

Source: MMA, 2016a.

4.2.1 Institutional Framework of the National GHG Inventory System

Since 2012, the DCC of the MMA has designed, implemented and coordinated the National Greenhouse Gases Inventory System of Chile (SNICHILE by its acronym in Spanish), which contains the institutional, legal and procedural measures established for the biannual updating of the GHG Inventory in Chile, thus guaranteeing the sustainability of the preparation of GHG inventories in the country, the consistency in notified GHG flows and the quality of the results. The permanent work of SNICHILE is divided into five areas: updating the GHG Inventory in Chile; ongoing improvement system; building and maintaining capacities; institutional mainstreaming; and dissemination.

The process for elaborating the GHG Inventory is the result of a compilation of the GHG Sectoral Inventories (ISGEI by its acronym in Spanish) prepared by the Division of Prospection and Energy Policy of the Ministry of Energy (MINENERGÍA by its acronym in Spanish), the DCC of the MMA; the Ministry of Agriculture (MINAGRI by its acronym in Spanish), where the Office for Agrarian Studies and Policies (ODEPA by its acronym in Spanish) coordinated the work of the National Forestry Corporation (CONAF by its acronym in Spanish) to develop the topics dealing with land use change, the Forestry Institute (INFOR by its acronym in Spanish) to develop the topics on forestry lands, and the Institute for Agriculture and Livestock Research (INIA by its acronym in Spanish) to develop the topics on agriculture and livestock. The waste sector was prepared by the Solid Waste Section of the MMA.

4.3 Mitigation

In August 2010, the country voluntarily took on the challenge of joining global action to mitigate worldwide GHG emissions, submitting to the Secretariat of the Convention Appendix II of the Copenhagen Agreement. Chile committed to taking mitigation actions that will enable it to deviate, by 2020, by 20 percent below its projected emissions based on 2007 data, through Nationally Appropriate Mitigation Actions (NAMAs). Its main application initiatives will take place in the fields of energy efficiency, non-conventional renewable energies and the land use, land use changes and forestry (LULUCF) sector. President Bachelet ratified in her Government Program the will to fulfill this commitment.

The Intended Nationally Determined Contributions (INDC) submitted by Chile in the 2015 Paris Climate Agreement (COP21) declares the commitment to decouple the country's economic growth from its GHG emissions. The proposal includes mitigation options in non- LULUCF (non-FOLU) sectors apart from those of the LULUCF sector, such as:

- Carbon intensity goal, without including the LULUCF sector:
    - Chile commits, by 2030, to reduce its CO_2 emissions per GDP unit by 30 percent in comparison to the level reached in 2007, considering a future economic growth that will enable it to implement the adequate measures to fulfill this commitment.
    - Additionally, and depending on the possibility of obtaining international grants, the country commits, by 2030, to increase its CO_2 emissions reduction per GDP unit until reaching a reduction ranging between 35 and 45 percent in comparison to the level reached in 2007, considering, at the same time, future economic growth that will enable it to implement the adequate measures to fulfill this commitment.

- Specific contribution for the LULUCF sector:
  - Chile commits to the sustainable management and recovery of 100,000 hectares of forest, mainly native, which will represent GHG sequestration and reduction by nearly 600,000 metric tons of CO_2E per year, starting in 2030. This commitment is conditioned to the approval of modifications to the Law on the Recovery of Native Forests and Forestry Development.
  - Chile commits to foresting 100,000 hectares, mostly with native species, which will represent a sequestration ranging between 900,000 and 1,200,000 metric tons of CO_2E per year, starting in 2030. This commitment is conditional to the extension of Decree with Force of Law 701 and to the approval of the new Law on Forestry Development.

The main progress made in terms of mitigation in the country by 2015 are detailed below.

4.3.1 Actions and Policies Associated with Mitigation by Sectors

There are several mitigation actions carried out by different sectors of the country that are being developed or coordinated by State institutions.

Energy: The Ministry of Energy has promoted institutional improvements, the gradual introduction of non-conventional renewable energies (NCRE) into the electricity matrix, and moving towards efficient energy use, among other measures. In 2014, it published its Energy Agenda, in 2015 the "2050 Road Map: Towards Sustainable and Inclusive Energy", which establishes significant concrete mitigation goals, the "2050 Energy Policy", which seeks to move forwards towards sustainable energy in all its dimensions, and it is already working on the future sectoral Mitigation Plan within the framework of the 2017-2022 PANCC, the Energy Policy and the INDC. This institution is also the Technical Focal Point of the PMR29 project (Partnership for Market Readiness, World Bank, www.thepmr.org).

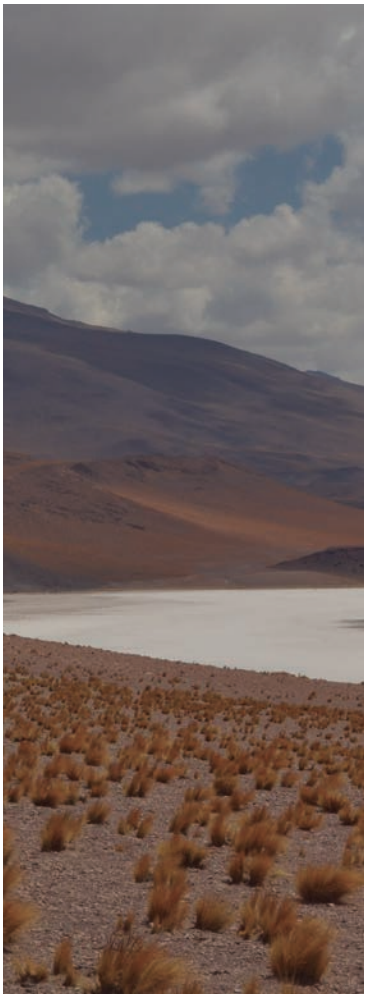
In the private energy sector, it is worth highlighting the investment in power generation plants based on renewable sources, some of them registered under the Clean Development Mechanism (MDL by its acronym in Spanish). The definition of an internal carbon price in the economic valuation of projects, the calculation and report of corporate GHG emissions inventory; the development of R+D lines to create pilot innovation projects, such as CO_2 sequestration through algae; the interruption of the development of thermal power plants; the implementation of initiatives that seek to reduce losses that may occur in transmission and distribution processes, where these losses could be linked to emissions leaks.

Transportation: The Ministry of Transportation and Telecommunications, through the Under Secretariat of Transportation, is the public institution in charge of generating policies, conditions and standards for the development of efficient, safe and environmentally-friendly transportation systems. Some highlights: Economic incentives and technical assistance programs for freight forwarding; economic incentives for passenger transportation; bike lane plans; energy efficiency initiatives; energy efficiency labeling.

In addition, other actions stemming from transportation companies stand out, such as the extension of the Metro de Santiago (subway) network; new railroad routes; reduction in fuel consumption by LATAM.

Agriculture, forestry and other land use (AFOLU): The Ministry of Agriculture

[29] *For greater details about the PMR project, see the section on market instruments for environmental externalities.*



Northern Chile | MARÍA INÉS FUENTEVILLA

is the institution in charge of promoting, guiding and coordinating the activity of this sector in the country. Among the actions carried out, the following stand out: Economic incentives for forestation and forestry management; the Native Forest Law; the Land Recovery Program; and the launch of the work to prepare a National Strategy for Climate Change and Vegetation Resources (ENCCRV by its acronym in Spanish) in order to comply with the forestry goal of the INDC.

Some forestry companies carry out emissions reduction measures. In addition, there are mitigation measures with co-benefits, such as the co-generation of energy from biomass, where the primary objective is to re-use industrial waste[30].

The wine production sector has defined a series of programs and measures to introduce sustainability attributes that will improve the sector's positioning and contribute to developing more efficient and resilient operations to future climate change. These are established in a Sustainability Program that includes projects such as "Energy and Climate Change" and "Climate Change and Wine-Producing Zones". In addition, this sector is working together with CORFO in the "Chile Wine Production 2.0 Strategic Node", which has three lines of work (climate change, development of new products and recovery of genetic material), as well as other initiatives with mitigation co-benefits that include the "Wine Production Industry Sustainability Code"[31].

Waste: Actions include the Sanitary Regulations for Waste Management; the National Solid Waste Program; the Regulation of Management of Sludge in Wastewater Treatment Plants; the Regulation for the Pollutant Release and Transfer Register (PRTR); Framework Law on Waste Management, Extended Producer Responsibility and Promotion of Recycling N° 20.920 (known as "EPR Law").

Mining: Climate change mitigation actions mostly stem from private sector initiatives aimed at reducing their levels of GHG emissions. A clear example of these initiatives is the publication (December 2015) of the "Principles of the Mining Council on Climate Change" [32] within the framework of Chile's submission of its INDC to the UNFCCC in Paris, thus becoming the first industrial sector to generate exclusive principles on the matter. In addition, some measures with mitigation co-benefits stand out, such as the report on GHG emissions; the identification of GHG reduction measures; the calculation of corporate carbon footprints; the purchase of NCRE through long-term contracts[33]; the enabling of financing and implementation of NCRE projects by purchasing stocks; and the installation of solar and/or solar concentration panels in mining sites.

On behalf of the public sector, the Chilean Copper Commission (Cochilco by its acronym in Spanish) constantly collects information on energy consumption, water consumption and direct GHG emissions of the sector. It is estimated that, between 2007 and 2013, given the implementation of early initiatives, a total of 0.08 MM tCO_2E was reduced in the mining sector.

Other industries: It is worth highlighting the efforts to reduce emissions made by the pulp production, cement and steel industries, which include measures such as self-generation and co-generation of electricity from NCRE, replacement of fuels and equipment, and the implementation of energy management systems. For example, between 2010 and 2013, it is estimated that the industrial sector reduced 3,629 tCO_2E of emissions as a result of the energy efficiency programs promoted by the Chilean Agency for Energy Efficiency (AChEE by its acronym in Spanish). In the specific case of the pulp sector, the reduction of 0.36 MM tCO_2E has been estimated due to the implementation of biomass co-generation plants between 2007 and 2013.

[30] *The mitigation co-benefit is explained because nearly 50 percent of the energy generated is allocated for self-consumption by the company and the remaining percentage is injected into the Central Interconnected System (SIC by its acronym in Spanish), avoiding emissions associated with the generation of that portion of energy. Because of this, most of the co-generation projects are listed under the Clean Development Mechanism (MDL by its acronym in Spanish), with a total installed capacity of 1,000 MW.*

[31] *Voluntary standard that currently includes 59 certified wineries (encompassing 70 percent of exports of bottled wine) and it includes social, environmental and economic components, among which requirements related to biodiversity, the application of pesticides, the efficiency in the use of machinery, the use of fuel, transportation and efficient energy use stand out.*

[32] *http://www.consejominero.cl/wp-content/uploads/2016/07/Principios-cambio-clim%C3%A1tico.pdf*

[33] *In the specific case of some companies, it is declared that, because of these purchasing contracts, starting in 2019 almost 80 percent of the supply will be provided by NCRE.*

4.3.2 Other Mitigation Actions

In addition to sectoral actions, in Chile there are other initiatives with influence on mitigation that include cross-cutting measures, such as the Clean Production Agreements (CPAs), the Strategy for Sustainable Construction, local initiatives and actions developed by the private sector.

Clean Production Agreements (CPAs): are the main management instrument created by the National Council for Clean Production (CPL by its acronym in Spanish). Between 2002 and 2010, the Council commissioned a study to estimate GHG reductions in 16 CPAs of different industrial sectors. The results show that CPA activities in the 16 sectors analyzed have reduced GHG emissions by 4,050,973 tCO_2E. Considering an eight-year framework to achieve these reductions and, assuming a linearity from their origin, the mean annual reduction for each of the 16 CPAs is estimated at 31.6 thousand tCO_2E. In 2012, the CPL recorded the first NAMA, which is currently operating and has incorporated diverse GHG mitigation options into the CPAs and monitoring indicators.

Sustainable construction: The Ministry of Housing and Urban Development (MINVU by its acronym in Spanish) includes sustainable development in its management. To that end, it has a National Strategy for Sustainable Construction and a Sustainable Construction Code. It develops measures aimed at reducing energy consumption, adopting the life cycle concept in building assessments, and the reduction of pollutant emissions in the construction phases and the useful life of infrastructures.

Chilean Network of Municipalities to Face Climate Change: The Chilean Network of Municipalities to Face Climate Change (RCMCC by its acronym in Spanish) was created in 2014. It is a community open to all municipalities in Chile that wish to explicitly commit to planning and managing their territory, services and goals considering climate change as the new scenario that is defining the challenges of the 21st century. The RCMCC operates in accordance to the "Agenda for Municipalities to Face Climate Change", which includes among its objectives GHG mitigation in the transportation, energy and waste management sectors, although there are also co-benefits with the objectives of biodiversity and green spaces (due to their capacity for CO_2 sequestration), and infrastructure (i.e. green procurement). In 2015, through the Adapt Chile project, a methodological tool was designed to prepare local climate change plans that enabled six municipalities in Chile –Colina, Independencia, Lampa, La Pintana, Providencia and Santiago, all of them members of the RCMCC– to prepare the Local Climate Change Plans in a participative manner[34].

Other initiatives: There are other initiatives aimed at managing and reporting their GHG emissions, such as the Center for Business Leaders Against Climate Change (CLG-Chile by its acronym in Spanish), and the Chilean Global Compact Network, the Santiago Climate Stock Exchange (SCX by its acronym in Spanish), the Carbon Disclosure Project (CDP), Company Action (Acción Empresas), the Chile Footprint Program (Programa Huella Chile), the National Council for Clean Production, and ProChile.

34 *http://www.adapt-chile.org/web/wp-content/uploads/2015/04/Agenda-Para-Municipios-Ante-el-Cambio-Climatico.pdf Available at: http://www.adapt-chile.org/ web/academias*

4.3.3 Actions and Policies Associated with Mitigation by Sectors

The Nationally Appropriate Mitigation Actions (NAMAs) refer to any action that reduces emissions in developing countries and that are prepared under the auspices of a government initiative. They may be policies aimed at achieving transformational changes within an economy sector or actions for all sectors with a broader national approach. The NAMAS are supported and facilitated by technology, funding and capacity building and are aimed at achieving a reduction of emissions for the business-as-usual scenario by 2020.

The country began working on the design of these action and, to date, there are five NAMAs included in the NAMA Registry of the UNFCCC, which cover the transportation, non-conventional renewable energies, waste, forestry and industrial sectors (see **Table 03** – Chile's Nationally Appropriate Mitigation Actions - NAMAs).

TABLE 03

CHILE'S NATIONALLY APPROPRIATE MITIGATION ACTIONS (NAMAS)

NAME	INSTITUTION	STATUS	REDUCTION TARGET
NAMAs Registered with the UNFCCC			
Renewable Energy for Self-Consumption in Chile	MINENERGIA - CER	Under implementation	2 $MtCO_2eq$
National Program to Boost Industry and Trade in Organic Waste Management in Chile	MMA	Seeking support for implementation	12 $MtCO_2eq$
Design and implementation of the National Strategy for Climate Change and Vegetation Resources (ENCCRV)	CONAF	Seeking support for implementation	42 $MtCO_2eq$
Clean Production Agreements in Chile	CPL	Under implementation	18,4 $MtCO_2eq$
Green Zone for Transportation in Santiago (ZVTS by its acronym in Spanish)	Municipality of Santiago	Seeking support for implementation	1,43 $MtCO_2eq$
NAMAs under preparation			
Carbon Sequestration Through Sustainable Land Management	INIA and SAG	Design stage	65 a 80 $MtCO_2eq$
Mitigation of GHG Emissions Stemming from Industrial, Commercial and Institutional Boilers	MINENERGIA	Design stage	1,25 $MtCO_2eq$
National Strategy for Sustainable Construction	MINVU	Design stage	No information
Assisted Phyto-Stabilization of Mining Tailing Ponds in Chile	MMA	Design stage	No information

Source: MMA, 2014b.

4.3.4 MAPS Chile Project

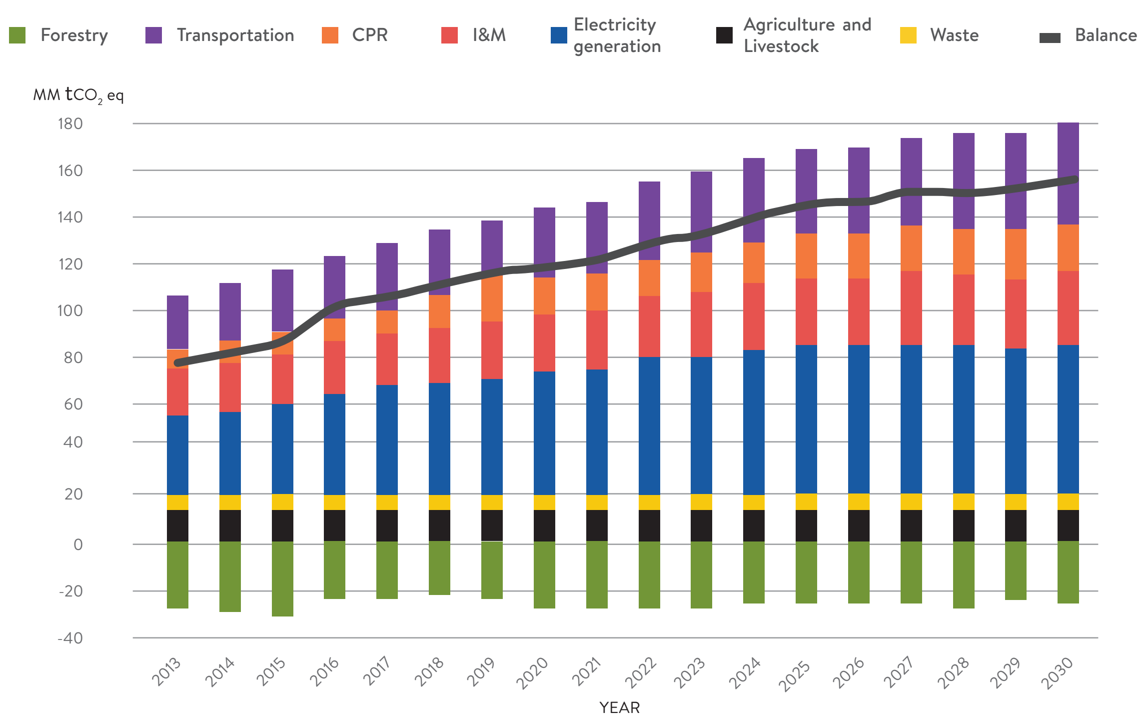
The Mitigation Action Plans and Scenarios (MAPS) Chile project was developed between 2011 and 2015, seeking to study different GHG emissions projection scenarios to generate necessary evidence about several actions the country may take.

The MAPS-Chile project was carried out in three phases. During phase 1 (results presented in July 2013), a projection was made for a 2007-2030 Baseline Scenario or Growth without Restrictions and the Required by Science Scenario. In Phase 2, projections were made for a 2013-2030 Baseline Scenario ("business as usual") for emissions and sequestration for the sectors of the country (**Figure 15**). Potential mitigation measures were assessed for the economy sectors included in the project, identifying and evaluating different mitigation scenarios (**Figure 16**) and results were presented on the economic impact of the implementation of the mitigation measures and scenarios based on a general balance. Finally, during the third phase of the project, the results for phase 2 were refined, analyzing the co-benefits of mitigation measures and identifying mitigation options for the 2030-2050 horizon, with an out-of-the-box approach (MAPS Chile, 2014).

The result of the MAPS process allowed building Chile's contribution, submitted in Paris to the COP 21 in 2015, which was created considering the medium-effort scenario.

FIGURE 15

2013-2030 GHG EMISSIONS BASELINE (PROJECTION OF AVERAGE GDP) CONSIDERING ALL SECTORS

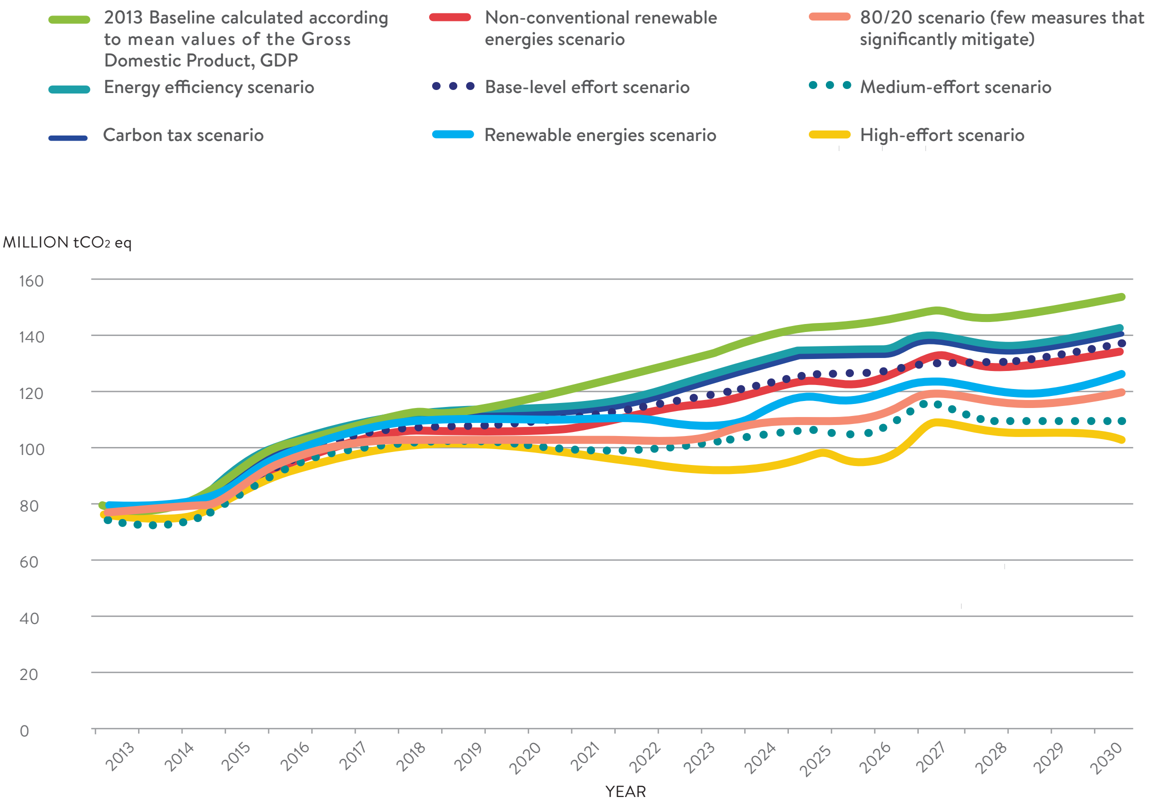


Source: MAPS Chile, 2014.

Note: CPR = Commercial, Public and Residential; I&M = Industry and Mining.

FIGURE 16

PROJECTION OF GHG EMISSIONS FOR EACH ANALYZED MITIGATION SCENARIO



Source: MAPS Chile, 2014.

4.3.5 Low Emission Capacity Building (LECB-Chile) Project

The "Low Emission Capacity Building" (LECB-Chile) project was launched in 2012 and is part of an initiative led by the United Nations Development Programme (UNDP) in 25 countries. The project is funded by the governments of Germany, Australia and the European Commission to promote and build capacities in the public and private sectors to measure and mitigate their GHG emissions through nationally appropriate actions in order to achieve the country's development with low carbon emissions and improving public policies that address climate change.

The LECB-Chile project has four components: 1) Updating of the national GHG registry and creating a national system for the inventory of these gases (SNICHILE by its acronym in Spanish); 2) implementing the National Carbon Management Program (HuellaChile – ChileFootprint – Program); 3) NAMAs measurement, reporting and verification system (MRV by its acronym in Spanish) in the public and private sectors; and 4) designing a national development strategy with low emissions (LEDS by its acronym in Spanish) that incorporates the results of the first three components.

4.3.6 National Carbon Management Program (ChileFootprint Program)

The *HuellaChile* program[35] (ChileFootprint Program) was launched in 2015 with the aim of promoting GHG emissions in public and private organizations. The program has a free quantification tool installed in the one-stop-shop of the Ministry of the Environment, in addition to granting recognition to its participants for the different levels of management of their emissions. The next steps of this program will be the implementation of a dissemination plan and continuing with a national-level training agenda. Initiatives like *HuellaChile* are of great relevance by providing a concrete opportunity for cooperation and work between the public and private sectors.

4.3.7 Measurement, Reporting and Verification (MRV) of Mitigation Actions

Measurement, Reporting and Verification (MRV) is a term used to describe all measures taken by countries to: collect data on emissions, mitigation and support actions; compile this information in reports and inventories; and submit them to some form of revision or analysis (MMA, 2014b).

The objective of creating MRV in Chile is to promote transparency in GHG mitigation activities carried out by the country through mechanisms that will enable monitoring the fulfillment of its objectives. Following the international approach for MRV, Chile divides its efforts into two lines of action: National MRV and NAMAs MRV. The National MRV refers to the monitoring of Chile's voluntary reduction commitment. This MRV will be internationally led by the UNFCCC and will include national mitigation efforts and the national GHG emissions inventory, which will be reported through the bi-annual update reports. Given the competences of the Ministry of the Environment, the DCC coordinates the validation process of the MRV for each NAMA. To that end, it is supported by sectoral experts and, during 2014 and 2015, a guide was prepared with guidelines for an overall NAMAs MRV framework, in response to the need to standardize procedures, methodologies and baseline information.

It is expected that over the next few years Chile will have a consolidated and integrated MRV system[36], which will enable monitoring individual mitigation actions, as well as State policies with impacts on GHG emissions and on the commitments for reduction made within the framework of international negotiations on climate change.

4.3.8 Carbon Footprint

The measurement of carbon footprints[37] is being promoted in the country, as a mechanism for raising awareness on the issue of climate change. This initiative has been developed both at the public level and among private companies. The Ministry of the Environment has estimated its carbon footprint for 2009, 2010, and 2011.

4.3.9 Market Instruments for Environmental Externalities

Chile is exploring new innovative and profitable ways to intensify the reduction of emissions and foster financial flows, including the implementation of market-based instruments.

Clean Development Mechanism (CDM)

Chile has promoted and executed projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol, becoming a relevant actor at the Latin American level (third after Mexico and Brazil). This is reflected in 141 projects approved by the National Designated Authority (up to July 2014), of which 101 have been registered with the CDM Executive Board (up to June 2014).

35 *http://www.huellachile.cl/*

36 *Achieved with the technical and financial support of international projects (Prosperity Fund, Information Matters and LECB).*

37 *"The carbon footprint is defined as the set of GHG emissions produced, directly or indirectly, by people, organizations, products, events or geographical regions, in terms of CO_2 equivalent units, and serves as a useful management tool to learn about the behaviors or actions that are contributing to increase our emissions, how we can improve them and use resources more efficiently" (MMA, accessed from http://portal.mma.gob.cl/cc-02-7-huella-de-carbono/).*

Most of the projects are related to hydroelectric power generation, methane sequestration and wind energy. However, a marked decreasing trend has been observed since 2012 in terms of the submission of new projects seeking approval.

“Partnership for Market Readiness” (PMR) Project

The Government of Chile, represented by the Ministry of Energy, officially expressed its interest in participating in the World Bank’s “Partnership for Market Readiness” (PMR) initiative, recognizing in it a valuable platform for learning and cooperation with countries that have already set up emissions trading schemes and other market-based instruments to limit the growth of their GHG emissions and learn from their experiences.

Chile joined the PMR in May 2011, after the PMR Assembly approved its expression of interest and allocated USD $350,000 for the preparation phase, which was used to conduct a series of baseline analyses, including those of the necessary elements for the design and application of an emissions trading system in Chile, such as the MRV system, as well as proposals to design and implement sectoral carbon credit mechanisms and study tours to visit ETS regulators in other countries.

The country submitted its PMR proposal to the Assembly, which reviewed it and approved it, allocating USD $3,000,000 as a donation. The Finance and Environment ministries will support the Ministry of Energy in its supervision and focal point roles for the execution of the project in Chile. In order to provide technical and political supervision during the project’s execution, a Steering Committee was created in March 2012. The technical components of the project, which will help build capacities and design and implement carbon pricing instruments in the country, with an initial emphasis on the energy sector, are:

- Component 1:

  Feasibility assessment for one or more carbon pricing instruments in the energy sector, considering regulatory, institutional, and economic analyses necessary for their implementation.

- Component 2:

  Design and Implementation of a Measurement, Reporting and Verification (MRV) System and GHG Registry, in order to monitor and record GHG emissions online. Taking into account the existence of the PRTR, the legal attributes associated with the collection of data for this registry, as well as its capacity to serve as a single platform for reporting emissions, the Government of Chile is considering improving and strengthening the calculation and reporting in the specific field of GHG within the PRTR.

- Component 3:

  Communication strategy and commitment to participate by diverse stakeholders linked to the instruments under evaluation. Among other things, they will identify gaps and training needs in the public and private sectors and technical visits will be conducted to countries with experience in these instruments.

PRM PROPOSAL

Chile submitted its PMR proposal to the Assembly, which reviewed it and approved it, allocating USD $3,000,000 as a donation. The Finance and Environment ministries will support the Ministry of Energy in its supervision and focal point roles for the execution of the project in Chile.

Green Taxes

On September 26, 2014 the Tax Reform Law was passed, which, as previously mentioned, includes "green taxes" for the first time in Chile. One of them is a direct tax to CO_2 emissions.

The CO_2 tax affects mainly electric power plants. This tax will not be applied to stationary sources operating based on non-conventional renewable generation means whose source of primary energy is biomass. It is estimated that between 100 and 150 facilities will be part of the tax, encompassing approximately 12 percent of total emissions.

The collection of this tax will be applied to a greater extent to CO_2 and will represent approximately 84 percent of the total collection of all green taxes. Although it is still not clear what impact this tax will have on global CO_2 emissions, preliminary estimates indicate that it will have significant impact. For example, KAS consultancy firm estimates a significant reduction, although it does not specify the amount (KAS Ingeniería, 2013). Meanwhile, another study conducted by the Pontifical Catholic University indicates a reduction of emissions of 3 million metric tons of CO_2 by 2020 and 8 million by 2030. The accumulated reduction for 2017-2030 period reaches 59 million metric tons (CCG-UC, 2014).

4.4 Adaptation

In Chile's Intended Nationally Determined Contribution (INDC) for the 2015 Paris Climate Agreement, actions were presented regarding adaptation that are structured based on two different cycles: the first will end in 2021 and the second, in 2030.

TABLE 04

ADAPTATION GOALS OF CHILE'S INTENDED NATIONALLY DETERMINED CONTRIBUTION (INDC) FOR THE PARIS CLIMATE AGREEMENT

CYCLE	GOALS
by 2021	Implementing specific actions aimed at increasing resilience in the country, under the National Climate Change Adaptation Plan and the sectorial plans, with a decentralized perspective and seeking to integrate efforts among the different decision-making levels (national, regional, and municipal).
	Identifying sources of financing to implement said plans, based on the considerations set forth in the financing section of this contribution.
	Building synergies with the contemplated mitigation initiatives, and maximizing the benefits that stem from the development and capacity-building pillars, as well as technology creation and transfer included in this contribution.
	Strengthening the institutional background of the adaptation in Chile.
	Preparation of metrics and measurement tools of the sectorial plans.
2021-2030	Creating the enabling conditions for the implementation, compliance and monitoring of Chile's commitments to the UNFCCC to reduce GHG emissions so that it will contribute consistently to the sustainable development of the country and to growth with low carbon emissions.
	Having an updated National Adaptation Plan.
	Developing a national assessment practice by 2026, through vulnerability indicators and methodologies aimed at determining the increase of the capacity of adaptation of the individuals, communities and systems impacted by Climate Change.

Source: Authors' own elaboration, based on Gobierno de Chile (2015).

Since the PANCC-I adaptation actions were already included and applied in sectors such as agriculture and livestock, energy, infrastructure and fishing, the same was done for some strategic resources, like water and biodiversity. In addition, this Plan entailed adaptation measures in specific areas, such as urban coastal zones.

A significant part of the actions developed within the framework of this plan were linked to specific studies, which made up the essential inputs for the definition of actions in the sectors that are vulnerable to climate change.

One of the goals established in the PANC-I was to prepare a National Plan for Adaptation to Climate Change, published[38] in 2014, and sectoral plans. The general objectives of the National Plan for Adaptation to Climate Change are: 1) To establish a conceptual framework for adaptation in Chile; 2) to establish the institutional framework under which the National Plan for Adaptation and the sectoral plans will operate; 3) to establish and update the sectors that require adaptation plans and to establish the criteria and guidelines for their preparation and implementation; and 4) to define the necessary cross-cutting climate change adaptation actions for the sectors.

Within the framework of these objectives, a series of cross-cutting activities is established, dealing with scientific research (vulnerability studies), communication and environmental education, institutional strengthening[39], disaster risk management, and sectoral activities involving the preparation and implementation of sectoral plans.

Between 2013 and 2015, three Sectoral Plans for Adaptation to Climate Change were approved: Agriculture and Livestock; biodiversity; and fishing and aquaculture. Six are programmed until 2018 (health, cities, infrastructure, energy, tourism, and water resources). The institution responsible for coordinating the preparation and implementation of these plans at the inter-ministerial level is the Ministry of the Environment, through the Department of Climate Change (DCC).

By the end of 2015, a first partial report of activities implemented under the framework of the National Plan for Adaptation, up to June 2015, was submitted to the Council of Ministers for Sustainability. Later on, the First Annual Report of the National Plan for Adaptation will be submitted, incorporating results of the sectoral plans under implementation.

[38] *Available at: http://portal.mma.gob.cl/cambio-climatico/*

[39] *For example, the National Plan for Adaptation proposed changes to the institutional structure for climate change, incorporating the ETICC and the CORECC.*

Guanacos in Torres del Paine National Park 2015 | VALERIA PIZARRO

4.5 Building and Promoting Capacities, Education and Awareness and Technology Transfer

The INDC submitted by the country during the COP21 in 2015 includes goals for the “Capacity Building and Strengthening” and “Technology Development and Transfer” axes (**Table 05**).

TABLE 05

GOALS FOR THE “CAPACITY BUILDING AND STRENGTHENING” AND “TECHNOLOGY DEVELOPMENT AND TRANSFER” AXES PROPOSED IN CHILE’S INDC FOR THE 2015 PARIS CLIMATE AGREEMENT (COP21)

AXIS	GOAL
Capacity Building and Strengthening	The creation of forecast models that Chile can share and distribute nationally and internationally, both through individual efforts and jointly with other countries determined to take action.
	Seminars, organized in conjunction with other countries willing to provide training and coaching support to nations which so require it, through the preparation and reporting of their planned national contributions, greenhouse gas emission inventories, national communications, biennial update reports, and nationally appropriate mitigation actions (NAMAs).
	The preparation of instruments to promote research and capacity-building at the national and sub-national level, strengthening the response capacity of the communities and local governments, so as to strengthen national adaptation capacity through institutional development and the capacity-building of the groups and sectors of the country which are most vulnerable to the impacts of Climate Change.
Technology Development and Transfer	A baseline analysis of spending and investment in technology.
	Mapping of needs and technological priorities for climate change.
	Identification of possible implementation synergies to be used in the technological response for adaptation and mitigation of Climate Change.

Source: Authors' own elaboration, based on Gobierno de Chile (2015).

The new PANCC-II proposes to continue deepening the work in matters dealing with “Building and Promoting Capacities, Education and Awareness”, through the new axes “Means of implementation, which has five specific objectives, 11 lines of action and 26 measures, and “Climate Change management at the regional and communal levels”, which contains three specific objectives, six lines of action and 16 measures.

On the other hand, the Environmental Protection Fund (FPA by its acronym in Spanish) has two categories that explicitly address climate change, a narrow one (“Climate Change”) and a broader one (“Climate Change and Environmental Decontamination”). In the case of the first category, “Climate Change”, projects submitted doubled from three to six between 2012 and 2014, as did the grant amount (from CLP $60 to CLP $120 million). The “Climate Change and Environmental Decontamination” category presents inter-annual variations between 2009 and 2015, starting in 2009 with a maximum of 104 projects for CLP $596.2 million, going through a minimum of 51 projects for CLP $233.8 million in 2012, and rising up to 82 projects totaling CLP $410 million in 2015.

The Ministry of the Environment implemented the Sustainable Neighborhoods and Climate Change Program and has established relevant partnerships for capacity building and technical assistance with diverse stakeholders, including the Federal Republic of Germany, the European Commission, Spain and the World Bank.

Regarding glaciers, an inventory[40] was prepared, installing more gaging and meteorological stations and a study was conducted to assess the behavior of glaciers in the central and northern zones of the country. The National Strategy for Glaciers[41] was prepared in 2009. The internal structure of large masses of ice and the existing volume of frozen water have yet to be determined, in order to model and project future glacier retreat. The Glaciology and Snow Unit of the General Water Directorate is the competent technical body carrying out monitoring and measurement actions of these resources.

In terms of technology transfer, initiatives related to solar energy, GHG measurements and the generation of crops resistant to climate change have been developed in the country.

State funding has been provided for research on vulnerability, adaptation, mitigation and climate science. In this regard, for example, the National Science and Technology Fund (FONDECYT by its acronym in Spanish) has significantly increased funding for projects dealing with climate change over the past decade.

4.6 International Funding and Support

Chile has constantly applied for international support in the areas of financial resources, capacity building and technical assistance, and technology transfer, in order to implement an ambitious project portfolio and to contribute to the achievement of the UNFCCC's objectives. This has been a complement to the country's own funds allocated to local actions and to bilateral and multilateral cooperation actions with donor countries.

Chile has received a total of USD $9,874,030[42] between 2011 and 2014. Out of this total, approximately 40 percent corresponds to donations made by a group of countries or organizations gathered for a specific initiative, 31 percent to bilateral or country donations, 25 percent to multilateral funds or institutions and 4 percent to international financial institutions. These financial resources have been mainly executed by the following projects and programs: MAPS Chile, LECB-Chile, projects of the Global Environment Facility (GEF) on climate change, the Forestry Carbon Cooperative Fund and the PMR.

[40] *Available at: http://aprchile.cl/pdfs/Inventario%20de%20glaciares.pdf*

[41] *Available at: http://documentos.dga.cl/GLA5194v1.pdf*

[42] *Excluding contributions that have been approved but are not yet available, which represent USD $37,368,269.*

Transformation | NICOLÁS LAGOS

Regarding capacity building and technical assistance, the support received from the Federal Republic of Germany, the European Commission, Spain and the World Bank stand out, among others, in addition to other specific support from donors.

In the INDC submitted during COP21, the country committed to communicating in 2018 a cross-cutting National Financial Strategy for Climate Change, which will include at least the following elements:

- A periodical Climate Change public spending analysis, both direct and indirect, which will be updated annually after 2020;
- Creation of internal institutions which will allow to optimally manage and coordinate the relationship with the Green Climate Fund, which from a multi-sectorial perspective will be in charge of selecting and assessing the fundable project portfolio, among other duties;
- Design of financial instruments which can be used for purposes such as adaptation and technology transfer.

4.6.1 Climate Expenditure Project

The Climate Expenditure Project seeks to quantify and analyze expenditure on climate change to develop an adequate policy for mitigation and adaptation, to contribute to building institutional capacities for its potential continuity and also to contribute to fulfilling the country's commitment made with the COP21 (National Financial Strategy) and with the OECD (reporting "expenses and funds related to the environment").

The project is framed within the "Climate Public Expenditure and Institutional Review" (CPEIR) methodology. Its specific objectives are to: Define, agree upon and validate an ad-hoc concept of climate expenditure, for both mitigation and adaptation; prepare and pilot a (single) form to be completed by the professionals in charge of each agency's budgetary report; generate synergies with other public (GPA and BIOFIN) and private (GCPR(LECB) expenditure accounting and analysis initiatives; and prepare concrete proposals to move forward in the process of mainstreaming climate expenditure reporting.

This project, launched in 2015, has a duration of two years, is funded by the LECB-Chile Program and led by the Department of Climate Change of the Ministry of the Environment, in collaboration with the Ministry of Finance and with the participation of the ministries of Energy, Agriculture, Interior, Economy and Mining.

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Red Rocks | MARÍA INÉS FUENTEVILLA

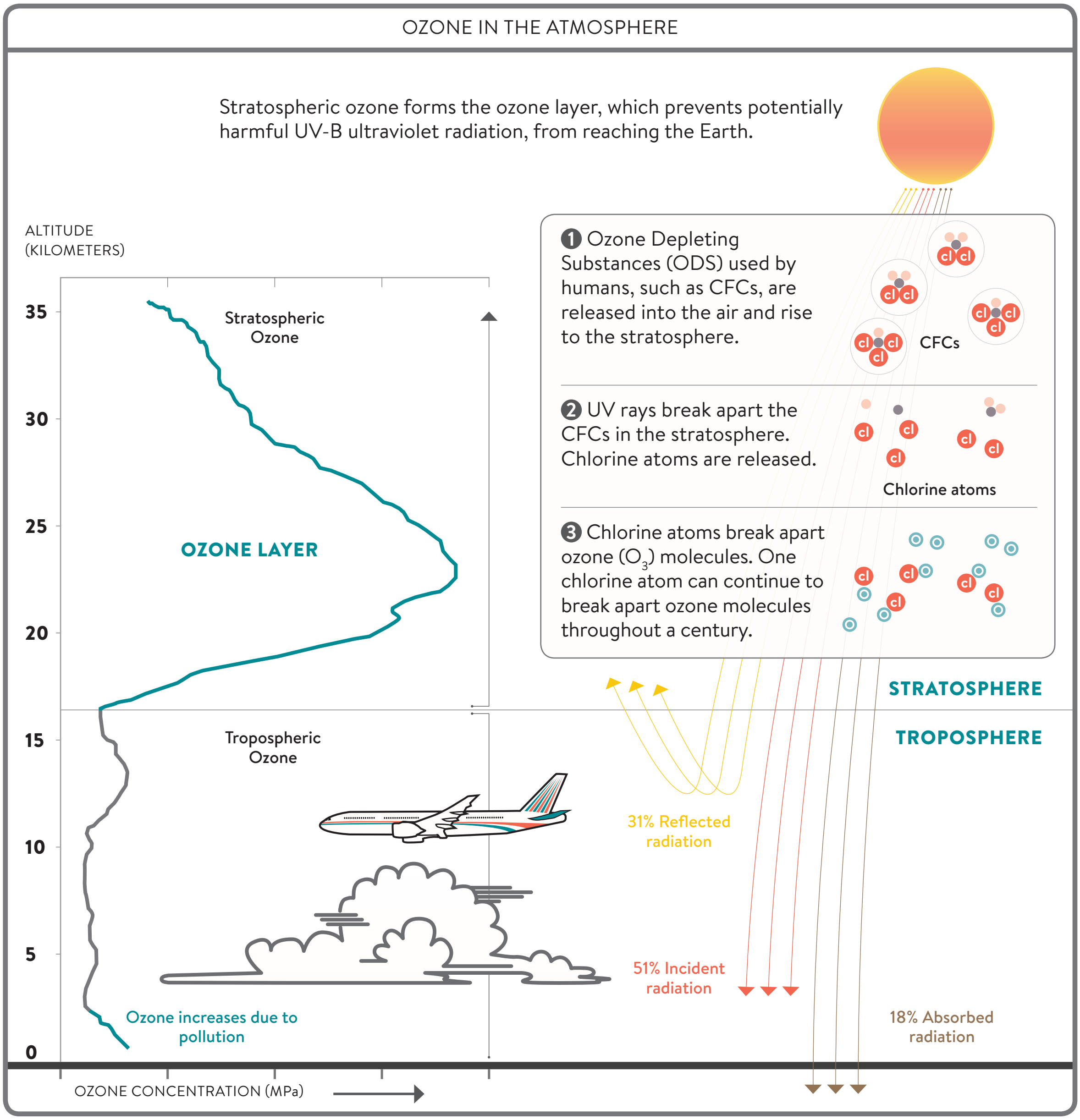
CHAP **09**

OZONE LAYER

CONTENT

INTRODUCTION

The ozone layer is a shield that protects us from ultraviolet radiation coming from the Sun. If the levels of ultraviolet radiation reaching the Earth is high, significant problems can be caused to humans, as well as to biodiversity. The depletion of the ozone layer occurs due to the anthropic use of several compounds called Ozone Depleting Substances (ODS). Chile is particularly vulnerable to this phenomenon, because it is located near the Antarctic Ozone Hole. Chile has contributed to the global effort to recover the ozone layer by ratifying the Vienna Convention and the Montreal Protocol, and all of their amendments, and by complying with the commitments to reduce the consumption of ODS.



1 • BACKGROUND INFORMATION

The Sun emits an electromagnetic spectrum that reaches the Earth in the form of visible radiation waves, heat (infrared) and ultraviolet radiation (UV), which enables life on the planet. In small quantities, UV radiation is essential for human life, it promotes the production of vitamin D on the skin, which in turn helps develop the bone system, regulates the circadian rhythm or biological rhythms and aids in the production of endorphins, which have an antidepressant effect.

However, excessive and prolonged exposure to UV radiation is harmful for humans and the environment. It causes damage to the skin and even skin cancer (melanoma and non-melanoma), as well as problems with the eyes, such as cataracts, and a negative effect on the immune system. In the environment, it slows down the growth of plants, unicellular organisms are affected, and aquatic systems are altered.

Ozone is a gas formed by three oxygen atoms (O_3) that is present in the Earth's atmosphere, distributed in different concentrations, with geographical, seasonal and altitudinal variations.

The ozone layer is the zone of the stratosphere which concentrates more than 90 percent of the Earth's ozone[1], located between 15 and 24 km of altitude above the surface. It is higher near the poles and lower near the Equator, due to the behavior of winds in the stratosphere. The ozone layer acts as a protective shield preventing UV radiation, particularly UVB, and when the layer is weakened UV radiation increases, thus augmenting the aforementioned damaging effects.

Ozone concentrations during the colder seasons are higher than those observed during the warmer ones. In the winter, in the case of Antarctica, the polar vortex, a persistent large-scale cyclone, isolates cold air masses in its core, forming stratospheric clouds.

Chemical reactions occurring inside these clouds are unique on the planet, releasing chlorine and bromine atoms, which are derived from ODS generated by anthropogenic activities. Regarding the increase of solar radiation flows during the spring, these chemicals break and are released, generating a significant thinning of the ozone layer in the Antarctic, a phenomenon known as the Antarctic Ozone Hole (AOH).

It is estimated that, under conditions without clouds, a reduction of 1 percent of the ozone translates to 1.5 percent of UVB radiation increase that reaches the Earth's surface (MINSAL, 2011).

[1] *The remaining 10 percent of ozone, which is not part of the ozone layer, can be found in the troposphere (lowest layer of the atmosphere located closest to the Earth's surface) and does not function as a UV radiation protector. Tropospheric ozone is a dangerous pollutant for living organisms due to its oxidizing nature, which forms photochemical smog when found in high concentrations.*

01

UV RADIATION AND HEALTH: SKIN CANCER

One of the most aggressive impacts of radiation on the population is skin cancer.

There are several types of cancer: the non-melanoma, which include the Basal Cell Carcinoma (BCC) and the Squamous Cell Carcinoma (SCC), which are common but less lethal, and the malignant melanoma, which is less frequent than the non-melanoma but is the main cause of death of skin cancers.

Malignant Melanoma Cancer

According to the International Agency for Research on Cancer (IARC) of the World Health Organization (WHO), in 2012 the global mortality rate for malignant melanoma was 0.9 for every 100,000 inhabitants in the male population and 0.6 for every 100,000 inhabitants in the female population (IARC, 2016).

The WHO also indicates that a reduction of 10 percent of ozone levels produces 4,500 additional cases of malignant melanoma skin cancer worldwide (WHO, 2015).

There are factors that increase the risk of skin cancer in people, including: considerable sun exposure; light skin, hair and eyes; some types of moles; family history of melanoma; having suffered a type of skin cancer; weak immune system; and old age, among others.

Source: MINSAL (2011) and American Cancer Society (2016).

The WHO, in collaboration with the United Nations Environment Programme (UNEP) and other organizations, created a solar protection index, the UV Index. This index measures the intensity of UV radiation on the Earth's surface. The higher its value, the greater its intensity, and thus, the greater the health risk.

In the last few decades, NASA has carried out periodical measurements of the thickness of the ozone layer in different latitudes and stations using the Dobson Unit (DU)[2] measure. Conventionally, the AOH is defined as the region where the ozone column is equal to or less than 220 DU. The usual values observed in the atmosphere range between 230 and 500 DU.

THICKNESS OF THE OZONE LAYER

Conventionally, the AOH is defined as the region where the ozone column is equal to or less than

220 DU (DOBSON UNIT)

02

TYPES OF UV RADIATION AND THE FACTORS THAT DETERMINE ITS INTENSITY

There are three types of ultraviolet radiation (UV), which differ in the range of their wavelengths: UVA, UVB and UVC. UV radiation is most harmful at a lesser wavelength. However, its capacity to reach the skin is also lower. UVA is the longest wavelength (315-400 nanometers (nm)), almost all of it reaches the Earth's surface and it penetrates the skin up to the dermis; UVB rays possess a medium wavelength (280-315 nm) and are completely absorbed by the ozone layer and reach the first layers of the skin (epidermis); and UVC radiation, the one with the shortest wavelength (100-280 nm) and, in theory, the most dangerous, does not reach the Earth since it is entirely absorbed by the ozone layer.

The intensity of UV radiation depends on several factors:

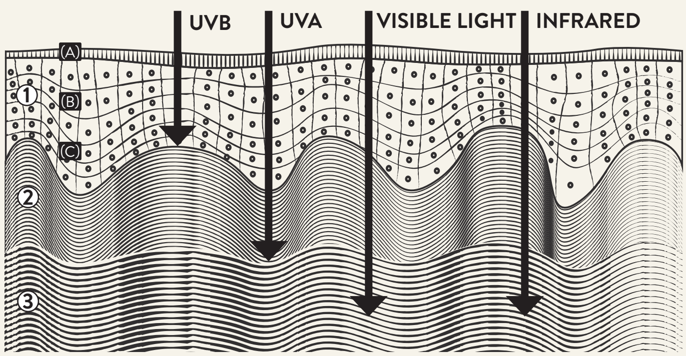
- **Date and time:** The time of year determines the maximum altitude reached by the Sun over the horizon during the day and the time of day determines how close the Sun is to the zenith of the site. This combination determines that the highest intensity of UV radiation occurs during the summertime between 11 a.m. and 3 p.m. and during the winter between noon and 3 p.m.
- **Latitude:** Closer to the Equator, the intensity of UV radiation is higher since the solar rays reach the surface at a perpendicular angle and pass less through the ozone layer. Towards the poles, the angle that the UV rays must pass increases and, therefore, the intensity of the radiation is diminished towards those latitudes.
- **Altitude:** The intensity of radiation increases at higher altitudes because the atmosphere is thinner.
- **Cloud cover:** Clouds slightly reduce UV radiation (approximately by 10 percent).

SKIN LAYERS

① **Epidermis** (A) STRATUM CORNEUM (B) STRATUM SPINOSUM (C) STRATUM BASALE AND MELANOCYTES

② **Dermis**

③ **Hypodermis**



Source: MINSAL 2011.

[2] *The Dobson Unit (DU) is a measurement of the thickness of the ozone layer, equivalent to 0.01 mm at normal pressure and temperature conditions (1 atm and 0 °C, respectively), and it is expressed in number of molecules.*

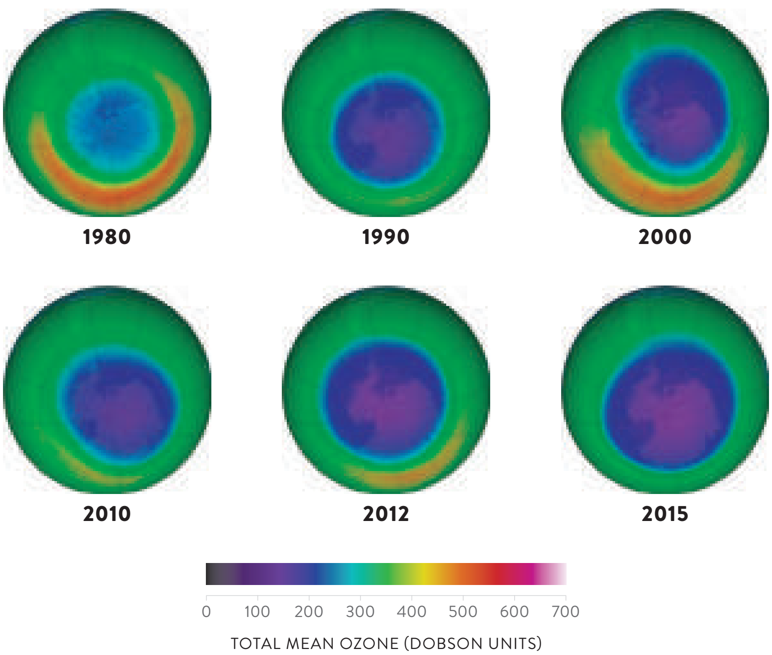
2 • STATUS: ANTARCTIC OZONE HOLE AND UV RADIATION IN CHILE

Figure 01 shows images of the Antarctic Ozone Hole between 1980 and 2015 presented by NASA, which reveal the false-color view of the total ozone column. The purple and blue colors indicate where the ozone column is between 0 and 200 DU, below 200DU is considered a hole in the ozone layer. The yellow and red are where there is more ozone and, therefore, the ozone layer is thicker. The images show that a section of the AOH is located above the Magallanes and Chilean Antarctic Region, leaving the country under a particular condition of vulnerability in comparison to the rest of the world.

When contrasting the figures for the years 1980 and 1990, it clearly shows the onset of the ozone layer hole phenomenon. Between 1990 and 2010, it remains relatively stable in terms of its magnitude, with only slight displacements of the AOH area surrounding the South Pole. Although a reduction of the hole can be appreciated in 2012, in 2015 the problem regains strength and records an even greater size.

FIGURE 01

TOTAL OBSERVED OZONE*
monthly mean for October each year, 1980-2015



Source: NASA, http://ozonewatch.gsfc.nasa.gov

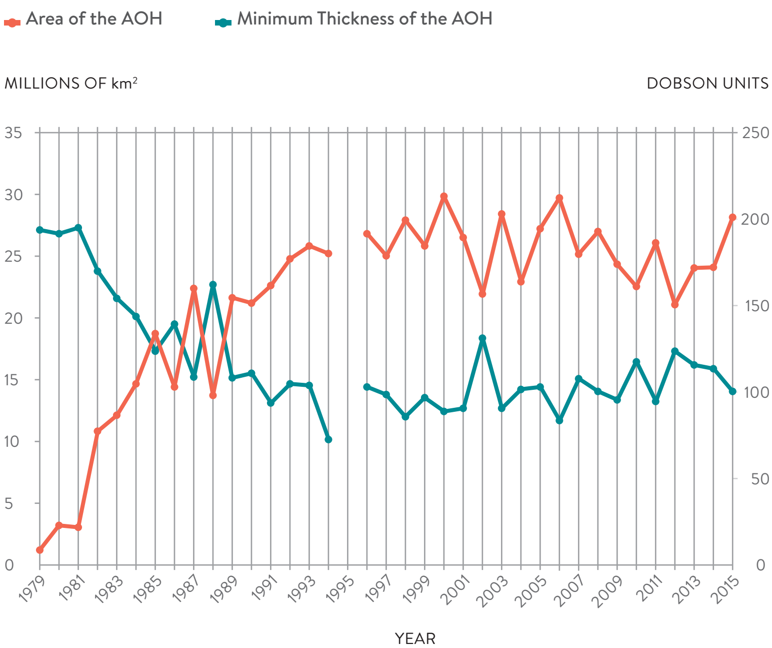
** The images represent the total mean ozone over the Antarctic pole, with intervals of values in Dobson Units in color gradients. The purple and blue colors show where there is the least ozone (the thinnest part of the ozone layer), while yellow and red show where there is more ozone (the thickest part of the ozone layer).*

Figure 02 shows the evolution of the series of annual maximum area and minimum thickness of AOH from 1979 until 2015. Between 1980 and 1993, more dramatic changes can be observed in its area as well as its thickness. The series reveals a tendency towards stabilization, despite recording significant inter -annual variations. Since 2012, signs that the problem is becoming more serious reappear. While the maximum area of the AOH in 1979 was 1.1 million square kilometers (km^2), by 2015 it had reached 28.2 million km^2, the fourth largest record in the series. On the other hand, the thickness of the total ozone column measured in the Antarctic was reduced to almost half of the values registered at the beginning of the 1980s.

These conclusions of the analysis of the AOH with data from NASA coincide with measurements conducted in the field by researchers of the University of Santiago de Chile (USACH) during the Union Glacier Campaign of the Antarctic Scientific Expedition that the Chilean Antarctic Institute (INACH, by its acronym in Spanish) carried out between November and December 2015, which showed record minimum historical levels for the ozone column in the month of December of that year.

FIGURE 02

MAXIMUM AREA AND MINIMUM THICKNESS*
of the Antarctic Ozone Hole (AOH), 1979-2015



Source: NASA, Ozone Hole Watch.

** Ozone (DU) = Ozone column measured in Dobson Units. The values showed correspond to the maximum annual record of the area of AOH and the minimum annual record of thickness of the AOH.*

According to historical data presented by the University of Magallanes, obtained from instruments on satellites and latitudinal means, **Table 01** shows the means of the ozone column for some cities of Chile and different periods. Three means are shown: 1) for the 1978 to 1987 series, which corresponds to a period without AOH influence; 2) a mean for a larger period between 1978 and 2010; and 3) the mean for 2010. In addition, each period has been sub-divided according to the seasons of the year, mainly due to the seasonal variation shown by the ozone layer, with minimum values during fall-winter and maximum ones in spring-summer.

The data show that there are no large variations of the total ozone column in the selected cities, except for the two southernmost areas, where the AOH influences the values for the spring-summer season. All values presented in the chart coincide with the global trends of the Scientific Assessment of Ozone Depletion report from 2010, published by the Panel of Experts of the World Meteorological Organization (WMO). Furthermore, this information confirms that, overall, total ozone is lower in the regions near the Equator and higher near the poles.

Table 02 shows that the maximum UVB index during the summer months for the 2000-2014 period reaches extreme levels in 14 out of the 15 regions of the country.

Sky | SOLEDAD GAJARDO

TABLE 01

OZONE COLUMN MEANS (DOBSON UNITS),
according to the seasons of the year and periods, for different selected cities of Chile.

	SUMMER (DEC-FEB)			FALL (MAR-MAY)		
CITY	1978-1987	1978-2010	2010	1978-1987	1978-2010	2010
Arica	263	262	263	257	255	255
Iquique	268	266	267	261	258	261
Copiapó	274	272	271	267	263	266
Valparaíso-Santiago	281	278	277	273	269	273
Concepción	288	284	283	280	275	278
Valdivia - Puerto Montt	296	290	289	287	280	282
Aysén	305	298	296	294	286	286
Punta Arenas	318	306	304	301	292	291
Base Frei - Antártica	323	311	307	305	297	295
	WINTER (JUN-AUG)			SPRING (SEP-NOV)		
CITY	1978-1987	1978-2010	2010	1978-1987	1978-2010	2010
Arica	265	263	263	276	275	279
Iquique	276	273	274	288	286	286
Copiapó	292	287	287	302	299	297
Valparaíso-Santiago	309	303	302	317	313	310
Concepción	324	317	317	333	327	322
Valdivia - Puerto Montt	331	325	324	346	340	331
Aysén	334	327	326	357	349	338
Punta Arenas	331	322	291	365	353	342
Base Frei - Antártica	321	310	212	363	345	334

Source: Information provided by the University of Magallanes, based on data from the Meteorological Service of Chile (DMC by its acronym in Spanish).

TABLE 02

MAXIMUM UVB INDEX DURING THE SUMMER MONTHS IN PLACES OF CHILE, 2000-2014

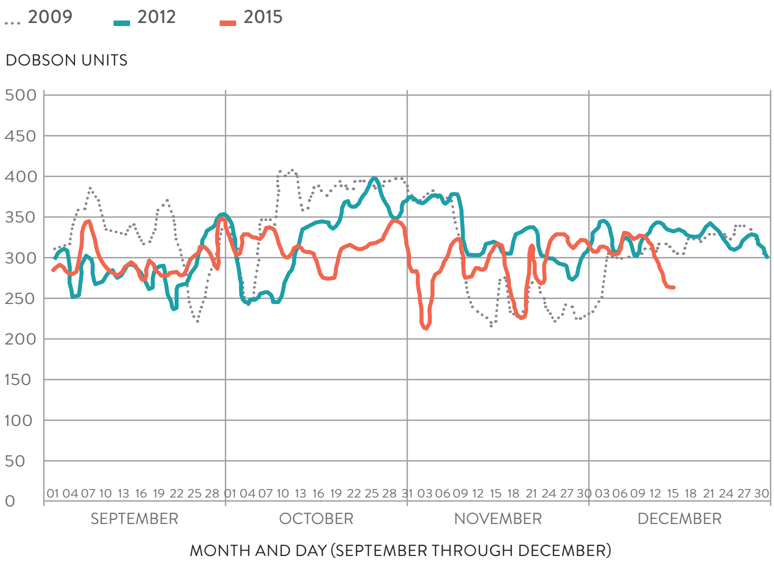
		UV INDEX MAXIMUM PER YEAR														
REGION	**STATION**	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Arica and Parinacota	Arica	-	-	-	-	-	-	13	14	16	14	14	13	14	15	12
Tarapacá	Iquique	15	16	12	12	13	13	13	12	11	11	11	13	13	-	-
Antofagasta	Antofagasta	-	-	-	-	-	-	-	-	-	-	-	15	15	16	15
	San Pedro de Atacama	-	-	-	-	-	-	-	-	-	-	-	20	21	20	20
	María Elena	-	-	-	-	-	-	-	-	-	-	-	18	17	-	-
Atacama	Caldera	-	-	-	-	-	-	-	-	-	-	-	-	18	18	16
Coquimbo	La Serena	-	-	-	-	-	-	-	-	-	-	-	17	16	15	13
Valparaíso	Valparaíso	-	-	11	13	14	12	13	14	14	12	14	13	16	16	13
	Isla de Pascua (Easter Island)	-	-	-	-	-	-	-	-	-	-	-	15	16	15	-
Santiago Metropolitan	Santiago	14	14	13	12	12	12	13	12	12	13	14	14	16	14	14
	Farellones	-	-	-	-	-	-	-	-	-	-	-	18	18	-	-
O´Higgins	Rancagua	-	-	-	-	-	-	-	-	-	-	-	12	15	14	13
Maule	Talca	-	-	-	-	-	-	-	-	-	-	-	15	15	-	14
Biobío	Concepción	-	-	12	13	12	13	14	12	12	12	12	12	11	11	12
Araucanía	Temuco	-	-	-	-	-	-	-	-	-	-	-	15	17	15	14
Los Ríos	Valdivia CECS	-	-	-	-	-	-	-	-	-	-	-	15	15	14	14
Los Lagos	Puerto Montt	-	-	13	12	12	12	12	12	13	13	14	14	14	13	14
Aysén	Coyhaique	-	10	12	12	12	13	12	11	13	13	13	13	14	13	13
Magallanes and Chilean Antarctica	Punta Arenas	-	-	9	9	10	10	10	10	10	10	9	9	9	10	10
	Antártica - Eduardo Frei	-	6	6	-	-	7	7	7	8	8	8	7	7	6	7

Source: MMA, based on data provided by the DMC, 2015.

UVB INDEX	**EXPOSURE RISK**	**RECOMMENDATIONS**
11 or more	EXTREME	Maximum protection; avoid mid-day radiation; wear proper clothing; stay in the shade and use sunscreen.
8 to 10	VERY HIGH	
6 to 7	HIGH	
3 to 5	MODERATE	Requires protection; avoid mid-day radiation; wear proper clothing; if you must be under the sun; seek shade and use sunscreen.
1 to 2	LOW	Does not require protection.

FIGURE 03

OZONE COLUMN (DOBSON UNITS)
in Punta Arenas, September through December 2009, 2012 and 2015

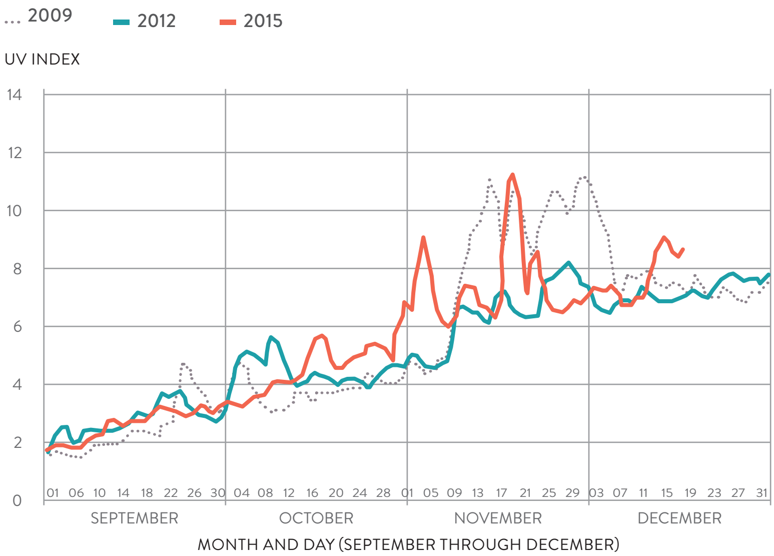


** Ozone Column (thickness of the ozone layer) in Dobson Units. The series correspond to the moving mean of two years in order to be able to compare trends between years with discontinuous data.*

Source: Tropospheric Emission Monitoring Internet Service (data from 17/12/2015).

FIGURE 04

ULTRAVIOLET RADIATION (UV INDEX)
observed in Punta Arenas, September through December 2009, 2012 and 2015



** The series correspond to the moving mean of two years in order to be able to compare trends between years with discontinuous data.*

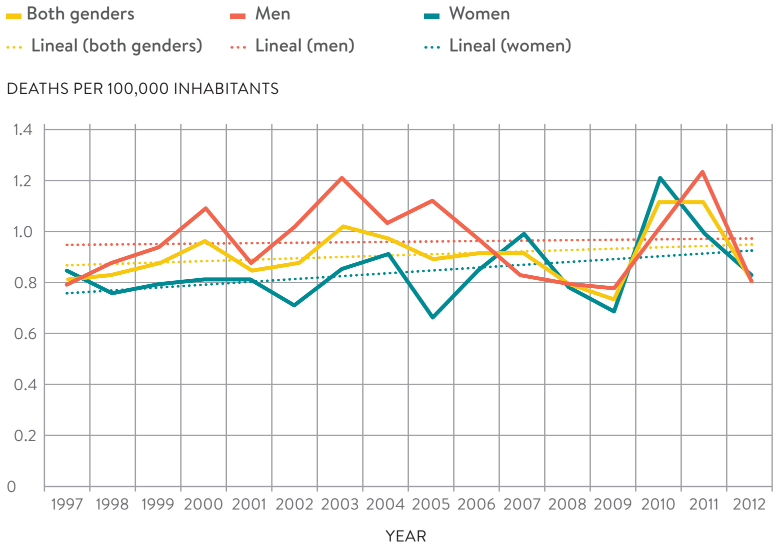
Source: Tropospheric Emission Monitoring Internet Service (data from 17/12/2015).

Figure 03 shows the daily evolution of the total ozone column and **Figure 04** the Ultraviolet Index (UVI), both for the city of Punta Arenas, between the months of September and December for 2009, 2012 and 2015. The chart shows that the AOH was positioned during several days of 2015 over this area of the country, generating an increase in ultraviolet radiation.

Experts working in the trinational project "Development of a Social and Environmental Atmospheric Risk Management System for South America" (*"Desarrollo de un sistema de gestión social y ambiental de riesgos atmosféricos de Sudamérica (SABER-NET)"*), led by the Japan International Cooperation Agency (JICA) with the participation of researchers of the University of Magallanes and Argentina, warned about an abnormal thinning of the ozone layer during the month of November 2014. They observed that the phenomenon was not restricted solely to Antarctica, but that through its breaking process it had grown and moved further north, covering almost half of the territory of both countries. This project began in April 2013 and will last five years.

FIGURE 05

MALIGNANT MELANOMAS MORTALITY RATE
at the national level, 1997-2012



** Observed annual mortality rate (cases per every 100,000 inhabitants).*

Source: MMA, based on data from the Ministry of Health, Department of Health Statistics and Information (DEIS by its acronym in Spanish), retrieved from www.deis.cl (data from 1/02/2016).

Figure 05 shows a slight increasing trend in the mortality rate by malignant melanoma at the national level between 1997 and 2012, reaching 0.83 per every 100,000 inhabitants during the last year. A more rapid growth can be observed in women than men. In 2012, the mortality rate was 0.81 for men and 0.85 for women.

In absolute terms, these mortality rates by melanoma are equivalent to 2,380 accumulated deaths at the national level during the 1997-2012 period, out of which 52.7 percent were men and 47.4 percent were women. In 2012, 145 deaths were recorded, 48.3 percent men and 51.7 percent women (**Figure 06**).

FIGURE 06

DEATHS BY MALIGNANT MELANOMAS
at the national level, 1997-2012

BETWEEN 1997 - 2012

2,380

Accumulated deaths at the national level, caused by malignant melanomas.

1997 ▶ 2012

145

Deaths caused by malignant melanomas during 2012.

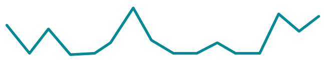
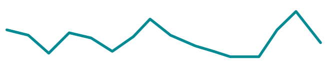
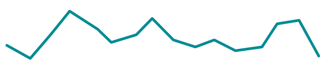
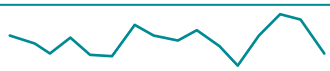
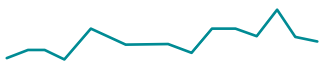
2012

Source: MMA based on data from the Ministry of Health, Department of Health Statistics and Information (DEIS by its acronym in Spanish), retrieved from www.deis.cl (data from 1/02/2016).

Table 03 shows the cancer mortality rates caused by malignant melanomas in the regions of the country during the 1997-2012 period. A heterogenous behavior can be observed in the regional time series, without clear trends, but showing that in eight regions of the country the mean rate for the 1997-2012 period surpasses 0.9 per every 100,000 inhabitants, while the national mean is 0.83.

TABLE 03

MALIGNANT MELANOMAS MORTALITY RATE, BY REGION, 1997-2012

REGION	SERIES (1997 - 2012)	MEAN (1997 - 2012)
Arica and Parinacota		0.5
Tarapacá		0.5
Antofagasta		0.6
Atacama		0.8
Coquimbo		0.9
Valparaíso		1.1
Santiago Metropolitan Region		0.9
O’higgins		0.7
Maule		0.9
Biobío		1.0
Araucanía		1.0
Los Ríos		0.9
Los Lagos		1.0
Aysén		0.4
Magallanes and Chilean Antarctica		0.9

Source: MMA based on data from the Ministry of Health, Department of Health Statistics and Information (DEIS by its acronym in Spanish), retrieved from www.deis.cl (data from 1/02/2016).

3 • PRESSURE: OZONE DEPLETING SUBSTANCES

The ozone layer problem originated primarily by the release of hazardous substances into the atmosphere due to industrial production and to the use of Ozone Depleting Substances (ODS). These substances have interrupted the natural formation and destruction cycle of ozone, which has led to the weakening of the ozone layer. While this problem is the responsibility of all the countries in the world, it does not affect every country proportionally.

According to the Montreal Protocol[3], the main ODS correspond to compounds such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), used in refrigeration, foams, propellants, solvents and fire extinguishers; methyl bromide (BrMe), used in soil fumigants and pesticides; halons to extinguish fires; methyl chloroform, previously used as an industrial solvent; carbon tetrachloride (CCI4), which was used as an industrial solvent in chemical laboratories; and Bromochloromethane for disinfecting water.

The national consumption of ODS is estimated as the sum of the generation, plus the national imports, minus the exports of products that contain them. In the case of Chile, there is no ODS generation, and the exports are not significant, therefore, the national consumption calculation is made based on statistics of ODS imports as pure or mixed substances, which are regulated by the National Customs Service.

According to the National Customs Service, there has been a significant reduction between 1989 and 2014 (82 percent), which can be attributed to the compliance with the reduction goals set forth by the Montreal Protocol. In 1989, there were 6 recorded ODS (CFCs, halons, methyl bromide, methyl chloroform and carbon tetrachloride) which totaled 1,298.3 metric tons of substances with ODP; in turn, during 2014 only two were consumed (methyl bromide and HCFCs), totaling 236.4 metric tons of substances with ODP.

Between 1989 and 2006, the consumption of substances with ODP was dominated by CFCs. Their reduction is due to the application of the Montreal Protocol. On the other hand, the increase of HCFCs is a result of the substitution of CFCs.

TOTAL NATIONAL CONSUMPION OF ODS

They have significantly diminished between 1989 and 2014

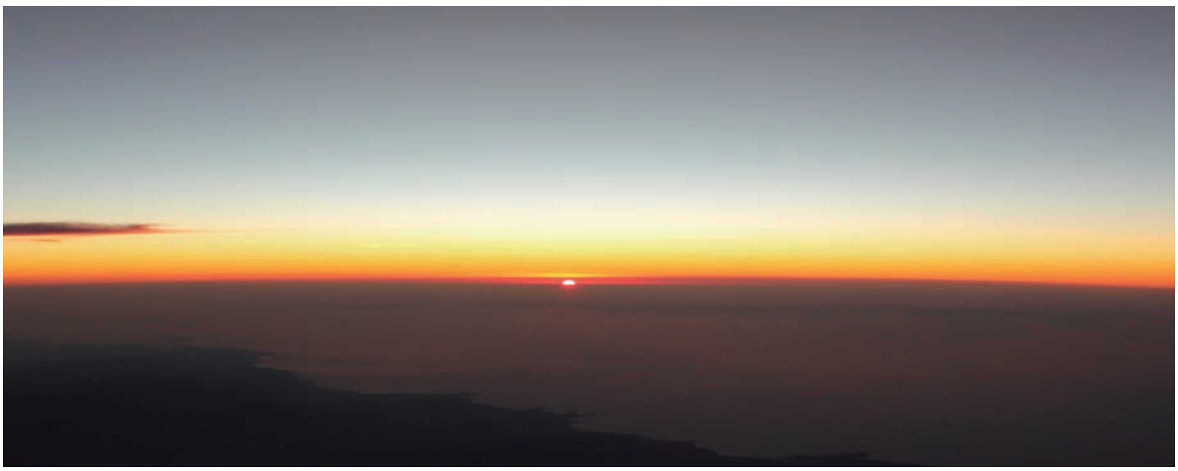
▼ **82%**

In 1989, there were 6 recorded ODS (CFCs, halons, methyl bromide, methyl chloroform and carbon tetrachloride) which totaled

1,298.3

METRIC TONS OF SUBSTANCES WITH ODPs

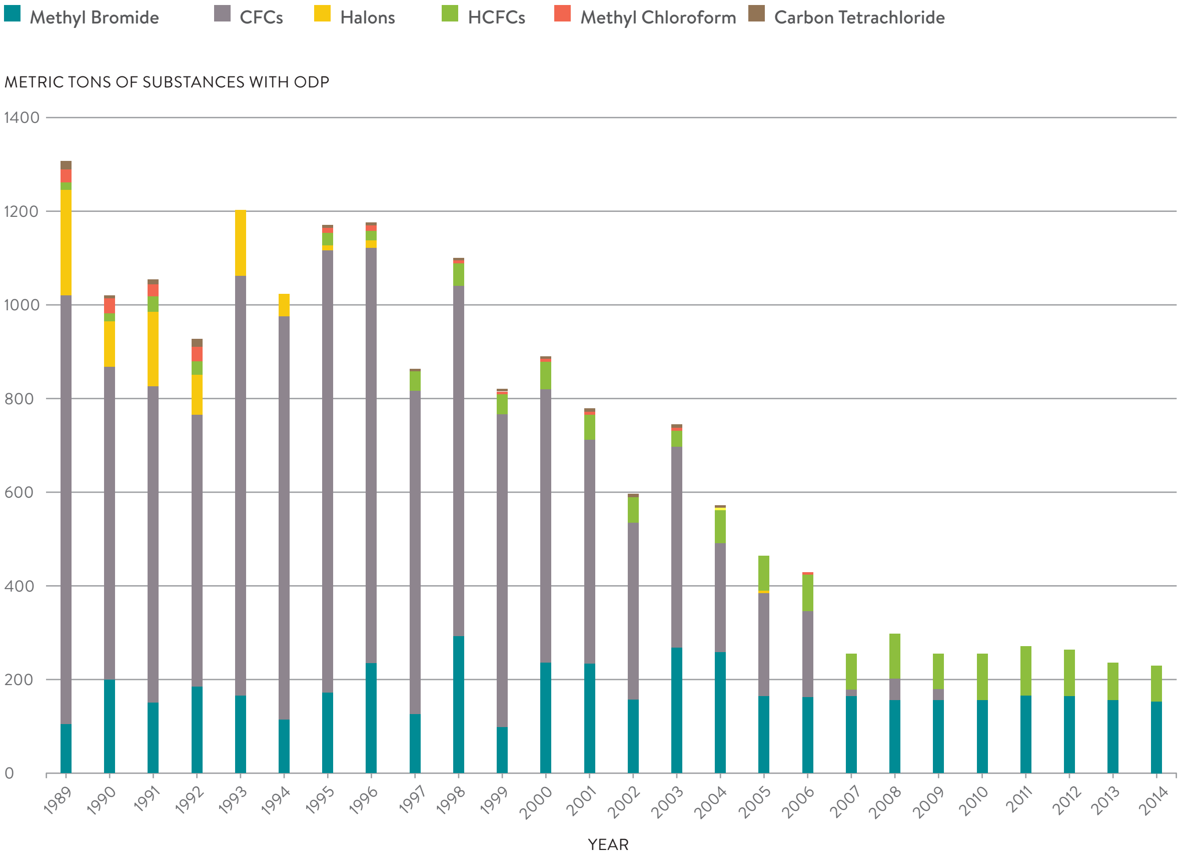
[3] *International agreement on ozone depleting substances whose objective is to protect the ozone layer by reducing the generation and consumption of several substances that are responsible for its depletion. This agreement came into force on January 1, 1989.*



Sunset | SOLEDAD GAJARDO

FIGURE 07

TOTAL CONSUMPTION OF OZONE DEPLETING SUBSTANCES (metric tons of substances with ODS), 1989-2014.



** ODP = Ozone Depletion Potential. National Consumption of ODS = imports of ODS.*

Source: Authors' own elaboration based on data reported by the Ministry of the Environment to the Ozone Secretariat.

Sunset | SEBASTIÁN PAUBLO

4 • NATIONAL RESPONSE TOWARDS THE DEPLETION OF THE OZONE LAYER

Ozone layer depletion has been treated as a global problem. In this context, the Vienna Convention was subscribed as an agreement that promotes research and the exchange of information in order to evaluate the impacts of human activities on the ozone layer and the effects of its alteration on human health and the environment. At the same time, the convention requests adopting legislative or administrative measures to control, limit, reduce or prevent human activities that have adverse effects on the ozone layer.

Under the framework of the Vienna Convention, the Montreal Protocol was prepared with the aim of establishing a gradual timeframe to diminish the consumption of Ozone Depleting Substances (ODS)4. This protocol establishes deadlines for the reduction and elimination of such substances. The Panel of Experts of the Protocol estimates that, if all obligations the countries committed to are met, by 2050 the ozone layer in the Northern Hemisphere will have recovered its levels from the 1970s. In the case of the Southern Hemisphere, this will occur by 2065.

Chile ratified the Vienna Convention and the Montreal Protocol in 1990, therefore the country has an obligation to meet the deadlines for the reduction and elimination of ODS, from the entry into force of each one of the corresponding deadlines.

Since January 1st, 2010 the import of CFCs, halons and carbon tetrachloride were banned in Chile and, since 2008, no imports of methyl chloroform (whose import and use are prohibited since January 1st, 2015) have been reported. The import and use of bromochloromethane has been banned since January 1st, 2025. The prohibition to import methyl bromide began on January 1st, 2015 and its industrial use is prohibited. In the case of HCFCs, a deadline for their reduction was established beginning on January 1st, 2013.

Figure 08 shows the evolution of the national consumption of each type of ODS during the 1989-2014 period and the maximum consumption limits established by the Montreal Protocol. The chart shows that the goals for all the ODS have been met by the country.

In the case of carbon tetrachloride, the consumption value is slightly above the stipulated limit for 2007. However, this was not considered a non-compliance because it was proven that its import was for analytical and laboratory use. This argument was presented by Chile to the Ozone Secretariat in its Action Plan and later accepted by the Implementation Committee.

Regarding HFCFs, the XIXth Conference of Parties to the Montreal Protocol, which took place in September, 2007, approved an amendment to the deadlines for the reduction of these ODS. This amendment consisted of moving the baseline to the 2009-2010 period and the total elimination date, beginning on January 1st, 2040 and allowing the use of only 2.5 percent between 2030 and 2039, exclusively for justified technical service and maintenance operations, this measure will be revised in 2020. This adjustment starts with freezing the consumption starting on January 1st, 2013, at the baseline level. Then it sets reductions of 10 percent for 2015, 35 percent for 2020, 67.5 percent for 2025 and 97.5 percent for 2030, leaving 2.5 percent for 2040.

Figure 09 shows the participation of different uses in the national consumption of HCFCs for 2008, identified in Chile's Management Plan for the Elimination of HCFCs.

VIENNA CONVENTION

Chile ratified the Vienna Convention and the Montreal Protocol in 1990. Since it is currently in force, the country has an obligation to meet the deadlines for the reduction and elimination of ODS.

The Panel of Experts of the Protocol estimates that, if all obligations the countries committed to are met, **by 2050 the ozone layer in the Northern Hemisphere will have recovered its levels from the 1970s. In the case of the Southern Hemisphere, this will occur by 2065.**

[4] The Montreal Protocol groups the main ODS into the following 5 appendices: Appendix A: CFCs and halons; Appendix B: Other CFCs, methyl chloroform, carbon tetrachloride; Appendix C: CFCs, HCFCs, HBFCs and bromochloromethane; and Appendix E: Methyl bromide (BrMe). Appendix D is an indicative list of products containing ODS.

[5] Supreme Decree (S.D.) 37/2007 and current S.D. 75/2015, both of the Minsegpres; and Law 20.096/2006.

The reduction of HCFCs marks the second and final phase of ODS reduction. To that end, all parties to the Montreal Protocol must elaborate a Management Plan for the Elimination of HCFCs (or HPMP for "HCFCs Phase-out Management Plan").

In this context, in December 2010, Chile submitted to the Multilateral Fund Secretariat, through the United Nations Development Programme (UNDP), the request to fund its HCFCs Phase-out Management Plan (HPMP), which contains 5 strategic lines of action: **(1)** a regulatory framework; **(2)** support to the foam sector (discontinuous panels and spray); **(3)** support to the refrigeration sector (refrigeration services and maintenance and air conditioning, including system cleansing); **(4)** dissemination and **(5)** monitoring. The plan has a chronogram of activities, from 2011 to 2015 in Phase 1, where the country will work with international implementation agencies such as the UNDP and the UNEP to execute all of the strategic lines of action, except for (2). Later, in Phase 2 (2016-2020), the United Nations Industrial Development Organization (UNIDO) will be incorporated as international implementing agency and is included in the activities for strategic line of action (2).

The national plan sets two phases. The first, between 2011 and 2015, established activities to reduce the consumption of HCFCs in the refrigeration sector, with the support of regulatory aspects and public dissemination. Between 2016 and 2020, reduction and phase-out activities will be implemented for the consumption of HCFCs in the refrigeration, air conditioning and foam sectors, with regulation support and public dissemination measures.

National Program for the Protection of the Ozone Layer

The Ozone Program was created in Chile by the National Environment Commission (CONAMA) in 1993, with the aim to ensure the compliance with the Montreal Protocol in the country, acting as a focal point of said agreement. As part of this program, investment and technical assistance projects are prepared and executed, complemented with dissemination and awareness activities. To that end, financial resources have been obtained from the Multilateral Fund of the Montreal Protocol, which have been disbursed by international implementation agencies (UNEP, UNDP, UNIDO, World Bank) or bilateral agencies (Environment Canada).

Regarding regulatory aspects, on March 23, 2006, Law 20.096 came into force known as the "Ozone Law" [6], which establishes control mechanisms that are applicable to all ODS as well as dissemination, evaluation, prevention and protection measures against ultraviolet radiation[6]. Complementary to this, Chile has developed other regulations, decrees and resolutions to contribute to the decrease in the consumption of ODS which are detailed in **Table 04**.

Additionally, as part of the implementation of the National Program for the Protection of the Ozone Layer, several projects have also been implemented to reduce and phase-out the use of ODS (**Table 05**). As a complementary measure, projects that join the protection of the ozone layer with climate protection have been developed, with an approach on the conversion of systems towards alternatives that do not affect both environmental parameters (**Table 06**).

[6] *Parallel to these actions to reduce the consumption of ODS, ozone layer monitoring initiatives are being developed in the country. This is why, since 1991, the Ozone and UV Radiation Laboratory of the University of Magallanes has been researching the ozone levels in the stratosphere of Magallanes and the Chilean Antarctic. It is precisely the project to "Strengthen the ozone layer and UV radiation measurement capacities in Southern Patagonia, and their projection towards the community", and its continuation (2013-2018), "Project to Develop the Management System for Atmospheric Environmental Risks in South America (Science and Technology Research Partnership for Sustainable Development SATREPS)", that are the most relevant and where the Ministry of the Environment works as the governmental counterpart.*

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TABLE 04

STANDARDS APPLICABLE TO ODS

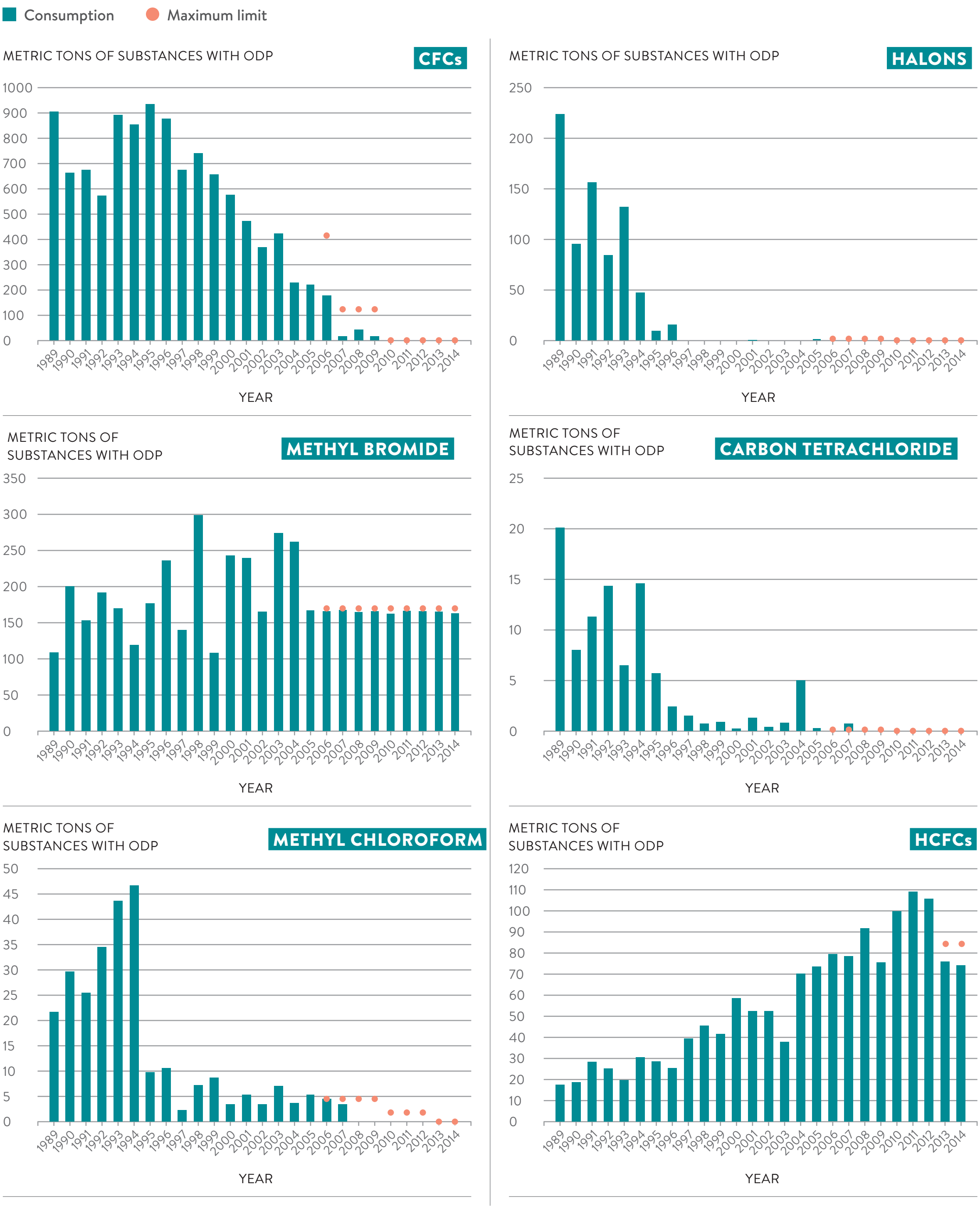
NAME	YEAR	DESCRIPCIÓN
Law 20.096/2006, MINSEGPRES	2006	Known as the "Ozone Law", establishes control mechanisms for ODS.
S.D. N° 75/2012 which abolishes S.D. N° 37/2007, (MINSEGPRES)	2012	Establishes maximum volumes of imports*.
Res. N° 3577/2005, Agriculture and Livestock Service	2006	Establishes the obligation to declare the use of methyl bromide.
Res. Ex. N° 5630, 5638/2007, Res. Ex. N° 10.109/2012 National Customs Service	2007 2012	Establishes the distribution mechanism for maximum volumes of imports*, the registry of ODS importers and exporters and the way they will be applied.
Res. N° 1059/2010, Public Health Institute, Ministry of Health	2010	Establishes labelling for metered-dose inhalers with CFCs.
Res. N° 183/2012 Res. N° 02/2013 Ministry of Economy	2012 2013	Establishes technical standards that regulate the characteristics of the warning message that must be exhibited by the controlled product that depletes the ozone layer.

Source: Authors' own elaboration.

**Distribution mechanism for maximum volumes of imports: 80 percent among historical importers; 18 percent among new importers; 2 percent at the discretion of the Customs Director.*

FIGURE 08

NATIONAL ODS CONSUMPTION AND MAXIMUM IMPORT LIMITS
allowed by the Montreal Protocol, 1989-2014



Source: Authors' own elaboration, based on data reported by the Ministry of the Environment to the Ozone Secretariat.

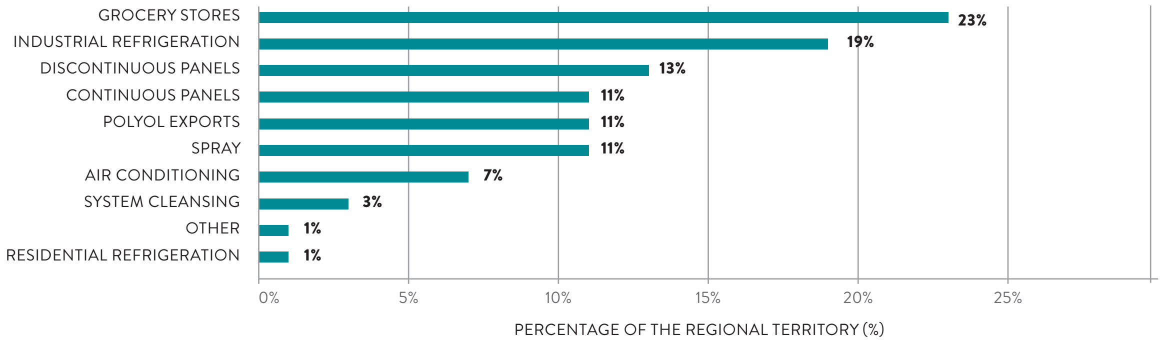
TABLE 05

PROJECTS EXECUTED BY AN INTERNATIONAL IMPLEMENTATING AGENCY, SINCE 2004 TO DATE.		
AGENCY	**PROJECT**	**YEAR**
World Bank	Institutional Strengthening	2004 - 2007
	Technology Conversion Financing Programme (TECFIN I and II)	1995–1997 (TECFIN I)
UNDP	Terminal Plan for Solvents	1997-2008 (TECFIN II)
	Terminal Plan for Commercial Refrigeration	2005 - 2010
	Terminal Project for Foams	2007 - 2011
	Halons Project	2007 - 2011
	Institutional Strengthening	2008 - 2011
	HCFCs Phase-out Management Plan (HPMP) Preparation - General strategy and refrigeration components (N° 3) and monitoring (N° 5)	2007 - 2015
	Phase I of the HCFCs Phase-out Management Plan (HPMP) - Refrigeration components (N° 3) and monitoring (N° 5)	2009 - 2010
	Preparation of Phase II of the HCFCs Phase-out Management Plan (HPMP-II) – General Strategy and foam components (N° 2) and monitoring (N° 5)	2011 - 2016
Environment Canada	Management Plan for Refrigerants, Module 2 (Training in good refrigeration practices (GRP), Syllabus Evaluation).	2015 - 2016
	Management Plan for Refrigerants, Module 2 (GRP standards, Demonstrative Reconditioning).	2003 – 2006
	Management Plan for Refrigerants, Module 3 (Recycling and Recovery Programs).	2005 – 2006
	Terminal Plan for CFCs	2006 - 2009
PNUMA	Management Plan for Refrigerants, Module 1 (Training and Customs Information System).	2009 - 2013
	Management Plan for Refrigerants, Module 4 (Awareness Campaign).	2006 - 2009
	Management Plan for Refrigerants, Module 5 (Monitoring).	2007 - 2010
	Preparation of the HCFCs Phase-out Management Plan (HPMP) – Regulatory framework (N° 1) and dissemination (N° 4).	2003 - 2010
	Phase I of the HCFCs Phase-out Management Plan (HPMP) – Regulatory framework (N° 1) and awareness (N° 4).	2009 - 2010
	Preparation of Phase II of the HCFCs Phase-out Management Plan (HPMP-II) – Regulatory framework (N° 1) and awareness (N° 4).	2011 - 2016
	Terminal Project for Methyl Bromide (Regulatory framework component).	2015 - 2016
UNIDO	Terminal Project for Methyl Bromide (Investment component)	2010 - 2015
	Preparation of Phase II of the HCFCs Phase-out Management Plan (HPMP-II) – Refrigeration components (N° 3).	2010 - 2014
	National Survey on Alternatives to ODPs.	2015 - 2016

Source: Authors' own elaboration.

FIGURE 09

NATIONAL CONSUMPTION (%) OF HCFCS BY TYPE OF USE, 2008



Source: Authors' own elaboration based on data reported by the Ozone Unit of the Ministry of the Environment.

TABLE 06

PROJECTS EXECUTED SINCE 2013 TO DATE BY AN INTERNATIONAL IMPLEMENTING AGENCY

AGENCY	PROJECT	YEAR
UNDP	Survey on the uses of HFCs in Chile	2013
	Implementation of transcritical CO_2 technology in a grocery store in Chile.	2014 - 2016
UNIDO	Preparation of the project to eliminate ODS in the agro-industry sector.	2014 - 2016

Source: Authors' own elaboration.

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Traffic congestion | KARINA BAHAMONDE

CHAP **10**

ENVIRONMENTAL NOISE

CONTENT

INTRODUCTION

Due to its effects, noise is considered an environmental issue, but, in contrast to other pollutants, noise does not produce any waste, nor does it have any flavor, smell, texture or color. Therefore, it is usually called an invisible pollutant. Its scope or impact is limited to the characteristics of the source generating it and to the environment where it propagates.

In Chile, according to the Second National Environment Survey (2016), conducted by the Ministry of the Environment, noise is considered as one of the four main environmental issues that affect people.

This Chapter presents the diagnosis and actions that will be developed in order to prevent and address the noise issue.

1 • BACKGROUND INFORMATION

Noise refers to any sound qualified as disturbing, unwanted, or inappropriate by the person who perceives it. Therefore, it depends on the perception of the person who is exposed, as well as the duration of the exposure. In this regard, it is possible that what is qualified as noise by some, could be considered by others a loud sound, normal in their sound environment. Despite this, there are sound levels that cause problems which, depending on the level, can range from sleep disorders or concentration problems, to health damage. This is why international organizations have established standards or acceptable thresholds for day and night exposure for people.

In contrast to sounds, that can be generated by nature, noise is a direct consequence of any human activity and has significant effects on people's health, beyond those exclusively related to hearing. Although noise will depend on the environment of the person perceiving it, the most aggressive ones are produced in urban areas, particularly large cities.

2 • SOURCES OF ENVIRONMENTAL NOISE

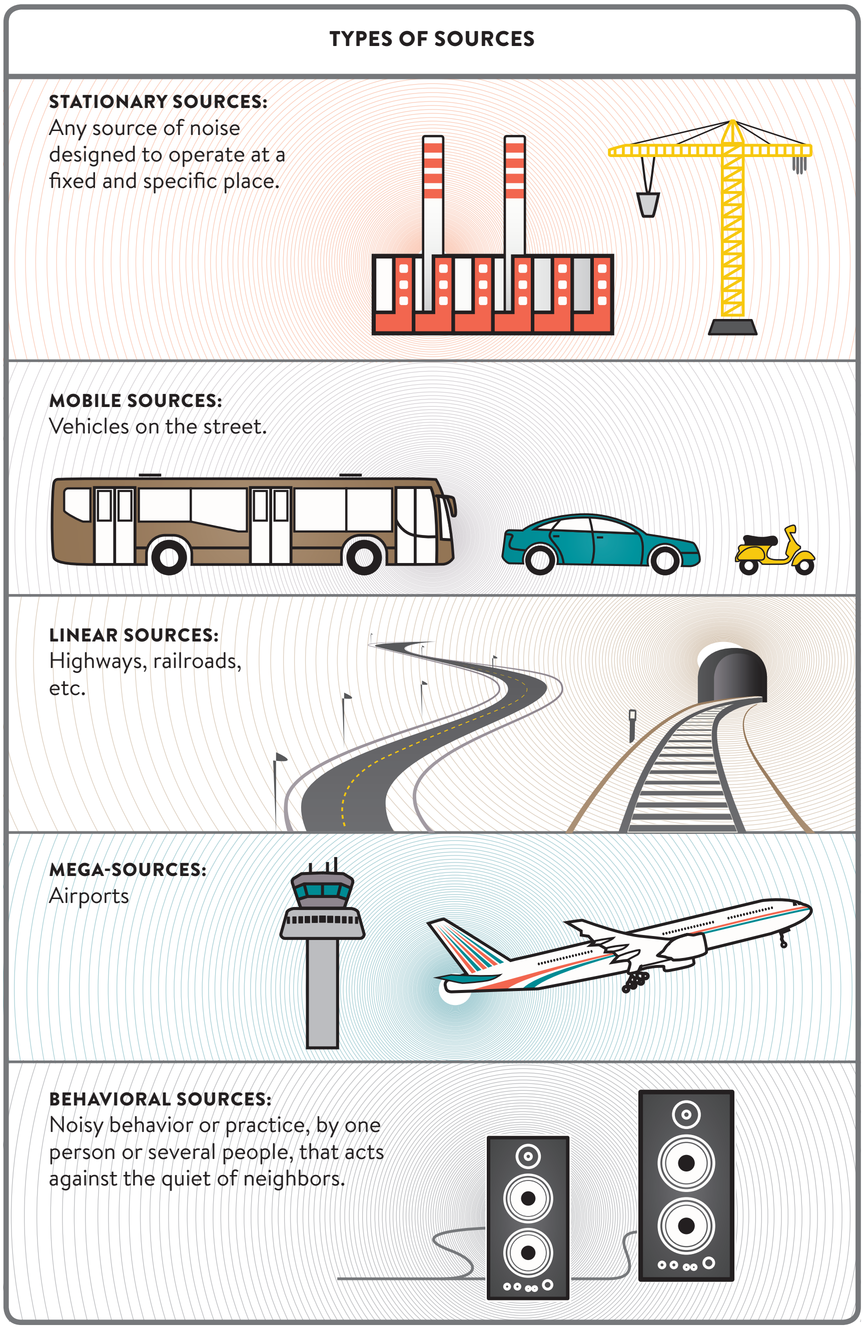
In urban areas the main sources of noise are related to transportation, with road traffic broadly standing out and recognized internationally as being responsible for over 70 percent of environmental noise in a city.

This situation is caused not only by the steep rise experienced by vehicle fleets over the last few years, but also by the fact that, in general, the cities where those vehicles circulate were not designed to support them. The basic level of noise emissions from vehicle circulation is determined by the noise of motor engines and exhaust pipes. Another source of vehicle noise corresponds to that originated by the contact of tires with the pavement, which increases with speed. In the case of light vehicles, the tires and surfaces are the main sources of noise for speeds of over 60 km/h.

In addition to traffic noise, sounds generated by industrial facilities, mechanic shops or construction sites must also be considered. The latter are commonly known as "stationary sources", generally have a localized impact on their neighboring environment. At the same time, railway and aircrafts also produce high noise levels, but for short periods, that need to be considered. However, the case of airports is a special one, since due to their ongoing activity and the impact that they generate, they tend to be considered "mega-sources" of noise.

However, transportation and industrial facilities are not the only current causes of the sound situations in cities, since human activity is also a source that contributes to rising sound levels, especially at the local level.

FIGURE 01



3 • EFFECTS OF NOISE

Hearing loss is one of the first proven effects of noise, especially in the case of industrial noise. However, there are currently many studies that have provided evidence regarding the effects of other environmental noise in other systems of the human body, which generate problems at the cardiovascular level, as well as stress or sleep disorder, among others.

Research carried out using the Disability-Adjusted Life Year (DALY)[1], shows the impact of noise on people's health. The "Environmental Burden of Disease" working group estimated the DALYs in six European countries, due to environmental stressors, which included transportation (Hänninen et al., 2011)." As a result of this research, noise was identified as one of the three stressors with major impact. The main problems were sleep disorders since they cause cardiovascular diseases (Fuentes et al., 2015).

The World Health Organization (WHO) has estimated that in Europe, each year, one million healthy life years are lost from traffic-related noise, including 61,000 years for ischaemic heart disease, 45,000 years for cognitive impairment of children, 903,000 years for sleep disturbance, 22,000 years for tinnitus and 654,000 years for annoyance. This data must guide control measures for traffic-related noise (WHO, 2011).

On February 27, 2015, the WHO warned that 1.1 billion teenagers and young adults are potentially at risk of hearing loss as a result, due both to the use of personal devices as well as external noise.

01

NOISE AND CARDIOVASCULAR DISEASES

According to the "General Stress Theory", noise affects the autonomic and endocrine nervous systems, altering the homeostasis of the human organism (Henry, 1992; McEwen, 1998a; McEwen, 1998b). Persistent changes due to dysregulation and disturbed metabolic function, promote the development of chronic disorders such as atherosclerosis, hypertension, and ischemic heart diseases in the long run. Noise generates stress reactions, affecting the sympathetic and endocrine system. These reactions could even occur at moderate noise levels, mainly when the noise interferes with activities such as learning, concentration and attention (Babisch, 2011, in Fuentes et al., 2015).

WORLD HEALTH ORGANIZATION

World Health Organization (WHO) has estimated that in **Europe, each year, one million healthy life years are lost from traffic-related noise.**

As a result of this research, noise was identified as one of the three stressors with major impact. The main problems were sleep disorders since they cause cardiovascular diseases.

[1] *The DALY combines in one measure the time lived with disability or Years Lost due to Disability (YLD) and the time lost due to premature mortality or Years of Life Lost (YLL) in the general population. (WHO, 2011).*

Vehicle traffic | VICTORA CÁRCAMO

4 • INTERNATIONAL CRITERIA

At the international level, both the Organisation for Economic Co-operation and Development (OECD)[2] as well as the European Union (EU) recommend acceptable values for environmental noise. Both organizations propose a difference for daytime and nighttime based on standard noise parameters, which enable the representation of an energetic noise average for each of those time periods. Said values represent referential standards that allow the generation of a common environmental indicator, which in turn allows for the measurement of progress in matters related to the control of environmental noise in member countries.

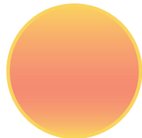
The WHO published a study related to night noise and its effects on health, Night Noise Guidelines for Europe (NNG, 2009), which indicates that for the primary prevention of subclinical adverse health effects related to night noise in the population, it is recommended that the population should not be exposed to night noise levels greater than 40 dBA of $L_{night,outside}$ during the part of the night when most people are in bed. The Lowest Observed Adverse Effect Level (LOAEL) of night noise, 40 dBA $L_{night,outside}$, can be considered a health-based limit value of the night noise guidelines (NNG) necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise. However, an Interim Target (IT) of 55 dBA $L_{night,outside}$ is recommended in situations where the achievement of NNG is not feasible in the short term for various reasons (WHO, 2009).

On the other hand, the OECD established recommendations for the member countries regarding noise control policies, such as:

- **Reinforcing existing regulations,** especially those related with mobile sources and aircrafts.
- **Promoting the manufacture of quieter products,** product labeling, economic incentives and informative actions.
- **Establishing funding mechanisms;** protecting the most exposed members of the population by means such as traffic management, the construction of noise barriers, and building insulation; and
- **Preventing** the creation of new noise situations through appropriate land use planning, especially in urban areas.

OECD-EU RECOMMENDATIONS

Daytime noise levels



65 dBA

Nighttime noise levels

55 dBA

[2] *Chile has been a member country of the OECD since 2010.*

Costanera Bridge, Santiago | KARINA BAHAMONDE

5 • NOISE IN CHILE

The presence of excessive levels of noise in the cities is a problem that affects the inhabitants of our country more significantly each and every day. It is not only limited to traffic problems in urban areas, but also extends to other fields such as projects in mining exploitation, ports, airports, etc. Although, in most of the cases, the environmental noise that people are exposed to in cities does not have serious characteristics in the short term, it can certainly have them in the long term.

Before the enactment of Law19.300 on the General Environmental Framework in 1994, Chile had some specific initiatives related to noise control and a great dispersion regarding regulations, which had been historically developed in a reactive manner when facing specific problems. In addition, several municipalities had general ordinances on the matter, according to their local reality.

Since Law19.300 was passed, the management of noise control was established in an integrated manner and it was defined that it would be addressed through a multi-sectoral approach. In addition to defining noise as a pollutant, this law established environmental management instruments, which include environmental standards and the Environmental Impact Assessment System (SEIA by its acronym in Spanish), which are fundamental pillars for the management of this pollutant.

From the beginning, a special emphasis was placed on the coordination with other sectors, mainly with the health and transportation sectors, as well as on the development of guidelines to dictate environmental standards. The initial management focused on reviewing current regulations and establishing minimum requirements for the projects that would be submitted to the SEIA. This was a challenge for the private sector, which had to comply with the regulations, especially for environmental consulting firms, who provided acoustic assessment services.

Until now, management had revolved around the control of the sources, more specifically the development of emission standards. The need to reinforce is evident, for example, in the case of acoustic insulation requirements in constructions (*façades*). In addition, it is necessary to analyze the possibility of developing a noise quality standard or other regulations for product and equipment certification, among others.

On the other hand, there are deficiencies in the field of supervision and territorial planning. The weaknesses in supervision are mainly caused by the multiplicity of noise generating sources. Territorial planning has been carried out without taking the noise variable into consideration. Therefore, many of the conflicts arise from the incompatibility of the activities that are being carried out in a specific area.

In terms of road infrastructure and traffic congestion, noise emissions are not considered explicitly as a design factor, which can result in the loss of opportunities to reduce massive impacts on the acoustic quality of the surrounding areas.

An additional aspect that makes the management of environmental noise control difficult is the scarce general awareness related to its effects on human health. Therefore, the implementation of policies must be complemented with awareness campaigns aimed at the general public.

NOISE COMPLAINTS

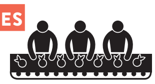
The complaints due to noise disturbance are made to the Superintendency of the Environment (SMA by its acronym in Spanish).

According to their records, the fields that concentrate the greatest number of complaints between 2013 and 2015 correspond to:

1. **DISCOTHEQUE**

2. **TRANSPORT INFRASTRUCTURE**

3. **AGRO-INDUSTRIES**



5.1 City Noise Maps

Noise maps are graphic representations of existing noise levels in a geographical area, for a specific moment. Normally, the noise levels are represented with colors, similar to the topographic curves used on a map.

At the international level, Europe, through the Environmental Noise Directive 2002/49/EC, is at the forefront of noise maps, as well as in action plans that are implemented based on their results. This model presents advantages, since the actions of the plans are mandatory for member countries.

In the case of Chile, two important phases can be identified. The first one consisted of studies with measurements, such as the study carried out by the Metropolitan Intendency and the University of Santiago, in Santiago in 1989 and its later update in 2001, carried out by the Metropolitan Environmental Health Service (SESMA by its acronym in Spanish). The second phase is characterized by the studies based on modeling, that is, those that do not require field work as they used to. In the latter case, Chile is at the forefront among its neighboring countries, and already has a line for national studies of city noise maps, using the previously mentioned European Directive as a reference. As a result of this work, noise maps have been made for the commune of Santiago (Phase III – 2010), Greater Santiago (Phase IV – 2011), Valdivia, Temuco-Padre Las Casas and Coquimbo-La Serena (Phase V 2013-2015)[3].

Towards the end of 2015, Phase VI of the city noise maps line began with the update of the noise map for Greater Santiago, with the aim of complementing and managing the existing information on environmental noise for this area and gathering information regarding the main roads for transportation infrastructure in the Santiago Metropolitan Region.

Noise Maps

The preparation of noise maps began at the end of the 1970s in the areas surrounding airports, when the exposure to noise of the population residing close to them turned into a severe problem. In the United States, air transportation grew very quickly with the economic development that followed the end of the Second World War. In the 1960s the noise from airplanes was a big issue and efforts to control and reduce the noise generated studies on the design of aircrafts along with airport planning. Limits were established for noise levels and serious legal restrictions were adopted, which are still in force to this day.

The environmental management and municipalities noticed that the complaints of the exposed population could not be faced solely by noise measurements in specific places. Studies on broader geographical areas involved measurements and predictions that finally led to the noise maps. Today, the maps offer a view of the distribution of noise levels over a larger area, turning them into a tool for planning and for the purposes of managing environmental noise (UACH, 2015).

[3] *Phases I and II of the city noise maps line were configured as pilot cases, in which preliminary noise maps were developed for Antofagasta and the communes of Providencia and Santiago.*

HOW ARE NOISE MAPS USED?

Noise maps constitute a fundamental management tool for environmental noise control, since they allow showcasing the presence and magnitude of noise, as well as its distribution and the extension of the affected areas, enabling guidance in decision making in different fields, highlighting the following:

- **Land Use Planning:** It helps to consider noise as a decision variable when designing and updating Land Use Planning Instruments (IPT by their acronym in Spanish), and thus makes different activities that occur in a specific area compatible among them.

- **Acoustic Insulation:** Based on the characterization of noise in a specific road, it is possible to recognize the acoustic insulation needs of the *façades*, taking into consideration the sensitiveness of the activity that is being considered to take place in the area along with the existing noise in the sector where it will be built.

- **Environmental Regulations:** By having the results of the main cities of the countries, the conditions will be in place to initiate the work towards beginning the process of preparing a noise quality standard, regardless of the information it could provide to other regulatory processes (emission standards).

- **Prevention of Acoustic Conflicts:** By identifying existing noise, it is possible to recognize the Quiet Zones, where an increase of the sound situation must be avoided, through the implementation of requirements for the installation and inauguration of noisy activities, as well as the areas where it is necessary to take action and where it is not convenient to allow the emplacement of sensitive activities.

- **Housing Selection:** Under the framework of the purchase or rental of a property, noise maps will enable the recognition of places potentially apt for residential use.

- **Education and Awareness:** Given that noise is an invisible pollutant, having the noise maps will allow showing its existence, concentration and distribution in the city, providing evidence of the exposure we are facing.

- **Monitoring of Environmental Goals:** Taking into consideration the periodical update of noise maps, it is possible to study and recognize the evolution of the sound situation, allowing the verification of the efficiency of the environmental measures and goals that are being sought.

- **Other applications:** Noise maps have multiple applications, they will basically depend on the cartographic cover with which it is possible to cross information. They can be used to determine a place for the establishment of a new hospital or school, as well as to optimize supervision, among others.

5.1.1 Noise Maps – Phase V
Valdivia / Coquimbo - La Serena / Temuco - Padre Las Casas

Between 2013 and 2015, noise maps were developed for the city of Valdivia, as well as for the conurbations of La Serena-Coquimbo and Temuco-Padre Las Casas. The modeled noise sources correspond to vehicle traffic -in all three cases- and to railroad traffic in the cases of Temuco-Padre Las Casas and La Serena-Coquimbo.

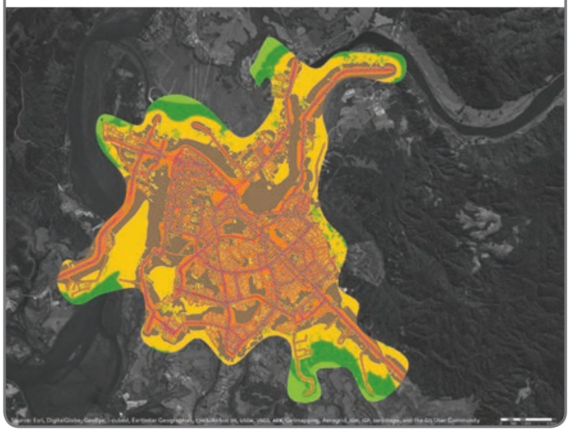
NOISE LEVELS dBA

◄ 40	45-50	55-60	65-70	75-80
40-45	50-55	60-65	70-75	► 80

MAP 01

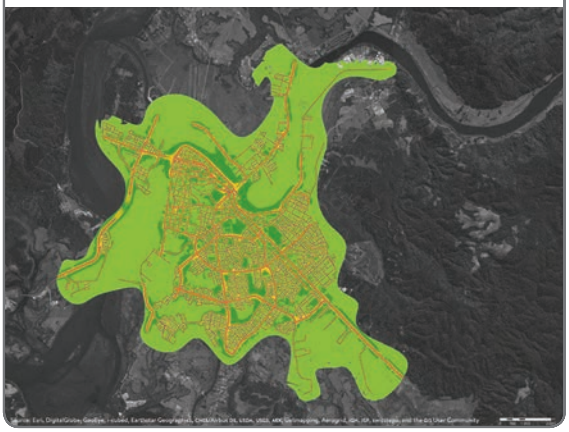
VALDIVIA

Day



Noise Levels (Ld dBA)

Night

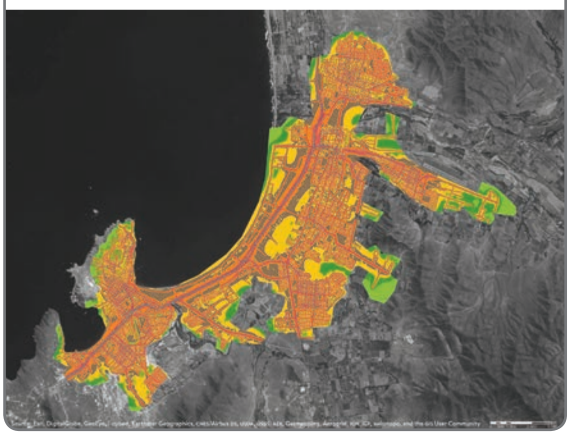


Noise Levels (Ln dBA)

MAP 02

COQUIMBO-LA SERENA

Day



Noise Levels (Ld dBA)

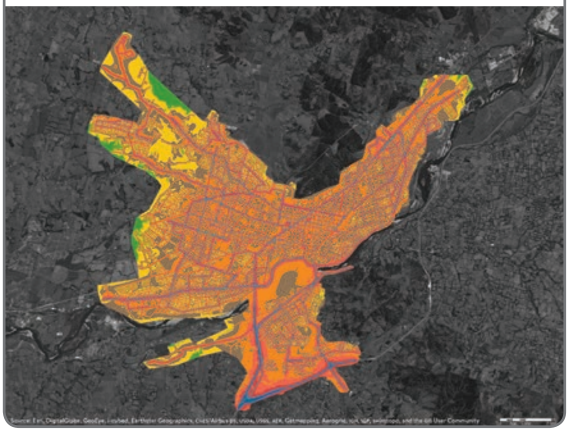
Night

Noise Levels (Ln dBA)

MAP 03

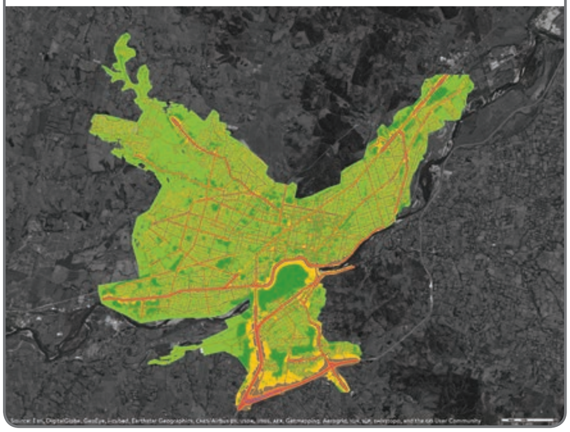
TEMUCO-PADRE LAS CASAS

Day



Noise Levels (Ld dBA)

Night



Noise Levels (Ln dBA)

5.1.2 Some Results from Phase V

According to the information provided by the noise maps for the conurbations of La Serena-Coquimbo, Temuco-Padre Las Casas and the city of Valdivia, the modeled levels were analyzed, in accordance to the values recommended for noise exposure, with the aim of determining, for example, the exposure to traffic noise in educational and health establishments. This analysis considered the evaluation criteria established by the European Union [SILENCE 2009], in accordance with the mentioned criteria indicated by the OECD and the WHO.

a) Impact of environmental noise on educational facilities

This analysis considered educational infrastructure, according to the regional and communal scales, based on the guidelines of the Ministry of Housing and Urban Planning (MINVU): universities, high-schools, elementary schools and academies [Urban Development Division – (DDU by its acronym in Spanish) 2009]. From those facilities, the *façade* with most exposure to noise was considered, since the real effects will be determined by different factors outside the scope of this study, such as: the acoustic quality of the building, the orientation and location of the most sensitive areas above other less sensitive ones (for example: classrooms or libraries in comparison with gymnasiums and hallways), etc.

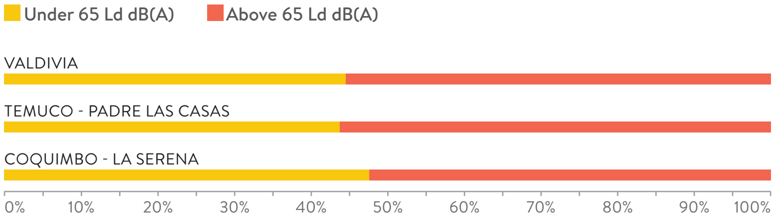
b) Impact of environmental noise on health facilities

Just as in the previous case, health infrastructure was considered in accordance to the guidelines from the MINVU: hospitals, clinics, rehabilitation centers and cemeteries [Urban Development Division – (DDU by its acronym in Spanish) 2009]. From those facilities, the façade with most exposure to noise was considered, following the same previously mentioned considerations.

FIGURE 02

PERCENTAGE OF EDUCATIONAL FACILITIES EXPOSED TO NOISE LEVELS

IN VALDIVIA, TEMUCO - PADRE LAS CASAS AND COQUIMBO - LA SERENA, ACCORDING TO INTERNATIONAL CRITERIA.

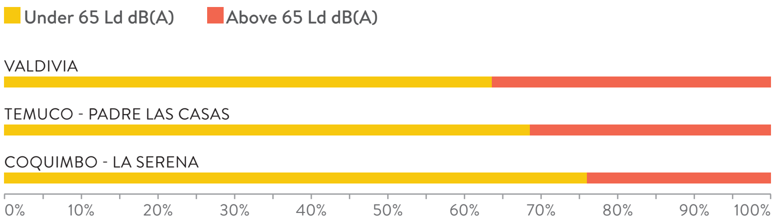


The data shows that close to 50 percent of educational facilities are exposed to levels above the internationally recommended criteria.

FIGURE 03

PERCENTAGE OF HEALTH FACILITIES EXPOSED TO NOISE LEVELS

IN VALDIVIA, TEMUCO - PADRE LAS CASAS AND COQUIMBO - LA SERENA, ACCORDING TO INTERNATIONAL CRITERIA.



The data shows that less than 40 percent of the health facilities are exposed to levels above the internationally recommended criteria.

c) Contribution of public transportation to environmental noise

In order to estimate the average of heavy shared public transportation, a modeling and comparison exercise was conducted of the roads that include this type of vehicle flow[4].

Estimate of the influence that public transportation has on environmental noise in Valdivia
In order to estimate the contribution of heavy public transportation (buses) to environmental noise in the city of Valdivia, 41 measurements were made in the streets of the city, in places where flows of this type of transportation were identified. **Figure 04** shows the difference between both cases.

Estimate of the influence that public transportation has on environmental noise in Temuco - Padre Las Casas
In this case, 48 measurements were made in the streets of the city, in places where flows of this type of transportation were identified.

Estimate of the influence that public transportation has on environmental noise in La Serena – Coquimbo
In this case, 51 measurements were made in the streets of the city, in places where flows of this type of transportation were identified.

[4] *It is worth noting that this is an estimation exercise. However, it provides an idea of the magnitude.*

FIGURE 04

VALDIVIA / Comparison of the influence of public transportation on environmental noise

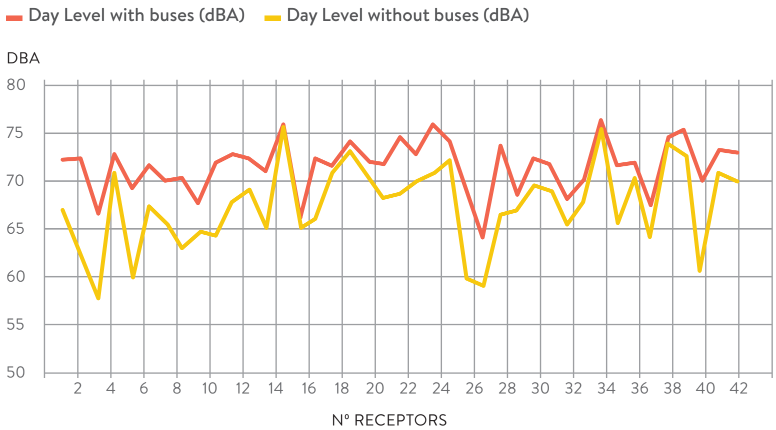


FIGURE 05

TEMUCO - P. LAS CASAS / Comparison of the influence of public transportation on environmental noise

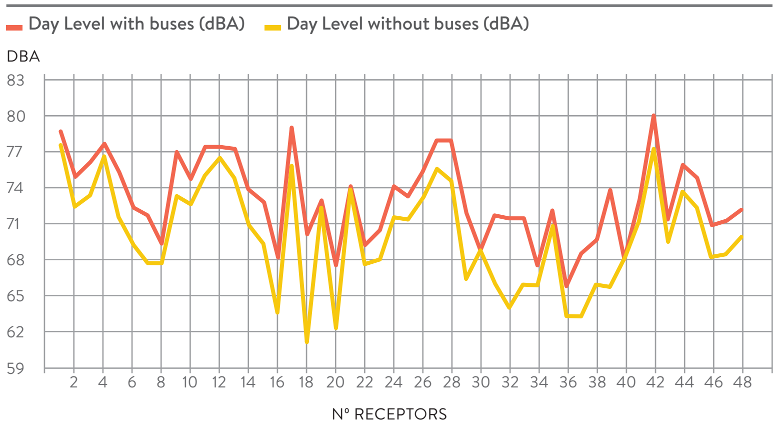
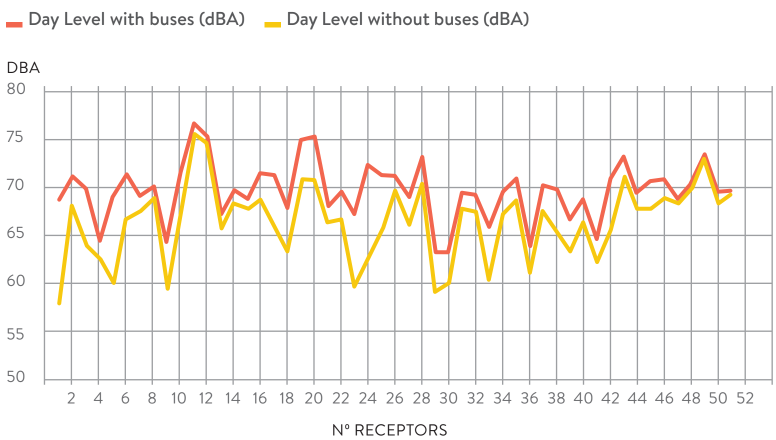


FIGURE 06

LA SERENA - COQUIMBO / Comparison of the influence of public transportation on environmental noise



03

ADDITIONAL STUDIES IN VALDIVIA

Subjective Study on Environmental Acoustics in Valdivia

In addition to the development of noise maps, an online survey on environmental acoustics was conducted in Valdivia[5]. The main results that can be highlighted include that 46 percent of the population declare themselves as moderately sensitive to environmental noise, 26 percent very sensitive and 3 percent non-sensitive. This last value is unique, since it shows greater sensitivity than the inhabitants of Santiago, where 17 percent of the population indicated being “non-sensitive”.

The population of the commune of Valdivia clearly identifies the effects of noise on them: 3.4 percent indicate that noise always makes them nervous and 16 percent that it often makes them nervous; while for 4.4 percent noise always provokes insomnia and for 15 percent it often does. On the other hand, 5.3 percent indicate that environmental noise always gives them a headache and 11 percent respond that it often gives them a headache.

Soundscape Study in Valdivia

Soundscapes are a significant element of the human environment, defining the sound environment that permanently surrounds us and affecting the well-being of people and their quality of life. They can be evaluated in positive and/or negative terms. Some positive soundscape examples that can be mentioned are the sound of the ocean or an environment where a river flows or the sound of rain. On the contrary, a negative soundscape would be an environment with high levels of noise, harmful for the physical and mental health of people, where the sound is an element of disorder, displeasure and nuisance.

Soundscape studies can be used as environmental conservation tools, providing useful information regarding the interactions of sound and the acoustic environment of a specific geographical area.

In the case of Valdivia, 16 soundscapes were selected which included the most visited green areas in the city (Botanical Garden, Harnecker Park, Krammer Park, etc.), environments considered to be characteristic of the city (rain and storms, bird songs, river market, sea lions, etc.) and environments related to types of streets in the city (local, services and transport with/and without public transportation, respectively). This material enables highlighting the contribution of sounds to certain places in the city, complementing the noise map.

With the recordings made, a CD with the Sound Map of Valdivia was developed, which is available for listening at the Center for Documentation (CDOC by its acronym in Spanish) of the Ministry of the Environment[6].

[5] *This survey was a part of the study carried out by the Austral University of Chile in 2015.*
[6] *Also available from http://mapa.acusticauach.cl*

Instruments used for recording Valdivia’s soundscapes. Dummy Head Neumann, KU 100.

6 • STRATEGY FOR MANAGING ENVIRONMENTAL NOISE CONTROL

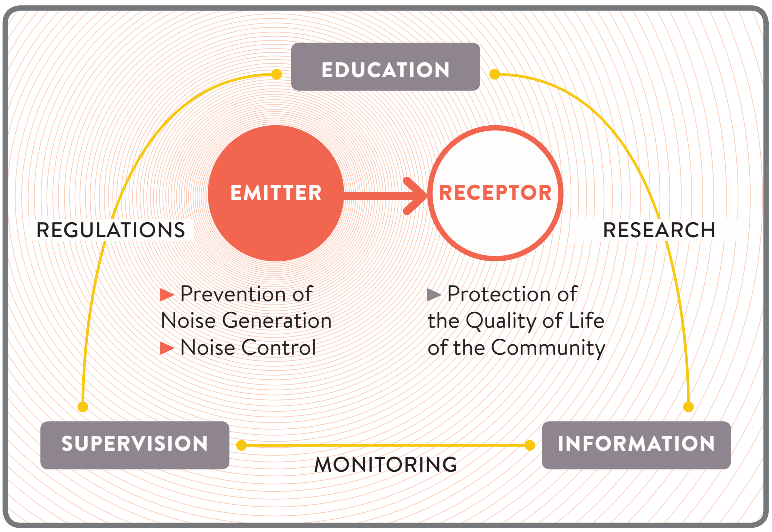
The effects that environmental noise has on people, as well as the increase shown due to the growth of cities and traffic, motivated the development of a Strategy for Environmental Noise Control in the country, which, although it is based on local diagnosis, incorporates international experiences and criteria.

The strategy takes, as a starting point, the relation between emitter-receptor, defining priorities and objectives such as the prevention of noise generation, the control of sources and the protection of the quality of life of the population.

Hence, there are three lines of work included:

1. **Regulations:** which includes the design, development and review of environmental regulations for noise, as well as the coordination for the development and implementation of complementary regulations.
2. **Information:** aimed at generating and improving the information on environmental noise.
3. **Dissemination:** focused on developing awareness and education programs.

FIGURE 07



STRATEGY FOR MANAGING ENVIRONMENTAL NOISE CONTROL

6.1 Regulations

As previously mentioned, in the regulation field, the management for noise control has been aimed at regulating emission sources.

- Supreme Decree N° 38/2011 MMA – Emission standard for noise generated by the sources indicated in it, developed from the review of Supreme Decree N° 146/97 MINSEGPRES. This standard establishes maximum permissible limits for noise emission, both for the daytime and nighttime generated by stationary sources, such as industrial, commercial, recreational and services activities, among others, something that must be verified at the place where the receptor is located. The update of the standard implied the modification of some concepts and establishing new maximum limits for noise during the nighttime period, with the aim of safeguarding people's rest. The supervision of this standard is the responsibility of the Superintendency of the Environment (SMA by its acronym in Spanish), which can establish supervision subprograms with other organizations, such as the Ministry of Health.

- Supreme Decree N° 129/02 MTT – Emission standard for both urban and rural public transportation buses. This regulation sets standards for entry-level buses. At the same time, the control for its compliance is carried out through technical inspections and the Ministry of Transportation and Telecommunications is responsible for its supervision.

- Supreme Decree N° 129/02 MTT – Emission standard for light and medium vehicles and motorcycles. This is only an entry-level standard and, just as in the case for buses, the regulatory compliance must be accredited once they enter the national vehicle fleet. the Superintendence for the Environment (SMA by its acronym in Spanish) supervises the standard, notwithstanding the attributions that correspond to the Ministry of Transportation and Telecommunications.

6.1.1 Updating of the Regulations

The standard for Noise Emission from Urban and Rural Public Transportation Buses (S.D. N°129/02 MTT), in force since 2003, has been under review since February 2015.

The main modification is the establishment of new levels of noise emissions for the public transportation buses that enter the country, beginning with the entry into force of the new standard. The proposed criterion is to adjust existing levels to those of international regulations. The line of noise maps falls under this component.

6.2 Dissemination

An important part of the management aimed at controling environmental noise must be supported and complemented by actions that people can develop. Hence, it is important to educate and raise awareness among the population regarding the effects of noise on the quality of life and health.

This is why there is an ongoing effort to carry out awareness workshops, dissemination of the regulations and publications in the media.

International Noise Awareness Day (INAD) | MMA

04

INTERNATIONAL NOISE AWARENESS DAY (INAD)

Each year, the International Noise Awareness Day (INAD) is celebrated the last Wednesday of April. On that occasion, a call is made to gain awareness of noise as a polluting element, present in all cities of the country and that we face on a daily basis. The invitation is to take measures to minimize noise emissions, such as carrying out proper maintenance of vehicles, especially to the silencer and not using resonators, avoiding abruptly accelerating at traffic lights or corners, using the horn only when necessary or in case of an emergency.

7 • FUTURE LINES OF WORK – ACTION PLANS

The European Environmental Noise Directive 2002/49/EC [13], along with defining the concept of noise maps, establishes that member States must develop action plans to address issues related to noise and its effects, including, if necessary, reducing noise related to places near large roads, large railroads, large airports and crowds. The Action Plans include a group of priority measures that, at the local scale, seek to protect the health and well-being of citizens, with the aim of reducing environmental noise and preserving Quiet Zones.

Based on the European experience as part of the updating of the Noise Map for Greater Santiago, which is under development at the time of this publication, the Ministry of the Environment has defined the incorporation of the design of an action plan that will enable a technical and legal analysis of the effectiveness and efficiency of a management instrument of this nature.

The concrete measures of the action plans are left at the discretion of the competent authorities, but must address the priorities that can be identified as a consequence of surpassing the determined limit values or according to other criteria that could be applied, especially in more important areas as defined through the noise maps.

Valdivia | IGOR VALDEBENITO

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AURA/CTIO | DANIEL MUNIZAGA

CHAP **11**

SKIES FOR ASTRONOMICAL OBSERVATION

CONTENT

INTRODUCTION

The privileged sky conditions of northern Chile have allowed it to become a window from which scientists improve their understanding of the place and time in the Universe that we are living in. The important astronomical capacity already installed in the northern regions of the country, which will increase over the next decade to 70 percent of the total global existing capacity, is evidence of the need to value and protect this heritage, which is not only Chilean, but of humanity.

This chapter seeks to contribute to the understanding and the recognition of the importance that the scientific work on astronomy being developed in Chile has for everyone. In a collaborative endeavor, without borders, it has been possible to unveil areas of the Universe that were unthought of and provide answers to several questions that have accompanied humans since our origins.

THE UNIVERSE FROM CHILE

The privileged sky conditions of northern Chile are, without a doubt, a national heritage (and to many a world heritage) that must be safeguarded. This is a task to which all of us can contribute.

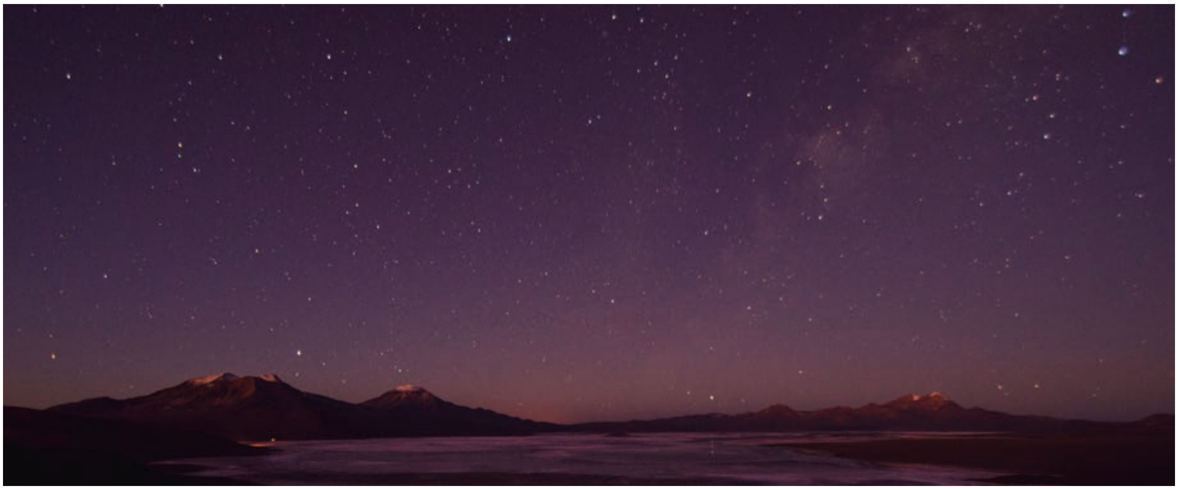
1 • BACKGROUND INFORMATION

Observing beyond our sky and knowing that we are witnesses of the past is part of the knowledge that has been reached thanks to scientific work and astronomical observation.

Conserving the skies of northern Chile through the control of light pollution and the use of appropriate lighting technologies and practices is a responsibility of all Chileans with humanity. Thus, this report seeks to show the main contributions made by astronomical observatories located in Chile, as well as the efforts being made by the country to ensure that the skies of the northern regions of the country continue to be a window to the Universe[1].

“Our roots can be found above, in the Cosmos, each one of the atoms that make up our body were formed during the Big Bang 13.7 billion years ago. More specifically, the hydrogen that composes water, which forms most of our body, and the other chemical elements such as calcium, iron, and the oxygen that we breathe, come from within the heart of these stars” (Mario Hamuy, National Science Prize Winner 2015, interview in ANIP, 2015).

[1] *Just as it is done in astronomy and in science in general, this chapter is the result of the contribution of several people. In this case, thanks to the coordination of the Chilean Millennial Institute of Astrophysics. The following astronomers participated in its development: Mario Hamuy; Manuela Zoccali; Guillermo Blanc; Juan Carlos Beamin and Ezequiel Treister, all of whom, from their experience and knowledge, open an important space to spark the reflection and curiosity to learn more about our Universe.*



Astronomical Resource | JOSE GERSTLE

2 • CHILE, GLOBAL CENTER FOR ASTRONOMICAL OBSERVATION

Over the past twenty years, the skies in Chile have provided a natural laboratory in which thousands of Chilean and foreign astronomers have studied the mysteries of the Cosmos and have found answers to some of the most fundamental questions we have asked ourselves. Questions and answers that bring us closer to understanding the origin and the place of humans in the Universe.

In northern Chile, there are currently seven out of the 18 largest optical telescopes in the world, with a diameter greater than 6 meters. This situation also repeats itself in other wavelengths, for example in the millimeter and sub-millimeter[2] with the ALMA radio telescope complex being the most powerful and modern on the planet.

These instruments have played an essential role in practically all astronomical discoveries made in the past few years. With the arrival of the new generation of giant telescopes to Chile, such as the Giant Magellan Telescope (GMT), located in Las Campanas, and the European Extremely Large Telescope (E-ELT), on Armazones hill, it will be possible to detect and study many other planets in detail and see atmospheric signals in increasingly smaller planets, making progress to answer one of the most important questions of humankind throughout history: Is there life beyond Earth? It is possible that the answer to this question could be known in the following years from the top of a mountain in northern Chile.

[2] *It is a band on the electromagnetic spectrum that allows observations that do not require the emission of visible or infrared light.*

Inside the Large Magellanic Cloud (LMC), the ESO's Very Large Telescope in the Paranal Observatory, in Chile, enabled capturing this view of the LHA 120-N 44 nebula, around the NGC 1929 star cluster. ESO/MANU MEJIAS

Full field perspective above the La Silla Observatory | P. HORÁLEK/ESO

2.1 Great Discoveries made from Chile

2.1.1 Extrasolar Planets, Atmospheres and the First Image of an Exoplanet

Researching the presence of planets around other stars posed tremendous technical challenges. The quantity of light emitted by a star is about a million times greater than that of the light that is reflected by a giant planet such as Jupiter. Due to the complexity of being able to detect a planet in a direct manner, at the end of the 20th century astronomers began thinking about several indirect ways this could be achieved, such as the periodic measurement of the velocity of the stars (radial velocity methods).

The use of this method had its first breakthrough in 1995, when the discovery of the 51 Pegasi b was announced. A giant gas type planet -such as Jupiter- orbiting a star similar to the Sun but in an orbit that is extremely close to its star, much closer than the orbit that Mercury follows around the Sun.

Since then, new planets have been discovered using this same method. Hundreds of them have been discovered since 2003, through a telescope located at La Silla Observatory, in the Coquimbo Region of northern Chile, more specifically the 3.6-meter telescope along with its stable and precise High Accuracy Radial Velocity Planet Searcher (HARPS).

The Gliese 581 system stands out among those discoveries, particularly the planet Gliese 581 g, whose mass is only 2.2 times that of our Earth and which has an orbit in what is known as a habitable zone, that is, the temperature of said planet could allow the existence of water in its liquid state on the surface.

But there are other ways of finding extrasolar planets. One of them is the constant observation of the stars in the sky, with the aim of detecting changes in the quantity of light that we receive from the star. In 1999, a team of astronomers discovered the first planet using this technique.

In April 2005, the European Southern Observatory (ESO) announced that, for the first time, a direct image of an extrasolar planet had been taken from the Very Large Telescope (VLT) Observatory on Paranal hill (Antofagasta). These observations made in northern Chile traveled the world, announcing the beginning of a new era in the search and study of extrasolar planets (**Image 1**).

Successful projects are currently being carried out in the observatories located in northern Chile, some alongside with observatories in different parts of the world, that continue finding planetary systems, such as in the case of the HAT-South, which has identified fifteen new extrasolar planets.

OBSERVATIONS FROM CHILE

Hundreds of the planet discoveries made since 2003 have been made, and continue to be made, from a telescope located in the La Silla Observatory, in the Coquimbo Region.

PROXIMA CENTAURI B: PROBABILITY OF LIFE OUTSIDE OF EARTH 01

In August 2016, the existence of an exoplanet orbiting the star Proxima Centauri was confirmed. This is the closest one to Earth (located a little over 4 million light years away). It is the planet Proxima Centauri b, which presents similar characteristics to those of the Earth. In fact, its temperature allows thinking that there might be liquid water on its surface and, therefore, opens up the possibility that it might also hold life.

This discovery was possible thanks to the collaborative work under the framework of the Pale Red Dot project. The observations of this project began in January 2016, and were carried out with the High Accuracy Radial Velocity Planet Searcher (HARPS) installed in the 3.6-meter telescope of the European Southern Observatory (ESO) at the La Silla Observatory. In addition, the project had the support of the Burst Optical Observer and Transient Exploring System (BOOTES), along with the Las Cumbres Observatory Global Telescope (LCOGT). The results of this project, in addition to previous observations, helped determine the existence of this exoplanet.

Although many exoplanets have been discovered, the main relevance of Proxima Centauri b is its similarity to Earth. It has rocky characteristics, it possesses a mass 1.3 times greater than that of our planet, it is calculated that its temperature is approximately 4 C° and it is located in the habitable zone of Proxima Centauri.

Photo Credit: ESO/Pale Red Dot

Photo Credit: ESO/M. Kornmesser

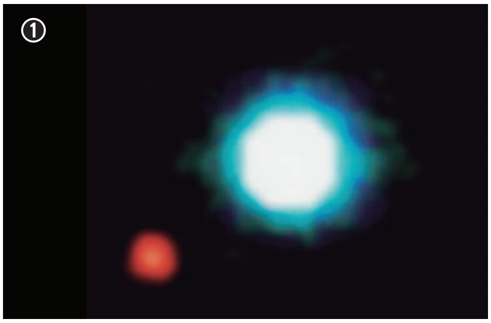
Towards the end of 2014, the Atacama Large Millimeter/submillimeter Array (ALMA) installed in the Chajnantor plain, in the Atacama Desert, took an image of a planetary system under formation. A gas and dust disk around a young star, which showed empty straps due to the presence of proto-planets that have incorporated, through gravity, all of the particles and fragments in orbit at the same distance from the star. Thus, now there is important confirmation of the Solar System formation models and its faraway equivalents (**Images 2 and 3**).

Also, during 2014 and 2015 at the Las Campanas Observatory, at Gemini South and VLT, three dedicated and optimized instruments began their observations to enable the detection of extrasolar planets in a direct manner as well as planets under formation. These instruments possess unique characteristics to achieve images with high contrast and incredible spatial resolution, allowing a better understanding of how planetary systems are formed and what fraction of the stars have gas giants in very large orbits[3].

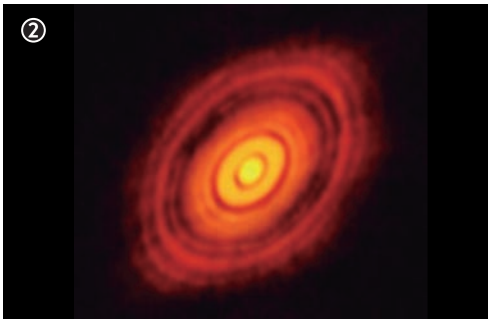
An era in which discovering more and more planets is almost a routine in the astronomical arena has been reached, but there are new challenges, such as learning about the type of atmosphere of extrasolar planets. Thanks to instruments such as FORS2 or HAWK-I at VLT and IMACS at Las Campanas, it is possible to detect cloud signals and some elements such as Sodium in the atmospheres of said planets.

[3] *In VLT (SPHERE), at Las Campanas (Mag AO) and at Gemini South (GPI).*

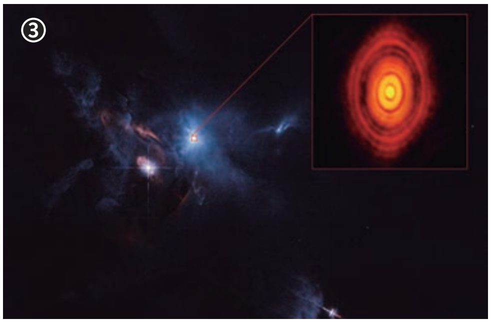
OBSERVATION FROM CHILE



1. This composed image shows an exoplanet (the red dot below towards the left), orbiting the brown dwarf 2M1207 (in the center). 2M1207 is the first direct image of an exoplanet discovered orbiting a brown dwarf. It was taken for the first time by the VLT in 2004. Its identity and planetary characteristics were confirmed after a year of observations in 2005. ESO.



2. This clear image shows the protoplanetary disk that surrounds the young HL Tauri star. This is the first ALMA image that exceeds the usual sharpness that Hubble images usually reach. ALMA (ESO/NAOJ/NRAO)



3. Composition of images that show the young HL Tauri star and its surroundings, based on data from ALMA (enlarged in the top right corner) and the Hubble Space Telescope (HST) of the NASA/ESA (the rest of the image). ALMA (ESO/NAOJ/NRAO/NASA/ESA)

2.1.2 A Supermassive Black Hole in the Center of our Galaxy

At the core of the Milky Way there is a supermassive black hole, known as Sagittarius A* (SgrA*), which would be the closest one to Earth and would be at an approximate distance of 26,000 light years away. This black hole is being studied from Chile.

With the arrival to the country of new infrared detectors with higher resolution, greater sensitivity and groundbreaking observation techniques, at the beginning of the 1990s it was possible to identify a group of stars very close to SgrA*. Through the New Technology Telescope (NTT), located at the La Silla Observatory, images of the galactic core were taken, achieving unprecedented details in this region. Towards the mid-1990s, the first movements of some stars were already available.

In 2002, an article was published based on data from different telescopes and instruments, almost all of them from the ESO at La Silla or Paranal, which included details about a specific orbit. A star named S2 had traveled two-thirds of its orbit trajectory since its observation had begun, an orbit of only 15.2 years that passed at only 17 light years from the point in which it was orbiting (close to 3.5 times the distance between Neptune and the Sun). The result was clear: the trajectory showed that it orbits an object, which is approximately 3.5 million times the mass of the Sun. This confirmed that at the core of the Milky Way there is a supermassive black hole.

Today, there is GRAVITY, an instrument that was initially tested at the VLT (Paranal Observatory) and enables the observation of orbits of stars closer to the black hole, with unprecedented precision.

The core parts of our galaxy, the Milky Way, observed in the near infrared with the NACO instrument of ESO's VLT. Following the movements of the star closer to the core for 16 years, astronomers were able to determine the mass of the supermassive black hole that lies inside it. ESO/S. Gillessen et al.

2.1.3 Supernovae and the Accelerated Expansion of the Universe

One of the most relevant questions posed by astronomy towards the end of the 20th century was how fast or how slowly was the Universe coming to a halt. When Edwin Hubble discovered that the Universe was expanding[4], the logical conclusion was that, before this, the Universe was smaller. Going back in time would show that the entire Universe was a single spot. The theory explained the origin of the Universe through a large explosion that became known as the Big Bang, but if said Universe had been born from an explosion and is still expanding, logic and common sense indicated that that expansion should become slower, that is: the expansion of the Universe would be coming to a halt.

During the 1990s, a Chilean-American team of scientists under a collaboration named Project Calán-Tololo, aimed to search for supernovae in the southern hemisphere and to research their usefulness as luminous patterns. After four years, nearly 50 supernovae were observed, and some of the best measurements of the brightness variation (light curves) obtained until then were achieved. At the time, the importance of that property to measure distances and, thus, contribute to the current understanding of the Universe was unforeseeable.

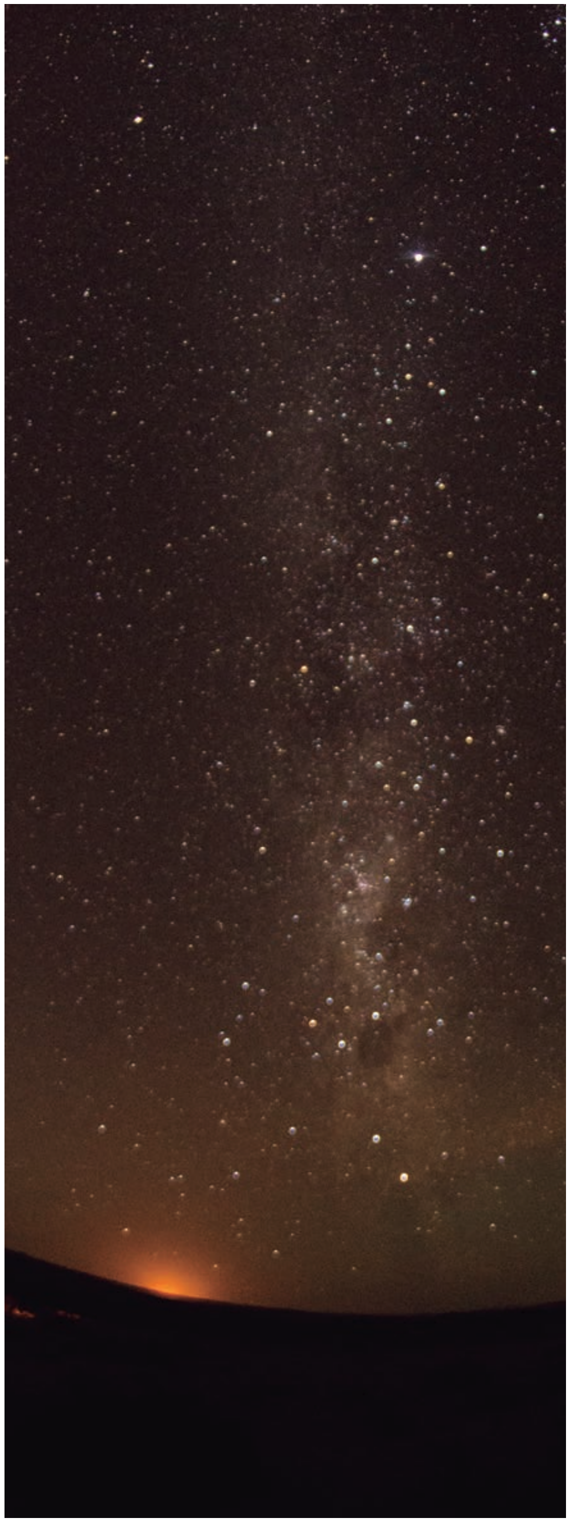
02

SUPERNOVAE

Supernovae are highly energetic phenomena produced by the complete or partial explosion of a star, towards the final phase of its life. Depending on whether the star is isolated or can be found within a binary system, there can be two types of Supernovae. Both become as bright as the entire galaxy where they are produced. However, the light emitted by them has different characteristics.

The great brightness of the Supernovae makes it possible for them to be seen from huge distances, as far as thousands of million light years away and, since light travels at a finite velocity, the further the observation, the further back in time it is. With the Supernovae, it is possible to see the Universe when it was very young.

[4] *In 1929, Edwin Hubble revolutionized cosmology by discovering that the Universe is expanding.*



Sky | JOSE GERSTLE

It was in Chile, through the Supernovae discovered by the Calán-Tololo Project, that the bases were set to standardize their brightness and trace the expansion of a "local" Universe. Now, in order to see the change in the velocity of expansion[5], two other additional projects were needed, whose aim was to seek Supernovae at greater distances, the "High-Z SN search" (High Red Shift Supernovae Search) and the "Supernova Cosmology Project".

Once more, the observatories located in Chile and in the United States played a key role in the development of said projects. This joint effort by Chilean and American astronomers enabled the generation of a methodology to measure the distance of faraway galaxies with a precision that was non-existent until then.

In 1998, both projects shared their results and the surprise could not have been greater: the "deceleration" factor of the Universe was negative. The measurements of the distant Supernovae contradicted all logic, and indicated with scientific data that the Universe, despite what was thought until then, was expanding with acceleration. During the following years, the evidence in favor of the idea of an accelerated expansion of the Universe continued to grow, until in 2011 said discovery was awarded the Nobel Prize in Physics, recognizing the important contribution of the research carried out in Chile, through the Calán-Tololo Project (**Image 02**).

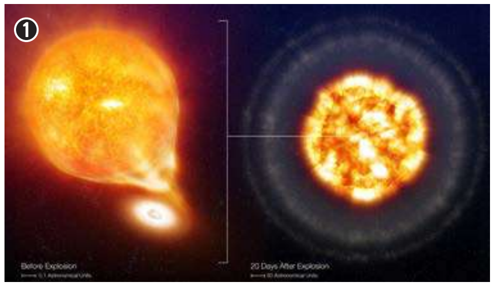
At present, there are several projects in Chile dedicated to the search of Supernovae, since it is necessary to better understand how those explosions are and what the physics in those objects is like.

Towards 2021, a hill close to La Serena will receive the Large Synoptic Survey Telescope (LSST) Observatory, whose main motivation is precisely to map the entire southern sky in search of very distant objects whose brightness varies, such as the Supernovae.

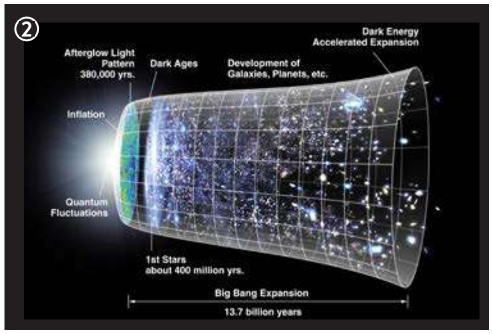
Answering the question of how the Universe expands opened up many new questions: What is causing the accelerated expansion of the Universe? What is the Universe composed of? What is the final destination of the Universe?

Today, nearly 20 years after the discovery of the accelerated expansion of the Universe, the Chilean skies are still the laboratory from which this mystery is trying to be solved. Several experiments, among which the Dark Energy Camera (DECAM) -a 4-meter telescope located on Tololo Hill- stands out, use cutting-edge technology to clarify the nature of "Dark Energy", which is believed to be behind the accelerated expansion of the Universe.

SUPERNOVAE AND THE EXPANSION OF THE UNIVERSE



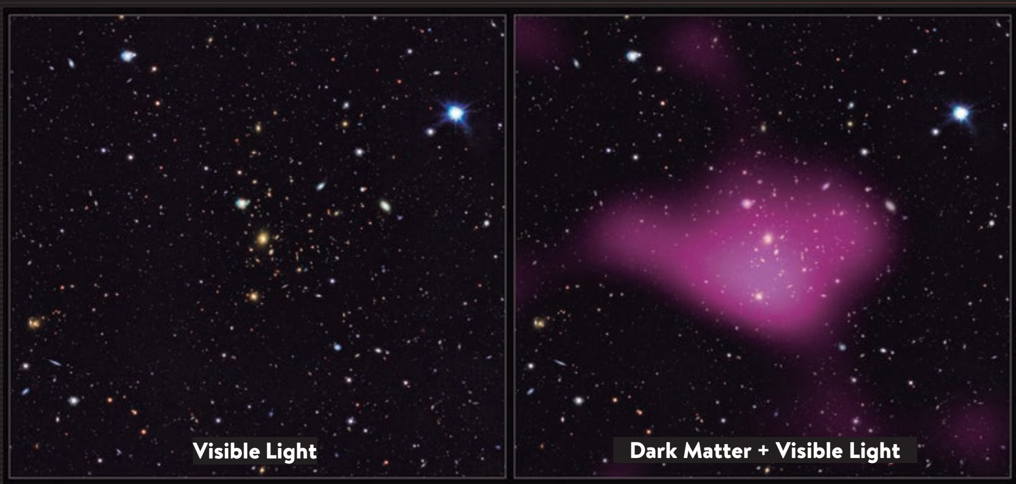
1. Artistic representation of a typical supernova before and after its explosion. ESO



2. Accelerated expansion of the Universe.
MILLENNIAL INSTITUTE FOR ASTROPHYSICS

[5] *At the time, it was believed that the most likely probability was that the expansion of the Universe was coming to a halt.*

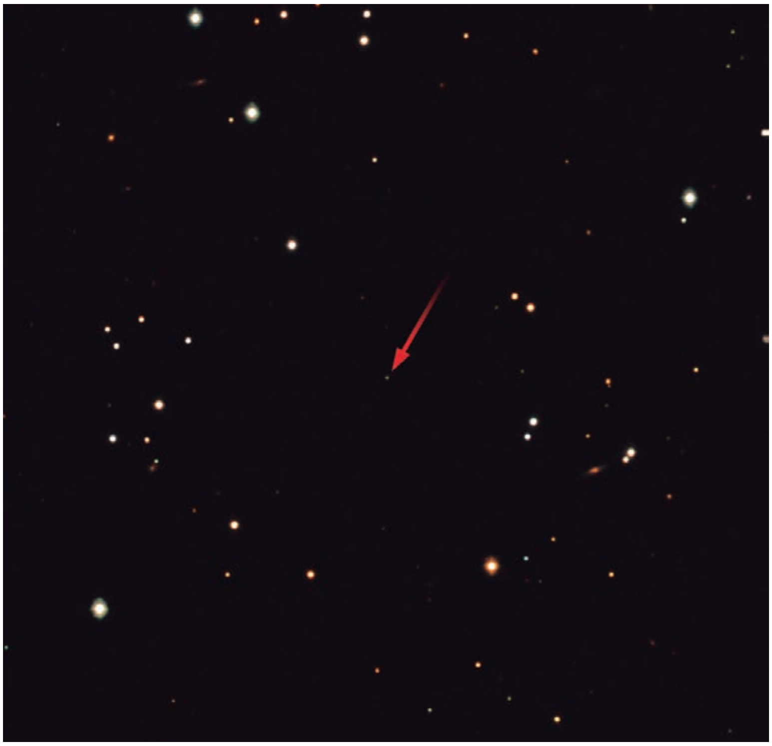
Where there is an acceleration, there is a force. The discovery of the accelerated cosmic expansion in 1998, in which the telescopes from the Tololo Hill Observatory installed in Chile played a crucial role, posed an enigma that has yet to be solved: What is the force that drives the expansion of the Universe and makes it faster every time? For cosmologists it is the “dark energy”, because behind a force an energy can also be defined. This is the most elementary principle from which force can be calculated, which, at the same time, causes the acceleration of mass. Actually, no one knows what it is. The principle acting behind all of this is unknown. Furthermore, such a force is not even included on the “menu” of options of the “Standard Model” of particle physics. There was a paradoxical place reserved for it in Einstein’s General Relativity equations (he called it “Cosmological Constant”). But, once again, this is only an elegant mathematical disguise. There are experiments underway to try to understand a little better what it is about, how it evolved throughout the history of the Universe. But it is still at the very basic stages of conceptual understanding, which is also logical. Dark energy was discovered less than twenty years ago.



First results of the new and immense tracking of dark matter carried out in the southern skies using ESO’s VLT Survey Telescope (VST), installed in the Paranal Observatory in Chile. The project is known as the Kilo-Degree Survey (KiDS). KILO-DEGREE SURVEY COLLABORATION/A. TUDORICA & C. HEYMANS/ESO

2.1.4 Gamma-Ray Burst

Also related to the far Universe, observations made from northern Chile have enabled the measurement of the distance to the farthest gamma-ray burst confirmed to date, for the GRB 090423 source, emitted approximately 600 million years after the Big Bang. Carrying out this measurement requires combining the large telescopes installed in northern Chile with the excellent existing atmospheric conditions. In this case, it was possible to establish the distance, thanks to the observations of the Very Large Telescope, making it the farthest object discovered to date.



On October 27, 2015 the NASA/ASI/UKSA Swift satellite discovered its number 1,000 gamma-ray burst (GRB). This important event was later observed and detailed by ESO's telescopes at the La Silla and Paranal Observatories in northern Chile. This image shows the optic and infrared brightness of this object, captured by the Gamma-ray Burst Optical/Near-infrared Detector (GROND) system through the MPG/ESO 2.2-meter telescope at ESO's La Silla Observatory. What seems like a faint star in the center of the image is actually the GRB, which only seems small because it is very far away. ESO/GROND

Artistic illustration | ESO/A. ROQUETTE

2.1.5 Satellite Galaxies of the Milky Way

Many of the instruments that are part of the astronomical observatories installed in northern Chile, in addition to enabling the study of the Universe at the greatest scales known to date, are also revolutionizing the way in which our local neighborhood is observed, our own galaxy (the Milky Way) and the systems that surround it.

Some of the smallest and most ancient galaxies in the Universe have been detected and studied from Chile, the ones seen orbiting the Milky Way as small satellites. These objects hold essential information to be able to understand how the first stars of the early Universe were formed and how matter is organized and distributed in space throughout the history of the Cosmos. These studies have allowed, for example, the discovery in Chilean skies of the most ancient star ever observed in our Galaxy and the mapping of the position of millions of stars in the sky to be able to reconstruct the shape of the Milky Way with an unprecedented level of detail.

This photograph shows two spiral galaxies, similar in appearance to the Milky Way, which are participating in a cosmic ballet that in a few billion years will end in a complete galactic fusion -both galaxies will become one larger one. This photograph was taken with the ESO's Faint Object Spectrograph and Camera (EFOSC2) through three broad-band filters (B, V, R). The EFOSC2 has a visual field of 4.1 x 4.1 arcminutes and it is attached to the 3.6-meter telescope at ESO's La Silla Observatory. ESO

3 • MAIN OBSERVATORIES

1 ALMA (Atacama Large Millimeter/submillimeter Array Observatory)
It is a radio telescope composed of 66 high-precision antennas, each with 12-meter and 7-meter diameters. It is located 5,000 meters above sea level, in the Chajnator plain (which in Kunza tongue means "launch site"), in the middle of the Atacama Desert. In contrast to optical telescopes, radio telescopes capture the Universe's radio waves, which are reflected on the surface of its dishes. Thanks to their parabolic shape, they concentrate on the focal point, where a receptor receives the radio waves, amplifies them and digitizes them, enabling their information -which includes the intensity of the waves captured and the exact position of the spot in the Universe they come from- to be converted into images (ALMA, n.d.)

"ALMA is an interferometer[6] that can operate as a single huge telescope equal to a 16-kilometer diameter antenna" (ALMA, n.d., p. 12)

2 PARANAL OBSERVATORY
Observatory of the European Organisation for Astronomical Research in the Southern Hemisphere(ESO). **Location:** Is sits on top of Paranal hill, at 2,635.43 meters above sea level, in the Coastal Mountain Range, 130 kilometers south of Antofagasta and 12 kilometers from the coast. **Telescopes:** Four Unit Telescopes with main mirrors of 8.2 meters diameter or Very Large Telescope (VLT). Four movable 1.8 meters diameter Auxiliary Telescopes for interferometry. Two broad range telescopes, VISTA (Visible and Infrared Survey Telescope for Astronomy), with a main mirror of 4.1 meters, and 2.6-m VST (VLT Survey Telescope). **Website:** http://www.eso.org/sci/facilities/lpo/

3 ARMAZONES HILL OBSERVATORY
Observatory of the Astronomy Institute of the Northern Catholic University and the Astronomical Institute of the Ruhr-University in Bochum (AIRUB). **Location:** It is located 130 kilometers southeast of the city of Antofagasta, at 3,064 meters above sea level. **Telescopes:** It has three telescopes of 1.5 meters, 84 centimeters and 41 centimeters in diameter. At the same time, the ESO's European Extremely Large Telescope (E-ELT) will also be located here and will have a primary 39-meter mirror and will be the largest telescope in the world to observe in the visible and the near-infrared.

[6] *An interferometer is an instrument that uses wave interferences to measure wavelengths.*

REGIONS IN NORTHERN CHILE

Milky Way from the Paranal Observatory | ESO/H.H. HEYER

❹ LAS CAMPANAS OBSERVATORY

Observatory operated by the Carnegie Institution of Washington. **Location:** Manqui hill, close to Las Campanas hill, 160 kilometers north of La Serena, between the borders of the Atacama and Coquimbo regions, at 2,380 meters above sea level. **Telescopes:** The twin 6.5-meter Magellan I and II telescopes; 2.5-meter Irénée du Pont telescope; and the 1-meter Swope Telescope. **Website:** www.lco.cl

❺ LA SILLA OBSERVATORY

It is the first observatory of the European Organisation for Astronomical Research in the Southern Hemisphere (ESO). The observations made at La Silla have provided the bases for several discoveries, giving way to a large amount of annual publications. **Location:** It is located 160 kilometers north of La Serena, between the borders of the Atacama and Coquimbo regions, at 2,400 meters above sea level. **Telescopes:** Three 3.6-meter, 3.5-meter, and 2.2-meter telescopes operated by the ESO. Two 1.2-meter and 1.5-meter telescopes operated by Switzerland and Denmark, respectively, and the 1-meter Schmidt telescope.
Website: http://www.eso.org/sci/facilities/lpo/

❻ CERRO TOLOLO INTER-AMERICAN OBSERVATORY (CTIO)

Inaugurated in 1967, it is the first international observatory built in the country. This observatory is part of the United States National Optical Astronomy Observatory (NOAO), operated by AURA, under a cooperation agreement with the National Science Foundation (NSF). **Location:** Tololo hill, 80 kilometers east of La Serena, in the Coquimbo Region, at 2,200 meters above sea level. **Telescopes:** Five operational telescopes. CTIO operates the 4-meter Blanco telescope on Tololo hill, the CTIO 1.5-meter, 1.3-meter and 0.9-meter telescopes, and the Yale 1.0-meter telescope are being operated by the SMARTS Consortium, in addition to the Curtis/Schmidt telescope. **Website:** www.ctio.noao.edu/

❼ SOUTHERN ASTROPHISICAL RESEARCH (SOAR)

It is a 4.1-meter telescope built by the Ministério da Ciencia e Tecnologia of the Federal Republic of Brazil (MCT), the United States National Optical Astronomy Observatory (NOAO), the University of North Carolina at Chapel Hill (UNC), and Michigan State University (MSU). **Location:** Pachón hill, 80 kilometers away from La Serena, in the Coquimbo Region, at 2,700 meters above sea level. **Telescopes:** Optical and azimuth 4.1-meter diameter telescope. **Website:** www.soartelescope.org/

❽ GEMINI SOUTH OBSERVATORY

This observatory is operated by a partnership of five countries: The United States, the United Kingdom, Canada, Brazil, Argentina and Chile AURA (Association of Universities for Research in Astronomy). This consortium also operates the Gemini North telescope, located in Hawaii. **Location:** Pachón hill, 80 kilometers away from La Serena, in the Coquimbo Region, at 2,700 meters above sea level. **Telescope:** 8.1-meter diameter optical/infrared telescope. **Website:** www.gemini.edu/

4 • PROJECTS UNDER DEVELOPMENT: NEW TIME MACHINES

Chile concentrates nearly 40 percent of the global astronomical observation capacity. As mentioned before, this percentage will increase over the next few years, when new projects begin operations, which will involve setting up telescopes that will come to revolutionize astronomical observation and will place Chile at the core of this scientific field, harboring approximately 70 percent of the world's astronomical observation capacity.

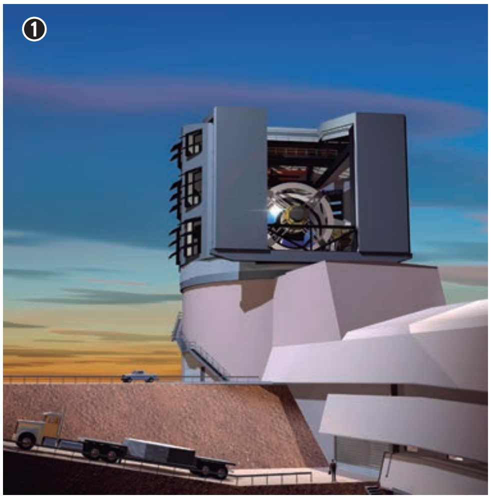
These are advanced-technology instruments that will allow looking into the past, like true **time machines**.

❶ **Large Synoptic Survey Telescope (LSST):** the construction of the Large Synoptic Survey Telescope (LSST) began on April 14, 2015, in the Coquimbo Region. This telescope will provide valuable information to understand the Milky Way, the asteroids population and will contribute to the understanding of dark energy, which is accelerating the expansion of the Universe.

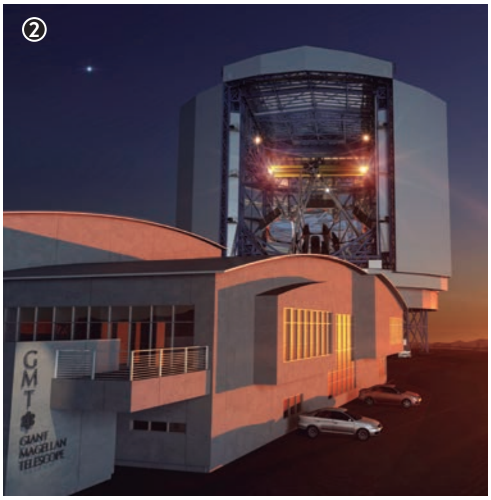
The LSST will be located on Pachón hill and will have an 8.4-meter telescope and a 1.6-meter and 3,200-megapixel camera, both of which will enable capturing images from the entire visible sky for 10 years. It is a telescope that will make it possible to build the most complete image of the Universe, revealing changes or movements, as well as to identify potentially dangerous asteroids. It is expected that the telescope will begin providing images starting in 2019 and that it will be fully operational by 2022.

❷ **Giant Magellane Telescope (GMT):** The construction of the Giant Magellan Telescope began in November 2015. It will be located on Las Campanas hill in the Atacama Region, at 2,400 meters above sea level. It is planned to begin operations in 2021. At that time, it will be the largest telescope in the world and will enable observing the Universe with a clarity ten times greater than the Hubble Space Telescope. It will be like traveling in time, taking a peak a little after the Big Bang explosion, when the first stars and galaxies were formed. This high capacity and possibility of exploring the Universe with a clarity never seen before will allow researching the origins of the elements that make up our planet and humans. Likewise, it will search for traces of biological processes in planets beyond our galaxy.

❸ **European Extremely Large Telescope (E-ELT):** It will be located on Armazones hill, in the Antofagasta Region, approximately 20 kilometers away from Paranal hill, where the Very Large Telescope is located, which is also operated by the European Organisation for Astronomical Research in the Sou-



1. Large Synoptic Survey Telescope (LSST) (Retrieved March 4, 2016 from http://www.lsst.org/about)



2. Giant Magellan Telescope (GMT) (Retrieved March 4, 2016 from http://www.gmto.org/gallery/) | GMTO

thern Hemisphere (ESO). It is a 39-meter diameter telescope, the largest in the world. It is expected that, when it begins operations, in 2024, it will revolutionize astronomical observation and current knowledge on the matter. "The ELT will gather 100 000 000 times more light than the human eye, 8 000 000 times more than Galileo's telescope" (ESO, n.d.). (www.eso.org)

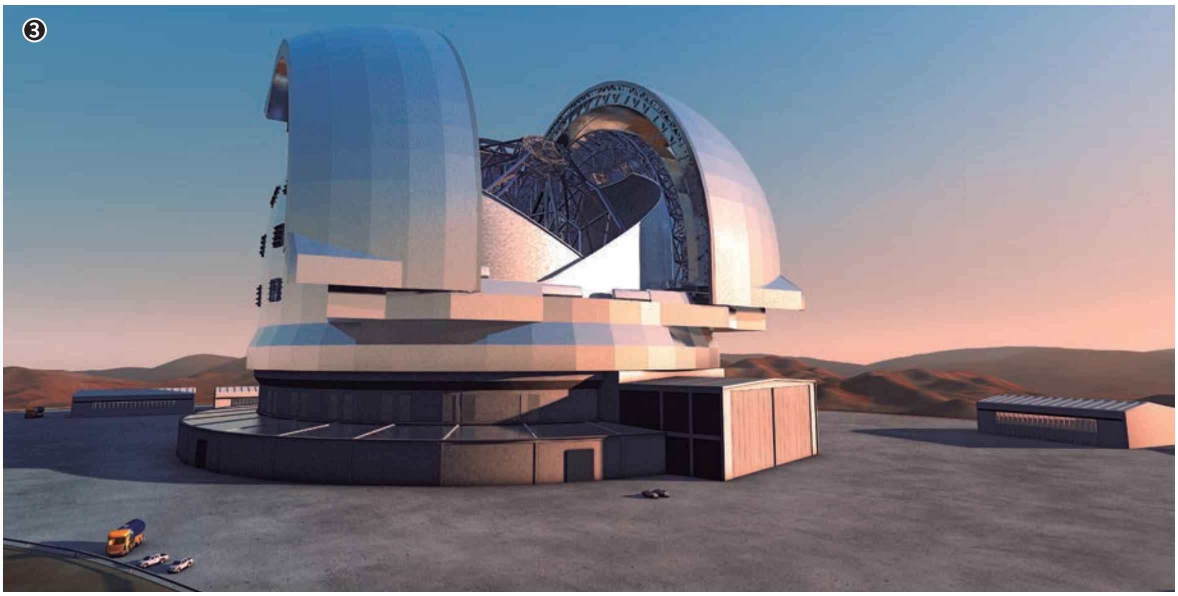
The E-ELT will enable progress in astronomy in topics such as the search for life in the Universe, learning about the first stars and galaxies, and probing the nature of dark matter and dark energy. One of the most significant challenges for this telescope is the study of the process of accelerated expansion of the Universe.

"The ELT has embraced the quest for extrasolar planets — planets orbiting other stars. This will include not only the discovery of planets down to Earth-like masses through indirect measurements of the wobbling motion of stars perturbed by the planets that orbit them, but also the direct imaging of larger planets and possibly even the characterization of their atmospheres" (ESO, n.d.). (www.eso.org)

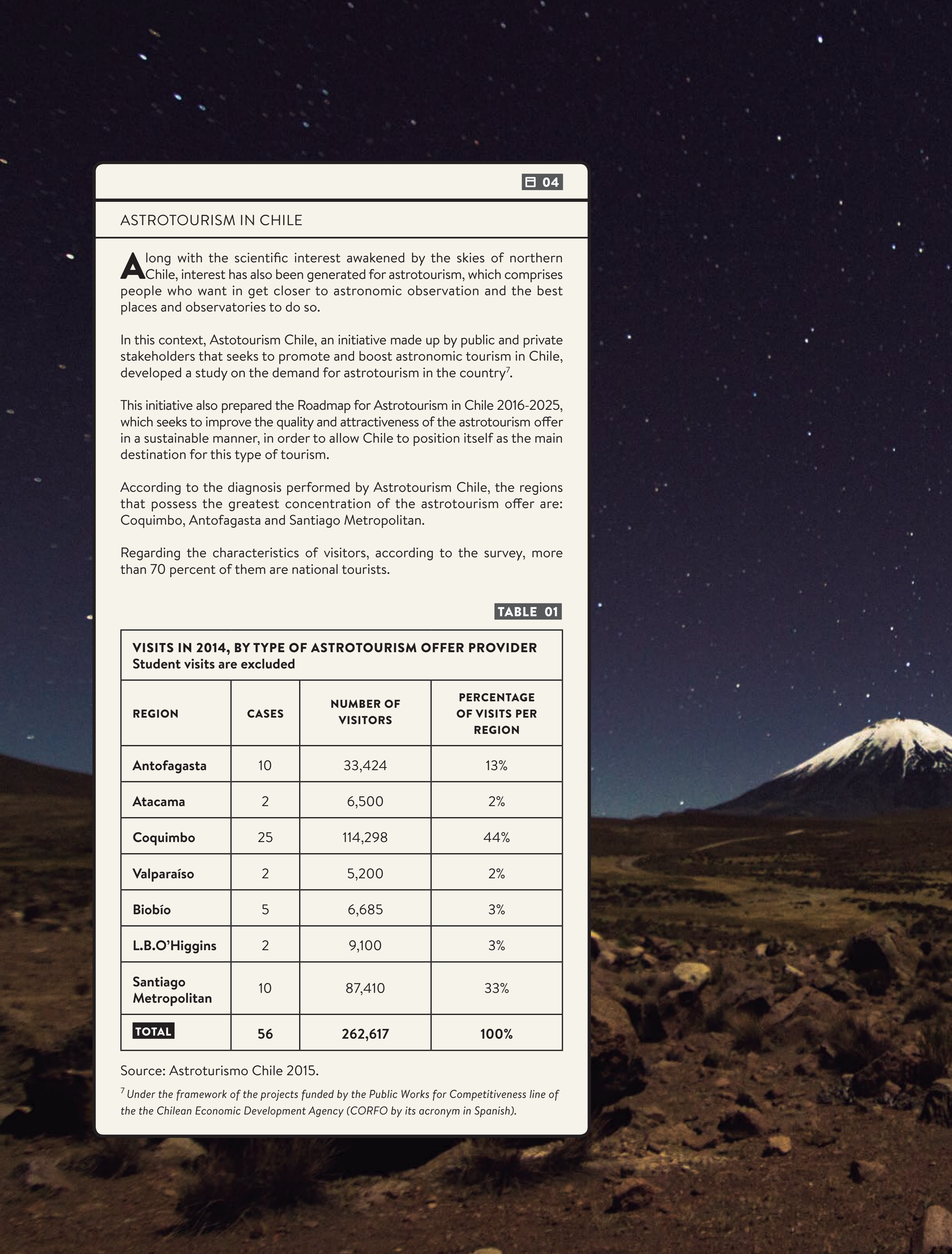
ASTRONOMICAL OBSERVATION

Over the next few years, Chile will have cutting-edge technology instruments that **will enable looking into the past, like actual time machines.**

These new telescopes, which will come to revolutionize astronomical observation, will place Chile at the core of this scientific field, harboring approximately 70 percent of the global astronomical observation capacity.



3. Artistic impression of the European Extremely Large Telescope (E-ELT). The E-ELT will be the largest optical/near-infrared telescope in the world -the world's biggest eye on the sky. | ESO



04

ASTROTOURISM IN CHILE

Along with the scientific interest awakened by the skies of northern Chile, interest has also been generated for astrotourism, which comprises people who want in get closer to astronomic observation and the best places and observatories to do so.

In this context, Astotourism Chile, an initiative made up by public and private stakeholders that seeks to promote and boost astronomic tourism in Chile, developed a study on the demand for astrotourism in the country[7].

This initiative also prepared the Roadmap for Astrotourism in Chile 2016-2025, which seeks to improve the quality and attractiveness of the astrotourism offer in a sustainable manner, in order to allow Chile to position itself as the main destination for this type of tourism.

According to the diagnosis performed by Astrotourism Chile, the regions that possess the greatest concentration of the astrotourism offer are: Coquimbo, Antofagasta and Santiago Metropolitan.

Regarding the characteristics of visitors, according to the survey, more than 70 percent of them are national tourists.

TABLE 01

VISITS IN 2014, BY TYPE OF ASTROTOURISM OFFER PROVIDER
Student visits are excluded

REGION	CASES	NUMBER OF VISITORS	PERCENTAGE OF VISITS PER REGION
Antofagasta	10	33,424	13%
Atacama	2	6,500	2%
Coquimbo	25	114,298	44%
Valparaíso	2	5,200	2%
Biobío	5	6,685	3%
L.B.O'Higgins	2	9,100	3%
Santiago Metropolitan	10	87,410	33%
TOTAL	**56**	**262,617**	**100%**

Source: Astroturismo Chile 2015.

[7] *Under the framework of the projects funded by the Public Works for Competitiveness line of the the Chilean Economic Development Agency (CORFO by its acronym in Spanish).*

Payachatas stars | NICOLÁS LAGOS

5 • LIGHT POLLUTION

One of the main factors that threatens the quality of astronomical observation in the skies of northern Chile is light pollution. It is a problem that mainly affects the cities and it occurs when the level of evening environmental light level, derived from artificial lighting, increases. This occurs when light is not efficiently aimed at illuminating the ground or buildings, but rather it is pointed upwards towards the sky, affecting the possibility of watching the stars and the night sky. This type of pollution has negative impacts for astronomic observation, as well as for human health and biodiversity.

Light pollution is most evidently manifested as the increase in the brightness of the night sky, through the reflection or diffusion of the artificial light among the gases and particles of the urban air, in a way that reduces the visibility of stars and other celestial objects (MMA, 2012).

5.1 Light Pollution in Northern Chile

The privileged conditions for astronomical observation in northern Chile are increasingly more at risk, due to the urban growth of the cities close to the observatories. When facing the presence of lines of artificial light emission sources, the observatories require more exposure time to carry out spectroscopy[8] of faint objects.

Although towards the end of the 1990s the country had sought to protect the quality of the skies through emission standards, as well as through guidelines on outdoor luminaires, it has been necessary to increase said regulatory requirements, in order to ensure the care of this heritage.

ASTRONOMICAL OBSERVATORIES

[8] *Spectroscopy is the study of the interaction between electromagnetic radiation and matter, with the absorption or emission of radiant energy. In astronomy, the subject matter is the spectrum of electromagnetic radiation, including visible light, that radiates from stars and other celestial objects.*

Panoramic of the Cerro Tololo Observatory |ESO

5.2 Emission sources

The main emission source of light pollution is public lighting, followed by advertisement lighting. Also, activities such as construction or mining, can also be emission sources for light pollution.

Along with public lighting, the type of light source used is one of the conditions that affects the quality of night skies. Also, the location and direction in which the lighting is located is another cause of light pollution.

The worst sources of outdoor light for astronomy are incandescent lights (such as the lightbulbs commonly used in homes), since they emit a continuous spectrum of many bands of color that block the spectral information originating from faint cosmic objects. The sources that emit light in color band characteristics are less damaging for observation, since they do not pollute the full spectrum. However, some of them can also be just as damaging.

TABLE 02

DISTANCES OF THE ASTRONOMICAL OBSERVATORIES in relation with the main cities of northern Chile, in km

NAME	**Antofagasta** 404,000 INHABITANTS	**Calama** 178,000 INHABITANTS	**Copiapó** 163,000 INHABITANTS	**Vallenar** 48,000 INHABITANTS	**Coquimbo La Serena** 486,000 INHABITANTS	**Ovalle** 172,000 INHABITANTS	**Vicuña** 24,000 INHABITANTS
1 **TAO**	-	135	-	-	-	-	-
2 **Paranal**	108	-	-	-	-	-	-
3 **E-ELT**	105	-	-	-	-	-	-
4 **Las Campanas**	-	-	185	49	115	181	112
5 **La Silla**	-	-	213	75	93	155	85
6 **Tololo**	-	-	-	177	55	60	17
7 **SOAR**	-	-	-	184	62	60	22
8 **Gemini South**	-	-		184	62	60	23
9 **LSST**	-	-	-	185	61	58	23

Source: Chile, MMA, 2012.

6 • SKY PROTECTION IN NORTHERN CHILE

The importance of astronomical observation for scientific progress has given prominence to places that still possess the conditions to develop this type of work.

In this context, during the light pollution Starlight Conference of 2007 carried out in La Palma, Spain the International Astronomical Union (IAU) presented the idea of proposing these astronomical sites as Human Heritage. This, since “skies” for astronomical observation cannot be registered as part of said heritage.

Later, UNESCO’s the World Heritage Committee, in its 34th session carried out in Brasilia (Brazil, 2010) approved the study on “Heritage Sites of Astronomy and Archaeoastronomy in the context of the World Heritage Convention: A Thematic Study”, developed under the framework of the International Year of Astronomy 2009. This study identifies certain places of the world as astronomical heritage, among which are Northern Chile, the Canary Islands, Hawaii and Namibia, all of them denominated as “Windows to the Universe”.

According to the study, “the effective preservation of dark areas requires the establishment of appropriate criteria for their management, especially with regard to the mitigation or elimination of light pollution” (Clive Ruggles and Michel Cotte, 2010).

In this context, the IAU created the World Heritage Commission, which seeks to promote the protection of some of the most important places for astronomical observation. In August 2015, during the XXIX General Assembly of the IAU, participating countries were called upon to coordinate the efforts to carry forth this initiative. In said occasion, Chile announced the creation of the “Windows to the Universe” working group, acting as focal point for this international initiative. Furthermore, during the assembly Chile was elected as coordinator of the Global Network of Astronomical Observatories with Heritage Value.

6.1 “Windows to the Universe” Working group

The working group Windows to the Universe of Chile is coordinated by the Energy, Science and Technology and Innovation Directorate of the Ministry of Foreign Affairs and the Library, Archives and Museums Directorate (DIBAM by its acronym in Spanish). Also participating in this initiative are the directors of the observatories, the Minister of the Environment, the Office for the Protection of the Quality of the Skies in Northern Chile (OPCC by its acronym in Spanish), the National Monuments Council and the UNESCO Commission of the Ministry of Education.

The objective of this working group is to coordinate the necessary strategy and actions to make progress in declaring astronomical sites in Chile as National Monuments, under the framework of achieving their nomination on the UNESCO Astronomy and World Heritage Initiative (AWHI).

05

ASTRONOMICAL SITES AS WORLD HERITAGE

There are several places in the world where a unique combination of environmental and natural circumstances can be found; spaces that are well conserved with little disturbance of the natural quality of the sky, really dark, with a large percentage of days with clear skies and with maximum sharpness and transparency.

These exceptional sites, including their natural components, can be considered as “landscapes of science and knowledge”. As can be expected, the largest observatories of the contemporary world, true scientific monuments, can be found in these places and are, to a greater or lesser extent, historical sources of the native astronomical culture. This is the case of Hawaii, the Canary Islands and Northern Chile, a group of sites that, within this context, have an exceptional universal significance as a group.

1 Arizona (Mexico - Baja California)
2 Hawaii (Mauna Kea - Haleakala)
3 Canary Islands (La Palma - Teide)
4 Northern Chile
5 South Africa

Retrieved on March 24, 2016 from https://www3.astronomicalheritage.net/index.php/show-theme?idtheme=21

7 • NEW LIGHT STANDARD

In 1998, Chile enacted the Emissions Standard for the Regulation of Light Pollution (Supreme Decree N° 686/1998, Ministry of Economy), with the aim of preventing light pollution and protecting the skies of northern Chile. Although the standard implied a contribution in the reduction of light pollution of approximately 30 percent, in addition to generating an energy saving in the regulated areas, it slowly began to show a halt in the level of compliance with the regulation, regarding the change of public luminaires.

In this context, and after several years of the entry into force of the regulation, it came under review. As a result, in 2013, Supreme Decree N° 43/2012 of the Ministry of the Environment was published, compiling international experience and standards, using places such as Italy, Spain and the United States, where astronomical observation and research are developed.

The new regulation establishes greater requirements for ambient light, for luminaires with different technologies (including LED technology) for advertisements or signs. The regulation specifically restricts the emission of radiant flux towards the upper hemisphere, as well as certain spectral emissions of lamps, except in specific applications that are explicitly indicated.

Regulated Emission Sources

According to the regulation, emission sources are lamps, whichever their technology that are installed in luminaries, in projectors or by themselves, that are used in what is known as ambient light. This also includes signs, digital signage displays, projectors or other illumination devices that can be moved while being operated and similar ones.

The following are not considered as ambient light, for example, the illumination caused by the combustion of natural gas or other fuels, from vehicles and emergency lights necessary for public safety.

What are the Main Requirements of the Supreme Decree N° 43/ 12 of the MMA?

- ▶ Complete restriction of the radiant flux emitted towards the upper hemisphere.
- ▶ Spectrum restriction.
- ▶ Incorporation of limits for emission reflected on the road (on illumination).
- ▶ Incorporation of advertisement and digital signage displays.
- ▶ Elimination of the scheduled restrictions of Supreme Decree N° 686/98 MINECON.
- ▶ Requirements of incandescent-filament lamps, high intensity discharge lamps and solid-state lamps (LED).

LIGHT POLLUTION

The standard implied a contribution to the reduction of light pollution by

▼30%

In addition to generating energy savings in regulated areas, **they will enable looking into the past, like actual time machines.**

Supervision

The Superintendency for the Environment (SMA by its acronym in Spanish) is in charge of supervising. Likewise, the control of the compliance of these requirements is carried out through a certification of the emission limits in charge of the Superintendency for Electricity and Fuels (SEC by its acronym in Spanish), prior to the installation of lamps. Once they have been installed, the SMA will verify the luminescence of the digital signage displays that are already installed and the correct installation of emission sources, according to what is established in the regulation.

What are the timeframes to comply with the new standard?

The new emission standard to regulate light pollution entered into force on May 3, 2014. The emission sources in existence prior to its entry into force, must comply with this regulation once they change the source or within a maximum timeframe of five years since the entry into force of the standard. Nevertheless, in the meantime they must comply with the requirements of Supreme Decree N° 686/98 MINECON. On the other hand, new emission sources must comply with this standard once they are installed.

7.1 Progress on the implementation of the Standard

Supreme Decree N° 43/12 of the Ministry of the Environment became fully operational through the implementation of the lamp certification system, starting with the officialization of the certification protocols for luminaries and the authorization of the first certification laboratory by the Superintendency for Electricity and Fuels (SEC by its acronym in Spanish). Said protocols are the standardized procedures for the measurement or trial that must be done to lamps in order to certify the compliance of some of the main requirements of the regulation, the protocols had to be developed and validated by a working group coordinated by the SMA and made up by the SEC, the Ministry of Energy and the Ministry of the Environment.

The certification protocols (for discharge, incandescent and LED technologies) were approved through Exempt Resolution N° 731, dated 26 August 2015, by the Superintendency for the Environment (SMA by its acronym in Spanish) and published by the Official Gazette on August 31, 2015.

Although it includes the new standards and requirements to ensure the protection of the skies of northern Chile, the success of this regulation depends largely on the commitment and participation of everyone who lives or visits the northern zone of the country.

ⓘ **Ambient Light:**
Outdoor, sport and recreational lighting, functional lighting, industrial lighting, ornamental and decoration lighting.

Digital Signage Displays:
Signs, advertisements, urban furniture, phone booths and alike, illuminating from inside or through direct emission, with static or dynamic images, such as visual communication screens.

Lamp: Device built with the aim of producing a luminous flux.

Luminaire: The device that serves to distribute, filter or transform the light from a lamp or lamps, which includes all the necessary parts to position, protect and connect them to the power supply.

Luminance: The ratio between the luminous intensity in the direction of an observer and its projection in that same direction of the emission area.

Lumen: Unit of the Luminous Flux System emitted within a solid angle unit (steradian) by a specific uniform source with the luminous intensity of one candela.

Spectral Radiance: Intensity of the energy radiated by surface unit, wavelength and solid angle.

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Valle de la Luna, largest dune | DANIEL VICENTE

CHAP **12**

LAND

CONTENT

INTRODUCTION

The Sustainable Development Goals (SDGs) include concrete goals aimed at protecting land and soil, due to their importance for sustaining food production as well as their broader scope, which includes services and functions that are necessary for the adequate conservation of ecosystems and biological diversity.

This chapter shows a general outlook of the main characteristics of this environmental component in the country, the problems it currently faces, particularly erosion and desertification, as well as the actions being developed to make progress in its protection.

ⓘ In order to highlight the importance of this environmental component, the "International Year of Soils" was celebrated in 2015. During this period, several initiatives were developed to disseminate the importance of soils.

ⓘ **Pedology:** Science that studies soils, their structure and formation.

1• BACKGROUND INFORMATION

Although in Spanish many people use the terms "soil" and "land" as synonyms, there are conceptual differences to be considered. According to the United Nations Convention to Combat Desertification (UNCCD), " 'land' means the terrestrial bio-productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system" (Article 1 (e) of the Convention).

Soil is the thinnest layer of land and, since its formation is very slow, it is considered a non-renewable element. This component provides essential goods and services to ecosystems, wildlife and people, such as water storage and filtering, carbon consumption, and the conditions to grow healthier food. It is estimated that 95 percent of worldwide food is directly or indirectly obtained from soil. Likewise, approximately one-fourth of the planet's biodiversity is found in this environmental component (FAO, 2015b).

It is important to mention that soil management and conceptualization has evolved. At first, it was considered as a means to grow plants, then it was recognized as an integrated and dynamic unit that requires conservation and, in this context, a series of concepts, models and research were developed to learn more about its formation and evolution. At present, there are several specialized fields of work that seek to gain a better understanding of this component, in light of the recognition that it is part of a larger system, which requires care because it is an essential element for life (FAO, ITPS, 2015).

1.1 Ecosystem Services Provided by Soils

Through its functions, soil provides support for several ecosystem services. They are key aspects that enable the provision of direct and indirect benefits to the population and the environment. Its role in the nutrient cycle, filtering and regulating water, in climate, in the support of human activities, and as habitat are some of land's main functions, among many others. Indeed, one of its most relevant functions is currently linked to land's contribution to carbon sequestration, which is key for climate change.

TABLE 01

ECOSYSTEM SERVICES AND THE SOIL FUNCTIONS THAT SUPPORT THEM	
ECOSYSTEM SERVICES	**SOIL FUNCTIONS**
Supporting Services: They are necessary for the production of all other ecosystem services; their impact on people is often indirect or is felt after a very long period.	
SOIL FORMATION	▶ Weathering of primary minerals and release of nutrients. ▶ Transformation and accumulation of organic matter. ▶ Creation of structures (aggregates, horizons) for gaseous exchange (including oxygen) with the nutrients and water surface that are necessary for root growth. ▶ Creation of loaded surfaces to retain ions and their exchange, which are required to feed plants.
PRIMARY PRODUCTION	▶ Support for plant germination and growth. ▶ Supply of nutrients and water for plants and other life forms. ▶ Support for biodiversity in and on the soil.
NUTRIENT CYCLE	▶ Transformation of organic matter and facilitation of the carbon and nitrogen cycles, which are essential for all life forms. ▶ Retention and release of nutrients in loaded surfaces (in terms of electricity).
Regulating Services: Benefits obtained from the regulations of ecosystem processes.	
WATER QUALITY	▶ Filtering and storage of water substances in the soil. ▶ Transformation of pollutants.
WATER SUPPLY	▶ Regulation of water infiltration and flow in the soil. ▶ Drainage of excess water outside the soil and entry into groundwater and surface water.
CLIMATE	▶ Regulation of CO_2, N_2O and CH_4 emissions.
EROSION	▶ Reduction of soil loss.

CONTINUES ▶

Provisioning Services: Products (goods) obtained from ecosystems that directly benefit people.	
FOOD	► Provision of water, nutrients and physical support to grow plants for human and animal consumption.
WATER	► Water retention and purification.
FIBER AND FUEL	► Provision of water, nutrients and physical support to grow plants for bioenergy and fiber.
SOIL MATERIALS	► Provision of topsoil, aggregates, peat, etc.
SURFACE STABILITY	► Support for human housing and infrastructure.
SHELTER	► Provision of habitat for vertebrate, invertebrate, higher plants, algae, fungi, and bacteria species, etc.
GENETIC RESOURCES	► Source of unique biological materials.
Cultural Services: Non-material benefits that people obtain from ecosystems through spiritual enrichment, aesthetic experiences, heritage preservation and recreation.	
AESTHETIC AND SPIRITUAL	► The preservation of landscape, natural and cultural diversity. ► Source of pigments and dyes.
HERITAGE	► Preservation of archaeological records.

Source: FAO, ITPS, 2015.

2 • SOILS IN CHILE

The development of soils is associated with geological, geomorphological, and climatic factors as well as with the volcanic activity present in all events that model the natural landscape (Casanova et al., 2004). In this regard, soil properties influenced by these characteristics, and by the way it is used for production, determine the land's potential as well as its resilience and recovery capacities when faced with degradation processes. At the same time, they are essential for explaining their capacity to provide ecosystem services.

It is important to consider that soil properties, such as the ecosystem services they provide, are dynamic, as are their resistance and recovery capacities. In this context, and as pointed out by the UNEP's International Resource Panel (IRP), it is important to assess the land's potential in order to identify possible uses and, among these, potential sustainable uses.

According to the IRP, learning about the land's potential requires identifying places where there are unsustainable production practices and yield gaps to promote management systems that will improve their use, both in terms of efficiency and effectiveness.

In Chile, the traditional approach for gathering information about soils has been associated with agrological issues. However, the importance of this component for food production as well as its role and inter-relation with the other environmental components is gradually promoting a different perspective and the need to collect information that will enable learning about its state and potential. The country currently has official agrological information that includes morphological, physical and chemical characteristics and interpretive soil classifications.

2.1 Land Suitability

Continental Chile has a land area exceeding 75 million hectares, out of which nearly 54 percent is productive soil. Soil classifications are used to define soil characteristics and learn about its adaptability to different forestry, agriculture and livestock uses. Of the interpretive classifications, the one most broadly used is the Land Use Capability (LUC) Classification, an organization of existing soils to indicate their relative adaptability to certain crops. In addition, it indicates the difficulties and risks that can arise when using them. It is based on the Earth's capacity to produce, pointing out its natural limitations.

There are eight Land Use Capability Classes, which are designated with Roman numerals from I to VIII, organized according to their increasing limitations and risks for use (**see diagram ►**).

According to the agrological studies conducted by the Center for Information on Natural Resources (CIREN by its acronym in Spanish), between 1996 and 2009, which covered an area of approximately 18 million hectares between the Atacama and Aysén regions, it was possible to identify the different LUC categories at the regional level. **Figure 01** shows the soil area by region, according to their different capabilities and limitations for choosing crops.

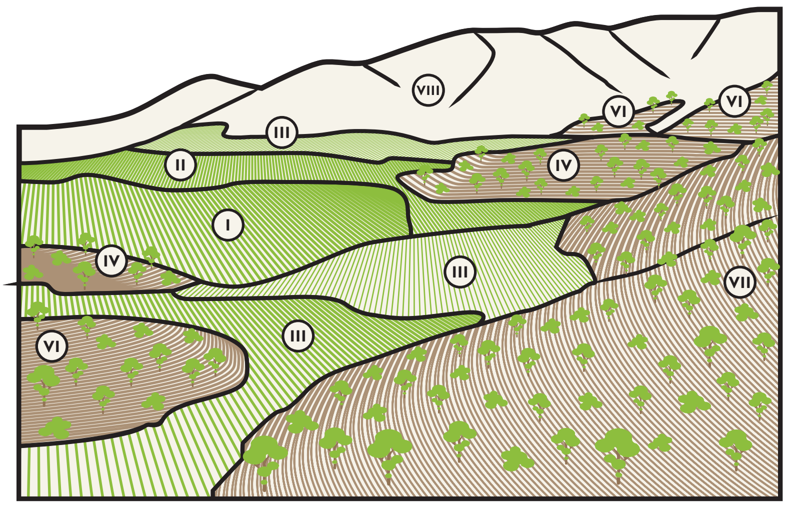
DISTRIBUTION OF THE LAND USE CAPABILITY CLASSES

INCREASING USE INTENSITY ►

	GRAZING				CROPS			
LAND USE CAPABILITY CLASSES	**Wildlife**	**Limited**	**Moderate**	**Intensive**	**Limited**	**Moderate**	**Intensive**	**Highly intensive**
I	✓	✓	✓	✓	✓	✓	✓	✓
II	✓	✓	✓	✓	✓	✓	✓	
III	✓	✓	✓	✓	✓	✓		
IV	✓	✓	✓	✓	✓			
V	✓	✓	✓	✓				
VI	✓	✓	✓					
VII	✓	✓						
VIII	✓							

Limitations and risks increase vertically. ►
Only **Class I** could sustain highly intensive crops.

Bare Soil Destruction and Erosion Rate	
I	EXTREMELY SLOW
II	VERY SLOW
III	SLOW
IV	MODERATE
V	VARIABLE
VI	FAST
VII	VERY FAST
VIII	EXTREMELY FAST



Source: Manual de Edafología (Cassanova, M. et al., 2004).

2.2 Land Degradation

According to the CIREN (2010), “land degradation means the change of one or more of its properties to conditions below the original ones, as a result of physical, chemical or biological processes.”

Physical degradation refers, for example, to the loss of its capacity to retain water or permeability, while biological degradation refers to a reduction of microorganisms, which can directly affect its fertility. Finally, chemical degradation is associated with salinization, alkalization, acidification and toxicity issues.

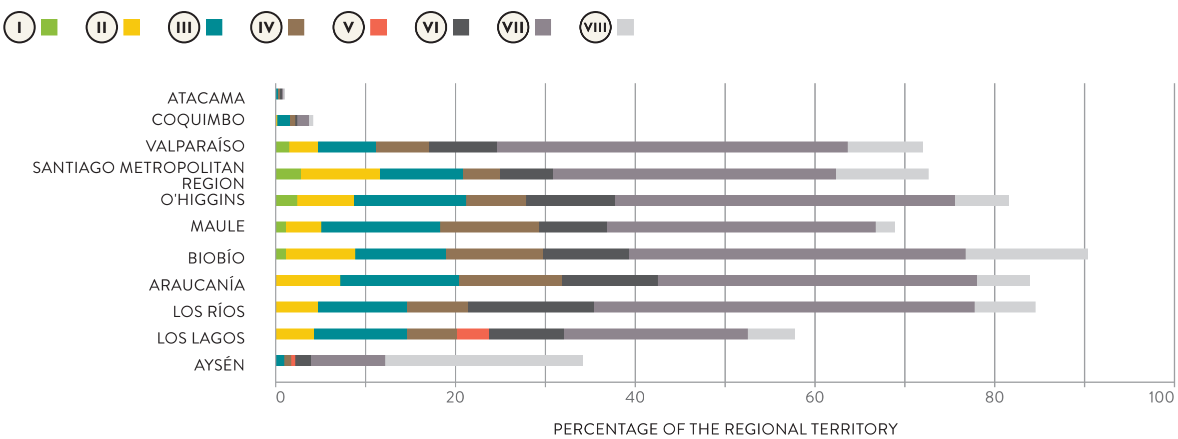
Meanwhile, land degradation is a broader issue that includes all negative changes in the ecosystem’s capacity to provide goods and services (FAO, 2015).

Land degradation is an increasing environmental issue that affects more people each day. At the beginning of the 1990s, it was estimated that approximately 20 percent of land surface, excluding hyper-arid zones, presented land degradation processes (Oldeman et al., 1991 in ENCCRV, 2015). Likewise, “the annual loss of soil is estimated at 24 billion tons” (UNCCD, 2011).

This issue may bring about consequences such as the loss of productive capabilities, as well as the services and functions of this environmental component. Land degradation is essentially caused by erosion, its degrading use – for unsustainable forestry, agricultural and livestock practices, industrial activities, human settlements, among others -, as well as by climate factors, pollution and the loss of vegetation cover.

FIGURE 01

REGIONAL LAND AREA, BY USE CAPABILITY



Source: Agrological studies by CIREN (1996-2009).

2.2.1 Erosion

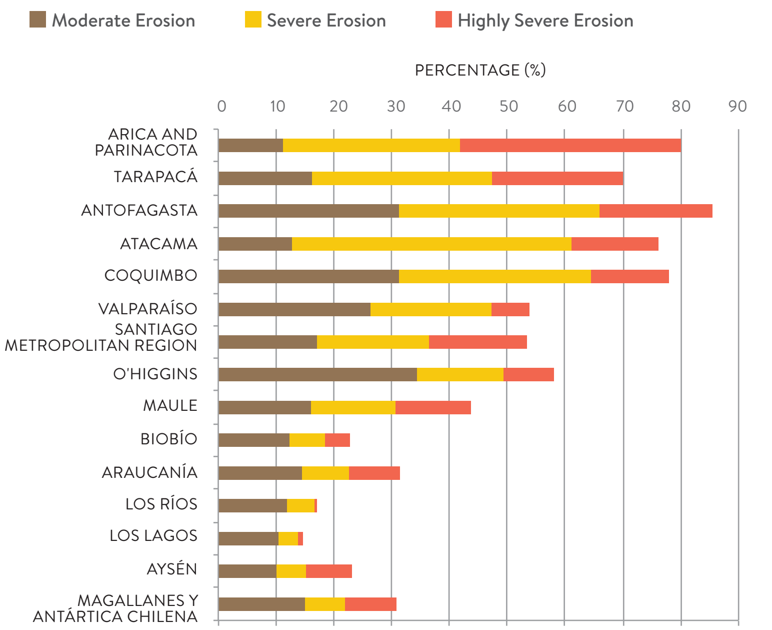
In Chile, according to the CIREN, erosion is the most important cause of land degradation. According to the Soil Survey Division Staff (1993), is the detachment and movement of soil material. It is produced when the strength of certain external agents, among them water and wind, is superior to the strength of the cohesion that adheres particles to the soil. Hence, particles are disaggregated and can be transported by these or other agents, causing the partial or total disappearance of the surface horizon or even of the entire soil.

In 2010, the CIREN determined the cause for current and potential erosion in Chile, through geomatics and remote sensing techniques. According to the results, nearly 38 million hectares of the national territory present some degree of erosion. **Map 01** shows the result obtained at the national level, distinguishing erosion categories.

Figure 02 shows the percentage of the national area affected by moderate, severe and highly severe erosion. In the northern zone of Chile, particularly in the Arica and Parinacota, Tarapacá and Antofagasta regions, over 60 percent of the regional area is affected by these three erosion categories. However, in these cases it is mainly due to geological (natural) processes.

FIGURE 02

PERCENTAGE OF THE REGIONAL AREA AFFECTED BY EROSION*



Source: Authors' own elaboration, based on CIREN (2010) data.
* This percentage excludes soils with human settlements, water bodies, mining, tailing ponds, landfills, beaches and dunes.

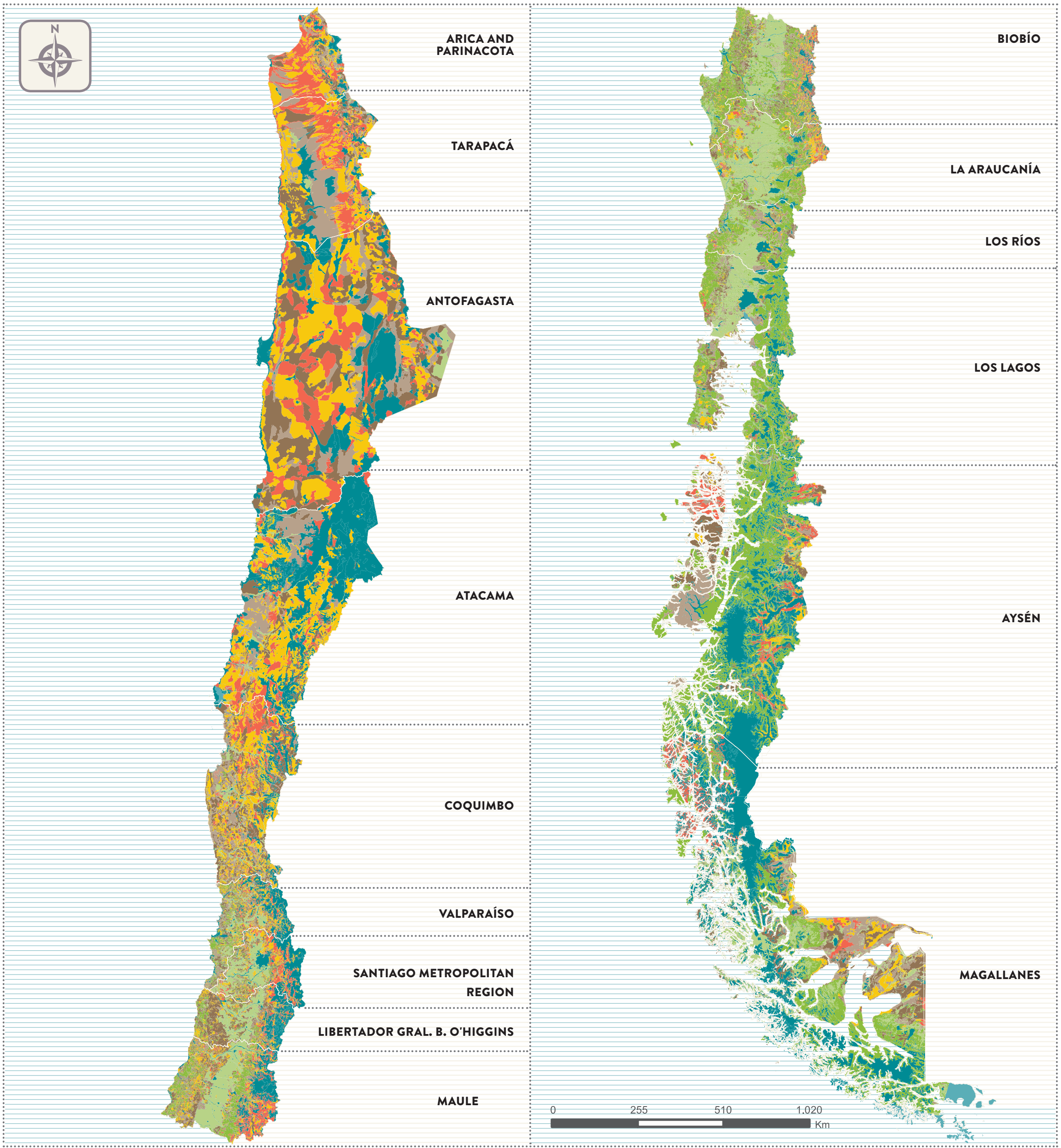
TABLE 02

SOIL EROSION CLASSIFICATION
Highly Severe Erosion Soils not suitable for crops. Topsoil loss exceeds 80 percent of the original soil.
Severe Erosion Soil loss ranges between 60 and 80 percent. It occasionally presents grooves and gullies.
Moderate Erosion Between 40 and 60 percent of the original soil has been lost.
Slight Erosion Slightly sloped or undulated soil with semi-dense native vegetation cover.
Null Erosion / Without Erosion No alterations or signs of soil loss are present.
No Apparent Erosion Sectors covered by highly dense vegetation or subject to good management practices.

Source: CIREN, 2010.

MAP 01

CURRENT EROSION AT THE NATIONAL LEVEL



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CURRENT EROSION

- Highly Severe Erosion
- Severe Erosion
- Moderate Erosion
- Slight Erosion
- Without Erosion
- No Apparent Erosion
- Exclusion Areas
- Other Uses

Source: Authors' own elaboration, based on CIREN (2010) data.

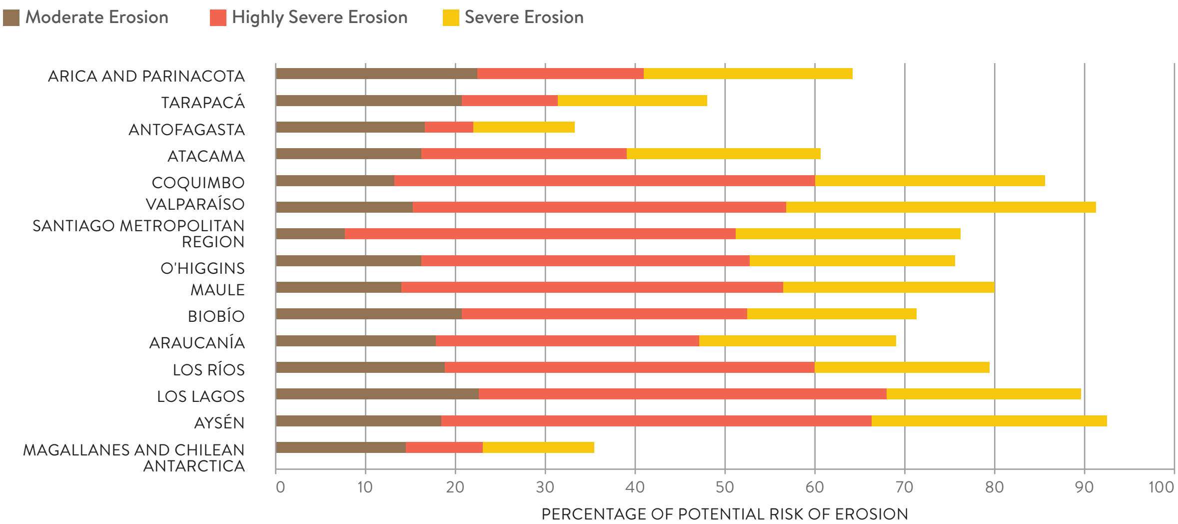

Maximum erosion | MARCELO BENAVENTE

In the central zone - Valparaíso to Maule regions -, where anthropic or accelerated erosion is dominant, the percentages of erosion, from moderate to highly severe, reach approximately 40 percent of the regional area. Meanwhile, starting in the Biobío Region, the percentage of erosion starts diminishing, due to the forest cover and to the presence of greater levels of organic matter. The Los Ríos and Los Lagos regions present the lowest levels of severe and highly severe erosion, with percentages below 5 percent.

Along with the map of current erosion, the CIREN created a map for potential erosion, referring to the maximum rate of erosion in case all vegetation cover disappears. According to the results, the risk for potential erosion in soils within the moderate, severe and highly severe categories would reach 34.1 million hectares at the national level, representing 45 percent of the national territory.

FIGURE 03

POTENTIAL RISK OF EROSION BY REGION*



Source: Authors' own elaboration, based on CIREN (2010) data.
* This percentage excludes soils with human settlements, water bodies, mining, tailing ponds, landfills, beaches and dunes.

2.2.2 Desertification

It is a gradual land degradation process with environmental consequences, such as the loss of flora and fauna, that at the same time has socio-economic effects including poverty and migration. According to the UNCCD's (1994) definition, desertification "means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities." According to the National Forestry Corporation (CONAF by its acronym in Spanish), this process is not a phenomenon exclusively affecting current deserts, but also extremely fragile dryland ecosystems due to overexploitation and inadequate use of the land.

This phenomenon also has effects on climate change. According to FAO (2011), an estimated 300 million tons of carbon are lost to the atmosphere from drylands each year, representing nearly 4 percent of global emissions, if all sources are included. It is estimated that Chile, along with Sub-Saharan African countries, would be one of the most affected by the increase in desertification, land degradation and drought (Alfaro, 2013).

In 1999, CONAF created the Preliminary Map of Desertification in Chile, which enabled to established that - out of a total of 290 rural communes studied – 270 communes presented some degree of desertification, 76 revealed a serious desertification process and 108 communes had moderate desertification levels. Likewise, at the time it was estimated that over one million people would be affected. In 2005, the Corporation analyzed the areas affected by desertification in order to prioritize interventions, determining that 11,803,351.2 hectares were of the highest priority (Alfaro, 2013).

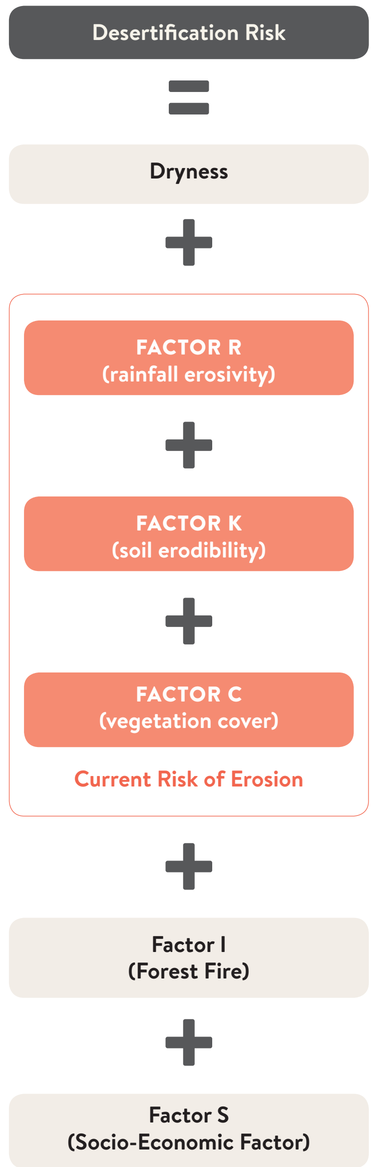
Within the framework of the National Strategy for Climate Change and Vegetation Resources (ENCCRV by its acronym in Spanish), led by the CONAF[1], the National Plan Against Desertification in Chile (PANCD-Chile by its acronym in Spanish) was updated for the 2016-2030 period, aligning it with the UNCCD's 10-year Strategy (2008-2018), the Land Degradation Neutrality (LDN) initiative, and the Sustainable Development Goals. Among the products generated during the PANCD update process, there is a desertification risk map for Chile, based on a multi-criteria analysis methodology that weighs in factors such as dryness, current risk of erosion, forest fires and socio-economic factors, as shown in **Figure 04**.

The study area was Chile's continental territory, covering approximately 75 million hectares. **Tables 03 and 04** show some of the results. Nearly 22 percent of the country's area, more than 16 million hectares, face some degree of desertification risk in its different categories (slight, moderate, serious) and 38 percent of the country's population is being affected by this risk. Likewise, 12 percent of the country's area is affected by serious drought, involving 57 percent of the national population.

Map 02 shows the risk of land degradation at the national level, using the same methodology applied for desertification risk, except that it does not include dryness. According to the results, 79 percent of the national territory has some degree of land degradation risk, which would affect 67 percent of the population.

FIGURE 04

MULTI-CRITERIA DESERTIFICATION RISK MODEL



Source: CONAF, 2016.

[1] *As National Focal Point for the United Nations Convention to Combat Desertification (UNCCD) and the approach to reduced GHG emissions.*

TABLE 03

DESERTIFICATION RISK AT THE NATIONAL LEVEL IN ITS DIFFERENT CATEGORIES						
	# OF COMMUNES	% OF COMMUNES	POPULATION	% OF THE POPULATION	(HA) AREA	% OF THE AREA
Serious Desertification	19	5.5	2,277,604	12.6	2,708,606	3.6
Moderate Desertification	85	24.6	2,915,621	16.2	8,851,704	11.7
Slight Desertification	52	15.1	1,623,436	9	4,819,032	6.4
Without Desertification	7	2	61,218	0.3	3,649,475	4.8
Not Applicable	150	43.5	5,621,054	31.2	55,411,347	73.3
Urban	32	9.3	5,507,282	30.6	203,064	0.3
TOTAL	345	100	18,006,215	100	75,643,277	100

Source: CONAF, 2016.

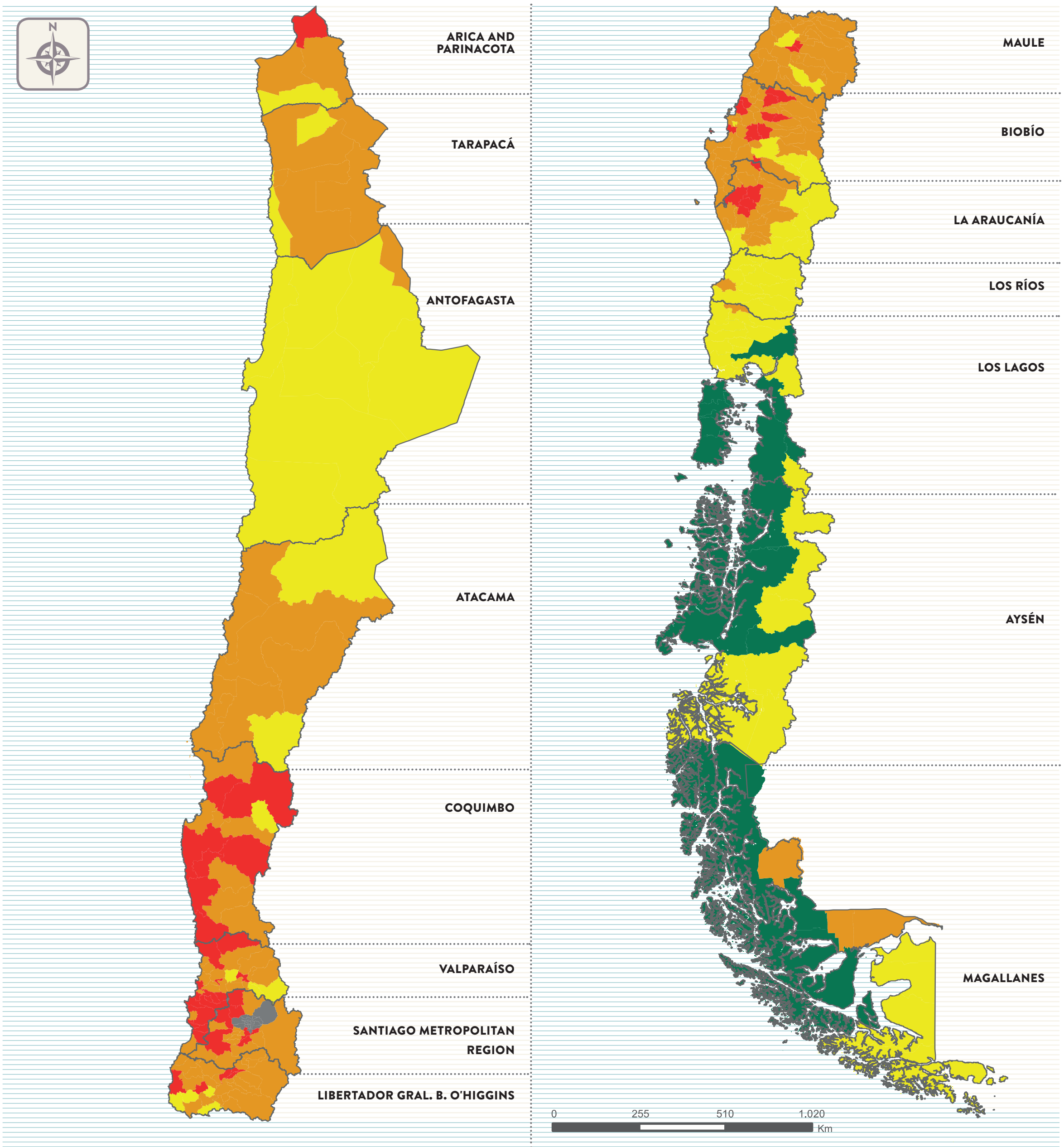
TABLE 04

NUMBER OF COMMUNES, POPULATION AND AREA WITH DROUGHT AT THE NATIONAL LEVEL IN ITS DIFFERENT CATEGORIES						
	# OF COMMUNES	% OF COMMUNES	POPULATION	% OF THE POPULATION	(HA) AREA	% OF THE AREA
Serious Drought	128	37.1	10,217,408	56.7	9,102,283	12
Moderate Drought	135	39.1	4,494,897	25	19,031,823	25.2
Slight Drought	54	15.7	1,528,428	8.5	26,636,833	35.2
Without Drought	28	8.1	1,765,482	9.8	20,872,288	27.6
OVERALL TOTAL	345	100	18,006,215	100	75,643,227	100

Source: CONAF, 2016.

MAP 02

LAND DEGRADATION RISK



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DEGRADATION LEVEL

Serious Degradation | Moderate Degradation | Slight Degradation | Without Degradation | Urban Use

Source: CONAF, 2016.

2.2.3 Land Pollution

The development of production, industry and energy throughout the country represents a pressure on land and it can also be a potential source of pollution[2]. Chile has made strides in generating information in certain zones of the country where productive activities could be having impacts on this component, as well as on people's health and quality of life.

Since 2012, the Ministry of the Environment implements a "Methodological Guide for Managing Land with the Potential Presence of Pollutants (LPPP)", which has provided the basis to identify and prioritize sites at the national level. It is worth mentioning the land with potential presence of pollutants refers to a geographically delimited place or land in which potentially polluting activities are being or have been developed. They include abandoned or active lands.

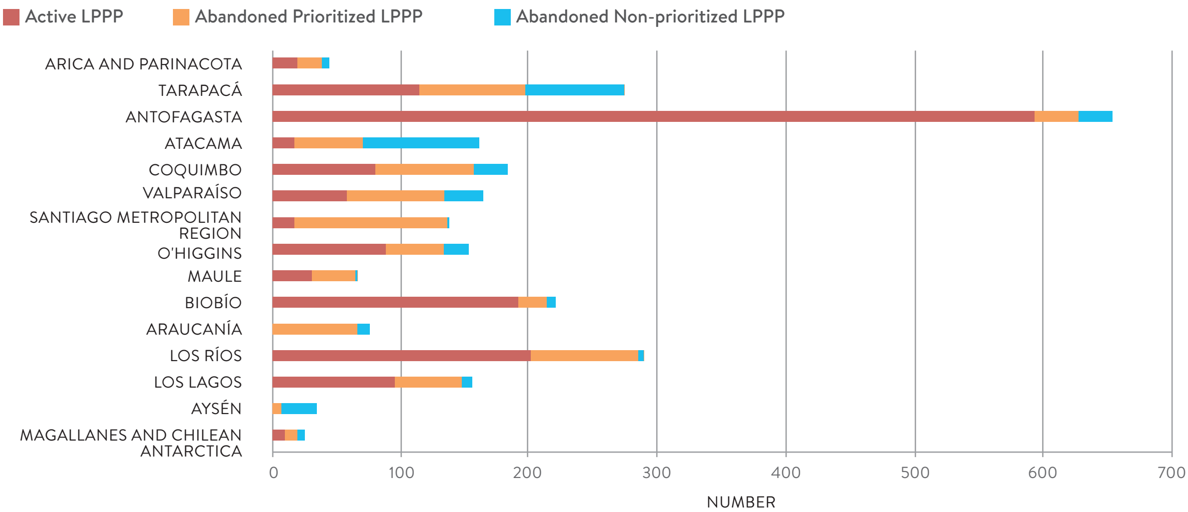
The methodological guide is composed of three phases:

- **Phase I:** Identifying, prioritizing and hierarchizing land with the potential presence of pollutants at the regional scale.
- **Phase II:** Conducting preliminary and confirming research in the lands/sites hierarchized in order to assess if there is pollution.
- **Phase III:** Assessing environmental risk and creating an action plan for managing it. The environmental risk assessment is aimed at establishing the risk that potential pollution represents in a specific place, assuming that the population and the environment are the subjects of protection.

[2] *Land pollution can represent a risk, depending on exposure to or contact of people or ecosystems with the pollutants. According to the "Methodological Guide for Managing Land with the Potential Presence of Pollutants" (Resolution N° 406/2013), risk is defined as the likelihood of occurrence of an adverse effect on people or the ecosystem.*

FIGURE 05

LAND WITH THE POTENTIAL PRESENCE OF POLLUTANTS AT THE NATIONAL LEVEL BY 2015



Source: MMA, 2016.

Identifying, prioritizing and hierarchizing these sites enables targeting environmental management in order to safeguard people's health and quality of life. After this phase, it is necessary to move on to determine whether there is presence of pollutants in the land and, if this is so, a risk assessment is conducted. The actions to be taken are defined based on these results.

In addition to this, specific studies have been conducted in places where, due to the large productive activity sustained, it was necessary to research certain chemical substances in terms of the concentration and distribution.

Puchuncaví and Quintero Communes

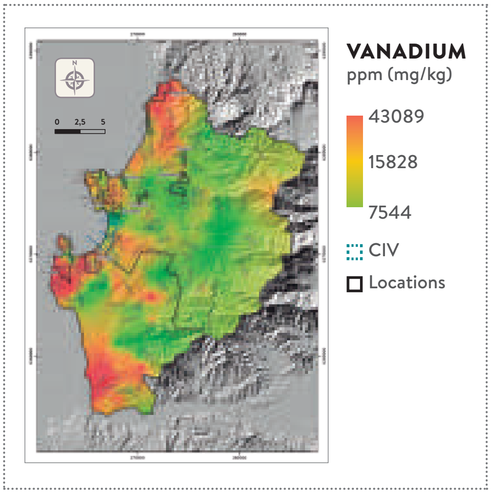
The Puchuncaví and Quintero communes, located in the Valparaíso region, harbor the Ventanas Industrial Complex (VIC), in which 14 companies are gathered including the Ventanas Foundry and Refinery, thermal power plants and copper storage facilities, among others. These activities generate the release of liquid waste to the sea, air emissions and ash deposits on the soil.

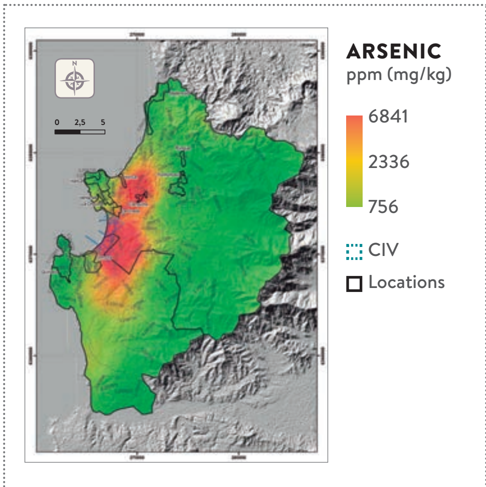
In order to generate inputs and determine environmental risk factors in the area, in 2014, at the request of the Ministry of the Environment, a study was conducted to measure the spatial concentration and distribution of metals and metalloids in the soils of the Puchuncaví and Quintero communes.

During the first stage, that the natural concentration (background) of metals and metalloids in the soils was determined[3]. According to the analyses, "the elements that present higher concentrations are mercury, arsenic, lead, cadmium, copper and iron," since between 66 and 99 percent of the sampled sites exceeds background values. "Copper, molybdenum, arsenic, lead, cadmium, selenium and mercury concentrations are notoriously higher in the vicinity of the VIC." Overall, it is concluded that "current concentrations of metals (and metalloids) in the study area, except for nickel, are significantly higher than their natural concentrations" (PGS, 2015 p.108).

Regarding their spatial distribution, the study concludes that there is a correlation between arsenic, copper, lead, molybdenum, cadmium, mercury and, to a lesser extent, zinc, which "could probably be associated with some phase of the metallurgic copper foundry and refining processes." Likewise, "selenium, tellurium and antimuonium are also correlated and could probably be related to the treatment and recovery processes of silver, gold, tellurium, antimuonium and selenium." Vanadium and iron, on the other hand, could probably be associated with thermal power plants in the area and/or to oil refinery activity (PGS, 2015).

PUCHUNCAVÍ AND QUINTEROS





[3] *Determining the background is not an easy task to carry out, even more so when there are areas with high levels of intervention throughout the years. According to the Environmental Protection Agency (EPA), "background sampling sites must be areas that have not received pollution, but have the same basic characteristics as the site under study." Hence, in order to take samples that would allow calculating the background value, reference sites were selected that had similar pedological and geological characteristics to soils of the Quintero and Puchuncaví communes.*

Copiapó and Tierra Amarilla Communes:

These communes are located in the Copiapó Province, in the Atacama Region, both of them have mainly developed based on mining and agriculture activities. Mining environmental liabilities (MEL) are located in these communes as a result of this activity.

In this context, in 2011 and 2012, studies were conducted in sites with potential presence of pollutants that may represent a risk for people's health. Out of 23 identified sites, eight were prioritized. For the confirmation research, samples were obtained following the Sampling Protocol for Metal Pollutants in Tailing Ponds prepared by the CENMA (2011) as well as international guidelines.

In 2014, the study "Human Health Risk Assessment and Management in the Pabellón and Totoralillo Tailing Ponds Areas, Tierra Amarilla Commune, Atacama Region" was conducted. This study enabled the implementation of the first stage of phase III of the "Methodological Guide for Managing Land with the Potential Presence of Pollutants", considering the assessment of exposure, toxicity, risk characterization and uncertainty analysis. The results show that these sites present indices of lead, mercury and arsenic. In this context, a series of action lines was proposed, recommending measures such as risk communication, remediation techniques, programs to monitor people's health, among others (CENMA, 2016).

Based on this background information, a diagnosis will be carried out, in addition to an assessment of potential risks and the preparation of a management plan for the Nantoco, Pabellón and Totoralillo sites.

TABLE 05

SITES AND MAIN RESULTS OF THE CONFIRMATION RESEARCH

ASSESSED SITES	MAIN FINDINGS
CASTELLÓN	Presents moderate enrichment of copper and boron.
SAN JUAN	Presents moderate enrichment of lead and boron.
PORVENIR	Presents enrichment of lead, iron and boron.
TANIA	Presents enrichment of copper, lead, iron and boron and traces of the presence of arsenic.*
LLAUCAVÉN	Presents enrichment of cadmium, copper, barium, cobalt, molybdenum and iron, and traces of the presence of arsenic and lead.*
ESCORIAL NANTOCO	Presents enrichment of several elements of environmental interest and significant traces of the presence of mercury, arsenic and lead.
TOTORALILLO	Presents enrichment of several elements of environmental interest and significant traces of the presence of mercury, arsenic and lead.*
PABELLÓN	Presents enrichment of several elements of environmental interest and significant traces of the presence of mercury, arsenic and lead.*

Source: Authors' own elaboration, based on CENMA, 2011 and 2012 data.

** It is recommended to continue assessing risks.*

3 • PRESSURES

3.1 Loss or Degradation Due to Land Use Change

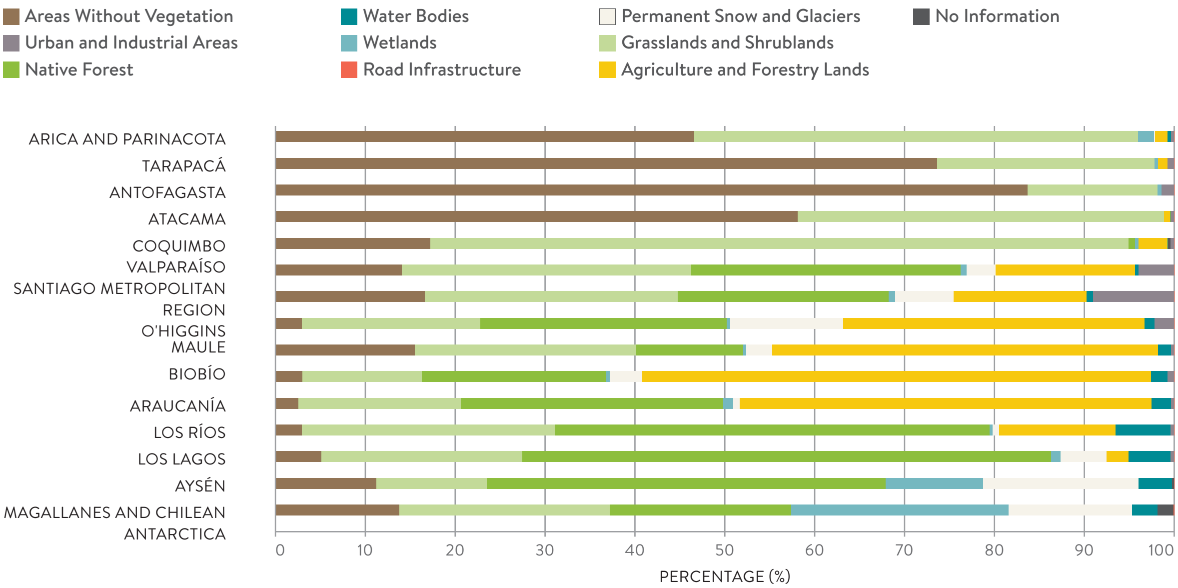
Land use in activities that modify it is one of the most significant pressures affecting the quality of this environmental component. In Chile, the baseline information to learn about land use at the national level is the Inventory and Assessment of Chile's Native Vegetation Resources, prepared by the CONAF. However, its preparation and updates are conducted at the regional level. Hence, it contains information for different years. In this context, the Ministry of the Environment developed a project to unify official and available geographical information, with a perspective of conducting territorial planning that contributes to the protection of biodiversity and sustainable development, based on CONAF's inventory. Thus, baseline maps were developed to learn about land use at the national level[4].

PLANNING

The Ministry of the Environment developed a project to unify official and available geographical information, with a perspective of conducting **territorial planning that contributes to the protection of biodiversity and sustainable development.**

FIGURE 06

LAND USE PERCENTAGE BY REGION AND CATEGORY, 2014

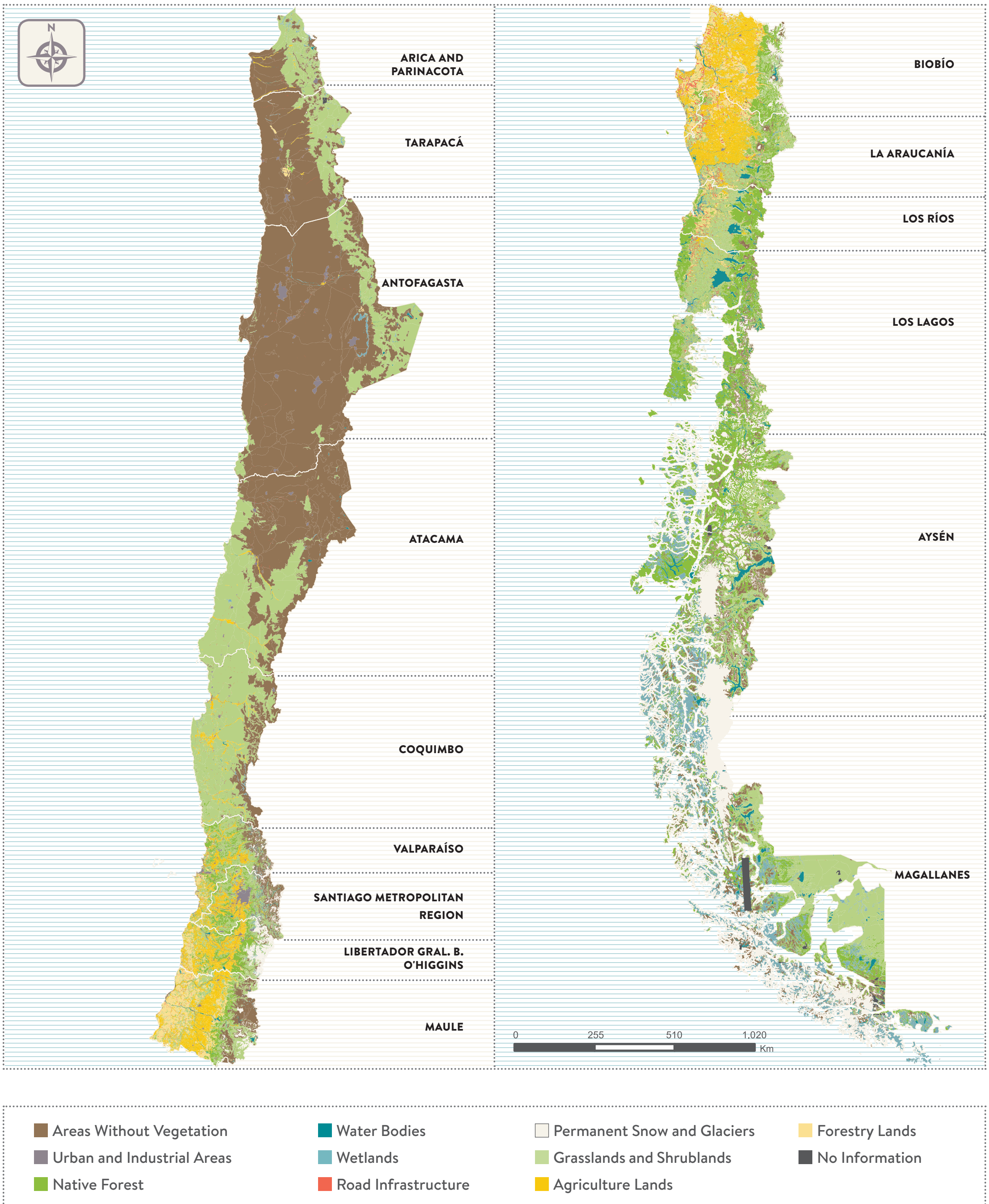


Source: MMA, 2015.

[4] *Land use is understood as the study of the characteristics of the land area, including its biophysical properties and the type of use (Equipo Técnico Nacional SIOSE, 2011 in MMA, 2015). Information from CONAF's inventory was used, along with urban stains by the Ministry of Housing and Urban Planning, the forestry inventory of the National Forestry Institute, the grasslands inventory of the Agriculture and Livestock Service, the wetlands inventory of the Ministry of the Environment and information from the Ministry of Public Works.*

MAP 03

ESTIMATED AREAS FOR THE NEW USE COVERAGE OF THE TERRITORY



Source: Authors' own elaboration, based on the "Updated Database on Territorial Used from the Ecological and Multi-Sectoral Perspectives." MMA, 2015

3.1.1 Urban Expansion

Urban expansion is one of the greatest pressures on land and its uses. The growth of Chilean cities, especially in the central zone, "has almost exclusively happened on agricultural lands" (Rivas and Traub, 2013, p.1). In addition to this situation's impact on crop production, it is important to consider the environmental consequences associated with soil functions for the balance and support of ecosystem services: soil elimination; soil sealing; compacting; pollution.

Although in the country there are mechanisms to regulate land use planning, in practice, land use is not always carried out based on a vision that involves the environmental variable and sustainable development. Likewise, land use regulation has certain flaws that have boosted agricultural land use change, such as the second home countryside sites. Indeed, through Supreme Decree N° 3.516 of 1980, which was aimed at avoiding the countryside-city migration of people who benefited from the agrarian reform[5], a subdivision of agricultural lands was allowed to build homes without having to change land use through an urban master plan. The minimum subdivision established was 0.5 hectares, thus seeking to avoid that farmers would lose all their land (Ladrón de Guevara, 2012).

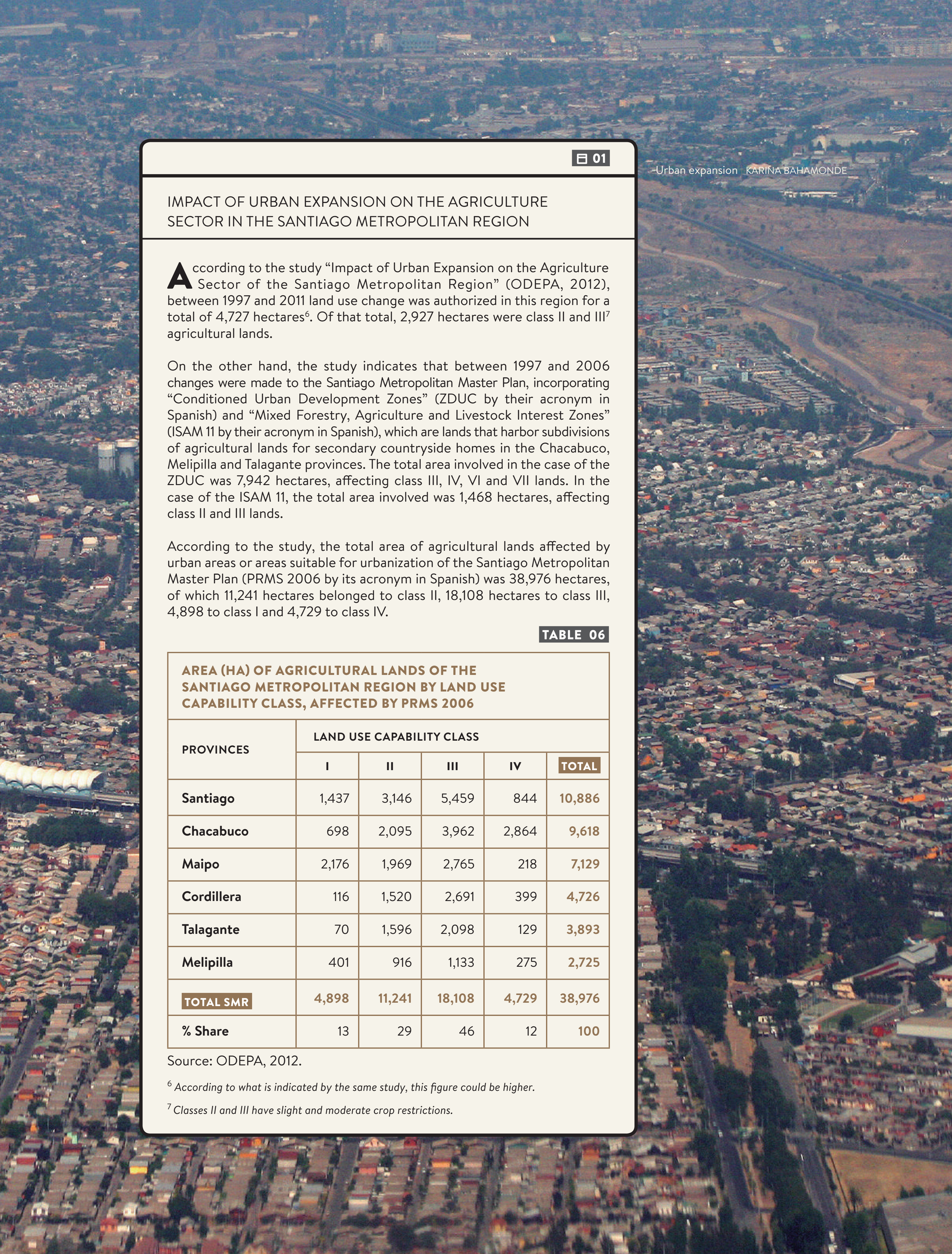
In practice, Supreme Decree N° 3.516 has enabled the loss of agricultural lands, transforming rural areas and their agri-food potential. In the case of the Santiago Metropolitan Region, this has resulted in "countryside urbanization outside the scope of land use planning instruments, which only regulate urban areas" (Naranjo, 2009).

According to Naranjo (2009), in the Chacabuco Province 60.13 percent of the area was subdivided based on said decree, which is equal to 122,542 hectares. In the case of the Til Til commune, between 1994 and 1997, 26,639 hectares (41 percent of the commune's area) was subdivided. In the case of Colina, 837 agricultural farms gave way to 48,641 sites. Naranjo also points out that 30.7 percent of the area of Paine and 45.7 percent of the area of El Monte were subdivided according to Supreme Decree N° 3.516.

AGRICULTURAL LAND USE

The growth of Chilean cities, especially in the central zone, "has almost exclusively happened on agricultural lands" (Rivas and Traub, 2013, p.1). In addition to this situation's impact on crop production, **it is important to consider the environmental consequences associated with soil functions for the balance and support of ecosystem services.**

[5] *Due to a lack of resources, they sold their lands in very unfavorable conditions, generating a significant social problem in urban areas.*



Urban expansion KARINA BAHAMONDE

01

IMPACT OF URBAN EXPANSION ON THE AGRICULTURE SECTOR IN THE SANTIAGO METROPOLITAN REGION

According to the study “Impact of Urban Expansion on the Agriculture Sector of the Santiago Metropolitan Region” (ODEPA, 2012), between 1997 and 2011 land use change was authorized in this region for a total of 4,727 hectares[6]. Of that total, 2,927 hectares were class II and III[7] agricultural lands.

On the other hand, the study indicates that between 1997 and 2006 changes were made to the Santiago Metropolitan Master Plan, incorporating “Conditioned Urban Development Zones” (ZDUC by their acronym in Spanish) and “Mixed Forestry, Agriculture and Livestock Interest Zones” (ISAM 11 by their acronym in Spanish), which are lands that harbor subdivisions of agricultural lands for secondary countryside homes in the Chacabuco, Melipilla and Talagante provinces. The total area involved in the case of the ZDUC was 7,942 hectares, affecting class III, IV, VI and VII lands. In the case of the ISAM 11, the total area involved was 1,468 hectares, affecting class II and III lands.

According to the study, the total area of agricultural lands affected by urban areas or areas suitable for urbanization of the Santiago Metropolitan Master Plan (PRMS 2006 by its acronym in Spanish) was 38,976 hectares, of which 11,241 hectares belonged to class II, 18,108 hectares to class III, 4,898 to class I and 4,729 to class IV.

TABLE 06

AREA (HA) OF AGRICULTURAL LANDS OF THE SANTIAGO METROPOLITAN REGION BY LAND USE CAPABILITY CLASS, AFFECTED BY PRMS 2006

PROVINCES	LAND USE CAPABILITY CLASS				
	I	II	III	IV	TOTAL
Santiago	1,437	3,146	5,459	844	**10,886**
Chacabuco	698	2,095	3,962	2,864	**9,618**
Maipo	2,176	1,969	2,765	218	**7,129**
Cordillera	116	1,520	2,691	399	**4,726**
Talagante	70	1,596	2,098	129	**3,893**
Melipilla	401	916	1,133	275	**2,725**
TOTAL SMR	**4,898**	**11,241**	**18,108**	**4,729**	**38,976**
% Share	13	29	46	12	**100**

Source: ODEPA, 2012.

[6] *According to what is indicated by the same study, this figure could be higher.*

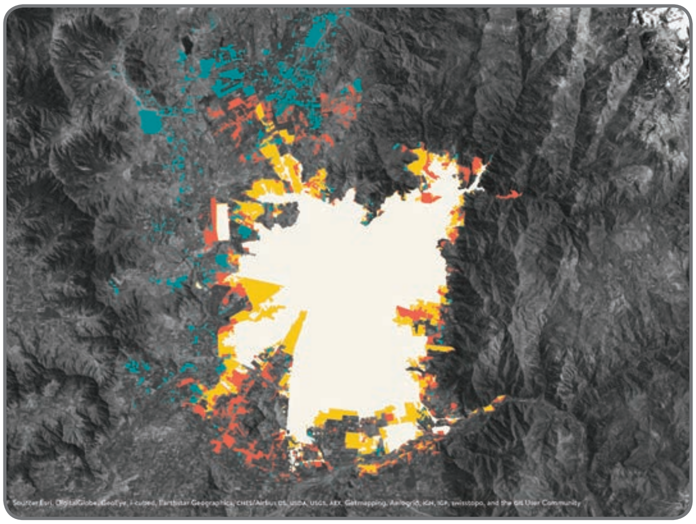
[7] *Classes II and III have slight and moderate crop restrictions.*

At the national level, it is also possible to see the growth of cities, especially of the regional capitals. The maps below show the advancement of built areas in Chilean cities. This work is a contribution of the Center for Territorial Intelligence of the Adolfo Ibáñez University (UAI by its acronym in Spanish) and it is framed within the update of the calculation of the built area in urban areas of Chile's main cities, carried out by the Ministry of Housing and Urban Planning (MINVU) in 2007 and 2011[8].

The maps show the urban expansion between 2003 and 2011, and in 2015. The 2015 update[9] was conducted using Lansat 8 satellite images.

[8] *In 2007, the area occupied by Chilean cities with more than 15,000 inhabitants between 1993 and 2003 was measured (Maturana and Muñoz, 2007). In 2011, a revision of each urban center was conducted: "Built Area in Chilean Cities" by the Commission of Housing and Urban Studies (CEHU by its acronym in Spanish) and the Ministry of Housing and Urban Planning (CEHU-DDU MINVU, 2011).*

[9] *This work was led by Ricardo Truffello.*



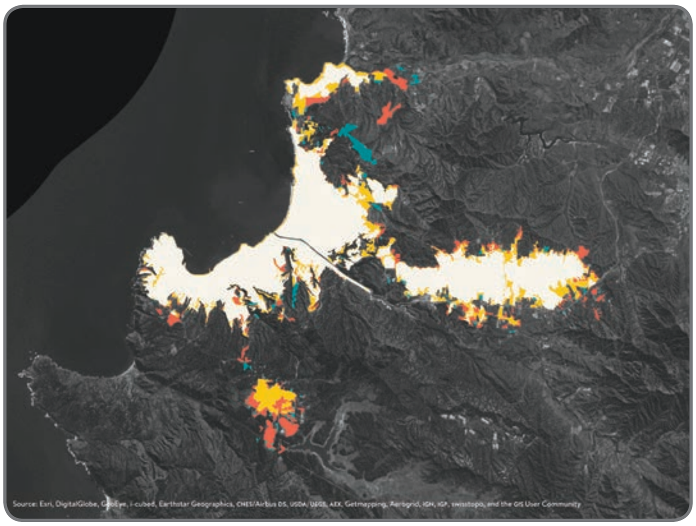
MAP 04

GREATER SANTIAGO

URBAN EXPANSION BY YEAR

- 1993 Situation
- 2003 Expansion
- 2011 Expansion
- 2015 Expansion

Prepared by the CIT, 2016, based on information from the MINVU, 2013 and the CIT 2015.



MAP 05

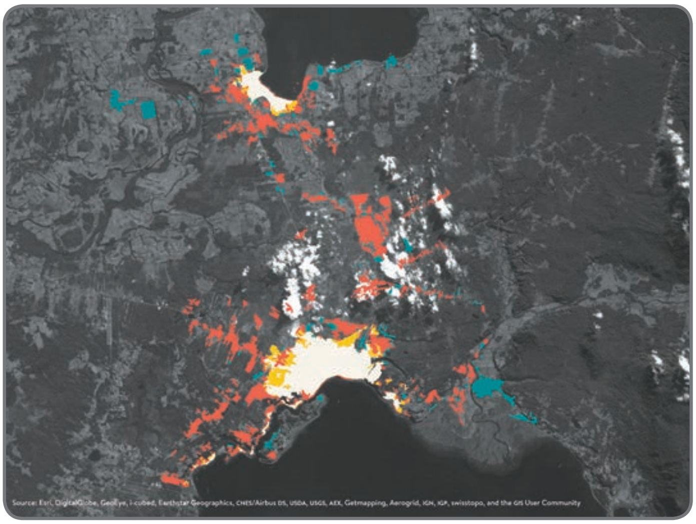
GREATER VALPARAÍSO*

URBAN EXPANSION BY YEAR

- 1993 Situation
- 2003 Expansion
- 2011 Expansion
- 2015 Expansion

Prepared by the CIT, 2016, based on information from the MINVU, 2013 and the CIT 2015.

**Quilpué, Villa Alemana, Valparaíso, Placilla, Concón.*



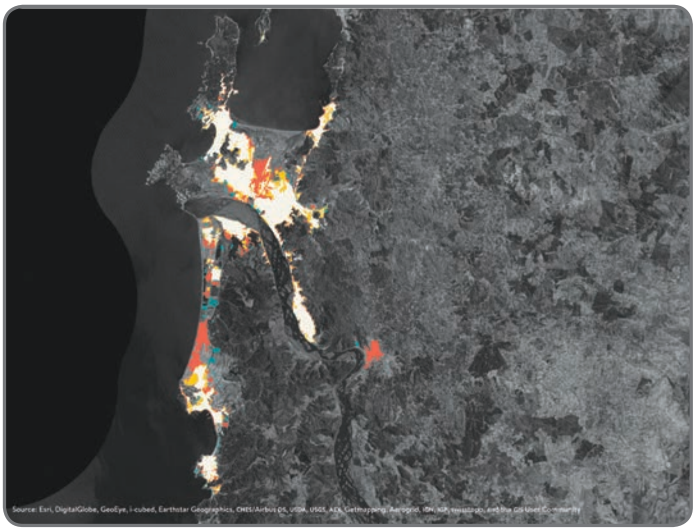
MAP 06

PUERTO MONTT - PUERTO VARAS CONNURBATION

URBAN EXPANSION BY YEAR

- 1993 Situation
- 2003 Expansion
- 2011 Expansion
- 2015 Expansion

Prepared by the CIT, 2016, based on information from the MINVU, 2013 and the CIT 2015.



MAP 07

GREATER CONCEPCIÓN*

URBAN EXPANSION BY YEAR

- 1993 Situation
- 2003 Expansion
- 2011 Expansion
- 2015 Expansion

Prepared by the CIT, 2016, based on information from the MINVU, 2013 and the CIT 2015.

**Includes Penco, Concepción, Chiguayante, San Pedro de la Paz, and Coronel. In 2011 and 2015 the city of Hualqui was included in the analysis.*

3.2 Productive Activities

The productive activities with the greatest impact on land degradation in Chile include mining, industrial activities and agricultural practices.

Mining, one of the country's main economic activities, is mainly concentrated in the northern zone in the Antofagasta, Atacama and Coquimbo regions, with a significant development in the O'Higgins Region as well.

Despite the economic importance of mining activity, and the fact that it is generally carried out far from populations, there are externalities that affect the soil and the environment and that could negatively affect people.

Indeed, the safety and management of tailing ponds and other mining waste is one of the issues that has caused greater concern in the population, especially in regard to abandoned sites. In this context, it is essential to have information of the location and characteristics of tailing ponds, in order to identify risks for the population and the environment.

According to the tailing ponds inventory of the National Geology and Mining Service (SERNAGEOMIN by its acronym in Spanish) by December 2015, 718 tailing ponds had been identified at the national level, of which 124 are abandoned, 119 are active and 437 are inactive[10]. It is worth noting that many of the abandoned tailing ponds belong to sites that were developed prior to the existence of environmental standards that regulate their construction and operation.

The largest active tailing ponds, considering their approved capacity, are located in the Antofagasta Region, as shown in **Table 07.**

TABLE 07

ACTIVE TAILING PONDS WITH GREATER APPROVED CAPACITY

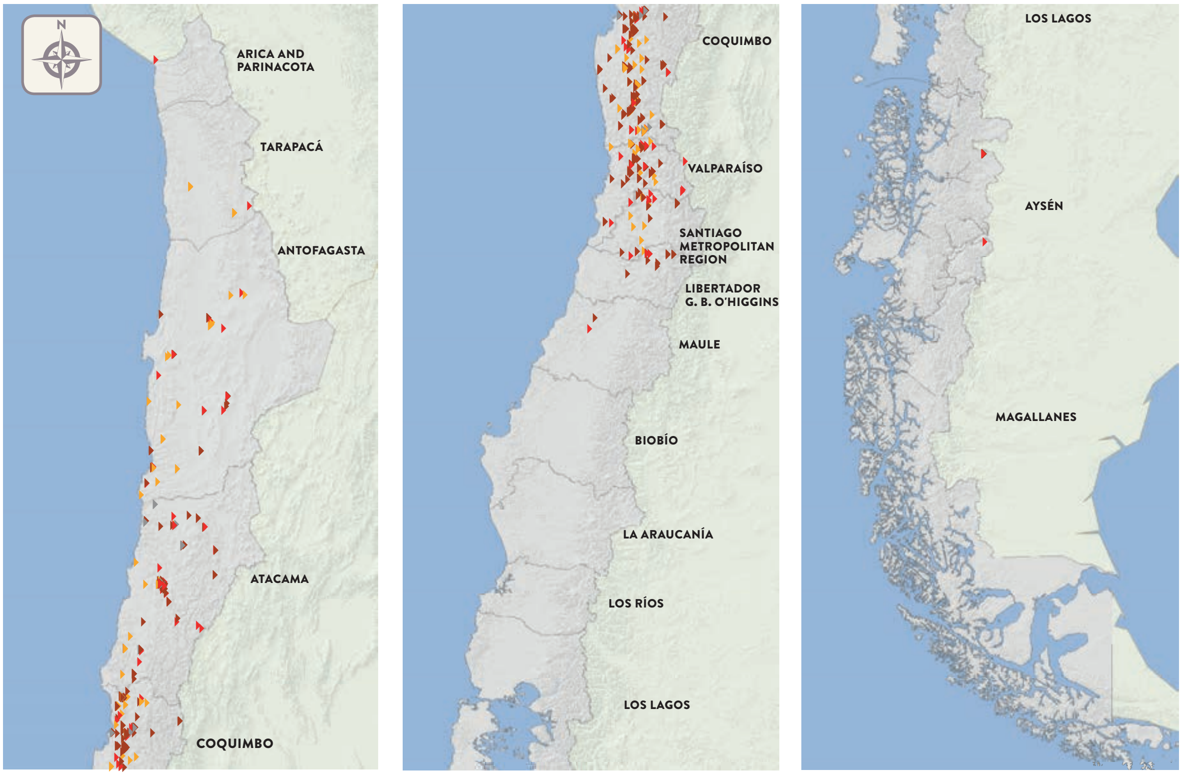
REGION	COMMUNE	DEPOSIT	APPROVED METRIC TONS
Antofagasta	Antofagasta	Laguna Seca	4,500,000,000
Antofagasta	Calama	Talabre	2,103,950,000
Santiago Metropolitan Region	Tiltil	Ovejeria	1,930,000,000
Coquimbo	Los Vilos	El Mauro	1,700,000,000
Antofagasta	Sierra Gorda	Sierra Gorda	1,350,000,000
	Pica	Pampa Pabellon	1,040,000,000
Santiago Metropolitan Region	Colina	Las Tortolas	1,000,000,000
Antofagasta	Sierra Gorda	Proyecto Esperanza	750,000,000
Atacama	Tierra Amarilla	Depósito de Arenas	570,000,000
Atacama	Tierra Amarilla	Candelaria	484,664,667

Source: SERNAGEOMIN, 2014.

[10] 32 recorded tailing ponds do not have information about their status in the SERNAGEOMIN inventory

MAP 08

DISTRIBUTION OF MINING TAILING PONDS*



The maps published in this report that refer to or are related to limits or boundaries of Chile do not commit the State of Chile in any way, according to Article 2, letter g of the Decree with Force of Law 83 of 1979 of the Ministry of Foreign Affairs. The cartographic information is based on Datum WGS84 and it is merely referential.

km
0 175 50

STATUS OF TAILING POND DEPOSITS

- Active
- Inactive
- Abandoned
- Without Information

Source: Authors' own elaboration, based on SERNAGEOMIN data.

*Information up to July 2015

Industrial activity can also be a potential source of pollution for soils and the environment. Although Chile has an Environmental Impact Assessment System (SEIA by its acronym in Spanish) in place, a procedure that seeks to assess and prevent potential negative impacts from these activities, the lack of specific regulations to safeguard soil quality make its difficult to adequately ensure its protection.

As in mining, certain industrial processes also exert pressures on the environment, through their emissions into the air and water and waste generation. In Chile, potentially polluting activities are "those that use, manipulate, handle, store, treat or dispose of substances that, due to their physical-chemical, biological and toxicological characteristics, cause or may cause temporary or permanent damage to human, animal or vegetation health" (MMA, 2012).

At present, in the Pollutant Release and Transfer Registry (PRTR) there are more than 19 thousand facilities whose productive processes or activities are regulated by some type of legislation. These facilities must declare their emissions into the air or water, as well as their waste generation and disposal, including the origin and destination of hazardous waste.

In the case of agriculture, the core aspects that can have an impact on soil are related to cultivation techniques, associated with the use of pesticides, the use of highly erodible soils, planting on slopes, monoculture, and livestock purine infiltration, among others. In the case of the excessive use of fertilizers and pesticides, the concrete impact can be observed in plants or vegetation, through which they may pose a risk to animals and humans.

According to CIREN's agrological studies, most class I, II and III soils are found between the Valparaíso and Los Lagos regions. On the other hand, the central zone, particularly between the Valparaíso and Maule regions, concentrates the production of vegetables in the country, reaching 75 percent of the national production in 2013 (ODEPA, 2012).

According to information provided by the Agriculture and Livestock Service – SAG by its acronym in Spanish – (2013), conventional agriculture tends to increase water use and loss of soil fertility. Nearly 40 percent of agricultural lands have some degree of erosion, reduction of fertility and overgrazing. The increasing levels of degradation cause significant changes in the biogeochemical cycle of carbon, nitrogen and phosphorus.

On the other hand, although in Chile there is control of fertilizers and pesticides, the inadequate use of the latter in agriculture has brought about, among other things, the presence of new plagues and diseases and the increase of their resistance. In this context, organic agriculture has emerged as an interesting alternative, both for the production of healthy food as well as for caring for the environment. According to SAG data (2013), in 2011 the total national certified organic area was 119,953 hectares, mostly located in the Biobío, Maule and Aysén regions.

Along with the advantages of organic agriculture production, there is an increasing preference by consumers, especially in foreign markets, that has resulted in the creation of an export market, mostly made up of fruit and processed products such as pulp and wine.

AGRICULTURAL LANDS

The production of vegetables in the country is particularly concentrated between the Valparaíso and Maule regions.

75% NATIONAL PRODUCTION

40% AGRICULTURAL LANDS

have some degree of erosion, reduction of fertility and overgrazing.

4 • RESPONSES

Although Chile does not have a specific regulation on land, since the 2010 reform of Law 19.300, in Article 39, it is established that "the law will safeguard the rational use of the land, in order to avoid its loss and degradation." Likewise, one of the functions of the Ministry of the Environment is: "to propose policies and formulate standards, plans and programs related to waste and polluted lands, as well as to assess the risk of chemical, genetically-modified organisms and other substances that can affect the environment" (Article 70, letter g). Along with that, land is also considered as one of the components that must be protected as part of the Environmental Impact Assessment.

Acknowledging that, the Ministry of the Environment began an analysis and discussion process with the public agencies with competence in land management matters, which seeks to create synergies for their regulation, recognizing pollution as a priority theme. To kick-start the process, the Inter-Institutional Land Management and Regulation Committee was set up through Exempt Resolution N° 1.302, dated December 3, 2015.

This Committee is made up of representatives of the ministries of Health, Mining, Housing and Urban Planning, Agriculture and the Environment. The aim of this body is to share, analyze and discuss information, perspectives and interests of each public agency. In addition, experts were called to support in environmental matters as well as those related to land management and regulation to enable consulting with them, facilitating technical information, and exchanging and discussing experiences and knowledge.

There are also land use regulations at the sectoral level:

- **General Law on Urban Planning and Constructions:** From the land planning and regulation perspective, it regulates zones for human settlements.
- **Law 18.755:** It establishes regulations for the Agriculture and Livestock Service. It defines that land use and conservation is one of its functions.
- **Law 18.450:** It regulates the promotion of private investments in irrigation and drainage works.

Grooves | SOLEDAD GAJARDO

- **Decree with Force of Law 701:** It regulates the promotion of forestry, aimed at regulating forestry land and promoting forestation.
- **Law 20.283:** It deals with the recovery of native forests and forestry promotion. Its aims are to protect, recover and enhance native forests with the purpose of ensuring forestry sustainability and environmental policy.
- **Decree N° 82 of the Ministry of Agriculture:** It approves the regulation on land, water and wetlands.

Regarding mining activity, the country has Law 20.551, which Regulates the Shut Down of Mining Works and Facilities. Said law forces all mining works to prepare a plan to shut down operations, before this process begins, which must be approved by SERNAGEOMIN. With this plan, the idea is to mitigate the effects caused as a result of mining activities, ensuring the physical and chemical stability of the facilities, in accordance with the environmental legislation.

As for tailing ponds, SERNAGEOMIN has a Geochemical Characterization Program of Tailing Pond Deposits in the Country. Likewise, since 2014 it has a Department of Tailing Pond Deposits dealing with, among other matters, improving the control of the legislation that regulates the sectoral authorization for the design, construction, operation and shutting down of tailing pond deposits (Supreme Decree N° 248 of 2006). With that objective, this unit is executing a field visits plan to confirm and collect as much information as possible regarding the characteristics of tailing ponds.

Likewise, there are some programs that have an impact on the land component.

4.1 Managing Sites with Potential Presence of Pollutants

Sites with potential presence of pollutants are managed within the framework of Resolution N° 406, dated May 15, 2013, of the Ministry of the Environment, which approved the "Methodological Guide for Managing Land with the Potential Presence of Pollutants" and its Annexes, and which overruled Exempt Resolution N° 1690 of 2011.

TABLE 08

SCHEMATIC OF ACTIVITIES ASSOCIATED WITH THE MANAGEMENT OF LPPPs

LEVEL	ACTIVITIES	MAIN RESULTS
REGIONAL **Identification, Prioritization and Hierarchization**	Collecting information	Potentially polluting activities by region
	Identifying and georeferencing LPPPs	Georeferenced list of LPPPs
	Prioritizing LPPPs	List of prioritized LPPPs
	Inspecting LPPPs	List of hierarchized LPPPs
SPECIFIC SITE **Preliminary Risk Assessment**	Preliminary research	Conceptual model of the presence of pollutants
	Confirming research	Quantitive determination of the presence of pollutants
SPECIFIC SITE **Risk Assessment and its Management**	Environmental risk assessment	Risk index
	Action Plan	Risk management

Source: MMA, 2012.

This methodology is aimed at defining the procedures to standardize the research on Land with the Potential Presence of Pollutants in the country. It is composed of phases, as shown on **Table 08**.

The procedures defined in this Guide can be aimed at and applied to any Land with the Potential Presence of Pollutants, or just to a part of them, such as, for example, abandoned lands.

Between 2013 and 2015, the Regional Ministerial Secretariats have successfully implemented phase 1 of the Methodological Guide. The studies corresponding to phases 2 and 3 are being developed in some regions.

4.2 Program to Combat Desertification

In 1997, Chile prepared the National Action Plan to Combat Desertification (PAN by its acronym in Spanish), which was updated establishing guidelines for the 2016-2030 period, in line with the UNCCD's 10-year Strategy (projected to 2018), the Land Degradation Neutrality (LDN) initiative and the Sustainable Development Goals (SDGs).

The general framework for addressing desertification in Chile is given by the National Strategy for Climate Change and Vegetation Resources (ENCCRV by its acronym in Spanish). This strategy is aimed at supporting the recovery and protection of native forests and xerophytic formations, as well as to strengthen the establishment of vegetation formation in soils where plantation is feasible, as mitigation and adaptation measures to the effects of climate change and to combat desertification.

The ENCCRV is focused on addressing the main causes of deforestation, degradation of forestry and vegetation resources, among which the effects of climate change are considered, as well as desertification and drought, establishing that a strategic activity to face them is to promote the adaptive management of vegetation resources in this area with concrete actions, such as:

- Creating a permanent monitoring system of the effects of drought in native vegetation formations.
- Preparing targeted studies on the water cycles of native vegetation communities present in areas with water scarcity, analyzing its impact of human activity and its effects on the degradation of ecosystems.
- Strengthening and expanding ex situ conservation programs, selection and genetical improvement of vegetation resources for climate change adaptation.
- Strengthening and expanding programs to generate and assess forestry methods and schemes for forestation, restoration and productive management, adapted to climate change.

The logic for action intends to integrate the knowledge and needs of stakeholders to locate the areas and risk factors that will enable estimating potential costs and benefits of the execution of intervention measures and their follow-up, analyzing technical and economic gaps to determine the optimal solutions and to obtain resources for their implementation and continuity over time.

PROGRAM TO COMBAT DESERTIFICATION

The logic for action intends to integrate the knowledge and needs of stakeholders to locate the areas and risk factors that will enable estimating potential costs and benefits of the execution of intervention measures and their follow-up, **analyzing technical and economic gaps to determine the optimal solutions and to obtain resources for their implementation and continuity over time.**

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CHAP **13**

WASTE

CONTENT

INTRODUCTION

The main issue with waste in the country is related to the lack of recycling, since both municipal and industrial waste is sent mostly to their final disposal (93.4 percent and 80 percent, respectively). This is a long-standing issue that requires decisive action by society as a whole in order to reduce the amount of waste disposed of, as well as to promote waste prevention and valuation. Progress in that direction is currently being observed with the passing of the Framework Law for Waste Management, Extended Producer Responsibility and Promotion of Recycling, but there is still a long way to go in comparison with the rest of the countries that are members of the Organisation for Economic Co-operation and Development (OECD), which have a valuation rate for solid municipal waste of 24 percent, versus Chile's 5.6 percent.

1 • BACKGROUND INFORMATION

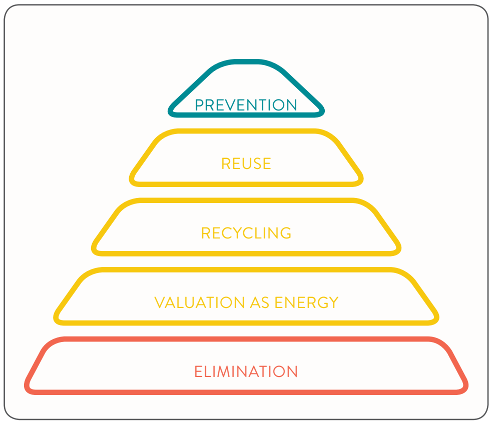
In most developed countries, the amount of waste sent to final disposal sites is limited, as a result of high recycling rates and its incineration to recover energy, a situation that is very different to the one in Chile. In 2014, the country generated a total of 45.3 million metric tons of waste, according to the reports submitted in 2015 by municipalities, industries and wastewater treatment plants (WWTPs) [1 and 2]. This is the first year in which the submission of reports is mandatory, in accordance to current legislation[3].

It is worth mentioning that these figures do not represent the total national waste generation, since this first year of reporting information was received from only 173 municipalities, representing 50 percent of the national total. Regarding non-hazardous waste, the figure includes the number of industrial facilities that are active in SINADER[4].

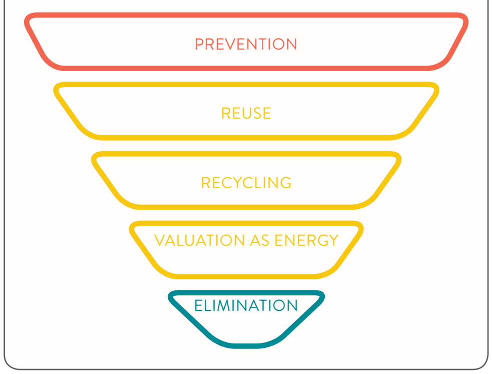
There are different definitions of waste in our legislation. For the purposes of this report, the definition to be used will be the one indicated in Supreme Decree N°1/2013 of the Ministry of the Environment on the Regulation for the Pollutant Release and Transfer Registry, which defines it as: a substance or object that: (i) is valued or eliminated; (ii) is aimed at being valued or eliminated; or (iii) must, within current legislation, be valued or eliminated.

Two alternatives can be distinguished for waste treatment: its valuation or its elimination. The term valuation does not refer to an economic value, but rather to an "environmental value" and is related to the use of resources present in waste, through their reuse (making the most of the product), recycling (using part or all the material present in waste), or its valuation as energy (taking advantage of the heat value of waste). Elimination refers to management without using the resources present in waste, including final disposal and incineration without recovering energy.

CURRENT SITUATION FOR VALUING WASTE



DESIRED SITUATION



[1] *For municipal waste or that which is similar to domestic waste, final disposal is considered in: middens, dumps and sanitary landfills. In the case of non-hazardous industrial waste, final disposal is considered in other types of non-specified final disposal, sanitary landfills, dumps, safety deposits, monofills, reception of sludge in wastewater treatment plants and incineration without energy recovery.*

[2] *Industrial waste figures were obtained from the reports through administrative records of 2,195 facilities at the national level for non-hazardous industrial waste and of 3,839 facilities at the national level for hazardous industrial waste.*

[3] *Articles 26 and 27 of Supreme Decree N°1/2013 of the Ministry of the Environment.*

[4] *In the case of non-hazardous industrial waste, at present there is no knowledge of the number of facilities forced to report. This situation should change with the supervision programs of the Superintendency of the Environment and the Ministry of Health.*

Waste management refers to all operational actions that waste undergoes, including collection, storage, transportation, pre-treatment and treatment.

The composition of solid municipal waste is related to the level of life and the economic activities developed in a region. This varies according to time and geographical area.

It is worth noting as an example that biodegradable waste, such as those generated by markets, parks and gardens, can be degraded either aerobically or anaerobically, as a result of the decomposition caused by microorganisms. On the other hand, glass, cardboard and plastic recipients can be recycled, producing new recipients or other products.

Waste Classification

ACCORDING TO ITS CHARACTERISTICS:

- **Hazardous Waste:** Waste or mix of wastes that represents a risk for public health and/or adverse effects on the environment, either directly or due to its current or foreseen management.
- **Non-Hazardous Waste:** Waste that does not represent a risk for public health or adverse effects on the environment.
- **Inert Waste:** It is non-hazardous waste that does not experience significant physical, chemical or biological variations, does not dilute, does not combust, and does not have physical or chemical or any other type of reaction. It is not biodegradable, and it does not negatively affect other materials it comes in contact with.

ACCORDING TO ITS ORIGIN:

- **Solid Municipal Waste:** Includes solid domestic and similar waste generated by the services sector and small industries. It also includes municipal waste originated from cleaning public roads, green areas and beaches.
- **Industrial Waste:** Waste resulting from manufacturing, transformation, use, consumption, cleaning and maintenance processes, generated by industrial activity. They can be solid or liquid waste or a combination of them which, due to their physical, chemical or microbiological characteristics, can not be assimilated to domestic waste[5].

[5] *Definition according to Supreme Decree N°594/1999 of the Ministry of Health.*

2 • PRESSURE: WASTE GENERATION

2.1 Waste Generation at the National Level

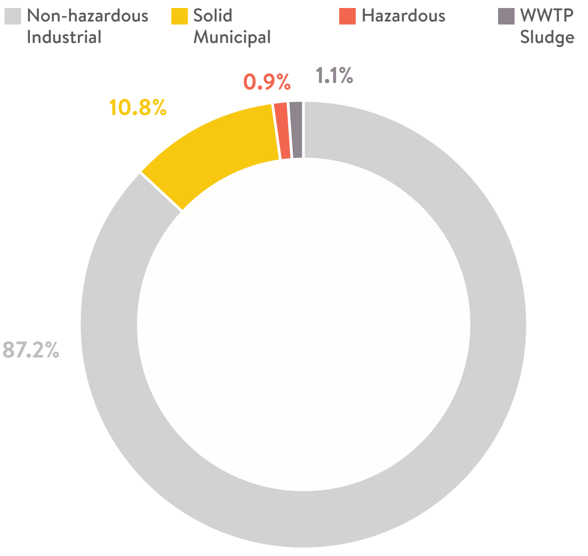
The country has taken a qualitative and quantitative leap in terms of waste statistics in comparison to the First State of the Environment Report (2012). This is due to the fact that in the first report the statistics published were based on surveys and estimates, while for this second report there are administrative records, validated by generators and receivers through an affidavit[6]. Nevertheless, it is important to bear in mind that not everyone submitted reports. Hence, it is to be expected that over the next few years the total amount of waste reported at the national level will significantly increase.

Indeed, during 2015, for the first time, the country's industrial and municipal waste generators and receivers reported to the National System for Waste Reporting (SINADER by its acronym in Spanish) of the Pollutant Release and Transfer Registry (PRTR)[7].

Thus, based on the information reported by municipalities, industries and wastewater treatment plants (WWTPs), waste generation[8] in 2014 reached 45.3 million metric tons, of which approximately 4.9 million metric tons (10.8 percent) correspond to solid municipal waste, 39.5 million metric tons (87.2 percent) to non-hazardous industrial waste, 440 thousand metric tons (0.9 percent) to hazardous waste and 492 thousand metric tons (1.1 percent) to WWTP sludge (**Figure 01**).

FIGURE 01

WASTE GENERATION AT THE NATIONAL LEVEL IN 2014



Source: SINADER, PRTR 2015.

SINADER

During 2015, for the first time, the country's industrial and municipal waste generators and receivers reported to the National System for Waste Reporting (SINADER by its acronym in Spanish) of the Pollutant Release and Transfer Registry (PRTR).

[6] *"When sending information about emissions, waste and/or pollutant transfer through the one-stop shop, the facility forced to do so will electronically sign an affidavit declaring the truthfulness of the information provided as well as that there are no omissions in that regard" (Article 16, S Supreme Decree N°1/2013 of the Ministry of the Environment).*

[7] *Supreme Decree N°1/2013 of the Ministry of the Environment, Regulation for the Pollutant Release and Transfer Registry (PRTR) establishes the following obligations:* **Article 26.**- *Waste Generator. Facilities that generate more than 12 metric tons of waste per year not subject to specific regulations will be forced to report by March 30 each year the amount of waste generated the previous year through the one-stop shop system of the Pollutant Release and Transfer Registry (PRTR). This will be so, notwithstanding the obligations stemming from Supreme Decree N° 148 of 2003 and Supreme Decree N° 6 of 2009, both of the Ministry of Health, as well as Supreme Decree N°4 of 2009, of the Ministry General Secretariat of the Presidency, regarding what is established by article 18 letter d) of this regulation.* **Article 27.**- *Municipal Waste. Waste receivers that receive more than 12 metric tons of waste per year must report the waste received during the previous year through the one-stop shop system of the Pollutant Release and Transfer Registry (PRTR) by March 30 each year. This will be so, notwithstanding the obligations stemming from Supreme Decree N°148 of 2003, Supreme Decree N° 189 of 2005, and Supreme Decree N° 6 of 2009, all of them of the Ministry of Health, as well as Supreme Decree N°4 of 2009, of the Ministry General Secretariat of the Presidency.*

[8] *It includes municipal, non-hazardous industrial, and hazardous waste, as well as WWTP Sludge.*

2.2 Waste Generation at the Municipal Level

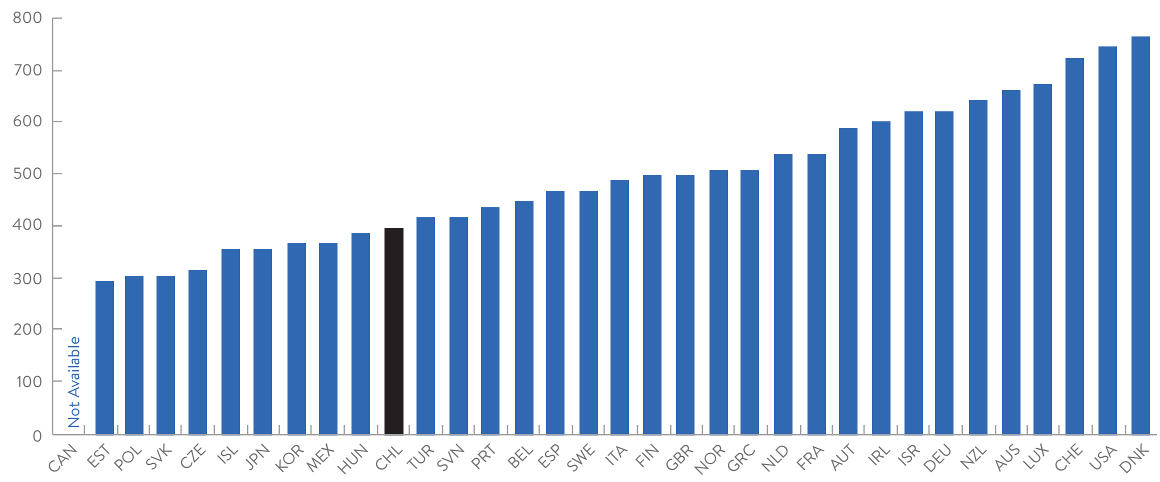
Municipal waste management, understood as the collection, transportation and disposal of waste, is a service provided by municipalities to their corresponding communes. This activity, although regulated and supervised, must, since 2015, be mandatorily reported to the Ministry of the Environment through a web platform called National System for Waste Reporting (SINADER by its acronym in Spanish). This annual municipal waste reporting process will allow preparing historical series characterizing waste generated by and disposed of by commune, as well as strengthening supervision by the authority.

There are two factors that mostly influence municipal solid waste generation: number of inhabitants and floating population. The number of inhabitants is the main factor that determines overall municipal solid waste generation. Nevertheless, floating tourism population has an incidence in waste generation, especially in coastal areas (see **Figure 04**).

When comparing per capita municipal solid waste generation with OECD countries, Chile presents a daily average rate of 1.1 kilograms, that is, 396 kilograms per year per person. This figure is relatively low in comparison with the rest of OECD countries, as shown in **Figure 02**.

FIGURE 02

PER CAPITA MUNICIPAL SOLID WASTE GENERATION OECD COUNTRIES, 2013



Source: OECD, Environmental Performance Reviews Chile, 2016.

Table 01 shows the estimated municipal waste generation based on the population projected for 2014, considering an average annual per capita production of 1.1 kilograms/person-day, versus the amount of waste reported through SINADER by the 173 municipalities. In addition, **Table 02** shows the degree of compliance of municipalities regarding the reporting of municipal waste for 2014.

TABLE 01

ESTIMATED AND REPORTED SOLID MUNICIPAL WASTE GENERATION AT THE REGIONAL LEVEL

REGIONS	**PROJECTED POPULATION FOR** 2014	**ESTIMATED AMOUNT** (metric tons/year)	**AMOUNT REPORTED SINADER** (metric tons/year)
Arica and Parinacota	235,081	97,817	1,560
Tarapacá	328,782	136,806	141,521
Antofagasta	613,328	255,206	1,100
Atacama	308,247	128,262	76,445
Coquimbo	759,228	315,915	354,121
Valparaíso	1,811,973	753,962	424,498
Santiago Metropolitan Region	7,228,581	3,007,813	2,418,081
O'Higgins	910,577	378,891	125,405
Maule	1,035,593	430,910	228,012
Biobío	2,100,494	874,016	565,344
Araucanía	983,499	409,234	196,291
Los Ríos	401,548	167,084	134,586
Los Lagos	834,714	347,324	158,311
Aysén	107,334	44,662	24,842
Magallanes and Chilean Antarctica	163,748	68,136	38,562
OVERALL TOTAL	**17,822,727**	**7,416,037**	**4,888,680**

Source: INE; SINADER, PRTR 2015.

It is important to highlight that the country is making progress in the formulation of a serious public policy regarding waste in order to have the best information possible that will enable making adequate decisions in a matter of great value for all citizens, such as its sound management.

TABLE 02

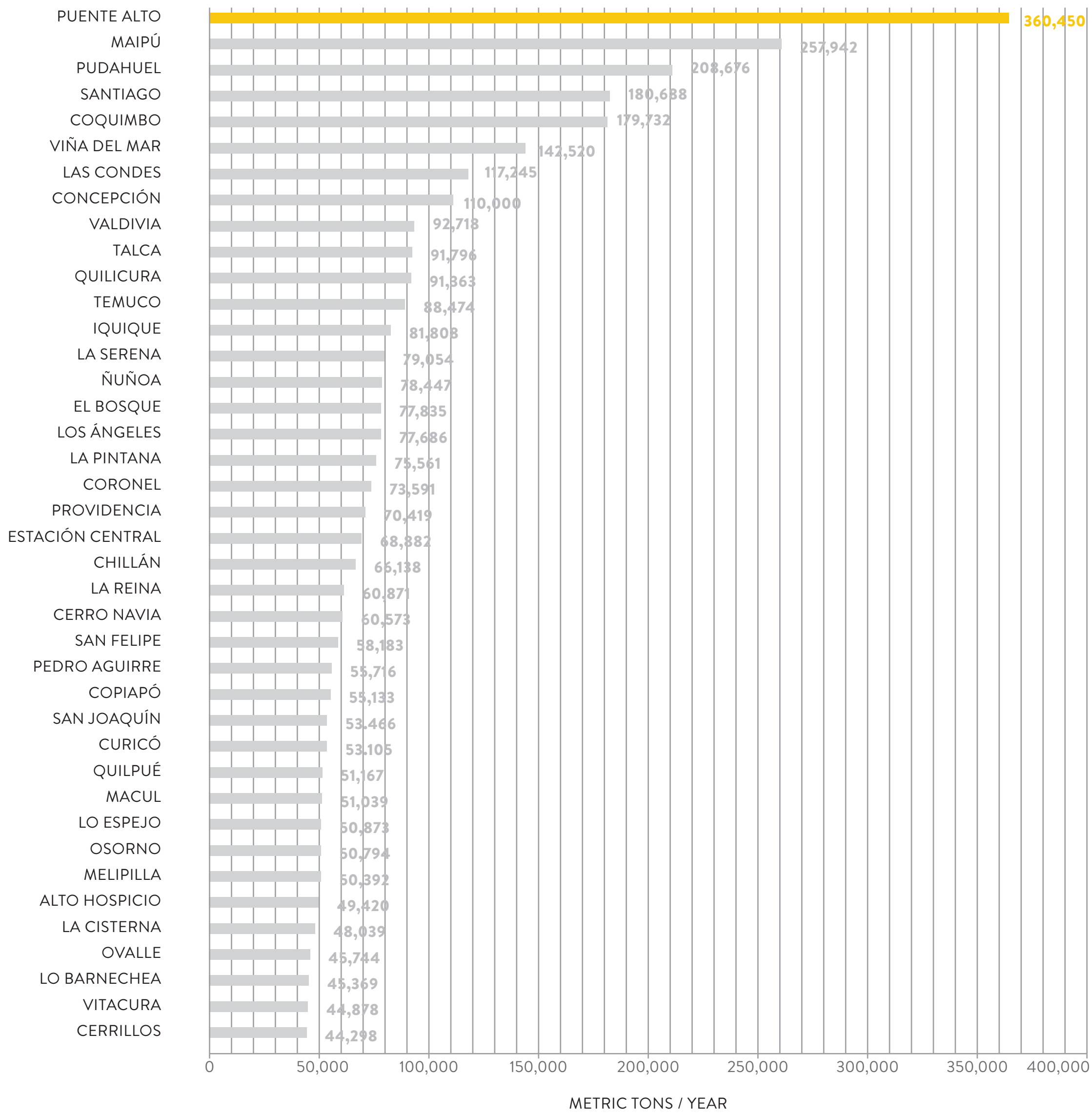
COMPLIANCE OF MUNICIPALITIES IN REPORTING THROUGH THE SINADER SYSTEM			
REGIONS	TOTAL MUNICIPALITIES	MUNICIPALITIES THAT REPORTED THROUGH SINADER	COMPLIANCE (%)
Arica and Parinacota	4	1	25%
Tarapacá	7	7	100%
Antofagasta	8	1	13%
Atacama	9	3	33%
Coquimbo	15	12	80%
Valparaíso	38	17	45%
Santiago Metropolitan Region	52	35	67%
O'Higgins	33	16	48%
Maule	30	13	43%
Biobío	54	24	44%
Araucanía	32	15	47%
Los Ríos	12	8	67%
Los Lagos	30	16	53%
Aysén	10	4	40%
Magallanes and Chilean Antarctica	11	1	9%
OVERALL TOTAL	345	173	50%

Source: INE; SINADER, PRTR 2015.

The Santiago Metropolitan Region, which concentrates 40.6 percent of the country's population, contributes 43.8 percent of municipal waste generated in Chile. **Figure 03** shows the 40 communes with the greatest solid municipal waste generation rates, of the ones that reported their waste. Out of these, the Puente Alto commune stands out, being the most populated one in the country. Other communes with high population rates are La Florida, Antofagasta and Valparaíso, but they did not report their municipal waste in the stipulated periods.

FIGURE 03

COMMUNES WITH THE GREATEST GENERATION OF MUNICIPAL WASTE IN 2014*

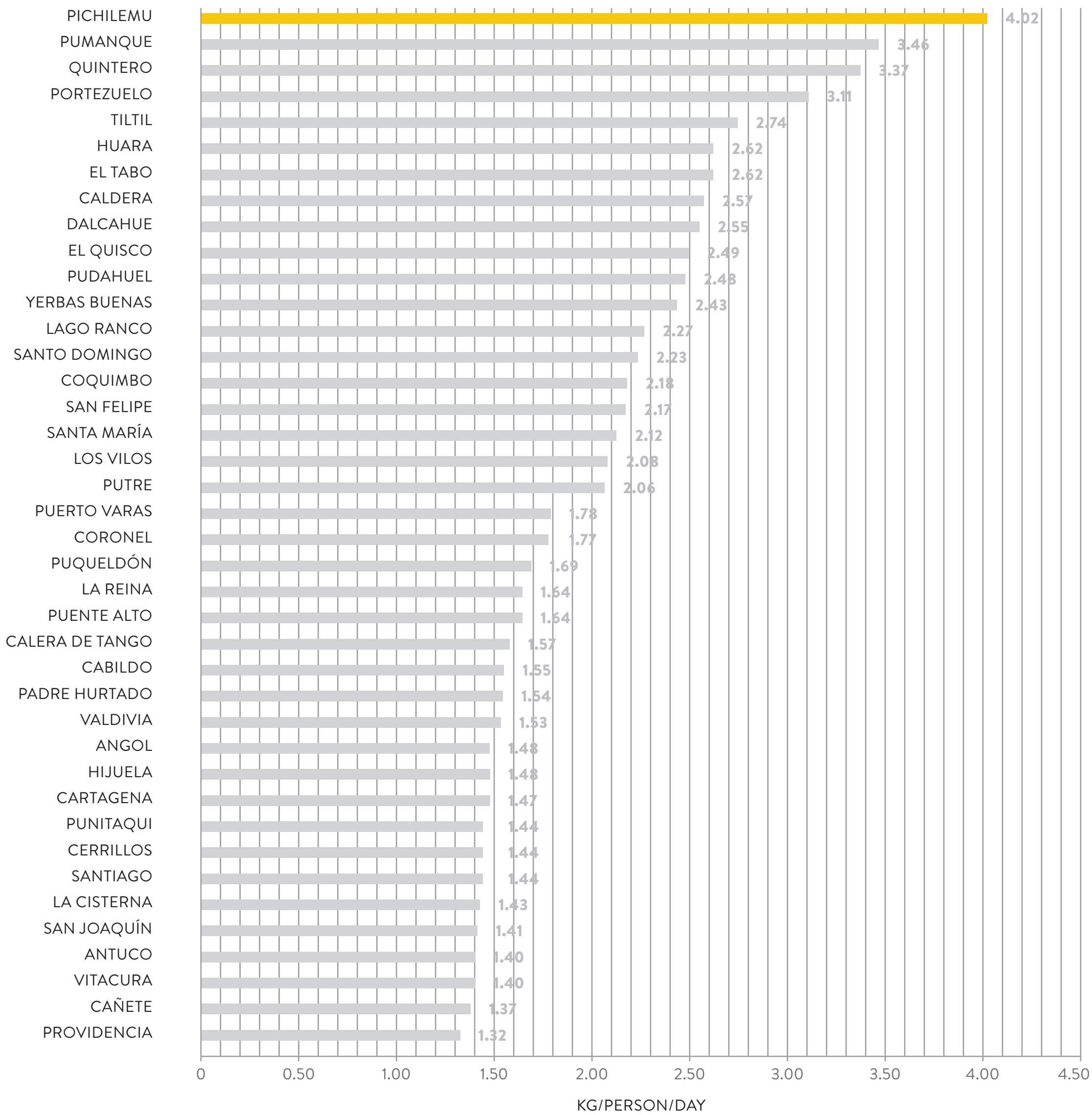


Source: SINADER, PRTR 2015.
* It only includes the 172 municipalities that submitted reports.

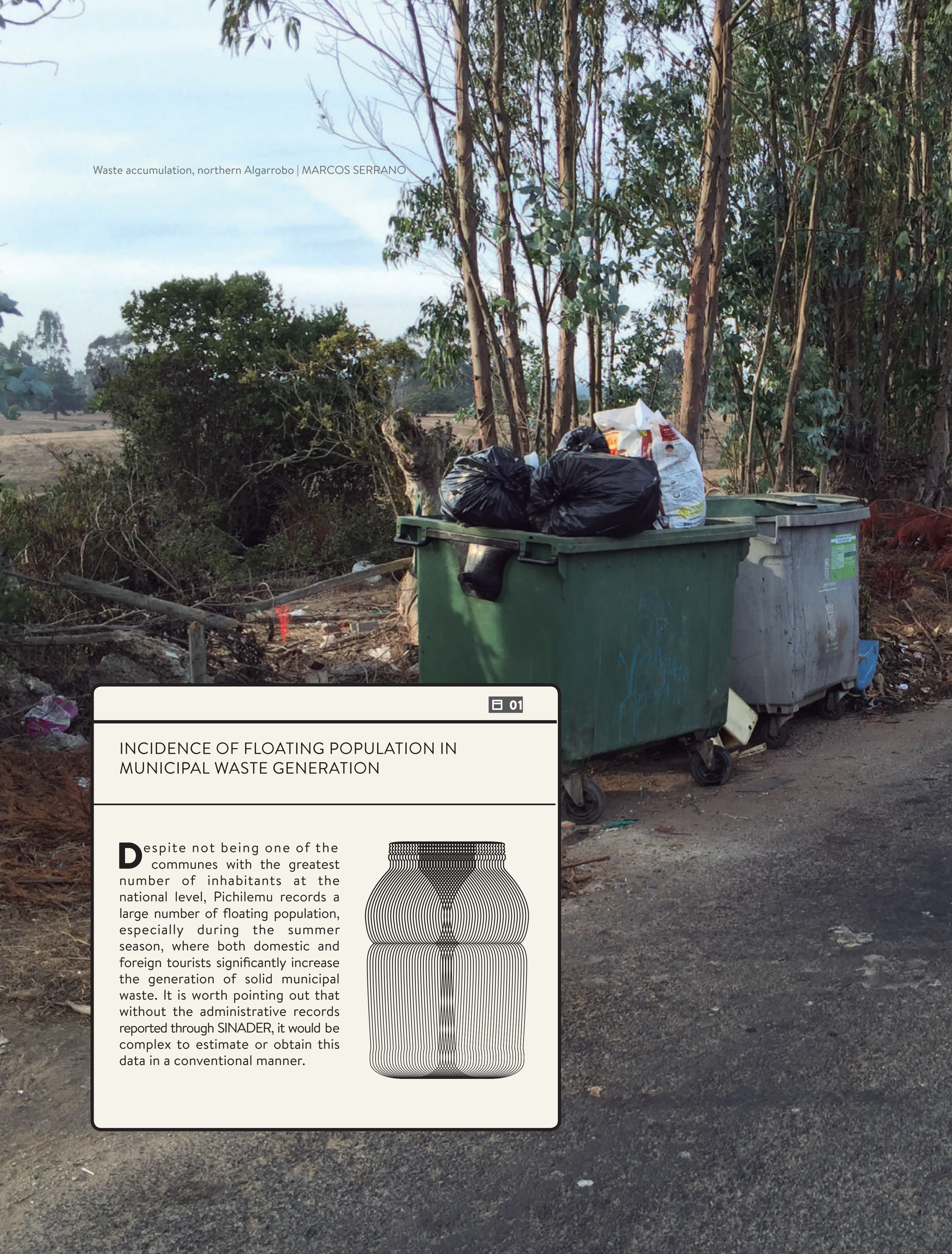
The Pichilemu commune records the greatest per capita generation, with 4.02 kg/person/day, because of the floating population that travels there, mainly during the summer (**Figure 04**).

FIGURE 04

COMMUNES WITH THE GREATEST PER CAPITA MUNICIPAL WASTE IN 2014*



Source: SINADER, PRTR 2015.
*The information reported by municipalities was not validated for all of them. These data will likely be adjusted with future annual reports.



Waste accumulation, northern Algarrobo | MARCOS SERRANO

01

INCIDENCE OF FLOATING POPULATION IN MUNICIPAL WASTE GENERATION

Despite not being one of the communes with the greatest number of inhabitants at the national level, Pichilemu records a large number of floating population, especially during the summer season, where both domestic and foreign tourists significantly increase the generation of solid municipal waste. It is worth pointing out that without the administrative records reported through SINADER, it would be complex to estimate or obtain this data in a conventional manner.

Composition of Municipal Waste at the National Level

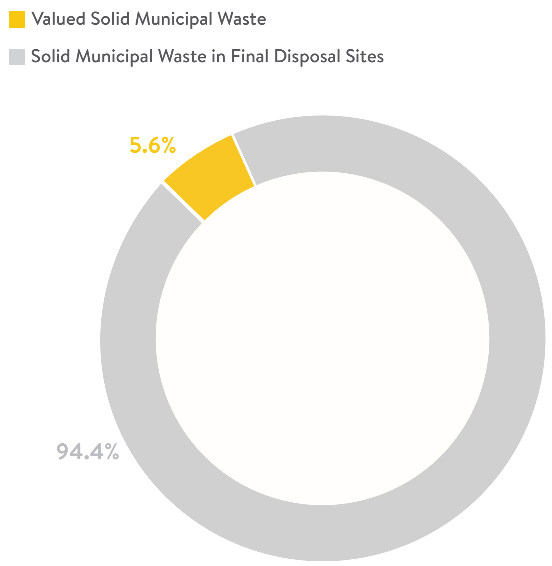
In order to determine the composition of municipal waste, the Ministry of the Environment established the use of the European List of Waste (ELW), for two main reasons. First, because that classification can, to a great extent, be adapted to the country's waste management needs and, second, because of the full compatibility with the questionnaires of the state of the environment regarding waste that the country must submit to the OECD. In addition, this list makes it easier to classify waste by origin and nature, considering the processes or activities that finally generate different types of waste.

Figure 05 shows that 94.4 percent of municipal waste goes directly to a final destination, while 5.6 percent are valued solid municipal waste.

Of the 5.6 percent of valued waste at the national level, the main products correspond to paper and cardboard, with a 61 percent share, biodegradable waste from kitchens and restaurants with a 15 percent share, and glass with a 14 percent share (see **Figure 06**). It is worth noting that the "other" category includes the aggregate of waste that does not exceed 500 metric tons per year, such as: clothing; fabric; metal; oil and edible fat; discarded appliances and batteries that do not contain hazardous components.

FIGURE 05

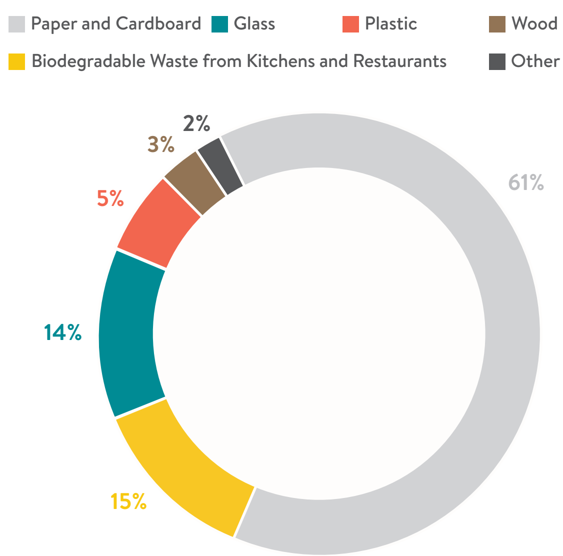
TYPE OF TREATMENT FOR SOLID MUNICIPAL WASTE GENERATION IN 2014*



Source: SINADER, PRTR 2015.
* According to the classification of the European List of Waste.

FIGURE 06

COMPOSITION OF VALUED SOLID MUNICIPAL WASTE IN 2014



Source: SINADER, PRTR 2015.

2.3 Generation of Non-Hazardous Industrial Waste [9 and 10]

The information regarding industrial waste was quite limited up to 2014, although there were estimates about industrial, hospital, mining, construction, agriculture and forestry waste. These indicated that 10.4 million metric tons were generated in 2009. After the SINADER reporting exercise, the total amount of these types of waste increased to 39.5 million metric tons, representing 87.2 percent of the total waste generated in the country. It is important to point out that this is the first reporting exercise. Hence, it is expected that over the next few years this figure will be closer to the actual national amount, since 2,194 facilities reported in 2014, but it is estimated that this figure should increase in future reporting exercises.

Figure 07 shows a regional outlook regarding the distribution of the generation of non-hazardous waste. The Santiago Metropolitan Region, where most of the country's industrial facilities are located, concentrates 60 percent of the total national generation of non-hazardous waste.

Table 03 shows the regional distribution of the facilities that declared their non-hazardous industrial waste for 2014.

INDUSTRIAL WASTE

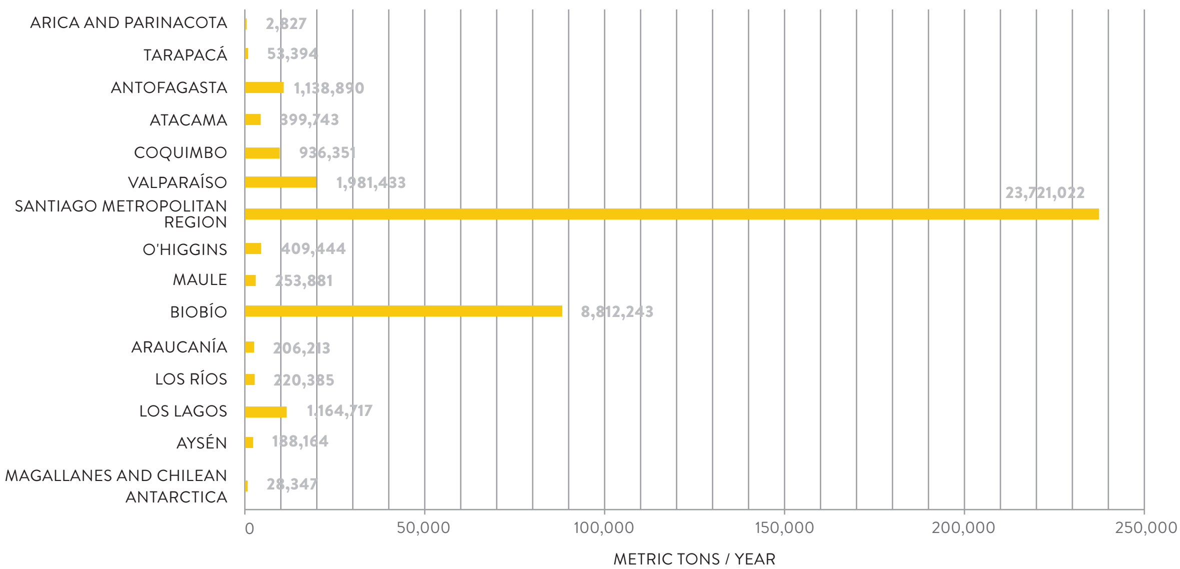
It is important to highlight that, despite the fact that the figure does not cover the entire number of facilities forced to report, **non-hazardous industrial waste reached 39.5 million metric tons in 2014.**

[9] *For this reporting exercise, the generation and management of radioactive waste, regulated and supervised by the Chilean Commission on Nuclear Energy, were not considered.*

[10] *Supreme Decree N°1/2013 of the Ministry of the Environment, which regulates the Pollutant Release and Transfer Registry indicates in article 3 that "for the purposes of the application of this regulation and as long as the final disposal is not carried out together with domestic or similar waste, sterile material, low-grade minerals, minerals treated with leaching, tailing ponds or slag resulting from mineral extraction, benefit or processing are not considered waste."*

FIGURE 07

NON-HAZARDOUS INDUSTRIAL WASTE GENERATION BY REGION, 2014



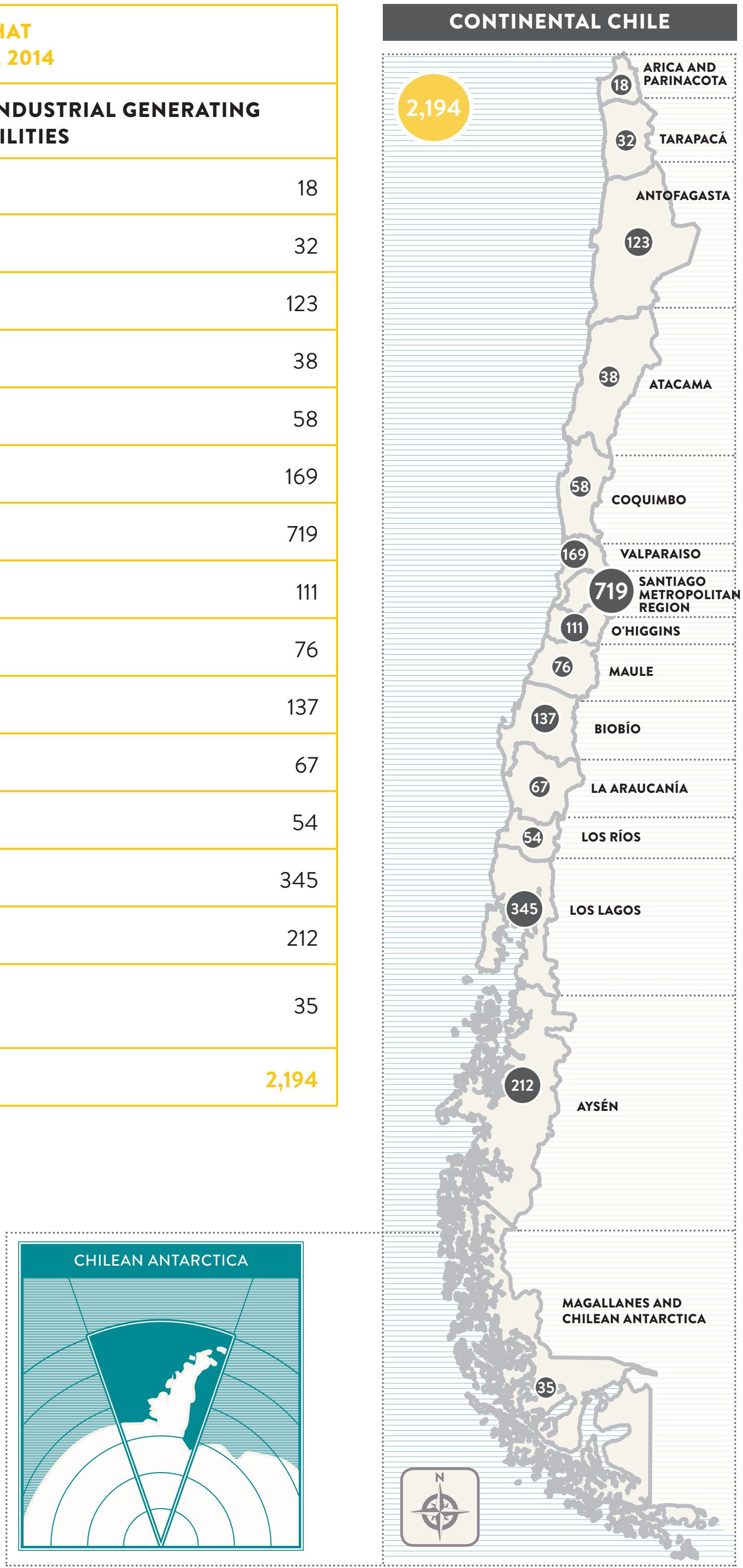
Source: SINADER, PRTR 2015.

TABLE 03

NUMBER OF FACILITIES BY REGION THAT REPORTED NON-HAZARDOUS WASTE, 2014	
REGIONS	**N° INDUSTRIAL GENERATING FACILITIES**
Arica and Parinacota	18
Tarapacá	32
Antofagasta	123
Atacama	38
Coquimbo	58
Valparaíso	169
Santiago Metropolitan Region	719
O'Higgins	111
Maule	76
Biobío	137
Araucanía	67
Los Ríos	54
Los Lagos	345
Aysén	212
Magallanes and Chilean Antarctica	35
OVERALL TOTAL	**2,194**

Source: SINADER, PRTR 2015.

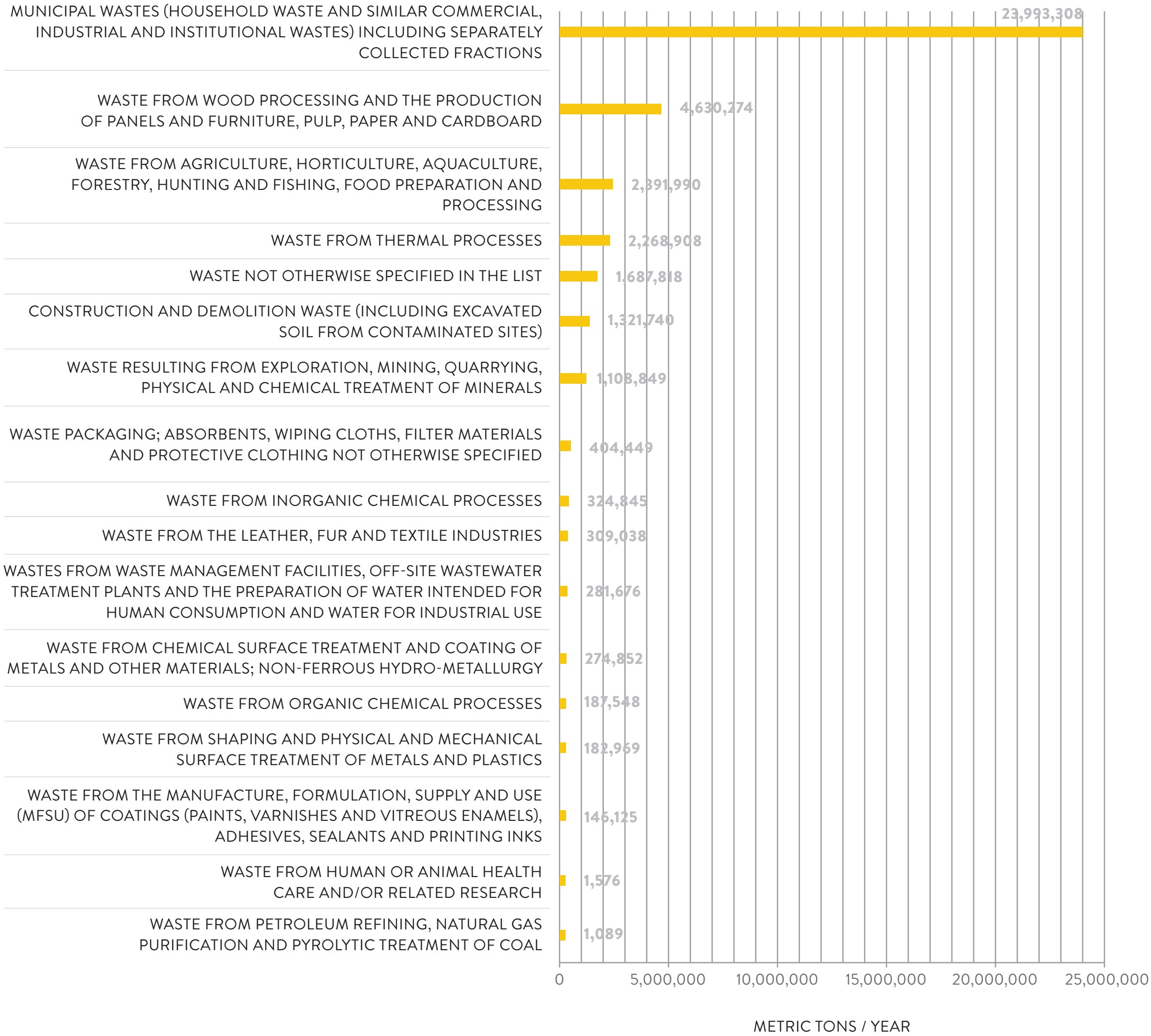
The maps published in this report that refer to or are related to limits or boundaries of Chile do not commit the State of Chile in any way, according to Article 2, letter g of the Decree with Force of Law 83 of 1979 of the Ministry of Foreign Affairs. The cartographic information is based on Datum WGS84 and it is merely referential.



As in the case of solid municipal waste, in order to determine the composition of non-hazardous industrial waste, the Ministry of the Environment established the use of the European List of Waste (ELW). **Figure 08** shows that, of the total non-hazardous industrial waste, almost 61 percent is classified as solid municipal waste, that is, they are similar to solid domestic waste. It is important to point out that this collection is outsourced by the industry.

FIGURE 08

COMPOSITION OF NON-HAZARDOUS INDUSTRIAL WASTE GENERATION IN 2014
According to the ELW Classification



Source: SINADER, PRTR 2015.

According to the International Standard Industrial Classification (ISIC), the Manufacturing sector concentrates 58.7 percent of non-hazardous industrial waste generation, as shown on **Table 04**.

TABLE 04

NON-HAZARDOUS INDUSTRIAL WASTE GENERATION IN 2014 ACCORDING TO THEIR ISIC* CODE

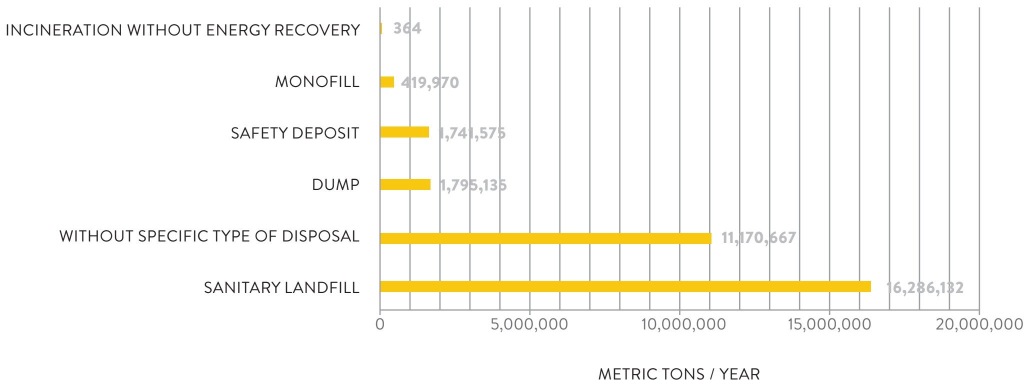
ISIC CODE	INTERNATIONAL STANDARD INDUSTRIAL CLASSIFICATION (ISIC)	TOTAL GENERATION (METRIC TONS)	% OF THE TOTAL
A	Agriculture, animal production, hunting and forestry	394,617	1
B	Fishing	430,283	1.1
C	Mining and quarrying	1,070,417	2.7
D	Manufacturing	23,188,742	58.7
E	Electricity, gas, steam and air conditioning supply	1,601,070	4.1
F	Construction	1,102,899	2.8
G	Wholesale and retail trade; repair of motor vehicles and motorcycles, personal items and household goods	1,647,708	4.2
H	Accommodation and food service activities	385,481	1
I	Transportation, storage and communications	284,400	0.7
J	Financial brokerage	116	0.0
K	Real estate, business and rental activities	7,394,081	18.7
L	Public administration and defense; compulsory social security	794,618	2
M	Education	215,721	0.5
N	Human health and social work activities	986,888	2.5
O	Other community, social and individual service activities	20,013	0.1
TOTAL		**39,517,055**	**100**

Source: SINADER, PRTR 2015.
*The data may be underestimated in some sectors, since not all facilities submitted reports.

Unfortunately, as in the case of municipal waste, the largest percentage (80 percent) of non-hazardous industrial waste ends up in final disposal sites, while 20 percent is valued, as shown in **Figures 09 and 10**.

FIGURE 09

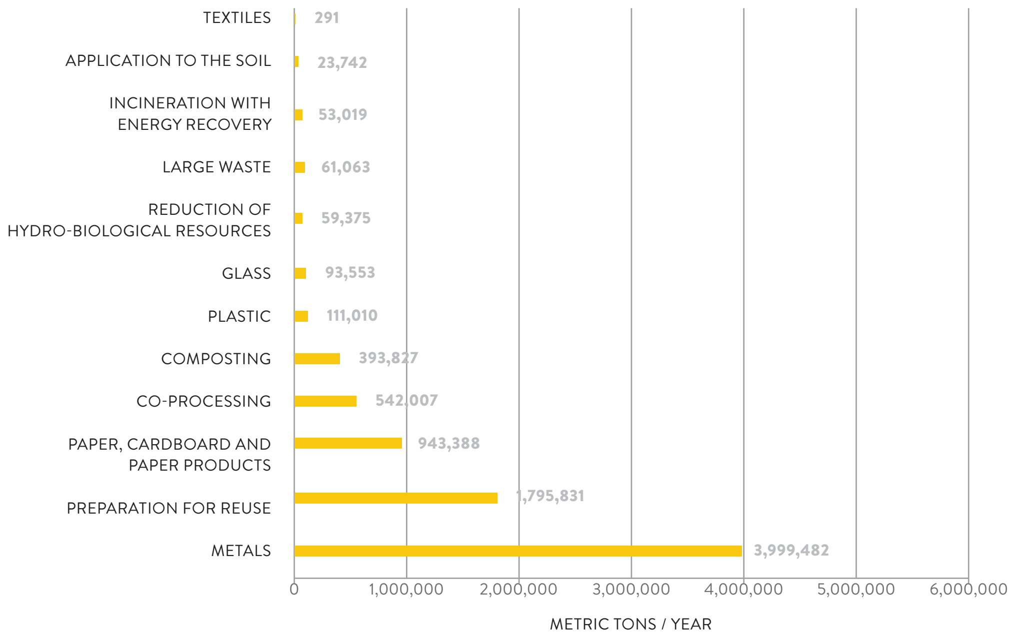
TYPE OF FINAL DISPOSAL OF NON-HAZARDOUS INDUSTRIAL WASTE IN 2014



Source: SINADER, PRTR 2015.

FIGURE 10

TYPE OF NON-HAZARDOUS INDUSTRIAL WASTE VALUATION IN 2014

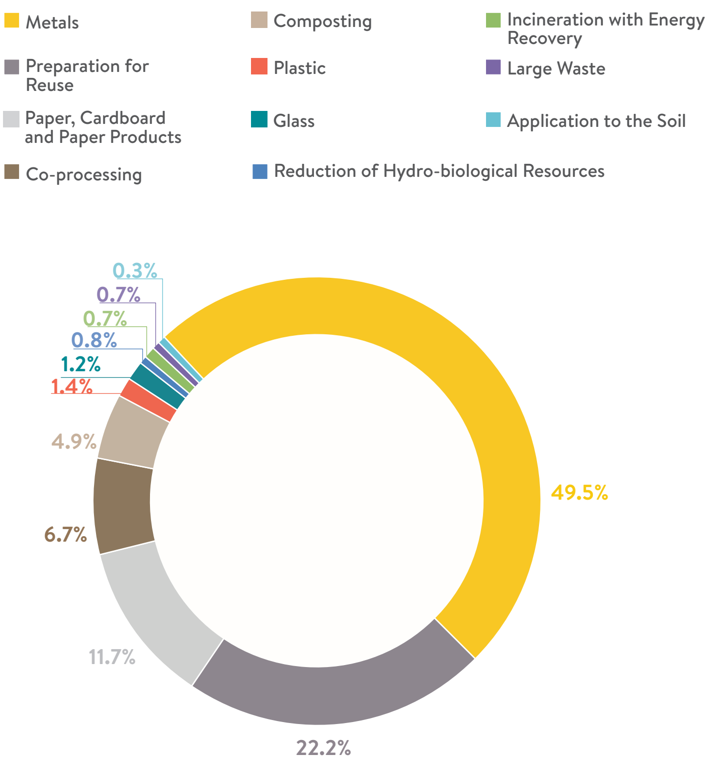


Source: SINADER, PRTR 2015.

According to the reports submitted by facilities through SINADER, it is observed that 8 million metric tons (representing 20 percent of the total industrial waste generated) is valued. The largest percentage (49.5 percent) corresponds to metal recycling (see **Figure 11**).

FIGURE 11

VALUATION OF NON-HAZARDOUS INDUSTRIAL WASTE IN 2014 (expressed in share percentage)



Source: SINADER, PRTR 2015.

NON-HAZARDOUS INDUSTRIAL WASTE

80%

ends up in final disposal sites without any sort of treatment

20%

of all industrial waste is valued (8 million metric tons)

Out of the valued non-hazardous industrial wastes, the largest percentage (49.5%) corresponds to metal recycling

3.9 MILLION METRIC TONS

Preparation for reuse
It is understood as the action of checking, cleaning or repairing through which discarded products or product components are conditioned to be reused without any other previous transformation (Law 20.920, 2016).

2.4 Wastewater Treatment Plant Sludge Generation

Since 2009, the country has been ruled by Supreme Decree N°4 of the Ministry General Secretariat of the Presidency for managing sludge generated in wastewater treatment plants (WWTPs). However, until 2015, there were no statistics that would enable to size up the generation and type of disposal of this waste.

With the passing of Supreme Decreee N°1/2013 of the Ministry of the Environment, the obligation is established for this waste to be reported through the PRTR's[11] one-stop shop in SINADER.

According to the reports submitted by wastewater treatment plants, in 2014 the total generation of sludge in the country reached 492,846 metric tons. **Figure 12** shows the regional distribution of sludge generation and disposal.

Figure 13 shows that 51 percent of sludge, which correspond to 322,360 metric tons, were disposed of in sanitary landfills or monofills, while 170,485 metric tons, representing 35 percent, were used on soil, covering a total area of more than 1,000 hectares. Of this area, 77 percent corresponds to forestry plantations, as shown in **Figure 14**.

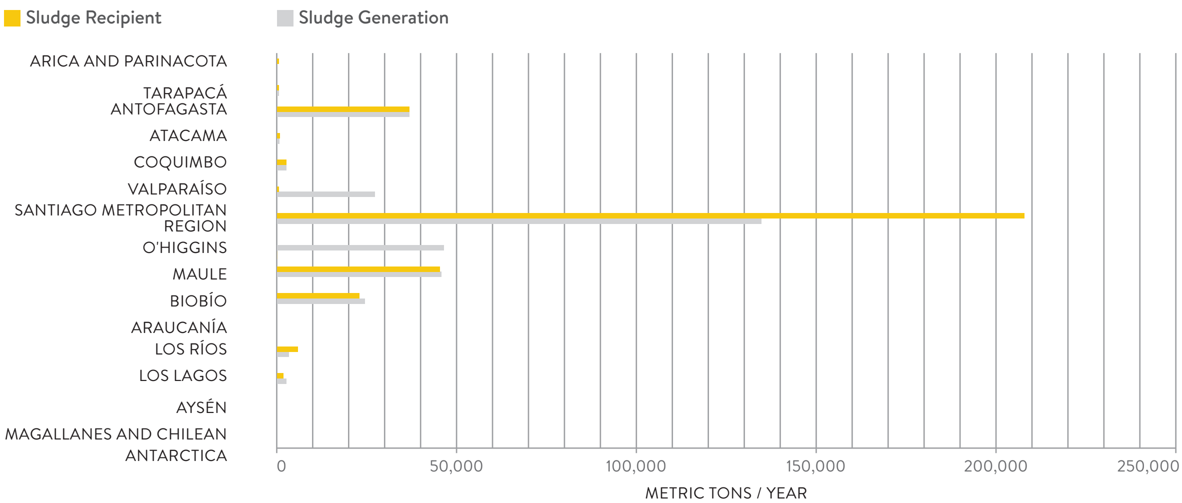
SLUDGE GENERATION

By 2014, the total generation of sludge reported by wastewater treatment plants in the country reached 492,846 metric tons, out of which 322,360 metric tons were disposed of in sanitary landfills or monofills, while 170,485 metric tons were used on soil.

[11] *Electronic system that includes a single form available on the PRTR portal, through which it is possible to access the reporting systems of the supervising institutions in order to comply with the obligation emitting or generating facilities to submit their reports.*

FIGURE 12

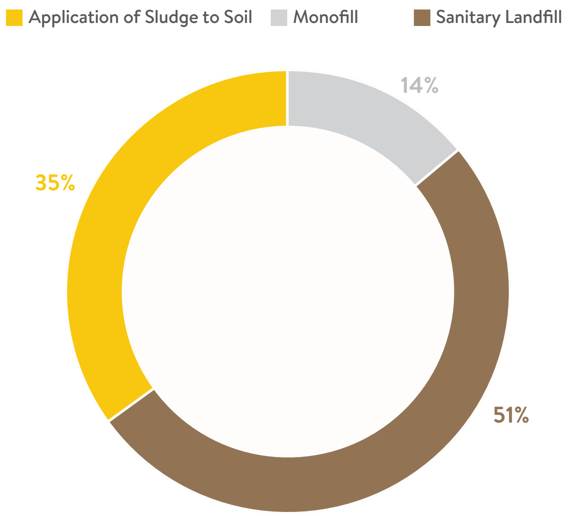
GENERATION AND DISPOSAL OF SLUDGE GENERATED BY WASTEWATER TREATMENT PLANTS AT THE REGIONAL LEVEL IN 2014



Source: SINADER, PRTR 2015.

FIGURE 13

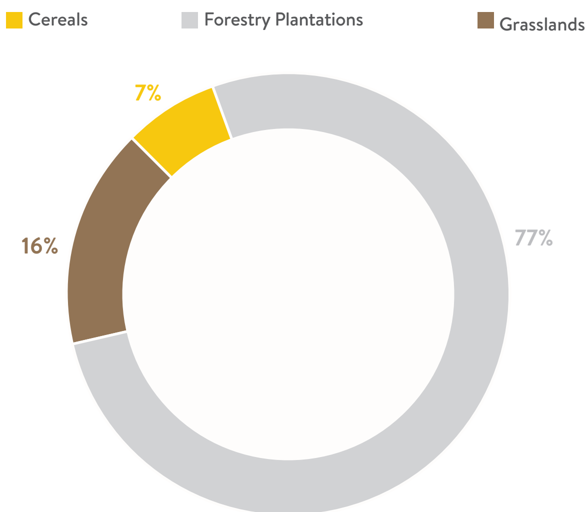
PERCENTAGE BY TYPE OF FINAL DISPOSAL OF SLUDGE GENERATED BY WASTEWATER TREATMENT PLANTS IN 2014



Source: SINADER, PRTR 2015.

FIGURE 14

APPLICATION OF SLUDGE TO SOIL IN 2014
by percentage of type of crop

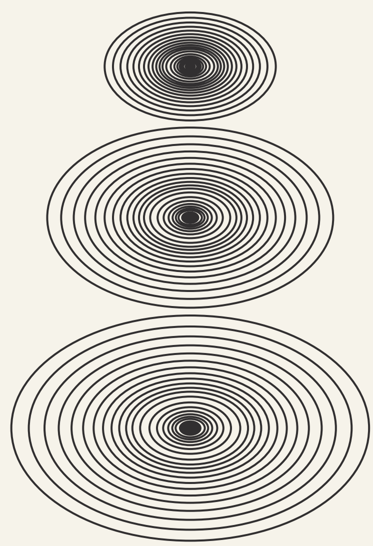


Source: SINADER, PRTR 2015.

02

SLUDGE GENERATED BY WASTEWATER TREATMENT PLANTS

Most of the sludge obtained from Wastewater Treatment Plants or by Industrial Facilities that generate this type of waste are sent to final disposal sites, such as sanitary landfills or authorized monofills. Hence, it is important to verify that final disposal is made in accordance to the requirements in terms of compaction, minimum thickness of coverage material and including a control of deformities or cracks that may pose a risk for the management of this waste and cause situations such as the one occurred in January 2016 in the Santa Marta Sanitary Landfill, which belongs to Consorcio Santa Marta S.A.



2.5 Generation of Hazardous Waste

Hazardous waste statistics began in 2006. Before the entry into force of the regulation on hazardous waste management (Supreme Decree N° 148 of the Ministry of Health) in 2005, the generation of this type of waste was estimated at approximately 30,000 metric tons per year.

Said regulation established a definition of hazardous waste[12] and created a reporting and monitoring system for large generators of this type of waste (facilities or activities that generate over 12 kilograms of acute toxic waste or over 12 metric tons of hazardous waste per year). Thus, starting in 2006, the System for Reporting and Monitoring Hazardous Waste (SIDREP by its acronym in Spanish) was implemented. The data generated by SIDREP reveal a steady increase in the reporting of waste up to a total of 440,687 metric tons in 2014, as shown in **Figure 15** [13].

Although the number of industrial facilities reporting through SIDREP has constantly increased, over the last few years waste generation has not shown a sustained increase, but rather remains above 400,000 metric tons.

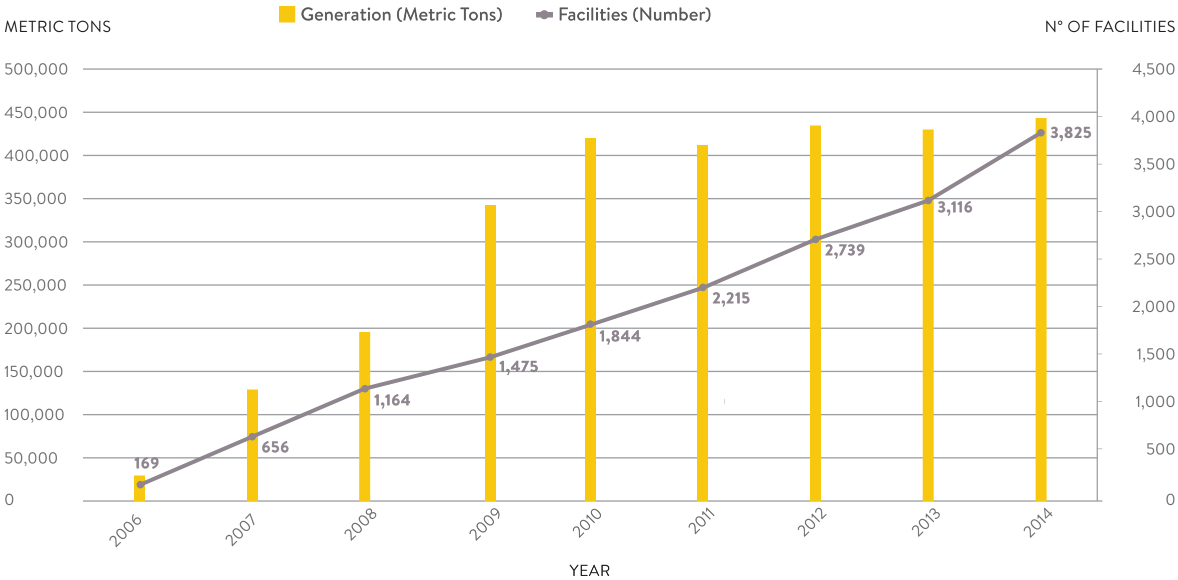
According to the International Standard Industrial Classification (ISIC), the Mining and Quarrying sector concentrates 38.9 percent of hazardous waste generation, as shown in **Table 05**. On the other hand, the Libertador General Bernardo O'Higgins Region is the one that generates the largest amount of hazardous waste in 2014, with more than 91 thousand metric tons per year, while the Santiago Metropolitan Region concentrates the largest amount of final disposal with over 193 thousand metric tons, as shown in **Figure 17**.

[12] *Waste or mixture of waste that poses a risk for public health and/or adverse effects on the environment, whether directly or due to its current or foreseen management, as a result of presenting some of the characteristics indicated in article 11.*

[13] *There are a number of facilities that report in paper, but, given that there is no capacity to handle this information, this figure is unknown.*

FIGURE 15

HAZARDOUS WASTE GENERATION PER YEAR VERSUS THE NUMBER OF FACILITIES, 2006-2014, Series 2006 - 2014



Source: SIDREP, PRTR 2015.

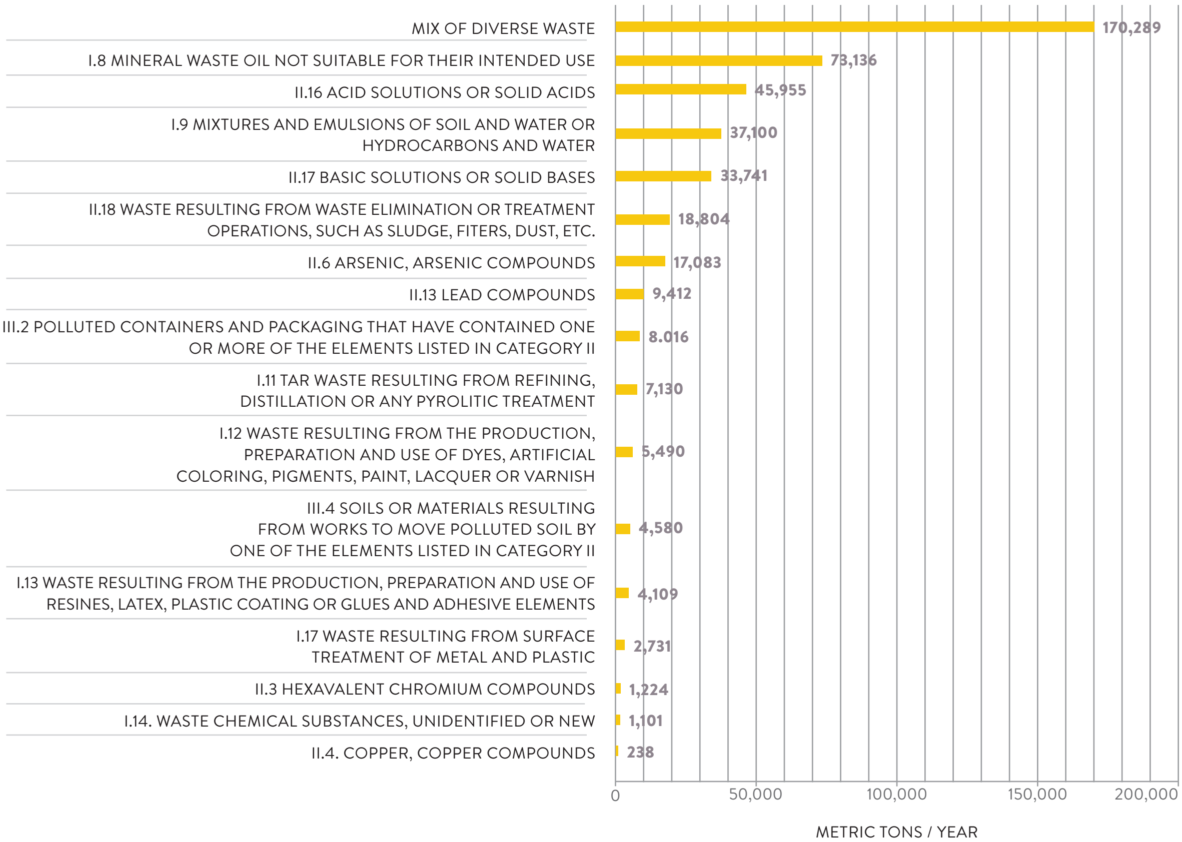
TABLE 05

SHARE OF PRODUCTIVE SECTORS IN HAZARDOUS WASTE GENERATION BY ISIC, 2014			
ISIC CODE	**ISIC LEVEL 1**	**TOTAL GENERATION (METRIC TONS)**	**PERCENTAGE OF THE TOTAL**
A	Agriculture, hunting and forestry	830	0.19%
B	Fishing	982	0.22%
C	Mining and quarrying	171,464	38.9%
D	Manufacturing	159,915	36.3%
E	Electricity, gas, and water supply	45,914	10.4%
F	Construction	1,547	0.35%
G	Wholesale and retail trade; repair of motor vehicles and motorcycles, personal items and household goods	13,555	3.1%
H	Accommodation and food service activities	3	0.001%
I	Transportation, storage and communications	17,944	4.1%
J	Financial brokerage		
k	Real estate, business and rental activities	6,921	1.6%
L	Public administration and defense; compulsory social security	666	0.15%
M	Education	63	0.01%
N	Human health and social work activities	1,831	0.42%
O	Other community, social and individual service activities	19,051	4.3%
	OVERALL TOTAL	**440,687**	**100%**

Source: SIDREP, PRTR 2015.

FIGURE 16

HAZARDOUS WASTE GENERATION IN 2014 BY CLASSIFICATION IN THE LIST OF SUPREME DECREE N°148/2003 MINISTRY OF HEALTH

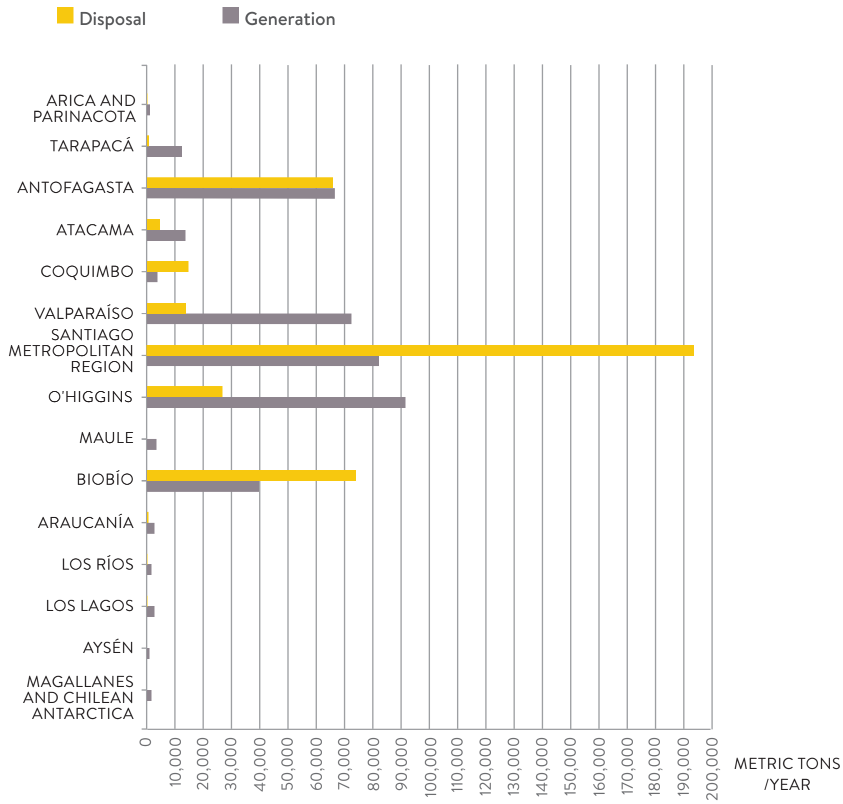


Source: SIDREP, PRTR 2015.
**Mixture of diverse waste* is the sum of all specific waste fractions classified according to the list of Supreme Decree n°148/2003 Ministry of Health and, due to the high number of subclassifications and their relatively low individual amounts, they were consolidated into this category, in order to make the graph understandable.

El Molle Landfill | KARINA BAHAMONDE

FIGURE 17

ORIGIN AND DESTINATION OF HAZARDOUS WASTE IN 2014
at the regional level



Source: SIDREP, PRTR 2015.

HAZARDOUS WASTE

The Santiago Metropolitan Region concentrates the greatest amount of hazardous waste disposal

193,000
METRIC TONS

The Libertador General Bernardo O'Higgins Region recorded the greatest hazardous waste generation in 2014

91,000
METRIC TONS

3 • ACTIONS TO FACE THE WASTE ISSUE

In Chile, the legal framework associated with waste dates from 1967, with the publication of the Sanitary Code in the Official Gazette. The Code regulates specific aspects related to hygiene and environmental safety at the work place. **Table 06** provides a list of laws and decrees in force to date.

TABLE 06

LAWS AND DECREES ASSOCIATED WITH SOLID WASTE MANAGEMENT	
ENTRY INTO FORCE	**LAWS AND DECREES**
1967	Decree with Force of Law (D.F.L.) N° 725, of the Ministry of Health, that establishes the Sanitary Code.
1992	Supreme Decree (SD) N° 685 in which Chile ratifies the Basel Convention that regulates transboundary movements of hazardous wastes and stipulates the obligations of the Parties to ensure the environmentally sound management of them, particularly their disposal.
1994	Law 19.300 Environmental Framework Law, which incorporates the topic of waste into the Environmental Impact Assessment System, article 10, (letters i and o).
2000	Supreme Decree N° 594 of the Ministry of Health on basic sanitary and environmental conditions in the workplace (derived from Supreme Decree N° 745 of 1993).
2004	Supreme Decree N°148 of the Ministry of Health, which establishes the Sanitary Regulation on Hazardous Waste Management.
2007	Supreme Decree N° 45, of the Ministry General Secretariat of the Presidency, which establishes the emission standard for incineration and co-incineration.
2008	Supreme Decree N°189 of the Ministry of Health, which regulates basic sanitary and safety conditions in sanitary landfills.
2009	Supreme Decree N° 6 of the Ministry of Health, on the management of waste generated in health care facilities.
2009	Supreme Decree N° 4 of the Ministry General Secretariat of the Presidency, for the management of sludge generated by wastewater treatment plants.
2010	Law 19.300 Environmental Framework Law modified by Law 20.417, which establishes the roles of the Ministry of the Environment in: ► Proposing policies and creating regulations, plans and programs related to waste (article 70 letter g). ► Managing a Pollutant Release and Transfer Registry, which will record and systematize, by source or group of sources of a same facility, nature, streamflow and concentration of emissions of pollutants subject to an emission standard as well as the nature, volume and destination of the solid waste generated that are indicated in the regulation (article 70, letter p).
2012	Supreme Decree N°3 of the Ministry of the Environment, which establishes the regulations for managing sludge generated in effluents from the fruit and vegetable processing industry.
2013	Supreme Decree N°1 of the Ministry of the Environment, which establishes the regulations for the pollutants release and transfer registry.
2016	Law 20.920 Framework Law for Waste Management, Extended Producer Responsibility and Promotion of Recycling

Source: Ley Chile, retrieved March, 2016 www.leychile.cl

National Solid Waste Program of the Under Secretariat of Regional and Administrative Development (SUBDERE)

Since 2007, the SUBDERE has a National Solid Waste Program whose objective is to improve health and environmental quality conditions of urban and rural centers, as well as to implement integrated and sustainable systems for the efficient management of solid domestic waste.

The program includes the construction of new sanitary landfills, purchasing machinery and equipment, shutting down dumps, training and advice for municipalities, strengthening supervision capacity, and State sanitary and environmental control, among others. **Table 07** shows the Program's progress since 2015.

TABLE 07

NATIONAL SOLID WASTE PROGRAM AT THE REGIONAL LEVEL, 2015

REGION	SHUTTING DOWN DUMPS		CONSTRUCTION OF NEW SANITARY LANDFILLS			MANAGEMENT PLANS			MINIMIZATION PROJECTS
	STUDIES OF SHUTTING DOWN PLANS	DUMPS THAT HAVE BEEN SHUT DOWN	STUDIES	DESIGNED LANDFILLS	LANDFILLS UNDER CONSTRUC-TION	COMMUNAL PLANS	REGIONAL PLANS UNDER DEVELOP-MENT	APPROVED PLANS	
Arica and Parinacota	1	1	1	1	-	2	1	-	1
Tarapacá	1	3	2	3	-	-	-	1	-
Antofagasta			1	4	4	-	1	-	1
Atacama	7	1	1	-	2	-	1	-	-
Coquimbo	4	2	1	-	-	-	-	1	1
Valparaíso	3	-	-	2	-	1	1	-	3
Santiago Metropolitan Region	1	-	-	-	-	-	-	-	7
O´Higgins	1	-	-	-	-	-	-	1	3
El Maule	2	-	-	2	-	-	1	-	9
Biobío	11	5	-	1	2	9	1	-	1
Araucanía	3	15	11	2	-	2	-	-	2
Los Ríos	4	3	2	1	-	-	2	-	3
Los Lagos	11	6	10	2	2	-	-	-	2
Aysén	1	-	1	3	7	-	1	-	-
Magallanes	-	1	1	2	-	1	1	-	1
TOTAL	**50**	**37**	**31**	**23**	**17**	**15**	**10**	**3**	**34**

Source: Subdere, 2015.

Environmental Certification System for Municipalities of the Ministry of the Environment

The Ministry of the Environment works with volunteer environmental management tools, such as the Environmental Certification System for Municipalities (SCAM by its acronym in Spanish), which operates throughout the national territory and is based on national and international standards including the ISO 14,001 and the Community Regulation of Eco-management and Eco-auditing (EMAS by its acronym in Spanish). The SCAM seeks to incorporate the environmental factor into municipal work through municipal organization, infrastructure, personnel, internal procedures and services provided to the community.

The SCAM is a gradual, realistic and flexible system, capable of being adapted to the reality of each municipality, which can gain advantages such as:

- ▶ Institutional prestige
- ▶ Active participation in the care for the environment
- ▶ Support in the dissemination of its activities
- ▶ Water and energy efficiency
- ▶ Waste reduction

Of the 345 municipalities of the country, 40 percent has joined SCAM, as shown in **Figure 18**.

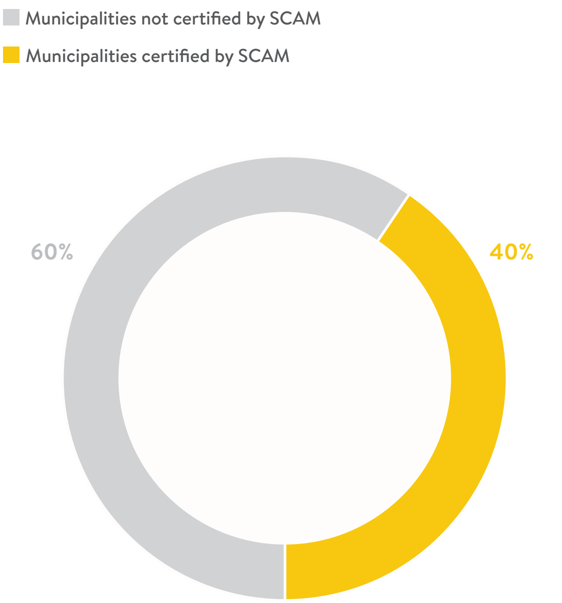
Of the 139 municipalities that are at some stage of the Environmental Certification System for Municipalities by 2015, only 81 municipalities reported waste managed in their communes, representing 58 percent of environmentally certified municipalities (see **Figure 19**).

Table 08 shows the municipalities that valued more metric tons, in comparison to the total amount of municipal waste managed in their communes. This effort must be boosted and promoted as an example for other municipalities.

It is interesting to consider that there are communes that have promoted and developed segregated collection services, clean spots, and recovery programs, among others, but these actions were not reported through SINADER.

FIGURE 18

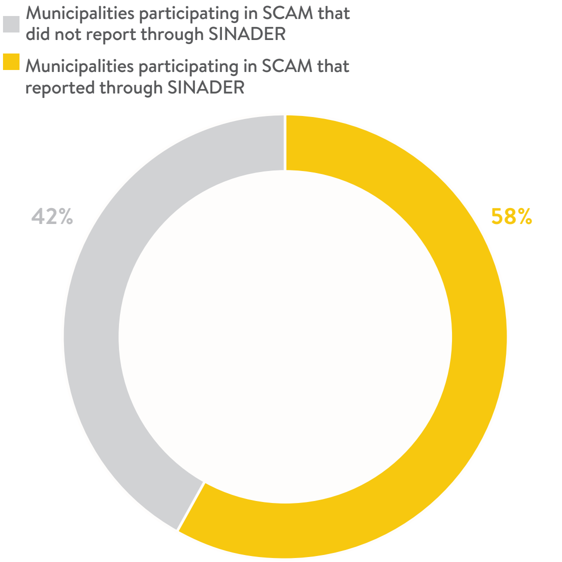
MUNICIPALITIES PARTICIPATING IN SCAM IN 2015



Source: Department of Local Environmental Management of the Ministry of the Environment, 2016.

FIGURE 19

MUNICIPALITIES PARTICIPATING IN SCAM THAT REPORTED THROUGH SINADER IN 2015



Source: SINADER, PRTR, 2015.

TABLE 08

MUNICIPALITIES THAT VALUED A GREATER SHARE OF THEIR GENERATED WASTE IN 2014	
COMMUNES	**AMOUNT (METRIC TONS/YEAR)**
Santiago	2,348.7
Maipú	2,188.3
Putre	1,560.0
Puente Alto	1,530.7
Lo Barnechea	1,056.4
Alto Biobío	972.0
Viña del Mar	931.0
Angol	822.0
Pucón	528.6
Paine	445.0
Independencia	361.7
San Miguel	303.6
Tiltil	249.0
San Joaquín	153.4
San Antonio	133.7
Calera de Tango	110.2
Limache	63.0
La Reina	62.9
Villarica	52.0
Padre Hurtado	46.4
TOTAL	**13,918.4**

Source: SINADER, PRTR 2015.

03

MUNICIPALITIES WITH RECYCLING PROGRAMS NOT REPORTED THROUGH SINADER

Although there are municipalities that carry out waste valuation programs, in the annual reports submitted through SINADER in 2014 several of them did not include waste valuation information, but rather indicate that waste was sent to a final disposal site.

The following are some outstanding municipalities in the Santiago Metropolitan Region due to the programs they carry out: La Pintana, Las Condes, and Vitacura, to mention a few that only reported final disposal in sanitary landfills and not in sites linked to recycling and valuation.

1 La Pintana
2 Las Condes
3 Vitacura

4 • FRAMEWORK LAW FOR WASTE MANAGEMENT, EXTENDED PRODUCER RESPONSIBILITY AND PROMOTION OF RECYCLING

4.1 Making Progress Towards Extended Producer Responsibility

Although significant progress has been made in municipal waste management throughout the country, from the regulatory perspective, the emphasis for waste management has been placed only in final disposal and it has become evident that targeting efforts in finding sanitary and environmental solutions for final disposal is not enough and that it is necessary to redefine the approach for managing waste, so that it includes its valuation in all its aspects. Likewise, Chile's current market conditions do not enable fully internalizing negative externalities caused by waste management or reducing its final disposal.

At present, most of the municipalities limit their management to just the final disposal of solid municipal waste through contracts with private companies or through their own management. Notwithstanding, some municipalities have formalized recycling through contracts for segregated collection. Along with that, there is an informal market of recyclers and intermediaries for the collection of paper and cardboard, metal scraps and other recyclable waste.

To face the complexity of this problem, as early as in 2005, the Steering Council of the National Commission for the Environment approved the Integrated Solid Waste Management Policy. The aim of this policy is to "*achieve solid waste management with the minimum risk to people's health and the environment, promoting an integrated vision of waste that ensures a sustainable and efficient development of the sector*" and it points out the concept of Extended Producer Responsibility (EPR) as an important element of waste regulation in the European Union and in other countries that are members of the Organisation for Economic Co-operation and Development (OECD), considering that its development is relevant to Chile.

On the other hand, the country's Environmental Performance Review, conducted by the OECD in 2005, established a series of recommendations to promote the waste valuation in Chile, such as to: "*further apply the polluter pays and user pays principles through appropriate charges (e.g. on waste management, for access to protected areas, for natural resources), with due regard to social constraints*" and "*review the scope for introducing new economic instruments (e.g. product charges on hazardous waste, air emission charges, water pollution charges) and improve trading mechanisms.*" The economic instruments proposed by the OECD use market forces to boost the compliance of environmental goals. This type of mechanism enables internalizing, at the moment consumption occurs, the negative externality associated with the product on demand. Price and quantity instruments are among the most broadly used to control externalities. In the international context, over 45 countries use quantity instruments to promote the waste valuation through the mechanism known as Extended Producer Responsibility (EPR). EPR is a special regime for managing waste in which producers are responsible for organizing and financing waste management of products they sell in the country that are defined as a priority.

Taking these recommendations into account, a draft bill was prepared and, at the same time, working groups were organized with four sectors for the voluntary implementation of extended producer responsibility, targeting products considered as a priority due to the volume of waste or negative externalities associated with their management. The sectors that participated in the working groups were: *tires, motor oil, computer equipment and lead-acid batteries*. In addition, a Clean Production Agreement was signed with four companies of the tire sector and in 2010 a new working group was added for the containers and packaging sector.

Between 2008 and 2014, the Ministry of the Environment hired a series of diagnosis studies regarding the production of certain priority products, the management of their corresponding waste and an analysis of the economic, environmental and social impacts of the implementation of EPR.

In August 2013, the draft bill for the Framework Law for Waste Management and Extended Producer Responsibility was submitted. It was passed by the National Congress in April 2016 and published in the Official Gazette on June 1, 2016 as the Framework Law for Waste Management, Extended Producer Responsibility and Promotion of Recycling. This law regulates the obligations of waste generators, importers and exporters. Among them, producers of priority products will have to organize and finance the collection of waste derived from those products throughout the national territory, as well as its storage, transportation and treatment, ensuring that its management is done by authorized managers registered with the corresponding authority in order to fulfill the waste collection and valuation goals set by the Ministry of the Environment.

The law includes the following six priority products to be regulated:

a) Motor oil
b) Appliances and electronics
c) Containers and packaging
d) Tires
e) Batteries
f) Vehicle batteries

It is important to consider that the information about non-hazardous municipal and industrial waste that has been reported by municipalities and industrial facilities at the national level through SINADER will become a baseline input for the success of EPR, because in order to meet its objective of reducing waste generation and promoting its reuse, recycling or other type of valuation, the authority will need quantitative data on the traceability of waste in Chile. That is, it must know the flow that begins with generation up to its final destination, verifying the different types of treatment applied according to its specific classification.

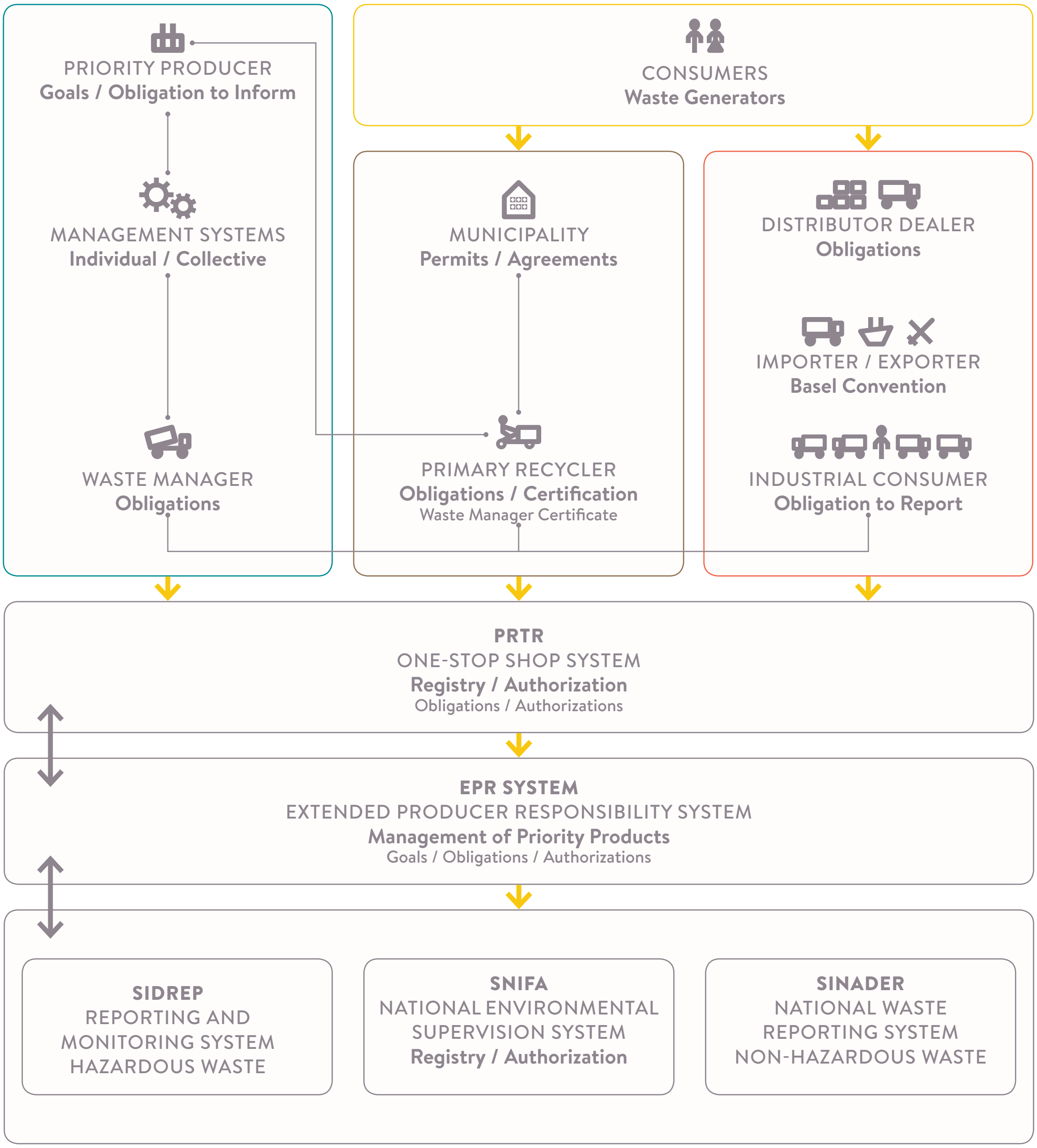
The law considers an Extended Producer Responsibility Information System (web portal), that will be integrated with the PRTR's one-stop shop, thus strengthening information management at the national level, contributing to the verification of waste declarations reported through the SINADER and SIDREP systems.

It is important to point out that the PRTR's one-stop shop will be the place that will enable the compliance with the obligation to register for different types of users, including: priority producers; management systems; primary recyclers; distributors; dealers; importers; exporters; industrial consumers; and waste managers of priority products.

A preliminary diagram of the Extended Producer Responsibility Information System integrated with the PRTR's one-stop shop is presented below.

FIGURE 20

GENERAL DIAGRAM OF THE EXTENDED PRODUCER RESPONSIBILITY INFORMATION SYSTEM INTEGRATED WITH THE ONE-STOP SHOP OF THE POLLUTANT RELEASE AND TRANSFER REGISTRY



Source: MMA, 2016.

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A green perspective | FRANCISCO DONOSO

CHAP **14**

GREEN URBAN INFRASTRUCTURE

CONTENT

INTRODUCTION

The objective of green urban infrastructure is to improve nature's capacity to generate ecosystem goods and services in the city, with biodiversity being its central axis. The benefits provided enable promoting a better quality of life and human well-being, improving biodiversity, increasing protection against climate change and developing an integrated development approach that fosters the sustainable and planned use of the land (European Union, 2013).

Santa Lucia Hill | KARINA BAHAMONDE

GREEN INFRASTRUCTURE

ENVIRONMENTAL BENEFITS
Clean water, air purification, pest control, improvement of the soil's capacity to infiltrate water to aquifers, and reduction of heat islands, among others.

SOCIAL BENEFITS
Improvement of human health and well-being, generation of more attractive and greener cities, raising property value and local distinction, enabling the generation of integrated solutions for energy and transportation, as well as spaces for recreation and opportunities to boost tourism, among others.

CLIMATE CHANGE BENEFITS
Flood mitigation, carbon sequestration and storage, and prevention of catastrophes, among others.

BENEFITS TO BIODIVERSITY
Biological corridors, landscape permeability, habitat improvement, and increased awareness of urban population towards other living organisms that share their habitat.

Source: European Union, 2014.

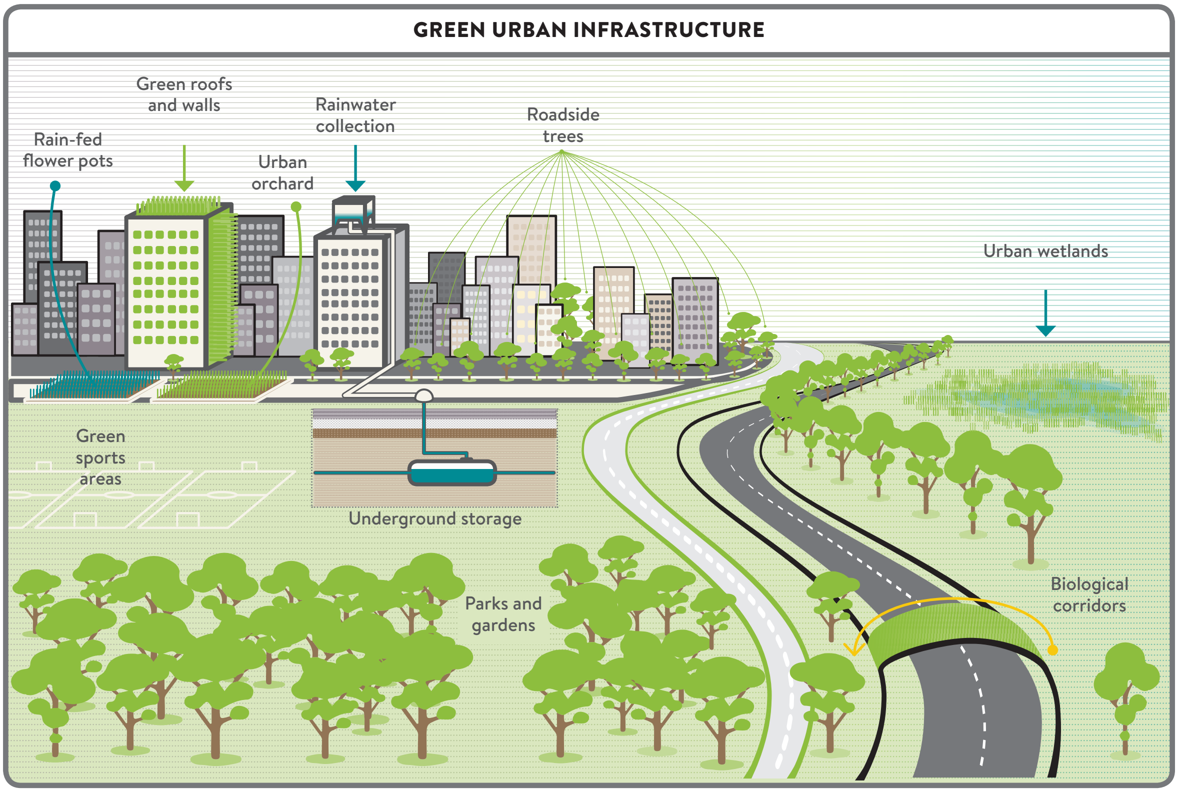
1 • BACKGROUND INFORMATION

Green infrastructure is an emerging concept that seeks to contribute to the sustainability of urban landscapes, from planning interconnected networks of natural and semi-natural spaces that support ecological processes and functions, thus favoring human well-being. Urban green infrastructure fosters the integration of nature in the city, contributes to mitigate environmental impacts and to climate change adaptationand enablesthe creation of more sustainable cities (Ahern, 2007; Tzoulas et al., 2007 ; Benedict and McMahon, 2006).

The urbanization of cities has generated the disappearance or fragmentation of ecosystems, which has negatively affected the functions and services they provide. Because of that, it is necessary to have a planning approach that enables making progress in the understanding and valuation of nature's role in human well-being, emphasizing on connectivity and the ecological processes that interact with urban spaces.

Green infrastructure seeks to make urban growth compatible with environmental protection, highlighting the importance of green areas in generating benefits for city dwellers, highlighting temperature regulation, air purification, noise reduction, areas for jogging, walking or riding bicycles, recreation areas, contact with nature and improving the visual quality of the landscape, among others (Ribeiro and Barao, 2006; Conine et al ., 2004 in www.corredoresverdes.cl, 2016).

FIGURE 01



Source: Authors' own elaboration.

This type of planning considers green areas beyond their landscape or recreation value. According to Vásquez (2016), it includes a series of material manifestations with different purposes, technologies and scales. Because of that, it is said that green infrastructure involves diverse multi-functional spaces, according to the scale being worked on.

Green infrastructure provides a new approach in terms of land use planning and urban planning, since it involves an integrative, strategic and systemic approach of open urban spaces that enables long-term projections and going beyond recreational or scenic beauty appreciation.

ECOSYSTEM SERVICES

Green urban infrastructure seeks to improve and strengthen ecosystem services in the city. It includes green urban spaces (street trees, parks and gardens, green sports areas, urban orchards), other semi-natural or artificial elements (green façades and roofs, rain-fed gardens, permeable pavement) and it incorporates new designs and more efficient management styles that emulate natural processes and improve urban biocapacity (CEA, Ayuntamiento de Vitoria-Gasteiz, 2014).

01

ECOSYSTEM SERVICES

Nature provides a series of benefits that society takes advantage of but, in many cases, underestimates. In order to understand the value of ecosystems for human well-being, the concept of ecosystem services is used to refer to "the direct or indirect contribution of ecosystems to human well-being" (Teeb, 2014).

In the Millennium Ecosystem Assessment (2005), ecosystem services are classified into four groups: provisioning, regulating, supporting and cultural. Provisioning services generate material resources, products and goods (food, fresh water, fuel, and fibers, among others); regulating services are obtained from the regulation of ecosystem processes (climate regulation, disease regulation, and water regulation, among others); supporting services are those necessary for the production of all other environmental services (soil formation, biogeochemical cycles, and primary production, among others); and cultural services are immaterial benefits derived from ecosystems (spiritual and religious, recreation, aesthetics, and educational, among others).

Parque Bustamante | SEBASTIAN SOZA

Characteristics of Green Infrastructure

Multi-Functional

Multi-functional design of green infrastructure involves the coexistence of different uses in a same space, allowing for the simultaneous satisfaction of diverse needs, making it a cross-cutting instrument that supports the development of sustainable cities (CEA, Ayuntamiento de Vitoria-Gasteiz, 2014).

The multi-functional factor is what distinguishes green infrastructure from the so-called grey or concrete infrastructures, which only satisfy one or two needs and which, due to their mono-functionality, do not allow for the inclusion of ecological processes. Grey infrastructure includes highways, energy distribution networks, tap water, and sewerage, among others.

Multi-Scale

Green infrastructure enables multi-scale planning, which requires an explicit knowledge of the relations and connectivity between ecological processes taking place simultaneously at diverse scales, and how these patterns and processes interact in urban environments (Ahern, 2007).

Planning at different scales enables diverse intervention levels, since each scale presents different needs and possibilities for action. Interventions go from the broadest, at the national level, to the narrowest (urban and neighborhood), passing through the intermediate scale (local and municipal), conceiving green infrastructure differently in each of them (CEA, Ayuntamiento de Vitoria-Gasteiz, 2014).

Parque Bicentenario | KARINA BAHAMONDE

NATIONAL SCALE

- ► Public policies
- ► Sectoral plans
- ► Presidential commitments

Scale of highest hierarchy. It is related to decision making by authorities, mostly associated with public policies and guidelines. Examples: Urban Development Policy; Regional Development Strategies; Regional Land Use Plan.

INTERMEDIATE SCALE

- ► Communal Master Plans
- ► Communal Programs

This intermediate scale acts as a nexus between the local and the regional or national. Example: Communal Master Plans; Chile Green Area Plan; Tree Planting Programs.

LOCAL SCALE

- ► Project
- ► Urban Design

It involves local-level decision making by municipal stakeholders and communities. Example: Renato Poblete Park, improvement of street furniture and trees in neighborhood green areas.

Source: Adapted from CEA, Ayuntamiento de Vitoria-Gasteiz, 2014.

Río Clarillo National Reserve, Santiago Metropolitan Region | KARINA BAHAMONDE

GREEN INFRASTRUCTURE

Benedict and McMahon (2002) point out that: “Green infrastructure is our nation’s natural life support system — an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for America’s communities and people.”

Green infrastructure provides the necessary functional and spatial connectivity to ensure the flows of species, genes, mass and energy that sustain ecological processes. In this regard, it goes beyond the atomized logic of conspicuous and functionally isolated areas, proposing an interconnected network of areas that, together, contribute to maintain biodiversity, protect ecosystem processes and ensure the provision of indispensable services for society’s well-being in the short and long terms. Today, there is ample recognition of the contribution of green infrastructure as a climate change adaptation mechanism (Matthews et al., 2015; Andrade et al., 2010). In this regard, the Climate Change Adaptation Plan for Biodiversity, included in the National Biodiversity Strategy, promotes it as part of its actions.

Green infrastructure is made up of protected areas, other areas that are sustainably managed and also by those whose restoration is a condition to recover the functional connectivity of green infrastructure. Thus, the traditional creation of protected areas could be supported by other types of management schemes for biodiversity conservation and ecological restoration such as buffer zones, biological corridors, conservation landscapes (called biodiversity “support areas”), etc. Thus, areas with high ecological value, as well as associated management processes, tools and goals could come together for the zoning of ecological infrastructure.

Green infrastructure can be planned at different consistently connected scales, from the national and even supra-national scale to the regional and local scales. It is worth noting that the Ministry of the Environment is boosting the first studies to identify regional green infrastructure. A first effort is being developed with the support of the University of Concepción, in the Biobío Region, and it is expected to carry out a second study in the Santiago Metropolitan Region. The intention is for these initiatives to contribute to incorporate biodiversity objectives into land use planning and to target resources and tools in favor of an improved conservation of biodiversity and ecosystem services.

2 • GREEN INFRASTRUCTURE IN LAND USE PLANNING

Urban land use planning in Chile has a series of regulatory tools: Inter-commune Master Plan (PRI by its acronym in Spanish)[1]; Commune Master Plan (PRC by its acronym in Spanish)[2]; and Sectional Master Plan[3]. The responsible institutions vary depending on the scale of the tool, Commune and Sectional master plans are within the competence of municipalities, while Inter-commune master plans are the responsibility of the Regional Secretariats of the Ministry of Housing and Urban Planning (SEREMI MINVU by their acronyms in Spanish). Along with these, is the Regional Urban Development Plan, a tool that also falls under the competence of the SEREMI MINVU and deals with urban development at the regional scale (roles of urban centers, areas of influence, and growth goals, among others). That is what defines its guiding and non-binding role. On the other hand, at a regional scale there are Regional Plans for Land-Use Planning (PROT by their acronym in Spanish), under the responsibility of the Regional Governments. The PROTs integrate visions and interests of different sectors that require distinct uses within the territory.

To sum up, the zoning and establishment of urban regulations is defined by the Inter-commune Master Plans, the Commune Master Plans, and Sectional Master Plans. Commune Master Plans have influence over urban areas and establish the regulations and zoning of cities, Inter-commune Master Plans regulate territories between communes and expand their influence towards rural areas. These tools have a significant role when thinking about the cities a society wants and, therefore, should be a contribution to urban sustainability.

Green infrastructure must be conceived as a contribution to the city planning processes and a means to improve and contribute to their sustainability, since it enables applying an integrated and broader approach to green areas, thus incorporating the contribution in terms of ecosystem services. This is pointed out by Reyes-Paecke (2015, p. 76), who states that "adopting a sustainability approach, which links the potential offer of ecosystem services (ecological dimension) with the needs of the population (social dimension) is indispensable for generating long-term policies that integrate the functions of vegetation with the needs of human communities in harmony."

The planning tools of the country enable the creation of green areas and public spaces that can contribute to the adoption of the green infrastructure approach. However, that will depend on the budgetary restrictions faced by local municipal management. This stems from a restricted municipal budget focused only on maintaining the already created green areas. Likewise, public spaces are a weakness of many municipalities that must prioritize health and education issues, or other types of more pressing matters. This is reflected, for example, in the largest cities of the country (Valparaíso, Santiago and Concepción), where urban segregation patterns are evident, revealing a correlation between socioeconomic condition and urban morphology, land size, percentage of soil use and area covered by green areas (Reyes-Paecke, 2015) and less quality and number of ecosystem services.

[1] *Inter-Commune Urban Planning regulates the physical development of urban and rural areas in several communes which, because of their relations, are integrated into a single urban unit (Article 34, General Law on Urban Planning and Constructions).*

[2] *Commune Urban Planning promotes the harmonious development of the commune's territory, especially their population centers, in accordance with the regional goals for economic and social development. Commune urban planning is done through the Commune Master Plan (Article 41, General Law on Urban Planning and Constructions).*

[3] *Whenever the Commune Master Plan requires more detailed studies, Sectional Master Plans will be developed, setting exact trajectory and width of streets, detailed zoning, mandatory construction and remodeling areas, harmonious housing, land affected by expropriations, etc. (Article 46, General Law on Urban Planning and Constructions).*

This urban segregation conditions the number and quality of ecosystem services that could be provided by an adequate green infrastructure in the cities. One example of this is the study conducted in the Santiago Metropolitan Area by De la Maza et al., (2002, p. 353), which identified 84 species with a density of 28 species per hectares in high-income communes, and 41 species with a density of 16 species per hectares. Regarding tree area, according to Hernández (2008, pp. 4-5) the communes with higher socioeconomic income, located in the northeastern sector of the Santiago Metropolitan Area have high percentages of tree cover. For example, Vitacura has 44 percent, La Reina 38.3 percent, and Las Condes 37.3 percent. The communes with lower incomes, located in the southwestern sector of the Santiago Metropolitan Region show lower percentages of cover, such as 4.3 percent in Pudahuel and 6.44 percent in Puente Alto. The central sector of the Santiago Metropolitan Region also presents low values of tree cover: Estación Central with 1.45 percent and Santiago with 1.61 percent. These data enable inferring that ecosystem services in the communes with lower incomes will, hence, be less in number and lower in quality.

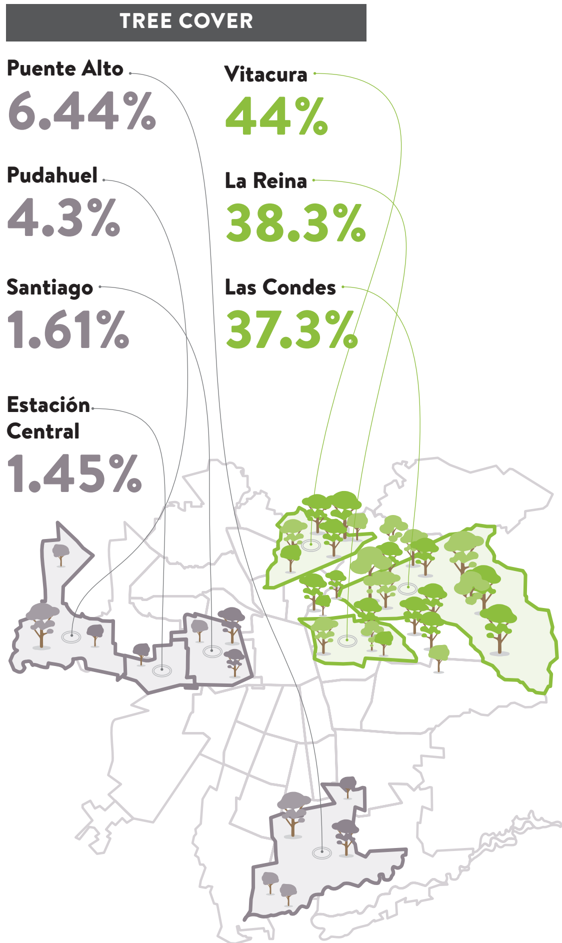
Another aspect that has brought about the current situation of public spaces and green areas in the city is the urban regulation for new urbanization projects, which has contributed to the creation of small green areas with little functionality for the adoption of the green infrastructure concept. This is due to the fact that the urban regulations of the General Ordinance for Urban Planning and Constructions (OGUC by its acronym in Spanish) establishes that new urbanizations must create green areas in proportion to the size of the urbanization (between 7 and 10%), without considering the associated population densities. As a result, there is smaller housing without communal or inter-communal parks, with small backyards and gardens, or even without them, which makes the population even more vulnerable (Reyes-Paecke, 2015 ; Bascuñán et al., 2006).

The challenge faced by urban planning to move forward towards more sustainable cities can be supported by adopting green infrastructure, since it "recognizes the key components of the territory and their interactions, aiming at the integration of human settlements with the territory" (Riveros et al., 2015, p. 104).

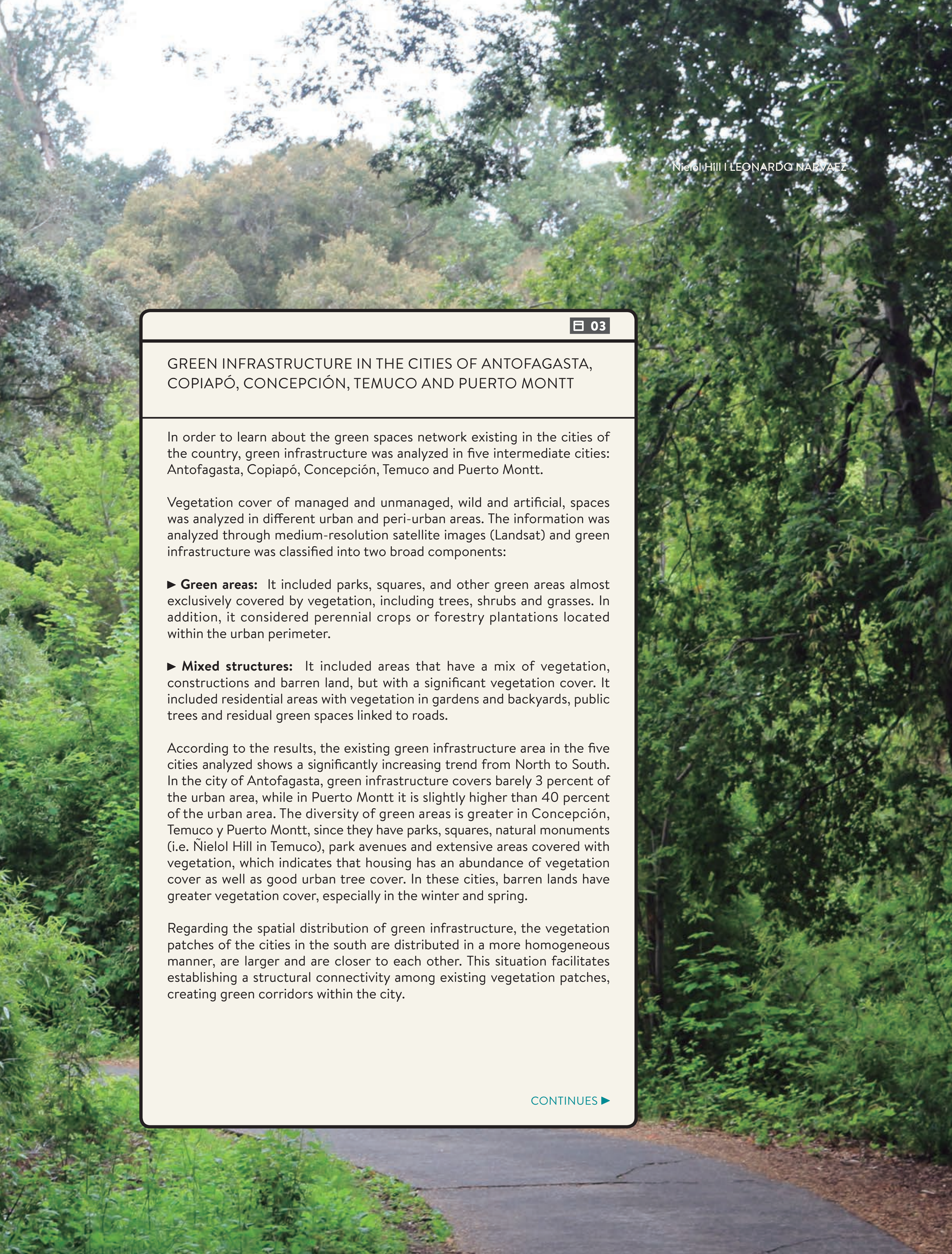
Green infrastructure is in line with the processes to formulate land use planning tools that incorporate the recovery, protection, and safeguarding of natural spaces in riverbanks, streams, and shorelines, among others, which grant a series of benefits to the population and, at the same time, enable planning multi-functional spaces.

In order for Chilean city planning to have a friendlier approach towards the environment, it is necessary to pose the challenge of incorporating the green infrastructure concept into the discussion of urban plans and programs. Academia has already begun research along this line and the public sector is also making progress in the incorporation of public spaces that go beyond an aesthetic value.

The Strategic Environmental Assessment can contribute to integrate the green infrastructure concept in the country's land use planning, facilitating integrated approaches when defining planning and investment strategies by incorporating topics such as natural risk areas, areas for safeguarding environmental values, and environmental management of sacrifice areas, among others.



Source: Authors' own elaboration, based on Hernández, 2008.



Ñielol Hill I LEONARDO NARVAEZ

03

GREEN INFRASTRUCTURE IN THE CITIES OF ANTOFAGASTA, COPIAPÓ, CONCEPCIÓN, TEMUCO AND PUERTO MONTT

In order to learn about the green spaces network existing in the cities of the country, green infrastructure was analyzed in five intermediate cities: Antofagasta, Copiapó, Concepción, Temuco and Puerto Montt.

Vegetation cover of managed and unmanaged, wild and artificial, spaces was analyzed in different urban and peri-urban areas. The information was analyzed through medium-resolution satellite images (Landsat) and green infrastructure was classified into two broad components:

▶ **Green areas:** It included parks, squares, and other green areas almost exclusively covered by vegetation, including trees, shrubs and grasses. In addition, it considered perennial crops or forestry plantations located within the urban perimeter.

▶ **Mixed structures:** It included areas that have a mix of vegetation, constructions and barren land, but with a significant vegetation cover. It included residential areas with vegetation in gardens and backyards, public trees and residual green spaces linked to roads.

According to the results, the existing green infrastructure area in the five cities analyzed shows a significantly increasing trend from North to South. In the city of Antofagasta, green infrastructure covers barely 3 percent of the urban area, while in Puerto Montt it is slightly higher than 40 percent of the urban area. The diversity of green areas is greater in Concepción, Temuco y Puerto Montt, since they have parks, squares, natural monuments (i.e. Ñielol Hill in Temuco), park avenues and extensive areas covered with vegetation, which indicates that housing has an abundance of vegetation cover as well as good urban tree cover. In these cities, barren lands have greater vegetation cover, especially in the winter and spring.

Regarding the spatial distribution of green infrastructure, the vegetation patches of the cities in the south are distributed in a more homogeneous manner, are larger and are closer to each other. This situation facilitates establishing a structural connectivity among existing vegetation patches, creating green corridors within the city.

CONTINUES ▶

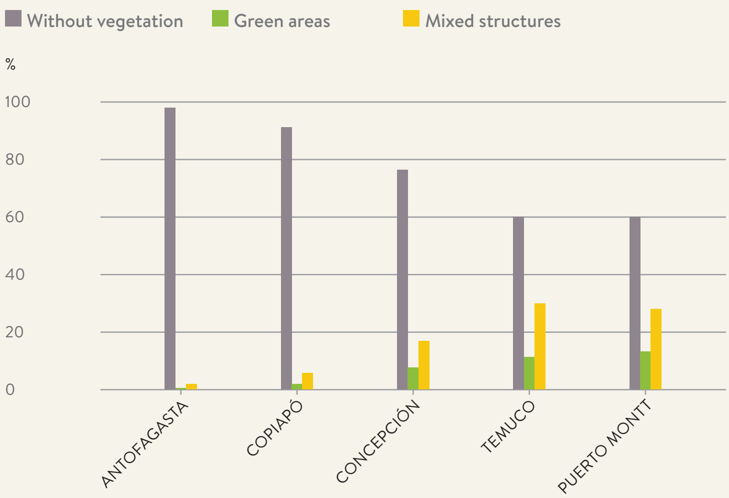
Cerro Ñielol | LEONARDO NARVAEZ

03

The study analyzed the surface temperature of the entire city, establishing differences between the city zones with green areas and those without vegetation. Although average temperature differences are low, there are vegetation patches that reach differences above 2°C in Concepción, Temuco and Puerto Montt. The greatest capacity to cool down temperature is associated with the size of the green area and greater tree cover.

FIGURE 02

GREEN INFRASTRUCTURE IN CHILEAN CITIES



Source: Dobbs et al., 2016.

3 • ELEMENTS FOR IMPLEMENTING GREEN URBAN INFRASTRUCTURE

Despite the fact that in Chile there is no urban planning based on a network of green spaces that promotes the maintenance and improvement of services provided by nature, there is a series of public and private initiatives that have enabled the development of green areas that offer compatibility between the environment and the city's growth.

3.1 Green Areas

Green areas, specifically public ones, which are of free access to the population, face a situation of deficiency in number and quality. This is expressed by different studies in Chile (Reyes et al., 2012; Fundación Mi Parque, 2011; Reyes and Figueroa, 2010; Dascal, 1993 and 1994). The importance of the area covered by green areas, their equipment, their condition and accessibility has been recognized.

These areas (squares, parks or others) in practice are conceived as an extension of home that do not have their own open spaces for the enjoyment and use of the families. This situation is explained by the vertical growth of cities of the last few years as well as by the small area of social housing, which barely consider space for private gardens or backyards.

In this regard, the population's demands for better living conditions, greater social equity and better opportunities are also related to how these types of urban spaces have been built. Because of that, citizens expect to improve their quality of life with them.

According with the results of the survey of perception of quality of life conducted in 2010 by Adimark and the Ministry of Housing and Urban Development, the absence of green areas is important for the quality of life of people. Out of a total of 103 communes that participated in the survey, in 91 communes 50 percent of the people considers the lack of green areas as a problem. **Figure 03** shows the survey results and their relation to the total household income, according to the CASEN 2009. It reveals that the communes with higher incomes do not consider the lack of green areas as a significant problem for their quality of life, a situation that is justified because these communes present greater coverage of green areas, both public and private, and their homes have their own open spaces for recreation.

GREEN AREAS

In Chile, the official definition of a green area is presented in the General Ordinance of the General Law on Urban Planning and Construction, which defines them as "land areas preferably set aside for recreation or pedestrian circulation, generally made up of vegetation species and other complementary elements" (Ministerio de Vivienda y Urbanismo, 2007, p. 4).

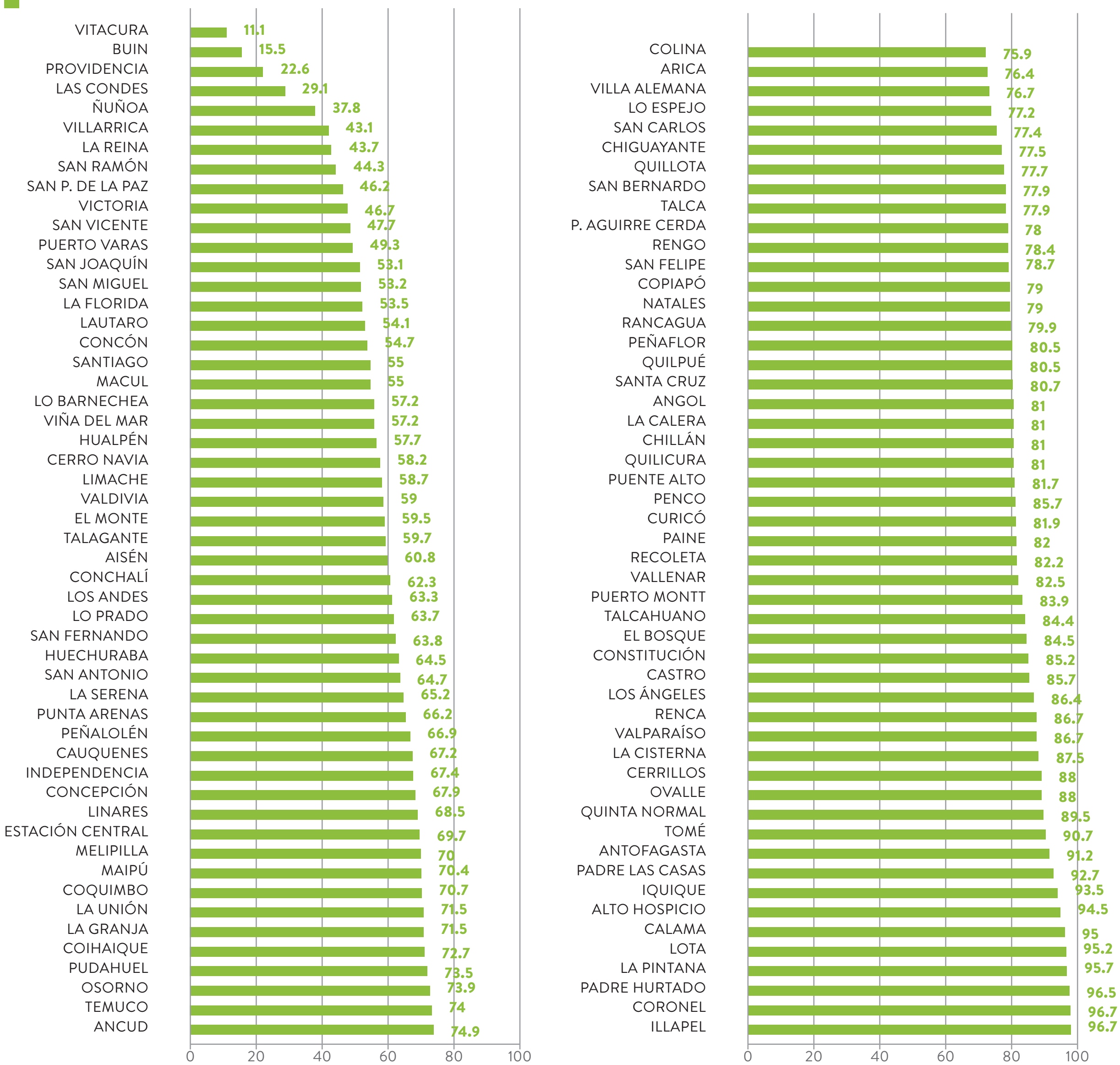
At present, the concept goes beyond recreational and landscape aspects and there's a broadened vision that considers green areas as essential green zones to provide socioeconomic functions and services of great importance for the design of green urban infrastructure (CEA, Ayuntamiento de Vitoria-Gasteiz, 2014).

Parque Bustamante | SEBASTIÁN SOZA

FIGURE 03

IMPORTANCE OF THE LACK OF GREEN AREAS BY COMMUNE

Percentage of people who consider that the lack of green areas is a significant problem in their commune (2010)



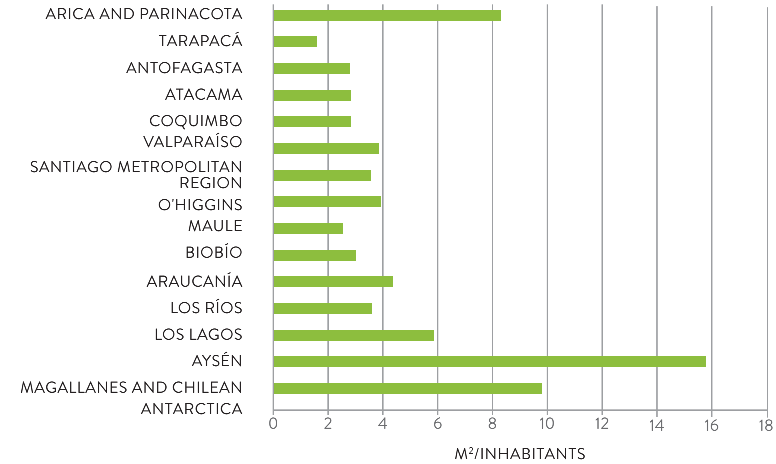
Source: Adimark and Ministry of Housing and Urban Planning, 2010; CASEN, 2009.

3.1.2 Green Areas Maintained by the Municipality

Figure 04 shows the area covered by green areas maintained by the municipality (urban and rural), which do not include information on private areas.

FIGURE 04

AREA COVERED BY GREEN AREAS WITH MAINTENANCE PER PERSON, 2014



Source: Under Secretariat of Regional and Administrative Development (SUBDERE by its acronym in Spanish), 2015; National Statistics Institute (INE by its acronym in Spanish), 2015.

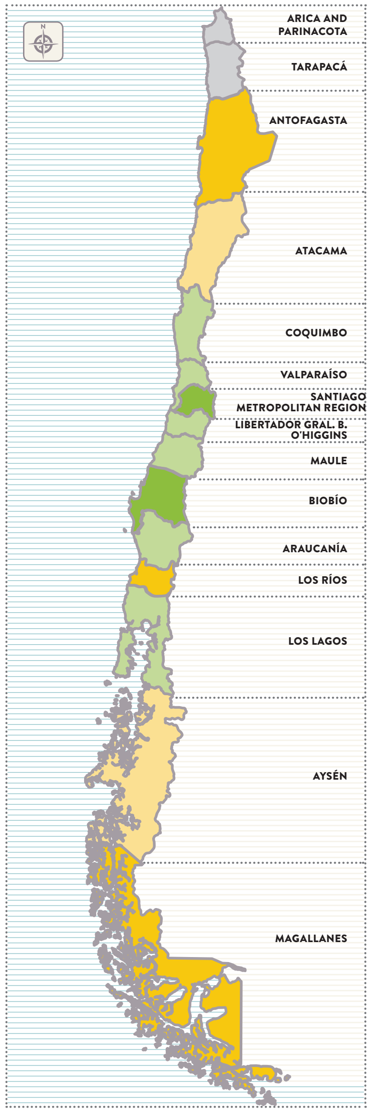
3.1.3 Area and Maintenance of Green Areas

In order to improve the management of urban green areas, in 2014, the Ministry of Housing and Urban Planning (MINVU by its acronym in Spanish) conducted a study of the costs of maintaining green areas (Reyes et al., 2014). All green areas (public and private) were analyzed, based on information obtained through the analysis of satellite images[4]. The country was divided into macrozones (see **Table 01**).

The central macrozone presents the greatest number of green areas, while they are scarcer in the little north zone. The smaller areas (m2) of green areas per person are found in Concepción, Coquimbo and Antofagasta, and the largest areas are located in Talcahuano and Las Condes (Reyes et al., 2014) (see **Figure 05**).

MAP 01

AREA COVERED BY GREEN AREAS WITH MAINTENANCE BY REGION (M²)



300,000 - 500,000
500,001 - 1,000,000
1,000,001 - 2,000,000
2,000,001 - 7,000,000
7,000,001 - 30,000,000

The maps published in this report that refer to or are related to limits or boundaries of Chile do not commit the State of Chile in any way, according to Article 2, letter g of the Decree with Force of Law 83 of 1979 of the Ministry of Foreign Affairs. The cartographic information is based on Datum WGS84 and it is merely referential.

[4] *Whose statistics are different than those published in the National Municipal Statistics System (SINIM by its acronym in Spanish).*

Regarding the maintenance costs obtained, the most significant cost component is labor, equal to 60 and 75 percent of the total cost. There are changes in the design, management, and irrigation techniques that will enable reducing costs and optimizing the use of water resources. Some municipalities in the northern to central areas of the country have implemented water saving measures, selecting species with low irrigation requirements, resistant to solar radiation and high temperatures and adapted to water stress, as well as the reduction of the area covered with grass (Reyes et al., 2014) (see **Table 02**).

TABLE 01

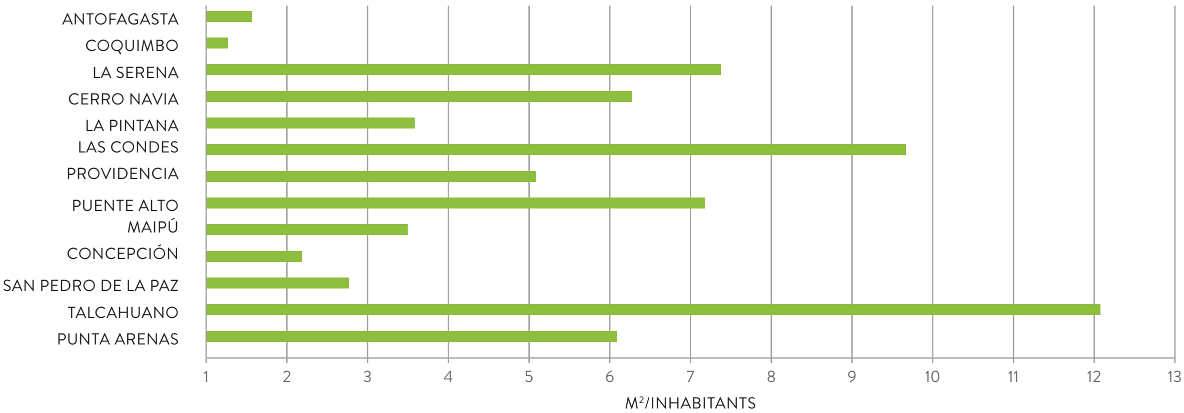
GREEN AREAS BY MACROZONE

MACROZONE	COMMUNE	PROJECTED POPULATION BY 2012 (2002 CENSUS)	GREEN AREAS GREATER THAN 1,000 M^2 (M^2)	TOTAL GREEN AREA PER PERSON
North	Antofagasta	378,923	615,496	1.6
Little North	Coquimbo	219,639	288,078	1.3
	La Serena	82,973	614,033	7.4
Center	Cerro Navia	129,630	812,424	6.3
	La Pintana	201,726	734,715	3.6
	Las Condes	291,971	2,854,323	9.7
	Providencia	126,595	640,604	5.1
	Puente Alto	779,984	5,631,146	7.2
	Maipú	931,211	3,233,745	3.5
South	Concepción	229,684	509,598	2.2
	San Pedro de la Paz	98,973	281,480	2.8
	Talcahuano	171,463	1,513,239	12.1
Extreme South	Punta Arenas	125,483	773,750	6.1

Source: Reyes et al., 2014.

FIGURE 05

TOTAL GREEN AREA PER PERSON



Source: Reyes et al., 2014.

TABLE 02

GREEN AREAS MAINTENANCE COSTS

MACROZONE	COMMUNE	AREA WITH MUNICIPAL MAINTENANCE (M^2)	M^2 COST/MONTH (AVERAGE) ($)	ANNUAL MAINTENANCE COST (MM CLP $)	MONTHLY MAINTENANCE COST (MM CLP $)
North	Antofagasta	958,094	265.93	2264.39	188.70
Little North	Coquimbo	1,219,455	81.49	1192.55	99.38
	La Serena	1,362,079	138.92	1946.65	162.22
	La Pintana	673,000	120.00	906.34	75.53
	Las Condes	2,000,000	183.90	4413.86	367.82
	Providencia	750,000	301.90	2716.86	226.40
	Puente Alto	2,621,701	233.00	2844.08	237.01
	Maipú	3,046,099	180.50	7384.86	615.41
	San Bernardo	1,215,074	162.30	2142.61	178.55
South	Concepción	1,078,000	115.00	1800.00	150.00
	Talcahuano	1,212,693	118.00	1432.17	119.34
Extreme South	Punta Arenas	1,300,000	36.00	848.56	70.71

Source: Reyes et al., 2014

3.2 Urban Parks

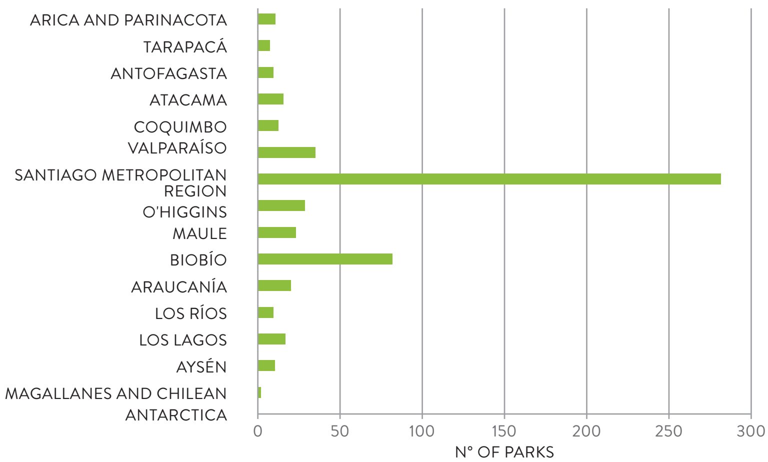
Urban parks are public-use green areas of over 1 hectares (10,000 m^2), located within the urban limits of a city or commune. These areas support recreational, sports, faith, cultural, scientific, and tourism outdoor activities[5]. The construction of a network of urban parks consistent with a green areas system gives way to a series of biological corridors that provide environmental and social benefits to the city.

By 2014, the Metropolitan Region is the one with the greatest area of urban parks, with 2,450 hectares distributed over a total of 282 parks, representing 0.2 percent of its regional area.

[5] *Ministry of Housing and Urban Planning, 2015.*

FIGURE 06

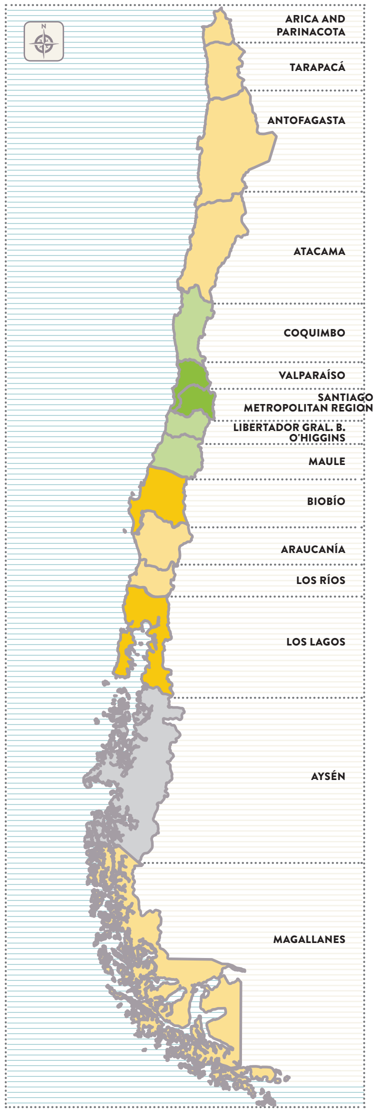
NUMBER OF URBAN PARKS, 2014



Source: Ministry of Housing and Urban Planning, 2015.

MAP 02

AREA OF URBAN PARKS (M^2)



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- 150,000 - 200,000
- 200,001 - 1,000,000
- 1,000,001 - 2,000,000
- 2,000,001 - 8,000,000
- 8,000,001 - 25,500,001

Antofagasta | SOLEDAD GAJARDO

04

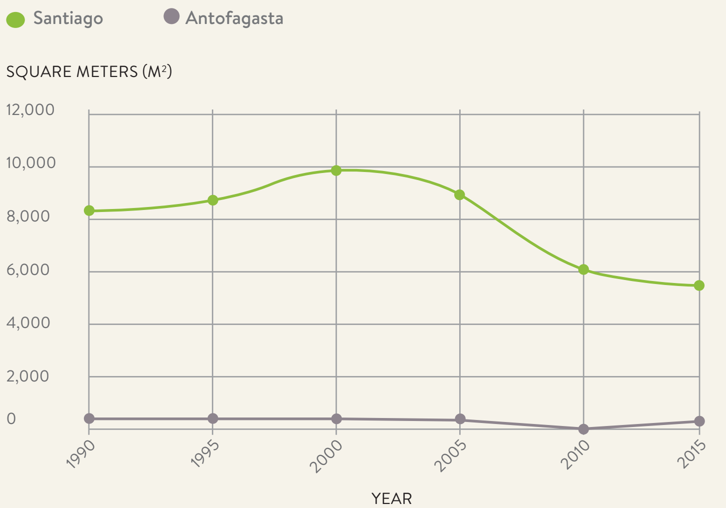
AREA COVERED WITH VEGETATION PER CITY BLOCK

Urban vegetation is that which can be sensed by the NDVI[6] spectrum index within city limits. During 2015, the Ministry of the Environment conducted a study to establish an indicator for average annual vegetation area by city block, with a five-year periodicity, between 1990 and 2015, through Landsat satellite images.

As an example, the results obtained are compared for the cities of Santiago and Antofagasta, with a clear difference in vegetation cover, which is a situation derived from the geographical context of each city. Both cities show a trend of reduced vegetation cover and, in the case of Santiago, there is a clear social segregation in the distribution of vegetation, explained by the differences between communes, particularly in the private space.

FIGURE 07

AVERAGE ANNUAL VEGETATION AREA PER CITY BLOCK



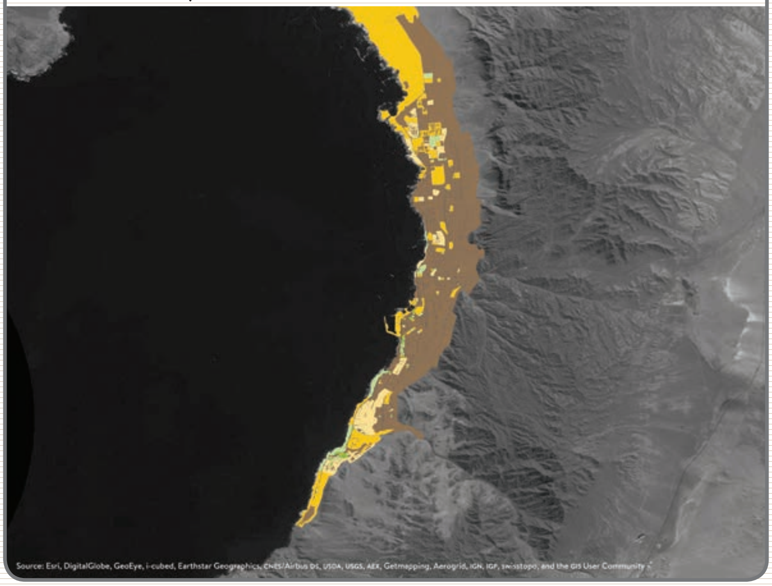
Source: Centro de Inteligencia Territorial, Universidad Adolfo Ibáñez (CIT-AUI), 2015.

[6] *Normalized Difference Vegetation Index (NDVI): It is an index used to measure the normalized difference between visible and near-infrared sunlight reflected by plants, providing a measure of the amount, quality and development of vegetation cover and its vigor in extensive areas (Source: CIT-UAI, 2015).*

MAPS 03 AND 04

ANNUAL AREA COVERED WITH VEGETATION

ANTOFAGASTA, 2015



SANTIAGO, 2015

PERCENTAGE OF VEGETATION PER CITY BLOCK

0.00 | 0.01 - 2.69 | 2.70 - 11.21 | 11.22 - 27.86 | 27.87 - 100.00

Source: Centro de Inteligencia Territorial, Universidad Adolfo Ibáñez (CIT-AUI), 2015.

3.3 Urban Trees

City trees are usually considered because of their aesthetic and decorational benefits. At present, this vision has expanded, recognizing it as a key element when planning green infrastructure. Its benefits include the reduction of temperature and the generation of microclimates, the reduction of pollutants, carbon sequestration and storage, regulation of erosion, retention of soil humidity, urban recreation and decoration, among others.

3.3.1 Reduction of pollutants

One of the ecosystem services related to city trees is the removal of urban pollutants, since trees capture particulate matter and suspended gases in the air. Likewise, trees sequester carbon, an element generated by the combustion of fossil fuels and that trees reduce through their photosynthesis process. It is estimated that city trees in Santiago currently sequester approximately 34,000 metric tons of carbon each year (Hernández, 2008).

The study conducted by Dobbs and Reyes-Paecke (2016) quantified the provision of ecosystem services of urban trees in 13 Chilean cities in 2005 and 2015, identifying the change in tree cover and in the removal of pollutants between both years. In order to perform this measurement, the study

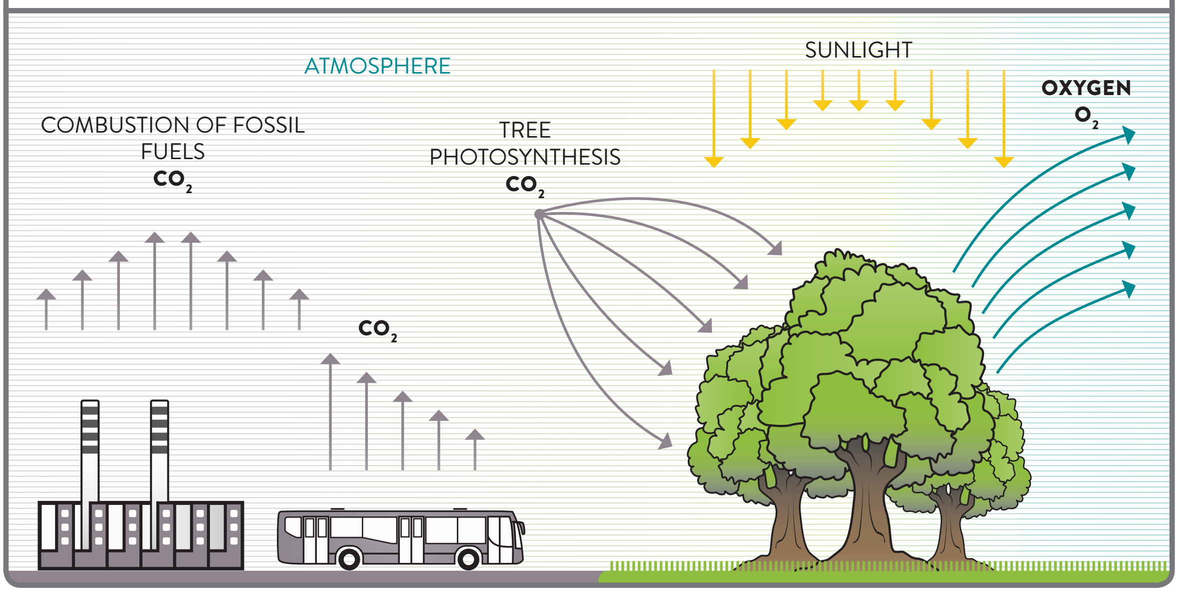
BENEFITS FROM TREES

1. Carbon Sequestration — CO_2
2. Temperature Regulation — °T
3. Water Provision (Quality and Quantity)
4. Oxygen Generation — O_2
5. Impact Buffer for Natural Phenomena
6. Soil Protection and Recovery (slope stability)
7. Noise Barrier (reducing it between 10 and 12 decibels)
8. Biodiversity
9. Landscape and Recreation
10. Mental Health and Well-Being

Source: Authors' own elaboration, based on Gutiérrez et al., 2010.

FIGURE 08

CARBON SEQUESTRATION



identified the coverage of wild trees, street trees, trees in urban parks, shrubs, grass and grasslands. A calculation was then made of the annual volume of pollutants removed by trees in each city, using the i-TreeMR software. The sequestration of the most frequent pollutants in Chilean cities - CO, NO_2, O_3, SO_2, $PM_{2.5}$ and PM_{10} - was estimated, along with the sequestration and storage of carbon.

Between 2005 and 2015 street trees diminished significantly throughout the country, with the cities of Iquique, Talca and Coyhaique the ones showing the greatest reductions. In contrast, Puerto Montt and Rancagua showed an increase in street tree cover. These differences are more linked to urban processes than to climate factors. The reduction in the sequestration of pollutants in most of the analyzed cities stands out. Between 2005 and 2015, pollutant removal dropped by 47 percent in Iquique, while in Viña del Mar and Valparaíso, the pollutants sequestration rate increased by approximately 23 percent.

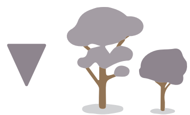
Street trees are predominant in all cities, except for Punta Arenas and the conurbations of La Serena-Coquimbo and Valparaíso-Viña del Mar. Wild trees are predominant in Valparaíso and Viña del Mar. In these last two cities, the topography has contributed to maintaining an unplanned cover, which has facilitated the permanence of remnant native species and other alien ones that have adapted and have the capacity to grow spontaneously, particularly in creeks and slopes facing South. The greatest proportional coverage of shrubs is observed in the conurbation of La Serena-Coquimbo, reflecting its semi-arid condition and the importance of shrubs as wild vegetation, since they are also found in abandoned agricultural lands and in the riverbanks of the Elqui river. But there is also a significant contribution made by decorative trees present in public and private spaces.

STREET TREE COVER

Between 2005 and 2015, street trees diminished significantly throughout the country:

IQUIQUE, TALCA AND COYHAIQUE

GREATEST REDUCTION OF COVERAGE

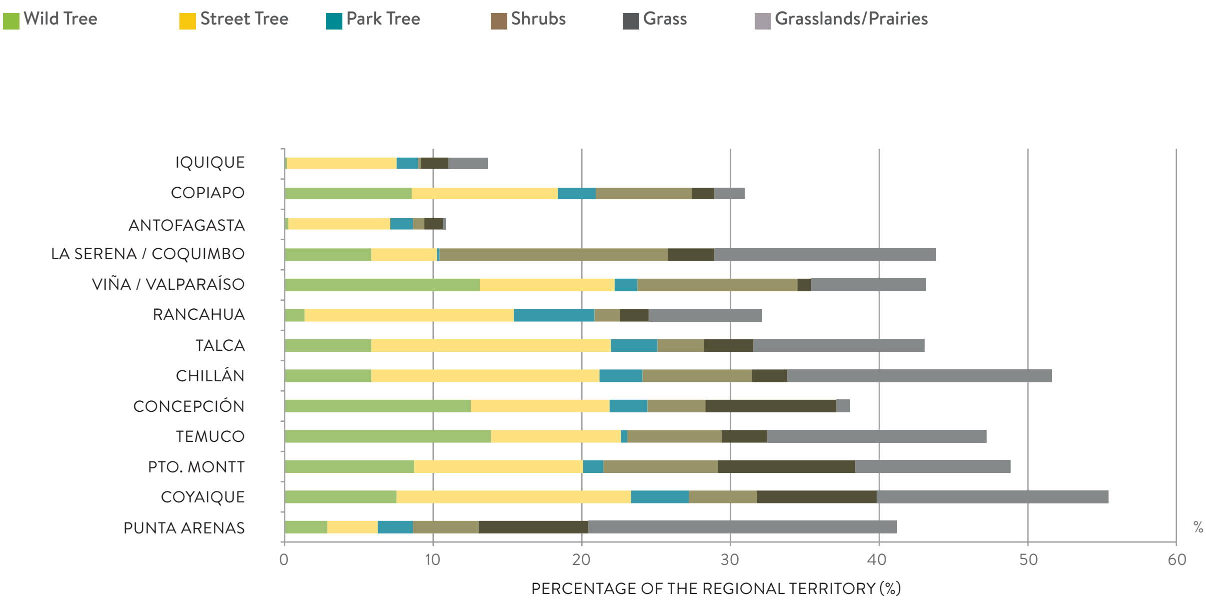


PUERTO MONTT Y RANCAGUA

INCREASE IN COVERAGE

FIGURE 09

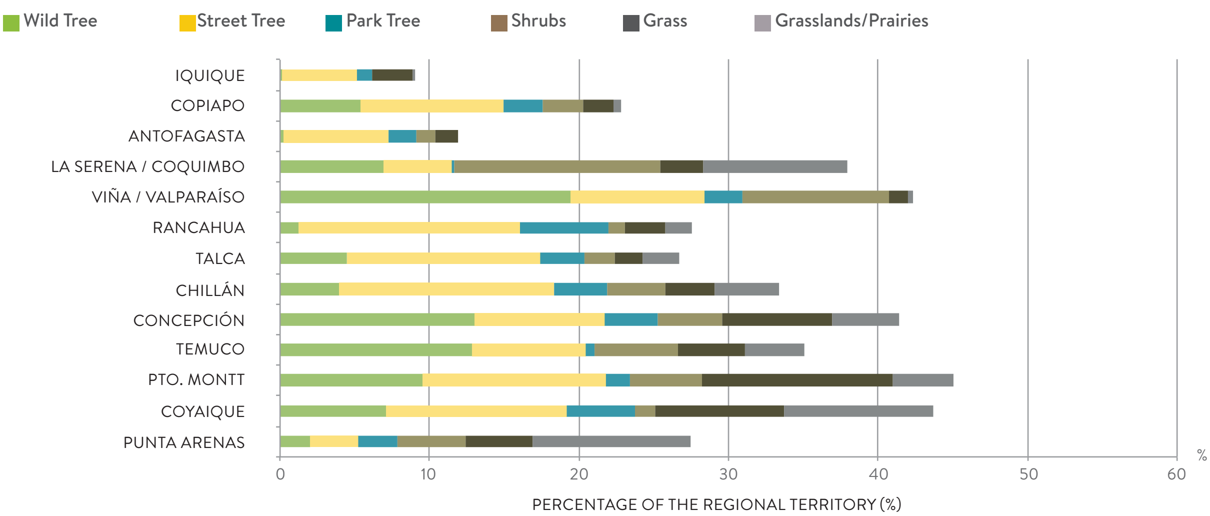
PERCENTAGE OF URBAN LAND COVERED BY TYPE OF VEGETATION, 2005



Source: Dobbs and Reyes, 2016.

FIGURE 10

PERCENTAGE OF URBAN LAND COVERED BY TYPE OF VEGETATION, 2015



Source: Dobbs and Reyes, 2016.

TABLE 03

AIR POLLUTANTS REMOVED OR SEQUESTERED BY URBAN TREES (KG/YEAR)

CITY	PM10		PM2.5		O3		CO KG/YEAR	
	2005	2015	2005	2015	2005	2015	2005	2015
Iquique	16,440	11,190	289.27	196.80	8,100	5,510	140.00	95.30
Copiapó	22,990	19,290	956.29	802.70	51,410	43,150	788.27	661.66
Antofagasta	5,610	5,940	135.27	143.11	14,810	15,670	444.79	470.57
La Ser /Coq	52,120	58,390	2,170.00	2,430.00	116,560	130,600	1,790.00	2,000.00
Viña / Valp	55,540	72,290	2,975.00	1,080.00	125,040	162,750	7,550.00	9,830.00
Rancagua	11,500	12,060	1,660.00	1,740.00	69,000	72,390	2,000.00	2,100.00
Talca	10,320	8,370	3,350.00	2,720.00	35,870	29,090	1,280.00	1,040.00
Chillán	13,280	12,120	2,790.00	2,550.00	41,280	37,680	1,270.00	1,150.00
Concepción	37,510	38,960	8,770.00	9,110.00	138,130	143,450	2,660.00	2,760.00
Temuco	31,460	28,760	5,650.00	5,160.00	88,040	80,480	1,460.00	1,330.00
Pto Montt	8,380	9,170	1,710.00	1,870.00	30,710	33,630	443.24	485.30
Coyhaique	4,620	4,050	828.75	726.50	12,920	11,330	213.90	187.50
Pta. Arenas	3,060	2,790	585.53	534.60	12,070	11,020	128.94	117.70
CIUDAD	NO2		SO2		CO2 SEQ		CO2 STORED	
	2005	2015	2005	2015	2005	2015	2005	2015
Iquique	320.00	383.40	316.48	215.40	1,340,000	915,330	49,970,000	34,000,000
Copiapó	5,700.00	4,790.00	3,780.00	3,180.00	10,130,000	8,500,000	220,090,000	184,740,000
Antofagasta	700.80	741.42	515.45	545.33	3,830,000	4,050,000	83,130,000	87,950,000
La Ser /Coq	12,930.00	14,490.00	8,580.00	9,610.00	22,970,000	25,740,000	499,000,000	559,120,000
Viña / Valp	19,900.00	25,910.00	7,990.00	10,410.00	32,130,000	41,820,000	635,200,000	826,800,000
Rancagua	16,030.00	16,820.00	4,310.00	4,530.00	10,030,000	10,530,000	198,370,000	208,140,000
Talca	8,130.00	6,590.00	2,680.00	2,180.00	8,470,000	6,870,000	269,220,000	218,320,000
Chillán	11,170.00	10,190.00	2,180.00	1,990.00	12,210,000	11,150,000	241,460,000	220,350,000
Concepción	18,850.00	19,580.00	5,890.00	6,110.00	22,520,000	23,390,000	715,690,000	743,250,000
Temuco	11,490.00	10,510.00	3,770.00	3,450.00	15,670,000	14,330,000	467,210,000	427,120,000
Pto Montt	3,950.00	4,320.00	1,440.00	1,580.00	4,750,000	5,200,000	141,500,000	154,940,000
Coyhaique	1,690.00	1,480.00	553.65	485.40	2,300,000	2,020,000	68,570,000	601,100,000
Pta. Arenas	1,140.00	1,040.00	327.76	299.30	1,930,000	1,760,000	67,240,000	61,390,000

Source: Dobbs and Reyes, 2016.

Beech in Santiago | CAROLINA RODRIGUEZ

05

STRUCTURE AND COMPOSITION OF TREES IN PARKS OF THE SANTIAGO METROPOLITAN REGION*

The study, conducted in 16 parks of the Santiago Metropolitan Region described as urban and natural in the Parks Inventory of the Ministry of Housing and Urban Planning (MINVU), sought to survey existing tree species and compare the richness and diversity of trees in the parks managed by the Santiago Metropolitan Park, so that tree planting will be done in accordance to the available resources and the species present in the region, thus favoring the use of native species.

The parks of the Santiago Metropolitan Region present an abundance of alien species (64 percent) that surpasses that of native species (36 percent). This abundance is more pronounced in urban parks, where it reaches 71 percent, while in natural parks 51 percent are alien species and 49 percent are native. The two most abundant species are *Platanus orientalis var. acerifolia l.* (oriental plane), with 14 percent of relative abundance, and the *Quillaja saponaria molina* (quillay), with 13.8 percent. The oriental plane is the most abundant and dominant species in urban parks (15.4 percent), while the quillay is the most abundant in natural parks of Santiago (20.9 percent).

Most of the existing trees are species with low water requirement (55 percent), while the ones with the greatest demand for water correspond to 18 percent and are mainly located in urban parks.

The ecological heterogeneity of parks in the Santiago Metropolitan Area (urban and natural, according to the classification of the MINVU's Parks Inventory) is quite diverse. There are natural parks such as Cerro Blanco (17 ha), which presents the greatest richness with 52 species, while the Bicentenario de la Infancia urban park (4 ha) has only 8 species, a diversity that does not depend or is not explained just by the size of the park.

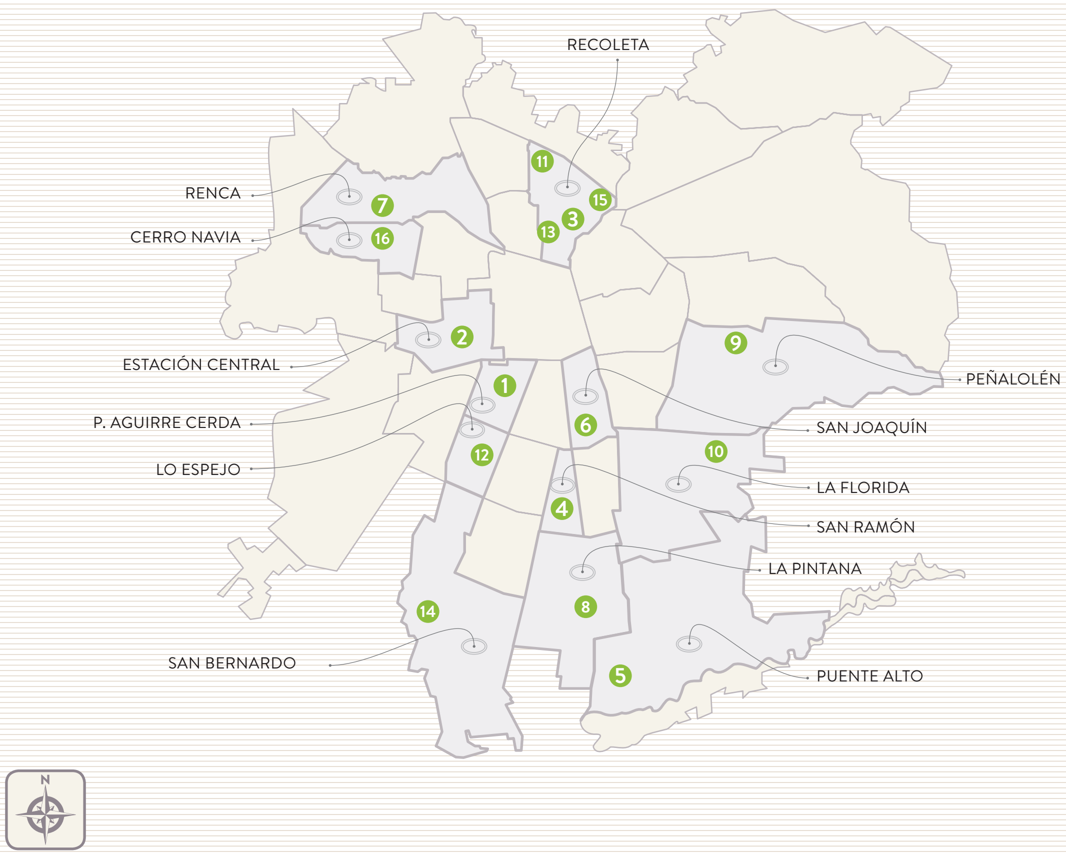
*Correa-Galleguillos, P. and De La Barrera, F. 2014

FIGURE 11

DISTRIBUTION OF ANALYZED PARKS – SANTIAGO METROPOLITAN REGION

URBAN PARKS	YEAR	COMMUNE	AREA (HA)
1 **André Jarlan (AJ)**	1997	P. Aguirre Cerda	10.9 HA
2 **Bernardo Leighton (BL)**	S/I	Estación Central	7.2 HA
3 **Bicentenario de la Infancia (BDI)**	2012	Recoleta	3.9 HA
4 **La Bandera (LB)**	1987	San Ramón	9.2 HA
5 **La Cañamera (L. Cañ.)**	2010	Puente Alto	3.8 HA
6 **La Castrina (L. Cas.)**	1997	San Joaquín	7 HA
7 **Lo Varas (LV)**	1992	Renca	1.4 HA
8 **Mapuhue (Ma)**	1996	La Pintana	5.7 HA
9 **Peñalolén (Pe)**	2006	Peñalolén	8 HA
10 **Quebrada de Macul (QM)**	2007	La Florida	4.6 HA
11 **Santa Mónica (SM)**	S/I	Recoleta	10.2 HA
12 **Violeta Parra (VP)**	2013	Lo Espejo	2.5 HA

NATURAL PARKS	YEAR	COMMUNE	AREA (HA)
13 **Cerro Blanco (CB)**	1990	Recoleta	17.3 HA
14 **Cerros de Chena (CC)**	2002	San Bernardo	27 HA
15 **Mahuidahue (Mah)**	S/I	Recoleta	10.6 HA
16 **Mapocho Poniente (MP)**	S/I	Cerro Navia	12.9 HA



3.4 Green Corridors

Green corridors are linear planned (linear parks, coastal walkways) or natural (urban riverbanks, shoreline) spaces that contain vegetation. They are components of green infrastructure because they provide connectivity. Because of that, they require special attention in urban planning, since they create connections that are essential for ecological processes, such as the movement of urban birds, seed transportation and propagules. They can also be designed to facilitate the circulation of rainwater, reducing risks of flood, and the regulation of urban heat islands.

3.4.1 Riverbank Corridors

Riverbanks can act as green corridors, generating multiple ecosystem services, including erosion control, water quality improvement, habitat, flood control, temperature regulation, and reduction of noise levels (Schreier et al., 2004; Apan et al., 2002, in Vásquez, 2016; Maekawa and Nakagoshi, 1997). In addition, they provide cultural services as non-motor transportation sites (walking, jogging and riding bicycles), opportunities for recreation, conservation of cultural heritage, and aesthetic quality (Hellmund and Smith, 2006; in Vásquez, 2016).

There is a series of riverbanks inserted in urban areas and large cities, such as the riverbanks in Santiago, which have mostly been absorbed by the city's urbanization. According to Vásquez (2016), 30 percent of the urban riverbank of the Mapocho river is occupied by residential sectors, industries and urban highways, while the rest is lined with green and open spaces, which in some parts reach high levels of spatial connectivity. Likewise, it presents significant ecosystem services for recreation, non-motor transportation and wind corridors, as well as flood mitigation and a cooling effect. In this regard, the Mapocho river is an essential element for planning a green infrastructure system in the city of Santiago.

CORRIDORS

According to Ahern (1995), **"greenways are networks of land containing linear elements that are planned, designed and managed for multiple purposes** including ecological, recreational, cultural, aesthetic, or other purposes compatible with the concept of sustainable land use."

Rosenberg et al. (1997) poses that **a corridor is a linear landscape element that provides for movement between habitat patches,** but not necessarily reproduction.

Riverbank Mapocho River | CARLA SANTIBÁÑEZ

06

CONSTRUCTION OF BIKE LANES

The construction of bike lanes favors non-motor mobility within the city, reducing air pollution levels generated by the vehicle fleet. Thus, bike lanes are an important element when planning and designing a city's green infrastructure.

In 2014, the construction of 190 kilometers of high-standard bike lanes was announced for 150 axes distributed throughout the country's 15 regions, benefiting the regional capitals and intermediate cities. Public investment is estimated at CLP $42 thousand million and favors cities and neighborhoods inhabited by the most vulnerable families (MINVU, 2014).

TABLE 04

CONSTRUCTION OF BIKE LANES

REGION	CITY	KM	ROAD AXES
Tarapacá	Iquique	3.4	Esmeralda, Orella.
	Alto Hospicio	3.9	Las Parcelas, La Rampa.
Antofagasta	Antofagasta	10.0	Costanera, Av. República de Croacia-Universidad de Chile.
	Calama	10.3	Borde Río, Diego de Almagro, Vasco de Gama, Sotomayor, Granaderos, Grau.
Atacama	Copiapó	5.0	Los Carrera.
Coquimbo	La Serena	2.5	Perú, Gaspar Martín, Zorrilla, Cuatro Esquinas, Av. del Mar.
Valparaíso	San Felipe	9.4	Salinas, Chacabuco, Benigno Caldera, Arturo Prat, Merced, Tocornal, Encon.
	La Calera	8.9	J.J. Pérez, teresa, Pedro de Valdivia, Carrera Pinto, Lautaro, Carrera, Josefina, Aldunate, Arturo Prat, Padre Hurtado.
Libertador G.B. O'higgins	Santa Cruz	4.6	Adriano Días, Rafael Casanova, Diego Portáles, Erázuriz, Los libertadores, O'Higgins, San Martín.
	San Vicente	3.9	El Cristo, Germán Riesco, Diego Portales.
	Rancagua	4.5	Manuel Montt, Diego de Almagro.
Maule	Talca	9.2	Alameda, 11 Oriente, 12 Norte, 5 Oriente, 6 Oriente.
Biobío	Los Ángeles	2.6	Ricardo Vicuña, Alcázar, Patricio Lynch.
	Concepción	6.2	O'Higgins, C. Avello, Ongolmo, Manuel Rodríguez, Angol, Janequeo.

CONTINUES ▶

06

REGION	CITY	KM	ROAD AXES
Biobío	Talcahuano	5.8	Desiderio García, J.Sosa, Las Hortensias, lago Llanquihue, Río Maule.
	Coronel	1.8	Alcalde Oñate, Los Chiflones.
	Hulapén	1.3	Curanilahue, Nueva Imperial.
Araucanía	Villarrica	4.2	Juan Antonio Ríos, Vicente Reyes, Calle Matta, Julio Zegeres.
	Temuco	14	Luis Durand, Gabriela Mistral, Javiera carrera, Hochstetter, Pablo Neruda, Pedro de Valdivia, Los Poetas.
	Padre Las Casas	6.3	Av. Huichachue, Los Araucanos, Av. La Quebrada, Sarmiento, Av. Martín Alonqueo, Av. Circunvalación.
	Angol	7.6	Circunvalación Sur, Ilabaca, Camino Utaco, Los Confines, Los Coihues, Rancagua.
	Victoria	3	Circunvalación Sur, Tacna, Sargento Aldea, San Martín.
Los Lagos	Puerto Montt	11.1	Av. Norte Sur, Av. Norte Sur 2, Av. Ferrocarril, Av. Austral, Presidente Ibáñez.
	Osorno	9.1	Bolivia/Acapulco, Meyer/Argentina, Chillán, Santiago, Por la Razón o la Fuerza, Victoria, Inés de Suarez, Av. Zenteno, Ercilla, Almagro-Argomedo, Buenos Aires, Hollstein, Rene Soriano, Av. Real, Concepción.
	Puerto Aysén	6.4	Ibar, Sargento Aldea, Municipal, Childo Vera, Benigno Díaz, Costanera, Eleuterio Ramírez.
Magallanes	Punta Arenas	6.4	Manantiales, Bulnes, Costanera Sector Norte.
	Puerto Natales	6.4	Philipi, Ebherhad, Prat, Esmeralda, E. Ramírez, Pardo Bulnes, Yungay, Lillo.
Santiago Metropolitan Region	Buin	7	Santa María, Manuel Rodríguez, O'Higgins, San Martín, J.A. Bravo, Camino Buin- Maipo.
	Talagante	4.8	O'Higgins Oriente, O'Higgins Poniente.
Los Ríos	Valdivia	4.7	Gral. Lagos, Prat/San Carlos, C. Henríquez, A. Muñoz, Baquedano, Pinto, Canal Catrico.
	La Unión	2	Riquelme, Cayetano Letelier, Los Laureles, R. Boettcher.
Arica and Parinacota	Arica	4.4	Santa María.
TOTAL		**190.3**	**Over 150 axes throughout the entire country.**

Source: MINVU 2014.

3.5 Green Roofs and Walls

Green cover allows for the development of an urban habitat, which contributes to generate environmental ecosystem services in it. These types of elements enable providing a sustainable solution to existing constructions in cities, since they have benefits such as thermal and acoustic insulation, rainwater collection, biological corridors and the reduction or urban heat islands.

In the country, there are some green covers that have been incorporated into new buildings. Several public and private buildings have implemented these types of technologies. However, there is no legislation that forces constructions to include this element as part of the project. Neither are there incentives for its inclusion.

ⓘ Heat islands refer to the increase of temperature in the cities and originate due to the large amount of buildings and pavement existing in the city that have replaced vegetation.

El Carmen Hospital (Maipú), Vegetation Cover | TECPRO.

Dra. Eloísa Díaz Insunza Hospital (La Florida) Vegetation Cover | TECPRO

4 • ACTIONS RELATED TO GREEN INFRASTRUCTURE ELEMENTS

4.1 Green Areas

The main current legislation in Chile, which includes aspects related to the creation and management of green areas, is made up of the Organic Constitutional Law on Municipalities (Law 18.695), the General Law on Urban Planning and Constructions (Decree with Force of Law 458), General Ordinance on Urban Planning and Constructions (Supreme Decree N° 47), and the Forest Law (Supreme Decree N° 4.363). Other relevant regulations encompass regional urban development plans, inter-commune master plans, commune master plans, sectional plans and municipal ordinances (Vargas and Balmaceda, 2011).

The creation and conservation of green areas is mainly done through municipal budgets, a situation that creates huge inequalities among rich and poor communes. Other public agencies that also provide funding for the creation and conservation of green areas are the Ministry of Housing and Urban Planning (MINVU by its acronym in Spanish), the Regional Governments (GORE by its acronym in Spanish) and the Concessions Law of the Ministry of Public Works (MOP by its acronym in Spanish), among others.

In addition, there are non-governmental organizations working for the construction and transformation of public spaces integrated with the environment and society. These include the Fundación Mi Parque and the Corporación Cultiva, among others. Likewise, the private sector also contributes to the creation of green areas through mitigation projects.

On the other hand, since 1992, the MINVU has been developing the Urban Parks Program, which seeks to reduce the green areas deficit in the country, along with their uneven distribution.

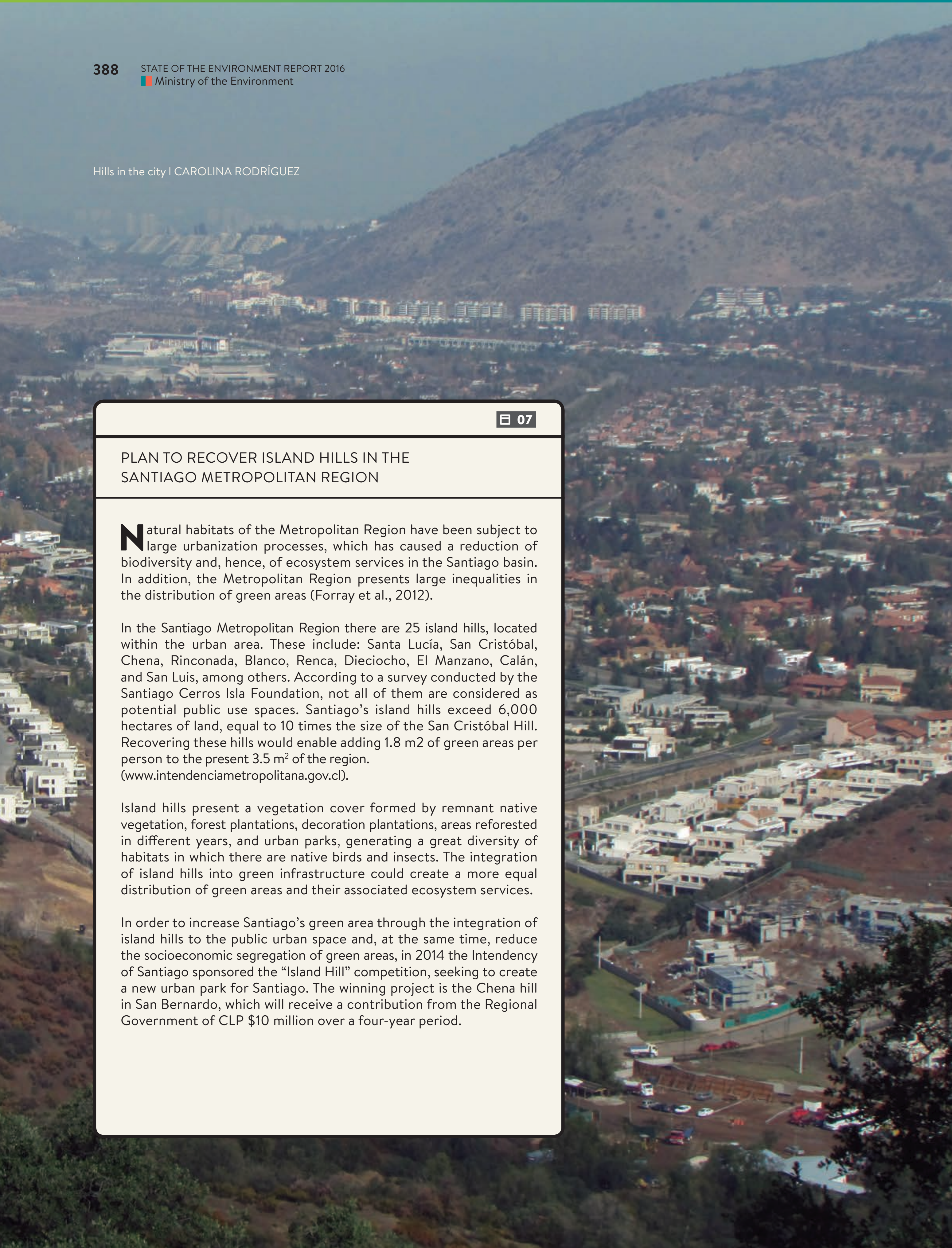
During 2014, the President of the Republic announced the “Green Areas Chile Plan”, which includes a Parks and Green Areas Program aimed at creating and conserving urban parks, particularly in the areas with the greatest deficit of green areas and highest social vulnerability. Through this program, the MINVU will incorporate 15 new parks to the 19 urban parks already being conserved in the Metropolitan Region, thus generating a national network of 34 parks managed by said ministry, which will be finalized by the end of 2018.

4.2 Forestation Program of the National Forestry Corporation

The forestation program was launched in 2010 and is executed by the National Forestry Corporation (CONAF by its acronym in Spanish). Its main objectives are to improve people’s quality of life through the multiple benefits provided by trees.

In 2014, the program was restructured as the +Trees for Chile program, which includes handing trees, working with the community and providing assistance for planting and caring for the trees. CONAF has 25 greenhouses, six Conditioning Centers and one Collection Center, which are distributed throughout the country. Each region produces the species that are more appropriate for its area and 51 percent of the entire production is made up of native species. In addition, 22 endangered species are being reproduced in the greenhouses, such as the Monkey Puzzle Tree, the Toromiro, the Chilean Palm, the Pitao, and the Belloto, among others (CONAF, 2015).

During 2014, 2,394,499 plants were handed out, out of which 56 percent were native species. For 2015, the goal was to hand out 1,530,000 plants and to create, by 2018, 115 community programs in the lowest income communes (CONAF, 2015).



Hills in the city I CAROLINA RODRÍGUEZ

07

PLAN TO RECOVER ISLAND HILLS IN THE SANTIAGO METROPOLITAN REGION

Natural habitats of the Metropolitan Region have been subject to large urbanization processes, which has caused a reduction of biodiversity and, hence, of ecosystem services in the Santiago basin. In addition, the Metropolitan Region presents large inequalities in the distribution of green areas (Forray et al., 2012).

In the Santiago Metropolitan Region there are 25 island hills, located within the urban area. These include: Santa Lucía, San Cristóbal, Chena, Rinconada, Blanco, Renca, Dieciocho, El Manzano, Calán, and San Luis, among others. According to a survey conducted by the Santiago Cerros Isla Foundation, not all of them are considered as potential public use spaces. Santiago's island hills exceed 6,000 hectares of land, equal to 10 times the size of the San Cristóbal Hill. Recovering these hills would enable adding 1.8 m2 of green areas per person to the present 3.5 m^2 of the region. (www.intendenciametropolitana.gov.cl).

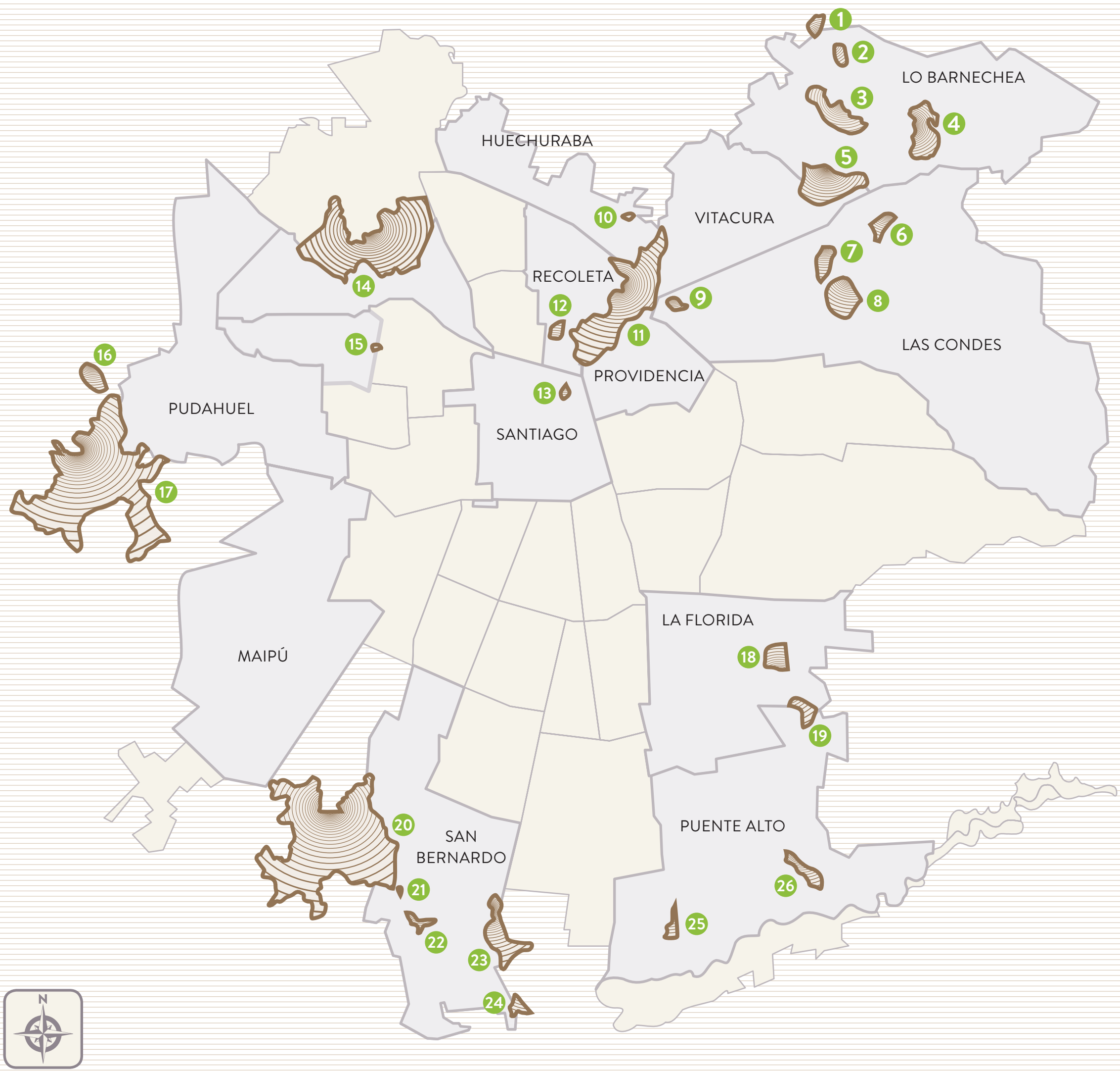
Island hills present a vegetation cover formed by remnant native vegetation, forest plantations, decoration plantations, areas reforested in different years, and urban parks, generating a great diversity of habitats in which there are native birds and insects. The integration of island hills into green infrastructure could create a more equal distribution of green areas and their associated ecosystem services.

In order to increase Santiago's green area through the integration of island hills to the public urban space and, at the same time, reduce the socioeconomic segregation of green areas, in 2014 the Intendency of Santiago sponsored the "Island Hill" competition, seeking to create a new urban park for Santiago. The winning project is the Chena hill in San Bernardo, which will receive a contribution from the Regional Government of CLP $10 million over a four-year period.

FIGURE 12

ISLAND HILLS

HILL	COMMUNE	AREA (HA)	HILL	COMMUNE	AREA (HA)
1 **Loma Larga**	Lo Barnechea	31.4 HA	14 **Renca**	Renca y Quilicura	879.82 HA
2 **El Manzano**	Lo Barnechea	11.93 HA	15 **Navia**	Cerro Navia	2.57 HA
3 **Del Medio**	Lo Barnechea	126.91 HA	16 **Amapola**	Pudahuel	70.12 HA
4 **Dieciocho**	Lo Barnechea	214.64 HA	17 **Lo Aguirre**	Pudahuel - Maipú	1692.12 HA
5 **Alvarado**	Lo Bar. - Vitacura	214.64 HA	18 **Jardín Alto**	La Florida	25.33 HA
6 **Los Piques**	Las Condes	11.15 HA	19 **Chequén**	La Flo. - Pte. Alto	41.98 HA
7 **Calán**	Las Condes	52.99 HA	20 **Chena**	Sn Ber. - Cal. de T.	1476.08 HA
8 **Apoquindo**	Las Condes	62.85 HA	21 **Hasbún**	San Bernardo	8.09 HA
9 **San Luis**	Las Condes	17.61 HA	22 **Adasme**	San Bernardo	24.57 HA
10 **Rinconada**	Huechuraba	6.22 HA	23 **Negro**	San bernardo	127.89 HA
11 **San Cristóbal**	Prov. - Recoleta	632.16 HA	24 **Los Morros**	San Bernardo	32.01 HA
12 **Blanco**	Recoleta	20.55 HA	25 **Las Cabras**	Puente Alto	730 HA
13 **Santa Lucía**	Santiago	6.96 HA	26 **La Ballena**	Puente Alto	59.72 HA



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Vizcacha and offspring (*Lagidium viscacia*) | NICO LAGOS

CHAP **15**

BIODIVERSITY

CONTENT

INTRODUCTION

The biodiversity present in the terrestrial, marine and continental water ecosystems constitutes complex systems, where a variety of habitats for species develop, allowing living beings to access a number of resources such as food, shelter, clothing, productive processes, and natural cycles, among others. The balance and maintenance of biodiversity reveals the available ecosystem services, which can be classified into: provisioning, regulating, cultural and supporting services. All living creatures, including humans, depend on those services. Thus, the quality of soil, the availability of water, the maintenance of ecological characteristics of the ecosystems and their health improve people's well-being.

In all natural environments, such as the ocean, rivers, lakes, wetlands and terrestrial environments such as forest ecosystems, processes occur that impact climate balance, water cycles and the evolution of soils. For example, some bacteria that live in the soil contribute to plant growth -including crops- by decomposing organic and inorganic waste (supporting services). On the other hand, plants in all their habitats, from mountains to the bottom of the sea, hold the soil or substrate (supporting services), they are food for animals and regulate the cycle for drinking water and water for agricultural use (provisioning services), among others. This is how ecosystem services can be direct or indirect. The former, are mainly obtained from plants and animals as commodities. Genetic resources also provide direct benefits since they contribute genes that can improve the performance of a crop or make it resistant to diseases, or can be used to develop medications.

Indirect services arise from the interactions and feedback between the organisms living in an ecosystem. For example, they can be found in the control of erosion, purification and storage of water by plants and soil microorganisms in a basin or the pollination and dispersion of seeds through insects, birds and mammals. Finally, there are other less tangible high valued benefits, such as scenic beauty, enjoying a landscape and the spiritual meaning of a forest.

The loss of biodiversity translates into a reduction of genetic variability, loss of species, reduction of ecosystems, difficulties in climate change adaptation and reduction of ecosystem services. Therefore, biodiversity, understood as the environmental heritage of each country, is an asset that must be safeguarded. This chapter shows the disturbance in ecosystems, the critical conditions of some species, both terrestrial and marine, and raises challenges that go hand-in-hand with the Sustainable Development Goals, the OECD recommendations and the 2030 National Biodiversity Strategy.

Biodiversity contributes with a psychological and spiritual framework to our existence, it is closely linked to the health and well-being of people, contributing one of the basis of social and economic development.

1 • STATE OF BIODIVERSITY

The broad latitudinal extent of the Chilean territory, in addition to its geographical relief -determined mainly by the Andes and Coastal Mountain Ranges- and a marked oceanic influence, allow for the understanding of the variety and diversity of ecosystems in the country. Given its condition of biogeographical island, Chile is endowed with a great diversity of terrestrial, marine, coastal, glacial, river, lake, wetland and insular ecosystems, which together harbor close to 31,100 species of plants, animals, fungi and bacteria. In addition, it holds a large degree of endemic species (22 to 25 percent), that transform broad spaces of the territory into true natural laboratories.

In order to give an account of their status, this report has been organized into three major groups of ecosystems: terrestrial, continental aquatic and marine.

1.1 Terrestrial Ecosystems

To determine the loss of terrestrial ecosystems and establish risk categories through the Assessment of Qualitative and Quantitative Thresholds, the Ministry of the Environment (Pliscoff, 2015) used the methodology developed by the International Union for Conservation of Nature (IUCN). It is a referential methodology to assess the conservation status of ecosystems at the local, national, regional and global levels.

01

RED LIST OF ECOSYSTEMS

The IUCN's Red List of Ecosystems allows quantifying the loss of ecosystems in terms of area, degradation or other ecosystem changes that may occur. It establishes a standardized procedure that can be applied at diverse scales of analysis and it is easy to understand for the general public and decision makers. Likewise, it facilitates the management of:

- Conservation.
- Land use planning.
- Improvement of governance and livelihoods.
- Macro-economic planning.

The methodology of the IUCN's Red List of Ecosystems establishes eight risk categories for each ecosystem. Three of them are assigned on the basis of quantitative thresholds and, together, these categories are described as threatened: Critically Endangered (CR), Endangered (EN), and Vulnerable (VU).

The remaining categories are qualitative and are applied when:

- Ecosystems fail to meet the quantitative criteria for the threatened ecosystem categories (NT, Near Threatened)
- Ecosystems unambiguously meet none of the quantitative criteria (LC, Least Concern)
- Ecosystems for which too few data exist to apply any criterion (DD, Data Deficient)
- Ecosystems have not yet been assessed (NE, Not Evaluated).
- An additional category (CO, Collapse) is assigned to ecosystems that have lost their key characteristics and functions throughout their distribution, the analogue of the extinct (EX) category for species.

http://www.iucnredlistofecosystems.org/

The assessment of terrestrial ecosystems was carried out using vegetation layers (Luebert and Pliscoff, 2006), as an analysis unit, applying the criteria from the IUCN's Red List of Ecosystems methodology to those that had information at the national level (**Map 01**). The criteria of the Red List of Ecosystems focus on four ecological symptoms that allow an estimation of the risk that a type of ecosystem may lose the characteristics that define it (Keith et al., 2013 in Pliscoff, 2015): (A) decreases in process throughout its distribution; (B) restricted distribution, which predisposes the system to be under spatially explicit threats, along with a decrease, threat or demonstrated fragmentation; (C) degradation of the abiotic environment, reducing habitat quality or diversity of the abiotic niche for the constituent biota, such as, for example, ocean acidification or loss of soil fertility; (D) interruption of biotic processes and interactions, which may result in loss of mutualisms, diversity of the biotic niche or exclusion of constituent biota (Rodríguez et al., 2015 in Pliscoff, 2015).

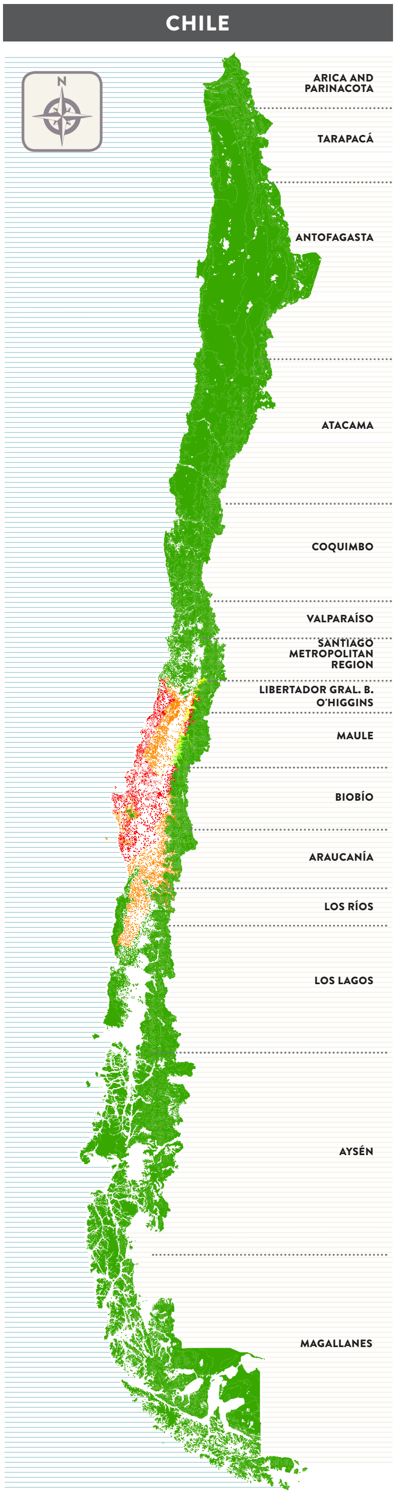
For the study, the following criteria were used:

- **Reduction in distribution.** This analysis was presented over three periods of time that define the sub-criteria. The first refers to a decrease in the present time (A1), which is evaluated for the last 50 years. The second implies the future reduction, over the next 50 years (A2a) or throughout any 50-year period that includes the present and the future (A2b). The last one is the historical decrease that is calculated from 1750 (A3). In this evaluation, sub-criteria A2b and A3 were used.
- **Restricted geographical distribution.** This criterion seeks to identify the ecosystems whose distribution is so restricted that they are at risk of collapse due to the concurrence of threatening events or processes. This criterion is subdivided into three sub-criteria: extension of the occurrence (B1); occupation area (B2); and the combination, defined by the number of locations and the risk of the ecosystem to collapse (B3). For this evaluation, sub-criterion B2 was used.
- **Environmental degradation.** The identification of the degradation of certain habitat components can generate a diagnosis of the risk to which the other components of the system would be subject to, although it also influences the resilience capacity of the system. The evaluation of this criterion is subdivided according to the degree of severity of environmental degradation, which may or may not be expressed in terms of distribution. The defined sub-criteria are based on the same three periods of criterion A: environmental degradation over the last 50 years (C1); environmental degradation over the next 50 years (C2); and environmental degradation calculated from the historical period of 1750 (C3). In this case, sub-criterion C2 was selected.

Southern Chile | FELIPE ANDAUR

MAP 01

CHILEAN TERRESTRIAL ECOSYSTEMS ASSESSED UNDER CRITERION A2B, ACCORDING TO THE IUCN'S METHODOLOGY



The results of the analysis of criterion A2b (future reduction during the last 20 years, between 1992-2012 and projected for the next 30 years), determined that there are eight Critically Endangered vegetation layers, six Endangered and one Vulnerable. These three categories constitute threatened ecosystems and occupy 4 percent of the national territory. In addition, one layer is in the Near Threatened category (**Map 01**).

It is important to point out that the vegetational layers that are most threatened in the future are located in the central zone of the country, a place that withstands the greatest environmental pressures (**Map 02**).

Legend

- Critically Endangered (CR)
- Endangered (EN)
- Vulnerable (VU)
- Near Threatened (NT)
- Least Concern (LC)

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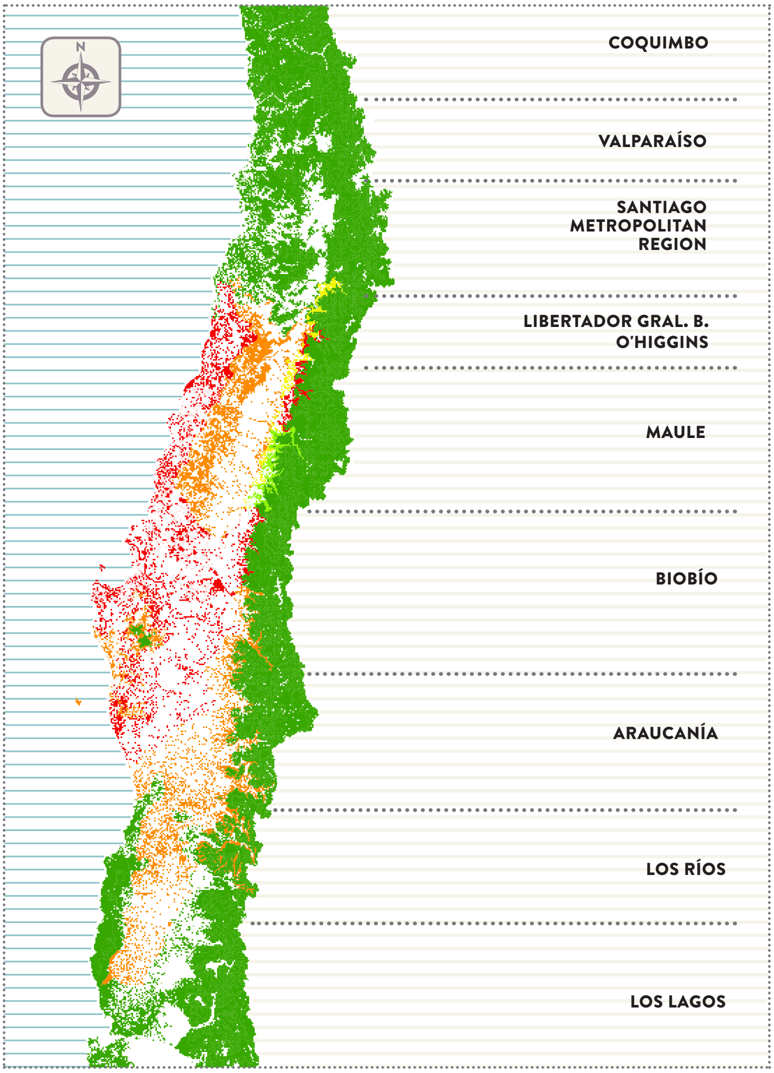
Source: Authors' own elaboration based on Pliscoff, 2015

MAP 02

CENTRAL CHILEAN TERRESTRIAL ECOSYSTEMS ASSESSED UNDER CRITERION A2B, ACCORDING TO THE IUCN'S METHODOLOGY



Legend

- Critically Endangered (CR)
- Endangered (EN)
- Vulnerable (VU)
- Near Threatened (NT)
- Least Concern (LC)

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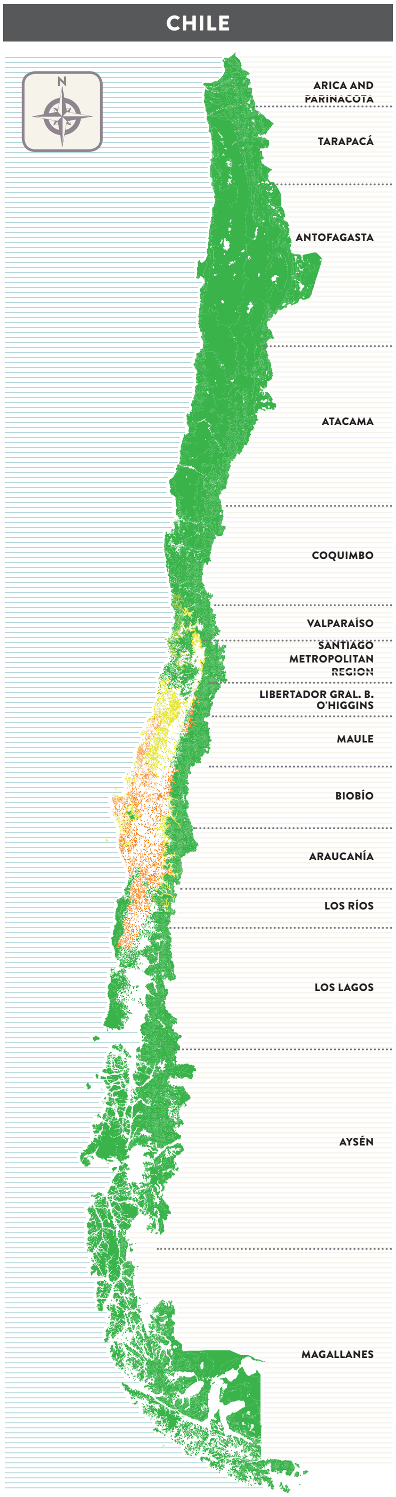
Source: Authors' own elaboration based on Pliscoff, 2015

MAP 03

CHILEAN TERRESTRIAL ECOSYSTEMS ASSESSED UNDER CRITERION A3, ACCORDING TO THE IUCN'S METHODOLOGY



On the other hand, the results of sub-criterion A3 (estimated reduction of the potential distribution of the vegetational layer calculated by the difference between what existed in 1750 and the remaining area in 2014) indicate that there was a significant reduction in the vegetation layers, mainly in the central zone of the country, which was subject to great anthropic pressures, such as population growth, the presence of forestry and agricultural activities, among others, which have generated ecosystem loss, fragmentation and degradation (**Map 03**).

Legend

- Endangered (EN)
- Vulnerable (VU)
- Near Threatened (NT)
- Least Concern (LC)

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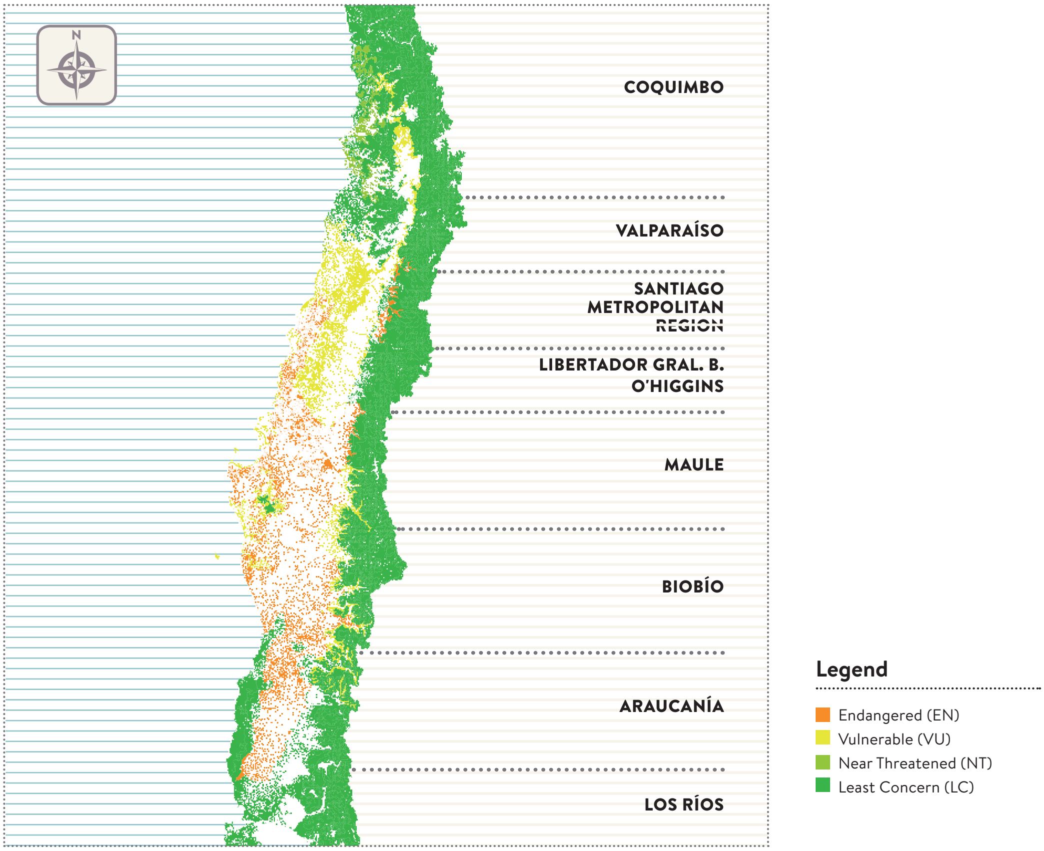
Source: Authors' own elaboration based on Pliscoff, 2015.

MAP 04

CENTRAL CHILEAN TERRESTRIAL ECOSYSTEMS ASSESSED UNDER CRITERION A3, ACCORDING TO THE IUCN'S METHODOLOGY

Under this sub-criterion there are eight Critically Endangered layers, eight Vulnerable and one Near Threatened, which corresponds to 4.5 percent of the area of existing ecosystems in the country (**Map 04**).



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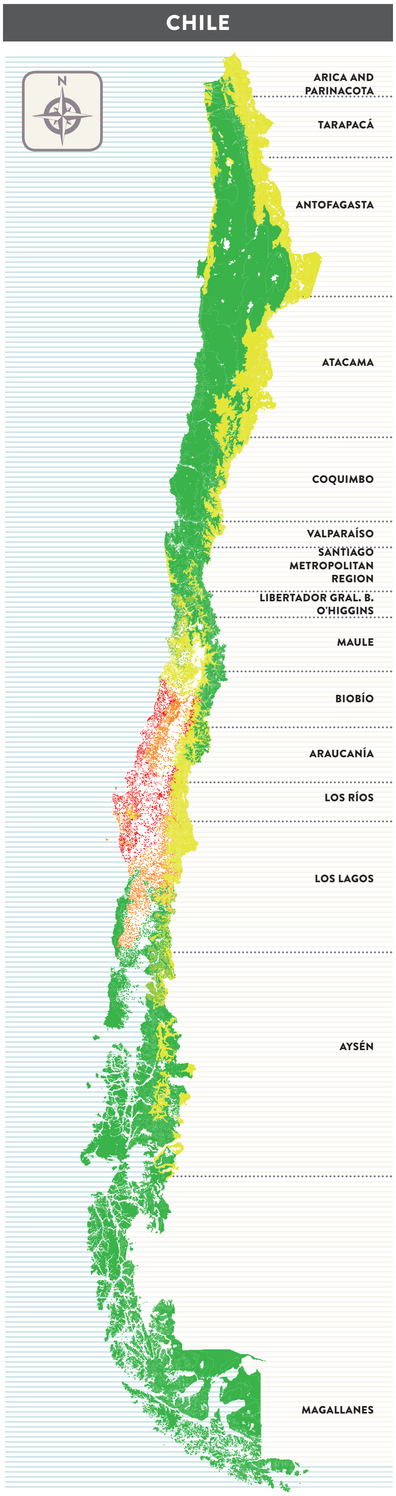
Source: Authors' own elaboration based on Pliscoff, 2015.

In relation to the restricted geographic distribution (sub-criterion B2), a Vulnerable vegetational layer and five Near Threatened layers were found, equivalent to 0.1 percent of the country's ecosystem area.

MAP 05

CONSERVATION STATUS OF CHILEAN TERRESTRIAL ECOSYSTEMS ASSESSED ACCORDING TO THE IUCN's METHODOLOGY[1]



In the case of the criterion of environmental degradation, during the next 50 years (sub-criterion C2), the estimate was based on the decrease of the area of vegetation layers due to bioclimatic factors. In this case, a bioclimatic stress index was used, obtained from water stress and thermal, summer and winter stress (Pliscoff, 2015). Thus, it was determined that during the next 50 years, 36 vegetational layers will be in the Vulnerable category due to water stress (10 percent of the area of national ecosystems), 24 vegetation layers in a Vulnerable state (10 percent of national ecosystems) and two Nearly Threatened by summer thermal stress and 20 layers in Vulnerable state due to winter thermal stress (15 percent of national ecosystems).

Likewise, from the application of all the indicated criteria (**Map 05**), it was determined that at the national level, eight vegetational layers are Critically Endangered, six are in Danger, 49 Vulnerable, five Near Threatened and 59 in Least Concern. This means that out of a total of 127 vegetation layers, 63 of them are threatened (classified as Critically Endangered, Endangered or Vulnerable), equal to 49.6 percent of the total ecosystems existing in the country (Pliscoff, 2015).

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Legend

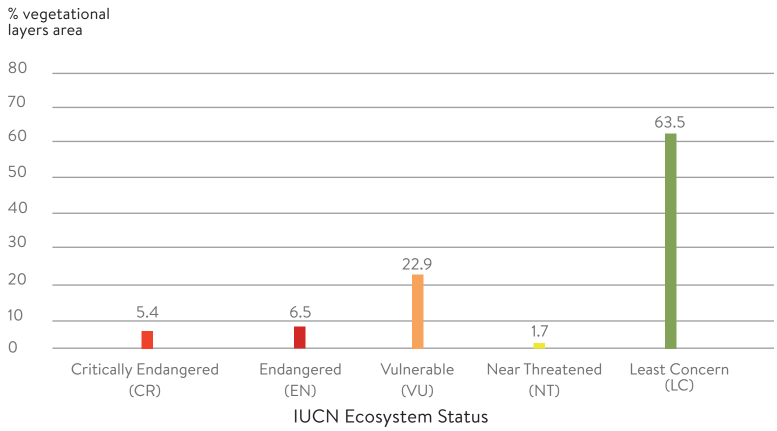
- Critically Endangered (CR)
- Endangered (EN)
- Vulnerable (VU)
- Near Threatened (NT)
- Least Concern (LC)

[1] *For this evaluation, the four previously applied criteria (A2b, A3, B2 and C2) were considered.*

Source: Authors' own elaboration based on Pliscoff, 2015.

FIGURE 01

AREA OF CHILEAN TERRESTRIAL ECOSYSTEMS, ACCORDING TO CONSERVATION STATUS



Source: Authors' own elaboration based on Pliscoff, 2015.

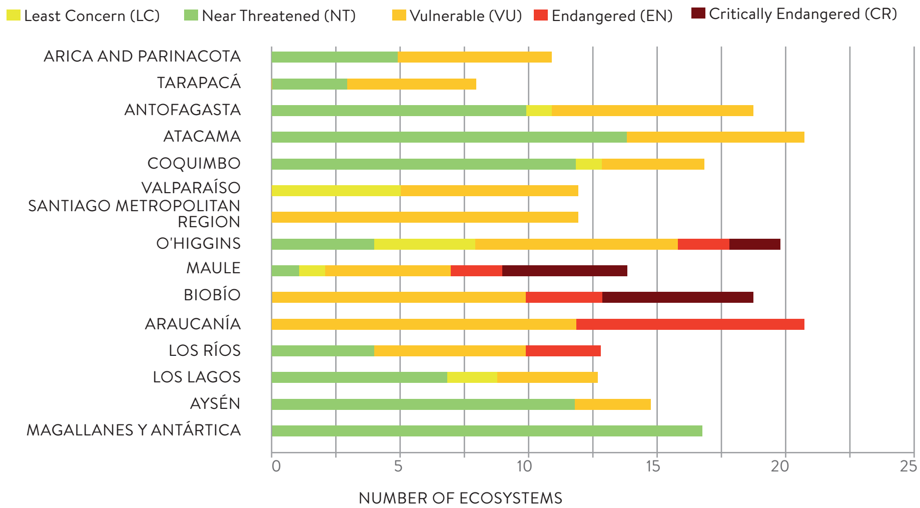
Of the total area of terrestrial ecosystems of the country, the threatened vegetational layers (Critically Endangered, Endangered and Vulnerable) cover more than 30 percent, and 65 percent as Near Threatened and Least Concern (**Figure 01**).

The distribution at the regional level (**Figure 02**), indicates that "the threat categories (CR, EN or VU), are mainly concentrated in the central zone of Chile, with the categories of greater degree of threat (CR) between the regions VI a VIII, followed by the EN category between regions VI to XIV and a large part of the regions of the country with vulnerable ecosystems, being between regions XV to XI "(Pliscoff, 2015).

Torres del Paine | JORGE HERREROS

FIGURE 02

CONSERVATION STATUS OF CHILEAN TERRESTRIAL ECOSYSTEMS BY REGION



Source: Authors' own elaboration based on Pliscoff, 2015.

1.1.1 Native Forests

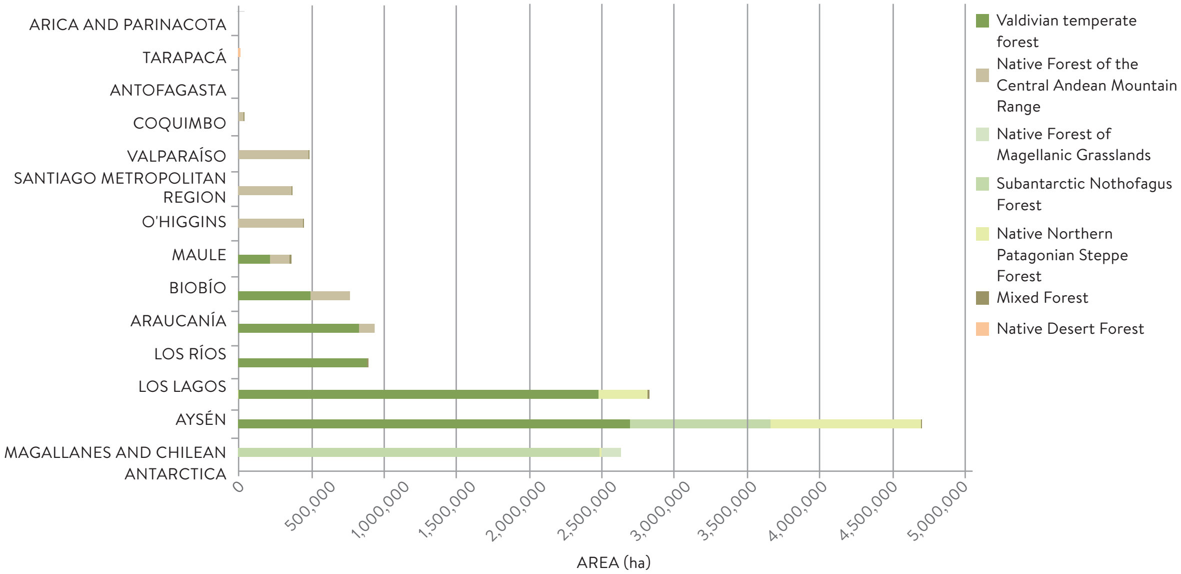
The native forest corresponds to the forests formed by original species, stemming from natural generation, natural regeneration or canopy plantation with the same species existing in the original distribution area. However, Law 20.283, on the Recovery of the Native Forest and Forest Development, indicates that the species existing in the original distribution area may have an accidental presence of exotic species distributed at random.

The native forest area in the country is 14,430,909 ha, with the Valdivian temperate forest being the most extensive, with an area of 7,582,484 ha (**Map 06; Figure 03**).

"The current isolation of temperate and sub-Antarctic forests and the legacy of their ancient biogeographical history is expressed in the remarkable diversity of families with endemic genera (28 genera of angiosperms out of a total of 82 present in Chile, that is, 34 percent), most of them monotypic, that is, with only one living species. These ecosystems have been classified as priority conservation areas worldwide (Myers et al., 2000, Armesto et al., 2009)" (Armesto and Núñez-Ávila, 2016).

FIGURE 03

AREA OF NATIVE FORESTS IN CHILE, BY TYPE OF FOREST

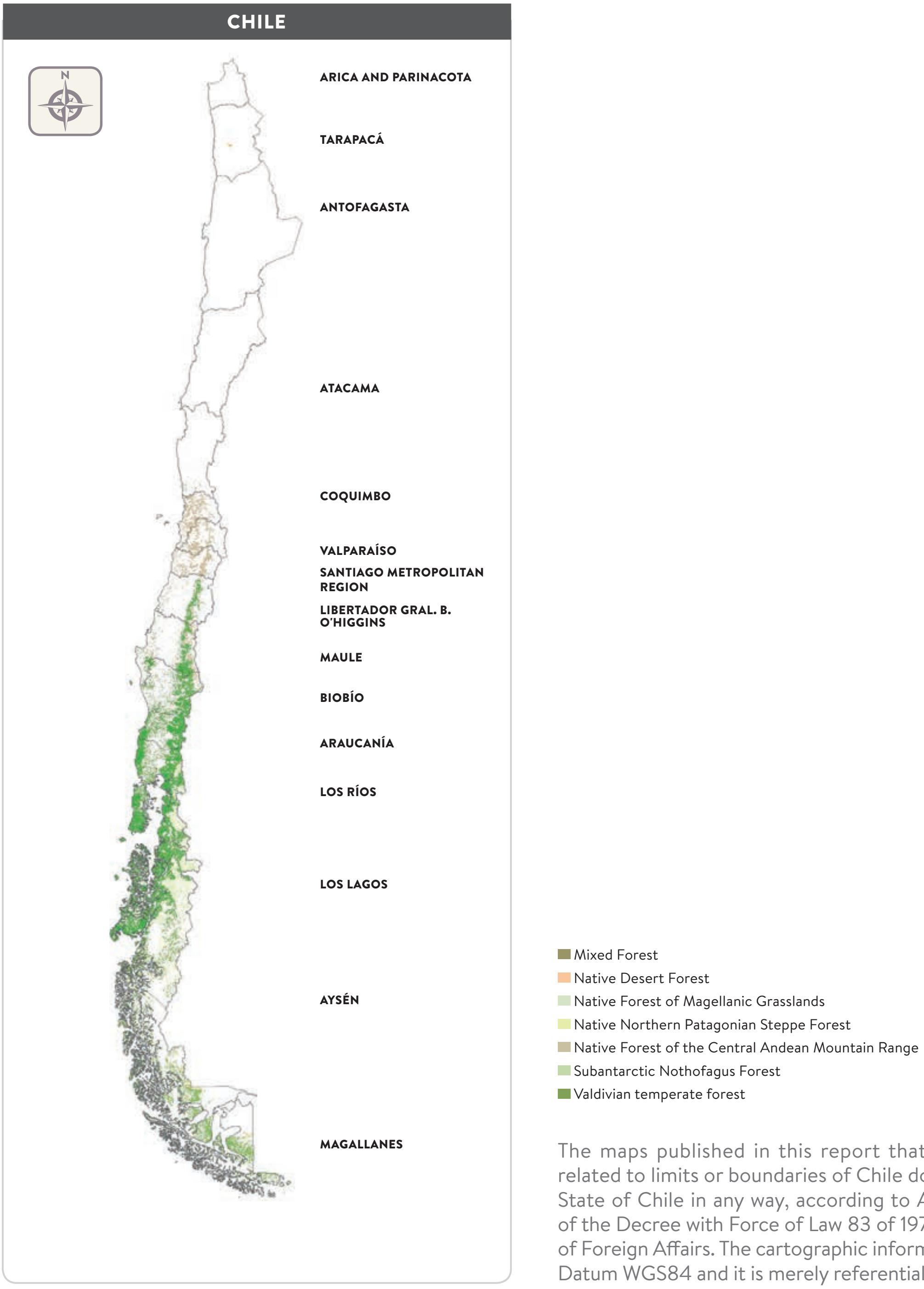


Source: Authors' own elaboration based on the "Updated National Land Use Database of from the Ecologic and Multi-Sectoral Perspectives", Ministry of the Environment (MMA) 2014

Humidity | FELIPE ANDAUR

MAP 06

FOREST DISTRIBUTION IN CHILE



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1.2 Continental Aquatic Ecosystems

Continental aquatic ecosystems, understood as rivers, lakes or wetlands, fulfill fundamental functions for the existence of life. Wetlands correspond to limnic subsystems integrated into river basins (Vila et al., 2006). The types of wetlands are the reflection of their geographic location and physical and chemical characteristics of their environment. Therefore, their biology (aquatic plants, fish, algae, birds, amphibians, microorganisms and several other species of fauna and flora), will depend on these last two factors. Internationally, wetlands encompass lakes and rivers, underground aquifers, marshes and swamps, wet grasslands, peat bogs, oases, estuaries, deltas and low tides, mangroves and other coastal areas, coral reefs, and artificial sites such as fish ponds, paddy fields and salt flats (Ramsar Convention Classification).

In Chile, the most frequent are boglands, peat bogs, fertile plains, estuaries, salt flats, marshes, floodplains, marshes, lakes, lagoons and rivers, among others. Some of them stand out for their uniqueness, such as the high-Andean wetland complexes, which have a unique biology, extreme organisms or native fish of the genus Orestias, whose common name is pupfish, with six endemic species and whose habitat is found exclusively in some lagoons and estuaries from endorheic basins of the Chilean Altiplano (between 3,000 and 4,500 meters above sea level). Other special systems are the coastal wetlands, which sustain local economies such as artisanal fisheries, distributed along the Chilean coast.

Wetlands offer different ecosystem services. They are a source of water for human consumption and for the supply of food. Aquatic ecosystems control the risk associated with changes in the hydrology of the territory, since they store water, regulating the floods of rivers and periods of drought. In addition, they constitute places for the development of biodiversity. Plants and microorganisms (microalgae, photosynthetic bacteria) that inhabit the wetlands, capture part of the carbon that causes the increase of greenhouse gases, so they also contribute to mitigate the effects of climate change. On the other hand, many wetlands can be indicators of the general state of the basins to which they belong, which is why they are good early warning indicators.

Several studies have shown the systematic loss of these ecosystems, a product of urban expansion of development actions without ecological planning, in addition to changes in climate patterns (rainfall and temperature).

In relation to the number of wetlands in Chile and their level of protection, the update of the National Wetlands Inventory (Ministry of the Environment, 2012) done in 2015, showed that the country has a total of 40,378 wetlands, which corresponds to 1,317.704 ha of the National Territory[3]. By superimposing the National Wetlands Inventory, with the information from Protected Areas, a low representativeness of aquatic ecosystems was established in the National System of Wild Protected Areas of the State (SNASPE by its acronym in Spanish) at a regional and national scale, since only 0.5 percent of the country's wetlands are officially protected areas, equal to 2.7 percent of protected areas.

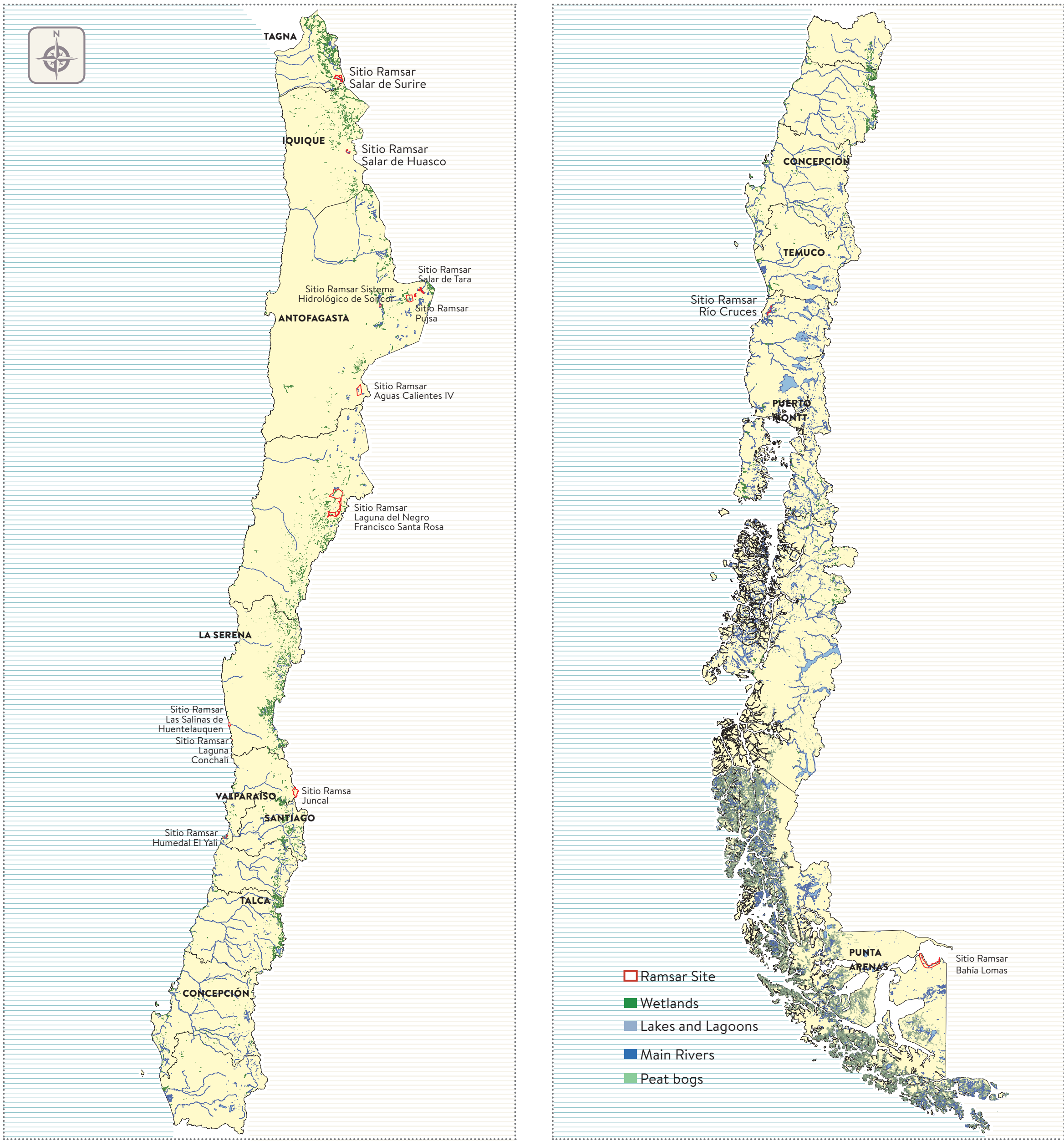
[2] This inventory was updated in the years 2012, 2014, 2015.

[3] This number does not include the wetlands of the oceanic islands, the peat bogs, or the mallines (swamps) of the southern zone (Aysén and Magallanes regions).

Wetland and life | MARÍA CECILIA JIMÉNEZ

MAP 07

WETLANDS AND RAMSAR SITES IN CHILE



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Source: Author's own elaboration based on the National Wetlands Inventory of the MMA, updated 2015.

In relation to the environmental condition of continental aquatic ecosystems, it is considered that both high Andean wetlands (meadows, lagoons, boglands), peat bogs and coastal wetlands are fragile ecosystems. The former, because their hydric and botanical components are unique and critical, while the latter, concentrated in the Chilean Patagonia, because its local and global ecosystem services are irreplaceable. The existing monitoring network is insufficient to adequately characterize the rivers, lakes, estuaries and coastal zones of the country. At present, there are areas of the territory where water quality information is not available, the minimum lakes network considers only 14 of the 375 lakes with an area greater than 3 km^2. Complementary to the quality monitoring carried out by the DGA, the Ministry of the Environment began monitoring the coastal wetlands in 2011 to assess their trophic status. High levels of trophic values are evident in high road systems, due to the high concentration of nitrogen and phosphorus from the Maule Region to the North, a section in which barred estuaries and human activities are concentrated. The same conditions were observed in the monitoring of 2013 [4] and 2015.

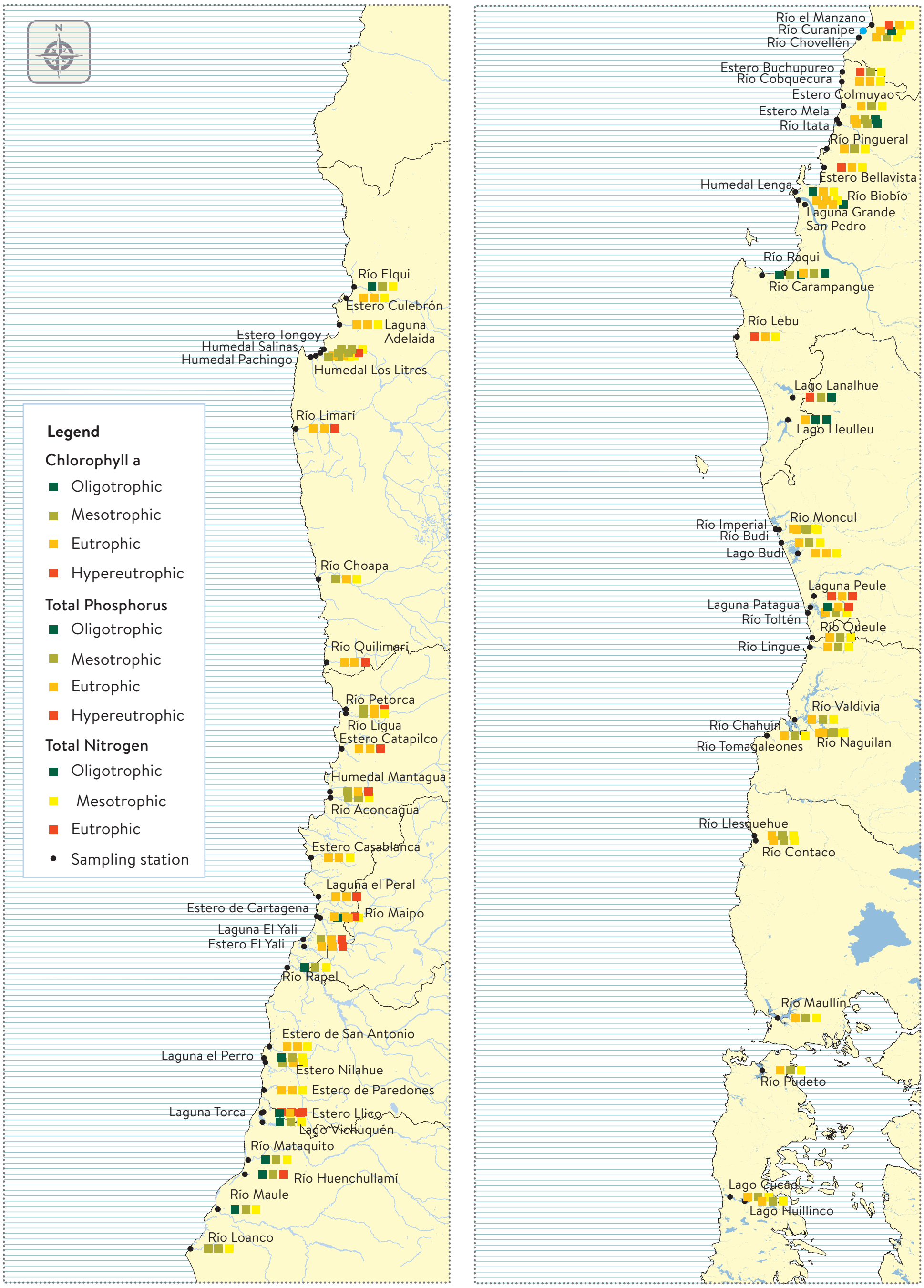
Another study (Ministerio del Medio Ambiente, 2013) that monitored more than 60 basins in their terminal zone and some Andean lagoons (**Map 08**), showed that the central-northern zone of Chile presents a higher extent of eutrophic wetlands (eutrophic and hypereutrophic) than the ecosystems of the southern zone (mesotrophic and oligotrophic). This would be explained because in the northern zone the lower natural availability of water and the greater effect of its consumptive uses -such as mining and agriculture- generate a greater proliferation of barred estuaries, which, being disconnected from the ocean for different periods, have a lower capacity to renew water, as they are prevented from removing the nutrients received from the basin through a direct effluent.

In the southern zone, the greater availability of flow allows a greater capacity of dilution and cleansing of the coastal system (estuary or freshwater), which does not generate the effect of excessive accumulation of nutrients by the anthropic factor.

[4] *National Center for the Environment (CENMA by its acronym in Spanish), (2013).*

MAP 08

TROPHIC STATE OF CHILEAN COASTAL WETLANDS, 2013 MONITORING



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Source: Authors' own elaboration based on National Center for the Environment (CENMA by its acronym in Spanish). 2013.

MAP 09

NETWORK OF CHILEAN ACQUATIC ECOSYSTEMS: AN INPUT FOR THE WETLANDS PLATFORM

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Source: Authors' own elaboration based on National Center for the Environment (CENMA by its acronym in Spanish). 2015.

Lluta River Mouth I JORGE HERREROS

02

TROPHIC STATE

The alteration of the trophic state (oligotrophic, mesotrophic, eutrophic, hypereutrophic) causes changes in the conditions of any aquatic ecosystem, so much so that it can result in massive growth of phytoplankton, a phenomenon known as algal bloom and as harmful algal bloom (HAB) when these microalgae (mainly cyanobacteria) are toxic. As a consequence of the microalgal blooms, transparency can be reduced and, hence, the amount of solar radiation available for the photosynthesis of macrophytes (aquatic plants) present in the aquatic ecosystem.

These changes have sanitary (European Commission & World Health Organization, 2002), touristic, and ecological consequences. Algal bloom causes water toxicity, emitting smells, changing the structure and function of aquatic ecosystems, resulting in social, economic and environmental impacts. The production of toxic compounds, such as methane and carbon dioxide, is caused by anaerobic decomposition bacterial activity. Under these conditions, sensitive species, especially fish and benthonic invertebrates, cannot survive, and massive mortality events are reported.

Eutrophication events in Chile's aquatic ecosystems are ever more frequent and intensify during the spring-summer period. This is the case of the Lago Vichuquén-Laguna Torca river system (Maule Region), where HAB has been observed over the last five years.

EUTROPHICATED LAGO VICHUQUÉN, MARCH 2015

Source: 24 horas[5]

[5] *http://www.24horas.cl/nacional/impresionantes-imagenes-revelan-la-alta-contaminacion-en-el-lago-vichuquen-1637250*


Short-beaked Common Dolphin (*Delphinus delphis*) | JORGE HERREROS

1.3. Marine Ecosystems

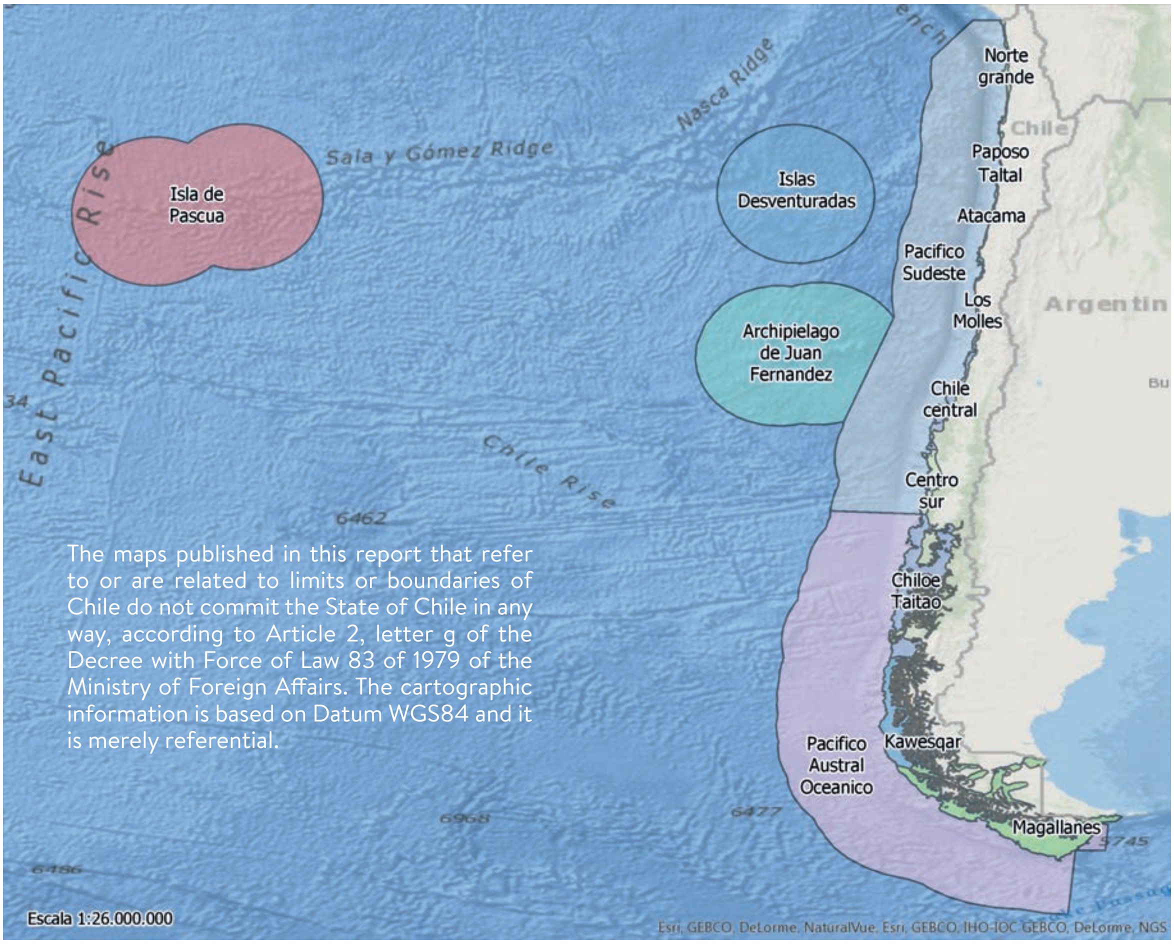
According to many authors, oceans can be subdivided into kingdoms, provinces and marine ecoregions (Spalding et al., 2007). On the other hand, ecoregions can be divided into marine ecosystems and, in turn, these are subdivided into biotopes or marine habitats.

Marine ecoregions are ocean areas with a relatively homogeneous species composition, determined by few ecosystems and/or sites with different topographic and oceanographic features (Spalding et al., 2007). Based on the proposals of Spalding et al. (2007), Jaramillo et al. (2006), and background information from recent years (Friedlander et al., 2016), the Ministry of the Environment has defined a classification of marine ecoregions and ecosystems for the entire Exclusive Economic Zone (EEZ) of Chile.

As a member country of the Convention on Biological Diversity (CBD), Chile undertook the protection of 10 percent of marine and coastal ecosystems, especially those of particular importance for biological diversity, through ecologically representative protected area systems. The classification of the ecoregions makes it possible to visualize the different marine ecosystems and thus develop a system of protected areas that includes each of these, in order to comply with the agreement (Ministerio del Medio Ambiente, 2014).

MAP 10

CHILEAN MARINE ECOREGIONS



Source: MMA, 2016a.

Likewise, for each ecoregion, considering their particular conditions (seamounts, upwellings, type of bottom, depth), the ecosystems that compose them were classified. As a result, 96 ecosystems were defined.

1.4 Species

1.4.1. Native Species Described for Chile

For Chile, 31,099 native species have been described, highlighting the high level of endemism at the global level, since almost 25 percent of these species are only found in our country. Almost 50 percent of the species described correspond to invertebrates, with insects being the largest group with 10,254 species. They are followed by algae, flora and fungi (43.6 percent) and, finally, vertebrates, which only represent 6.7 percent (**Table 01**).

TABLE 01

NUMBER OF NATIVE SPECIES DESCRIBED FOR CHILE, BY BIOLOGICAL GROUP

BIOLOGICAL GROUP	N° OF DESCRIBED SPECIES	PERCENTAGE PER GROUP
Algae, flora and fungi	13,561	43.6%
Diatoms	568	
Dinoflagellates, silicoflagellates	295	
Fungi	3,300	
Lichens	1,383	
Multicellular algae	945	
Non-vascular plants (mosses, liverworts, and hornworts)	1,400	
Ferns	170	
Dicotyledons	4,250	
Monocotyledons	1,250	
Invertebrates	15,466	49.7%
Mollusks	1,187	
Crustaceans	606	
Insects	10,254	
Other invertebrates	3,419	
Vertebrates	2,072	6.7%
Marine fish	1,182	
Inland fish	44	
Amphibians	64	
Reptiles	122	
Birds	498	
Mammals	162	
TOTAL	**31,099**	**100%**

Source: MMA (2014), modified for amphibians according on Lobos et al. (2013) and Charrier et al. (2015) and for birds according to Barros et al. (2015).

Chapo Lake | PAMELA HENRIQUEZ

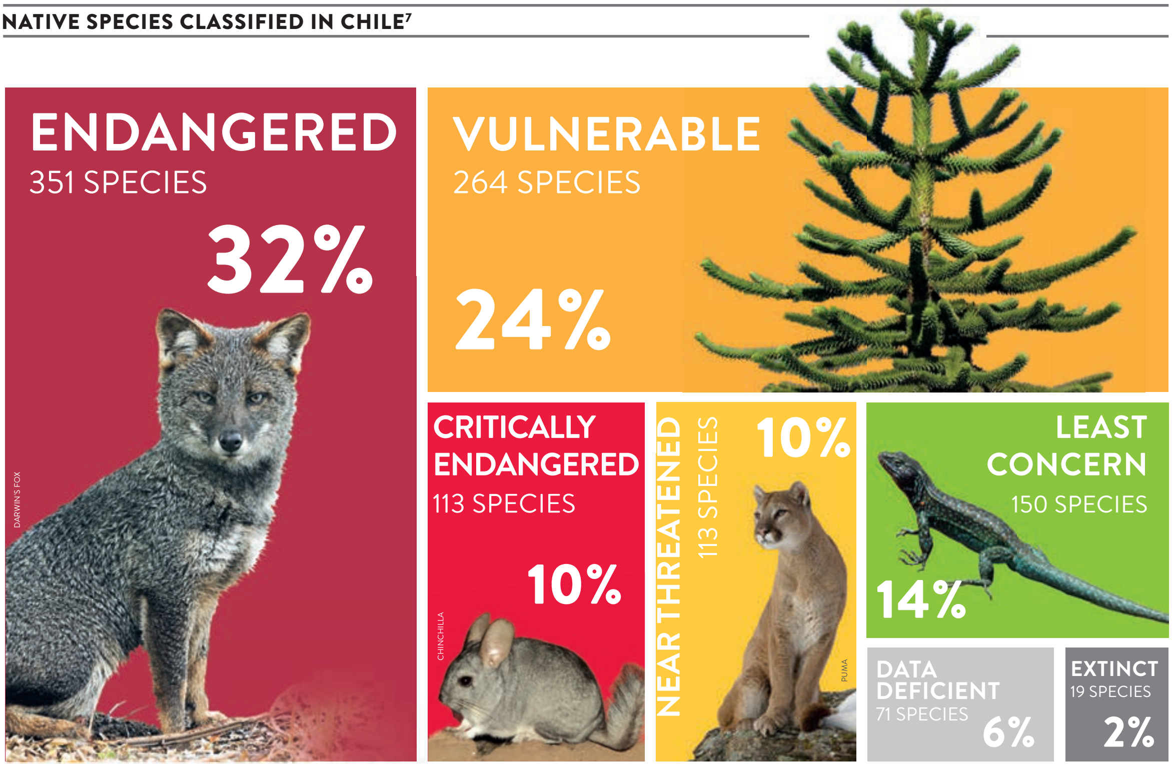
Of the total of 31,099 known species in Chile, 1,110 (3.5 percent) have been classified by one of the current instruments:

- ▶ Regulation for the Classification of Wild Species (RCE by its acronym in Spanish)
- ▶ Hunting Law
- ▶ Workshop on Reptiles (Núñez et al., 1997)
- ▶ Workshop on Marine Mammals (Yáñez, 1997)

Threatened species[6] in the country amount to 728, with 66 percent of the classified species being Critically Endangered (113), Endangered (351) or Vulnerable (264) (**Figure 04**). This percentage is high, given that species that are suspected of being at greater risk of extinction have been intentionally classified.

FIGURE 04

NATIVE SPECIES CLASSIFIED IN CHILE[7]



Note: Authors' own elaboration based on data from the Department of Species Conservation, Division of Natural Resources and Biodiversity, Ministry of the Environment, 2016.

Since 2005, the RCE has been used as the only instrument for classifying species according to conservation status, not including the Hunting Law and the reptile and marine mammal workshops. In the framework of its 12 processes[8], a total of 993 species have been classified, a number that represents only 2.8 percent of the native species of Chile that can be classified.

6 Threatened species are those classified in one of the following categories: Critically Endangered (CR), Endangered (EN) and Vulnerable (VU).

7 Includes the Regulation for the Classification of Wild Species (RCE by its acronym in Spanish), the Hunting Law, the Workshop on Reptile (Núñez et al., 1997), and the Workshop on Marine Mammal (Yáñez, 1997).

8 http://mma.gob.cl

TABLE 02

CHILEAN NATIVE SPECIES CLASSIFIED BY THE RCE (BY ITS ACRONYM IN SPANISH), BY BIOLOGICAL GROUP			
GROUP	TOTAL CLASSIFIED SPECIES	TOTAL SPECIES DESCRIBED FOR CHILE*	PERCENTAGE OF CLASSIFIED SPECIES IN RELATION TO THE TOTAL SPECIES DESCRIBED FOR CHILE
Invertebrates	117	15,466	0.7%
Vertebrates	282	2,072	10.1%
Plants	572	7,070	7.9%
Fungi and Lichens**	22	4,683	0.5%
Algae**	0	1,808	0
TOTAL	**993**	31,099	**3.2%**

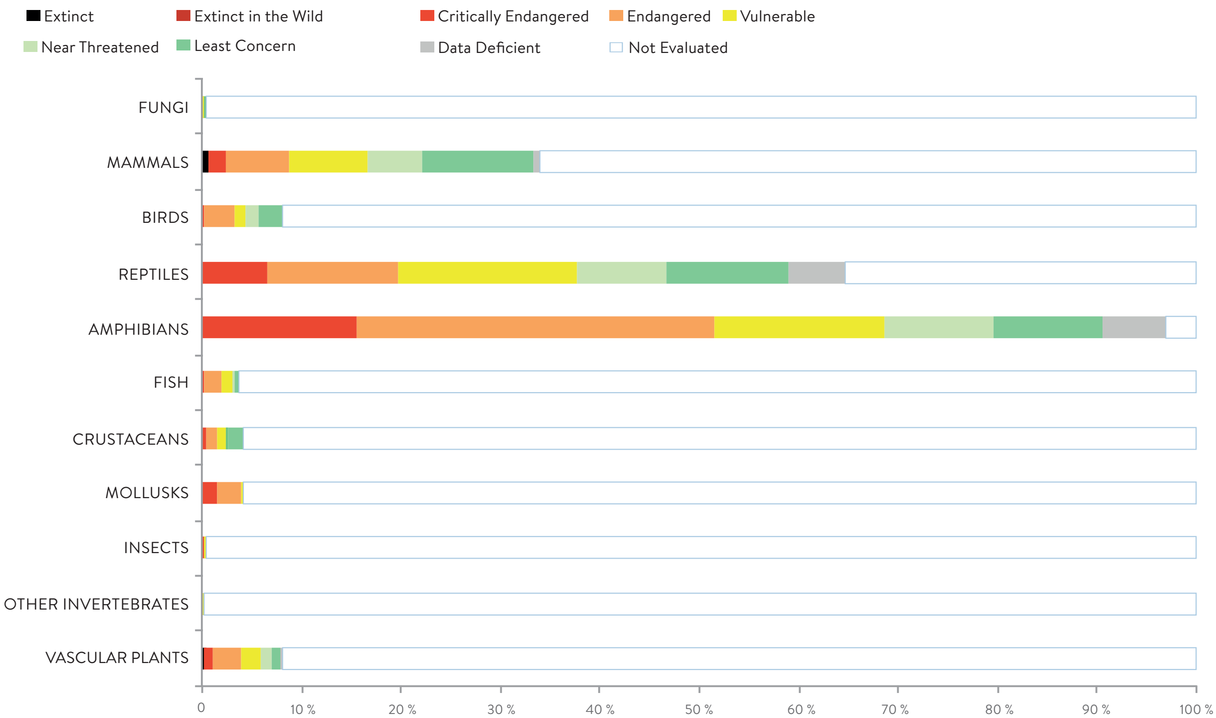
* Department of Species Conservation, Ministry of the Environment 2016.
** Fungi and algae are less studied taxonomic groups; this number must be carefully considered.

Figure 05 shows the composition of classified species, according to their taxonomic group in the case of animals and fungi, and according to their life form in the case of plants. Only for taxonomic groups where all, or most, of the species have been evaluated, is it possible to ensure that the result is a good indicator of the general state of conservation of the group. Such is the case of amphibians, fish in continental waters, and the plants and terrestrial mollusks of the Juan Fernández Archipelago, where most of their species have already been assessed by the RCE.

Fox ears (*Aristolochia chilensis*) | CHARIF TALA

FIGURE 05

PERCENTAGES OF CLASSIFIED SPECIES*



* Includes the 12th species classification process under the framework of the Regulations for the Classification of Wild Species Chile (RCE by its acronym in Spanish).

Source: Department of Species Conservation, Division of Natural Resources and Biodiversity, Ministry of the Environment, 2016.

03

AMPHIBIANS AND INLAND FISH

Most species in these groups have been classified within the framework of the RCE. Hence, the percentage of threatened species is a good indicator of the level of threat both taxonomic groups face. Ten amphibian species are classified as CR, 22 EN and 11 VU (71 percent of threatened species), while of the 41 species of inland fish one is classified as CR, 22 EN and 13 VU (87.8 percent threatened) (Tala et al., 2016).

It is not strange for both groups to be among the most threatened in Chile, since the aquatic habitat and water resources in general are among the most intervened by human actions such as drainage, filling and pollution. In addition, in the case of aquatic habitats, another problem is the presence of exotic species, including the Rainbow trout (Oncorhynchus mykiss) and the Brown trout (Salmo trutta), which are broadly distributed in Chile and are listed among the 100 most invasive species in the planet according to the IUCN. These species represent a strong pressure for the populations of native species, since alien species feed off the eggs and larvae of native species, also competing for food and habitat with our species (Tala et al., 2016).

http://www.iucnredlistofecosystems.org/

1.4.2 Population Studies of Some Species in the Conservation Category

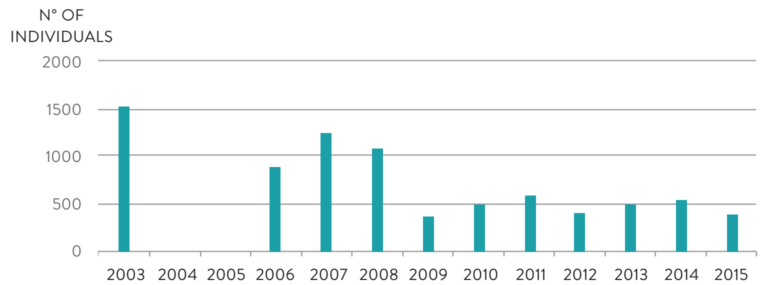
Chilean Woodstar *(Eulidia yarrellii)*

The Chilean Woodstar was evaluated in the first species classification process and, since 2007, it has been classified as Endangered (EN). Its population has declined dramatically, mainly due to the change in land use of the valleys of the Arica and Parinacota Region, the destruction of its habitat through regular burning of areas with native vegetation, the application of pesticides and the competition for territories with other species of hummingbirds, such as Peruvian Sheartail (*Thaumastura cora*).

This species is endemic to the valleys of the Arica and Parinacota Region. In four decades, it went from being the most common hummingbird in northern Chile valleys to the scarcest, and was officially declared Endangered (Supreme Decree N° 151 Ministry General Secretariat of the Presidency, 2007, 1st RCE Process). Although its original distribution also included the coastal valleys of southern Peru, it is currently restricted only to the valleys and coastal streams of the Arica and Parinacota Region. Since the first population estimate in 2003, its size has been reduced by more than 70 percent, with less than 500 individuals estimated for 2015 (**Figure 06**).

FIGURE 06

POPULATION TREND OF CHILEAN WOODSTAR

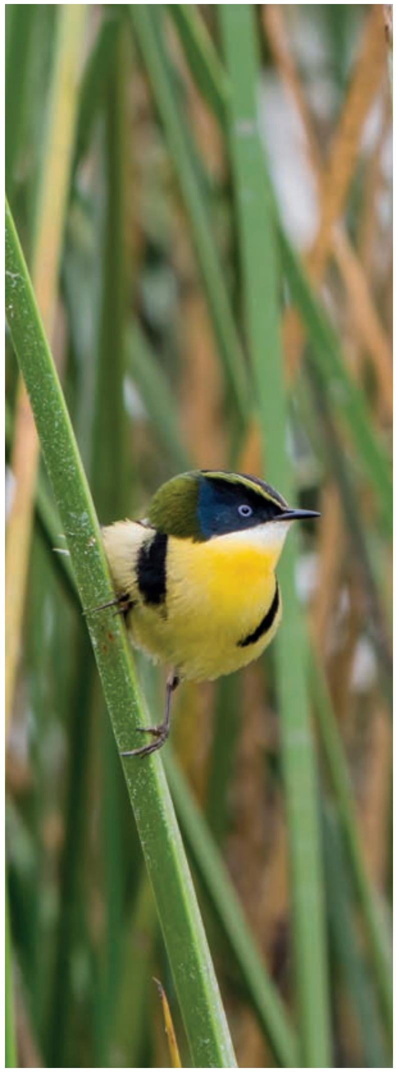


Source: Agriculture and Livestock Service (SAG by its acronym in Spanish) – MMA, 2016.

Ruddy-headed Goose *(Chloephaga rubidiceps)*

The Ruddy-headed Goose is an endemic species of the Eastern Patagonia and Falkland Islands that lives in humid steppe environments. It was assessed in the first species classification process and, since 2007, it has been classified as Endangered (EN). Its continental population has declined dramatically, which is evident both in its reproductive area in Chile and in the wintering zone in Argentina.

At the end of the 1990s, the Ruddy-headed Goose population that lives in the extreme south in Chile and Argentina, showed a clear downward trend. This is mainly related to habitat modification and predation by the South American Grey Fox (*Lycalopex griseus*), introduced to the island of Tierra del Fuego in the 1950s (Jaksic and Yáñez, 1983). In addition to this situation, there is the potential action of the Mink (Neovison vison), a predator introduced in the southern parts of Tierra del Fuego between 1940 and 1950 (Lizarralde, 2000). Furthermore, the effects of the intervention of their habitat are compounded by mining, livestock, incidental hunting and the disturbance of key sites for recreational activities.

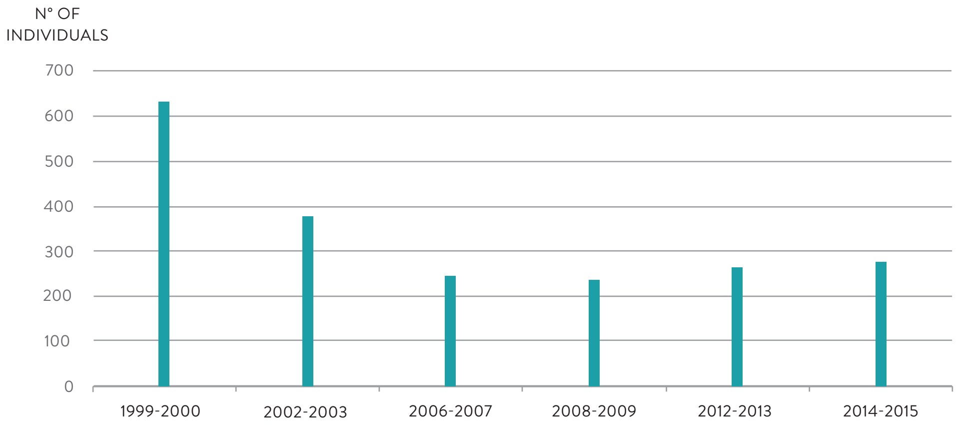


Many-colored Rush-tyrant (*Tachuris rubrigastra*)
JORGE HERREROS

In the available literature, evidence of reproduction after 1950 is only found in a few records, mostly limited to the Chilean sector. At present, most of its reproduction occurs in the eastern sector of the continental steppe (Matus et al., 2000). This reproduction has also decreased and, in fact, in the last census carried out in the 2014-2015 season, only eight breeding pairs and 40 offspring were observed out of almost 300 individuals. The rest of the individuals correspond to non-reproductive adults, which may be due to pressures such as predation by Minks and dogs or the effect of anthropic activities.

FIGURE 07

POPULATION TREND OF RUDDY-HEADED GOOSE



Source: CONAF, 2015.

Flamingos

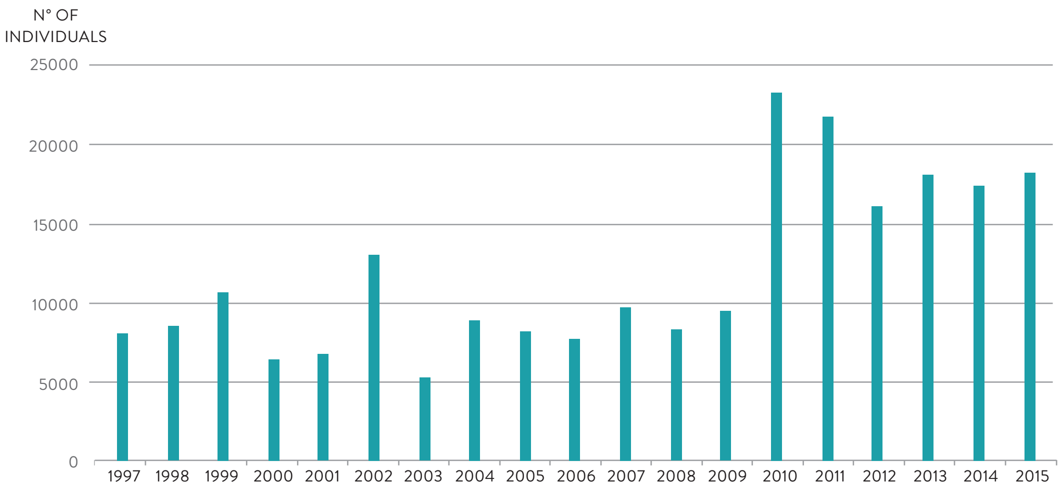
Of the three species of flamingo that inhabit Chile, only the Andean Flamingo or Parina Grande (*Phoenicoparrus andinus*) has been classified within the framework of the RCE as Vulnerable (VU, Supreme Decree N° 38/2015 of the Ministry of the Environment). The other two species are rated by the Regulation of the Hunting Law as Vulnerable (VU), in the case of James' Flamingo or Parina Chica (*Phoenicoparrus jamesi*), and the Chilean Flamingo as rare (*Phoenicopterus chilensis*) between the regions of Coquimbo and Los Lagos and Vulnerable (VU) in the Arica and Parinacota, Atacama, Aysén, and Magallanes and Chilean Antarctica regions.

The summer censuses of the three species of flamingos have been developed simultaneously, by direct counts and estimates in the high-Andean zone of northern Chile. They are carried out in the regions of Arica and Parinacota, Tarapacá, Antofagasta and Atacama, encompassing all the high-Andean salt flats and lagoons.

The variations of the flamingo censuses represent a fraction of the South American population, since these species migrate along the central Andes and their movements are associated with the availability of habitat for nesting in the summer period. There are years in which there have been declines in populations at the national level, which have been associated with periods of drought due to the decrease of water mirrors of the high-Andean wetlands in the area.

FIGURE 08

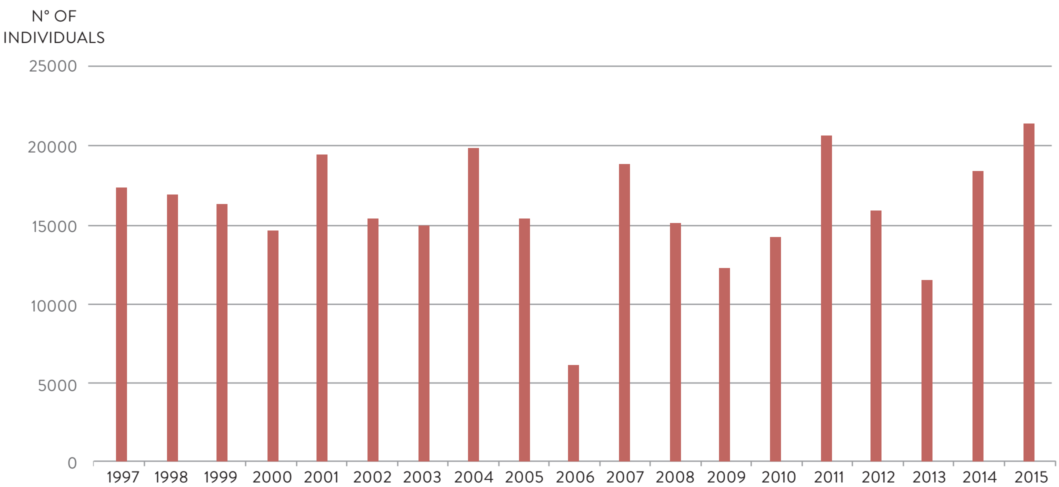
POPULATION TREND OF JAMES' FLAMINGO



Source: CONAF, 2015.

FIGURE 09

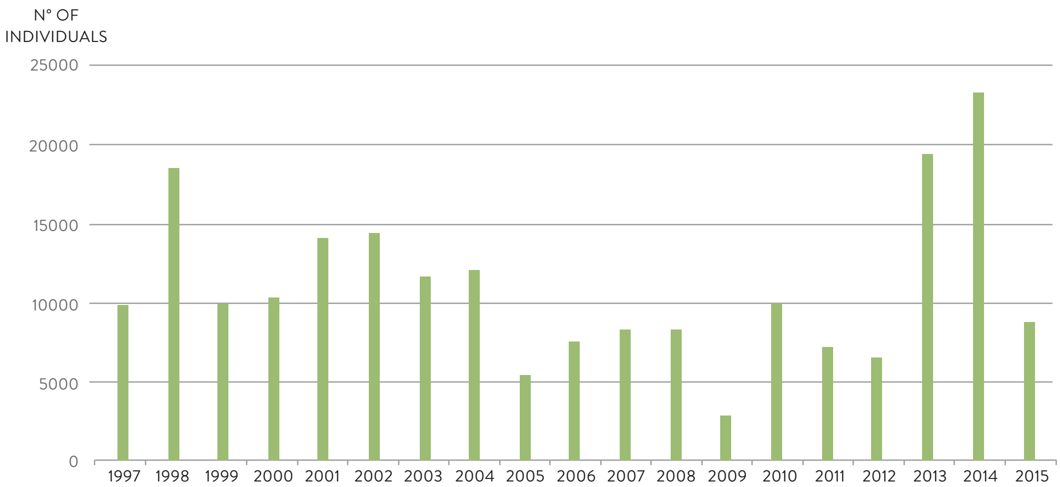
POPULATION TREND OF ANDEAN FLAMINGO



Source: CONAF, 2015.

FIGURE 10

POPULATION TREND OF CHILEAN FLAMINGO



Source: CONAF, 2015.

James' Flamingo and Chilean Flamingo Chick | JORGE HERREROS

2 • PRESSURES ON BIODIVERSITY

The pressures described in this chapter are not exhaustive, but they are consistent with the pressure classification of the United Nations Environment Programme (UNEP), which includes: habitat loss; overexploitation; pollution; introduction of alien species; and climate change (United Nations Environment Programme, 2012).

2.1. Habitat Fragmentation and Loss

Fragmentation is the division of continuous areas of natural habitat into smaller parts (patches) for the conversion of land to agricultural or urban uses (Harvey and Sáenz, 2007). According to different researchers, fragmentation is considered one of the main threats to ecosystems (Altamirano, 2007).

The effects of fragmentation in the natural environment can reduce or change the diversity and abundance in wildlife and vegetation. Hence, natural processes such as pollination are negatively affected, since pollinators (birds and insects) will have to travel a greater distance, invest more energy and take more risks to perform their task. The fragments of native forests in Chile are distributed with different degrees of isolation.

The loss of biodiversity due to habitat fragmentation has led to the isolation of populations of species and reduces vital movements among them (Secretariat of the Convention on Biological Diversity, 2014). In the case of our country, this alteration has been caused by deforestation, forest fires and subsequent processes of land use change. Intensive agricultural use has caused processes of desertification and drought in Chile (Universidad de Chile, 2013; Alfaro, 2013), as well as the urbanization of coastal lands (Rojas et al., 2015).

The fragmentation of terrestrial ecosystems is an important factor that has affected species in the central-southern zone of the country, especially in terms of their number and distribution. In the future, it is estimated that the composition and distribution of some assemblages of small mammals will be modified and that the same will occur with some plant species (Kelt & Meserve, 2014; Gutiérrez et al., 2010).

Another factor of pressure on biodiversity is the change in land use. In Chile, there are few studies that have recorded this change, especially at the national level. The inventory and assessment of the native vegetational resources of Chile was initiated in 1993 by the National Forestry Corporation (CONAF by its acronym in Spanish). Although this information base enables the detection of changes in land use in the region, updates are made in one region per year, which does not allow an assessment of the change in homogeneous land use for the same time series.

In order to create a national estimate of the land coverage and use in Chile, the Ministry of the Environment systematized and built a national database from the ecological perspective (2015), in which it integrated the aforementioned inventory, with other databases (inventories of wetlands, meadows, forest plantations, glaciers, urban spots, among others). From this work (see chapter on Land), it is evident that the central-southern zone of Chile concentrates the highest proportion of agricultural and forestry lands in comparison to the regional areas.

Lluta Valley | JORGE HERREROS

2.1.1 Loss of Habitat Due to Land Use Change in Terrestrial Ecosystems

Land use change is the main anthropic factor that has caused changes in the natural terrestrial ecosystems of our country (Sala et al., 2000). Thus, it has been identified for the central and south-central areas of the country that the main pressures for ecosystems are the forestry industry, through plantations with exotic species (Pinus radiata and Eucalyptus globulus) and the illegal logging of forests (Schulz et al., 2010). The agricultural industry, through the clearing of forests and bushes for the establishment of pastures and crops, and urban development, are also factors of land use change.

In the central-southern zone, between 1999 and 2011, an increase in the area of forest plantations has been estimated at approximately 40 percent. Between 1975 and 1990, 41.5 percent of new plantations was established by replacing secondary native forests, while the number was 22.8 percent between 1990 and 2007 (Ministerio del Medio Ambiente, 2014). This activity takes place in the Chilean biodiversity hotspot, which includes the Norpatagonico and Valdiviano rainforests, deciduous forests of Nothophagus and sclerophyll forest and shrublands, typical of the Mediterranean regions (Arroyo et al., 2006). In the Andean foothills of the Maule Region alone, 44 percent of the native forest was lost at an annual deforestation rate of 4.1 percent between 1989 and 2003 (Altamirano and Lara, 2010). Likewise, over the last 20 years the area of avocado plantation (Persea americana) has tripled and the vineyard area has doubled, leaving the Mediterranean ecosystems confined to island hills without connection between them (Armesto et al., 2010).

According to studies carried out in the 1990s, 81 percent of the loss of native forest, recorded in the Maule Region, was due to the substitution of the forest for plantations of exotic species to produce pulp for export. In the Río Maule and Cobquecura sector (VII and VIII regions), a reduction equal to 67 percent of native forest was recorded between 1975 and 2000 (Echeverría et al., 2006).

By 2012, the ecosystems of sclerophyllous forest and diverse temperate forests of central and south-central Chile had their original area reduced by 83 percent. According to the study by Pliscoff (2015), to assess the conservation status of terrestrial ecosystems, most of the area of lost forests between 1992 and 2012 was occupied by pine and eucalyptus plantations. Because of this, 13 ecosystems are Endangered (EN) and Critically Endangered (CR), (**Table 03** and **Map 11**).

TABLE 03

ASSESSMENT OF THE CONSERVATION STATUS OF FOREST ECOSYSTEMS			
ID	**FOREST ECOSYSTEM**	**PERCENTAGE OF AREA LOST BETWEEN 1992 AND 2012**	**CONDITION OF THE ECOSYSTEM**
35	Inland Mediterranean thorny forest of *Acacia caven* and *Lithrea caustica*	23.43	Endangered
42	Coastal Mediterranean sclerophyllous forest of *Lithrea caustica* and *Azara integrifolia*	35.08	Critically Endangered
43	Inland Mediterranean sclerophyllous forest of *Lithrea caustica* and *Peumus boldus*	25.66	Critically Endangered
45	Inland Mediterranean sclerophyllous psamophil forest of *Quillaja saponaria* and *Fabiana imbricata*	54.73	Critically Endangered
47	Inland Mediterranean deciduous forest of *Nothofagus obliqua* and *Cryptocarya alba*	48.49	Critically Endangered
49	Coastal Mediterranean deciduous forest of *Nothofagus glauca* and *Azara petiolaris*	44.3	Critically Endangered
50	Coastal Mediterranean deciduous forest of *Nothofagus glauca* and *Persea lingue*	46.58	Critically Endangered
52	Coastal Mediterranean-temperate deciduous forest of *Nothofagus obliqua* and *Gomortega keule*	55.11	Critically Endangered
53	Temperate deciduous forest of *Nothofagus obliqua* and *Persea lingue*	52.3	Critically Endangered
54	Temperate deciduous forest of *Nothofagus obliqua* and *Laurelia sempervirens*	26.72	Endangered
55	Coastal mixed temperate forest of *Nothofagus dombeyi* and *Nothofagus obliqua*	49.79	Critically Endangered
56	Coastal temperate deciduous forest of *Nothofagus alpina* and *Persea lingue*	24.68	Endangered
72	Coastal temperate broad-leaved forest of *Aextoxicon punctatum* and *Laurelia sempervirens*	26.84	Endangered

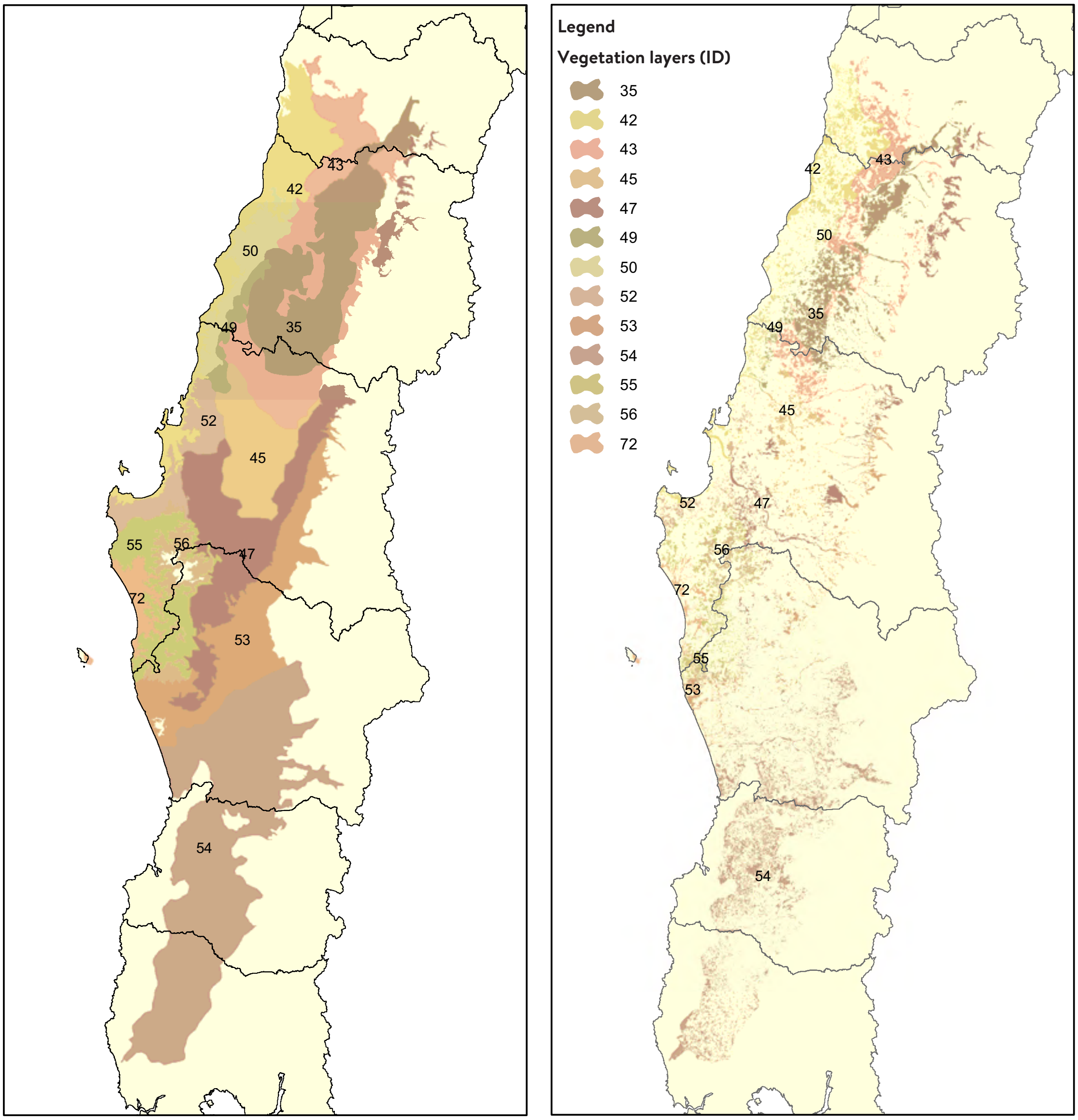
Source: Pliscoff, 2015.

MAP 11

HISTORICAL LOSS OF CHILEAN NATIVE FORESTS

Area of the country covered by currently endangered forests before 1740

Area of the country covered by endangered forests by 2014



The maps published in this report that refer to or are related to limits or boundaries of Chile do not commit the State of Chile in any way, according to Article 2, letter g of the Decree with Force of Law 83 of 1979 of the Ministry of Foreign Affairs. The cartographic information is based on Datum WGS84 and it is merely referential.

Source: Authors' own elaboration based on Pliscoff, 2015.

2.1.2 Loss of Habitat in Wetland Ecosystems Due to Land Use Change

Wetlands are other ecosystems strongly affected by urbanization due to the increase of the real estate and industrial sector, causing its fragmentation and disappearance, through its drainage or filling for housing construction and road infrastructure development (Pauchard and Barbosa, 2013).

In 2010, based on a work commissioned by the Ministry of the Environment to the EULA-Chile Center for Environmental Sciences of the Universidad de Concepción, the wetlands of the Biobío Region were assessed. Of 11 systems, 72 percent are in a bad or very bad state of conservation, while 83 percent of 12 systems assessed for coastal sub-basins between the Andalién River and Biobío are classified as bad or very bad (Ministerio del Medio Ambiente - Centro de Ciencias Ambientales EULA-Chile, 2011).

Complementarily, in 2015, another study in the same region (Rojas et al., 2015), assessed the Rocuant-Andalién, Lenga, Laguna Verde, San Andrés, Paicaví and Sector Cuatro Esquinas wetlands. The state was measured through the richness of insect and plant species and the characteristics of land use. The study determined that the wetlands with less urbanization nearby, such as Laguna Verde and Lenga, have a greater insect richness, but not the Rocuant-Andalién wetland, which has a higher presence of introduced insects and flora, characteristics that can be linked to its historical pollution conditions.

According to the planned urbanization, the Rocuant-Andalién wetland would be the most affected, being an ecosystem relevant for the migration of associated birdlife, rainwater drainage and protection against tsunamis. According to the authors, the services provided by the wetland could be eliminated or reduced by urbanization projects. The results presented help reflect the idea of sustainable development in the Concepción metropolitan area.

Regarding groundwater ecosystems, the extraction of water from aquifers has occurred at a faster rate than its recovery, altering the hydrological connection between groundwater and surface water and, consequently, over wetlands such as boglands, meadows, and lagoons, among others.

2.1.3 Forest Fires in the Native Forests

Another cause of the loss of biodiversity is forest fires, whose increase over the last decade contributed to the high degree of fragmentation of the native forest and, consequently, to the deterioration and loss of other ecosystems and habitats. Fires can severely alter the stability of ecosystems, modifying the structure and composition of species, factors that together result in a loss of functionality of the ecosystem of difficult recovery (Fernández et al., 2010), mainly due to the high costs involved its control and restoration.

According to González et al. (2011), over the last three decades, the center-south zone has shown a consistent and significant increase in the number of forest fires with 99 percent of anthropic origin. On the other hand, in Chile there has been a particularly highly burned area associated with the occurrence of severe El Niño events. It should be noted that the arborescent and open sclerophyllous vegetation predominates in the Valparaíso and Maule regions, where rainy winters and springs in El Niño years promote the accumulation of "fuel". In some cases, this annual accumulation is accompanied the following year by the occurrence of drier than normal conditions associated with La Niña events. This results in a larger burned area during the fire season, as it did during the 1997-1998 season (**Figure 11**).

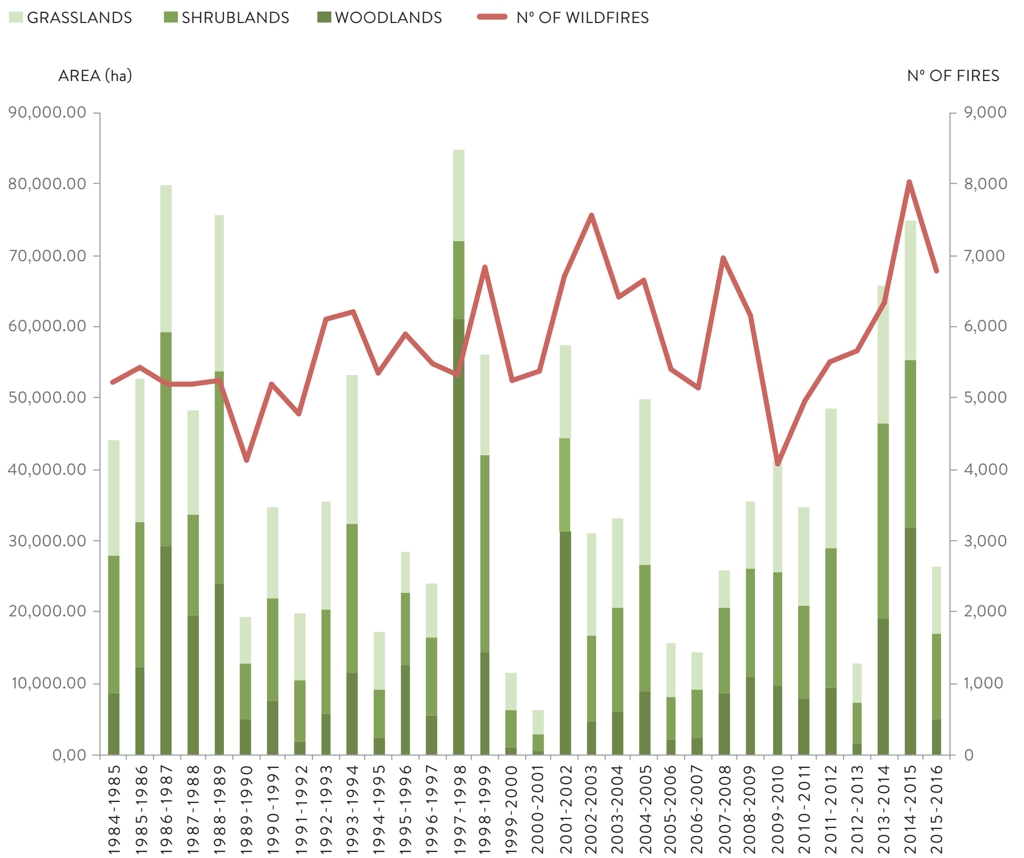
According to data from CONAF[9], between 1964 and 2016, the annual average of hectares consumed by fire was 48,390, with an average of 4,329 fires. In the five-year period between 2012 and 2016, there was an average of 6,465 fires, which affected on average more than 76,000 hectares per year, 60 percent of which corresponded to native formations.

During the 2015-2016 season, the Biobío Region accounted for the largest number of fires, with 2,691, while the Araucanía Region recorded the largest area affected, with 12,231 hectares burned.

[9] *http://www.conaf.cl/incendios-forestales/incendios-forestales-en-chile/estadisticas-históricas/*

FIGURE 11

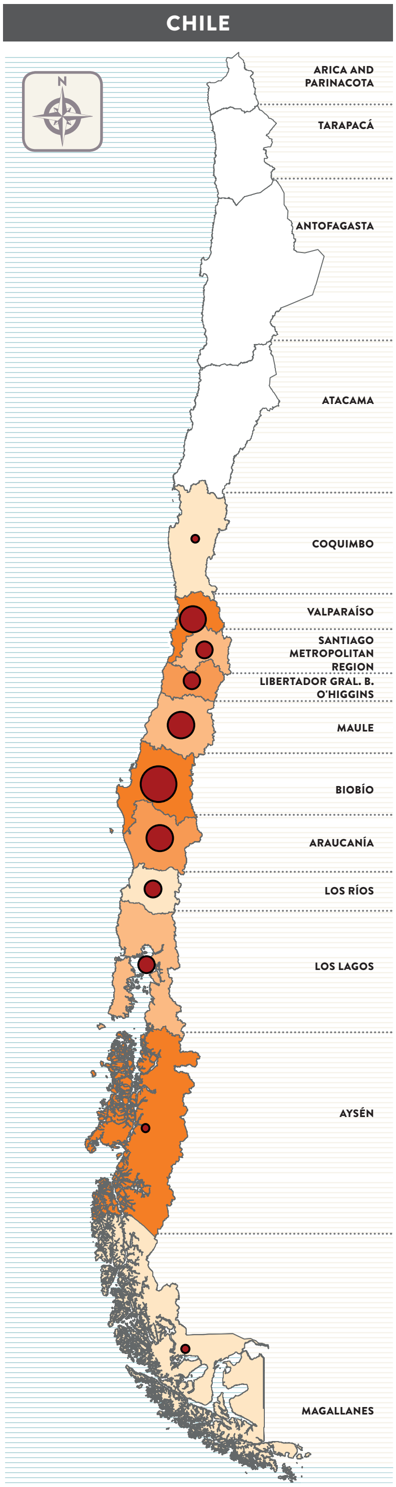
NUMBER OF FIRES AND AFFECTED NATURAL VEGETATION AREA



Source: CONAF, 2016.

MAP 12

AFFECTED NATURAL VEGETATION AREA AND NUMBER OF FIRES IN 2016



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Affected Area (ha)

- 0 - 416
- 417 - 2.441
- 2,442 - 3,386
- 3,387 - 4,706

Number of fires

- 25 - 96
- 97 - 333
- 334 - 1,344
- 1,345 - 2,691
- No information

Source: Authors' own elaboration based on data from CONAF, 2016.

2.2. Overexploitation

2.2.1. Logging

"Out of Chile's energy matrix, 23 percent comes from wood combustion, 70 percent of which comes from native forest. It is the key factor in the degradation of the forest and the loss of biodiversity in forests of global importance in central and southern Chile "(Ministerio de Energía et al., 2016).

Logging is a major threat to the conservation of native forests. In Chile, between 1989 and 1995, woodchip production represented an important consumption of this resource. However, as of 1996, the forestry sector has reduced the consumption of native wood chips significantly, reducing pressure on native forests.

Although the industrial extraction of native wood has decreased, the consumption of firewood of native tree species has practically doubled over the last 20 years, going from four to nearly nine million solid m^3 per year, becoming the main pressure on native forests.

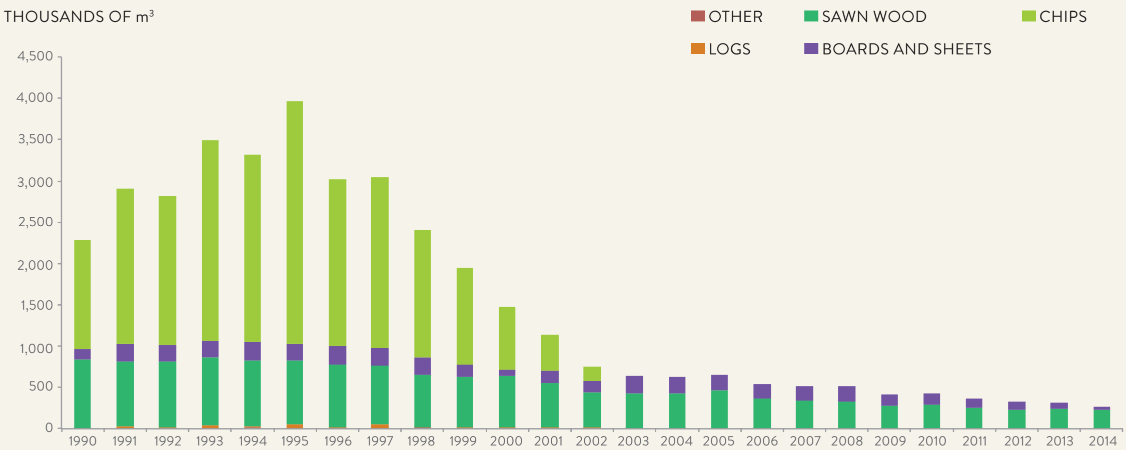
04

NATIVE SPECIES WITH COMMERCIAL VALUE

Our native forests are of high value, not only because of their great biodiversity and endemism, but also because of the great diversity and quality of their wood, which includes the millennial beech conifers, monkey-puzzle trees and cypress, whose woods are highly resistant to degradation and possess high commercial value, along with *Maňíos*, *Lingues*, *Tepas*, *Ulmos*, *Raulí* beeches, *Lenga* beeches, farther north, which have been exploited for several centuries.

FIGURE 12

PRODUCTS MADE FROM NATIVE WOOD BY 2014



Source: INFOR, 2016.

According to the Technology Development Corporation, CDT (2015), 33.2 percent of households in the country (1,721,032) use firewood, which is especially relevant in the regions of Araucanía, Los Ríos, Los Lagos and Aysén, where more than 90 percent of homes use it. The total consumption at the national level reaches 11,770,675 m^3 st/year, of which 58 percent corresponds to native firewood, with the Oak or Hualle being the most consumed species (**Table 04**).

TABLE 04

FIREWOOD IN BIODIVERSITY

NAME	TYPE	PERCENTAGE OF RESIDENTIAL CONSUMPTION	m3 st/YEAR
PATAGONIAN OAK	Native	23	2,753,038
NATIVA	Native	12	1,416,268
ULMO	Native	6	701,063
CHILEAN MYRTLE	Native	5	553,270
TEPU MYRTLE	Native	4	437,725
LENGA BEECH	Native	4	423,735
DOMBEY'S BEECH	Native	2	206,957
THORN-BUSH	Native	1	136,267
ÑIRRE	Native	1	110,715
RAULÍ BEECH	Native	0,1	12,701
LINGUE	Native	0,1	10,022
TOTAL		58,2	6,761,761

Source: CDT, 2015.

2.2.2. Illegal Logging

The logging of native forest species is banned in Chile, according to the Law for the Recovery of Native Forest and Forest Development (20.283), which considers all native plant species in a conservation category.

According to the classification of Donoso (1981), the evergreen forest type is composed of Southern oak beeches (*Nothofagus sp.*), Ulmo (*Eucryphia cordifolia*), Chilean myrtle (*Luma apiculata*), and Mañíos (*Podocarpus nubigenus*), among others. Meanwhile, the forest type Roble-Raulí-Coihue, corresponds to renewal and pure or mixed forests of the Patagonian oak (*Nothofagus obliqua*), Raulí beech (*Nothofagus alpina*) and Dombey's beech (*Nothofagus dombeyi*) species. In most of the reports of illegal logging in recent years, the forest types are evergreen and Roble-Raulí-Coihue. The latter has a high economic value, since it corresponds to forests of species with a faster growth.

2.2.3. Overexploitation of Fisheries

Among the pressure factors that affect Chile's marine and coastal ecosystems is the inadequate use of resources due to overexploitation, bycatch and discards. Information gaps on marine and coastal biodiversity are a critical factor in effectively measuring the health of marine ecosystems and the impacts of the factors mentioned above.

From a fishing perspective, the rate of loss of marine ecosystems is unknown, but it is presumed that the seabed has been damaged as a result of years of trawling fisheries with harmful fishing gear. Fisheries are currently in a so-called "marine drought", with the least amount of fish in its history (Sociedad Nacional de Pesca, 2013).

Demersal fisheries face significant exploitation problems, but of less intensity with respect to pelagic fisheries. In this group of species, recent information is available on the biomass of Chilean hake (*Merluccius gayi*), Southern hake (*Merluccius australis*), Golden kingklip conger (*Genypterus blacodes*) and Chilean seabass (*Dissostichus eleginoides*).

In fact, of the 33 most important fisheries for the country, eight were classified in 2014 as overexploited (Southern blue whiting and Southern hake, among them), eight as exhausted or collapsed (Golden kingklip conger and Anchovy, among them) and five with data deficiency (Subsecretaría de Pesca y Acuicultura, 2014).

The main threats to marine biodiversity are the depletion of its exploited populations, the reduction of the average size of the resource and reduction of its populations, the depletion of benthic and pelagic marine ecosystems, both coastal and oceanic, changes in the community trophic structure, and the loss of biodiversity, among others (United Nations Development Programme, 2009).

Punta Lobos Pichilemu | JORGE HERREROS

05

SOME CASES OF OVEREXPLOITATION OF FISHERIES

The Southern hake and the Southern blue whiting (both present from the Los Lagos Region to the Magallanes and Chilean Antarctic Region), changed their conservation status from full exploitation to overexploitation.

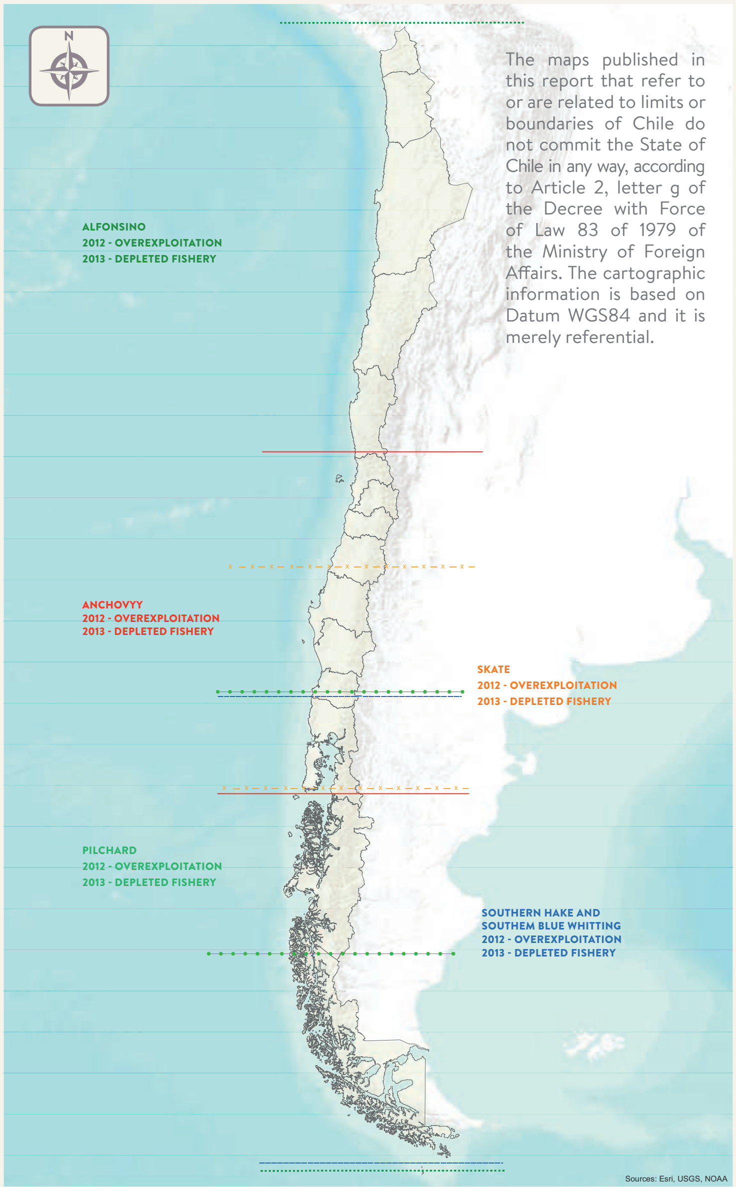
The Anchovy in the central-southern zone (present from the Valparaíso Region to the Los Lagos Region), the Golden kingklip (present from the Los Lagos Region to the Aysén Region) and the Alfonsino (throughout the country) went from overexploitation to a depleted fishery situation.

The case of the Pilchard (*Sardinops sagax*) is critical in the northern zone of the country, since its biomass has significantly diminished over the last two decades. Studies indicate that the decline in production has mostly been caused by the crisis of the pelagic fisheries of the Jack mackerel and the Anchovy.

The Jack mackerel (*Trachurus murphyi*) has disappeared from the list of the 10 most caught species in the world, going from 5 million metric tons by the mid-1990s to 0.7 million metric tons in 2010 (FAO, 2012).

MAP 13

STATE OF ALFONSINO, ANCHOVY, SKATE, GOLDEN KINGKLIP, SOUTHERN HAKE AND SOUTHERN BLUE WHITING FISHERIES (2012-2013)



Source: Authors' own elaboration based on Undersecretariat for Fisheries and Aquaculture, 2014.

2.3 Pollution

Pollution is one of the causes of the loss of biodiversity that is generated by the presence of substances or a combination of these, in concentrations and permanence higher than those naturally found in a natural ecosystem. Unsustainable human activities are the main causes of environmental pollution. Thus, in the northern zone, for example, as a consequence of mining, the existence of environmental liabilities or the presence of tailings (fine sediment from the refining of metals) has generated contamination in the soil and groundwater. The central zone, focused on agriculture - where the largest proportion of inhabitants are concentrated - presents diffuse sources issues, with high organic load coming from agricultural (Morlans López, 2010) and industrial activities and human settlements. Finally, in the southern zone, salmon farming and aquaculture generate various pressures on biodiversity in the water column, the seabed and the coast.

It is estimated that the large amount of antibiotics, especially quinolone derivatives, used over the last 20 years in salmon farming, in the estuaries of the Los Lagos Region, will select and promote the dissemination of resistance genes and resistant bacteria in aquatic and terrestrial environments, negatively impacting animal and human health. For every metric ton of salmon produced in Chile, 36,600 times more antibiotics are used than in Norway (Millanao et al., 2011). At present, the development of profound reforms aimed at achieving more sustainable practices in the sector has been promoted, such as the diversification of the industry towards other crops and reducing the scale of the activity, among other measures.

2.4 Introduction of Invasive Alien Species

Invasive Alien Species (IAS) depredate native species, compete for resources, transmit diseases, alter, fragment ecosystems and degrade ecosystem services with significant social and economic effects. Although there are some studies, Chile still lacks exhaustive inventories of invasive alien species, which makes it difficult to assess the degree of dispersion and invasiveness. Likewise, the country does not have a regulatory framework or an institutional framework to take over the control of IAS.

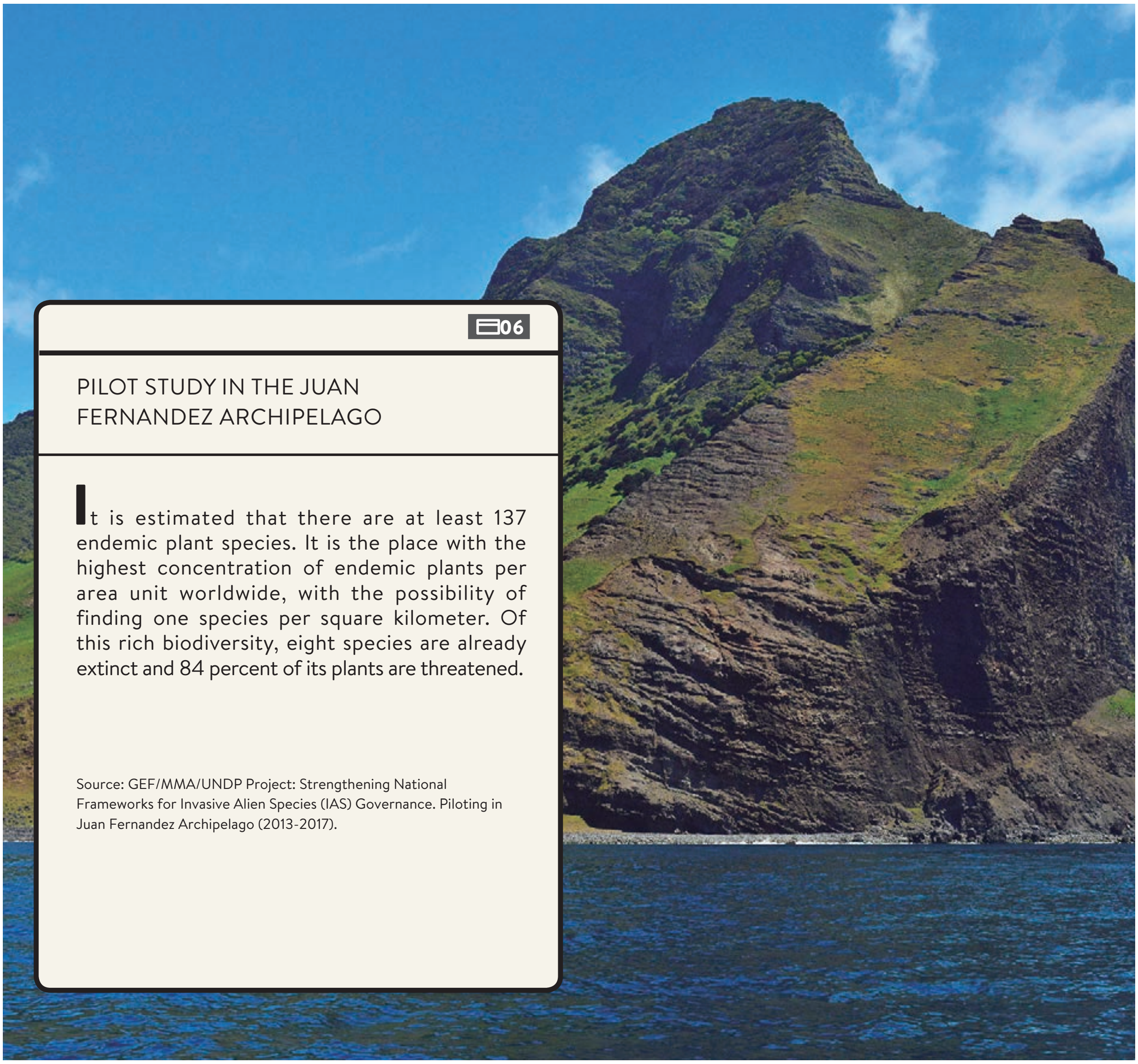
In 2014, through a diagnosis of the situation of exotic species[10], more than 2,000 feral or naturalized species were counted in the national territory, of which 25 have been classified within the 100 most harmful invasive species in the world (Lowe et al., 2004).

One of the most harmful invasive species is the Didymosphenia geminata, better known as Didymo, a microalgae that was recorded in 2010 for the first time in southern Chile and it is unknown when it was introduced to the country. This species has spread massively, modifying the ecosystems of rivers and lakes, causing the reduction of fish and other species populations, also affecting the tourism industry and generating a high management cost

The Castor canadensis, present in continental water ecosystems of Tierra del Fuego in Chile and Argentina, is the invasive alien species of which there is greater knowledge. This species, introduced in Tierra del Fuego in 1946, expanded its impact area to the continent and currently threatens to colonize all of Patagonia. It has modified rivers and peatlands of Tierra del Fuego, and it is estimated that it has modified approximately 5,400 ha of native forest in the Chilean sector and at least 5,200 ha in the Argentine sector (Wallem et al., 2007). Its speed of terrestrial expansion varies according to the ecosystems, being able to surpass six kilometers per year.

[10] *GEF/MMA/UNDP Project: Strengthening National Frameworks for IAS Governance - Piloting in Juan Fernandez Archipelago (2013-2017).*

The Red Deer, introduced in Tierra del Fuego, is ranked among the 100 most harmful invasive species in the world by the International Union for the Conservation of Nature (IUCN). It represents a high risk for the natural ecosystems of southern Chile to Tierra del Fuego (Flueck and Smitth-Flueck, 2012). Other exotic predatory species, such as the Mink (*Neovison vison*) and the wild boar (*Sus scrofa*), are mammals that are dispersing over large areas of the country, but there are no studies that evaluate the economic damage caused.



06

PILOT STUDY IN THE JUAN FERNANDEZ ARCHIPELAGO

It is estimated that there are at least 137 endemic plant species. It is the place with the highest concentration of endemic plants per area unit worldwide, with the possibility of finding one species per square kilometer. Of this rich biodiversity, eight species are already extinct and 84 percent of its plants are threatened.

Source: GEF/MMA/UNDP Project: Strengthening National Frameworks for Invasive Alien Species (IAS) Governance. Piloting in Juan Fernandez Archipelago (2013-2017).

Juan Fernández | MIGUEL STUTZIN

Right Estuary Elqui Valley Natural Sanctuary | NATALIA MATURANA

2.5. Climate Change

Due to the vulnerability of the country in terms of climate change, different studies have been carried out to model the future behavior of species and terrestrial ecosystems in Chile, in the face of climate change scenarios. Regarding the distribution and dispersion of the species, it is pointed out that the consequences of this change would depend esentially on the dispersion or large-scale migration capacity of the species studied (Marquet et al., 2010).

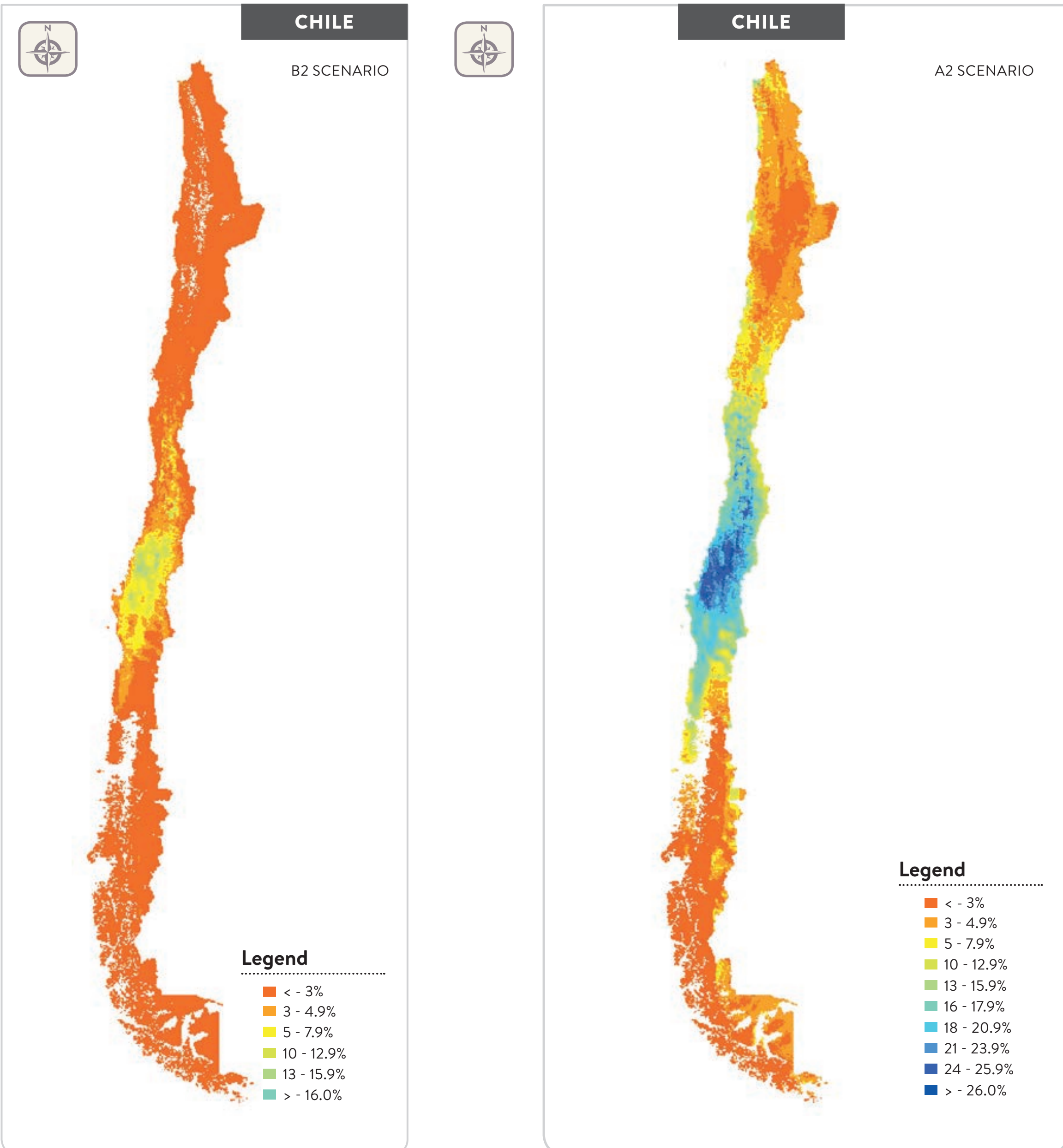
In 2010, the Ecology and Biodiversity Institute (IEB by its acronym in Spanish), entrusted by the then CONAMA (Marquet et al., 2010), developed the study entitled "Vulnerability of Terrestrial Biodiversity in The Mediterranean Eco-Region, at the Level of Ecosystems and Species, and Adaptation Measures in the Face of Climate Change Scenarios". If species are considered to have limitations to disperse when environmental conditions change in their traditional areas, the vast majority of the 1,447 species of terrestrial flowers and 67 species of fauna analyzed would present reductions in their projected distribution area.

The impacts of climate change on the 36 ecosystems, based on aggregations of the 127 vegetation layers of Luebert and Pliscoff (2006), show a latitudinal variation pattern in almost all the units present in the coastal and interior zone of northern and central Chile. Likewise, units with sclerophyll and thorn vegetation show the greatest variation in their current distribution ranges.

Parry Bay Glacier | JORGE HERREROS

MAP 14

PERCENTAGE OF CHANGE IN THE DISTRIBUTIONS OF PLANT AND WILDLIFE SPECIES FOR SCENARIOS A2 AND B2, IN RELATION TO THE CURRENT SITUATION (BASELINE)



The maps published in this report that refer to or are related to limits or boundaries of Chile do not commit the State of Chile in any way, according to Article 2, letter g of the Decree with Force of Law 83 of 1979 of the Ministry of Foreign Affairs. The cartographic information is based on Datum WGS84 and it is merely referential.

Source: Marquet et al., 2010.

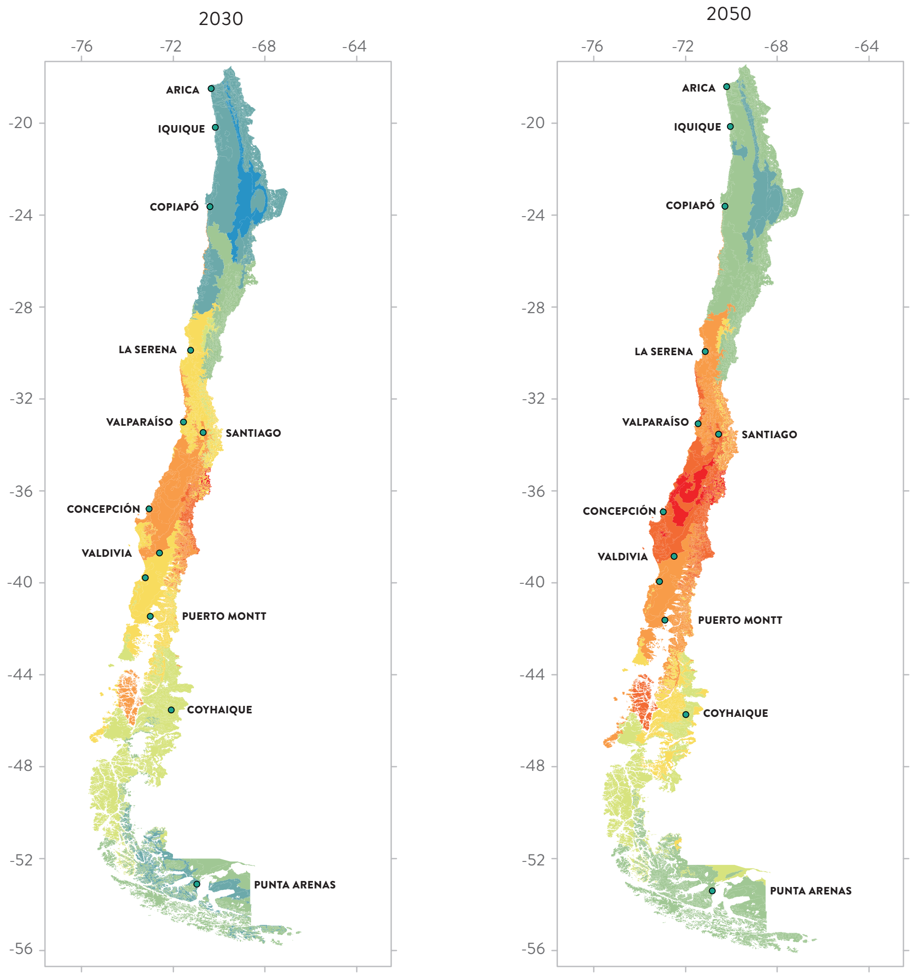
In the case of the High Andean wetlands, in the extreme north of the country, eight sites corresponding to the basins with the greatest amount of wetland habitat were selected (Altiplano Basin, Lluta River Basin, Atacama Salt Flat Basin, Loa River Basin, Endorheic Basins of the Atacama Salt Flat, Northern Basin of the Pedernales Salt Flat, Pacific Slope Basin, Huasco River Basin). The results of the analysis indicate that the future water balance will be characterized by a trend towards increasing temperatures and a reduction in rainfall water, flows and surface runoff, the latter being the main support for wetlands in this area, which would mean a loss in the stability and ecological functionality of these ecosystems.

Complementarily, researchers from the University of Chile (Santibáñez et al., 2013) analyzed the bioclimatic stress[11] on each of the 127 vegetational layers (vegetation formations grouped by plant types) of Chile. Bioclimatic stress is estimated as a function of the differences between the average conditions during 1980-2010 (baseline) and the expected climatic conditions in 2030 and 2050. Based on this concept, and also incorporating other non-climatic variables that affect the vulnerability of ecosystems, the vegetation layers located in the central zone of the country, between the regions of Coquimbo and Los Lagos, are identified as being particularly affected for the 2050 scenario.

[11] *The following climate variables are applied: Summer temperature (January), winter temperature (July) and the degree of dryness.*

MAP 15

INTEGRATED STRESS INDEX



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Source: Santibáñez et al., 2013.

3 • RESPONSE

3.1 Biodiversity and Protected Areas Service

In 2010, with the amendment to Law 19.300 on General Environmental Framework Law (Law 20.417/2010), Chile committed to the creation of a public service in charge of biodiversity conservation, in order to consolidate the implementation of policies on the sustainable use and protection of the country's biodiversity.

In June 2014, the Executive Branch submitted a draft bill to the National Congress to create the Biodiversity and Protected Areas Service and the National Protected Areas System (draft bill for the SBAP (by its acronym in Spanish) [12], which is currently being discussed in Congress. This law will enable the implementation of a set of objectives and functions regarding the conservation and protection of ecosystems, species and genes, as well as the integrated management of public and private protected areas, among other matters.

Likewise, this law will allow the implementation of tools and mechanisms to reduce the loss of habitats of native species, pollution, the impacts of invasive alien species, overexploitation of species, and the effects of global climate change.

3.2 National Biodiversity Strategy

In 1994, Chile ratified the Convention on Biological Diversity (CBD) and made the commitment to implement actions for the conservation and sustainable use of biodiversity. In 2010, the CBD urged countries to update their National Biodiversity Strategies (NBS) under the "Strategic Plan for Biodiversity 2011-2020 and the Aichi Targets”[13].

The National Biodiversity Strategy is a document that countries prepare to guide their actions associated with the compliance with the CBD. This document recognizes the importance of biodiversity as an axis of life on earth and focuses its efforts on its conservation, including the sustainable use of its components. This commitment also recognizes that the conservation of biodiversity is of common interest for society as a whole, as well as an integral part of the development process.

The national strategy (2016-2030) is composed of two policies and four thematic strategies, each of which includes an action plan:

1. National Policy for the Conservation of Endangered Species.
2. National Protected Areas Policy.
3. Strategy for Marine Conservation and Oceanic Islands.
4. National Strategy for the Conservation and Rational Use of Wetlands.
5. Management Strategy of Invasive Alien Species.

3.3 Biodiversity as Pillar for the Sustainability of Natural Resources

The impacts on biodiversity have affected the quality and quantity of ecosystem services it provides. The degradation of the natural heritage leads to socioeconomic losses, in view of the country's dependence on the exploitation of its natural resources and the benefits of ecosystem services.

[12] *Draft Bill: Bulletin N° 9.404-12..*

[13] *See detail of the goals in http://biodiversidad.mma.gob.cl/?page_id=1612*

The main productive sectors that benefit from ecosystem services are the mining sector, an intensive user of the water supply service, which in turn contributes 12 percent to the national GDP; the tourism sector, which contributes 3.2 percent to the national GDP; the agroforestry sector, the main consumer of fresh water (73 percent in the country), which contributes 2.6 percent to the GDP; and the fishing sector, which represents 0.3 percent of the GDP (Ministerio del Medio Ambiente, 2014). The estimation of the economic value of tourism and recreation ecosystem services, considering only national parks, national reserves and natural monuments, amounts to 70.5 million dollars in 2010 (Figueroa, 2010), without considering the economic and employment concatenation towards related sectors. The other sectors mainly rely on services provided by ecosystems located outside protected areas.

On the other hand, the economic activities that benefit from the services provided by ecosystems do not sufficiently integrate conservation actions in their investment and planning schemes. This is associated with the absence of markets that allow for the development of conservation activities. Among the problems for developing these types of markets are a series of failures, such as high transaction costs, information asymmetries, the presence of externalities, coordination costs, uncertainty, and irreversibility, among others.

3.4. Economic Instruments for Promoting Biodiversity Conservation

Today, the instruments available to the Chilean State for the conservation of biodiversity and the provision of ecosystem services inside and outside protected areas are insufficient, scattered and incomplete. Because of this, the draft bill that creates the Biodiversity and Protected Areas Service (SBAP), includes a series of new instruments, such as the payment for ecosystem services, biodiversity compensations and certification or registration of preservation actions.

The draft bill for the creation of the SBAP can solve these problems through the development of certifications or registry of actions of maintenance or recovery of ecosystem services, standardization of their valuation and dissemination. Likewise, the promotion of practices for the preservation and restoration of biodiversity and ecosystem services, through their certification or registration, requires designing an institutional framework that defines the certifying entity (whether it is the State or independent actors) and the methodologies to be applied.

3.5. In-situ Conservation

3.5.1. Protected Areas

Internationally, consensus has been reached that in-situ conservation, that is, the creation and management of protected areas, is the most appropriate mechanism for the preservation and conservation of biodiversity at its three levels: genes, species and ecosystems.

Protected areas are an essential element in the conservation of biodiversity and consider a broad spectrum of levels of protection, with different types of protected areas depending on the level of restrictions established for each category.

SBAP

The **Law that creates the Service of Biodiversity and Protected Areas (SBAP),** contemplates a series of new instruments, such as the payment for ecosystem services, biodiversity compensations and certification or registration of preservation actions.

The law for the creation of the SBAP can solve these problems through the development of certifications or registration of actions of maintenance or recovery of ecosystem services, standardization of their valuation and dissemination.

The legislative and institutional development of protected areas in Chile has led to the creation of different categories of protected areas. This document presents nine categories as protected areas that meet the following criteria: (i) they are aimed at the conservation of biodiversity; (ii) they have institutional mechanisms for their designation and management; (iii) they are created over well-defined geographic areas. The nine categories are listed below with a proposal for their correspondence to the IUCN categories.

TABLE 05

CHILEAN PROTECTED AREAS AND THEIR EQUIVALENT TO THE IUCN CATEGORIES

PROTECTED AREA / IUCN CATEGORY	Ia	Ib	II	III	IV	V	VI
Marine Park	X						
Virgin Region Reserve		X					
National Park			X				
Natural Monument				X			
Nature Sanctuary				X	X		
Forestry Reserve					X		
National Reserve					X		X
Marine Reserve					X		
Multiple-Use Marine Protected Area (MU-MPA)						X	

Source: MMA, 2015b.

TABLE 06

NUMBER AND AREA COVERAGE OF CHILEAN PROTECTED AREAS

Nº	PROTECTED AREA CATEGORY	AREA (HA)
9	Multiple-Use Marine Protected Area (MU-MPA)	98,475.07
3	Marine Parks	45,005,063.05
5	Marine Reserves	7,810.57
16	Natural Monuments	34,429.28
36	National Parks	9,181,757.97
23	Forestry Reserves	4,663,040.73
26	National Reserves	751,304.73
45	Nature Sanctuaries	485,433.52
164	TOTAL	59,958,738.29

Source: MMA, 2016b.

The approval of the draft bill that creates the of Biodiversity and Protected Areas Service and the National Protected Areas System, will enable the integrated implementation of policies, plans, programs and standards for biodiversity conservation, both outside and inside protected areas, in an organic manner and consistent with the commitments made within the framework of the Convention on Biological Diversity (CBD), the Strategic Plan for Biodiversity (2011-2020)[14] and other conventions, in addition to the recommendations of the Organisation for Co-Operation and Economic Development (OECD) in matters of nature conservation (Ministerio del Medio Ambiente, 2015b).

Chile's protected areas cover an area close to 60 million hectares, distributed in 164 units, in different protection categories and located in different types of ecosystems. It is worth noting that the distribution by ecosystems is not homogeneous, since more than 80 percent of the units correspond to terrestrial ecosystems.

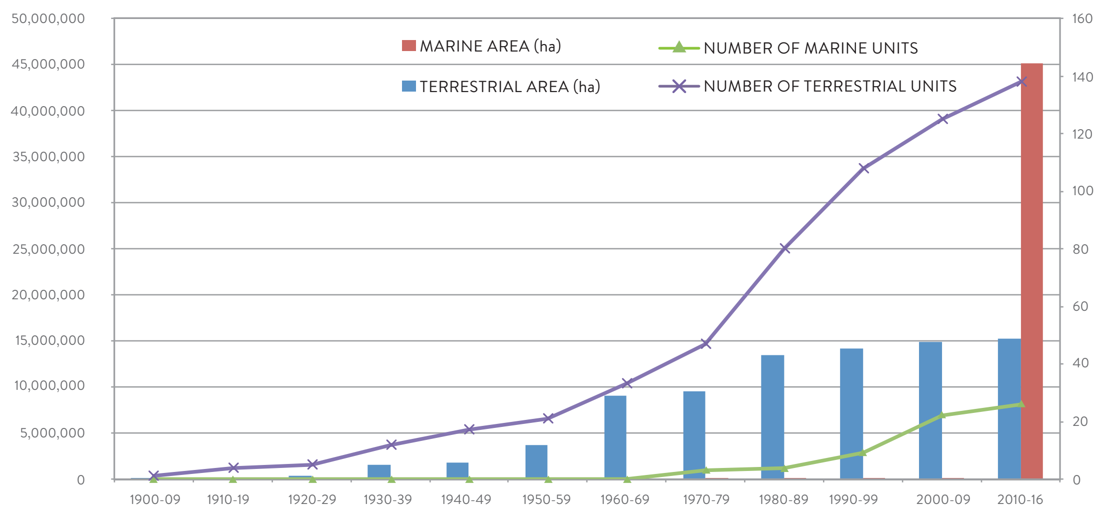
Figure 14 shows that most of the unprotected terrestrial ecosystems correspond to formations of coastal and inland shrublands in the northern zone; thorn scrubs, sclerophyllous forests, and deciduous coastal forests in the central zone; and steppes in the extreme southern zone. On the other hand, within the different categories of protected areas there are more than 2,000,000 ha of glaciers and more than 16,000 ha of wetlands. In addition, they harbor a significant number of species classified as endangered (Ministerio del Medio Ambiente, 2015b).

Regarding the protection of areas in marine and coastal environments, despite the fact that in general terms there is a 12.9 percent protection of the Exclusive Economic Zone, 97 percent of said area corresponds to two areas - Motu Motiro Hiva Marine Park, with 15,000,000 ha, and Nazca Desventuradas Marine Park, with 30,003,500 ha - that protect the bioregional province of Easter Island. The remaining area corresponds to the marine protected areas established on the continental shoreline and which contribute marginally to the representativeness of the rest of the marine ecoregions of the country (Ministerio del Medio Ambiente, 2015b).

[14] *Strategic Plan for Biodiversity (2011-2020) Aichi Target N° 11: " By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape."*

FIGURE 13

CHILEAN PROTECTED AREAS BY 2016



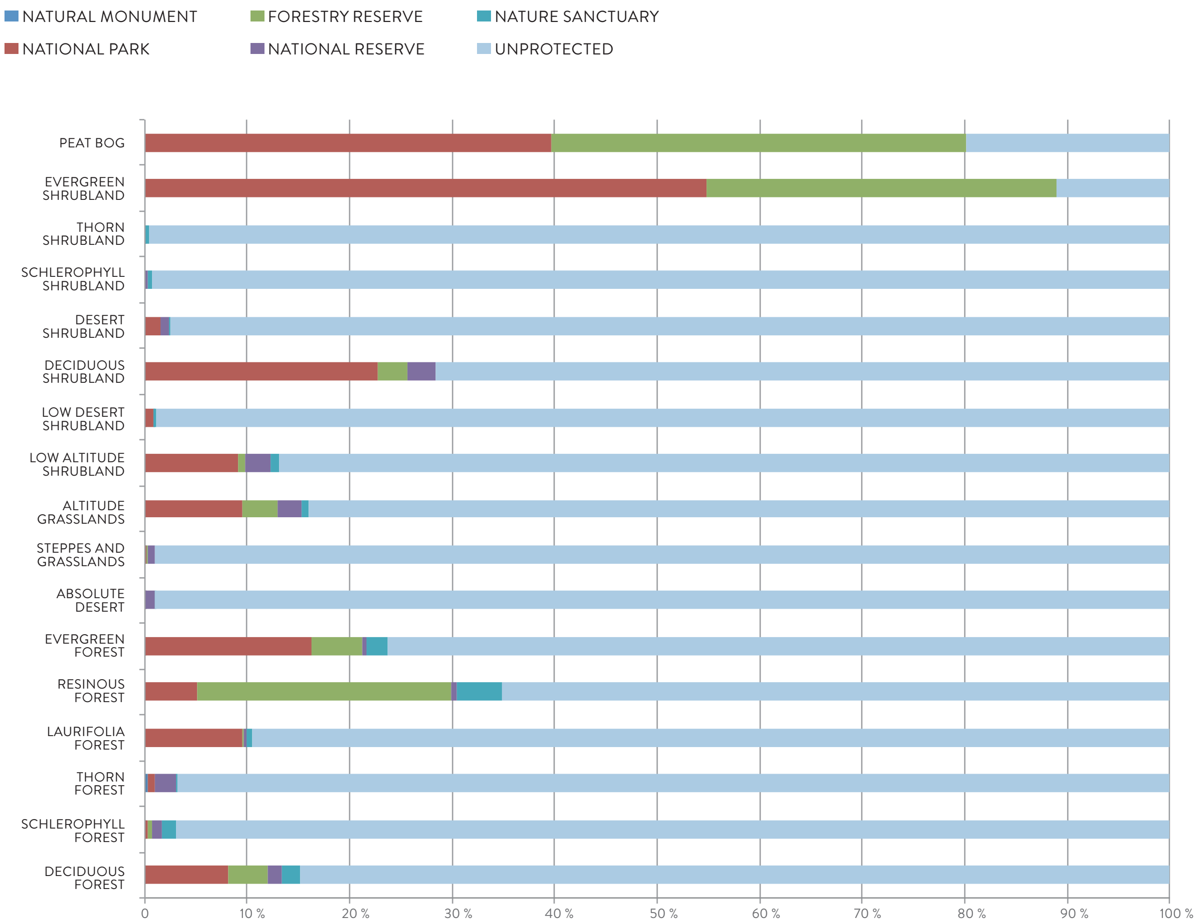
Source: MMA, 2016b.

Despite the high concentration of terrestrial protected areas - which cover approximately 20 percent of the continental and insular national territory -, significant representative gaps for a number of terrestrial ecosystems still persist. More than 12 percent of these are not included in any category of protected area and another 24 percent has less than 1 percent of their areas under some protection system (Ministerio del Medio Ambiente, 2015b).

In this context, there are gaps in ecosystem representativeness and inequality in coverage (area), geographical distribution and level of protection of marine protected areas. Among the environments that do not have conservation measures are the submarine canyons and plains and the pelagic and demersal environments. Likewise, there are gaps in conservation efforts in the northern and central zones, the fjords and channels and oceanic islands (Ministerio del Medio Ambiente, 2014).

FIGURE 14

REPRESENTATION OF TERRESTRIAL ECOREGIONS IN CHILE BY 2016



Source: MMA, 2016b.

3.5.2. Other Management Tools for In-Situ Conservation

In addition to protected areas, there are other tools for the conservation of terrestrial or aquatic environment, such as international protection designations. These include buffer zones, conservation landscapes, biological corridors or priority sites for the conservation of biodiversity. International protection designations include Biosphere Reserves, internationally relevant wetlands (Ramsar Sites) and World Heritage sites. These designations are based on international treaties signed by Chile.

Biosphere Reserves

Biosphere Reserves are encompassed by the IUCN protected area categories V or VI, although they are not considered official protected areas in our country. In Chile, there are ten biosphere reserves, which cover in total an area of nearly 11.4 million hectares.

1. Araucarias
2. Cabo de Hornos
3. Fray Jorge
4. Juan Fernández
5. La Campana-Peñuelas
6. Laguna San Rafael
7. Lauca
8. Torres del Paine
9. Bosques Templados Lluviosos de Los Andes
10. Nevados de Chillán

Wetlands of International Relevance or Ramsar sites

They include lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans, which have been designated at the national level to be part of this category, recognizing that they have a significant value for all mankind (according to the International Convention on Wetlands). In Chile, there are 13 Ramsar Sites:

TABLE 07

LIST OF RAMSAR SITES IN CHILE

ID	NAME OF THE RAMSAR SITE	REGION	AREA (ha)	YEAR
1	Salar de Surire	Arica and Parinacota	15,858	1996
2	Salar de Huasco	Tarapacá	6,000	1996
3	Salar de Tara	Antofagasta	96,439	1996
4	Sistema Hidrológico Sóncor del salar de Atacama	Antofagasta	67,133	1996
5	Salar de Pujsa	Antofagasta	17,397	2009
6	Salar de Aguas Calientes IV	Antofagasta	15,529	2009
7	Laguna del Negro Francisco y Laguna Santa Rosa	Atacama	62,460	1996
8	Las Salinas de Huentelauquén	Coquimbo	2,772	2015
9	Laguna Conchalí	Coquimbo	34	2004
10	Parque Andino Juncal	Valparaíso	13,796	2010
11	El Yali	Valparaíso	520	1996
12	Santuario de la Naturaleza Carlos Anwandter	Los Ríos	4,877	1981
13	Bahía Lomas	Magallanes and Chilean Antarctica	58,946	2004

Source: Ministerio del Medio Ambiente, 2016c.

3.6. Ex-situ Conservation: Germplasm Banks

Germplasm banks are centers for the ex-situ conservation of genetic resources that operate under adequate conditions to prolong the life of the conserved material. They play a key role in the conservation of agricultural, livestock, forestry and bio-industrially used biodiversity and, more recently, of endangered wild species. Their role in supplying genetic material for research, development of livestock breeds and crop varieties, as well as microorganisms in the various areas of industry is also crucial (León-Lobos et al., 2016).

The National Institute of Agricultural Research (INIA by its acronym in Spanish) formally established in 2013 the "Network of Germplasm Banks", made up of four active banks and a seed base bank, as well as a microbial bank where the Chilean Collection of Microbial Genetic Resources is conserved (CChRGM by its acronym in Spanish), adding in 2015 an active potato bank and base that conserves an important collection of native potatoes (León-Lobos et al., 2016).

Given the importance of conserving genetic resources to help preserve biodiversity, in 2001 the INIA initiated a seed conservation program for native plants with the support of the Millennium Seed Bank Partnership of the Royal Botanic Gardens, Kew (RBG Kew). At present, it has been possible to collect around 2,000 seed samples, corresponding to 1,266 species (León-Lobos et al., 2016). Of these, 67 percent are endemic and the remaining 33 percent are native to Chile. There is a fraction of less than 0.5 percent of introduced species. Of the total species conserved, 39 percent correspond to annual and perennial herbs, 36 percent to shrubs and 13 percent to geophytes, followed by cacti, trees and a smaller fraction of lianas and parasitic plants. A no lesser fraction corresponds to species threatened with extinction, such as pacul (*Krameria cistoidea*), algarrobilla (*Balsamocarpon brevifolium*), dalea (*Dalea azurea*), garra de león (*Leontochir ovallei*) and azulillo (*Tecophylaea cyanocrocus*) (León-Lobos et al. al., 2016).

The only banks that have online information about their collections and a system of documentation and public access to genetic resources are those of the INIA network (León-Lobos et al., 2016).

Regarding microorganisms, there are work collections maintained in universities, among which the University of Concepción, University of Chile, University of La Frontera and Universidad Austral stand out. There is also a collection of microorganisms conserved in the Forest Institute (INFOR by its acronym in Spanish). These collections have been created within the framework of research projects, so their conservation is not guaranteed.

3.7. Species Conservation

3.7.1. Classification of Species According to State of Conservation

The Regulation for the Classification of Wild Species (RCE) establishes the provisions for the classification of wild animal and plant species in the different categories of conservation status (Tala et al., 2013). Since 2005, when the first regulation for the classification of species was published, 12 processes have been undertaken [15].

[15] *At the time of this publication, the Supreme Decree has not been published.*

TABLE 08

NUMBER OF SPECIES CLASSIFIED BY ALREADY FINALIZED RCE PROCESSES			
RCE	**DECREE**	**OFFICIAL GAZETTE**	**N° SPECIES**
1	Supreme Decree N° 151/2007 Ministry General Secretariat of the Presidency	24-03-2007	33
2	Supreme Decree N° 50/2008 Ministry General Secretariat of the Presidency	30-06-2008	71
3	Supreme Decree N° 51/2008 Ministry General Secretariat of the Presidency	30-06-2008	61
4	Supreme Decree N° 23/2009 Ministry General Secretariat of the Presidency	07-05-2009	133
5	Supreme Decree N° 33/2011 Ministry of the Environment	27-02-2012	112
6	Supreme Decree N° 41/2011 Ministry of the Environment	11-04-2012	73
7	Supreme Decree N° 23/2011 Ministry of the Environment	11-04-2012	111
8	Supreme Decree N° 19/2012 Ministry of the Environment	11-02-2013	96
9	Supreme Decree N° 13/2013 Ministry of the Environment	25-07-2013	110
10	Supreme Decree N° 52/2014 Ministry of the Environment	29-08-2014	103
11	Supreme Decree N° 38/2015 Ministry of the Environment	04-12-2015	100
12	Supreme Decree N° 16/2016 Ministry of the Environment	16-09-2016	89

TOTAL assessed species	1,110
TOTAL different species	993

Source: Department of Species Conservation, Division of Natural Resources and Biodiversity, Ministry of the Environment, 2016.

There are several implications to the application of the procedure for classifying species according to their conservation status. One of the most obvious is that, in general, threatened species receive more attention from the State, due to their precarious conservation situation. This aspect is not only reflected in terms of financing management, but also in the generation and application of regulations tending to reduce the threats that affect them (Tala et al., 2016). On the other hand, the review of species within the framework of the RCE is an incentive that forces to collect and update information on them, especially on biological and ecological aspects, population dynamics and threats. The results of the RCE also generate some binding effects with Law 4.601 on Hunting, Law 20.823 on Recovery of the Native Forest, with the Environmental Impact Assessment System and with the formulation of Recovery, Conservation and Management Plans of Species (Tala et al., 2016).

3.7.2. Plans for Species Recovery, Control and Management

The Plans for Species Recovery, Control and Management (RECOGE by their acronym in Spanish) are administrative and management tools that contain the set of actions, measures and procedures that must be executed to recover, conserve and manage species classified by the Regulation for the Classification of Wild Species (RCE). The procedure for their creation is governed by Supreme Decree Nº 1 of 2014, and they can be designed both for a particular species and for a group of species when they present similar characteristics in terms of their biology, threats or distribution (Tala et al., 2016).

The main approach of these plans is the control of threats, and their development is governed by participatory and collaborative principles, including state agencies and the scientific, academic, social and productive sectors both in the preparation and implementation of the plans (Tala et al., 2016).

Up to April 2016, there are three RECOGE plans with resolution, which launches the process of preparing the plan and which correspond to: Plan for the Recovery, Conservation and Management of the Coastal Flora of Northern Chile; Plan for the Recovery, Conservation and Management of Lucumillo; and Plan for the Recovery, Conservation and Management of the Ruil. Two other plans that will soon have initial resolution will be the Short-Tailed Chinchilla and garra de león. In the meantime, there are six other RECOGE plans undergoing their design process that have not yet been evaluated.

Sunset | FELIPE ANDAUR

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Chilean Flicker | RODRIGO DITTBORN

CHAP **16**

WATER

CONTENT

INTRODUCTION

Water is an essential natural renewable resource for humanity's development and is a key element of all ecosystems. It is estimated that the total global water resources reach 1.45 million km^3, of which 90,000 km^3 (2.5 percent) are fresh water. Out of this total, only 1 percent corresponds to surface water, 30 percent to groundwater and 69 percent to ice (Ministerio del Interior y Seguridad Pública, 2015).

1• BACKGROUND INFORMATION

At present, Chile faces a drought that has extended for more than seven consecutive years in the northern and central zones of the country, which evidently shows the impacts of climate change. An increased desertification process is among the most significant effects of this long drought period in the northern zone of Chile, while in the southern parts of the country the water deficit reaches the Los Lagos Regions. Highly intense precipitation was recorded in the northern zone, which caused landslides in the Atacama and Coquimbo regions, along with much damage to people and the environment. An overexploitation of surface water and groundwater resources is also observed, particularly as a result of increased irrigation and the reduction of aquifer recharge through rainfall, snow and the contribution of glaciers.

In response to the water scarcity condition, the country records significant progress in terms of environmental protection and conservation, beginning to manage water resources in a more integrated manner, including economic, social and environmental factors. Thus, Chile is increasing the coverage of water legislation associated to water quality and improving the monitoring of water resources, in accordance to the recommendations made by the OECD (2016). In addition, the Action Plan of the National Wetlands Strategy is under preparation and it will become a highly demanded environmental management tool at the national level for the protection of the territory's wetlands.

Water | MARTA HERNÁNDEZ

2 • STATE OF WATER RESOURCES

2.1 Surface Water

Rivers
In general, Chilean rivers are short, with significant slope changes within a few kilometers and a high variability of their flow during the year, since its recharge depends on precipitation (water and snow) and the contribution from glacier ice melting. Most of its rivers have their headwaters in the Andes Mountain Range and extend with a West-East trajectory to their river mouth in the Pacific Ocean.

ⓘ **Basin:** A river basin is the area where the waters that precipitate are drained by a river or network of streamflows. When the main river flows into a body of water or the ocean, it is an exorheic basin. In the case of an endorheic basin, the river does not flow into the ocean (DGA, 2016). For purposes of water analysis, a basin can be divided into subbasins and sub-subbasins, smaller-sized territorial units that also constitute drainage areas.

Water mirror of the Río Limarí | NATALIA MATURANA

TABLE 01

MAIN BASINS IN CHILE

MACROZONE	REGION	NAME	AREA (km²)
North	Tarapacá	Pampa del Tamarugal	17,353
	Tarapacá/ Antofagasta	Río Loa	33,081
	Antofagasta	Salar de Atacama	15,576
	Atacama	Río Copiapó	18,703
	Coquimbo	Río Limarí	11,696
Center	Valparaíso/ Santiago Metropolitan Region/ O´Higgins	Río Maipo	15,273
	Valparaíso/ Santiago Metropolitan Region/ O´Higgins/Maule	Río Rapel	13,766
	Maule/Biobío	Río Maule	21,052
South	Maule/Biobío	Río Itata	11,326
	Biobío/Araucanía	Río Biobío	24,369
	Araucanía	Río Imperial	12,668
	Araucanía/ Los Ríos	Río Valdivia	10,244
	Los Ríos/ Los Lagos	Río Bueno	15,366
Extreme South	Aysén	Río Aysén	11,456
	Aysén	Río Baker	20,945

Source: General Directorate of Water (DGA by its acronym in Spanish), 2016.

Lakes

A lake is a continental body of water of variable depth and dimensions (the smaller ones are called lagoons) that are located in depressions of the land surface. Throughout the country, a total of 368 lakes and 12,146 lagoons have been identified, mainly located in the southern zones of the country between the Aysén and Magallanes and Chilean Antarctica regions.

TABLE 02

NUMBER AND DISTRIBUTION OF LAKES AND LAGOONS IN CHILE

REGION	LAKES		LAGOONS	
	N°	%	N°	%
Arica and Parinacota	1	0.3	91	0.7
Tarapacá	0	0	39	0.3
Antofagasta	0	0	115	0.9
Atacama	0	0	165	1.3
Coquimbo	0	0	134	1.1
Valparaíso	1	0.3	146	1.2
Santiago Metropolitan Region	0	0	80	0.6
O´Higgins	0	0	105	0.8
Maule	9	2.4	190	1.5
Biobío	94	25.5	107	0.9
La Araucanía	19	5.2	261	2.1
Los Ríos	20	5.4	139	1.1
Los Lagos	67	18.2	638	5.1
Aysén	119	32.4	5,242	42.3
Magallanes and Chilean Antarctica	38	10.3	4,964	40.1
TOTAL	368		12,416	

Source: DGA, 2016.

Regarding the area of these lakes, the ones with the largest water mirror are Lago General Carrera, in the Aysén Region, with an area of 964.7 km^2 and Lago Llanquihue, located in Los Lagos Region, with an area of 867.1 km^2.

TABLE 03

LAKES AND LAGOONS WITH THE LARGEST WATER MIRROR PER REGION

REGION	NAME	WATER MIRROR AREA (km²)
Arica and Parinacota	Lago Chungará	22.7
Tarapacá	Laguna Parinacota	1.1
Antofagasta	Laguna Miscanti	13.1
Atacama	Laguna Verde	15.2
Coquimbo	Laguna del Pelado	2.1
Valparaíso	Laguna Peñuelas	14.1
Santiago Metropolitan Region	Laguna de Aculeo	12.1
O´Higgins	Laguna Cauquenes	6.4
Maule	Laguna del Maule	51.2
BIOBÍO	Laguna de la Laja	80.5
La Araucanía	Lago Villarrica	174.7
Los Ríos	Lago Ranco	429.9
Los Lagos	Lago Llanquihue	867.1
Aysén	Lago General Carrera	964.7
Magallanes and Chilean Antarctica	Lago del Toro	191.7

Source: DGA, 2016.

Wetlands

There are different types of wetlands, such as bog land, peatland, alluvial soils, estuaries, salt flats, marshes, swamps, and flooding plains, among others, as well the previously mentioned rivers, lakes and lagoons (RAMSAR Convention definition). For further information, please see the chapter on Biodiversity.

Glaciers

Glaciers are one of the main continental water reserves of the planet and are one of the most important components of the water cycle. Chile is among the countries that have one of the greatest glacier areas in the world, harboring 3.8 percent of the planet's total glacier area (excluding Antarctica) and 76 percent of the area in South America (MOP, 2009).

At the national level, there is a total of 24,114 glaciers, distributed from the northern zone to the extreme southern zone, equal to 23,641 km² and representing a significant reserve of water in its solid state. The Aysén Region concentrates the highest number of glaciers, with 9,556, while the Magallanes and Chilean Antarctica Region concentrates 48 percent of the total national area, with 11,321.8 km².

ⓘ **Glacier Classification:**
Glaciers can be classified according to the following characteristics: a) primary morphology; b) accumulation area; c) types of fronts; d) thermal classification and e) dynamic classification. According to their primary morphology, they can be: ice sheets, ice shelves, ice streams, piedmont glaciers, valley glaciers, ice caps, ice fields, crater glaciers, mountain glaciers, cirque glaciers, glacieret and rock glacier (MOP, 2009. National Glacier Strategy).

The Glaciology and Snow Unit of the General Water Directorate (DGA by its acronym in Spanish) is working to increase glacier knowledge and monitoring in Chile, at the same time that the Ministry of the Environment is developing an Action Plan for the Climate Change Strategy, which includes special considerations for glaciers and climate change adaptation measures. In this regard, it is indispensable to learn about the area and change that glaciers are undergoing in the central zone, in order to assess impacts on the availability of water resources and take actions to maintain these water reservoirs. Most of Chile's river basins are rain-snow fed. For example, it has been ascertained that the Juncal Norte glacier (7.6 km^2), among the largest ones close to Santiago, lost 1.5 km^2 of its area within a 51-year period, between 1955 and 2006 (Bown et al., 2008). This loss is equal to more than 10 million m^3 of water.

TABLE 04

NUMBER OF GLACIERS PER REGION, AREA AND VOLUME

REGION	AREA OF GLACIERS (km^2)	%	NUMBER OF GLACIERS	%	VOLUME OF GLACIERS (km^3)	%	VOLUME IN WATER EQUIVALENT (km^3)	%
Arica and Parinacota	12.2	0.05	174	0.72	0.2	0.00	0.1	0.0
Tarapacá	24.6	0.10	244	1.01	0.4	0.01	0.3	0.0
Antofagasta	7.2	0.03	139	0.58	0.1	0.00	0.1	0.0
Atacama	89.3	0.38	776	3.22	1.9	0.05	1.5	0.0
Coquimbo	46.9	0.20	809	3.35	0.7	0.02	0.4	0.0
Valparaíso	135.8	0.57	715	2.97	4.0	0.11	2.9	0.1
Santiago Metropolitan Region	388.3	1.64	999	4.14	14.4	0.41	11.4	0.4
O´Higgins	292.3	1.24	683	2.83	13.2	0.37	11.5	0.4
Maule	38.2	0.16	218	0.90	0.9	0.03	0.8	0.0
Biobío	45.8	0.19	198	0.82	1.8	0.05	1.6	0.1
La Araucanía	53.3	0.23	124	0.51	2.3	0.06	2.1	0.1
Los Ríos	42.6	0.18	72	0.30	2.2	0.06	2.0	0.1
Los Lagos	785.5	3.32	2,602	10.79	27.4	0.77	24.6	0.8
Aysén	10,357.4	43.81	9,556	39.63	1,743.1	49.35	1,568.8	49.4
Magallanes and Chilean Antarctica	11,321.8	47.89	6,805	28.22	1,719.7	48.69	1,547.7	48.7
TOTAL	23,641		24,114		3,532		3,176	

Source: DGA, 2016.

2.2 Groundwater

An aquifer is a permeable layer of soil formed by sedimentary deposits or fractured rocks, where water can accumulate. Groundwater is stored in aquifers, as a result of the recharge through infiltration from precipitation. Precipitation water goes through the saturated zone of the soil profile until reaching the water table. Groundwater moves slowly in the aquifers following the trajectory of the slope. **Table 05** shows the number of aquifers in Chile, identified by region.

According to the "Water Resource Management Diagnosis" prepared by the World Bank in 2011, it is believed that Chile has a significant volume of underground resources and that the estimated average recharge reaches 55 m^3/s from the Santiago Metropolitan Region to the North and 160 m^3/s from the Maule Region to the Los Lagos Region. It was also estimated that the actual use of these waters if 88 m^3/s (2003), of which 49 percent is used for agriculture, 35 percent for population supply and 16 percent for industry.

Groundwater is currently used in many different ways. In the northern zone of the country it is crucial, since it is the main source for drinking water (from the Arica and Parinacota Region to the Coquimbo Region). In the central zone (from the Valparaíso Region to the Los Lagos Region), they are also used as a source for drinking water in combination with surface water. According to data of the Superintendency of Sanitation Services (SISS, 2015), "of the 326 drinking water services or systems that serve concessioned areas, 67.5 percent is exclusively supplied by groundwater[1]."

[1] *Out of the 326 drinking water services or systems, 67.5 percent is exclusively supplied by groundwater, 18.1 percent by surface water, and 14.4 percent by mixed resources.*

TABLE 05

 # OF KNOWN AQUIFERS IN CHILE

REGION	# OF AQUIFERS
Arica and Parinacota	3
Tarapacá	4
Antofagasta	8
Atacama	4
Coquimbo	6
Valparaíso	8
Santiago Metropolitan Region	5
O´Higgins	11
Maule	14
Biobío	20
La Araucanía	12
Los Ríos	11
Los Lagos	31
Aysén	-*
Magallanes and Chilean Antarctica	-*
TOTAL	**137**

Source: DGA, 2016 (*no information).

An unexpected visitor | FELIPE MENDEZ

At present, many aquifers are overexploited (mainly in the northern and central areas of the country), because of that, it is necessary to have accurate information on the level variations of groundwater in the different basins of the country. **Table 06** shows the average reduction rates in 29 selected wells. These data include statistics from 1970 to 2015.

[2] Average groundwater reduction rates over the last few years. It must be noted that there is a variation between wells for the period. For example, the AP Vallenar well has maintained its trend over the last 12 years, while the Quebrada Cerrillos Amancay has done so for the last three years.

TABLE 06

AVERAGE GROUNDWATER DEPLETION RATE IN 29 SELECTED WELLS

REGION	Nº	STATION	DEPLETION RATE (m/year)[2]	VARIATION
Arica and Parinacota	1	Jica A	0.25	No significant change
	2	Las Vargas	0.00	No significant change
	3	Escuela Chitita 28	1.17	Decline over time
Tarapacá	4	Salar Bellavista 26	0.09	No significant change
Antofagasta	5	Isla Grande 3	0.00	No significant change
	6	Pique AV-42	0.00	No significant change
Atacama	7	Hacienda María Isabel 4	0.00	No significant change
	8	Pueblo San Fernando Las Cañas	3.43	Decline over time
	9	Queb. Cerrillos Amancay	4.86	Decline over time
	10	Iglesia Colorada	0.83	Decline over time
	11	Canal Madariaga	0.08	No significant change
	12	AP Vallenar	2.92	Decline over time
	13	San Félix	1.56	Fluctuation over time
Coquimbo	14	Algarrobal	0.34	Fluctuation over time
	15	El Sauce 2	1.58	Decline over time
	16	Barraza	0.60	Decline over time
	17	Asentamiento Alborada Juntas	0.06	Fluctuation over time
	18	Pueblo Cárcamo	0.03	No significant change
	19	Asentamiento Panguecillos	0.43	Fluctuation over time
Valparaíso	20	Perfil San Felipe	1.69	Decline over time
	21	Rabuco 2	0.06	No significant change
Santiago Metropolitan Region	22	Dinamic Oil	1.92	Decline over time
	23	La Católica	0.07	No significant change
	24	Misión Corazón de María	1.74	Decline over time
	25	Industria Bata	0.06	Fluctuation over time
O'Higgins	26	Doñihue	0.19	No significant change
	27	Estadio Peumo	0.21	No significant change
	28	Asentamiento La Puerta	0.10	No significant change
	29	Pueblo Tres Puentes	0.46	Fluctuation over time

Source: DGA, 2016.

Landscape | FELIPE ANDAUR

01

INTERACTION OF SURFACE WATER AND GROUNDWATER

In Chile, the interaction between groundwater and surface water is extremely active throughout the streamflows, due to the geomorphological and geological characteristics of the country (Ministry of the Interior and Public Safety, 2015). Traditionally these systems have been treated independently, causing major problems in their management.

Since the mid-1990s, the concept that surface and groundwater systems are interconnected, and that the management of one of them affects the other, grew stronger. In some rivers, sectors can be observed where surface water recharges aquifers and others where groundwater rises. These hydrogeological processes are known as recoveries and losses, respectively, and explain the interaction between the systems (Arumí et al., 2012). In terms of rights, the Water Code (Law 20.017) establishes, under Article 22, that the existing relation between surface water and groundwater must be considered (MOP, 2005).

2.3 Water Balance

Regarding the country's water balance – which is the result of the equation between recharge or water entering a system and discharge or water extracted from the system -, in 1987, the DGA conducted a study that enabled estimating and learning about the behavior of water flow at the national level. The regions with the greatest amount of precipitation were Aysén (3,263 mm/year) and Magallanes and Chilean Antarctica (2,713 mm/year).

The regions with the highest runoff levels were also Aysén (10,134 m^3/s) and Magallanes and Chilean Antarctica (10,124 m^3/s), while the ones with the lowest runoff levels were Antofagasta (0.93 m^3/s) and Atacama (1,88 m^3/s). In terms of country totals, this balance enabled estimating the level of precipitation at 36,947 m^3/s, the runoff level at 29,244 m^3/s, and the natural evaporation levels at 7,357 m^3/s, including evaporation from lakes and salt flats with 178 m^3/s. According to this balance, the regions with the greatest water deficit are those located in the northern and central zones of the country (from the Santiago Metropolitan Region to the North), which currently present a negative balance.

TABLE 07

REGIONAL WATER BALANCE (m^3/s)

REGION	CURRENT DEMAND	CURRENT SUPPLY	CURRENT BALANCE
Arica and Parinacota - Tarapacá	16.7	11.9	-7.4
Antofagasta	23	0.9	-22
Atacama	16.7	1.9	-14.8
Coquimbo	35	22.2	-12.8
Valparaíso	55.5	40.7	-27.4
Santiago Metropolitan Region	116.3	103	-35.6
O´Higgins	113.5	205	38.7
Maule	177.1	767	442.5
Biobío	148	1,638	1,249.1
La Araucanía	25.5	1,041	767.3
Los Ríos -Los Lagos	12	5,155	3,905.8
Aysén	24.9	10,134	8,284.9
Magallanes	8.4	10,124	8,394.6
COUNTRY TOTAL	772.6	29,244.6	22,962.9

Source: DGA, 2011, based on a study of the demand between 1996 and 2007, based on the sixth national agriculture and livestock census, GDP according to the 2003-2005 baseline, Cochilco Annual Report 2005.

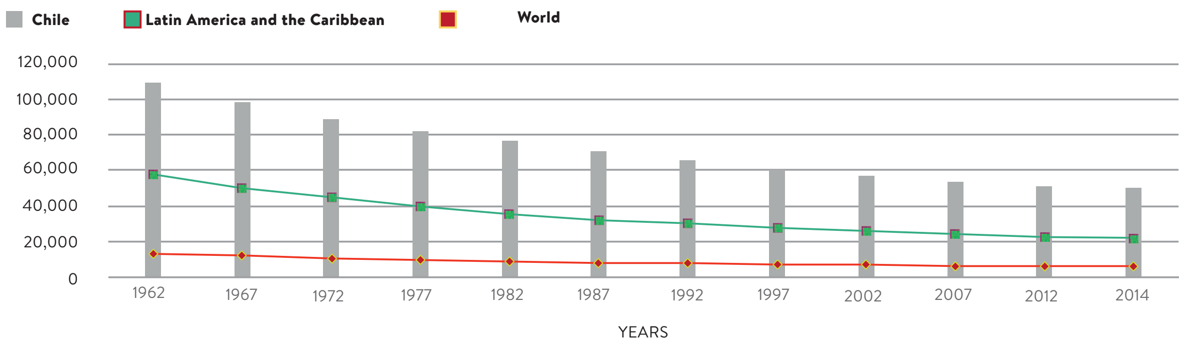
Water Availability

Compared to other countries, Chile is in a privileged position in terms of water resources, since the average total runoff – the water volume – stemming from precipitation is equal to an average of 49,824 m³/person/year. This is a much higher value than the global average, which is 5,925 m³/person/year, and the average for Latin America and the Caribbean, which is 22,162 m³/person/year [3], according to the World Bank's 2015 report (**Figure 01**).

[3] In regional terms (Latin America and the Caribbean), Chile is ranked fourth in the index of annual precipitation per person, following Guyana (315,489 m³/person/year), Suriname (183,930 m³/person/year) and Perú (52,981 m³/person/year)

FIGURE 01

RENEWABLE FRESHWATER RESOURCES (m³/person/year)

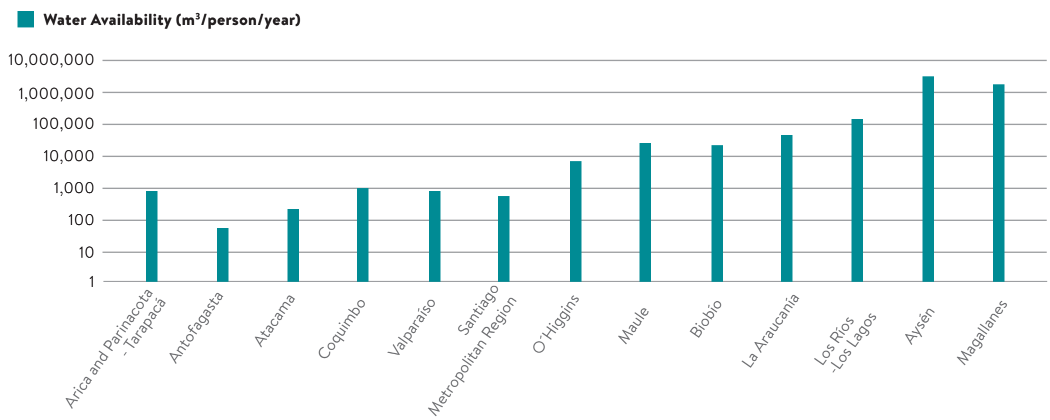


Source: World Bank, 2015.

Despite these indicators, the Chilean reality in terms of water resources is far from being considered privileged, since water availability is not equal for all regions of the country, with scarcity conditions prevailing from the Santiago Metropolitan Region to the North, where the average per capita runoff is below 500 m³/person/year. On the other hand, from the O'Higgins Region to the South, this value exceeds 7,000 m³/person/year, reaching 2,950,168 m³/person/year in the Aysén Region (DGA, 2016). Despite that, during the last few years the southern zones of the country have also been affected by water deficit.

FIGURE 02

WATER AVAILABILITY IN CHILE PER PERSON (m³/person/year)



Source: World Bank, 2015.

The interregional disparity of water availability per inhabitant is also reflected in the values of river flows present in each region. **Table 08** shows the main rivers of the country -selected by the DGA-, their associated flow stations and the average annual flows of each of them, while **Figure 03** shows a variation of the flow rates of the main rivers of the country.

TABLE 08

MAIN RIVERS AND THEIR CHARACTERISTICS

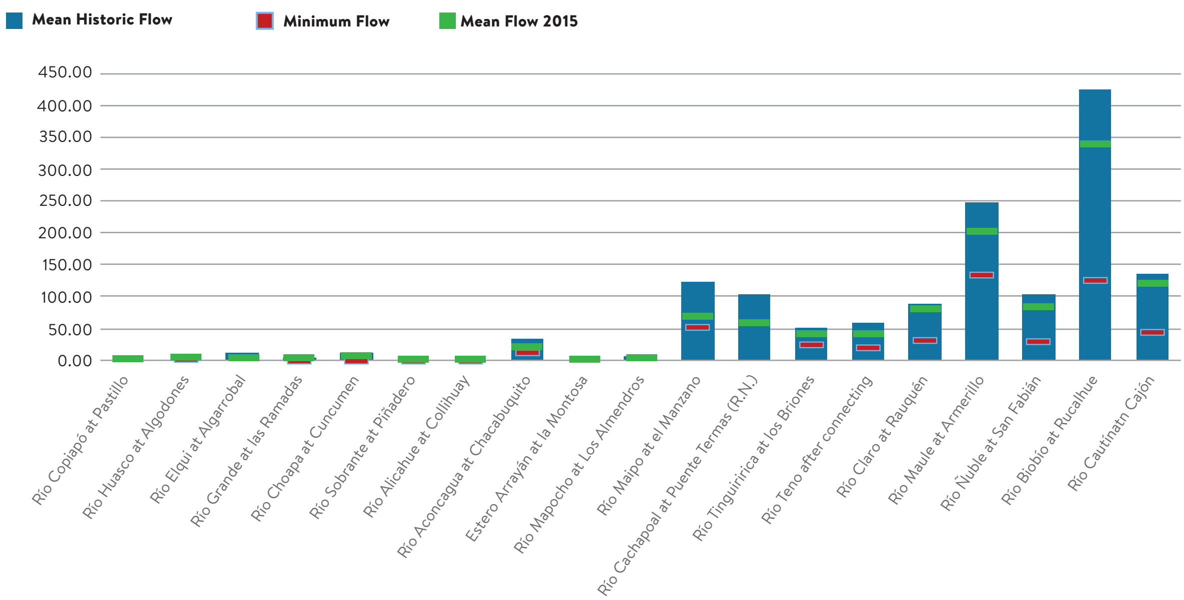
REGION	RIVER	BASIN NAME	TYPE	BASIN AREA (km²)	STREAMFLOW LENGTH (km²)	PLUVIOMETRIC STATION	MEAN ANNUAL FLOW (m³/s)
Arica and Parinacota	**Lluta**	Río Lluta	Basin	3,437	117	1. Río Lluta at Alcerreca 2. Río Lluta at Panamericana	1.9 1.4
	San José	Río San José	Basin	3,194	78	3. San José at Ausipar	1.1
Tarapacá	**Coscaya**	Pampa del Tamarugal	Basin	17,353	46	4. Río Coscaya at Saitoco	0.1
Tarapacá / Antofagasta	**Loa**	Río Loa	Basin	33,081	440	5. Río Loa at river mouth 6. Río Loa before the Lequata Dam 7. Río Loa at Chacance 8. Río Loa at Finca	0.3 0.6 0.9 0.7
Atacama	**Copiapó**	Río Copiapó	Basin	18,703	165	9. Río Copiapó at La Puerta	2.6
Atacama / Coquimbo	**Huasco**	Río Huasco	Basin	9,813	84	10. Río Huasco at Algodones	7.7
Coquimbo	**Elqui**	Río Elqui	Basin	9,825	80	11. Río Elqui at Algarrobal	11.2
	Limarí	Río Limarí	Basin	11,696	60	12. Río Grande at las Ramadas	4.2
	Choapa	Río Choapa	Basin	7,653	143	13. Río Choapa at Cuncumén	9.6
Valparaíso	**Petorca**	Río Petorca	Basin	1,988	79	14. Río Sobrande at Piñadero	1.1
	La Ligua	Río La Ligua	Basin	1,980	80	15. Río Alicahue at Colliguay	1.4
	Aconcagua	Río Aconcagua	Basin	7,334	145	16. Río Aconcagua at Chacabuquito	33.1
Valparaíso / SMR* / O'Higgins	**Maipo**	Río Maipo	Basin	15,273	225	17. Estero Arrayán at la Montosa 18. Río Mapocho at Los Almatdros 19. Río Maipo at el Manzano	1.6 6.3 117.2
SMR* / O'Higgins	**Rapel**	Río Rapel	Basin	13,766	43	20. Río Cachapoal at puente Termas Cauquates 21. Río Tinguiririca under Los Briones	38 50.2
O'Higgins / Maule	**Mataquito**	Río Mataquito	Basin	6,332	106	22. Río Tato after connecting with Claro	56.2
Maule / Biobío	**Maule**	Río Maule	Basin	21,052	213	23. Río Claro at Rauquén 24. Río Maule at Armerillo	83.6 63.8
Biobío	**Itata**	Río Itata	Basin	11,326	132	25. Río Ñuble at San Fabián N°2	100.3
Biobío / Araucanía	**Biobío**	Río Biobío	Basin	24,369	370	26. Río Biobío at Rucalhue	412
Araucanía	**Imperial**	Río Imperial	Basin	12,668	56	27. Río Cautín at Cajón	134.6
	Toltén	Río Toltén	Basin	8,448	135	28. Río Toltén at Teodoro Schmidt	559.1
Araucanía / Los Ríos	**Valdivia**	Río Valdivia	Basin	10,244	21	29. Río Calle Calle at Pupunahue	468.4
Los Ríos / Los Lagos	**Bueno**	Río Bueno	Basin	15,366	130	30. Río Buato at Buato	354.8
Los Lagos	**Puelo**	Río Puelo	Basin	3,094	97	31. Río Puelo at Carrera Basilio	641
	Chepu	Río Chepu	Subsub-basin	1,051	43	32. Río Grande at San Pedro	26.4
	Yelcho	Río Yelcho	Basin	4,084	41	33. Río Futaleufú before connecto with Río Malito	437.5
Los Lagos / Aysén	**Palena**	Río Palena	Basin	7,732	176	34. Río Palata under the Rosselot connection	848.6
Aysén	**Aysén**	Río Aysén	Basin	11,456	31	35. Río Aysén at Puerto Aysén	548
	Baker	Río Baker	Basin	20,945	175	36. Río Baker at Colonia	903.3
	Pascua	Río Pascua	Basin	7,590	56	37. Río Pascua at the Lago O'Higgins discharge	629
Magallanes and Chilean Antarctica	**Serrano**	Río Serrano	Subsub-basin	6,548	**45**	38. Río Las Chinas at Cerro Guido 39. Río Serrano at river mouth	8.1 395.5
	San Juan	Río San Juan	Subsub-basin	867	**79**	40. Río San Juan at river mouth	18.9

Source: DGA, 2016.

** Santiago Metropolitan Region*

FIGURE 03

STREAMFLOW VARIATIONS (m^3/s) year 2015



Source: Streamflow Variations (m^3/s) 2015 (Authors' own elaboration based on information from DGA, 2015a).

Availability of Water in Reservoirs

In Chile, there are more than 60 accumulation reservoirs destined mainly for irrigation, hydroelectricity or drinking water. These reservoirs allow storing a total of 12.9 billion cubic meters (Ministerio del Interior y Seguridad Pública, 2015). According to DGA data, in 2015 a total of 4,452 mill m^3 was stored on average in the 26 reservoirs for which there are monthly records[4]. This figure represents a slight increase compared to 2014, when an average of 3,999 million m^3 was stored.

Despite this increase, to date the state of the volume of reservoirs is critical throughout the country. They are well below historical values and each one's storage capacity. Indeed, in 2015, all the dams analyzed showed a deficit in maximum capacity and in relation to their historical average. The reservoirs that presented the greatest deficit in their storage capacity were Peñuelas (Río Peñuelas basin), La Paloma (Río Limarí basin) and Culimo (Río Quilimarí basin). The water stored during 2015 corresponds to less than 10 percent of its total storage capacity. In relation to the historical average, the reservoirs that showed the greatest deficit that year were La Paloma reservoir (Limarí River basin), Puclaro (Río Elqui basin) and Recoleta (Limarí river basin). These presented a historical volume of less than 25 percent. It should be noted that these reservoirs correspond, in most cases, to irrigation reservoirs, with the exception of the Peñuelas reservoir, which is made up of drinking water.

[4] *According to the data of the Bulletin N ° 452 December 2015 Rainfall Information, State of Reservoirs and Groundwater. General Directorate of Water.*

2.4 Water Quality

Surface Water

Water quality is determined by the chemical, physical and biological characteristics of a water body, which helps us interpret the state of the resource. Water bodies have a natural quality, understood as the characteristics of the system, where the concentration of a compound corresponds to the original situation of water and its ecosystems without anthropic intervention (DGA, 2003).

The DGA's water quality network makes it possible to assess the quality of the country's water bodies. This network includes a total of 829 monitoring stations, which are distributed in all regions. In addition, there is an environmental laboratory in charge of analyzing the samples. In the monitoring stations, parameters that are considered essential to assess quality are measured in the field: Temperature, pH, dissolved oxygen and electrical conductivity. Other parameters are analyzed in the laboratory, such as aluminum, arsenic, boron, cadmium, cobalt, copper, chromium, iron, manganese, mercury, molybdenum, nickel, silver, lead, selenium and zinc, calcium, chlorophyll a, chloride, chemical oxygen demand (COD), phosphate, magnesium, nitrogen, potassium, silica, sodium, and sulfate (DGA, 2016).

The measurement of these parameters makes it possible to identify and characterize changes or trends in quality over time, identify existing or emerging specific water quality problems, gather information to design environmental prevention or remediation programs, and assess compliance with regulations or measures of pollution control (DGA, 2016).

The natural waters of the country have a different chemical composition depending on the spatial location of the aquatic ecosystem to which they belong. In the northern part of the country, the chemical composition of the waters is characterized by high concentrations of salts and some metalloids such as arsenic, due to geological formations and high plateau Quaternary volcanism, while in the central zone natural waters are characterized by high concentrations of metals such as copper.

Although the lakes of Chile are considered an exceptional natural heritage in the regional and international context -since many of them have an oligotrophic condition[5], biodiversity and particular endemism-, the largest existing monitoring network considers the measurement of only 16 of these environments (the integration of seven more lakes is currently being evaluated). This number constitutes a sub-represented measurement area, since the total area of these ecosystems in Chile exceeds 9,000 km^2. In 2009, a critical analysis of the monitoring network of these ecosystems (DGA) was done, evidencing that the lakes of the Araucanía Region (limited by nitrogen and phosphorus) have historically presented levels of oligotrophy (2004-2007), a condition that persists since 2007 to date, in the Lakes Caburgua, Villarrica, Calafquén, Panguipulli, Riñihue, Ranco, Maihue, Llanquihue, Chapo, and Todos los Santos (MMA, 2014).

[5] The trophic degree is related to the productivity of the aquatic environment. The trophic state of the studied systems can be assessed based on the amount of nutrients and the response in terms of primary production, a process that can be accelerated with an increase in exogenous nutrients (anthropogenic activity). The trophic states: oligotrophic, mesotrophic and eutrophic correspond to systems that receive low, intermediate and high nutrient inputs, respectively.

Each of these systems has particular characteristics, such as, for example, the level of salinity and their trophic state, which condition the biodiversity they present. In relation to salinity, lakes and lagoons located in the Central Andean Dry Puna ecoregion show high salt levels, associated with high concentrations of sodium, chlorides and sulfates, while the Araucanian lakes are characterized by low salinity levels. In addition, it is possible to identify coastal brackish lakes where seawater is mixed with their fresh water (MMA, 2011).

The environmental condition of the main rivers of the country is variable, both in terms of latitude and altitude, especially in times of drought such as the last reported period (2010-2014)[6]. The presence of heavy metals stands out both in the water column and in sediments, due to the presence of metallogenic strips in the upper part of the Andes Mountain Range as a natural factor and to the extractive mining activities that take place mainly in the northern zone of the country. In the central valleys, agricultural development and agribusiness are concentrated in areas close to large and small cities, which has consequently entailed greater pressure due to nutrients (nitrogen and phosphorus), because of occasional discharges and leaching of agricultural areas; as well as greater urban residual discharges concentrated in fewer discharge points.

The incorporation of sediment and solids entrainment has not been sufficiently addressed in the management of Chile's water resources. It is necessary to analyze in greater detail possible influences of the dynamics of sediments and solids in a basin, the losses of vegetation and native surface and the function of riparian corridors, considering that the extraction of aggregates in Chile has had a marked development between 2009 and 2013.

Groundwater

The DGA measures the quality of groundwater in approximately 70 wells throughout the country. The majority of these wells are located in the northern zone of the country and in the Santiago Metropolitan Region. In southern Chile, the quality of very few aquifers is monitored and in some regions there are no observation wells. The graphs in **Figures 04 A-I** show the results for arsenic, conductivity, and nitrate (DGA data) and the variation of their concentrations between the northern, central and southern zones of Chile.

[6] *First report of the State of the Environment. Ministerio del Medio Ambiente (2013).*

FIGURE 04A

TOTAL ARSENIC (NORTHERN CHILE)

FIGURE 04B

CONDUCTIVITY (NORTHERN CHILE)

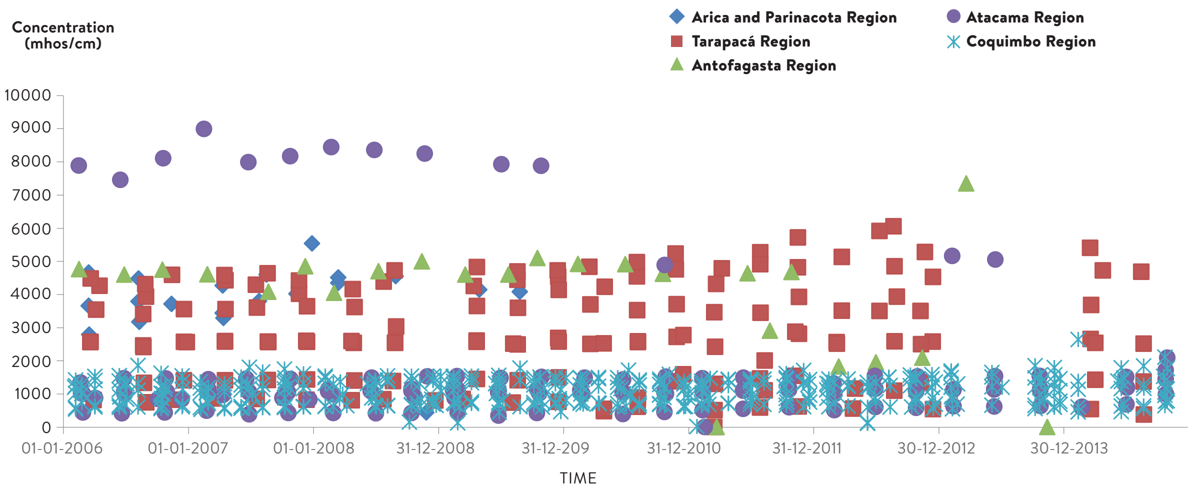


FIGURE 04C

NITRATE (NORTHERN CHILE)

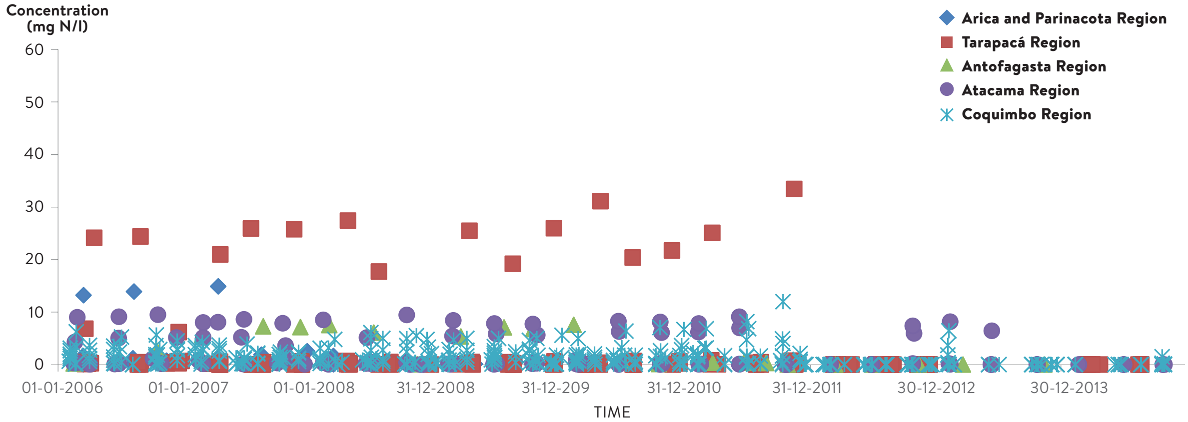


FIGURE 04D

TOTAL ARSENIC (CENTRAL CHILE)

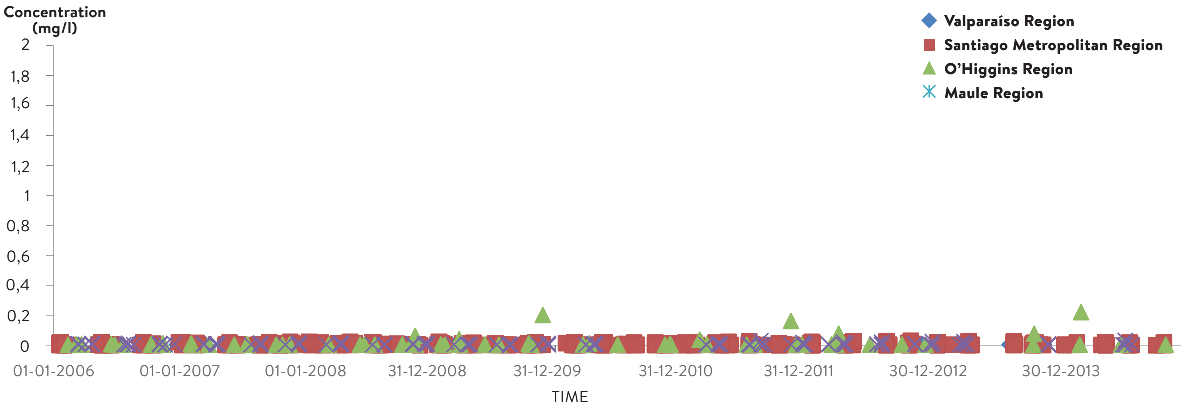


FIGURE 04E

CONDUCTIVITY (CENTRAL CHILE)

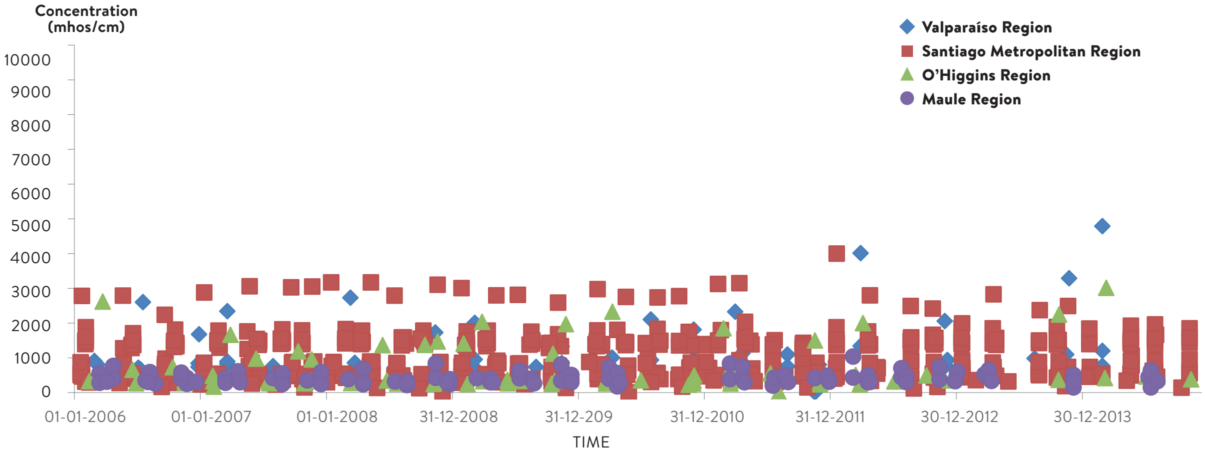


FIGURE 04F

NITRATE (CENTRAL CHILE)

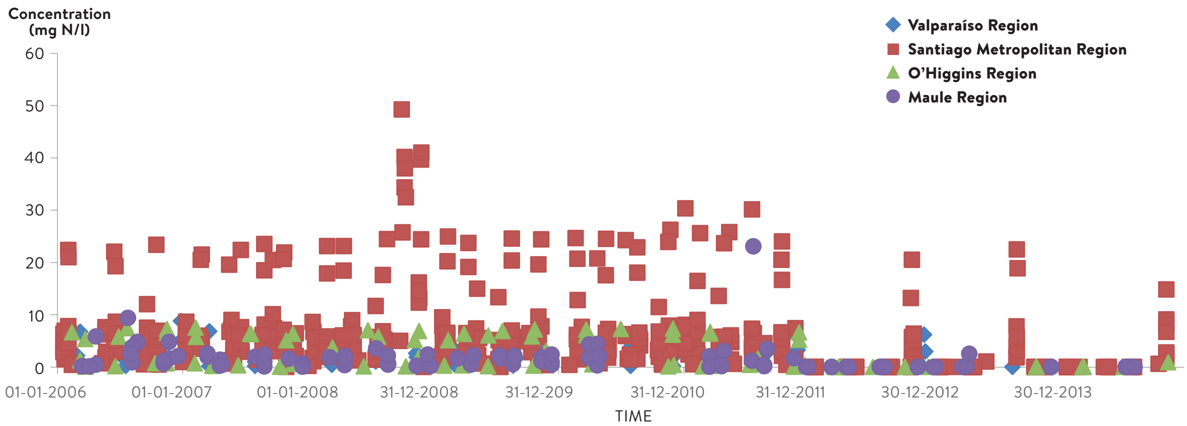


FIGURE 04G

TOTAL ARSENIC (SOUTHERN CHILE)

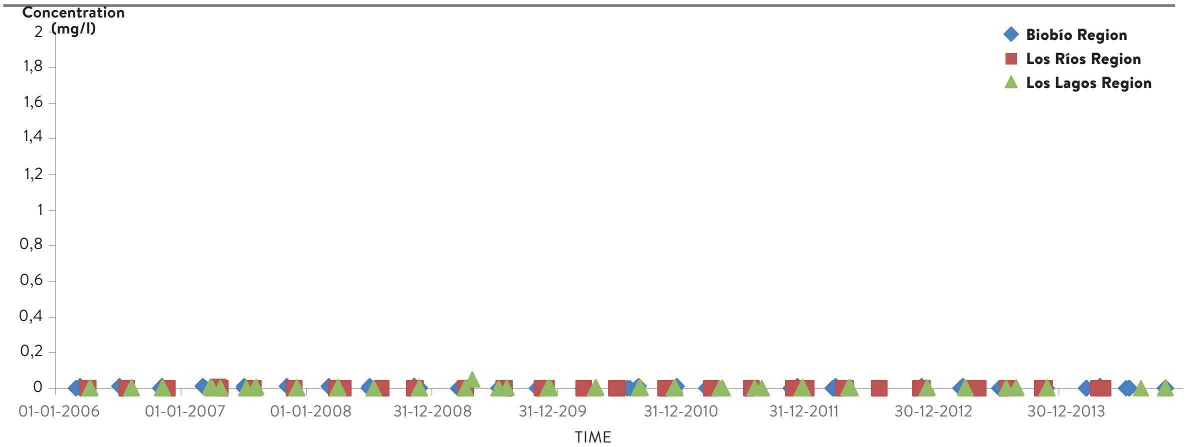


FIGURE 04H

CONDUCTIVITY (SOUTHERN CHILE)

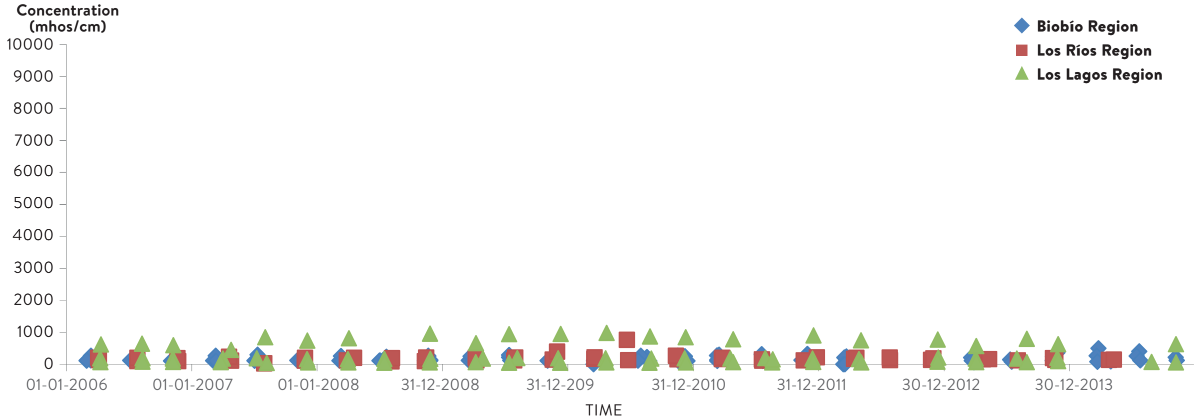
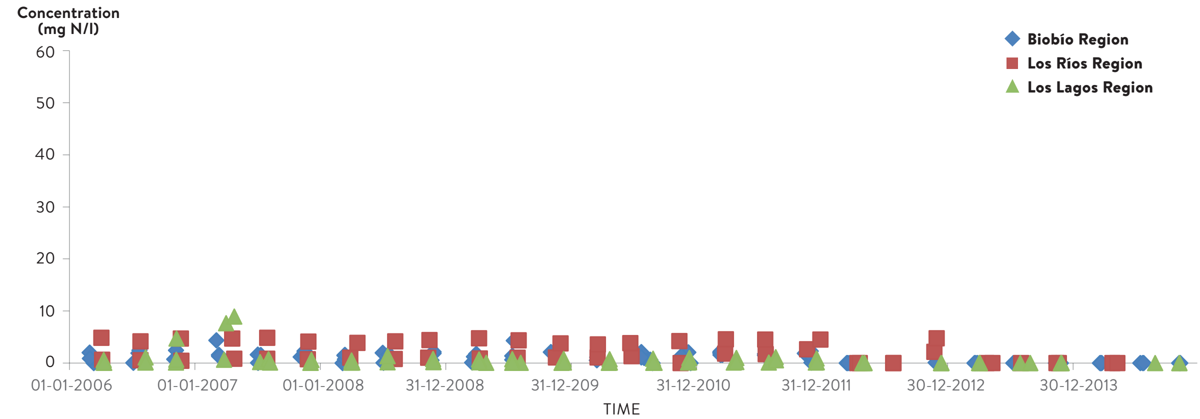


FIGURE 04I

NITRATE (SOUTHERN CHILE)



Source: Highlighted results from a groundwater quality analysis (authors' own elaboration based on data from the DGA, 2015).

The graphs show that arsenic is found in high concentrations in the northern zone, mainly due to its geological origin. In the O'Higgins Region, some values are shown above the average usual concentrations in the central zone. In the latter case, arsenic would have two origins: one geological and one from impacts generated by anthropogenic activities. Regarding conductivity, this parameter is elevated in the regions where the largest mining operations are located (regions I, II and III). Nitrate concentrations increase in regions with intensive agricultural activities. It is estimated that nitrate contamination in the Santiago Metropolitan Region could show the impact of sewerage systems in poor condition in the city of Santiago (Iriarte et al., 2009).

In 2014 and 2015, the DGA, in collaboration with the MMA, conducted a "Diagnosis of the Quality of the Groundwater of the Libertador Bernardo O'Higgins Region" (DGA, 2015b), which analyzed the diffuse contamination in 70 wells of the DGA plus others belonging to the Rural Drinking Water Committees of the region. Concentrations above the levels of current drinking water (NCh409/2005) and irrigation (NCh1333/1987) standards were observed in the nitrate (> 50 mg/l), arsenic, iron, manganese and zinc parameters.

2.5 Drinking Water and Sewerage

Compliance with Drinking Water Quality Requirements (percent) 2007-2015

Health companies must comply with certain standards in order to ensure that drinking water is suitable for human consumption. **Table 09** shows the percentages of compliance in the different indicators, both quality and sampling, according to information from the Superintendence of Sanitary Services (SISS by its acronym in Spanish).

TABLE 09

COMPLIANCE WITH DRINKING WATER QUALITY REQUIREMENTS (%)

ROW LABELS	2007	2008	2009	2010	2011	2012	2013	2014	2015	OVERALL TOTAL
QUALITY	**96.10%**	**96.90%**	**97.60%**	**99.20%**	**98.50%**	**99.30%**	**99.60%**	**98.80%**	**98.54%**	**98.28%**
Bacteriology	97.20%	99.30%	99.20%	100.00%	99.90%	99.90%	99.90%	99.70%	99.90%	99.44%
Free residual chlorine	98.80%	98.50%	99.40%	99.70%	99.20%	99.90%	99.90%	99.80%	99.30%	99.39%
Critical parameters	86.70%	94.60%	93.10%	97.40%	94.20%	97.60%	98.30%	98.00%	99.70%	95.51%
Non-critical parameters	99.00%	99.20%	99.30%	99.20%	99.80%	99.70%	99.80%	99.80%	97.60%	99.27%
Turbidity	98.80%	93.10%	96.80%	99.90%	99.40%	99.50%	99.90%	96.50%	96.20%	97.79%
SAMPLE	**76.70%**	**94.70%**	**97.20%**	**99.30%**	**97.60%**	**97.40%**	**98.90%**	**97.50%**	**99.48%**	**95.42%**
Bacteriology	74.20%	93.40%	96.00%	99.50%	96.40%	93.90%	98.90%	94.00%	99.50%	93.98%
Free residual chlorine	80.50%	93.70%	97.10%	99.60%	96.70%	98.20%	97.20%	98.20%	99.00%	95.58%
Critical parameters	54.80%	93.40%	97.50%	98.60%	98.90%	98.30%	99.30%	99.10%	99.30%	93.24%
Non-critical parameters	99.00%	99.20%	99.30%	99.30%	99.80%	99.80%	99.90%	99.90%	99.70%	99.54%
Turbidity	75.00%	93.80%	96.10%	99.80%	96.50%	96.70%	98.90%	96.60%	99.90%	94.81%
OVERALL TOTAL	**86.4%**	**95.80%**	**97.40%**	**99.30%**	**98.10%**	**98.40%**	**99.20%**	**98.20%**	**99.01%**	**96.87%**

Source: SISS, retrieved on August 5, 2016.

Urban Drinking Water, Sewerage and Sewage Treatment 1965-2014

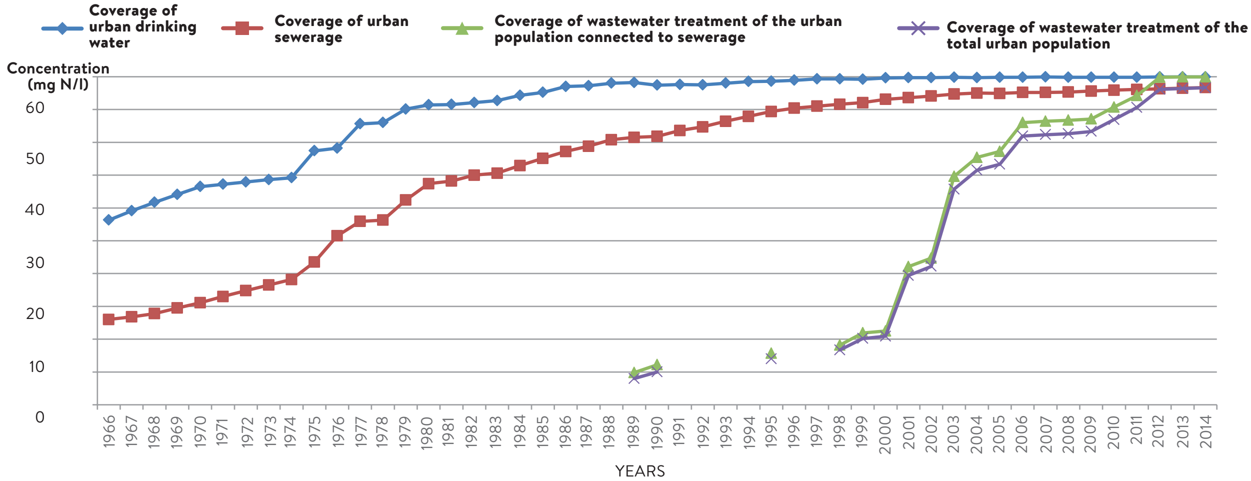
According to the 2002 Population Census, 86.6 percent of the Chilean population resides in urban areas. As shown in **Figure 05**, over a period of 48 years, 99.9 percent of the national urban population has managed to have access to drinking water, while in a period of 15 years, the urban coverage of treatment of sewage increased from 8 percent to 96.4 percent of the population.

Rural Drinking Water Coverage

The Rural Drinking Water Program (APR by its acronym in Spanish) has existed in Chile since 1960, with the purpose of supplying drinking water to the rural communities of the country. According to program estimates, 100 percent of the concentrated localities (those with more than 150 inhabitants and a density greater than 15 homes per kilometer of drinking water network) are supplied, leaving the semi-concentrated and dispersed localities as a supply gap. The estimated number of APR beneficiaries reaches 1,735,312 people based on 1,754 rural potable water services distributed in the country (DGA, 2016).

FIGURE 05

URBAN COVERAGE OF DRINKING WATER, SEWERAGE AND WASTEWATER TREATMENT



Source: Superintendence of Sanitation Services (SISS by its acronym in Spanish), retrieved on August 5, 2016.

TABLE 10

NUMBER OF RURAL DRINKING WATER (RDW) PROJECTS, PUMPS AND BENEFICIARIES AT THE NATIONAL LEVEL

REGION	NUMBER OF RDW PROJECTS	%	NUMBER OF PUMPS	%	NUMBER OF BENEFICIARIES	%
Arica and Parinacota	26	1.48	3,427	0.77	13,575	0.78
Tarapacá	21	1.2	3,117	0.7	12,396	0.71
Antofagasta	14	0.8	3,215	0.72	11,700	0.67
Atacama	38	2.17	5,239	1.18	15,530	0.89
Coquimbo	189	10.78	44,262	9.95	139,482	8.04
Valparaíso	158	9.01	41,282	9.28	165,128	9.52
Santiago Metropolitan Region	102	5.82	45,087	10.14	180,348	10.39
O´Higgins	220	12.54	78,121	17.56	312,484	18.01
Maule	274	15.61	79,459	17.86	317,836	18.32
Biobío	194	11.06	47,018	10.57	188,373	10.86
La Araucanía	217	12.37	33,780	7.59	135,120	7.79
Los Ríos	84	4.79	16,123	3.62	64,500	3.72
Los Lagos	171	9.75	37,978	8.54	151,910	8.75
Aysén	36	2.05	5,929	1.33	23,712	1.37
Magallanes and Chilean Antarctica	10	0.57	823	0.19	3,218	0.19
TOTAL	**1,754**		**444,860**		**1,735,312**	

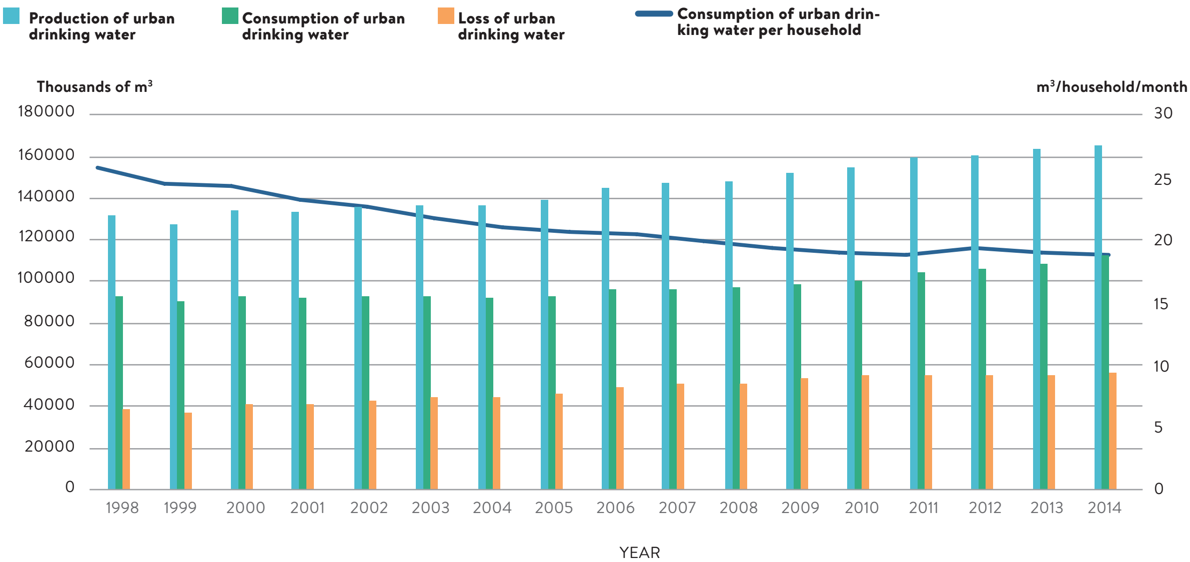
Source: DGA, 2016.

Consumption of Drinking Water

The consumption of drinking water in the urban centers of the country during 2014 was 1,109,370 thousand m^3, a figure that represents an increase compared to the consumption of 2013, which was 1,087,753 thousand m^3 (variation of 1.99 percent). The average monthly consumption per customer for 2014 was 18.6 m^3/customer/month, slightly lower than the figure for 2013, which was 18.7 m^3/customer/month (variation of -0.4 percent). The Metropolitan Region concentrates the highest average monthly consumption per customer, with an approximate value of 21 m^3/household/month (SISS, 2015). **Figure 06** shows, overall, the annual evolution of urban drinking water production and water consumption and loss between 1998 and 2014.

FIGURE 06

ANNUAL EVOLUTION OF PRODUCTION, CONSUMPTION AND LOSS OF URBAN DRINKING WATER



Source: Annual evolution of production, consumption and loss of urban drinking water (authors' own elaboration, based on 2015 Sanitation Sector Report, Superintendence of Sanitation Services (SISS by its acronym in Spanish).

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3 • PRESSURES ON WATER RESOURCES

The increase in demand for water resources, as a result of population growth and economic growth, makes it a highly vulnerable resource. This vulnerability has increased due to various pressures, mainly related to alterations in its availability and quality. The main pressures to water bodies are extractions and both point source and diffuse discharges of pollutants.

3.1 Overexploitation of Water Resources

The country's water resources are used for the development of various productive activities, which demand water in a differentiated manner in each of the country's regions. **Table 11** shows the water demands by region and by productive sector, highlighting the agricultural sector as the one that uses the most water (82 percent of the total), followed by water consumption for drinking water supply (8 percent), water use for industry (7 percent) and then water use for mining (3 percent). In regional terms, the Maule Region is the most demanding in water, associated mainly with the importance of agricultural activity in the region.

TABLE 11

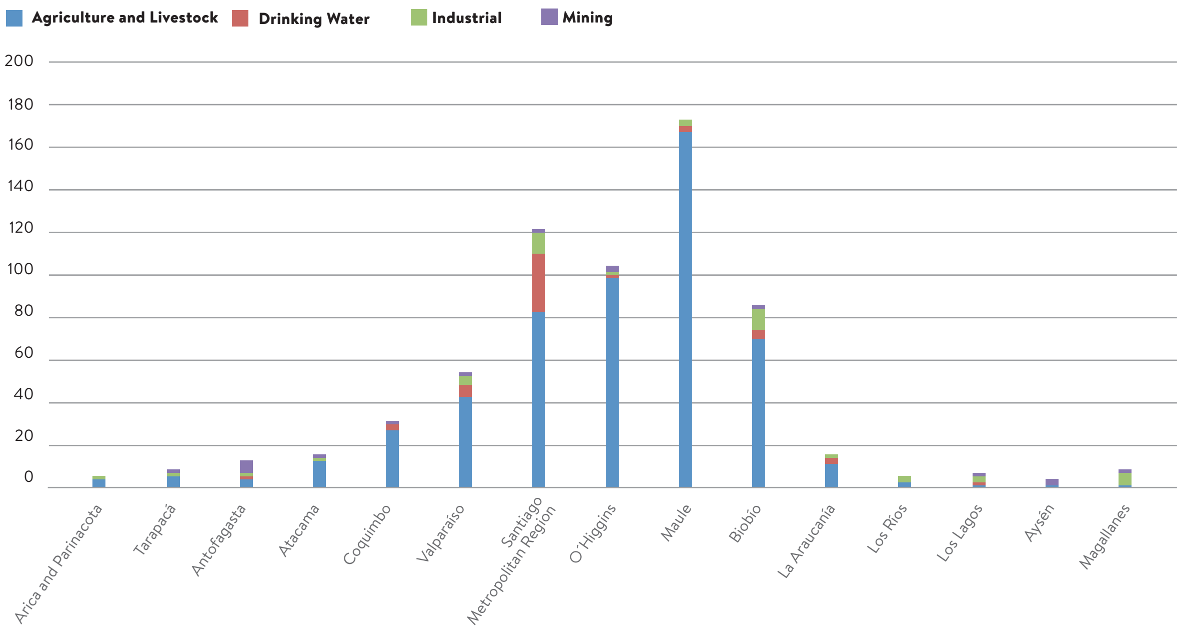
WATER DEMAND BY PRODUCTIVE SECTOR AND REGION (m^3/s)

REGION	AGRICULTURE AND LIVESTOCK	DRINKING WATER	INDUSTRIAL	MINING	TOTAL
Arica and Parinacota	3.71	0.96	0.25	0	4.92
Tarapacá	5.21	0.69	1.43	1.54	8.87
Antofagasta	3.31	1.68	1.29	6.26	12.54
Atacama	12.03	0.87	0.52	1.90	15.32
Coquimbo	27.19	1.89	0.25	0.71	30.04
Valparaíso	42.44	5.82	4.81	1.26	54.33
Santiago Metropolitan Region	82.36	27.41	10.42	0.90	
O´Higgins	97.96	2.41	1.23	1.88	121.09
Maule	166.49	2.53	3.77	0	103.48
BIOBÍO	69.44	5.16	9.54	1.21	172.79
La Araucanía	11.51	2.34	0.26	0	85.35
Los Ríos	2.21	1.02	1.63	0	14.11
Los Lagos	1.10	1.39	2.46	1.50	4.86
Aysén	0.64	0.29	0.08	2.60	6.45
Magallanes and Chilean Antarctica	1.12	0.38	5.91	0.23	3.61 7.64
TOTAL	**526.72**	**54.84**	**43.85**	**19.99**	**645.40**

Source: DGA, 2016.

FIGURE 07

WATER DEMAND BY PRODUCTIVE SECTOR (m^3/s)



Source: Water demand by productive sector (DGA, 2016).

When discussing the water availability of a hydrographic basin, reference is made to the volume susceptible to being occupied and granted through harvesting rights. As established in the Water Code (Article N° 6), "the right of use is a real right that falls on the waters and consists of the use and enjoyment of them," which will be the domain of a holder, who may use, enjoy and dispose of it in accordance to the law. These rights must be expressed in a unit of volume per unit of time and can be consumptive, non-consumptive, of permanent or temporary, continuous, discontinuous or alternating between several people.

Laguna Santa Rosa Nevado Tres Cruces| JORGE HERREROS

02

WATER RIGHTS

- **Non-Consumptive Water Use Right**: It is the right that allows the use of water without consuming it and forces its restitution in the manner established in the act of purchase or the constitution of the right (Article 14).

- **Permanent Water Use Right:** It is the right that is provided with said capacity in non-depleted supply sources, in accordance with the requirements established in the Water Code, as well as those with this capacity prior to its enactment (Article 16).

- **Temporary Water Use Right:** They are non-permanent rights and only allow the use of water during seasons when the main streamflow has a surplus after all permanent rights have been supplied (lakes and reservoirs are subject to temporary water use rights) (Article 18).

- **Continuous Water Use Right:** It refers to those rights that allow using water without interruption 24-hours a day (Article 19).

- **Discontinuous Water Use Right:** It refers to those rights that only allow using water during certain periods (Article 19).

- **Alternating Water Use Right:** It refers to those rights in which water use is distributed among two or more people who successively take turns (Article 19).

Source: Código de Aguas. Ministerio de Justicia, 1981.

Currently, the northern part of the country does not have water availability, since there is no available flow for granting new harvesting rights. In relation to surface water availability, **Table 12** shows the number of exploitation rights granted in the country's basins (consumptive and non-consumptive).

TABLE 12

CONSUMPTIVE AND NON-CONSUMPTIVE SURFACE WATER USE RIGHTS

NUMBER OF SURFACE WATER RIGHTS

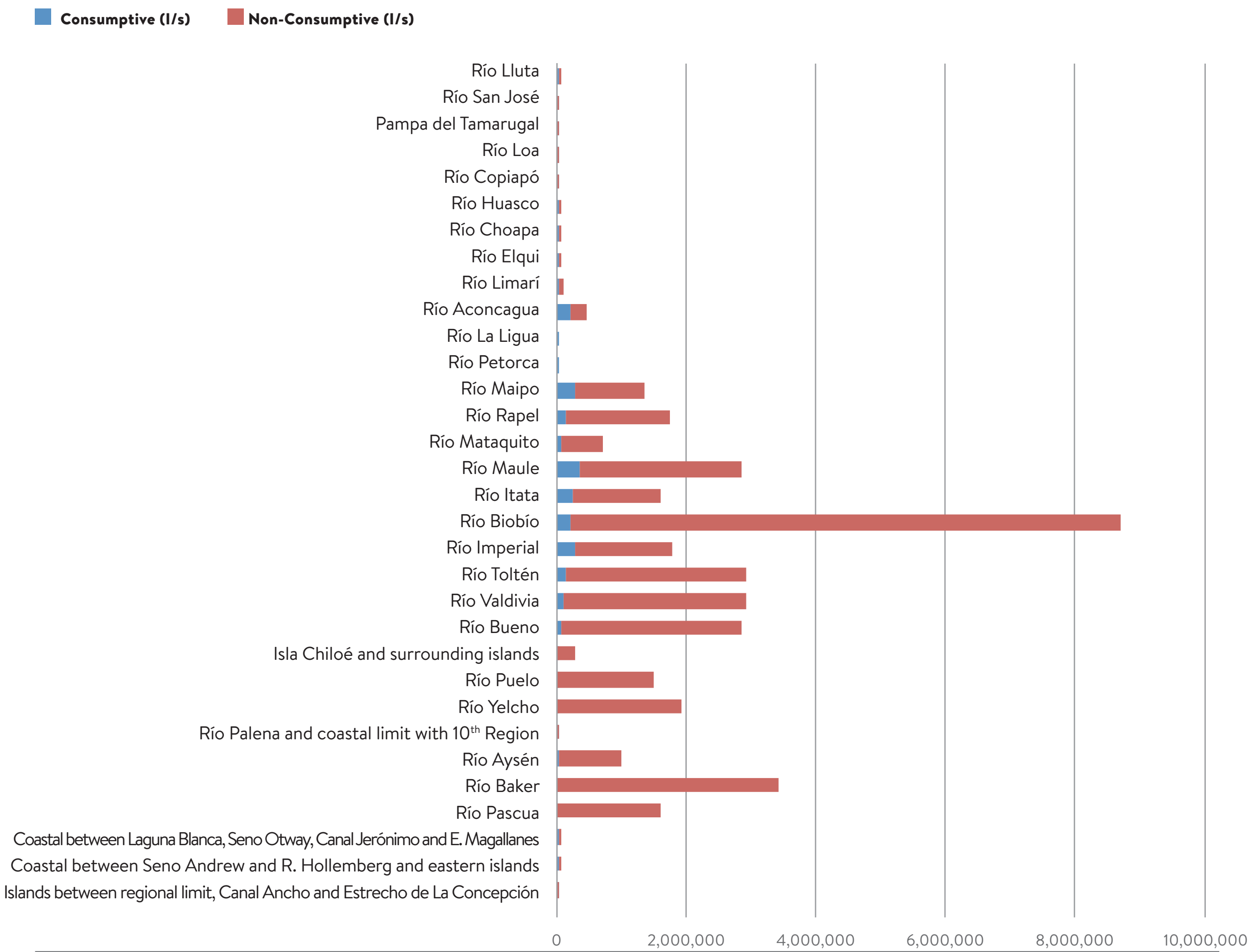
REGION	BASIN	CONSUMPTIVE N°	%	NON-CONSUMPTIVE N°	%	TOTAL
Arica and Parinacota	Río Lluta	296	0.9	4	0.05	300
Arica and Parinacota	Río San José	38	0.1	3	0.04	41
Tarapacá	Pampa del Tamarugal	452	1.3	4	0.05	456
Tarapacá / Antofagasta	Río Loa	247	0.7	26	0.33	273
Atacama	Río Copiapó	112	0.3	7	0.09	119
Atacama / Coquimbo	Río Huasco	123	0.4	4	0.05	127
Coquimbo	Río Choapa	585	1.7	34	0.43	619
Coquimbo	Río Elqui	770	2.3	22	0.28	792
Coquimbo	Río Limarí	2361	7.0	25	0.32	2,386
Valparaíso	Río Aconcagua	1,017	3.0	81	1.02	1,098
Valparaíso	Río La Ligua	47	0.1	0	-	47
Valparaíso	Río Petorca	89	0.3	0	-	89
Valparaíso / Santiago Metropolitan Region / O'Higgins	Río Maipo	1,759	5.2	200	2.52	1,959
Santiago Metropolitan Region / O'Higgins	Río Rapel	1,020	3.0	234	2.95	1,254
O'Higgins / Maule	Río Mataquito	350	1.0	187	2.36	537
Maule / Biobío	Río Maule	3,375	10.0	385	4.85	3,760
Biobío	Río Itata	1,678	5.0	239	3.01	1,917
Biobío / La Araucanía	Río Biobío	1,921	5.7	937	11.81	2,858
La Araucanía	Río Imperial	3,452	10.2	868	10.94	4,320
La Araucanía	Río Toltén	3,454	10.2	1451	18.28	4,905
La Araucanía / Los Ríos	Río Valdivia	4,241	12.6	873	11.00	5,114
Los Ríos / Los Lagos	Río Bueno	3,123	9.3	1191	15.01	4,314
Los Lagos	Isla Chiloé and surrounding islands	725	2.1	286	3.60	1,011
Los Lagos	Río Puelo	28	0.1	132	1.66	160
Los Lagos	Río Yelcho	105	0.3	36	0.45	141
Los Lagos / Aysén	Río Palena and coastal limit with 10th Region	78	0.2	42	0.53	120
Aysén	Río Aysén	1,366	4.0	397	5.00	1,763
Aysén	Río Baker	437	1.3	131	1.65	568
Aysén	Río Pascua	65	0.2	31	0.39	96
Magallanes and Chilean Antarctica	Coastal between Laguna Blanca, Seno Otway, Canal Jerónimo and E. Magallanes	272	0.8	48	0.60	320
Magallanes and Chilean Antarctica	Coastal between Seno Andrew and R. Hollemberg and eastern islands	169	0.5	50	0.63	219
Magallanes and Chilean Antarctica	Islands between regional limit, Canal Ancho and Estrecho de La Concepción	3	0.0	8	0.10	11
TOTAL		**33,758**	100	**7,936**	100	**41,694**

Source: DGA, 2016.

As can be seen in **Figure 08**, the hydrographic basin with the highest flow granted is the Biobío River basin with 8,693,985 l/s. Of this flow, 194,749 l/s correspond to consumptive use rights and 8,499,227 l/s to non-consumptive use rights.

FIGURE 08

SURFACE WATER USE RIGHTS, ALLOCATED FLOW (l/s)

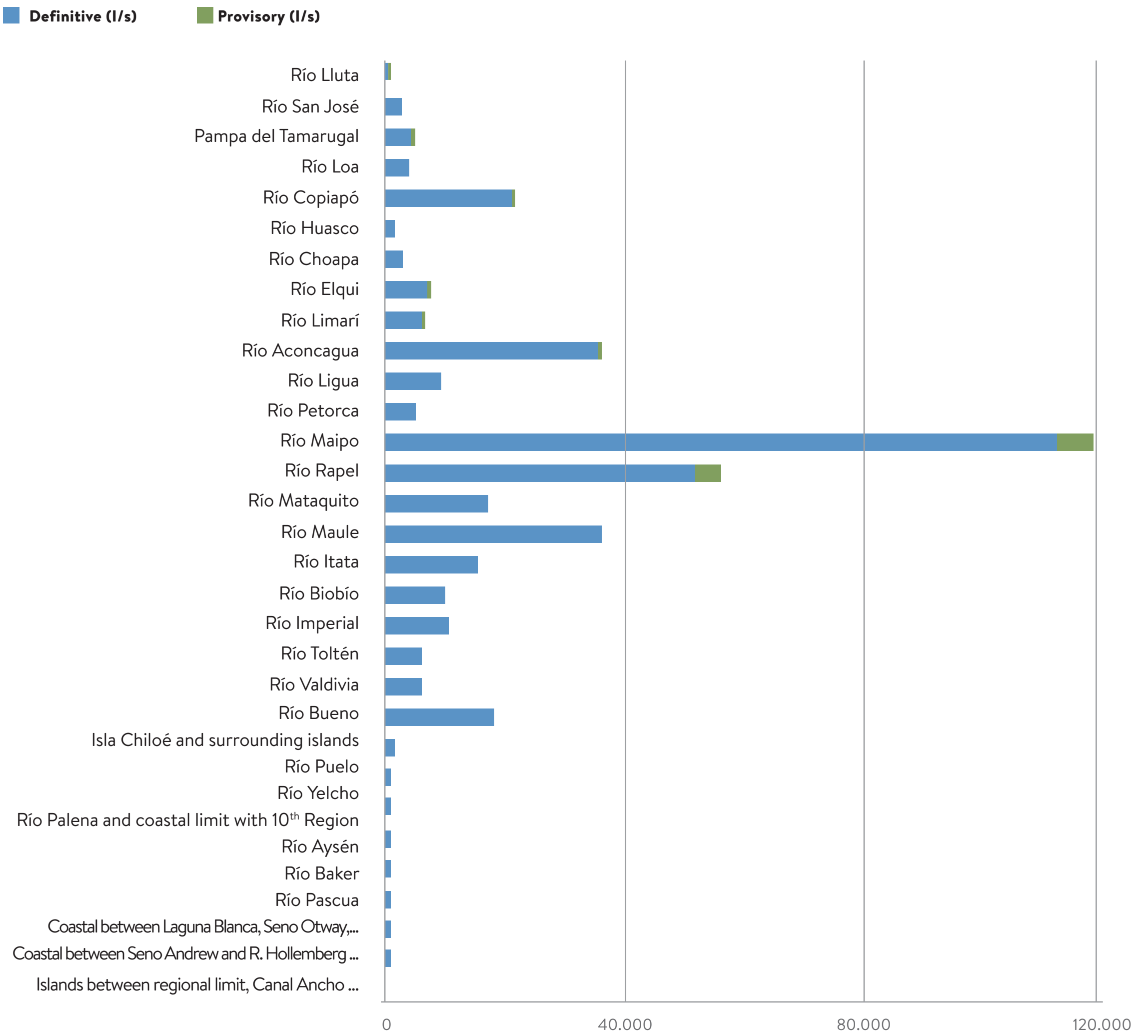


Source: SISS, retrieved August 5, 2016.

In relation to groundwater, the flows granted are shown in **Figure 09**.

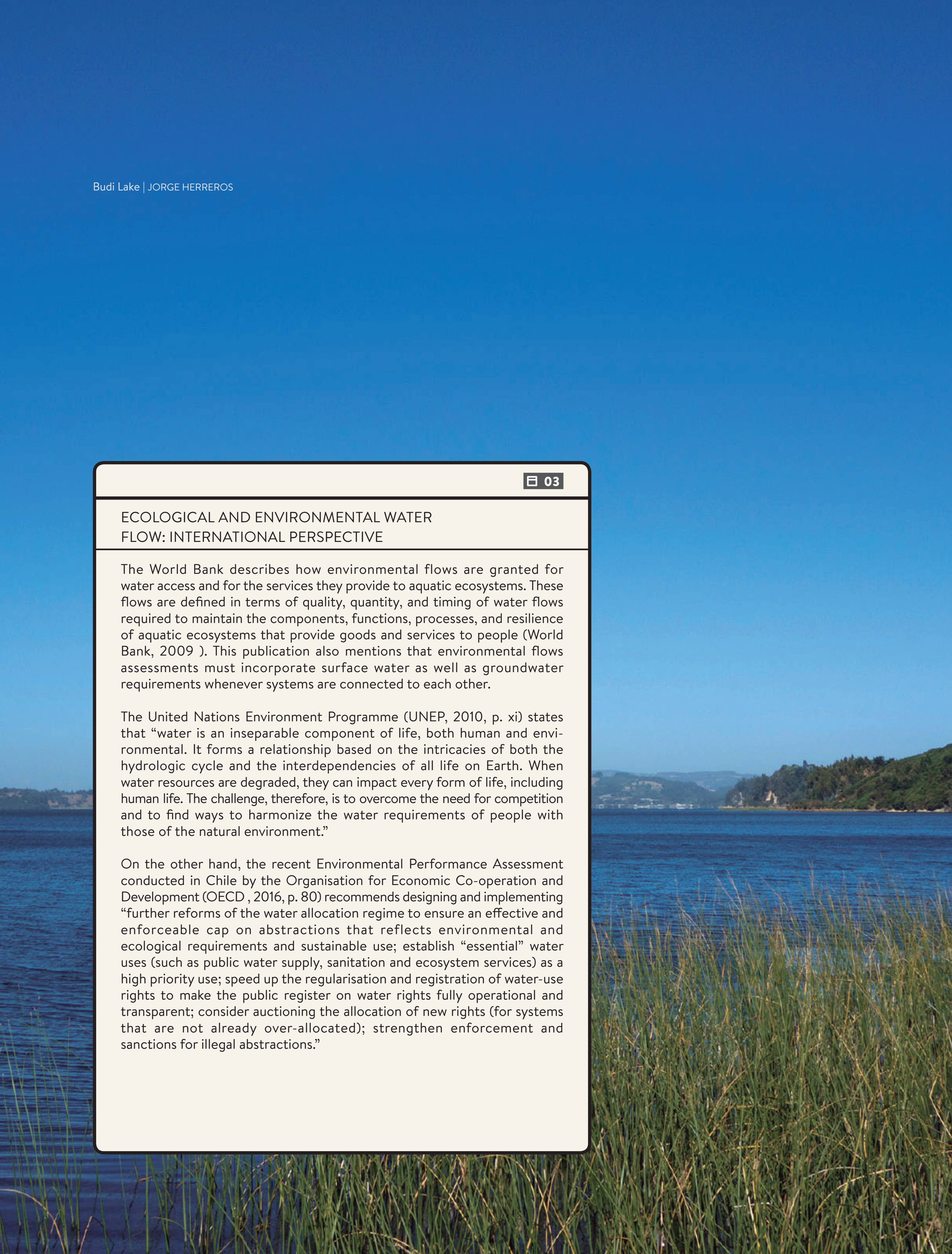
FIGURE 09

GROUNDWATER USE RIGHTS, ALLOCATED FLOW (l/s)



Source: Groundwater rights (permanent and future). Allocated flow (DGA, 2016).

As can be seen in **Figure 09**, the hydrographic basin with the highest flow of groundwater supply is the Maipo River basin with 119,354 l/s. Of this flow, 95 percent corresponds to the definitive rights (112,841 l/s) and the remaining 5 percent to provisory rights (6,513 l/s).



Budi Lake | JORGE HERREROS

03

ECOLOGICAL AND ENVIRONMENTAL WATER FLOW: INTERNATIONAL PERSPECTIVE

The World Bank describes how environmental flows are granted for water access and for the services they provide to aquatic ecosystems. These flows are defined in terms of quality, quantity, and timing of water flows required to maintain the components, functions, processes, and resilience of aquatic ecosystems that provide goods and services to people (World Bank, 2009). This publication also mentions that environmental flows assessments must incorporate surface water as well as groundwater requirements whenever systems are connected to each other.

The United Nations Environment Programme (UNEP, 2010, p. xi) states that “water is an inseparable component of life, both human and environmental. It forms a relationship based on the intricacies of both the hydrologic cycle and the interdependencies of all life on Earth. When water resources are degraded, they can impact every form of life, including human life. The challenge, therefore, is to overcome the need for competition and to find ways to harmonize the water requirements of people with those of the natural environment.”

On the other hand, the recent Environmental Performance Assessment conducted in Chile by the Organisation for Economic Co-operation and Development (OECD , 2016, p. 80) recommends designing and implementing “further reforms of the water allocation regime to ensure an effective and enforceable cap on abstractions that reflects environmental and ecological requirements and sustainable use; establish “essential” water uses (such as public water supply, sanitation and ecosystem services) as a high priority use; speed up the regularisation and registration of water-use rights to make the public register on water rights fully operational and transparent; consider auctioning the allocation of new rights (for systems that are not already over-allocated); strengthen enforcement and sanctions for illegal abstractions.”

Regulation of the Minimum Ecological Flow

Currently the calculation of minimum ecological flows, according to Supreme Decree N° 14/2012[7] and the changes that were introduced to this calculation system with the dictation of Supreme Decree N° 71/2014[8], is based on statistical data of the historical flows of the last 25 years. In this regard, the graphs in **Figures 10** and **11** show two examples of calculation of the current regulations. Thus, while for the Elqui river much lower flows than the minimum ecological flow were observed in the latter, in the Biobío River there are available flows for the granting of harvesting rights. It should be mentioned, however, that these graphs show statistical results, but do not take into account the ecological conditions of the river.

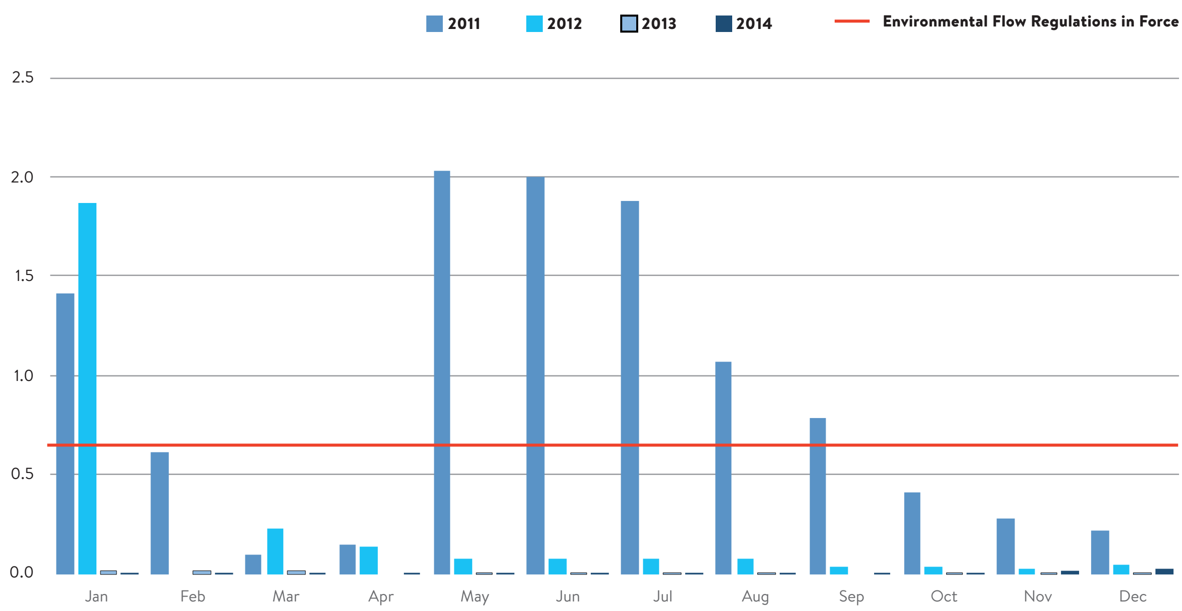
On the other hand, in Article 7 of Supreme Decree N° 14 of 2012, mention is made of cases classified as "those in which risks are identified in water quality and/or habitat of such magnitude that they compromise the survival of the species."

[7] Decree N° 14 of 2012, "Approves Regulation for the Determination of the Minimum Ecological Flow". Ministry of Environment.

[8] Supreme Decree N° 71 of 2014, "Modifies Decree N° 14 of 2012, which Approves Regulations for the Determination of the Minimum Ecological Flow". Ministry of Environment.

FIGURE 10

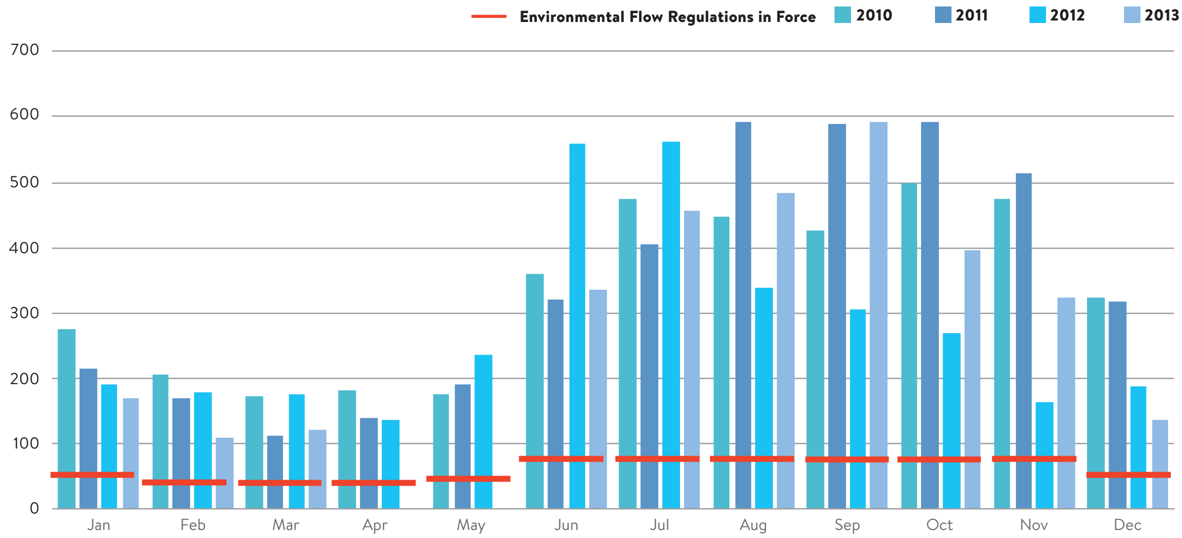
RÍO ELQUI IN LA SERENA



Source: Groundwater rights (permanent and future). Allocated flow (DGA, 2016).

FIGURE 11

RÍO BIOBÍO IN RUCALHUE



Source: Application of Supreme Decree N° 71/2014 for Biobío River (authors' own elaboration based on data from the DGA,http://snia.dga.cl/BNAConsultas/reportes, 2016).

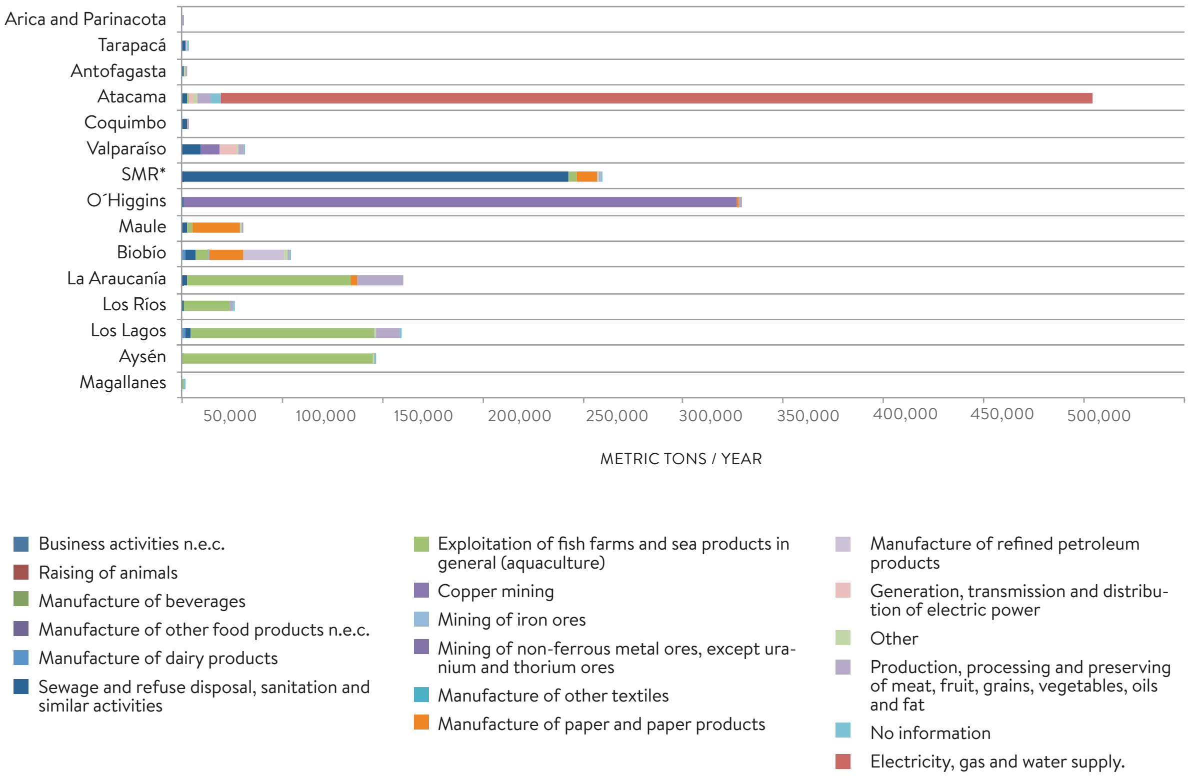
3.2 Point Source Emissions to Surface Water Bodies

According to the data from the Pollutant Release and Transfer Register (PRTR, MMA), pollutant discharges to surface waters during 2013 corresponded mostly to the "electricity, gas and water supply" sector, along with "waste and wastewater disposal, sanitation and similar activities"[9]. These data were obtained according to the discharges to surface waters regulated by Supreme Decree N° 90 (Ministry Secretary General of the Presidency, 2000).

[9] Chloride emissions from La Chimba Desalination Plant were excluded to preserve the statistical quality of the data.

FIGURE 12

TOTAL EMISSIONS PER REGION IN SURFACE WATER BODIES 2013



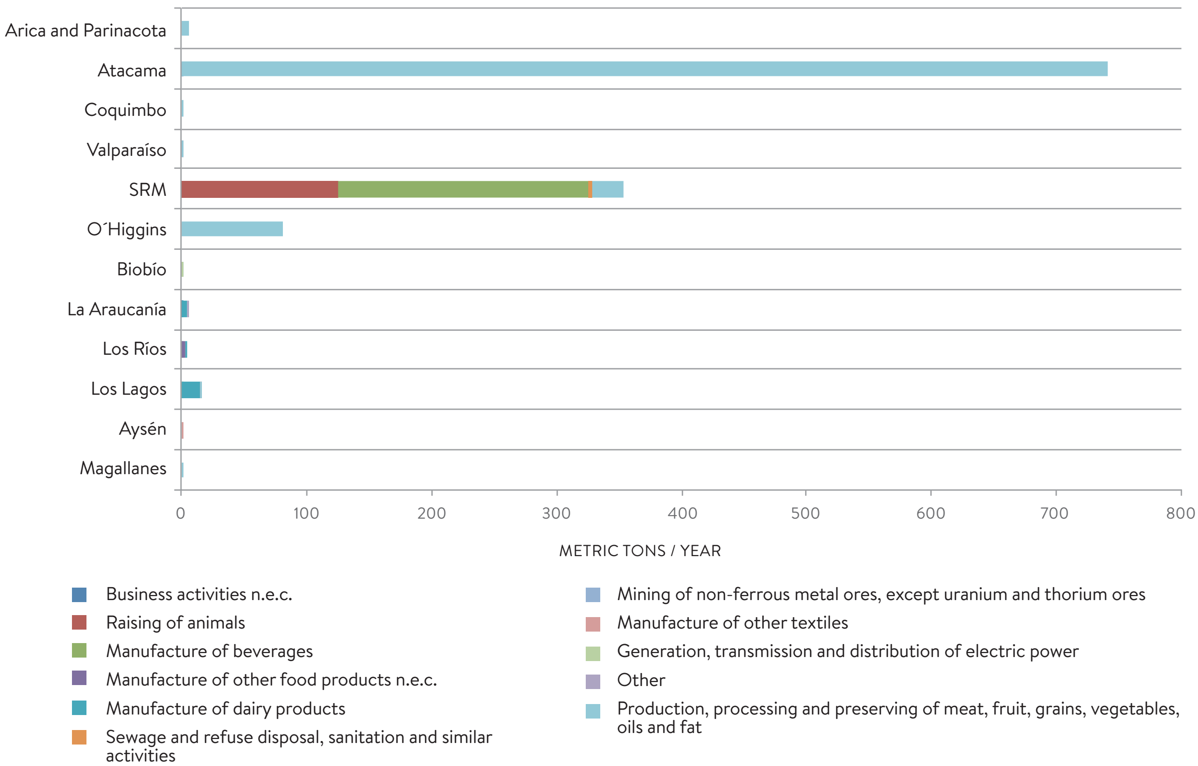
Source: Authors' own elaboration based on PRTR Database, 2015.
* *Santiago Metropolitan Region*

3.3 Point Source Emissions to Groundwater

The discharges of pollutants to groundwater during 2013 corresponded, according to the data of the Pollutant Release and Transfer Register (RETC, MMA), mostly to the production, processing and preserving of meat, fruit, grains, vegetables, oils and fat sector, which concentrated 70 percent of the emissions, followed by the manufacture of beverages sector and the raising of animals sector with 16 percent. This information corresponds to the discharge of effluents to groundwater regulated by the emission standard in Supreme Decree N° 46 (Ministerio Secretaria General de la Presidencia, 2002).

FIGURE 13

TOTAL EMISSIONS PER REGION IN GROUNDWATER 2013



Source: Authors' own elaboration based on PRTR Database, 2015.
** Santiago Metropolitan Region*

3.4 Desalination Plants

Water scarcity has motivated the use of water sources other than continental ones. In Chile, and particularly in the north of the country, a significant part of the water for mining and human use comes from the desalination process of seawater. Despite the fact that this type of technology has been widely promoted[10] and incorporated as one of the main actions of the "National Drought Plan", it is important to consider that it can generate different impacts on the environment. One of the main ones is the consumption of electrical energy and the associated transmission lines. The energy consumption provided by a system whose matrix is rich in thermoelectric plants that use fossil fuels presents a high emission of greenhouse gases and local pollutants, such as particulate matter, sulfur dioxide and NOx.

In addition, impacts generated by the suction of water, the discharge of brine and other liquid industrial waste (LIW) of the reject brine. Among the affected organisms are fish, eggs and larvae. The reject brine not only has a high saline concentration (nearly double that of the water source) but also contains chemicals that have been added to prevent biological contamination, scale and suspended solids. Reject brine affects the quality of water and sediments, and harms marine life (Lattemann and Höpner, 2008). According to some studies (MSPS, 2009) increases in salinity beyond 39.1 PSU affect species such as urchins and mysidacea.

[10] At present, there is a draft bill in the House of Representatives with the aim of promoting the creation and use of desalination plants. https://www.camara.cl/pley/pley_detalle.aspx?prmID=10286&prmBoletin=9862-33

TABLE 13

BUILT AND PLANNED DESALINATION PLANTS IN CHILE

MACROZONE	REGION	MAP Nº	NAME	BUSINESS	DESALINATION CAPACITY (l/s)	USAGE	STATE
North	Arica and Parinacota	1	Planta Desaladora Arica	Aguas del Altiplano	412	Drinking Water	Operating
		2	Pampa Camarones	Minera Pampa Camarones	-	Copper	Operating
	Tarapacá	3	Bullmine	SCM Bullmine	150	Iodine	Approved
		4	Planta Desaladora Quebrada Blanca Fase 2	Teck	1300	Copper	Feasibility
		5	Comité Caleta Chanavayita	Dirección de Obras Hidráulicas	9,25	Rural Drinking Water	Operating
		6	Eloísa	Eloísa S.A	200	Iodine	Approved
	Antofagasta	7	Planta Desaladora Tocopilla	Aguas Antofagasta S.A.	200	Drinking Water	Under Assessment
		8	Planta Desaladora RT Sulfuros	Codelco Norte	1.630	Copper	Under Assessment
		9	Mantos de La Luna	Compañía Minera Mantos de Luna	8,7	Copper	Operating
		10	Planta Desaladora Michilla	Minera Michilla (Antofagasta Minerals)	75	Copper	Operating
		11	Planta Desaladora Esperanza	Minera Centinela (Antofagasta Minerals)	50	Copper	Operating
		12	Agua Desalada Antucoya	Minera Antucoya (Antofagasta Minerals)	20	Copper	Operating
		13	Agua de Mar Encuentro	Antofagasta Minerals	20	Copper	Under Construction
		14	Planta Desaladora Hornitos	Caja Compensación Los Andes	4,3	Drinking Water	Operating
		15	Algorta	Algorta Norte	-	Iodine	Approved
		16	Planta Desaladora Moly-Cop	Moly - Cop Chile S.A.	4,3	Steel	Approved
		17	Sierra Gorda	Minera Sierra Gorda SCM	63	Copper	Operating
		18	Planta Desaladora La Chimba	Aguas Antofagasta S.A.	680	Drinking Water	Operating
		19	Planta Desaladora Sur Antofagasta	Aguas Antofagasta S.A.	1.000	Drinking Water	Approved
		20	Planta Desaladora Taltal	Aguas Antofagasta S.A.	5	Drinking Water	Operating
		21	Planta Coloso	Minera Escondida (BHP Billiton)	525	Copper	Operating
		22	Ampliación Planta Coloso	Minera Escondida (BHP Billiton)	2.500	Copper	Under Construction
		23	Agua de Mar Lomas Bayas	Xstrata	-	Copper	Feasibility
		24	Paposo	Dirección de Obras Hidráulicas	1,4	Rural Drinking Water	Operating
		25	Spence	Minera Spence (BHP Billiton)	800	Mining	Under Assessment
		26	Las Cenizas Taltal - Las Luces	Minera Las Cenizas	9,3	Copper	Operating
		27	Planta de Osmosis Inversa	Cementos Polpaico	4,6	Industrial	Operating
	Atacama	28	Diego de Almagro	Minera Can Can	-	Copper	Feasibility
		29	Abastecimiento de Agua Desalada Manto Verde	Anglo American	120	Copper	Operating
		30	Planta Desaladora Cerro Negro Norte	CAP	600	Iron	Operating
		31	Planta Desaladora Bahía Caldera	Seven Seas Water Chile SpA	95,6	Drinking Water	Under Assessment
		32	Planta Desalinizadora Minera Candelaria	Freeport- McMoRan	300	Copper	Operating
		33	Planta Desalinizadora de Agua de Mar	Econssa Chile S.A.	1.200	Drinking Water	Under Assessment
	Coquimbo	34	Proyecto Dominga	Andes Iron	450	Iron	Feasibility
		35	Comité de A.P.R. Chungungo	Dirección de Obras Hidráulicas	5,6	Rural Drinking Water	Operating
Extreme South	Aysén	36	Islas Huichas	Dirección de Obras Hidráulicas	2,8	Rural Drinking Water	Operating

Source: DGA, 2016.

04

DIFFUSE POLLUTION

Globally, diffuse pollution of water resources causes environmental damage of great magnitude, especially on aquatic ecosystems. The main sources of diffuse pollution stem from forestry, agriculture, agro-industry, and livestock sectors, aquaculture, extraction of aggregates, mining, wastewater (deficient sewerage) and solid (permeable deposits) and industrial (air, infiltration) waste. Diffuse pollution causes impacts that alter the physical-chemical conditions of aquatic ecosystems, generating changes in the trophic states of systems and, in extreme cases, the loss of biodiversity. For example, pesticides can substantially reduce plant and animal biodiversity in aquatic ecosystems due to their toxicity, whether acute or chronic. In Chile, there are several potential sources of diffuse pollution. However, in most cases they are not analyzed, there is a lack of information about their origin and the impact of the diffuse pollution they produce is unknown, particularly on native Chilean species.

Water Mirror | FRANCISCO DONOSO

4 • RESPONSES

4.1 Policies and Strategies for Water Resources

National Policy for Water Resources (2015)

The main objective of the National Policy for Water Resources (Ministerio del Interior y Seguridad Pública, 2015) is to guarantee current and future generations the availability and access to water in adequate quality and quantity standards, through rational and sustainable use of water resources, placing human consumption first. To do so, it proposes the following specific objectives:

1. Designing, developing and implementing different programs and actions that will enable mitigating the effects of the drought that affects a large part of the national territory and preparing the country to better face future events.

2. Proposing alternatives for institutional reorganization and modifications to the legal system that allow for better management of tools and resources, with the aim of achieving a better management of water resources in line with the magnitude and importance of current and future challenges.

On the other hand, the National Policy for Water Resources is framed under the following guidelines:

1. The consideration of most likely future scenarios, trends and projections in terms of availability and demand of water resources.
2. The sustainability and protection of water both in terms of quantity and quality.
3. The integration of water resources management with environmental management. The consideration of the physical, biotic, demographic, economic, social and cultural particularities of each of the regions of the country.
4. The articulation of the management of water resources with land use.
5. The management of water resources at the river basins level.

National Strategy of Water Resources 2012-2025, DGA, 2013

It raises the need to face the increase in demand for water resources and the effects of climate change, through a joint vision of the different interests around water and the need for assurances to current, as well as future, generations access to water, and in turn enhance the economic development of the country.

The strategy has 5 strategic axes for the Chile's waters: i) efficient and sustainable management; ii) better institutional framework; iii) face scarcity; iv) social equity; and v) informed citizens (MOP, 2013).

Declarations of Scarcity

The Ministry of Public Works, through the General Directorate of Water (DGA), has the power to declare basins, communes and provinces in a situation of water scarcity. The declarations of scarcity (drought) correspond to 74 percent of all the tools used in the 2008-2014 period by the DGA to safeguard water resources. The regions of Coquimbo, Valparaíso, Maule and Santiago Metropolitan account for 86 percent of the application of tools by the DGA. These same regions centralize the greater expenditure on water distribution by the ONEMI through tanker trucks, which has almost tripled between 2011 and 2014 (Center for Climate Science and Resilience (CR2, 2015) (**Figure 14**).

Climate Change Adaptation Plans (Ministry of the Environment)

These plans correspond to sectoral works derived from the 2008-2012 National Action Plan on Climate Change (PANCC), to enable the country's adaptation to the expected effects of this phenomenon. The Ministry of the Environment, the Ministry of Public Works and the Ministry of Agriculture are currently working on the preparation of these plans, specifically in the stage of assessing the vulnerability of water resources.

The Adaptation Plan for Water Resources includes the following priority axes:

a) Sustainably managing water resources, which enables the adequate protection of the quantity and quality of water.
b) Improving the institutional framework for the planning of the resource, its allocation, protection, control and resolution of conflicts.
c) Preventing and facing shortages: Overcoming short-term shortages and addressing them permanently. Understanding of the hydrological cycle in the management of resources, artificial recharge of aquifers, obtaining resources from new sources, such as desalination plants, construction of water infrastructure among others.
d) Strengthening and expanding the monitoring systems, with special attention to the installation of high-altitude stations, and expanding and improving the monitoring of the quality of waters and aquifers, the latter through a national monitoring program.
e) Maintaining and strengthening the inventory, monitoring and study of glaciers.
f) Encouraging the development of a Glacier Law, which enables the conservation of these bodies, considering the effects of climate change.
g) Improving the satisfaction of the demand for drinking water in areas with less coverage.
h) Reusing the resource.
i) Educating the population. Promoting the culture of water conservation in the community and actions for the efficient use of the resource (MMA, 2016).

4.2 Protection and Conservation

Chilean Drinking Water Standard

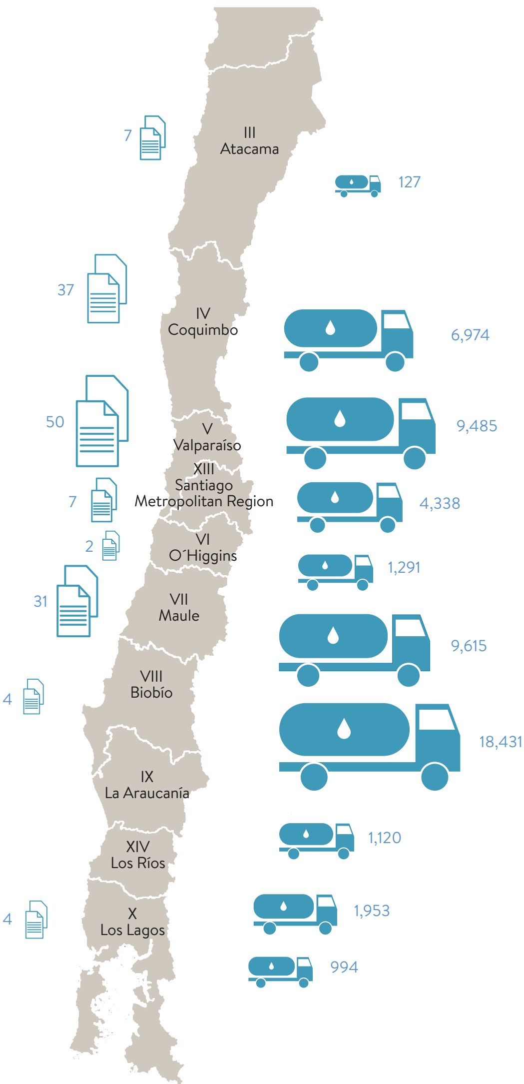
The NCH N° 409 (2005) for Drinking Water, parts 1 and 2, regulates the physical, chemical, bacteriological and disinfection requirements, which ensure its safety and suitability for human consumption.

Primary Standards of Environmental Quality

Are those that "establish the maximum or minimum permissible values of concentrations and periods, elements, compounds, substances, chemical or biological by-products, energies, radiations, vibrations, noise or combinations thereof, whose presence or lack thereof

FIGURE 14

NUMBER OF WATER RIGHTS AND WATER TANKER TRUCKS



The symbols to the left of the map are proportional to the number of scarcity decrees passed by the General Water Directorate (DGA by its acronym in Spanish) between 2010 and 2015. The symbols to the right are proportional to the expenditure of the National Office of Emergencies (ONEMI by its acronym in Spanish) in terms of water and tanker trucks between 2011 and 2014 in millions of Chilean Pesos.
Datos: DGA and ONEMI, respectively.

in the environment can constitute a risk to the life or health of the population, defining the levels that give rise to emergency situations" (Supreme Decree N° 38, Ministry of the Environment, 2012).

Current Primary Quality Standards in force:

- Primary quality standard for the protection of surface inland waters where recreational activities are carried out with direct contact. Supreme Decree N° 143/2009.
- Primary quality standard for the protection of marine and estuarine waters where recreational activities are carried out with direct contact. Supreme Decree N° 144/2009.

Secondary Environmental Quality Standards

They are the ones that "establish the maximum or minimum permissible values of the concentrations and periods of substances, elements, energy or a combination of them, whose presence or lack in the environment may constitute a risk for the protection or conservation of the environment, or the preservation of nature" (Supreme Decree N° 38, MMA, 2012).

The standards for rivers and lakes are tools to conserve or preserve aquatic ecosystems and their ecosystem services through the maintenance and improvement of water quality in river basins, including estuaries. Thus, they also include the control of diffused pollution.

Secondary Environmental Quality Standards in force:

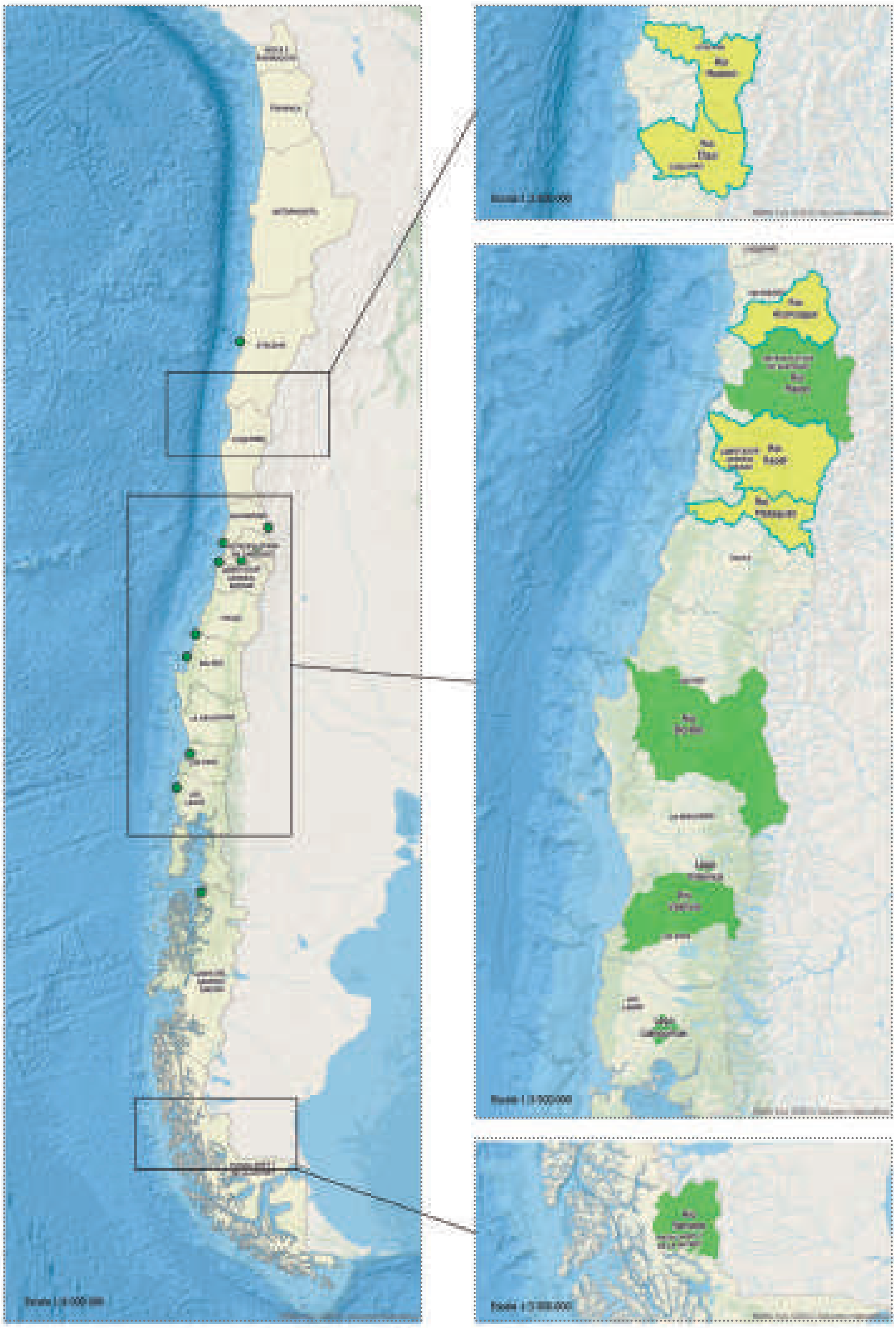
- Secondary Environmental Quality Standards for the Protection of Surface Inland Waters of the Serrano River Basin (Supreme Decree N° 75/2009).
- Secondary Environmental Quality Standards for the protection of the Lake Llanquihue Waters (Supreme Decree N° 122/2009).
- Secondary Environmental Quality Standards for the Protection of Surface Inland Waters of Lake Villarrica (Supreme Decree N° 19/2013).
- Secondary Environmental Quality Standards for the Protection of Surface Inland Waters of the Maipo River Basin (Supreme Decree N° 53/2013).
- Secondary Environmental Quality Standards for the Protection of Surface Inland Waters of the Valdivia River Basin (Supreme Decree N° 1, 2015).
- Secondary Environmental Quality Standards for the Protection of Surface Inland Waters of the Biobío River Basin (Supreme Decree N° 9, 2015).

In the latest report on the Environmental Performance Review, the OECD (2016) recommends that Chile "continue expanding coverage of water quality standards and accelerate implementation of the planned water quality and ecological information platform, with a view to systematically collecting and publishing water quality data; improve monitoring of soil contamination, as well as of water abstraction to protect ecosystems, notably wetlands."

In this context, the Ministry of the Environment is developing five new processes for the creation of Environmental Quality Standards, including the Secondary Environmental Quality Standard (NSCA by its acronym in Spanish) for the Rapel (includes the Cachapoal and Tinguiririca rivers, the Alhué estuary and the Rapel reservoir), Aconcagua, Elqui, Mataquito and Huasco river basins, with the aim of increasing regulatory coverage in the central and northern areas of the country.

FIGURE 15

SECONDARY ENVIRONMENTAL QUALITY STANDARDS (NSCA BY THEIR ACRONYM IN SPANISH) IN FORCE AND UNDER PREPARATION



Environmental Regulation Program for Secondary Water Quality Standards 2016-2017

Legend
Monitoring Program
NSCA

- **NSCA in force**
- **NSCA Included in the Environmental Regulation Program 2015-2017**

Source: Authors' own elaboration, MMA, 2016.

Programs for Measurement and Control of Environmental Quality

The Environmental Quality Measurement and Control Programs (PMCCA by its acronym in Spanish) correspond to systematic monitoring, designed to characterize, measure and control the variation of the quality of surface waters: continental, transitional and marine, over a certain period, with a preventive focus on the preservation and protection of ecosystems as an important part of the monitoring of the NSCA. The first PMCCA in force is that of Lake Villarrica, while the ones for the Maipo, Valdivia and Biobío rivers are in the process of being prepared. The Serrano River and Lake Llanquihue have surveillance programs.

The PMCCAs contain two types of monitoring networks, the control network and the observation network. In the control network, parameters are analyzed in the NSCA stations, limits required to evaluate compliance with the NSCA. The observation network contains basic parameters, for example temperature, and also additional parameters and stations as a basis for incorporating them in the following revisions of each NSCA, which by law must be done at least every five years. The Superintendency of the Environment is in charge of monitoring compliance with the PMCCAs, following a report from the Ministry of the Environment.

Prevention and Decontamination Plans

According to the Supreme Decree N° 39/2012[11], "the prevention plan is an environmental management tool, which - through the definition and implementation of specific measures and actions- is aimed at avoiding the exceedance of one or more primary or secondary environmental quality standards, in a latent zone."

Decontamination plans, which are also prepared according to the Supreme Decree N° 39/2012, are defined as "an environmental management tool that -through the definition and implementation of specific measures and actions –are aimed at recovering the levels indicated in the primary and/or secondary environmental quality standards of an area as qualified saturated by one or more pollutants". The content of these plans must include information on the identification, delimitation and description of the affected area, reference to the environmental quality data that the zone declaration is based on and those related to the emission sources that may impact this zone.

In addition, the plan must contain, at least the relationship between total emission levels and pollutants to be regulated, the deadline for emission reduction, those responsible for compliance with the plan, the management tools to be applied, the emission reduction ratio for those responsible for pollutants, the maximum permissible emission limits per emission load and/or concentration of pollutants and the estimation of costs and socioeconomic benefits. Whenever possible, it must include a proposal of compensation mechanisms, the contribution of the different sources to the total emission, it may formulate an Operational Plan for Critical Episodes (public cooperation actions, education and environmental dissemination programs), as well as tools for stimulating actions of environmental improvement and restoration, the conditions that will be required for new activities to be developed in the area of the plan, the program of verification of compliance with the established conditions and requirements, and the mention to the Superintendency of the Environment as the authority in charge of its supervision.

Protection of Ecological Flows

In the context of the determination of ecological flows and the conservation of ecosystem services of aquatic environments, during 2013 and 2014, the Ministry of the Environment developed the study "Conservation of Continental Aquatic Ecosystems and their Biodiversity, Implementation of Methodologies

[11] *Supreme Decree N° 39, of 2012, Ministry of the Environment. "Regulation for the Dictation of Prevention and Decontamination Plans".*

and Development of Tools for the Planning, Evaluation and Prioritization of Ecosystems". This tool will enable to evaluate the range of flows in which different aquatic species develop in the basins of the country (habitability curves). The objective of this work is to identify and classify the aquatic ecosystems of the territory (rivers, lakes, other wetlands) according to their potential capacity for the development of aquatic biodiversity.

Emission Standards

They establish the maximum amount allowed for a pollutant, measured in the effluent of the source, whose presence in the environment, at certain levels, may constitute a risk to the health of people, to the quality of life of the population, the preservation of nature or the conservation of environmental heritage. Four water standards of this type are in force.

- Emission Standard for the Regulation of Pollutants Associated with Discharges of Liquid Industrial Waste to Sewerage Systems (Supreme Decree N° 609/1998).
- Emission Standard for the Regulation of Pollutants Associated with Discharges of Liquid Waste to Marine and Continental Surface Waters (Supreme Decree N° 90/2000).
- Standard for the Emission of Liquid Waste to Groundwater (Supreme Decree N° 46/2002).
- Emission Standard for Molybdenum and Sulfates from Released Effluents from Tailings Ponds to Estero Carén (Supreme Decree N° 80/2006).

Environmental Qualification Resolution

An Environmental Qualification Resolution (RCA by its acronym in Spanish) is an administrative tool that is generated together with the approval of a project in the environmental impact assessment by the Environmental Assessment Service (SEA). The document delivered to the owner of the project establishes the conditions, requirements or measures associated with its activity that must be met during its installation and maintenance.

Declaration of Surface Water Depletion

According to what is stipulated in Article 282 of the Water Code, the Water General Director may declare -at the grounded request of the respective oversight board or any interested party and effects of the granting of new permanent consumptive rights- the depletion of natural water sources, be they natural flows, lakes, or lagoons, among others. Once the depletion has been declared, permanent consumptive rights cannot be granted (Ministerio de Justicia, 1981). To date, the depletion of 12 natural sources has been declared (**Table 14**).

TABLE 14

DECLARATION OF SURFACE WATER DEPLETION			
N°	**YEAR**	**RESOLUTION**	**NAME**
1	1952	**MOP Decree N° 1898**	Declaration of Depletion Laja River and its tributaries between its headwaters and BT Canal Siberia
2	1983	**DGA Acknowledgement Resolution N° 80**	Declaration of Depletion Tinguiririca River and its tributaries
3	1983	**DGA Acknowledgement Resolution N° 383**	Declaration of Depletion First Section Mapocho River and its tributaries
4	1985	**DGA Exempt Resolution N° 209**	Declaration of Depletion First Section Aconcagua River
5	1994	**DGA Acknowledgement Resolution N° 158**	Declaration of Depletion Diguillín River and its tributaries
6	1999	**DGA Acknowledgement Resolution N° 894**	Declaration of Depletion Chimbarongo Stream and its tributaries
7	2000	**DGA Exempt Resolution N° 197**	Declaration of Depletion Loa River and its tributaries
8	2004	**DGA Exempt Resolution N° 1278**	Declaration of Depletion Putaendo River and its tributaries
9	2004	**DGA Exempt Resolution N° 1432**	Declaration of Depletion Choapa River and its tributaries
10	2005	**DGA Exempt Resolution N° 72**	Declaration of Depletion Grande and Limarí rivers and their tributaries
11	2009	**DGA Exempt Resolution N° 1515**	Declaration of Depletion Elqui River and its tributaries
12	2016	**MOP Decree N° 24**	Declaration of Depletion Huasco River and its tributaries, Huasco Province, Atacama Region

Source: MMA based on data from DGA, 2016.

Water Reserve Decrees

As stipulated in Article 147 of the Water Code (Ministerio de Justicia, 1981), the President of the Republic may reserve the water resource for the population's supply when there is no other means to obtain water. Applications for non-consumptive exploitation rights may also be denied in the case of exceptional circumstances and national interest.

From 2007 to 2015, 28 water reserves have been declared at the national level between the Atacama and the Magallanes and Chilean Antarctica regions. **Table 15** shows the Water Reserve Decrees.

TABLE 15

WATER RESERVE DECREES

REGION	N°	NAME	TYPE OF WATER	WATER USAGE	DECREE N°	PUBLICATION DATE
Atacama	1	Freirina Bajo	Groundwater	Supply	2114	2014
	2	Freirina Alto	Groundwater	Supply	2114	2014
	3	Vallenar Bajo	Groundwater	Supply	2114	2014
	4	Embalse Santa Juana	Groundwater	Supply	2114	2014
	5	El Tránsito	Groundwater	Supply	2114	2014
	6	Río del Carmen	Groundwater	Supply	2114	2014
Santiago Metropolitan Region	7	Estero Popeta	Groundwater	Supply	830	2013
O´Higgins	8	Tinguiririca inferior	Groundwater	Supply	1,742	2013
	9	Las Cadenas - Marchigue	Groundwater	Supply	43	2014
	10	Estero Lolol	Groundwater	Supply	1,743	2013
	11	Nilahue antes de Quiahue	Groundwater	Supply	42	2014
Biobío	12	Río Queuco	Surface water	Supply	1,789	2009
Araucanía	13	Río Toltén	Surface water	Supply	462	2008
Los Lagos	14	Río Bueno	Surface water	Supply	793	2009
	15	Río Pilmaiquén	Surface water	Supply	461	2007
	16	Río Rahue	Surface water	Supply	665	2007
	17	San Juan de La Costa	Surface water	Supply	1,015	2013
	18	Río Petrohué	Surface water	Exceptional circumstances of national concern	1,706	2009
	19	Río Cochamó	Surface water	Exceptional circumstances of national concern	1,519	2009
Aysén	20	Rio Cisnes	Surface water	Supply	1,524	2009
	21	Río Emperador Guillermo	Surface water	Supply	361	2009
	22	Río Aysén	Surface water	Supply	1,524	2009
	23	Río Murta	Surface water	Exceptional circumstances of national concern	1,712	2009
	24	Río Baker	Surface water	Supply	316	2008
	25	Río Baker	Surface water	Exceptional circumstances of national concern	4	2015
	26	Río Bravo	Surface water	Supply	1,524	2009
	27	Río Pascua	Surface water	Exceptional circumstances of national concern	3	2015
Magallanes and Chilean Antarctica	28	Río del Oro	Surface water	Exceptional circumstances of national concern	137	2010

Source: DGA, 2016.

Restriction Areas for the Extraction of Groundwater

According to what is stipulated in Article 65 of the Water Code (1981), the Hydrogeological Sectors of Common Use (SHAC by their acronym in Spanish), where there is a risk of serious reduction of a certain aquifer, will be considered as restriction areas, with the consequent damage of rights of third parties already established in it, or when the technical reports issued by the agencies show that the sustainability of the aquifer is in danger. This measure corresponds to a response for the protection of the aquifers since once the declaration is issued, the DGA can only grant exploitation rights of a provisional nature. **Table 16** shows the detail of the restriction areas declared between 1997 and 2015.

TABLE 16

RESTRICTED AREAS FOR GROUNDWATER EXTRACTION

REGION	N°	AREA [KM²]
Arica and Parinacota	1	974
Tarapacá	3	7,050
Tarapacá / Antofagasta	1	8,832
Antofagasta	5	17,947
Atacama	7	10,921
Atacama / Coquimbo	1	451
Coquimbo	29	18,770
Valparaíso	51	9,180
Valparaíso / Santiago Metropolitan Region	2	752
Santiago Metropolitan Region	25	7,331
Santiago Metropolitan Region / O'Higgins	2	1,362
Valparaíso / Santiago Metropolitan Region / O'Higgins	1	141
O'Higgins	22	8,042
O'Higgins / Maule	1	575
Maule / Biobío	2	4,981
TOTAL	**153**	**97,306**

Source: DGA, 2015a.

Forbidden Areas for Groundwater Extraction

As stipulated in Article 63 of the Water Code (1981), the General Directorate of Water (DGA by its acronym in Spanish) may declare forbidden areas for new exploitations of groundwater, through a well-founded resolution, in order to protect the aquifers. The forbidden areas are declared when the availability of the water resource is fully compromised, both in a definitive and provisional way. Hence, it is not possible to establish new exploitation rights. To date, only six forbidden areas have been declared.

TABLE 17

FORBIDDEN AREAS FOR GROUNDWATER EXTRACTION

REGION	AQUIFER	SECTOR	AREA (km²)
Arica and Parinacota	Azapa	**Azapa**	341
Atacama	Copiapó	**Sector 1, Aguas Arriba Embalse Lautaro**	6,654
		Sector 2, Embalse Lautaro-La Puerta	860
		Sector 3, La Puerta-Mal Paso	1,439
		Sector 4, Mal Paso-Copiapó	1,754
Valparaíso	Estero El Membrillo	**Estero El Membrillo**	4
		TOTAL	**11,052**

Source: DGA, 2015a.

Standards for Exploration and Exploitation of Groundwater (Supreme Decree 203)

In 2014, the regulation on standards for exploration and exploitation of groundwater was approved (Decree 203, Ministry of Public Works), which establishes the general and specific conditions that will govern all groundwater in the country. The regulation establishes the conditions for the exploration of groundwater in publicly-owned real estate and in national assets, and establishes the conditions for the exploitation of groundwater, which include: protection areas; limitations to exploitation; the establishment of groundwater communities; changes in catchment and/or restitution points; changes in supply sources; alternative catchment and/or restitution points; artificial recharges; and special provisions.

Protection of Aquifers and Boglands

In order to protect those aquifers that feed meadows and boglands in the regions of Arica and Parinacota, Tarapacá, and Antofagasta, in 1992 a modification was made to the Water Code to ban the exploration and exploitation of the groundwater that supports these ecosystems.

The ecosystems of meadows and boglands should be considered as unique, given the biodiversity they harbor in the high-Andean plateaux, under extreme conditions of radiation, salinity and water stress. Also, these environments provide important ecosystem services to high-Andean communities, for example, in relation to their support activities (livestock and agriculture), cultural and religious. In 2015, 216 aquifers with a total surface area of 5,815 km^2 were declared protected, with the Antofagasta Region concentrating the largest number (122 aquifers), followed by the Arica and Parinacota Region (57 aquifers), and then the Tarapacá Region (37).

4.3 Collection of Information

Since 1910, Chile has had the National Hydrometric Network, which provides information on the characteristics of national waterways, through the measurement of flows and other quantitative data. This network is currently inserted in the National Hydrometric Service of the General Directorate of Water (DGA) and has a total of 2,895 stations and monitoring points throughout the country. This service has meteorological, rainfall, sediment, water quality, well levels and levels of lakes and reservoirs monitoring stations as well as monitoring points for snow routes and glaciers. Additionally, some real-time information stations of basic parameters are installed.

TABLE 18

DGA MONITORING STATIONS

REGION	METEOROLOGICAL STATIONS	PLUVIOMETRIC STATIONS	WATER QUALITY MONITORING NETWORK	WELL LEVEL STATIONS	LAKE AND RESERVOIR WATER LEVEL MONITORING STATIONS	SEDIMENT MONITORING STATIONS	SNOW ROUTE MONITORING STATIONS	GLACIOLOGICAL STATIONS	TOTAL
Arica and Parinacota	26	19	26	32	1	1	0	0	105
Tarapacá	26	13	24	61	0	1	0	0	125
Antofagasta	40	32	32	46	1	3	0	0	154
Atacama	29	27	60	86	2	3	0	0	207
Coquimbo	66	48	78	116	7	8	6	1	330
Valparaíso	62	22	68	123	1	8	3	0	287
Santiago Metropolitan Region	46	22	63	102	3	5	6	7	254
O´Higgins	29	19	51	83	2	2	1	1	188
Maule	62	59	76	4	9	5	1	0	216
Biobío	73	74	78	23	7	10	4	0	269
La Araucanía	54	41	55	7	4	10	0	0	171
Los Ríos	22	17	62	5	6	2	0	0	114
Los Lagos	38	35	57	3	6	1	0	0	140
Aysén	40	37	43	0	5	6	0	10	141
Magallanes	70	42	56	0	14	8	1	3	194
TOTAL	683	507	829	691	68	73	22	22	2,895

Source: DGA, 2016.

Chile lacks systematic data on the state of water resources, which limits an accurate and detailed assessment of the scope of the problem, constituting a serious obstacle to the management of these resources. The existing monitoring network is insufficient to adequately characterize the rivers, lakes, estuaries and coastal zones of the country. At present, there are areas of the territory where water quality information is not available. For example, the minimum network of lakes considers only 14 of the 368 lakes with an area greater than 3 km^2 [12].

On the other hand, coastal lakes are currently the most vulnerable water bodies because they receive the pollutant load from the central valley and are not considered within the minimum network of lakes. The network also includes a limited set of parameters and does not stratify them according to the heterogeneity observed throughout the national territory. Also, there is little understanding and information on aquatic ecosystems. Currently, the National Wetlands Platform is being developed, so that, through the internet, citizens and specialists can visualize, consult and manage all information related to wetlands in the country.

[12] *Minimum Lakes Network (RML by its acronym in Spanish) or lake monitoring network, DGA program.*

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CHAP **17**

NATURAL EVENTS AND ENVIRONMENTAL DISASTERS

CONTENIDO

INTRODUCTION

During our history as a country, numerous disasters have occurred in the territory, which in one way or another have been creating our identity, our culture, and the development processes. It is almost popular knowledge that every so often we must face some type of disaster, be it earthquake, volcanic eruption, fire, among others. However, despite the daily occurrence of these disasters in the lives of many people, there is still widespread ignorance about these phenomena, mainly about their causes and impacts.

The geographic characteristics of Chile, along with demographic, social, political and economic aspects, mean that a large part of its territory is exposed to the threat of disasters of various kinds. These disasters can affect the environmental conditions of the territory, a significant number of the population and the development of various activities. This reality requires a comprehensive disaster management at the Government level, but also includes all actors in society (UNESCO, 2013).

This chapter has been incorporated for the first time in the State of the Environment Report of Chile, following the guidelines of the Global Environmental Outlook 6 (GEO 6), prepared by the United Nations Environment Programme (UNEP) and it provides background information on the characteristics of our country, the main risks to which it is exposed, as well as the actions and activities that have been carried out in recent years to deal adequately with disasters.

1 • BACKGROUND INFORMATION

The main concept for understanding natural events and environmental disasters is risk, which is defined as the combination of the probability of an event occurring and its negative consequences, which may vary from one geographical area to another.

To understand risk, it is important to bear in mind that this is the result of the interaction of three variables: hazards, vulnerability and capacities, which are configured according to the following equation:

HAZARD

"It is a phenomenon, substance, human activity or dangerous condition that can cause death, injury or other health impacts, as well as damage to property, loss of livelihoods and services, social and economic disruption, or environmental damage" (UNESCO, 2013).

Hazards can have different origins: natural (geological, hydrometeorological and biological) or anthropic (environmental degradation and technological threats). Threats can be individual, combined or sequential in their origin and effects, and can be characterized by their location, magnitude or intensity, frequency and probability (UNESCO, 2013).

VULNERABILITY

They are "the characteristics and circumstances of a community, system or good that make them susceptible to the harmful effects of a threat. There are several aspects of vulnerability that arise from various physical, social, economic and environmental factors" (UNESCO, 2013).

CAPABILITIES

"The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve the agreed objectives. It can include the infrastructure and physical means, institutions and coping skills of society, as well as human collective skills and attributes such as social relations, leadership and management" (UNESCO, 2013).

The degree of knowledge of a risk will depend on the quantity and quality of the information available and how people perceive the risk. Having knowledge of the hazards and vulnerability, as well as having accurate and timely information in this regard, can influence this perception. On the other hand, they are more vulnerable to the extent that they are less aware of the hazards that endanger our lives and property (UNISDR, 2004).

The origin of the risks, that is, how they are initiated and the causes that generate them, are diverse and determine the types of risks. These can be classified as:

1 **Risks originating in the natural environment or natural risks:** within this category are risks in which the causing agent of danger is the natural environment. This category includes the following subtypes of natural risks:

a) Geophysical risks: those of the geosphere and the atmosphere:

- ▶ Climatic and meteorological risks.
- ▶ Geological and geomorphological risks.
- ▶ Risks originating in outer space.

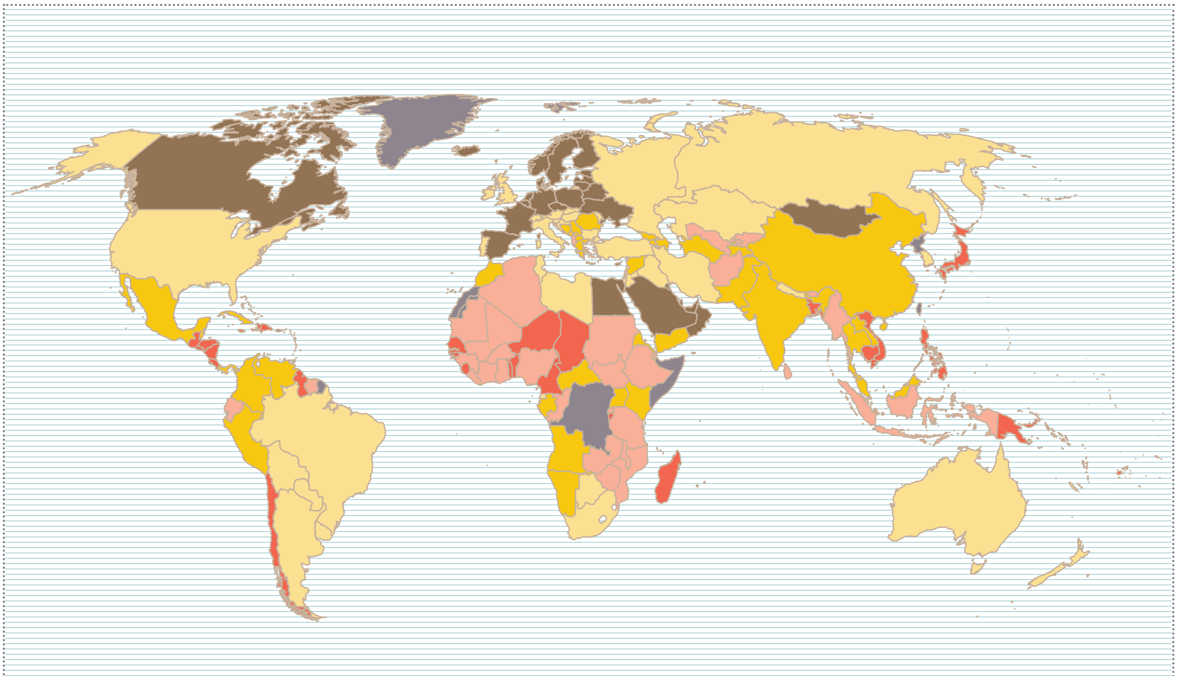
b) Biological risks: those of the biosphere:

- ▶ Origin in wildlife.
- ▶ Origin in plants.

Globally, Chile has a "very high" risk index (**Map 01**) and almost all types of natural risks are present in our country (except for hurricanes).

MAP 01

RISK MAP



RISK INDEX ■ Very High ■ High ■ Medium ■ Low ■ Very Low ■ No Data

Source: http://www.worldriskreport.org/

2 **Society risks:** these are risk situations in which the main agents are the different structures of social development outside the natural environment. Society risks are those that arise from the fact that people are grouped and live in society. Within these risks we find two subtypes:

a) Technological risks: those that derive from the technological activity itself. The risk situation is generated by the technology developed by human beings.

- ▶ Risk in industrial establishments.
- ▶ Nuclear and radiological risk.
- ▶ Risk in the transportation of dangerous substances.
- ▶ Risk to facilities and establishments of explosives and pyrotechnics.
- ▶ Risk due to faults and accidents in reservoirs.
- ▶ Risk due to dependence on infrastructures and basic services.
- ▶ Risk due to the fall of artificial satellites.

b) Human risks: they are associated with the behavior of people, that is, it is a risk situation in which the agent is the human being. We can identify them with the following specific risks:

- ▶ Human stampede.
- ▶ Altercations and vandalism.
- ▶ Sabotage.
- ▶ Collective damage (attacks or similar).

Risk, therefore, is any process that represents a threat to human life, property or assets and infrastructure. A disaster is the effect of a risk on society, which occurs for a limited period and in a specific geographical area, causing damage to the population, the planet, ecology and health. Although disasters generate visible impacts, there are also consequences that are only visible in the medium and long terms.

A catastrophe is a major disaster where the damage and number of victims are significant. It requires a high expenditure of time and money for recovery.

The country's historical disasters in the framework of the GEO methodology, in terms of their impact on the environment, are addressed below.

Linares | VICTORIA CÁRCAMO

2 • THREATS TO THE ENVIRONMENT

2.1 Historical Information on Disasters in Chile

The most common disasters in our country are earthquakes and floods. Of the total disasters registered between 1906 and 2014, they represent 28 percent and 24 percent respectively. In turn, the disasters with the least occurrences are epidemics, with 1 percent[1]. **Figure 01** shows the disasters recorded in the country from 1906 to 2014, according to their natural or technological origin (as a consequence of technological risks). Although the disasters that have occurred in the country have been mostly natural, those of technological origin have increased steadily in recent years.

As mentioned before, hazards, vulnerability and capacities explain the level of risk to which a population is exposed. In this context, knowing the threats is the first step for an adequate risk management, which allows to reduce the occurrence of disasters. This report addresses the two most relevant threats to the country, natural and technological.

2.2 Natural Hazards

Natural hazards can be classified by their origin as indicated in **Table 01**. In the case of Chile, the main threats documented are the geological and hydrometeorological ones detailed below.

2.2.1 Geological Threats

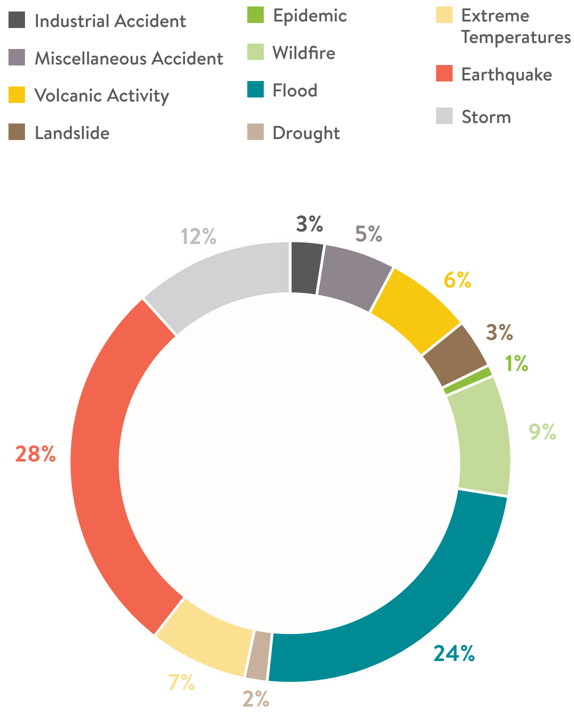
2.2.1.1 Seismic Activity

Seismic activity in Chile is explained because it is part of the "Pacific Ring of Fire", a strip of the planet that is characterized by concentrating some of the most important subduction zones in the world (**Map 02**). Approximately 90 percent of the earthquakes in the world take place here (United States Geological Survey - USGS, n.d.).

[1] *The Center for Research on the Epidemiology of Disasters (CRED) specializes in the study of health problems in emergency situations, as well as in disasters, public health and epidemiology. It has a registry of standardized data (EM-DAT, international database) on the main events recorded in different countries, including Chile, since 1900.*

FIGURE 01

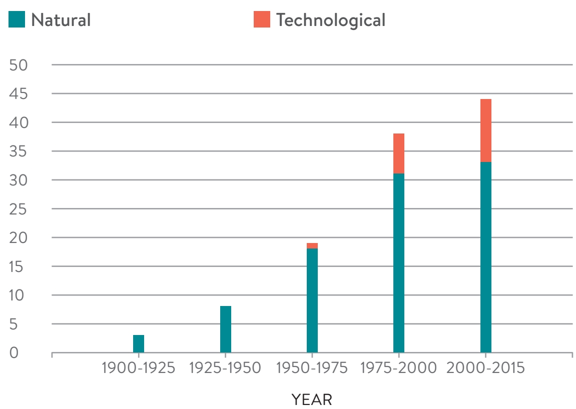
TYPES OF DISASTERS
occurred in Chile, 1906-2014



Source: EM-DAT DATABASE, 2016.

FIGURE 02

ORIGIN OF EVENTS AND DISASTERS
occurred in the country, 1900-2015



Source: EM-DAT DATABASE, 2016.

TABLE 01

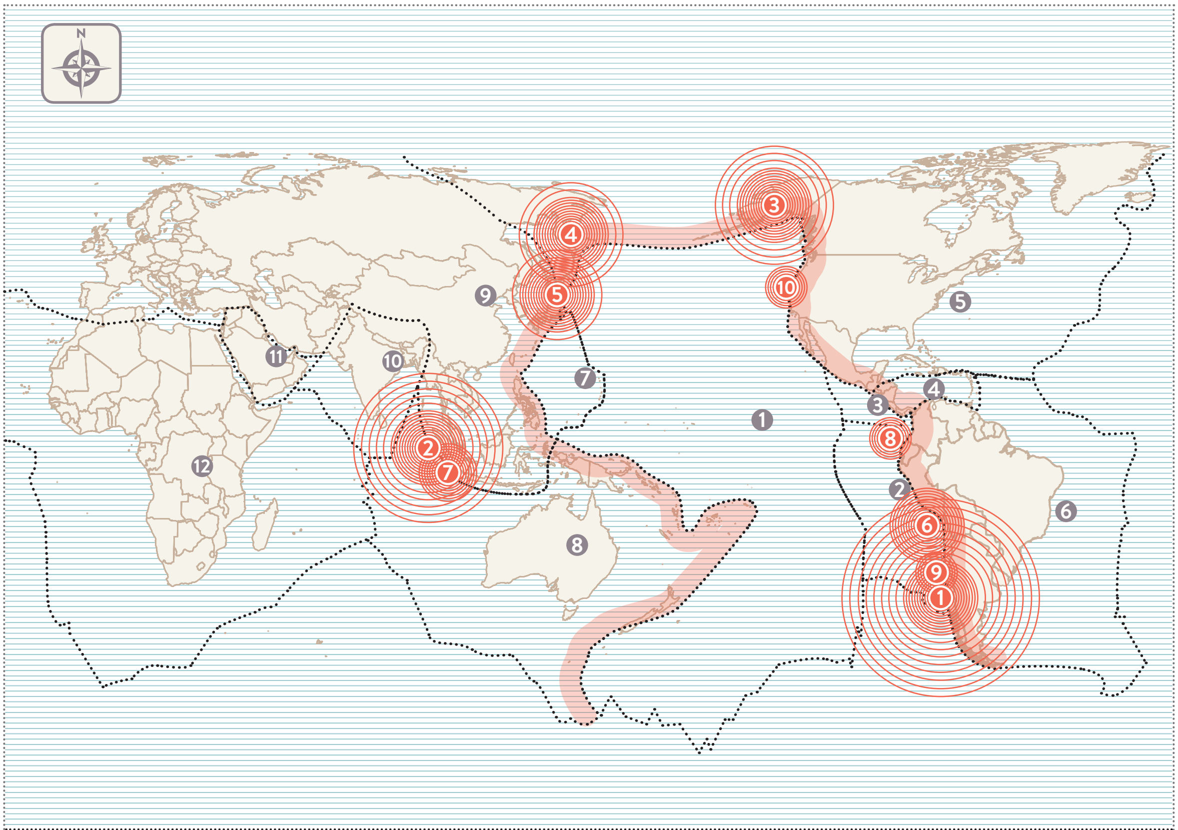
NATURAL HAZARDS	
Natural processes or phenomena occurring in the biosphere that may constitute a damaging event and cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.	
ORIGIN	**PHENOMENA/EXAMPLES**
HYDROMETEOROLOGICAL HAZARDS Natural processes or phenomena of atmospheric, hydrological or oceanographic nature, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.	► Floods, debris and mud floods. ► Tropical cyclones, storm surges, thunder/ hailstorms, rain and wind storms, blizzards and other severe storms. ► Drought, desertification, wildland fires, temperature extremes, sand or dust storms. ► Permafrost and snow or ice avalanches.
GEOLOGICAL HAZARDS Natural earth processes or phenomena that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.	► Earthquakes, geological fault activity, tsunamis. ► Volcanic activity and emissions. ► Mass movements: landslides, rockslides, rock falls or avalanches. ► Surfaces collapses, expansive soils and debris or mud flows.
BIOLOGICAL HAZARD Processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.	► Outbreaks of epidemic diseases, plant or animal contagion, insect plagues and extensive infestations.

Source: UNISDR, 2004.

Brazil Neighborhood | VICTORIA CÁRCAMO

MAP 02

PACIFIC RING OF FIRE



Tectonic Plates

1. PACIFIC PLATE
2. NAZCA PLATE
3. COCOS PLATE
4. CARIBBEAN PLATE
5. NORTH AMERICAN PLATE
6. SOUTH AMERICAN PLATE
7. PHILIPPINE SEA PLATE
8. AUSTRALIAN PLATE
9. EURASIAN PLATE
10. INDIAN PLATE
11. ARABIAN PLATE
12. AFRICAN PLATE

Global Ranking of Earthquakes

1. **9.5°** (Ms) CHILE, VALDIVIA / 22-05-1960
2. **9.3°** (Ms) INDONESIA, IN FRONT OF SUMATRA / 26-12-2004
3. **9.2°** (Ms) USA, ANCHORAGE, ALASKA. / 28-03-1964
4. **9.0°** (Ms) USSR, KAMCHATKA PENNINSULA / 4-11-1952
5. **9.0°** (Ms) JAPAN, HONSHU COAST / 11-03-2011
6. **9.0°** (Ms) PERÚ, ARICA, CURRENTLY CHILE / 13-08-1868
7. **8.8°** (Ms) INDONESIA, BENGKULU, SUMATRA / 24-11-1833
8. **8.8°** (Ms) ECUADOR-COLOMBIA, EMMERALD COASTS / 31-01-1906
9. **8.8°** (Ms) CHILE, COBQUECURA / 27-02-2010
10. **8.7°** (Ms) USA-CANADÁ, CALIFORNIA TO BRITISH COLUMBIA / 26-01-1700

RING OF FIRE AND PLATES

Ring of Fire ····· Plate Boundaries

Source: Gringer, 2009.

Seismic activity can generate destructive effects due to the association with other geological phenomena such as tsunamis, mass removals, liquefaction[2] of fine areas and soils, and possible reactivation of geological faults (SERNAGEOMIN, 2010).

Of the seismic events occurred in our country, those with a magnitude of superficial waves (Ms) greater than 7° stand out for their impact. In the last 400 years, there have been more than 100 events of this type, of which 25 have exceeded 8° (Ms).

With the exception of the southern part of the country, almost all of Chile has suffered a seismic event with an intensity greater than 7° (Ms). The regions of Valparaíso, Los Lagos and Arica and Parinacota stand out, which have presented an amount of 5 to 8 epicenters of earthquakes over 7° (Ms) since 1570, in addition to three earthquakes over 8° (Ms).

Map 03 shows the distribution of the earthquakes occurred in Chile since 1570 over 7° (Ms).

SEISMIC EVENTS

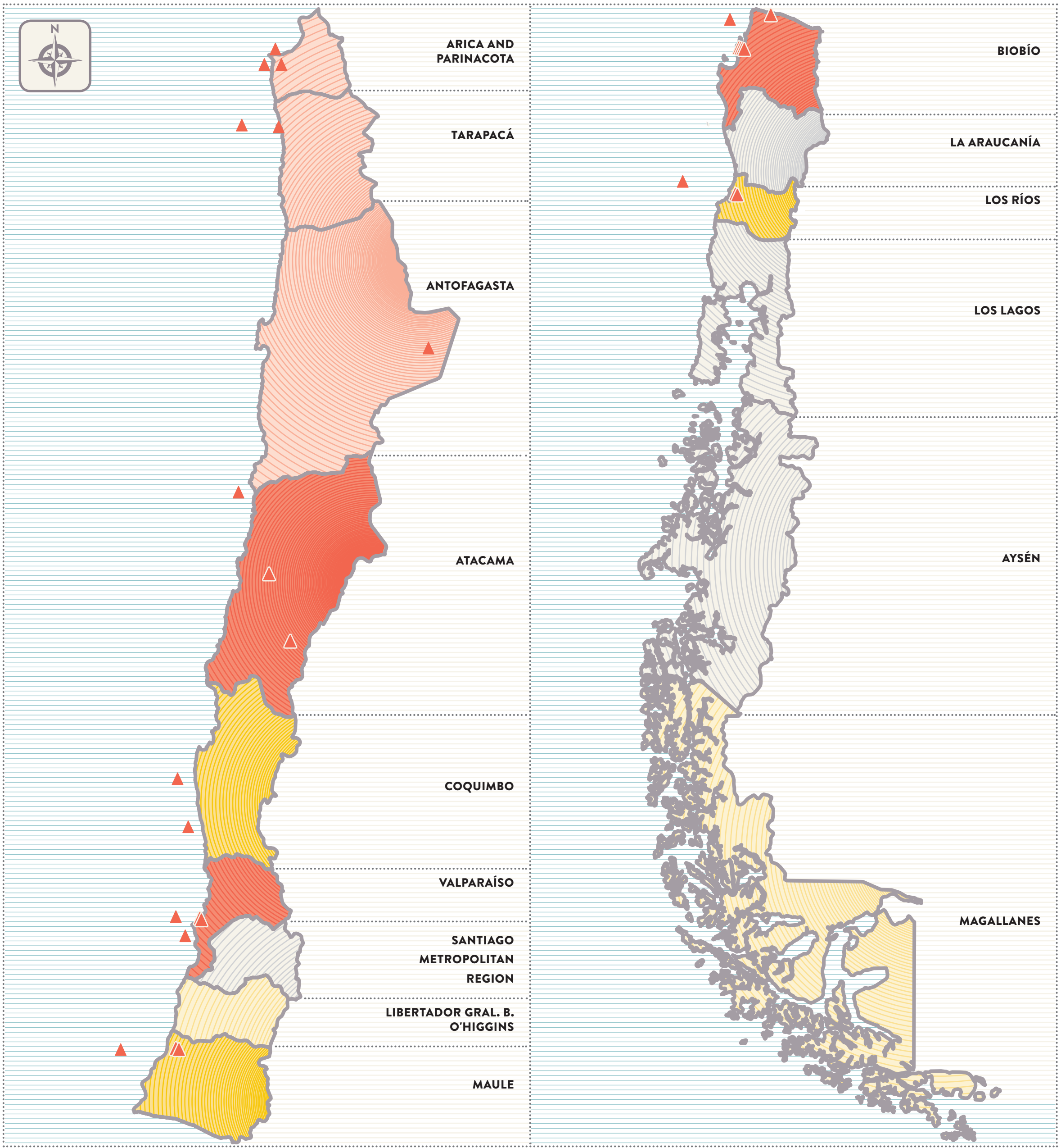
Of the seismic events occurred in our country, those with a magnitude of superficial waves (Ms) greater than 7° stand out for their impact. **Over the last 400 years there have been more than 100 events of this type, of which 25 have exceeded 8° (Ms).**

[2] *Liquefaction, in general terms, is the passage of a component or object, from a solid or gaseous state to a liquid state.*

Chaitén | SIOMARA GÓMEZ

MAP 03

MAP OF EARTHQUAKES OVER 7° (Ms) OCCURRED IN CHILE BETWEEN 1570 AND 2015



NUMBER OF EARTHQUAKES OVER 7° (Ms)

■ 7 - 8 ■ 5 - 6 ■ 3 - 4 ■ 1 - 2 ■ 0

▲ Earthquake over 8° (MS)

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Source: Authors' own elaboration based on information from the National Seismic Center, University of Chile, 2015.

2.2.1.2 Volcanic Activity

Chile has a mountain range that harbors more than 2,000 volcanoes, of which 91 are considered geologically active because they have presented some level of activity over the last 10,000 years. These present a potential threat according to their degree of danger[3]. Of the 43 most active volcanic complexes in the country, those with the highest risk index are the Villarrica and Llaima volcanoes, located in the Araucanía region, and the Calbuco volcano, located in the Los Lagos Region (SERNAGEOMIN, 2014).

Table 02 shows information on the ten most dangerous volcanoes, according to the criteria of SERNAGEOMIN.

2.2.2 Hydrometeorological Hazards

In Chile, hydrometeorological events are mainly landslides and mass removals due to rain[4]. Between 2010 and 2014, there were 38 hydrometeorological events, most notably in 2012, when 13 of these events took place. **Figure 03** shows the details of the events for the mentioned years[5].

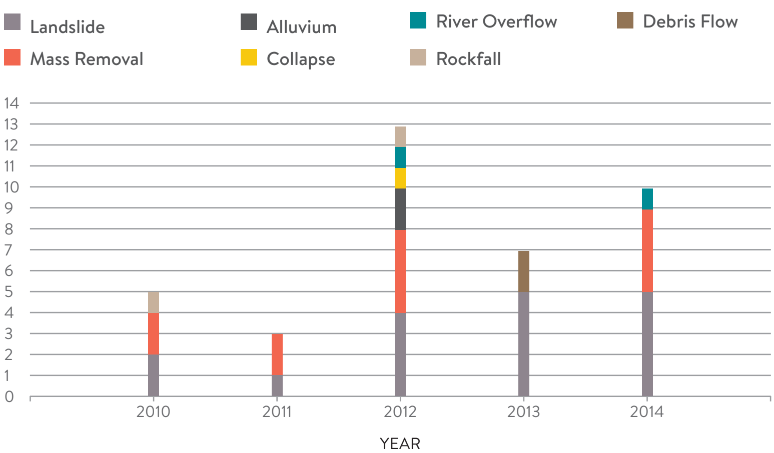
[3] SERNAGEOMIN, (2014) classifies the degree of danger of volcanoes according to three criteria: i) verifiable activity level in the recent 10,000 years or that the monitoring instruments show that it has activity; ii) proximity to population centers; iii) whether it represents a risk to people or public and private infrastructure.

[4] "First National Inventory of Natural Disasters Associated with Geological Hazards" (SERNAGEOMIN, 2015).

[5] In this table, mass removals and landslides caused by high intensity earthquakes have been ruled out, since their origin is not due to hydrometeorological events.

FIGURE 03

NUMBER OF HYDROMETEOROLOGICAL EVENTS between 2010 and 2014[5]



Source: SERNAGEOMIN, 2015.

ⓘ Debris flow
Flow made up of a mixture of rocks, sediments, water and gases, where the solid material constitutes between 50 and 80 percent of the flow. It moves gravitationally, with speeds up to 100 km/h and has great destructive capacity (SERNAGEOMIN, 2015).

CHILE

Source: SERNAGEOMIN, 2014.

TABLE 02

RANKING OF DANGEROUSNESS OF VOLCANOS IN CHILE
1 ▲ **VILLARRICA** Encompassed Regions **Araucanía / Los Ríos** Nearby Locations: **Pucón, Lican Ray, Coñaripe and Villarrica, entre otras.** Last Recorded Activity **March 2015.**
2 ▲ **LLAIMA** Encompassed Regions **Araucanía** Nearby Locations: **Melipeuco, Cherquenco, Cunco, Villa García and Curacautín, among others.** Last Recorded Activity **2012.**
3 ▲ **CALBUCO** Encompassed Regions **Los Lagos** Nearby Locations: **Ensenada, Correntoso, Alerce, Colonia Río Sur, among others.** Last Recorded Activity **April and May 2015.**
4 ▲ **CHAITÉN** Encompassed Regions **Los Lagos** Nearby Locations: **Chaitén, Santa Bárbara, Futaleufú, among others.** Last Recorded Activity **May 2008.**
5 ▲ **LÁSCAR** Encompassed Regions **Antofagasta** Nearby Locations: **Talabre, Toconao, Socaire.** Last Recorded Activity **July 2007.**
6 ▲ **MICHINMAHUIDA** Encompassed Regions **Los Lagos** Nearby Locations: **El Amarillo, Chaitén, Futaleufú, among others.** Last Recorded Activity **1835.**
7 ▲ **NEVADOS DE CHILLÁN** Encompassed Regions **Biobío** Localidad Cercana: **Centro de Ski Termas de Chillán.** Last Recorded Activity **1973.**
8 ▲ **LONQUIMAY / TOLHUACA** Encompassed Regions **La Araucanía** Nearby Locations: **Lonquimay, Malalcahuello, Manzanar, among others.** Last Recorded Activity **Between 1988 and 1990.**
9 ▲ **COPAHUE** Encompassed Regions **Biobío** Nearby Locations: **Butalelbún, Trapatrapa, Guallalí, Chenqueco, Copahue, Caviahue, among others.** Last Recorded Activity **1992.**
10 ▲ **CERRO AZUL / QUIZAPU** Encompassed Regions **Maule** Nearby Locations: **San Clemente, Vilches, Armerillo and Radal.** Last Recorded Activity **1932.**

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2.3 Technological Hazards

The main technological hazards in the country correspond to oil spills and fires, which can cause significant impacts on the natural environment, as well as affect people and the built environment.

2.3.1 Hydrocarbon Spills

Along the coast of Chile there are 41 maritime terminals, through which there is a massive transfer of hydrocarbons and other harmful substances that constitute a potential risk for spills. Added to this is the high traffic of tankers that sail through the sea, from the production centers and deposits, to the different refineries throughout the country (DIRECTEMAR, 2014).

The impacts to the environment caused by oil spills can be seen in the short, medium and long terms, including significant disturbances or damage to species and ecosystems, which can be identified immediately after an event or may happen many years later.

Between 2004 and 2014, there were 113 oil spill events on the Chilean coasts, with 2,559,500 liters of hydrocarbons spilled into the ocean, which correspond mainly to diesel and oil mixtures[6].

Table 03 shows the detail of the number of events and volume spilled. Of the record of spills, 2004 stands out as the year with the highest number of spills, and 2005 being the year when a greater volume of oil spilled into the sea.

TABLE 03

HYDROCARBON SPILLS ON CHILEAN COAST (2004-2014)

YEAR	NUMBER OF HYDROCARBON SPILLS	VOLUME (LITERS)
2004	21	177,689
2005	13	1,098,598
2006	12	199,024
2007	6	888,672
2008	8	1,550
2009	9	4,450
2010	8	15,520
2011	16	79,646
2012	10	19,101
2013	5	36,200
2014	5	39,050

Source: DIRECTEMAR, 2015.

[6] *Register of the General Directorate of Maritime Territory and Merchant Marine (DIRECTEMAR, 2015).*

01

HYDROCARBON SPILL IN THE QUINTERO BAY

On September 24, 2014, a hydrocarbon spill from the Mimosa Tanker Ship, of the Marshall Islands, was recorded in the Quintero Bay, Loncura Beach. Due to a defect in the hose that connected the ship and the Monoyoba Terminal of the National Oil Company (ENAP by its acronym in Spanish), 38,700 liters of Ecuadorian Oriente crude oil (API 24) were spilled into the ocean, affecting an area of 400,000 m^2 and its associated natural resources and ecosystem services in the coastal zone encompassed between the Quintero and Puchuncaví communes (DIRECTEMAR, 2015).

After the spill, both ENAP and several public agencies made efforts to carry out environmental and sanitary cleaning, monitoring and surveillance actions. In this context, the Agriculture and Livestock Service (SAG, 2014) implemented a rescue, recovery and release plan for affected birds, such as the Great Grebe, the Neotropic Cormorant, the Tern, and the Pelican. Out of a total of 29 birds captured alive, only 9 of them survived. It was concluded that all species presented injuries caused by hydrocarbon intoxication, with pulmonary edema being the most observed pathological sign (according to literature, pneumonia by aspiration is the main cause of death after exposure to hydrocarbons).

In addition to the damage to biodiversity in situations such as the one that occurred in Quintero, ecosystem services are affected and society stops receiving them due to environmental damage, including, for example, the use and enjoyment of the shoreline for recreational, educational/cultural and aesthetic appreciation purposes.

2.3.2 Fires

2.3.2.1 Urban

According to data provided by the Chilean Police (Carabineros de Chile)[7], on average 6,821 urban fire crimes occur each year in the country.

These crimes can be classified into 6 categories according to the type of fire and its consequences. Of these categories, "fires that cause damage without the danger of spreading" stands out for being the most frequent type of case.

Another year that also stands out is 2011, for having the highest number of registered urban fires (7,034). **Table 04** shows in detail the types of crimes and the numbers registered.

Figure 04 shows the number of crimes related to fires by region and by year, highlighting the Santiago Metropolitan Region, where the largest number of cases occur.

2.3.2.2 Wildfires

The number of forest fires that occurred in the country between 2012 and 2016 reached 26,818 (CONAF, 2016). The Biobío Region stands out because it is the one where there was a greater number of fires, with a total of 11,602 fires. **Figure 05** shows the number of fires per year and per region

Forest fires
A wildfire is a fire that spreads uncontrollably on rural land, through woody, shrub or herbaceous vegetation, living or dead. Whatever its origin, it represents a danger or damage to people, property or the environment. That is, it is a fire that burns trees, bushes and pastures. It is an unjustified and uncontrolled fire that fuels on vegetation and which, while spreading, can destroy everything in its path. A total of 99 percent of wildfires are caused by human action. (CONAF, n.d.).

[7] *Using data from 2010 to 2013 of the document "Statistical Table with the number of cases, for crimes related to fires registered at the national level, by regions, units and detachments".*

TABLE 04

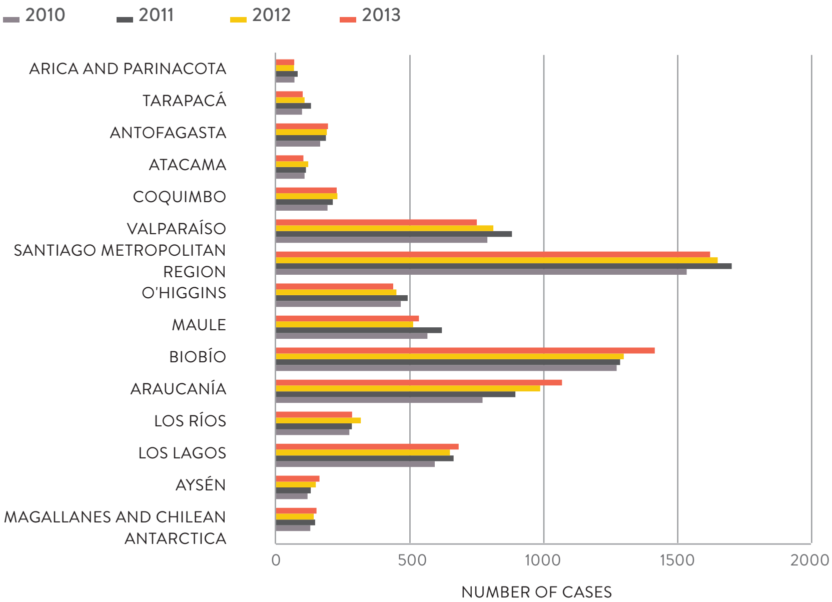
NUMBER OF CRIMES RELATED TO URBAN FIRES, RECORDED AT THE NATIONAL LEVEL BETWEEN 2010 AND 2013

TYPES OF CASES	NUMBER OF CASES PER YEAR			
	2010	2011	2012	2013
ANNUAL TOTAL	**6,345**	**7,034**	**6,953**	**6,952**
Fire	1	0	0	0
Fire with Danger to People	735	741	697	606
Fire Resulting in Deaths and/or Injuries	474	501	465	510
Fire Only with Damage or Without Danger of Spreading	5,116	5,791	5,789	5,835
Embezzlement, Fraud and Fire for Less Than 1 UTM	6	1	2	1
Illicit Use of Fire	13	0	0	0

Source: Carabineros de Chile, 2012.

FIGURE 04

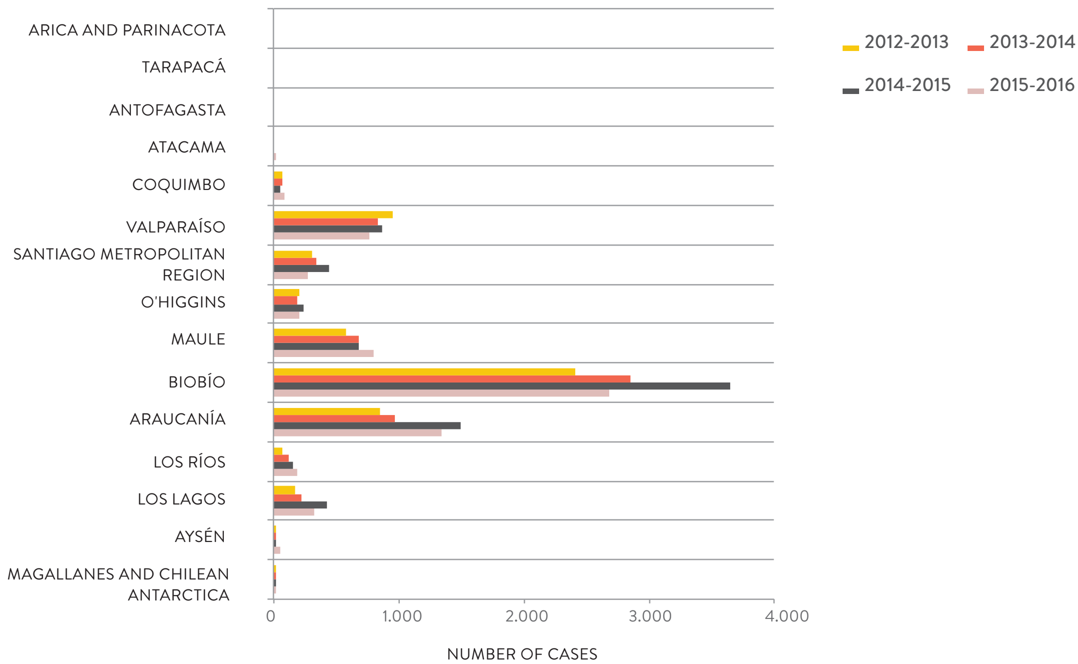
CRIMES RELATED TO FIRES RECORDED AT THE REGIONAL LEVEL BETWEEN 2010 AND 2013



Source: Carabineros de Chile, 2014.

FIGURE 05

NUMBER OF WILDFIRES BETWEEN 2012 AND 2016



Source: CONAF, 2016.

3 • IMPACTS

When analyzing the impacts generated by disasters, it is important to consider that they can affect both human and natural systems.

A disaster, depending on its magnitude and context, can cause significant changes in the landscape of a territory and can lead to changes in the structure and ecological functioning of one or more ecosystems. In addition, it can cause social, economic and cultural changes in a country or a locality, affecting the local economy, modifying citizen habits and behaviors, and generating organizational and legal changes.

3.1 Impacts of Seismic Events

Undoubtedly, in the case of Chile, the most significant natural phenomena are earthquakes. Considering the 10 earthquakes of greater intensity, it can be concluded that the main impacts are associated with significant changes in geography, in the people affected, whether deceased, injured or injured, as well as the destruction of homes.

The largest seismic event was recorded in 1960, in the city of Valdivia, with a magnitude of 9.5 on the Richter scale[8], considered the earthquake of greatest intensity recorded in the world. This earthquake generated the collapse of extensive areas around Valdivia, which were rendered unusable, and caused an overall lifting of the Arauco Peninsula, estimated at two meters (SERNAGEOMIN, 2010). This event left a total of 1,600 people dead, 4,350 injured and 50,000 people affected and in shelters.

The 2010 earthquake, called 27F (February 27), corresponds to another seismological event with the greatest impacts in Chile. Its epicenter was in the commune of Cobquecura (Biobío Region) and it is cataloged as the fifth earthquake of greatest intensity registered in the entire world, with a magnitude of 8.8 degrees on Richter scale. In relation to the damages caused, more than 500 dead and missing persons are estimated, more than 800,000 victims and 1.2 million people affected to some degree, in addition to more than 190,000 destroyed or severely damaged sites, 2,750 inoperable schools, a million children without classes and 35 unusable hospitals (SERNAGEOMIN, 2010).

Table 05 shows the most intense earthquakes in Chile and their impacts.

[8] *The Richter seismological scale, also known as the local scale of magnitude (ML), is an arbitrary logarithmic scale that assigns a number to quantify the energy released by an earthquake, named after American seismologist Charles Francis Richter (1900 - 1985).*

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CHILE

TABLE 05

RANKING OF THE 10 MOST INTENSE EARTHQUAKES IN CHILE AND THEIR IMPACTS

	Dead People	Injured People	People affected or in Shelters	Housing Destroyed or with Major Damage	Source
1 9.5° VALDIVIA (1960)	1,600	4,350	50,000	-	ONEMI, 2010
2 9° ARICA (1868)	312	-	-	100	Fernández, 2007
3 8.8° COBQUECURA (2010)	432	-	807,727	190,359	SERNAGEOMIN, 2010
4 8.7° VALPARAÍSO (1730)*	-	-	-	-	-
5 8.5° VALLENAR (1922)	70	300	-	8,500	Servicio Sismológico de Chile, 1926
6 8.4° COQUIMBO (2015)	15	14	27,738	5,050	ONEMI, 2015
7 8.3° TARAPACÁ (1877)	35	-	-	-	Urrutia de Hasbún, 1993, citado por ONEMI, 2012
8 8.2° VALPARAÍSO (1906)	3,882	20,000	-	-	Servicio Sismológico de USA (USGS) Terram, 2015
9 8.2° ILLAPEL (1943)	12	49	23,250	-	El Mercurio, 2007
10 8.2° ARICA AND IQUIQUE (2014)	6	-	21,000	6,000	ONEMI, 2015

*In the case of the 1730 earthquake, there is no information on the number of people affected.

To face the devastation of the 2010 earthquake (27F), the Ministry of Housing and Urban Development launched the "Chile Reconstruction Plan United Chile Rebuilds Better", whose main objective was to address the impacts of the earthquake through three main lines of action: Housing Reconstruction Program; Assistance Program for Emergency Villages and Social Condominiums; Territorial, Urban and Heritage Reconstruction Program.

For the Housing Rebuilding Program, a diagnostic study was conducted to estimate the number of damaged homes and the level of damage, which concluded that 81,445 homes were totally destroyed, 108,914 homes experienced great damage, while 180,143 homes had minor damages (MINVU, 2011). The main results of this diagnosis are presented in **Table 06**.

Seismic events in the country have generated other related events, such as mass removals. According to SERNAGEOMIN, the earthquake of April 27, 2007, registered in the city of Aysén (6.2 degrees on the Richter scale), presented significant mass removals, as did the 27F earthquake in 2010. In relation to the latter, mainly landslides and rock falls were generated in the Valparaíso, Santiago Metropolitan, O'Higgins, Maule, Biobío, Araucanía, Los Ríos, and Los Lagos regions. The material losses of this event are valued at US $ 30,000 million.

The earthquake of April 1, 2014 in the north of the country (Arica and Iquique), whose magnitude was 8.2 degrees on the Richter scale, generated numerous mass removals, mainly landslides and rock falls in the regions of Arica, Parinacota, Tarapacá and Antofagasta. This event caused the death of six people and the destruction of 2,500 homes (SERNAGEOMIN, 2015).

3.2 Impacts of Hydrometeorological Events

According to the records of the National Emergency Office of the Ministry of the Interior (ONEMI by its acronym in Spanish), the impact of hydrometeorological events is mainly reflected in the number of people and homes affected by storms[9]. **Table 07** [10] presents a summary of the data registry delivered by ONEMI for 2014 and 2015.

RECONSTRUCTION

To face the devastation of the 2010 earthquake (27F), the Ministry of Housing and Urban Planning launched the **"Rebuilding Plan Chile United Rebuilds Better", whose main objective was to address the impacts of the earthquake through three lines of action.**

[9] *ONEMI prepares an annual inventory of the main damages.*

[10] *Records until November 30, 2015*

TABLE 06

AMOUNT OF HOUSING DAMAGE AFTER THE 2010 EARTHQUAKE

TYPE OF HOUSING	DESTROYED HOUSING	HOUSING WITH MAJOR DAMAGE	HOUSING WITH LITTLE DAMAGE	TOTAL HOUSING
Coast	7,931	8,607	15,384	31,922
Urban Adobe	26,038	28,153	14,869	69,060
Rural Adobe	24,538	19,783	22,502	66,373
SERVIU Housing Neighborhoods	5,489	15,015	50,955	71,459
Private Housing Neighborhoods	17,449	37,356	76,433	131,237
TOTAL	**81,445**	**108,914**	**180,143**	**370,051**

Source: MINVU, 2011.

TABLE 07

NUMBER OF PEOPLE AND HOMES AFFECTED BY STORMS BETWEEN 2014 AND 2015

REGION	AFFECTED PEOPLE		SHELTERED PEOPLE		INJURED		DEAD		HOUSING WITH LITTLE DAMAGE		HOUSING WITH MAJOR DAMAGE		DESTROYED HOUSING	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
ARICA AND PARINACOTA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TARAPACÁ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANTOFAGASTA	-	6,484	-	-	-	-	-	8	50	6,709	-	871	-	71
ATACAMA	4	28,000	1	-	-	-	-	28	655	14,000	1	5,000	-	2,000
COQUIMBO	18	1,750	18	12	-	-	-	1	216	2,956	1	115	-	38
VALPARAÍSO	24	86	-	47	-	-	-	1	62	507	3	26	2	2
SANTIAGO METROPOLITAN REGION	30	-	-	-	-	-	-	-	57	-	8	-	-	-
LIBERTADOR GRAL B. O'HIGGINS	57	91	2	17	-	-	-	-	143	59	21	25	-	-
MAULE	15	-	15	-	-	-	-	-	106	-	4	-	-	-
BIOBÍO	1,141	66	86	20	-	-	-	-	2,917	123	258	6	18	2
LA ARAUCANÍA	172	41	83	16	-	-	-	-	437	32	26	1	25	2
LOS RÍOS	21	1	3	-	-	-	-	-	105	-	11	-	2	-
LOS LAGOS	1,198	4	115	2	-	-	-	-	686	38	42	2	13	-
AYSÉN	-	7		7	-	-	-	-	-	-	-	1	-	-
MAGALLANES AND CHILEAN ANTARCTICA	-	-	-	-	-	-	-	-	-	12	-	2	-	-
TOTAL	2,680	36,530	323	121	0	0	0	38	5,434	24,436	375	6,049	60	2,115

Source: ONEMI, 2015.

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3.3 Impacts of Fires

One of the most significant impacts of fires is the emission of toxic gases into the atmosphere, such as carbon dioxide (CO_2), sulfur dioxide (SO_2), and particulate matter (PM). From the record of fires occurred in the country between 2010 and 2014, a significant number of emissions from forest and urban fires stands out. **Table 08** shows that in 2014 the highest emissions in the atmosphere as a result of forest fires were recorded, with a total of 18,311,101 metric tons.

TABLE 08

AIR EMISSIONS BY FOREST AND URBAN FIRES BETWEEN 2010 AND 2014

EMISSIONS	FOREST FIRES (METRIC TONS/YEAR)				
	2010	2011	2012	2013	2014
Volatile organic compounds	141,316.23	109,189.79	165,566.61	301,452.61	404,785.11
Sulfur Dioxide (SO_2)	3,817	2,777.79	5,079.73	8,005.62	11,440.77
Carbon Dioxide (CO_2)	5,442,883.49	4,022,955.51	7,065,001.57	11,631,431.73	16,771,148.96
Carbon Monoxide	314,106.68	243,981.77	368,308.42	618,345.53	899,477.91
PM_{10}	33,509.89	25,764.44	40,417.07	71,337.76	101,010.37
$PM_{2.5}$	28,408.42	21,858.43	34,277.55	60,481.26	85,641.04
NOx	12,512.70	9,250.04	16,560.64	26,335	37,596.95
TOTAL	**5,976,554.41**	**4,435,777.77**	**7,695,211.59**	**12,717,389.51**	**18,311,101.11**
EMISSIONS	**URBAN FIRES (METRIC TONS/YEAR)**				
	2010	2011	2012	2013	2014
Volatile organic compounds	53.58	58.63	57.17	62.26	60.41
Carbon Monoxide	646.29	707.15	689.57	751.02	728.65
Ammoniacal nitrogen (NH3-N)	12.57	13.75	13.41	14.61	14.17
Particulate Matter	41.67	45.6	44.47	48.43	46.99
NOx	15.22	16.65	16.23	17.68	17.15
TOTAL	**769.33**	**841.78**	**820.85**	**894**	**867.37**

Source: PRTR, 2015

4 • RESPONSES

4.1 National Initiatives

In order to fulfill its Civil Protection[11] function, the State has built a legal framework addresses the events of risks and natural disasters that may occur in the country and assigs competencies and responsibilities to various public services. Some of the most important initiatives in this area are:

- National Civil Protection Plan (Supreme Decree N° 156, 2002) [12]
- Draft bill that establishes the National Emergency and Civil Protection System and creates the National Agency for Civil Protection (Bulletin N° 7550-06, 2011) [13]
- National Platform for Disaster Risk Reduction (2012) [14]
- National Policy for Disaster Risk Management (2014) [15]

4.1.1 National Plan for Civil Protection

In Chile, the National Civil Protection Plan[16] constitutes the first institutional effort that explicitly seeks to address the issues of risk reduction in a comprehensive manner. The Plan replaces the National Emergency Plan, thus responding to the new requirements of the country, and adapting to the new existing reality in relation to productive activities and the redesign of public administration. It also incorporates aspects of prevention, mitigation, preparation and early warning, responding to international commitments acquired by the country, and the modernization of the National Civil Protection System.

The core objective of this Plan is "to have a multi-sectoral civil protection plan, of an indicative nature, designed for the development of permanent actions for the prevention and attention of emergencies and/or disasters in the country, based on a comprehensive risk management vision" (Supreme Decree N° 156, 2002. Ministry of the Interior).

4.1.2 Draft Bill for the National Emergency and Civil Protection System

On March 22, 2011, the bill that establishes the creation of a National Emergency and Civil Protection System and the Civil Protection Agency was submitted to the National Congress. This bill is currently being discussed by the Senate, and is an important step forward in the institutional framework to deal with emergencies that may cause harm to people and natural systems.

The main objective of the National Civil Protection System is "to promote and implement prevention, response and emergency response actions in situations that cause or may cause collective damage to people, property or the environment" and "is made up of all public and private bodies, which, according to the particular realities and sectoral and territorial capacities, are set up in a deconcentrated or decentralized manner to prevent and react to emergencies, exercising advisory, technical and executive functions for such purposes" (Bulletin N° 7550-06, House of Representatives of Chile). This new system builds upon and bases its action on three guiding principles: prevention, subsidiarity and inter-sectorality, intending to make the current institutional framework more robust and modern.

[11] *Political Constitution of the Republic of Chile; Constitution 1980, Ministry General Secretariat of the Presidency. Art. 1, fifth paragraph, the State must "give protection to the population and the family."*

[12] *National Civil Protection Plan. Indicative Instrument for Integrated Management, 2002, Ministry of the Interior.*

[13] *Draft bill that establishes the creation of a National Emergency and Civil Protection System, constituted by the National Civil Protection Agency, the National Civil Protection Council and the Civil Protection and Emergency Operations Committee. The bill is being discussed by the House of Representatives.*

[14] *National Platform for Disaster Risk Reduction, 2012. National Emergency Office of the Ministry of the Interior and Public Security.*

[15] *National Policy for Disaster Risk Management, 2014. Ministry of the Interior and Public Security.*

[16] *Supreme Decree No. 156, Ministry of the Interior. Approves National Civil Protection Plan and Repeals Supreme Interior Decree N° 155 of 1977 that approved the National Emergency Plan.*

One of the major innovations of this bill is the creation of the National Civil Protection Agency, whose main objective will be to coordinate and implement emergency prevention and civil protection actions (replacing the current ONEMI) and advise the authorities in the tasks of planning and coordination of emergencies.

The bill also creates the National Council for Civil Protection, "a representative body in which different sectors of the executive power and civil society participate, and whose essential mission is to advise on the development of a national strategy to reduce risks and vulnerabilities," as well as the National Fund for Civil Protection in order to ensure minimum funding for sectoral initiatives in the area of emergency management (Bulletin N° 7550-06, House of Representatives of Chile).

4.1.3 National Platform for Risk Reduction and National Policy for the Management of Disaster Risk and Emergencies

Based on the recommendations in the framework of the implementation of the Hyogo Framework for Action, Chile created the National Platform for Risk Reduction (PNRR by its acronym in Spanish). This platform is a multi-sectoral space representative of disaster risk management in the country and aims to achieve the incorporation of disaster risk reduction in a cross-cutting manner in policies, national planning, and development programs (ONEMI, 2013).

The PNRR is coordinated by the ONEMI and operates through thematic panels, following the priority axes of Hyogo, namely: i) institutional strengthening; ii) strengthening of monitoring and early warning systems; iii) strengthening of the culture of prevention and self-insurance; iv) reduction of underlying risk factors; and v) strengthening of disaster preparedness to achieve an effective response.

The work carried out by the thematic working groups resulted in the National Policy on Risk Management of Disasters and Emergencies, a guiding document that will allow the different State institutions to significantly reduce the adverse effects caused by disasters. The policy provides a set of guidelines to develop a sustained process of disaster risk reduction and respond adequately to emergency situations that may arise in the country[17].

4.1.4 Regulation for the Control of Aquatic Pollution

The Regulation for the Control of Aquatic Pollution[18] (Official Gazette N° 34.419, 1992) of the General Directorate of Maritime Territory and Merchant Marine (DIRECTEMAR), establishes the rules for prevention, surveillance and combat of pollution in sea waters, ports, rivers and lakes subject to national jurisdiction. This regulation bans the discharge of hydrocarbons or oily mixtures in the waters subject to national jurisdiction from ships or naval devices, as well as in inland waters, ports and canals of the national territory.

4.1.5 National Response Plan to Hydrocarbon Spills and Other Spills of Harmful Substances into the Aquatic Environment

In 2014, the National Plan for Response to Spills of Hydrocarbons or Other Harmful Substances in the Aquatic Environment[19] was approved, which allows the National Maritime Authority to carry out the logistical and operational management of its resources, centralizing them in the main maritime governorates of the country, called Regional Pollution Control Centers (CERCON), on which the Sub-Centers and Local Centers of Contamination.

[17] *National Policy for Disaster Risk Management. ONEMI, Ministry of the Interior and Public Security, 2014.*

[18] *Regulation for the Control of Aquatic Pollution (Official Gazette No. 34.419, 1992). Ministry of National Defense, Undersecretary of the Navy.*

[19] *National Plan for Response to Spills of Hydrocarbons or other Harmful Substances in the Environment. General Directorate of Maritime Territory and Merchant Marine, 2014.*

One of the central objectives of this plan is "to establish an organization capable of effectively managing and directing response activities aimed at satisfactorily controlling and minimizing the consequences of a spill of hydrocarbons or other harmful substances" (DIRECTEMAR, 2014). To that end, it establishes a classification of spills (according to their quantity and level of danger) and the specific tasks that must be developed by each of the Control Centers.

4.1.6 Declaration of Catastrophe Zones and Agricultural Emergencies

The state of catastrophe is one of the mechanisms that the authority has to tackle situations that have generated public calamity and it is declared by supreme decree signed by the President of the Republic and the Ministers of the Interior and National Defense[20].

Once an area has been declared under the State of Catastrophe, the President of the Republic has the obligation to inform Congress of the measures adopted. After 180 days have elapsed since the declaration, Congress has the power to annul the declaration, if the reasons that motivated it have ceased absolutely. In addition, the President, with the agreement of Congress, may declare the state of catastrophe for more than one year. Regarding its processing, it is established that Congress can only accept or reject the proposal without modifying it.

Once the state of catastrophe has been declared, the respective zones are under the immediate dependence of the Chief of National Defense designated by the President, in accordance with the final paragraph of Article 41 of the Constitution. In addition, Article 43 establishes that the President may: restrict the freedoms of transportation and meeting; arrange the requisition of goods; establish limitations on the exercise of the right to property; and adopt all extraordinary measures of an administrative nature that are necessary for the prompt restoration of normalcy in the affected area (Biblioteca del Congreso Nacional, n.d.) [21].

For example, after the earthquake of February 27, 2010, a state of catastrophe was declared in the regions of Biobío and Maule, and a curfew was announced shortly by the Army in both regions. The same happened in the wake of the magnitude 8.4 Richter earthquake that affected the Coquimbo Region on September 16, 2015.

Regarding the declaration of Agricultural Emergency Zones, these must be declared by simple resolution by the Ministry of Agriculture, upon request of the Ministerial Regional Secretariats of Agriculture of the corresponding affected areas.

Agricultural Emergency Zones may be declared in sectors, communes or any territory in a situation of agricultural emergency, based on a technical report by the Institute of Agricultural Research (INIA), which must be prepared according to the information that the own Institute already has as well as that provided by the Agrometeorological Network. The technical report should be discussed in the corresponding Regional Agricultural Emergency and Agroclimatic Risk Management Commission (CREA by its acronym in Spanish). Once the report has been discussed, the corresponding Ministerial Regional Secretariat for Agriculture will decide whether or not to process the request. In case it is processed, the technical background must be sent to the Intendent, who must evaluate the decision to request a declaration of agricultural emergency by the Minister of Agriculture.

[20] *Organic Constitutional Law of the States of Exception, Ministry of the Interior, Article 8 Organic Law 18.415.*

[21] *Political Constitution of the Republic of Chile, Constitution 1980. Ministry General Secretariat of the Presidency.*

The declaration of agricultural emergency zones allows the Ministry of Agriculture to grant resources and specific aid to farmers and producers in the affected areas, mainly through the Agricultural Development Institute (INDAP by its acronym in Spanish), the Agricultural and Livestock Service (SAG by its acronym in Spanish), the National Forestry Corporation (CONAF by its acronym in Spanish) and the National Irrigation Commission (CNR by its acronym in Spanish).

4.2 Participation in International Initiatives

In December 1999, the General Assembly of the United Nations (UN) adopted the International Strategy for Disaster Risk Reduction (ISDR) and created the Office for Disaster Risk Reduction (UNISDR) as the secretariat responsible for ensuring its application. The ISDR seeks to promote a culture of disaster prevention and its vision is "to enable all communities to become resilient to the effects of natural, technological and environmental hazards, reducing the compound risks they pose to social and economic vulnerabilities within modern societies. To proceed from protection against hazards to the management of risk through the integration of risk prevention into sustainable development" (UNISDR , n.d.)

Chile has participated in the ISDR since its inception, as well as being part of the agreements derived from it, such as the Disaster Preparedness Program (DIPRECHO), whose main objective is to reduce the vulnerability of the population in the event of disasters of natural origin and improve the capacities of communities exposed to these risks so that they are better prepared and protected.

In this context, the country has made efforts to reduce disaster risk through a series of projects and initiatives (UNESCO, 2013), which has meant having more scientific and technical information regarding present threats. However, due to population growth and climate change, the incidence of threats is likely to increase, which will require additional efforts (UNESCO, 2013).

On the other hand, during the Second World Conference on Disaster Reduction held in Kobe, Hyogo, Japan, from January 18 to 22, 2005, the 2005-2015 Hyogo Framework for Action was approved. It was the most important instrument for the implementation of disaster risk reduction adopted by the Member States of the United Nations to date. Its general objective was to increase the resilience of nations and communities in the face of disasters by achieving, by 2015, a considerable reduction in the losses caused by disasters, both in terms of human lives and in terms of social, economic assets and environmental aspects of communities and countries.

Chile ratified the Hyogo Framework for Action (2005-2015) that commits signatory countries to actions to reduce vulnerability and increase the resilience of nations and communities and played a leading role in the preparation and ratification of the Framework for Action of Sendai[22] for Disaster Risk Reduction (2015-2030), which provides continuity and deepens the work carried out with the Hyogo Framework for Action.

[22] The Sendai Framework for Disaster Risk Reduction 2015-2030 was approved at the Third United Nations World Conference on Disaster Risk Reduction, held from 14 to 18 March 2015 in Sendai, Miyagi (Japan).

TABLE 09

SENDAI FRAMEWORK PRIORITIES FOR ACTION	
1	Understanding disaster risk
2	Strengthening disaster risk governance to manage disaster risk
3	Investing in disaster risk reduction for resilience
4	Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction

Source: Authors’ own elaboration, based on the document “Sendai Framework for Disaster Risk Reduction 2015 – 2030” (UNISDR, 2015).

TABLE 10

SEVEN GLOBAL TARGETS PROPOSED BY THE SENDAI FRAMEWORK	
1	Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015.
2	Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015.
3	Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030.
4	Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030.
5	Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020.
6	Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030.
7	Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

Source: Authors’ own elaboration, based on the document “Sendai Framework for Disaster Risk Reduction 2015 – 2030” (UNISDR, 2015).

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ANNEXES

SCENARIOS ACCORDING TO THE GOALS OF THE MMA

THEME	TARGET	ACTION	SDG
Water	6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all.	Have baseline information. It is in tender: "Study of Water Security in Chile in a Context of Climate Change for the Preparation of the of Water Resources Adaptation to Climate Change Plan ", carried out jointly with the DGA-MOP.	6
	6.4 By 2030, substantially increase ater-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.		
	6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.	The National Action Plan for Climate Change, PANCC 2017-2022, considers the management issue at the watersheds and micro-watersheds level. Initiative related to micro- watersheds (work carried out by the Department of Local Environmental Management of the Ministry of the Environment).	
	6.b Support and strengthen the participation of local communities in improving water and sanitation management.	Initiative related to micro- watersheds (work carried out by the Department of Local Environmental Management of the Ministry of the Environment).	
SCP	12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.	First Action Plan for Sustainable Consumption and Production of the National SCP Program.	13

CONTINUES ▶

Climate Change	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.	Implement the Climate Change Adaptation Plan: Development of a study on the Legal and Institutional Framework for Climate Change at the regional and community level; Both the National Adaptation Plan and the National Action Plan for Climate Change (PANCC) 2017-2022 have included measures to incorporate the impacts of climate change on disaster management in coordination with the ONEMI. Prepare sectoral adaptation plans; Draft Final Project and Approval of Health Adaptation Plan, Develop project draft, Infrastructure Adaptation Plan and Preliminary Draft Adaptation Plan for Cities. Preparation of the National Action Plan for Climate Change 2017-2022, in which Adaptation is one of its structural axes, together with an axis for means of implementation and an axis for the territorial-level management, which will help to support and develop adaptation at different levels.	13
	13.2 Integrate climate change measures into national policies, strategies and planning.	Work on the incorporation of climate change in the Environmental Assessment System, in the Strategic Environmental Assessment, and in the Territorial Planning Policy. Likewise, the National Climate Change Plan includes measures to incorporate this topic in all relevant public policies from other Ministries.	
	13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.	Education and awareness-raising are lines of action of the PANCC and the National Adaptation Plan, work carried out with the Ministry of Education to incorporate the climate change education into the curricula of basic and secondary education, as well as with the Department of Education and Local Management of the Ministry of the Environment through different means. In addition, the Action line of the PANCC 2017-2022 aims at the generation of institutional capacities at the National and Subnational Government levels.	

CONTINUES ▶

Climate Change	13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.	The Council of Ministries for Sustainability created (March 2016) the institutional framework that allows the operation in the country of the Green Climate Fund and mandated the Ministry of the Environment to chair the Technical Secretariat for the Green Climate Fund in Chile. During 2016, with the consent of the Technical Secretariat, the first letter of no objection of a national project was issued, allowing the Fund to approve assigning resources to a Chilean project (June 2016).	13
Ocean Life	14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.	Making progress in the formalization of the Action Plan for the Strategy of Marine Conservation and Oceanic Islands, where actions are established for sustainable use, creating and activating the Committee for the Strategy.	6
	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.	Making progress in the formalization of the Action Plan for the Strategy of Marine Conservation and Oceanic Islands, where actions for sustainable use are established.	
	14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.	Making progress in the formalization of the Action Plan for the Strategy of Marine Conservation and Oceanic Islands, where actions for sustainable use are established.	
	14.5 By 2020, conserve at least 10 percent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.	Creation of new MPAs through a subsystem or network operating through a Coordinating Council.	
	14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries.	Making progress in the formalization of the Action Plan for the Strategy of Marine Conservation and Oceanic Islands, creating and making operational a "Coordinating Council for the Research, Monitoring and Assessment of both Coastal and Oceanic Marine Biodiversity".	
	14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want".	Making progress in the formalization of the Action Plan for the Strategy of Marine Conservation and Oceanic Islands, where actions for sustainable use are established.	

CONTINUES ▶

Biodiversity	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.	Continue working on a National Mountain Policy; projects mentioned in SDG 12 are developed.	6
		Together with the IUCN, a seminar on ecosystem-based adaptation (EBA) solutions for disaster risk reduction will also be held. A Project (called EPIC) on EbA is also developed in coordination with IUCN and the SEREMI of Biobío, in the Nevados del Chillán Biosphere Reserve.	
		The MMA-CTCN-CATIE Project completed the Design of a Biodiversity Monitoring Network in the context of climate change. This has allowed to place the importance of this issue on the inter-institutional and academic agenda.	
		The Ministry of the Environment, through the Division of Natural Resources and Biodiversity participates in the GEF Sustainable Land Management Project, led by CONAF and in its implementation phase. This Project is trifocal, with actions for sustainable management, biodiversity conservation and Climate Change mitigation/adaptation. It will work both in the promotion of good practices at the level of five pilot areas (with local and regional actors), as well as in building capacities at the institutional level.	
		The National Biodiversity Strategy, ENB, incorporates as a strategic guideline: "Implementation and recognition of good productive practices that include biodiversity protection objectives, such as certifications, clean production agreements, and eco-labeling, among others".	
	15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.	GEF projects that address the issue. One begins its execution in 2016 with actions in the Santiago Metropolitan and Valparaíso regions; and the other is in the PIF revision stage by the GEF secretariat, considering actions in the regions of Aysén, Los Ríos, Araucanía and Biobío.	
		The Ministry of the Environment participates in the GEF MST Project (led by CONAF) mentioned above, which aims, among other things, at a sustainable management of forests, to control degradation, at the level of pilot areas. It is expected to recover these lessons learned for their adaptation to other areas.	

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Biodiversity	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.	In 2016, the GEF Mountain Biological Corridors project (GEF-5135) was initiated, which includes actions in these areas. It is led by the Ministry of the Environment and carried out in the Santiago Metropolitan and Valparaíso regions; CONAF leads another GEF project, currently under execution, to combat land degradation.	6
		The Ministry of the Environment participates in the GEF MST Project (led by CONAF) that aims, among other things, to combat desertification and drought, in a context of sustainable management of the Earth, conservation of biodiversity and Climate Change mitigation/adaptation.	
	15.4 By 2030, ensure the conservation of mountain ecosystems, including its biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.	In 2016, the GEF Mountain Biological Corridors project (GEF-5135) was initiated, which includes actions in these areas. It is led by the Ministry of the Environment and carried out in the Santiago Metropolitan and Valparaíso regions. In addition, the National Committee for the Sustainable Management of Mountains (Supreme Decree 108 of April 21, 2014) will complete a proposal for a National Policy for the Sustainable Management of the Mountains this year.	
		The National Biodiversity Strategy included as strategic guideline in objective V: "Definition and implementation of actions for the protection of mountain ecosystems, including glaciers, for territories that serve as safeguards against natural disasters, and for ecosystems that provide relevant ecosystem services."	
	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.	Creation of Protected Areas and RECOGE Plans for 5 threatened species.	
		The NBS included as a strategic guideline in Objective V: "Definition and implementation of mechanisms and management tools for the protection of native species and their habitats, strengthening, among others, the recovery, conservation and management plans of wild species."	
	15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.	The NBS included as a strategic guideline in Objective III: "Development of a regulation that safeguards the national interest against native genetic resources, including the ratification of the Cartagena Protocol and the Nagoya Protocol, and strengthening of national regulations aimed at the protection of genetically modified organisms, ensuring fair and equitable access to benefits that derive from its use."	

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Biodiversity	15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.	The NBS included as a strategic guideline in Objective III: "Definition and implementation of actions for the prevention, control or eradication of invasive alien species and decrease of the adverse effects they produce on habitats."	6
	15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.	Development of Ecological Planning in the Santiago Metropolitan and Biobío regions, which define zoning objectives for preservation, restoration and sustainable use, promoting their use in sectoral planning and in the Regional Plans for Land Use Planning.	
		The Ministry of the Environment participates in the inclusion of biodiversity and ecosystem objectives in the National Rural Development Policy (in the final review phase by COMICIVYT) and in the National Territorial Ordination Policy (in the beginning by COMICIVYT) coordinated by the Strategic Environmental Assessment Office.	
	15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.	In 2016, the GEF Mountain Biological Corridors project (GEF-5135) was initiated, which includes actions in these areas.	
		The NBS included as a strategic guideline in Objective IV: - Mobilization of public and private resources for the implementation and monitoring of the National Strategy of B6: E46 2016-2030 and its action plans. - Development, increase, and improvement of economic mechanisms and instruments for conservation, such as: compensation, evaluation metrics of ecosystems and compensation sites, among others.	
	15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.	Actions to obtain approval for the GEF Dendro Power project.	

Source: Authors' own elaboration.

LIST OF INDICATORS 2016 STATE OF THE ENVIRONMENT REPORT (IEMA by its acronym in Spanish)*

CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Land	Regional land area, by use capability	E	X	X								X
	Percentage of the regional area affected by erosion	E	X	X								X
	Current erosion at the national level	E	X									X
	Potential risk of erosion by region	E	X	X								X
	Desertification risk at the national level	E	X				X			X		
	Land with potential presence of pollutants at the national level by 2015	E	X	X								X
	Land use percentage by region and category, 2014	P	X	X			X		X		X	
	Estimated areas for the new use coverage of the territory	P	X	X							X	
	Urban expansion per year (Greater Santiago)	P			X							X
	Urban expansion per year (Gran Valparaíso)	P			X							X
	Urban expansion per year (Puerto Montt – Puerto Varas Conurbation)	P			X							X
	Urban expansion per year (Greater Concepción)	P			X							X
	Distribution of mining tailing ponds	P	X	X								X
Environmental Noise	Noise maps	E		X								X
	Percentage of educational facilities exposed to noise levels	E		X								X
	Percentage of health facilities exposed to noise levels	E		X								X
Environmental Management Tools	Number of facilities with current certification by year and level	R	X	X			X				X	
	Percentage of certified facilities by type of certification, valid in 2015	R	X	X			X				X	
	Number of municipalities with current certification per year	R	X	X	X							
	Percentage of municipalities with environmental certification at the regional level by 2015	R	X	X								X
	Number of environmental protection fund (FPA by its acronym in Spanish) projects and grant amount	R	X	X			X					X

*SDG (Sustainable Development Goals)
OECD (Organisation for Economic Co-operation and Development)
ILAC (Latin American and Caribbean Initiative for Sustainable Development)
N (National); R (Regional); L (Local)
E (Equivalent): the indicator is equivalent or exactly equal to the indicator proposed by some international organization considered.
A (Assimilable): the indicator is comparable or similar to the indicator proposed by an international organization considered. One or more variables are used, but the indicator is not exactly the same as the one proposed internationally
DPSIR: Driving force pressure state impact response framework

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CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Environmental Management Tools	Amount of expected investment in projects approved through the SEIA and number of projects by sector	P	X	X								X
	Distribution of projects approved in 2015	P	X	X								X
	Number of requests to access public information on environmental topics, by year	R	X									X
	Number of redress complaints filed to the council for transparency regarding environmental topics	R	X									X
	Number and type of projects submitted to Strategic Environmental Evaluation by 2015	R	X	X								X
	Tax collection from vehicles, 2015	R	X						X		X	
	Amount of subsidies granted for housing thermal refurbishment between 2008 and 2014	P	X	X							X	
	Amount of investment in solar thermal collectors between 2011 and 2015	P	X	X							X	
Gender and Environment	Labor share rate by sex	E	X				X					
	Coordination of projects executed by the Environmental Protection Fund by gender (2009-2015)	E	X									X
Natural Events and Environmental Disasters	Type of disasters occurred in Chile, 1906-2014	P	X								X	
	Origin of events and disasters occurred in the country, 1900-2015	P	X									X
	Map of records of earthquakes over 7° (Ms) occurred in Chile between 1570 to 2015	P	X	X								X
	Number of hydrometeorological events between 2010 and 2015	I										X
	Ranking of dangerousness of volcanoes in Chile	E	X	X								X
	Hydrocarbon spills in the Chilean coast (2004 - 2014)	P	X									X
	Number of crimes related to fires, recorded at the national level between 2010 and 2013	P	X									X
	Crimes related to fires recorded at the regional level between 2010 and 2013	P	X	X								X
	Number of forest fires between 2012 and 2016	P	X	X								X
	Ranking of the 10 most intense earthquakes in Chile and their impacts	I		X								X
	Amount of housing damage after the 2010 earthquake	I	X									X
	Number of people and homes affected by storms between 2014 and 2015	I	X	X			X					
	Air emissions due to forest and urban fires between 2010 and 2014	I	X									X

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CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Native Peoples	Distribution of indigenous population by region and ethnicity	E	X	X								X
	Percentage graph of the distribution of indigenous peoples	E	X									X
	Area shared by Wild Protected Areas and Indigenous Development Areas	E	X									X
	Area shared by Indigenous Development Areas and the SNASPE	E										X
	Projects with indigenous consultation process	R	X	X								X
	Resources by region 2012-2016	R	X	X								X
	Number of projects approved at the regional level, by indigenous people	R	X	X								X
	Resources allocated to advice and investment 2012-2014 period	R	X	X								X
	Number of beneficiaries PDTI program2012-2014 period	R	X	X								X
	Percentage of national territories set aside for indigenous population in Latin America and the Caribbean	R	X									X
	Investment and area granted through the subsidy for application article 20 letter b of the indigenous law (1994 – 2013)	R	X									X
Waste	Waste generation at the national level in 2014	P	X				X		X			
	Per capita municipal solid waste generation OECD countries, 2013	P	X				X		X			
	Estimated and reported solid municipal waste generation at the regional level	P	X	X			X					
	Compliance of the municipalities in reporting through the SINADER system	R	X	X								X
	Communes with the greatest generation of municipal waste in 2014	P	X	X	X		X					X
	Communes with the greatest per capita municipal waste in 2014	P	X	X	X		X					X
	Type of treatment for solid municipal waste generation in 2014	R	X	X			X		X			
	Composition of valued solid municipal waste in 2014	R	X				X					X
	Non-hazardous industrial waste generation by region, 2014	P	X	X			X					X

CONTINUES ►

CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Waste	Composition of non-hazardous industrial waste generation in 2014 according to the ELW classification	P	X				X					X
	Non-hazardous of industrial waste generation by ISIC code, 2014	P	X				X					X
	Type of final disposal of non-hazardous industrial waste in 2014	P	X				X					X
	Type of non-hazardous industrial waste valuation in 2014	R	X				X					X
	Valuation of non-hazardous industrial waste in 2014 (expressed as share percentage)	R	X				X				X	
	Generation and disposal of sludge from sewage plants at the regional level in 2014	P		X							X	
	Percentage by type of final disposal of sludge generated by wastewater treatment plants in 2014	P	X									
	Application of sludge to soil in 2014 by percentage of crop type	R	X									X
	Hazardous waste generation per year versus the number of facilities, 2006-2014	P	X				X					X
	Share of productive sectors in the generation of hazardous waste by ISIC code, 2014	P	X				X					X
	Hazardous waste generation in 2014 by classification in the list of Supreme Decree N°148/2003 Ministry of Health	P	X				X					X
	Origin and destination of hazardous waste in 2014 at the regional level	P	X	X			X					X
	National solid waste program at the regional level, 2015	R	X	X								X
	Municipalities participating in SCAM in 2015	R	X	X			X					
	Municipalities participating in SCAM that reported through SINADER in 2015	R	X	X								X
	Municipalities that valued a greater share of their generated waste in 2014	R										X
Air	Mean annual $PM_{2.5}$ concentrations at the national level, 2015 period	E	X	X	X	X		X				
	Mortality and morbidity associated with $PM_{2.5}$ exposure	I	X	X	X		X				X	
	Annual PM_{10} mean for 2015 at selected stations [µg/m³]	E	X	X	X	X		X				
	Evolution of the maximum triannual mean of the 99th percentile of the running means of the 8-hour concentrations of O_3 in the Metropolitan Region	E	X	X	X				X			

CONTINUES ▶

CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Air	Distribution by type of source, 2013	P	X	X	X							X
	SO_2 emissions by region and sector, 2013	P	X	X	X				X			
	NOx emissions by region and sector, 2013	P	X	X	X				X			
	$PM_{2.5}$ emissions by region and sector, 2013	P	X	X	X				X			
	Summary of critical PM_{10} episodes in the Santiago Metropolitan Region	E	X	X	X							X
	Estimated number of $PM_{2.5}$ episodes in the Santiago Metropolitan Region	E	X	X	X							X
	Evolution of breathable particulate material. Fine and coarse fraction (1985-2015)	E	X	X	X		X					X
	Exceedance of triannual standard (%)	E	X									X
	Recorded PM_{10} episodes in Coyhaique	E			X							X
	Changes committed in each Air Decontamination Plan	R										X
	Heater replacements since 2011 to date by region	R	X	X								X
Green Growth	Number of Sustainable Consumption and Production initiatives	R	X				X					X
	Sustainable Consumption and Production Initiatives developed by the public sector, broken down by economic sector	R	X				X					X
	Sustainable Consumption and Production Initiatives developed by the public sector by type of approach (consumption or production)	R	X				X					X
	Number of facilities with CPA by ISIC Code	R	X									X
Drivers	National area by region (km^2)	F	X	X								X
	Evolution of the total population in the country	F	X									X
	National population by age group and gender by 2015	F	X									X
	Urban/rural distribution of the population by region	F	X	X								X
	Global urban population 1950, 2010, 2050	F										X
	Estimate of foreign residents in Chile, 1982-2014	F	X									X

CONTINUES ►

CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Drivers	Immigration in Chile: the 10 largest immigrant communities, 2005-2014	F	X									X
	Immigration in Chile: internal percentage of immigrants by region, 2005-2014	F	X	X								X
	Twenty communes with the largest floating tourist population, 2013	F			X							X
	Comparison of GDP, poverty, GINI and HDI variations	F	X				X					X
	Gross Domestic Product by type of economic activity spliced data series, 2008 reference (CLP millions)	F	X									X
	Evolution of gross primary energy consumption	F	X				X					
	Hydrocarbon imports	F	X									X
	Energy consumption variation between 2002 and 2013	F	X								X	
	Evolution of the vehicle fleet	F	X									X
Ozone Layer	Total ozone observed monthly mean for October each year, 1980-2015	E										X
	Maximum area and minimum thickness of the Antarctic Ozone Hole (AOH), 1979-2015	E										X
	Ozone column means (Dobson Units)	E			X							X
	Maximum UVB index during the summer months in places of Chile, 2000-2014	E		X								X
	Ozone Column (Dobson Units) in Punta Arenas,	E			X							X
	September through December 2009, 2012 and 2015	E			X							X
	Ultraviolet radiation (UV Index) observed in Punta Arenas,	I	X									X
	September through December 2009, 2012 and 2015	I	X									X
	Malignant melanomas mortality rate at the national level, 1997-2012	I		X								X
	Deaths from malignant melanomas at the national level, 1997-2012	P	X							X		
	Malignant melanomas mortality rate by region, 1997-2012	P	X									X
	Total national consumption of Ozone Depleting Substances (metric tons of substances with ODS), 1989-2014											
	National ODS consumption and maximum import limits allowed by the Montreal Protocol, 1989-2014											

CONTINUES ▶

CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Ozone Layer	National consumption (%) of HCFCs by type of use, 2008	P	X									X
	Projects executed since 2013 to date by international implementing agency	R										X
Green Urban Infrastructure	Tree cover	E			X							X
	Green infrastructure in Chilean cities	E			X							X
	Importance of the lack of green areas by commune	E	X	X	X							X
	Area covered by green areas with maintenance per person, 2014	E	X	X						X		
	Area covered by green areas with maintenance by region (m^2)	E	X	X								X
	Green areas by macro-zone	E	X	X								X
	Total green area per person	E	X	X								X
	Green areas maintenance costs	E	X	X								X
	Number of urban parks, 2014	E	X	X								X
	Area of urban parks (m^2)	E	X	X								X
	Average annual vegetation area per city block	E	X	X								X
	Percentage of urban land covered by type of vegetation, 2005	E	X	X								X
	Percentage of urban land covered by type of vegetation, 2015	E	X	X								X
	Air pollutants removed or sequestered by urban trees (kg/year)	E	x	X								X
Biodiversity	Chilean terrestrial ecosystems assessed under criterion A2b, according to the IUCN's methodology	E	X				X					
	Percentage of area of continental Chile with ecosystems under threat	E	X									X
	Area of Chilean terrestrial ecosystems, according to conservation status	E	X	X								X
	Conservation status of Chilean terrestrial ecosystems by region	E	X	X								X
	Area of native forests in Chile, by type of forest	E	X	X			X		X		X	

CONTINUES ▶

CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Biodiversity	Forest distribution in Chile	E	X	X			X				X	
	Wetlands and Ramsar sites in Chile	E	X	X	X		X					
	Trophic state of Chilean coastal wetlands, 2013 monitoring	E	X	X	X							X
	Network of Chilean aquatic ecosystems: an input for the wetlands platform	E	X	X	X							X
	Chilean Marine Ecoregions	E	X									X
	Number of species described for Chile, by biological group	E	X									X
	Native species classified in Chile	E	X				X					
	Chilean native species classified by the RCE, by biological group	E	X				X		X			
	Percentages of classified species	E	X				X		X			
	Population trend Chilean Woodstar	E			X							X
	Population trend Ruddy-headed Goose	E			X							X
	Population trend James' flamingo	E			X							X
	Population trend Andean flamingo	E			X							X
	Population trend Chilean flamingo	E			X							X
	Assessment of the conservation status of forest ecosystems	E	X									X
	Historical loss of Chilean native forests	P	X	X			X					
	Number of fires and affected natural vegetation area	P	X	X								X
	Affected natural vegetation area and number of fires in 2016	P	X	X								X
	Products made from native wood by 2014	P	X									X
	Firewood in biodiversity	P	X									X
	Percentage of change in the distributions of plant and wildlife species for scenarios A2 and B2, in relation to the current situation (baseline)	P	X									X
	Integrated Stress Index	P	X									X
	Chilean protected areas and their equivalent to the IUCN categories	R	X				X					
	Number and area coverage of Chilean protected areas	R	X				X				X	
	Chilean protected areas by 2016	R	X				X					
	Representation of terrestrial ecoregions in Chile by 2016	R	X									X
	List of Ramsar Sites in Chile	R	X				X					
	Number of species classified by already finalized RCE processes	R	X				X				X	

CONTINUES ▶

CHAPTER	INDICATOR	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Climate Change	Standardized anomalies in extreme annual surface air temperatures (minimum and maximum) by zones of the country, 1961-2015	E	X									
	Number of heat waves at the national level per year, 1961-2015	E	X									
	Heat waves in Santiago (Quinta Normal meteorological station), 1968-2015	E			X							
	Number of cold waves in the central zone of the country, 1961-2015	E			X							
	Projection of changes in air temperature, for the 2031-2050 period, in comparison to the 1961-1990 period, for the most favorable (RCP 2.6) and least favorable (RCP 8.5) scenarios	I	X									
	Sea surface temperature	E	X									
	Number of surges in the country, 2011-2015	E	X									X
	Annual rainfall, in selected cities in areas of the country, 1969-2015	E	X		X							
	Projections of percentage change in rainfall in comparison to the normal period (1961-1990) for the following scenarios: A) RCP 2.6 2011-2030 period; B) RCP 8.5 2011-2030 period; C) RCP 2.6 2031-2050 period; and D) RCP 8.5 2031-2050 period	I	X									
	Streamflows of hydrographic basins observed and projected under climate change scenario A2. Average for periods 1960-2010, 2011-2040, 2041-2070 and 2071-2099	I	X									
	Glacier area variation	I	X	X								
	Greenhouse gases (GHG) emissions and sequestration by IPCC sector and balance 1990-2013	P	X				X	X			X	
	Greenhouse gases (GHG) emissions and sequestration in Gg C02 eq. by IPCC sector and balance 1990-2013	P	X				X	X				
	Net emissions by type of greenhouse gas (GHG), 1990-2013	P	X				X	X				
	National GHG emissions (excluding FOLU), GDP and population, 1990-2013	P	X				X	X				
	Chile's Nationally Appropriate Mitigation Actions (NAMAs)	R	X									
	2013-2030 Baseline of GHG emissions (projection of average GDP) considering all sectors	P	X									
	Projection of GHG emissions for each analyzed mitigation scenario	P	X				X					

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CHAPTER	PROJECTION OF GHG EMISSIONS FOR EACH ANALYZED MITIGATION SCENARIO	DPSIR	AVAILABLE INFORMATION			SDG		OECD		ILAC		MMA
			N	R	L	E	A	E	A	E	A	
Water	Number and distribution of lakes and lagoons in Chile	E	X	X								X
	Number of glaciers per region, area and volume	E	X	X								X
	Number of known aquifers in Chile	E	X	X	X							X
	Average groundwater depletion rate in 29 selected wells	E	X	X	X							X
	Regional water balance (m^3/s)	E	X	X					X			
	Renewable freshwater resources	E	X				X		X		X	
	Water availability in Chile per person	E	X	X								X
	Main rivers and their characteristics	E	X	X	X							X
	Streamflow variations (m^3/s) 2015	E			X							X
	Main findings in groundwater quality analysis	E	X		X							X
	Compliance with drinking water quality requirements (%)	E	X				X		X			
	Urban coverage of drinking water, sewerage and wastewater treatment	E	X			X		X			X	
	Number of rural drinking water (RDW) projects, pumps and beneficiaries at the national level	E	X	X							X	
	Annual evolution of production, consumption and loss of urban drinking water	E	X									X
	Basins declared with water scarcity between 2008 and 2014	R	X	X	X						X	
	Water demand by productive sector and region	P	X	X			X		X			
	Consumptive and non-consumptive surface water use rights	P	X	X	X							X
	Surface water use rights, allocated flow (l/s)	P			X							X
	Groundwater use rights, allocated flow (l/s)	P			X							X
	Total emissions per region in surface water bodies, year 2013	P	X	X								X
	Total emissions per region in groundwater, year 2013	P	X	X								X
	Number of water rights and water tanker trucks	R	X	X								X
	Restricted areas for groundwater exploration	R	X	X								X
	Forbidden areas for groundwater extraction	R	X	X	X							X

Source: Authors' own elaboration.

CONTENT TABLES, FIGURES, MAPS AND BOXES

CHAP 01 DRIVERS

TABLES

FIGURES

BOX

CHAP 02 GENDER AND ENVIRONMENT

FIGURES

BOXES

CHAP 03 NATIVE PEOPLES

TABLES

FIGURES

MAPS

BOXES

CHAP 04 ENVIRONMENTAL INSTITUTIONAL FRAMEWORK

TABLES

FIGURES

BOXES

CHAP 05 ENVIRONMENTAL MANAGEMENT TOOLS

TABLES

FIGURES

MAPS

BOXES

CHAP 06 GREEN GROWTH

TABLES

FIGURES

BOX

CHAP 07 AIR

TABLES

FIGURES

BOXES

CHAP 08 CLIMATE CHANGE

TABLES

FIGURES

MAPS

BOX

CHAP 09 OZONE LAYER

TABLES

FIGURES

BOXES

CHAP 10 ENVIRONMENTAL NOISE

FIGURES

MAPS

BOXES

CHAP 11 SKIES FOR ASTRONOMICAL OBSERVATION

TABLES

BOXES

CHAP 12 LAND

TABLES

FIGURES

MAPS

BOX

CHAP 13 WASTE

TABLES

FIGURES

BOXES

CHAP 14 GREEN URBAN INFRASTRUCTURE

TABLES

FIGURES

MAPS

CHAP 15 BIODIVERSITY

TABLES

FIGURES

BOXES

MAPS

CHAP 16 WATER

TABLES

FIGURES

BOXES

CHAP 17 NATURAL EVENTS AND ENVIRONMENTAL DISASTERS

TABLES

FIGURES

MAPS

BOX

Ministerio del
Medio
Ambiente

Gobierno de Chile