<u>PROLOGUE</u>

The submission of this First National Communication stems from the Government of Chile's decision to fully comply with the commitments assumed with the Conference of the Parties, on a common but differentiated manner, after having ratified and became a Law of the Republic the United Nations Framework Convention on Climate Change. The firm decision to implement the various international environmental treaties ratified by the country is an integral part of the Government's Environmental Policy. This has driven the formulation of strategic guidelines in the area of climate change, which were approved by the Council of Ministers of the National Commission for the Environment at the end of 1998.

These strategic guidelines have considered, among other issues, the formulation and implementation of a National Action Plan for Climate Change, which should incorporate a regular program to update the greenhouse gas inventory and the national communication; the ratification of the Kyoto Protocol in order to begin to use its flexible mechanisms as soon as possible, especially the Clean Development Mechanism —currently a proposal headed by Chile to create a learning phase for this is being developed— and a technical and political analysis to permit Chile to be more active in supporting the United Nations Convention on Climate Change and the Kyoto Protocol.

The national communication is not only a diagnostic tool to assess the country´s present status in the area of climate change but also —understanding that it will be evaluated and updated regularly — a tool on which to base decisions made on these matters and to collaborate with the Conference of the Parties in identifying the needs of developing countries in order to implement the commitments assumed under said Convention. For this reason, compliance with this obligation is one of Chile's first step in a dynamic process that includes the formulation of measures and policies to confront the problem of climate change, which will probably be the most important global environmental issue for the next millennium. The timely provision of funds from the Convention's Financial Mechanism: the Global Environmental Facility (GEF), has significantly contributed to the realization of this national effort.

Informing the country as a whole of the results and scope of this first diagnosis is a next step in the promotion of climate change, in order to seek the support needed to regularly carry out this task. This support will allow the current technical and institutional capabilities to continue into the future and will facilitate compliance with future commitments made in the framework of the Convention.

This national communication is a direct expression of the will to update and deepen Chile's knowledge on the impact of climate change and the possibility of introducing measures, in the form of specific actions and programs to favor the mitigation of those impacts. In order to reach these goals, we hope to continue to have the financial support and technical assistance of the GEF.

The Government of Chile hereby presents its First National Communication to the Conference of the Parties to the Convention, certain that the information contained in this document will be useful and serve the purposes of said Conference and will contribute to achieve the objectives established in the country´s environmental policy.

RODRIGO EGAÑA BARAONA
Executive Director

National Environmental Commission

October 1999
Santiago, Chile
EXECUTIVE SUMMARY

This document corresponds to Chile's First National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change (FCCC), in virtue of the compliance with the commitments made by the country on climate change matters. The Framework Convention was signed by Chile at the Rio Summit (1992), ratified by the National Congress on December 24, 1994 and became a Law of the Republic on April, 13, 1995, the date of its publication in the Official Newspaper.

This Executive Summary contains a brief abstract on the chapters on National Circumstances, Implementation of the FCCC in Chile, the results of the inventory studies and the mitigation, vulnerability and adaptation options analyses performed, and, lastly, the main conclusions reached after finishing this First National Communication.

1.1 National Circumstances

Chile's continental territory is located between 17º30' y 56º30' latitude south, on the western edge of South America. The total surface area is 2,006,096 square kilometers, of which 756,096 square kilometers correspond to continental Chile and its ocean territories and 1,250,000 km^2 to the Chilean Antarctic Territory. Continental Chile spans 4,300 kilometers from north to south. The average east-west distance is 232.5 km, making Chile the longest and narrowest country in the world.

Chile is divided into 13 administrative regions, from the First Region of Tarapacá in the north to the Twelfth Region of Magallanes and the Chilean Antarctic in the south. The great length of the country, the natural barriers formed by the mountain ranges and by the subtropical ocean currents in the north and the polar currents in the south provide Chile with its great biological and climatic diversity that can be seen not just from north to south but also from east to west.

The estimated population of Chile in 1998 was 14,821,714, with an average annual growth rate of 1.4%.

Chile's economic development throughout its history has been based on exploiting its natural resources, both renewable and non-renewable. The most important economic sectors are mining, commercial fishing, manufacturing and agriculture and forestry.

Over the past decade Chile has experienced steady high economic growth rates of up to 7% per annum. As a result, the country's per capita income has increased, reaching over $5,000 dollars in 1997. Chile's economy has focused on international commerce, which has led to the globalization of its economy, through an increase in the country's participation in the global flow of commerce and factors of production.

The rapid economic growth mentioned in the previous paragraph has driven the increase in energy use in the country. Between 1990 and 1996, both the Gross Domestic Product (GDP) and the average annual energy consumption increased at 7.4%.

The primary sources of energy are crude oil and hydroelectricity. Almost all of the oil is imported due to the lack of oil reserves in Chile, which only cover 4.7% (1996) of domestic demand.

The total area of continental Chile is approximately 756,096 sq. kilometers (75,609,600 hectares). The forests of Chile cover 15,647, 894 hectares, representing 20.7% of Chile's territory. Agricultural land and forest plantations cover approximately 6 million hectares.

The State's National Protected Wilderness Area System (SNASPE) consists of 90 land units and covers 13,837,458 hectares. Thirty percent of the country's forest area is included in this system.

1.2 Implementation of the Climate Change Convention commitments

Given the increased importance of climate control in the country, both due to international negotiation process and the beginning of cooperation projects in this area, it was necessary to create a body representing several institutions to serve as a forum for debate and to advise the government on climate control related decisions. For this purpose, on May 29, 1996, the National Advisory Committee on Global Change (CNAG) was created by the Ministry of Foreign Affairs through Supreme Decree N°466, published in the Official Newspaper on this same day.

In April, 1998 its working structure was defined. Specific work groups were formed and an agenda of tasks was developed for the short and mid-term. The National Environmental Commission serves as the Chair of the Committee and the Ministry of Foreign Affairs as Vice-Chair.

Originally, the Supreme Decree that created the committee, in addition to CONAMA and the Ministry of Foreign Affairs, provided for representatives from the following institutions:

- Ministry of Agriculture
- National Energy Commission
- General Directorate of Maritime Territory and the Merchant Marine
- Chilean Meteorological Service
- The Chilean Naval Hydrographic and Oceanographic Service
- National Science and Technology Research Commission
- Chilean Academy of Science

As the matters to be discussed required the participation of many different institutions, in 1998 several other institutions were invited to join the Plenary Committee in order to have representation for other sectors related to economic development, such as production, business as well as governmental administration bodiesand research organisations. The institutions invited to participate are listed below:

- Ministry of the Economy, Development and Reconstruction
- Ministry of Transportation and Telecommunication
- National Oil Company
- Production and Commerce Confederation
- Fundación Chile
- Chilean Copper Commission
- Copper Corporation of Chile
- Climate Action Network for Latin America
- Catholic University of Chile

The Plenary Committee meets regularly to discuss important issues dealing with climate change. In order to sufficiently cover the matters dealt with by the committee, specific work groups have been formed on specific subjects such as technology transfer, land use change, and the Kyoto Protocol flexible mechanisms, among others. Depending on the nature and importance of the subjects, the Committee will turn to CONAMA's Council of Ministers for decisions.

Strategic guidelines and Working Plan on Climate Change

One of the Committee's main duties has been the creation of the *Strategic guidelines on climate change in Chile,* approved on December 6, 1998 by CONAMA's Council of Ministers. These guidelines were used to prepare a *Working Plan on Climate Change.* The plan consists of specific actions to be taken in order to pursue the following main objectives:

- Reaffirm the commitments assumed in the FCCC
- Promote the ratification of the Kyoto Protocol
- Participation of the relevant sectors and Chilean specialists in discussing the economic mechanisms set forth in the Kyoto Protocol
- Application of the Clean Development Mechanism (CDM)
- Design basic guidelines on new ways to limit and/or reduce the emission of greenhouse gases for developing countries
- Develop and implement a National Action Plan for Climate Change
- Create a special fund for technical and scientific research and training in climate change in Chile

1.3 Results of the Inventory on Greenhouse Gases and Other Gases, 1993 and 94.

This inventory included the *Energy and Non-Energy Sectors* and was done on a preliminary[1] basis for the year 1993 and was then updated for 1994, in order to report on the reference year agreed upon by the Convention for developing countries. The methodology used corresponds to the guidelines drawn up by the IPCC and includes the changes introduced in 1996. The emission factors used for emission calculations were those suggested by the IPCC for those cases where no factors were available that could accurately reflect the conditions in the country.

The inventory includes direct greenhouse gases (CO_2, CH_4 y N_2O) controlled by the FCCC and, under the *Other Gases* category, ozone precursors and aerosols (NO_x, CO, COVNM, SO_2), hydrofluorocarbons (HFC), prefluorocarbons (PFC) and sulfur hexafluoride (SF_6), even though the last three gases were only included as controlled gases as of the Third Meeting of the Conference of the Parties.

Along with the inventory created for both sectors, a software was designed for the storage, management and updating of the basic data that are used to calculate emissions.

1.3.1 Energy Sector

The inventory for this sector includes the production and consumption of energy, industrial processes and the use of solvents.

The results of the GHG and other gases emission inventory for the production and energy using sectors is displayed in Table 1.1.

[1] For 1993, the categories of Industrial Processes and Solvent Use were not included.

Table 1.1 Emissions of GHG and Other Gases by the production and energy consuming sectors, 1994. (Gg)

	Greenhouse Gases			Other Gases			
Sector	CO_2	CH_4	N_2O	CO	NOx	COVNM	SO_2
Energy Industries	8439.8	0.2	0.1	3.0	25.7	0.6	58.8
Manufacturing and Construction	9255.3	1.6	0.2	32.8	38.8	2.7	48.5
Transportation	12695.3	2.1	1.1	378.3	77.7	74.2	6.1
Commercial, Residential, institutional	4049.6	28.9	0.4	464.5	14.9	55.7	27.8
Agriculture /fishing /forestry	787.1	0.7	-	6.0	4.6	1.1	5.0
Fugitive Emissions	-	40.7	-	0.7	0.4	13.2	6.8
TOTAL	**35227.0**	**74.1**	**1.7**	**885.2**	**161.9**	**147.5**	**153.0**

The GHG and other Gases emissions inventory for *Industrial Processes and Solvent Use* is shown in Table 1.2.

Table 1.2 GHG and Other Gas Emissions - Industrial Processes and Solvent Use, 1994 (Gg)

	Greenhouse Gases			**Other Gases**				
Sector	**CO_2**	**CH_4**	**N_2O**	**CO**	**NO_x**	**COVNM**	**SO_2**	**HFC,PFC, SF6**
Industrial processes	-	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	1775.3	-
Cement	1021.1	-	-	-	-	-	0.8	-
Asphalt	-	-	-	-	-	45.6	-	-
Glass	-	-	-	-	-	0.2	-	-
Chemicals	-	2.1	0.8	-	1.0	0.7	24.5	-
Steel and Iron	812.2	-	-	1.2	0.1	0.1	1.8	-
Iron Alloys	36.7	-	-	-	-	-	-	-
Pulp and Paper	-	-	-	9.8	2.6	6.5	12.7	-
Food and Beverages	-	-	-	-	-	24.7	-	-
Refrigeration, fire extinguishers, others	-	-	-	-	-	-	-	0.0
Subtotal	1870.0	2.1	0.8	11.0	3.7	77.8	1815.1	0.0
Solvents								
Paint production	-	-	-	-	-	1.0	-	-
Industrial use of paint	-	-	-	-	-	9.3	-	-
Residential use of paint	-	-	-	-	-	6.9	-	-
Painting cars	-	-	-	-	-	7.5	-	-
Solvents for household use	-	-	-	-	-	2.6	-	-
Dry cleaners	-	-	-	-	-	1.0	-	-
Subtotal	-	-	-	-	-	28.4	-	-
Sector Total	**1870.0**	**2.1**	**0.8**	**11.0**	**3.7**	**106.2**	**1815.1**	**0.0**

1.3.2 *Non-Energy Sector*

The inventory included three modules: *Agriculture, Land Use Change and Forestry, and Waste Management.* The gases inventoried were CO_2, CO, CH_4, N_2O, NO_x y COVNM.

The revised IPCC/OCDE guidelines (1996) were applied without major changes for the *Agriculture and Waste Management* segments. The second module, *Land Use Change and Forestry*, required an adaptation that, maintaining the original methodological basis, could reflect conditions in Chile.

The emissions inventory for GHG and Other Gases for the Non-Energy sector is shown in Table 1.3.

Table 1.3 Net GHG and Other Gas Emissions for the Non-Energy Sector, 1994 (Gg)

	Greenhouse Gases			*Other Gases*		
Segment/sub-segment	***CO_2***	***CH_4***	***N_2O***	***CO***	***NO_x***	***COVNM***
Agriculture:	***0.00***	***321.79***	***20.64***	***50.35***	***2.88***	***2.59***
Rice cultivation	0.00	6.40	0.00	0.00	0.00	0.00
livestock	0.00	313.00	0.00	0.00	0.00	0.00
Leaching	0.00	0.00	3.58	0.00	0.00	0.00
Land cultivation	0.00	0.00	15.90	0.00	0.00	0.00
Burning of agricultural Residues[2]	1223.64	2.40	1.98	50.35	2.88	2.59
Land Use Change and Forestry	***-29709.27***	***111.33***	***0.77***	***974.153***	***27.66***	***50.64***
Forestry management	-1899.70	0.00	0.00	0.00	0.00	0.00
Clearing	2629.94	4.94	0.03	43.20	1.23	2.22
Substitution	5451.95	7.54	0.05	65.99	1.87	3.40
Flowering	6917.01	7.37	0.05	64.47	1.83	3.32
Abandonment of managed land (natural regeneration)	-50917.06	0.00	0.00	0.00	0.00	0.00
Burning of forest residues[3]	17940.44	58.42	0.40	511.20	14.52	26.33
Forest fires	7856.34	33.06	0.23	289.30	8.22	15.37
Urbanization	252.24	0.00	0.00	0.00	0.00	0.00
Waste Management	***0.00***	***83.97***	***0.67***	***0.00***	***0.00***	***0.00***
Domestic wastewaters	0.00	0.15	0.67	0.00	0.00	0.00
Industrial wastewaters	0.00	10.08	0.00	0.00	0.00	0.00
Household solid waste	0.00	73.74	0.00	0.00	0.00	0.00
Industrial solid waste	0.00	0.00	0.00	0.00	0.00	0.00
Sector Total Gg	**-29709.27**	**517.10**	**22.08**	**1024.50**	**30.54**	**53.24**
Total Gg of CO_2 equiv.	**-29709.27**	**5688.1**	**7065.6**			

[2] According to the methodology used, burning of agricultural residues does not lead to CO_2 emissions since this is biomass that in synthesized in a year and can be regenerated in one year.

[3] According to the methodology used, burning wood does not lead to CO_2 emissions since this is biomass that is synthesized in a year and can be regenerated in one year.

1.3.3 *Aggregate Results of the GHG and Other Gases Inventory, 1994*

The Aggregate Emissions Inventory for the *Energy and Non-Energy Sectors* is displayed in Table 1.4.

Table 1.4 Estimate of Total Emissions of GHG and Other Gases, 1994
(Gg)

	Greenhouse Gases			***Other Gases***			
Sectors	CO_2	CH_4	N_2O	***CO***	NO_x	***COVNM***	SO_2
Energy							
Energy Combustion	*35227.0*	*74.2*	*1.8*	*885.3*	*162.1*	*147.5*	*153.0*
Industrial Processes	*1870*	*2.1*	*0.8*	*11.0*	*3.7*	*77.8*	*1815.1*
Solvent Use	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*28.4*	*0.0*
Subtotal	*37097.0*	*76.3*	*2.6*	*896.3*	*165.8*	*253.7*	*1968.1*
Non-energy							
Agriculture	*0*	*321.8*	*20.64*	*50.4*	*2.9*	*2.6*	-
Land Use Change and Forestry	*-29709.3*	*111.3*	*0.8*	*974.2*	*27.7*	*50.6*	-
Waste Management	*0.0*	*84.0*	*0.7*	*0.0*	*0.0*		-
Sub-total	*-29709.3*	*517.1*	*22.08*	*1024.6*	*30.6*	*53.2*	-
Country Total Gg (1994)	**7387.3**	**593.4**	**24.68**	**1920.9**	**196.4**	**306.9**	**1968.1**

Table 1.3 in the previous section shows the net GHG emissions in each sub-sector studied in the *Non-energy* module. In the *Energy* module, only gross emissions are available due to the absence of sinks in this sector. If the gross emissions and capture are analyzed, the balance between the sources and sinks of carbon dioxide shown in Table 1.5 can be obtained.

Table 1.5 Aggregate balance of CO_2 sources and sinks, 1994
(Gg)

Sector	*Emissions*	*Capture*	*Net Balance*
Energy	37097.0	0.0	37097.0
Non-energy	58043.3	87752.6	-29709.3
Totals	**95140.3**	**87752.6**	**7387.7**

The Aggregate emissions balance for 1994, expressed in Gg of CO_2 equiv. is indicated in Table 1.6.

Table 1.6 Aggregate GHG emissions balance (Gg of CO_{2equiv}), 1994

Sector	CO_2	CH_4	N_2O	***Total***
Energy	37097.0	839.3	832.0	38768.3
Non-Energy	-29709.3	5688.1	7065.6	-16955.6
Totals	**7387.7**	**6527.4**	**7897.6**	**21812.7**

1.3.4 *Analysis of the results*

The aggregate inventory of all the GHG sources and sinks in Chile during the base inventory year (1994) yielded net emissions of 7,387.7 Gg of CO_2 , from 95,140.3 Gg emitted and 87,752.6 Gg captured. The largest emissions source for the inventory year was the *Non-energy* sector with emissions of 58,043.3 Gg of CO_2.

For the other gases inventoried, there were net emissions of CH_4 equaling 7,387.7 Gg, mostly from agriculture, 1,921 Gg of CO, evenly distributed between the *Energy, Industrial Processes and Solvent Use and Non-Energy* sectors. The emissions of N_2O totaled 24.68 Gg, mainly produced by agriculture and 196.4 Gg of NO_x produced primarily by energy combustion. The inventory also showed SO_2 emissions of 1,968 Gg from the copper industry.

From a sectoral perspective, the main source of CO_2 emissions in the *Energy Sector* is *Transportation*, followed by *Manufacturing and Construction, and Residential, Commercial and Institutional.* In the *Non-energy* sector, the *Land Use Change and Forestry module* is both the main producer of CO_2 and responsible for a capture that is able to compensate for these emissions and generate a net capture balance in the sector. This capture is generated, primarily, through natural regeneration in abandoned lands.

The baseline data used for the sectoral inventories do not all reflect the same geographic breakdown: for the *Energy, Industrial Processes and Solvent Use* sector, national statistics were used; however, for the *Agriculture, Land Use Change and Waste Management* sectors, regional information was used. In order to accurately describe the emissions patterns and then evaluate the mitigation measures that are feasible in each sector, it is first necessary to have both inventories at a regional level, using a compatible geographic scale.

Moreover, the inventories must be updated in order to have information available on trends, sensitive areas, the inventory's response to extreme climate conditions (especially drought), economic conditions (the fluctuation of international prices, energy interconnection, etc.), the evolution of technological aspects and potential process changes in certain branches, sub-sectors and/or processes and other important variables, in order to propose and assess, based on the best available information, which mitigation measures could feasibly be applied, the costs and benefits of these and, lastly, the social players on whom these costs and benefits would fall.

Furthermore, it is also important that the software designed for the storage, management and updating of the data be standardized in order to have a single, useful and user-friendly tool that can be used for both sectors and which will allow a faster and more consistent administration of information for further updating this first communication.

1.4 Anthropogenic GHG emissions and sink projections for the *Baseline and Year 2020, mitigated* scenarios.

The future projections correspond to two scenarios: *Baseline scenario* (the year 2020 without mitigation measures) and *Year 2020, mitigated scenario* (year 2020, applying mitigation measures). The methodology used to calculate emissions corresponds to that proposed by the revised IPCC guidelines (1996).

Generally speaking, the projected scenarios included the following:

- Macroeconomic trends (evolution of the GDP) and expected demographic statistics for the period.

- Applying reforms in the energy sector (gas and electric interconnection between Chile and Argentina, policies affecting the supply of oil and natural gas, and the interconnection of the national generation systems of the Central Interconnected System (CIS) and the Northern Interconnected System (NIS).

- Applying sectoral policies that have already been approved, are already in place or are currently being carried out, related to the increase or decrease of GHG emissions (environmental, sanitation and forestry development policies).

- Projected growth of exports.

- Estimated import substitution rates, especially for agriculture (two substitution rates were considered: 30% and 50%).

- International context (technology transfer, expected growth of the relevant markets for Chile and the trends in international energy prices).

In simulating future scenarios, only variations of those global systems (production, services, life patterns) directly related to the *Energy and Non-energy* sectors were included. Thus, no proposed changes in policies in sectors such as transportation, housing, mining, the environment or others were analyzed, even though it is clear that these policies could have a significant impact on future emissions inventories and could be affected by the impacts of climate change in Chile.

1.4.1 Energy Sector

The projections of GHG emissions from the *Energy Sector* were obtained using the *Final Use Approach* method, based on the projected increase or decrease in sectoral energy consumption and its relationship to fuel use, including energy substitution, regional interconnection of electricity systems and the introduction of profitable improvements for users. *Industrial Processes and Solvent Use* were not included in the future scenarios.

Baseline Scenario

Projected GHG emissions associated with the *Energy Sector* for the Year 2020 *Baseline Scenario* are shown in Table 1.7.

Table 1.7 Energy Sector GHG emissions estimate: Baseline Scenario (with electricity interconnection)[4]
(Gg)

	Greenhouse Gases			Other Gases			
Sector	CO_2	CH_4	N_2O	CO	NO_x	COVNM	SO_2
Energy Industries	15678.0	96.57	0.073	8.77	44.68	17.32	40.23
Manufacturing and Construction	16371.05	5.63	0.28	72.99	78.61	6.25	35.4
Transportation	54539.9	15.8	18.2	627.1	255.6	86.8	15.4
Commercial, Residential, Institutional	9534.0	13.15	0.22	199.21	16.25	24.04	17.17
Burning Wood[5]	13067	-	-	-	-	-	-
TOTAL	**96122.95**	**131.15**	**18.77**	**908.7**	**395.14**	**134.41**	**108.2**

1.4.1.2 Year 2020, Mitigated Scenario

The *Year 2020, mitigated* scenario was projected assuming that there is an introduction of non-spontaneous technologies and measures that reduce GHG emissions or concentrations. Emphasis was placed on the introduction of measures that are profitable for the user, the adoption of which is hindered by market barriers. Thus, the mitigation options incorporated in the projections are directed at saving energy and efficient energy use.

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[4] The study included the exercise of estimating emissions without energy interconnection. The official approval of interconnection took place while this document was being written.
The CO_2 emitted by burning wood is not included, according to the IPCC methodology. The non-CO_2 gases emitted by burning wood have already been included in their final use subsectors.

As to the change in fuels, emerging technologies and source substitution were considered most significant, especially in the case of the energy industry. It was estimated that for final users the degree of penetration of natural gas and the degree of firewood substitution would be the same as in the *Baseline scenario*.

It is important to note that in the *Residential* sector, a major substitution of commercial fuel for wood burning is expected. This situation implies, according to the IPCC methodology, an increase in CO_2 emissions, since this methodology does not add the emissions of this gas caused by wood consumption to the emissions from the use of the other fuels.

The construction of the Year 2020 mitigated scenario, leaded to the results shown in Table 1.8:

Table 1.8 GHG Energy Sector[6] emissions estimate, *Year 2020,* *mitigated* scenario, with electricity interconnection. (Gg)

	Greenhouse Gases			Other Gases			
Sector	CO_2	CH_4	N_2O	CO	NOx	COVNM	SO_2
Energy Industries	13067.0	91.95	0.064	7.8	38.7	15.042	35.01
Manufacturing and Construction	13634.69	4.69	0.23	60.93	67.25	5.37	25.96
Transportation	47678.3	14.4	15.6	538.3	232.5	74.5	14.7
Commercial, residential and institutional	8734	13.05	0.21	198.79	15.23	23.98	16.64
Burning firewood[7]	12046	-	-	-	-	-	-
TOTAL	**83113.99**	**124.09**	**16.10**	**805.82**	**353.68**	**118.89**	**92.31**

1.4.2 Non-Energy Sector

The AGRI model from the Agriculture and Environment Center (AGRIMED) of the University of Chile's School of Agriculture and Forestry, was used to simulate the future scenarios. This model was constructed in order to analyze the limitations that natural resources could place on the expected growth of the forestry and agriculture sectors and was adapted for use in this study by incorporating the IPCC guidelines. The future scenarios were based on two import substitution rates for agricultural products: 30% and 50%.

In order to compare future scenarios and the 1994 Inventory using the same methodological base, the AGRI model was applied to the land use pattern observed in 1994, in order to estimate a *1994 Simulated Inventory,* which yielded slightly different results from the 1994 Inventory. (See section 6.2.2.4)

The simulation of future mitigation scenarios was accompanied by the economic valuation of applying a set of measures that were selected by Chilean specialists who also did the valuation. This assessment focused on estimating the economic costs and benefits, both public and private, of applying measures in the forestry sector.

1.4.2.1 Baseline scenario

The Baseline scenario for the year 2020, according to the IPCC methodology, does not include the application of mitigation measures. To estimate changes in emissions and/or gas sinks, the essential variable, according to the inventory results, is the sub-module *Land Use Change.*

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[6] The energy sector includes the *Industrial Processes and Solvent Use* sub-sectors for the 1994 Inventory. These sub-sectors, however, were not included in the future scenarios.
[7] See note 2

The results of the emissions inventory for the Baseline scenario are shown in Table 1.9.

Table 1.9 General Balance of GHG and Other Gases: 1994 Emissions (simulated inventory) and *Base Conditions*, for 30% and 50% import substitution.

	Gas	1994 Emissions (Simulated Inventory) (Gg)	Baseline scenario Emissions (Gg)	
			30% sub.	50% sub.
Greenhouse Gases	CO_2	-26570.86	-27840.69	-28806.75
	CH_4	507.01	858.57	867.52
	N_2O	19.58	31.12	28.91
Other Gases	CO	1024.50	1596.65	1577.46
	NO_x	30.55	48.44	47.58
	COVNM	27.07	33.43	32.52

1.4.2.2 Year 2020, Mitigated scenario

The analysis of mitigation measures was primarily based on the criteria of Chilean specialists and the work of *ad-hoc* workshops. As a result of these activities, an exhaustive list of possible options applicable to the *Non-energy* sector was drawn up. Quantifying the effect of each mitigation measure (as a percentage of the emissions reduction or the increase in the capture of GHG) and the establishment of a pessimist-optimist range (worst condition - best condition) for the degree of adoption was based on expert opinion.

The results provided by the AGRI model, based on the application of mitigation measures selected by specialists who also did the valuation of these measures, is displayed in Tables 1.10 and 1.11 below. As with the Baseline scenario, projections were done for cases in which internal demand is met with 30% and 50% import substitution for the agricultural sector.

Table 1.10 General balance of GHG and Other Gases, Non-energy Sector, for the Year 2020 mitigated scenario and 30% import substitution.

		Emissions, Year 2020 mitigated Scenario (Gg)		
Gas		*Pessimistic Scenario*	*Realistic Scenario*	*Optimistic Scenario*
Greenhouse Gases	CO_2	-30423.42	-35668.14	-44432.05
	CH_4	763.44	728.59	696.62
	N_2O	29.12	26.51	24.35
Other Gases	CO	1048.85	935.43	839.80
	NO_x	32.57	29.05	26.10
	COVNM	31.74	26.49	20.19

Table 1.11 General balance of GHG and Other Gases, Non-energy Sector, for the Year 2020 mitigated scenario and 50% import substitution.

Gas		Emissions, Year 2020 mitigated Scenario (Gg)		
		Pessimistic Scenario	*Realistic Scenario*	*Optimistic Scenario*
Greenhouse Gases	CO_2	-31315.69	-36454.53	-45016.97
	CH_4	773.00	738.53	707.15
	N_2O	27.03	24.62	22.61
Other Gases	CO	1032.29	921.18	829.12
	NO_x	31.81	28.39	25.56
	COVNM	30.97	25.82	16.69

1.4.2.3 Economic valuation of the application of mitigation measures.

The selection of mitigation measures was done by consulting a group of specialists from the Chilean agriculture-forestry sector. The later valuation of the impact of each selected measure was done in accordance with the national specialists' criteria, considering the positive and negative effects that the measure could have from an environmental, economic, social and technology transfer perspective.

The most effective mitigation measures focused on the increased capture of carbon as CO_2 in forestry (forestry plantations of Monterey Pine and eucalyptus). It was assumed that 60% of the surface area would be planted with eucalyptus and 40% with Monterey Pine. The economic assessment was, therefore, geared at estimating the costs resulting from expanding the surface area covered with forestry plantations.

Weighting the studies for the different "pessimistic - realistic - and optimistic" scenarios, from the capture point of view, showed an expansion of 534.2 kha (realistic scenario), ranging from 268.2 kha for the pessimistic scenario and 800.2 kha for the optimistic one, in a mitigation situation for the year 2020. The calculations included the already mentioned import substitution conditions (30% and 50%) and the costs to the State, since it will have to reinforce CONAF's current management, administration, regulation, control and sanction structures. Costs for education, research and technological changes were not considered.

The results show that the total costs for the private sector for the new plantations would reach $157.33 million dollars, ranging from $78.98 million (pessimistic) to $235.68 (optimistic). However, private income would be much above the costs to the sector, which would result in an economically advantageous situation for this sector. The income estimated for the three scenarios are as follows: $289.31 million dollars, on average, ranging from $145.24 million (pessimistic) to $521.03 in the best case scenario.

The total costs to the public sector include the credits provided under Supreme Decree N°701 and the costs for reinforcing the administrative, management, enforcement, regulation legislation and sanction application capacity of the National Forestry Corporation (CONAF). With the same assessment basis and the same discount rate, the costs to the State of Chile would total an average of $159.9 million dollars, ranging from $151.52 million to $168.29 million.

1.4.3 Baseline and Year 2020, Mitigated Aggregate Scenarios.

The aggregate contributions of the *Energy and Non-energy* sectors to the total GHG emissions expected for the *Baseline and Year 2020, Mitigated* scenarios, with 30% and 50% import substitution are shown in Table 1.12. The 1994 Inventory is included for comparison purposes.

Table 1.12 Total GHG emissions for the 1994 Inventory scenarios - *Baseline and Year 2020, mitigated,* for 30% and 50% agricultural import substitution. (Gg)

	Greenhouse Gases			***Other Gases***			
Scenario	***CO_2***	***CH_4***	***N_2O***	***CO***	***NOx***	***COVNM***	***SO_2***
Year 1994	***7387.7***	***593.4***	***24.68***	***1920.9***	***196.4***	***306.9***	***1968.1***
Energy Sector[8]	37097.0	76.3	2.6	896.3	165.8	253.7	1968.1
Non-energy Sector	-29709.3	517.1	22.08	1024.6	30.6	53.2	-
Baseline scenario-30%	***68282.26***	***989.72***	***49.89***	***2504.72***	***443.58***	***167.84***	***108.2***
Energy Sector	96122.95	131.15	18.77	908.07	395.14	134.41	108.2
Non-Energy Sector	-27840.69	858.57	31.12	1596.65	48.44	33.43	-
Baseline scenario - 50%	***67316.2***	***998.67***	***47.68***	***2486.16***	***442.72***	***166.93***	***108.2***
Energy Sector	96122.95	131.15	18.77	908.7	395.14	134.41	108.2
Non-Energy Sector	-28806.75	867.52	28.91	1577.46	47.58	32.52	-
Year 2020 Mitigated scenario –30%	***47445.85***	***852.68***	***42.61***	***1741.25***	***382.73***	***145.38***	***92.31***
Energy Sector	83113.99	124.09	16.10	805.82	353.68	118.89	92.31
Non-Energy Sector	-35668.14	728.59	26.51	935.43	29.05	26.49	-
Year 2020 Mitigated scenario –50%	***46659.66***	***862.62***	***40.72***	***1727.0***	***382.07***	***144.71***	***92.31***
Energy Sector	83113.99	124.09	16.10	805.82	353.68	118.89	92.31
Non-Energy Sector	-36454.53	738.53	24.62	921.18	28.39	25.82	-

If the gross emissions and captures are analyzed, the balance between the CO_2 sources and sinks estimated for the *Baseline scenario* can be obtained, as shown in Table 1.13, calculated for 30% and 50% import substitution levels.

[8]The Energy Sector includes the *Industrial Processes and Solvent Use sub-sectors for the 1994 Inventory. These sub-sectors were not included in the future scenarios.*

Table 1.13 Aggregate balance of CO_2 sources and sinks, Base Case (30% and 50% substitution) (Gg)

Sector	*Emissions*		*Capture*		*Net Balance*	
	30%	**50%**	**30%**	**50%**	**30%**	**50%**
Energy	96122.95	96122.95	0.00	0.00	96122.95	96122.95
Non-Energy	73264.72	72585.92	-101105.41	-101392.66	-27840.69	-28806.74
Totals	**169387.67**	**168708.87**	**-101105.41**	**-101392.66**	**68282.26**	**67316.21**

If the gross emissions and captures are analyzed, the balance between the CO_2 sources and sinks estimated for the *Year 2020 mitigated* scenario can be obtained, as shown in Table 1.14, calculated for 30% and 50% import substitution levels.

Table 1.14 Aggregate balance of CO_2 sources and sinks, Year 2020 mitigated scenario (Gg)

Sector	*Emission*		*Capture*		*Net Balance*	
	30%	**50%**	**30%**	**50%**	**30%**	**50%**
Energy	83113.99	83113.99	0.00	0.00	83113.99	83113.99
Non-Energy	77311.40	76871.26	-112979.54	-113325.79	-35668.14	-36454.53
Totals	**160425.39**	**159985.2**	**-112979.54**	**-113325.79**	**47445.85**	**46659.46**

The total estimated emissions for the future scenarios expressed as Gg of $CO_{2\ equiv}$,are shown in the table below.

Table 1.15 Aggregate emissions balance(Gg of $CO_{2\ equiv}$)
Baseline and Year 2020 Mitigated scenarios (30% import substitution)

Scenario	*Sector*	*CO_2 (Gg)*	*CH_4 (Gg CO_2 equiv)*	*N_2O (Gg CO_2 equiv)*	*Total (Gg CO_2 equiv)*
Baseline	*Energy*	96122.95	1442.65	6006.4	103572.0
	Non-Energy	-27840.69	9444.27	9958.4	-8438.02
	Total Baseline scenario	**68282.26**	**10886.92**	**15964.8**	**95133.98**
Year 2020 Mitigated	*Energy*	83113.99	1364.99	5152.0	89630.98
	Non-Energy	-35668.14	8014.49	8483.2	-19170.45
	Total Year 2020 mitigated scenario	**47445.85**	**9379.48**	**13635.2**	**70460.53**

Table 1.16 Aggregate emissions balance (gg of co_2 equiv) baseline and year 2020 mitigated scenarios (50% import substitution)

SCENARIOS	Sector	(Gg) CO_2	(Gg CO_2 equiv) CH_4	(Gg CO_2 equiv) N_2O	(Gg CO_2 equiv) Total
BASELINE	ENERGY	96.122,95	1.442,65	6.006,4	103.572,
	NON ENERGY	-28.806,75	9.542,72	9.251,2	-10.012,83
	TOTAL BASELINE SCENARIO	**67.316,2**	**10.985,37**	**15.257,6**	**93.559,17**
YEAR 2020 MITIGATED	ENERGY	83.113,99	1.364,99	5.152	89.630,98
	NON ENERGY	-36.454,53	8.123,83	7.878,4	-20.452,3
	TOTAL YEAR 2020 MITIGATED SCENARIO	**46.659,46**	**9.488,82**	**13.030,4**	**69.178,68**

Figure 1.1 (from Tables 1.15 and 1.16), allows us to compare the net aggregate emissions (in Gg CO_2 equiv), for the following scenarios: Inventory 1994, Baseline and year 2020 Mitigated, with 30% and 50% agricultural imports substitution.

Fig 1.1 Net Aggregate GHg emissions (as CO_2 equiv), with 30% and 50% agricultural imports substitution

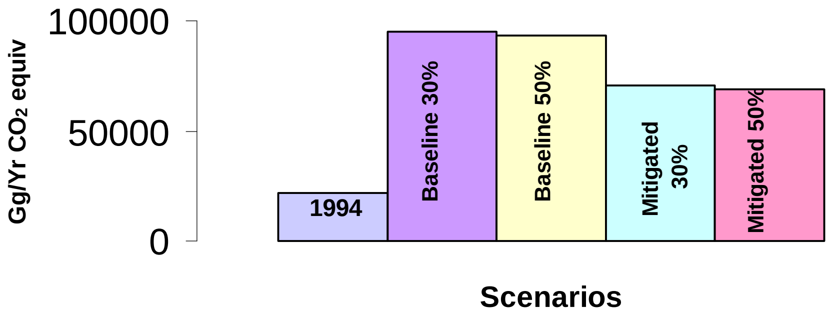


Fig. 1.2: CO_2 emissions share

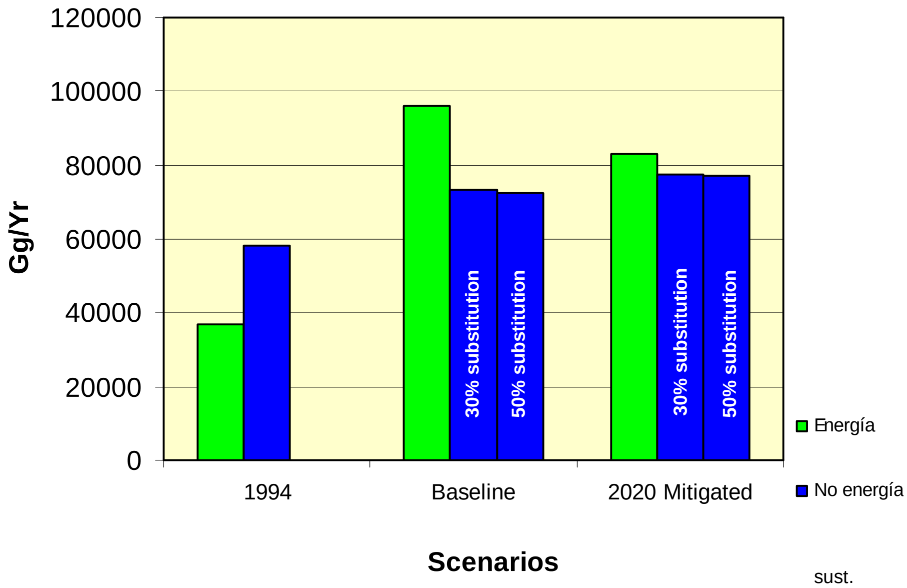


Fig. 1.3: CH_4 emissions share

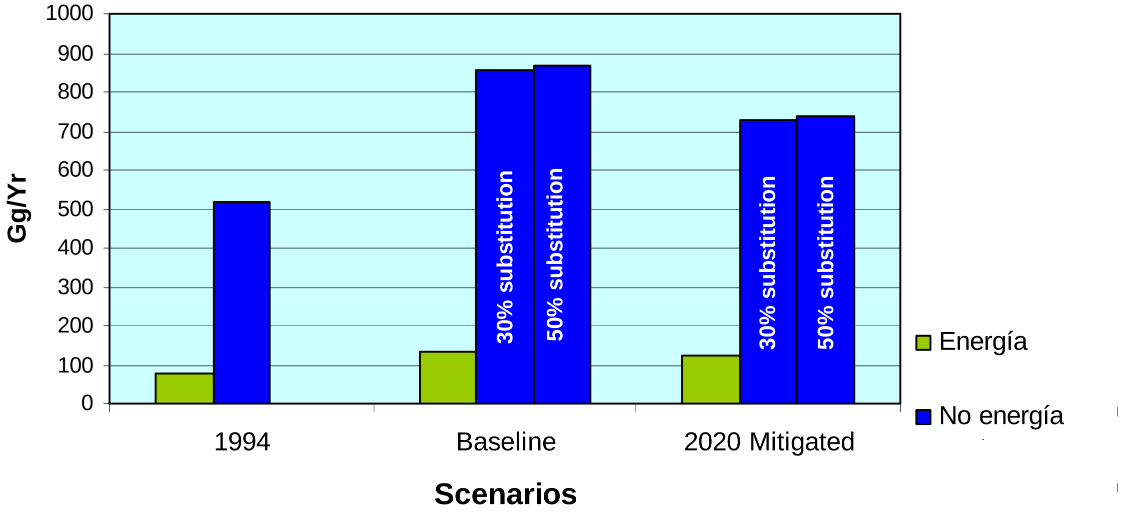
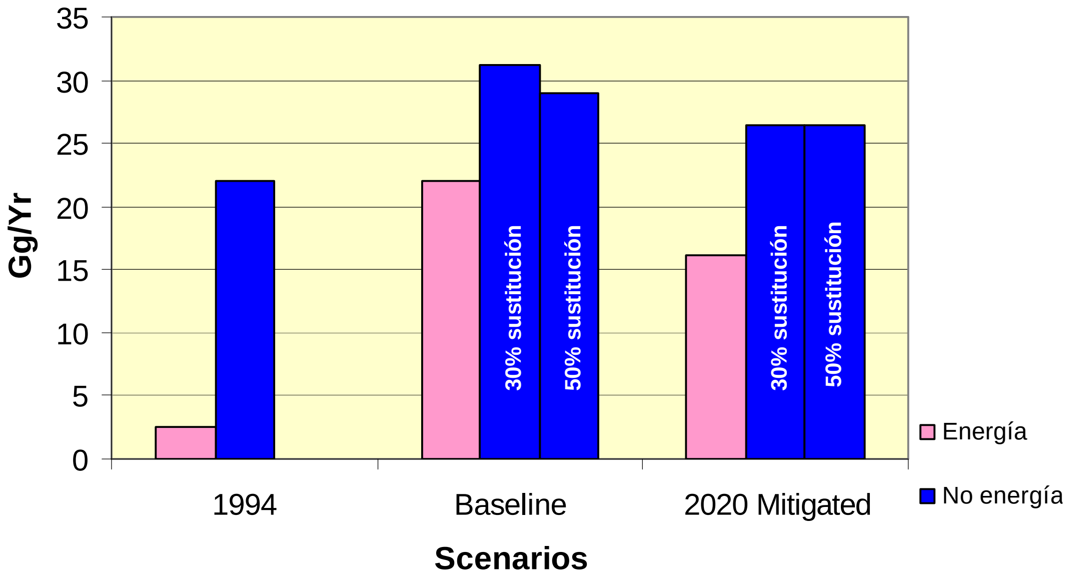


Fig. 1.4: N_2O emissions share



1.4.4 Analysis of the results

The aggregate emissions balance shows net emissions of 7,387.3 Gg of CO_2 in 1994 and a relative compensation between the *Energy* and *Non-energy* sectors; however, this is drastically changed in the future scenarios. This relative balance between emissions and capture indicates a marked shift toward the *energy* sector, especially in the area of *Transportation* and the maintenance of the *Non-energy* sector's capture capacity, yielding the same order of magnitude shown in 1994.

Concerning methane, the *Energy Sector's* share of total emissions increases, but always below the levels of the *Non-energy sector,* whose methane emissions increase by more than 50%. The same is true of N_2O: the share of the emissions produced by the *Energy Sector* is ten times greater than in the 1994 inventory.

This drastic increase in CO_2 emissions in the future scenarios, compared to the inventory year, was not substantially reduced by applying the proposed mitigation measures. The *Year 2020 mitigated* scenario, for both sectors, shows no great difference from the *Baseline scenario*. However, in terms of the calorie equivalencies (that is, considering both methane and nitrous oxide in CO_2 equivalencies) the mitigation measures would allow for a 25% reduction of the emissions shown in the *Baseline scenario.*

Chile, as a developing country and given its resource allocation priorities in order to improve the quality of life of its people, has major budget restrictions. For this reason, any mitigation measure that represents a net cost to the country, even if the will exists to apply the measure, will not be feasible if international cooperation funds are not available. Thus, future actions adopted by Chile should be geared at those measures that have not been introduced because of market barriers and whose cost is zero or negative (that is, actions that generate savings), be they for emissions reductions or the increase of sinks through absorption.

When this document was being prepared, the mitigation measures had only been identified and assessed on a preliminary basis. Future studies will be performed to conduct a detailed cost and benefit assessment for each, determine the feasibility of their application given current national priorities and policies, evaluate the joint benefits and identify the social players on whom these costs or benefits will fall.

1.5 Analysis of vulnerability and adaptation to Climate Change

This detailed vulnerability evaluation studies in areas identified as sensitive to climate change were begun in 1998 under the *Enabling Activities* program sponsored by the GEF.

These studies include those areas that are most sensitive to climate change, both in economic and social terms. The first study focused on agriculture, water resources and forestry; the second, on coastal areas and fishing resources.

When this First National Communication was being prepared, both of these studies were fully underway. The results obtained up to the present are summarized below.

1.5.1 Analysis of *Vulnerability and adaptation to Climate Change in Chile: Agriculture, Water Resources and Forestry.*

The study analyzed and evaluated the vulnerability of agriculture to climate variations, the vulnerability of different types of forests to precipitation patterns and variations of annual average surface run-off due to climate change. The atmospheric concentration of CO_2 was used as a parameter to show climate change, projecting that this would be double that observed in 1990, or *Future Scenario* 2*CO_2.

The analysis method was based on the IPCC guidelines, the United States Country Studies Program (USCSP), General Atmospheric Circulation models and local models.

Changes in Precipitation

The results of the GCM models for the *Future Scenario* 2*CO_2 show over a 30% variation in the annual rainfall in certain areas of the country. This means that over the next 40 years, rainfall patterns could experience the same amount of variation as during this century.

There could be an increase in precipitation in the altiplano areas due to the increase in tropical cyclone activity. From the Second Region to Puerto Montt, in the Tenth Region, precipitation will decrease up to 20-25% with respect to Scenario 1*CO_2. From Chiloé to the south, precipitation could increase, making the southern climates even rainier.

Temperature Changes

Based on the three models used[9], significant temperature changes are predicted for Chile. In the north (Regions I and II), temperature increases would be less than 2°C while in the center of the country and in the south the temperature could increase 3°C.

Changes in global water regimes

A significant decrease in yearly precipitation is expected, especially in the central area of Chile. Along with these precipitation changes, the increase in temperature will have a positive impact on evapotranspiration.

Given the variations in the *annual water deficit*, there is a clear increase in aridity in the north and central areas of the country, which will noticeably penetrate the Central Valley between the Metropolitan Region and the Eighth Region. The Ninth and Tenth Regions also show an increased water deficit. South of Puerto Montt this deficit disappears.

Changes in global heat regimes

The increases in temperature will affect secondary variables that are important for agriculture such as frosts, hours of cold, number of warm days, etc.

Climates will become considerably warmer, shifting the conditions currently present along the coast of the Second Region to the Fourth Region. There will also be a climate shift in the center of the country, which will become markedly warmer. Most likely, this change will have a major influence on the fruit-growing and industrial crops. The livestock potential for the southern regions could increase.

Grasslands

In the altiplano (high plains) we should see an extension of the area with a climate suitable for the development of grasslands and an increased yield from existing grasslands. In the south and far south, the future scenario should also be favorable. In the central area of the country, however, the effects of climate change should be negative and reflected in reduced yields.

In the 2*CO_2 scenario, there is a marked fall in productivity from the annual grasslands between the Fourth and Ninth regions. This decreasing trend ends in the Tenth Region where the current conditions are maintained. In the Eleventh Region, a decreased production is observed, probably related to excess water in the soil due to the increase in rainfall. However, in the dry areas in Tierra del Fuego, towards the east, productivity could increase along with the increased rain in the southern regions.

[9] The models used correspond to the general circulation models UKMO, GISS and GFDL

In the high plains in the far north, the natural grasslands could benefit from increased rainfall, thus improving yields.

Forestry Resources

In the *$2*CO_2$* scenario there is a notable decrease in the potential of regions V, VI and part of Region VII. However, there is also a marked expansion of the highest potential area from the Eighth Region to the south. The forestry potential of the Tenth Region shows a marked increase, spreading towards the center of the region and towards the foothills. Even in the Eleventh and Twelfth Regions the production potential could improve.

Crops

For the territory of Chile as a whole, the outlook is positive as long as the supply of water can cover irrigation needs. This may be the greatest uncertainty factor and, therefore, becomes an element of risk for the agriculture of several regions, especially in the center of Chile.

For dry-farming, the situation might be more negative in the center-north of the country (Fourth and Fifth Regions) where the only dry-farming crops are those planted in the winter. However, starting in the Sixth region, a raise in winter temperatures could attenuate the frosts, allowing spring planting, especially on the coast (beans, corn, potatoes) to be done in the winter, taking advantage of the moisture in the soil and winter rains.

Fruit Growing

Currently, fruit growing in temperate-warm climates takes place between the First and Eighth Regions. Towards the far north (Regions I-III), productivity falls due to the earliness of crops because of the high winter and spring temperatures which lead to very early sprouting. The most productive area is located between the Metropolitan Region and the Seventh Region. South of this, conditions deteriorate due to the decease in light and summer temperatures, increased precipitation and late spring frosts.

In the $2*CO_2$ scenario, these limitations are shifted south, greatly extending the productive area both to the north and south. In this scenario, vines are greatly benefited by the attenuation of the frosts towards the interior of Chile. Along with the production benefits associated with this trend, there could also be an increase in the earliness of crops, thus losing the current competitive edge in the north of Chile.

For peach producers, the most important change is the extension of the growing area to the Eighth and part of the Ninth Regions and the improvement of growing conditions near the foothills, where there will be a great deal of light, moderate temperatures in summer and milder winters than present.

Production conditions for temperate climate fruit growing will improve considerably due to the decrease in frosts and the milder spring temperatures. The only risk factor might be the decrease in cold winter temperatures, making it advisable to use species that are less demanding of cold temperatures or to use practices to induce the break in the winter recess. Probably for this reason, the Central Valley will continue to be more productive than the coastal areas.

Sub-tropical fruit growing will probably be one of the areas most benefited by the increase in temperature and, possibly, relative humidity. Production potential could spread to the south and towards the coastal regions that currently provide no guarantees for sufficient ripening of plants. The production potential of the valleys from the Third Region to the north should considerably increase. The milder frost patterns will allow for an expansion of the citrus growing area into the interior of the country.

Impact of irrigation on production

In the central region, despite the increase of evapotranspiration, the irrigation requirements of summer crops (corn, beans, sunflowers, vegetables) could decrease, especially along the coast, as a result of the shift of planting dates to the winter. This would make it possible to take better advantage of precipitation.

From the Sixth Region to the south, along the coast, the difference in irrigation and dry-farming yields will tend to decrease, while this will increase near the foothills, especially from the Seventh region to the south. An increase in productivity is expected around the Tenth Region.

Currently, in the central region, planting is done in the autumn in order to take maximum advantage of winter rains. A decrease in precipitation will, therefore, affect yields without changing planting dates. This situation can be clearly seen in the Fifth, Sixth and Metropolitan Regions where in the $2*CO_2$ scenario, irrigation becomes very important. In a climate change scenario, the change in planting dates could reduce irrigation requirements.

Vulnerability of forest tree species with the change in the current water regime.

In general terms, there will be a change from the current situation, moving towards less arid conditions in the far north (areas in the altiplano) and wetter conditions in the south of the country and dryer conditions in the rest of the country.

The forest tree species affected by the change to more arid conditions are as follows:

- *Esclerófilo* in the Fifth and Sixth Regions
- *Roble-Raulí-Coigüe (Oak -Evergreen Beech - Coehue)* and *Roble-Hualo* in the Seventh Region.
- *Roble-Raulí-Coigüe* , *Coigüe-Raulí-Tepa*, *Lenga* and *Ciprés de la Cordillera (Mountain Cypress)* in the Eighth Region.
- *Roble-Raulí-Coigüe*, *Coigüe-Raulí-Tepa*, *Lenga*, *Siempre Verde (Evergreen)* and *Araucaria (South American Pine)* in the Ninth Region.
- *Roble-Raulí-Coigüe*, *Coigüe-Raulí-Tepa*, *Lenga*, *Siempre Verde*, *Araucaria*

The forest tree species affected by the climate change resulting in increased precipitation are as follows:

- *Lenga*, *Siempre Verde and Roble-Raulí-Coigüe* in the southern part of the Tenth Region.
- *Siempre Verde, Ciprés de las Guaitecas* (*Guaitecas Cypress), Lenga y Coigüe de Magallanes* in the Eleventh Region
- *Lenga*, *Ciprés de las Guaitecas* and *Coigüe de Magallanes* in the Twelfth Region

Global Vulnerability of Agriculture

The increased vulnerability of agriculture occurs between the Fourth and Tenth Regions. If the coastal districts, intrinsically highly vulnerable, are compared with the Central Valley, with its intensive agricultural activity, we can see a certain amount of compensation between both variables, which makes the vulnerability of the Central Area more uniform. The desert and mountainous areas and the far south are the least vulnerable areas, where the role of agriculture is marginal.

Water Resources

The snow river regime in the central area could see a decrease in run-off due to decreased rainfall. However, in the short term, temperature increases could increase run-off due to the melting of ice reserves. The run-off from the watersheds of the Ninth and Tenth regions will be proportional to the change in rainfall. The same is expected for the basins in the Eleventh and Twelfth regions, where run-off could increase.

Considering the close link between agriculture and the availability of water resources, climate scenarios suggest that changes in agriculture could be negative or positive, depending on the region. The big unknown has to do with negative changes in the hydrology of the Andes Mountain Range, which would require major efforts to improve and expand the hidrological control infrastructure.

Incidence of pests and disease

After consulting with specialists, it was determined that for all of the crops studied (fruit, grape vines, grains etc.) fungus will increasingly be a problem during rainy years (severe negative effect on crops) for the future scenarios. This result will be lessened by the temperatures: in the south of the country, the fungus problem should be attenuated because of the low temperatures. Rainfall distribution is another important factor affecting the severity of the fungus problem. In future scenarios, with spring rains the negative effect will be more likely and more severe.

In the case of insects and mites, rainy years should create unfavorable conditions for agricultural production in the north due to an expected increase in the substratum on which these develop (slight negative effect). However, in the central and southern areas of the country, rainy years with low temperatures should lead to a decrease in the insect population as a result of the lengthening of the reproductive cycles (slight positive effect). The opposite should occur in dry years.

1.5.2 Analysis of Vulnerability and Adaptation to Climate Change in Chile: Coastal Areas and Fishing Resources.

The purpose of this study is to identify high vulnerability areas, assess the effects of the increase in sea level and the surface temperature of the ocean on the uses of the coastline and fishing resources and to then propose adaptation measures for the changes observed.

The proposed scenario to determine the vulnerability profile of the areas being studied is a one meter increase in sea level. This working hypothesis reflects a pessimistic scenario, though it is considered as the standard scenario for coastal area vulnerability studies.

For fishing, the vulnerability profile considers a variation of the surface temperature (ST) of the ocean of .5°C, which corresponds to the most probable scenario with global warming (IPCC, 1995).

The areas selected are listed below:

- Region I **-** Tarapacá (Arica sector)
- Region VIII **-** Bío Bío (Río Bíobío and Golfo de Arauco sector)
- Region X **-** Los Lagos (Valdivia sector)
- Region X **-** Los Lagos (Puerto Montt sector)

These regions are representative sectors of the Chilean coast, in terms of the location of human settlements with a significant population density and major economic activity. Moreover, there is also an element of complementarity in that the adjacent sea water has high yields, giving rise to centers of industrial and artesanal fishing activity.

This study is still underway and results are expected towards the end of 1999.

1.6 Final Conclusions and Future Actions

The following future actions have been identified by the Government as a result of this first diagnostic exercise and evaluation of the country's progress in applying the FCCC.

- *Define and implement a National Action Plan for Climate Change.*
  Including, but not limited to, the following actions: create a periodic updating schedule of the national communications and the GHG inventory; formulate a climate change mitigation and adaptation strategy (defining policies and measures, costs, institutional framework, etc.); define the institutional framework and operational characteristics necessary to establish the CDM in Chile; establish a development program and/ or technology transfer program to mitigate and adapt to the effects of climate change; define a national strategy to more effectively use the GEF resources; create a new national scientific research development program for climate change.

- ***Use of the Clean Development Mechanism (CDM)***

  This instrument is recognized by the Government as being fundamental in order to design early actions to deal with climate change. To do so, we must develop an institutional framework in Chile in order to coordinate domestic actions for the acceptance, revision and implementation of these projects and which will also serve as a link to the Executive Board of the Clean Development Mechanism. The formulation of national project acceptance criteria, determining baseline emission levels and developing future scenarios are just some of the aspects that should be included in the national institutional framework for the CDM.

- *Technical and institutional training to identify projects and carry out specific studies.*

  The execution of GHG inventory studies and the mitigation and evaluation analyses of vulnerability/adaptation have created the need to develop institutional and technical capabilities to identify specific projects and studies in areas of concern for the country, such as:

  <u>land use change and forestry</u> (for example, identifying and improving the understanding of the processes leading to increased CO_2 equivalent emissions in this sector, improving our understanding of the carbon capture processes on abandoned land, and identifying and proposing actions to improve the efficiency of processes in which firewood is used as fuel.

  <u>energy sector and industrial processes</u> (for example, identify and evaluate mitigation options for the transportation sector. Evaluate the costs and benefits of introducing energy efficiency standards. Explore other areas that could be attractive for introducing renewable energy sources.)

  <u>greenhouse gas emission inventories</u> (for example, updating the Energy and Non-energy sectors for the 1990-97 period and incorporating the Industrial Processes and Solvent Use sub-sectors; obtain information on a regional scale for the Energy, Industrial Processes and Solvent Use inventory; standardize the programs used to update the emissions and sinks inventory; improve the AGRI model to evaluate emissions from Agriculture, Land Use Change and Forestry, and Waste Management; standardize the definition of assumptions in projecting *Baseline* and *Year 2020 mitigated scenarios* for the Energy and Non-energy sectors.)

  <u>Mitigation and future scenario options</u> (for example, perform a detailed revision and go further into depth in the economic assessment developed for the change land use change and forestry, energy

consumption and industrial processes sectors, including factors such as the feasibility of applying measures given the current national priorities and policies and evaluate the joint benefits and determine on which social players these costs or benefits will fall; provide training to determine baseline emission levels and develop future mitigation scenarios; identify emission reduction and sink increase scenarios; establish and incorporate in the national action plan for climate change a mitigation strategy that considers the central aspects of the baseline and future projections scenario analysis.)

Vulnerability and adaptation studies (for example, study the replacement of crop varieties, changes in planting dates and the feasibility of relocation; evaluate the impact of climate change on protected wilderness areas; identify and deepen our knowledge on the impact caused by the water and heat conditions on the native forest species; identify and deepen our knowledge on the impact of climate change on the advance of desertification and erosion in the north and central areas of the country; evaluate and promote research in the use of comprehensive pest and disease control systems; design and implement early warning systems for El Niño and La Niña phenomena; establish and include in the national action plan for climate control an adaptation strategy, among others.

Scientific research on climate change (for example, study the possible inclusion of the study on climate change related phenomena in the formal education system; prioritize important areas of scientific study for the country; install a greenhouse gas monitoring station in the north of Chile.)

Define a National Strategy for the Global Environmental Facility, GEF

2. THE SCIENCE BEHIND CLIMATE CHANGE

This chapter contains extracts of scientific research gathered by the IPCC (Intergovernmental Panel on Climate Change) in its Second Assessment Report on Climate Change published in 1995. This panel provides the necessary support for the Convention on Climate Change by giving recommendations when decisions need to be made that involve scientific and technical issues in order to better carry out their commitments. Therefore, it is the official voice on climate change and has been validated as such by the Government of Chile.

Since 1990, this panel of scientists has made great progress in understanding climate change[9]. They are currently drawing up the Third Assessment Report, which is to be released to the international community at the beginning of the next millennium.

The information provided by the IPCC is outlined in this chapter so as to alert the national community to the seriousness of climate change. Another specialized scientific research study with similar findings is included at the end of this chapter.

2.1 WHAT IS THE GREENHOUSE EFFECT?

The temperature of the air on the Earth's surface is the result of the balance between the energy that reaches the planet from solar radiation and that which is lost through cooling, primarily through infrared radiation (See Figure 2.1).

The sun is the Earth's only external heat source. When solar radiation reaches the surface in the form of visible light, a portion is absorbed by the atmosphere and reflected by clouds, desert, and snow. The remaining radiation is absorbed by the Earth's surface, heating up and then warming the atmosphere, leading to the emission of invisible infrared radiation.

Due to the fact that the atmosphere is relatively transparent to solar radiation, small quantities of gases present in the atmosphere, known as greenhouse gases, GHG, absorb said infrared radiation. They act as a sheet that prevents the radiation from escaping into space, heating the Earth's surface by decreasing the emission of cooling radiation. This is what is referred to as the greenhouse effect, which has been acting upon the Earth's atmosphere for billions of years due to the presence of natural GHGs: water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). If these gases did not exist, the average temperature of the Earth would be 30 °C cooler than it is now, making in uninhabitable.

However, increases in GHG concentrations reduce the efficiency with which the Earth cools, resulting in a positive radiative effect[10] that tends to heat

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[9] The IPCC First Working Group refers to climate change as any change in the climate over time due to natural variation or as a result of human activity. This is different from the Climate Change Convention definition, which refers to the climate change that is directly or indirectly attributable to human activities that change the composition of the world's atmosphere, in addition to the natural variability of the climate in comparable periods of time.

[10] Radiative effect is the upsetting of the energy balance in the atmosphere-Earth system. This is expressed in watts per square meter (Wm^{-2}).

up the lower atmosphere and the Earth's surface. This is what is referred to as the increased greenhouse effect, the magnitude of which depends on how much the concentration of each greenhouse gas increases, the radiative properties of the gases involved, and the concentrations of other GHG already present in the atmosphere. This intensification of the natural greenhouse effect could then produce a change in the world's climate and unsuspected consequences for humanity.

FIGURE 2.1 Diagram illustrating the simplified greenhouse effect.
A portion of the infrared radiation is absorbed and re-emitted by the greenhouse gases, resulting in the heating up of the Earth's surface and the lower layer of the atmosphere.

Some solar radiation enters the atmosphere.

The Earth's surface heats up when it absorbs most of the solar radiation.

The Earth's surface emits infrared radiation.

2.2 INCREASE IN GREENHOUSE GAS CONCENTRATIONS

In order to understand the meaning of the anthropogenic effects on the greenhouse effect and to understand quantitatively what concentration of GHGs will not produce this dangerous interference in the climate, we must first know the current concentrations of GHG in the atmosphere, their trends and the consequences – both in the present and the future – for the climate system.

Ever since pre-industrial times (starting in approximately 1750), concentrations of these gases have produced a positive radiative effect that tends to heat the surface and leads to other climate changes as well.

- Average global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased considerably: CO_2 from 280 to almost 360 ppmv (30%), CH_4 from 700 to 1720 ppbv (145%), N_2O from 275 to 310 ppbv (15%) (1992 figures). According to the IPCC, to a large degree these trends can be attributed to human activities, especially to the use of fossil fuels, the change in land use and agricultural methods.

- There are greenhouse gases that remain in the atmosphere for a long time (for example, from several decades to centuries for CO_2 and N_2O), with the resulting impact on the radiative effect over the long-term [11].
- The direct radiative effect of the long duration greenhouse gases is 2.45 Wm^{-2}, primarily due to the increased concentrations of CO_2 (1.56 Wm^{-2}), CH_4 (0.47 Wm^{-2}) and N_2O (0.14 Wm^{-2}) (1992 values).

[11] These are also known as long duration greenhouse gases.

- The direct radiative effect resulting from the combination of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFC) is 0.25 $Wm^{-2.}$ However, its net radiative effect is reduced to 0.1 Wm^{-2} because they have caused the depletion of stratospheric ozone, which in turn produces a negative radiative effect. Thanks to the implementation of the Montreal Protocol and its amendments and modifications, it is predicted that CFC and HCFC concentrations, and the resulting ozone depletion, will decrease considerably by the year 2050.

- Currently other long duration greenhouse gases, especially hydrofluorocarbons (HFC), a substitute for CFCs, perfluorocarbons (PFC) and sulfur hexafluoride (SF_6) contribute little to the radiative effect, but their expected growth could increase the radiative effect in the 21 st century by several percentage points.

- If carbon dioxide emissions remain at current levels (using 1994 as the reference year), this will lead to the almost constant growth of atmospheric concentrations for at least two centuries, reaching some 500 ppmv by the end of the 21st century (approximately double that of the pre-industrial age concentrations).

- Many carbon cycle models show that atmospheric CO_2 concentrations will level off at 450, 650 or 1000 ppmv if world anthropogenic CO_2 emissions drop to 1990 levels in 40, 110 or 240 years, respectively, and if they then fall below 1990 levels.

- In the stabilization case series studied, stabilization of accumulated anthropogenic emissions at 450, 650 and 1000 ppmv from 1991-2100 was at 630 GtC, 1080 GtC and 1410 GtC, respectively (+/- 15% in each case).

- The stabilization of CH_4 and N_2O concentrations at current levels requires anthropogenic emission reductions of 8% and over 50%, respectively.

- There are signs that tropospheric ozone concentrations in the Northern Hemisphere have increased since the pre-industrial age due to human activity, creating a positive radiative effect. The effect is still not well defined, but it is estimated at 0.4 Wm^{-2} (15% of which is due to long duration greenhouse gases). However, observations made over the past few decades show that the upward trend has decreased or stopped, although future changes are expected in tropical and sub-tropical regions.

2.3 ANTHROPOGENIC AEROSOLS

Anthropogenic aerosols are those microscopic particles produced from fossil fuel combustion and the combustion of biomass and other sources. Its presence has produced a direct negative radiative effect of some 0.5 $Wm^{-2,}$ (world average) and may also be the cause of an indirect negative forcing of the same magnitude. Although the negative radiative effect is concentrated in certain regions and sub-continental areas, it may affect climate patterns on a continental or hemispheric scale.

Anthropogenic aerosols, in contrast to long duration greenhouse gases, do not remain long in the atmosphere. For this reason, their negative radiative effect adjusts quickly to the increases and decreases in emissions. Therefore, their cooling effect does not compensate for the warming effect generated by long duration GHG.

2.4 VERIFIED CLIMATE CHANGES OVER THE PAST CENTURY

According to the IPCC's report, analyses of meteorological, oceanologic, geological and other data on extensive areas and spanning several decades or more, have provided evidence of the existence of major systematic changes.

- The mean global air temperature close to the Earth's surface has increased between 0.3 and 0.6 °C since the end of the 19^{th} century. Additional data obtained after 1990 and the new analyses that have been conducted since then do not signal any significant change in the range of the estimated increase.

- The last few years have been the warmest since 1860, in spite of the 1991 cooling effect produced by the eruption of Mount Pinatubo in the Philippines.

- In general, nighttime temperatures on the Earth have increased more than daytime temperatures.

- Regional changes have also been seen. For example, the recent warming trend has been greater in the winter and spring above the middle latitude continents such as the North Atlantic, with some areas of cooling. Precipitation has increased on Earth at the high latitudes of the Northern Hemisphere, especially during the cold seasons.

- The world sea level has risen between 10 and 25 cm over the past 100 years. A large part of this increase is linked to the increase in the world mean temperature.

- Not enough information is available to determine if throughout the 20[th] century long-lasting changes have been produced in climate variation or in the highs and lows measured for various meteorological variables in the world. At a regional level, there are clear indications of changes in some highs and lows, such as in climate variation indicators. Several of these changes have been towards increased variability. In other cases, there has been a decrease.

- Between 1990 and mid-1995, the constant warming phase of the El Niño-Southern Oscillation phenomenon that led to drought and floods in many areas was exceptional in comparison with its behavior over the past 120 years.

2.5 THE DIFFERENCE BETWEEN NATURAL AND HUMAN INFLUENCE ON WORLD CLIMATE

From the time of the IPCC Report (1990), much progress has been made to attempt to distinguish between natural and anthropogenic effects on climate. This progress was achieved by including not only the effects of greenhouse gases, but also sulfated aerosols. In this way, more precise estimates were obtained for the radiative effect as a result of human activity. The most important results concerning detection and origin are described below.

- Evaluations of the statistical significance of the observed trend in the world mean temperature over the past century made use of a number of new estimates of natural variability caused by both internal and external factors. These estimates are based on instrument findings, paleo data, simple and complex climate models and statistical models adapted to observations. The majority of the studies detected a major change, signaling that the observed warming trend is most likely not completely attributable to natural trends.

- There is more convincing recent evidence from pattern based studies that attributes change in climate to human activity. These studies look at both the greenhouse gas radiative effect and that of the anthropogenic sulfated aerosols. Then, the climate responses of the models are compared with observed geographic, seasonal and vertical patterns of atmospheric temperature variation. The studies show that agreement among these patterns increases over time, as can be expected, because the anthropogenic signal increases in strength. It is very unlikely that this similarity could occur by chance as a result of a natural internal variability. The vertical change patterns are also incompatible with predictions for a solar or volcanic effect.

- The ability to quantify the human impact on world climate is currently limited because the expected signal is just beginning to arise from the noise of natural variability and because there is still uncertainty about certain key factors. These include the magnitude and patterns of natural variability over the long term, the radiative effect over time, and the response to changes in the concentrations of greenhouse gases and aerosols and changes in the Earth's surface. However, according to the IPCC, the balance of the tests suggests that there is a discernible human influence on climate change on both a regional and global scale.

2.6 CLIMATE CHANGES EXPECTED IN THE FUTURE

Without mitigation policies or major technological advances that allow us to reduce emissions and/or increase sinks, the concentrations of greenhouse gases and aerosols are expected to increase during the rest of the next century.

The IPCC, in an attempt to assess what might happen to the climate in the future due to changes in GHG concentrations, has drawn up a series of scenarios (IS92 a-f) of future greenhouse gas emissions and aerosol precursors. These scenarios are based on hypotheses on future population and economic growth, land use, technological change, availability of energy and the combination of fuels for the period 1990-2100 (See Figure 2.2).

According to these scenarios, in the year 2100 carbon dioxide emissions are expected to be between 6 GtC per year, approximately equal to current emissions, and 36 GtC per year (the lower end of the IPCC range). This assumes low population and economic growth up until the year 2100. Methane emissions are predicted to be between 540 and 1170 Tg CH_4 per year (emissions in 1990 totaled some 500 Tg CH_4) and nitrous oxide levels between 14 and 19 Tg N per year (1990 emissions were 13 Tg N). In all these cases, greenhouse gas concentrations in the atmosphere and the total radiative effect continue to increase during the simulation period from 1990 to 2100.

Potential Temperature Increases. The first scenario we will look at is the IPCC emissions scenario (IS92a) for the mid-term and starting with the value hypothesis of the "best estimate" of climate sensitivity[12], including the effects of future increases in aerosol concentrations. In the models, a 2 °C increase is predicted in the global mean surface temperature by the year 2100 (compared to 1990 figures). This estimate is approximately one third lower than the "best estimate" in 1990. The increase is primarily due to lower emissions scenarios (especially for CO_2 and CFC), incorporating the cooling effect of sulfates in aerosols and improvements in treating the carbon cycle.

By combining the lowest IPCC emissions scenarios (IS92c) with a "low" climate sensitivity value and including the effects of future changes in aerosol

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[12] In the IPCC reports, climate sensitivity is normally understood as the long-term change (equilibrium) of the global mean surface temperature resulting from the equivalent doubling of CO_2 concentrations in the atmosphere. Generally speaking, this refers to the change in the surface air temperature equilibrium as a result of a unitary change in the radiative effect (°C/ Wm^{-2}).

concentrations we obtain a predicted increase of approximately 1 °C by the year 2100.

The corresponding projection for the IPCC's higher emissions scenario (IS92e) combined with a "high" value for climate sensitivity results in a warming of 3.5°C. In every case, the average warming rate is probably greater than any of those observed over the past 10,000 years, but in the real annual and decade changes there will be a considerable amount of natural variability. The regional temperature changes can greatly differ from the global mean. Due to the thermal inertia of the oceans, only 50% to 90% of the final equilibrium temperature change will take place by the year 2100. The temperature will continue to increase after 2100, even if the concentration of greenhouse gases stabilizes.

FIGURE 2.2 Annual anthropogenic emissions of carbon dioxide according to IS92 emission scenarios.

Potential sea level increases. The mean sea level is expected to rise as a result of the thermal expansion of the oceans and the melting of glaciers and ice caps. The IS92a scenario assumes the "best estimate" values for climate sensitivity and for the sensitivity of the melting of ice due to the warming effect and includes the effects of future changes in aerosol concentrations. In the models, a rise of 50 cm in the sea level is predicted from the present until the year 2100. This estimate is 25% below the "best estimate" of 1990 due to a lower temperature projection. However, it does reflect improvements in climate and ice melting models. Combining the lowest emissions scenario (IS92c) with the "low" climate and ice melting sensitivities, including the effects of aerosols, results in an estimated sea level rise of some 15 cm by the year 2100.

The corresponding projection for the highest emissions scenario (IS92c), combined with "high" climate and ice melting sensitivities, yields a sea level rise of some 95 cm by the year 2100. Sea level will continue to rise at a similar rate during the centuries following the year 2100, even if by then greenhouse gas concentrations have stabilized. This process will continue even after the global mean temperature has stabilized. Regional changes in sea level may differ from the global mean due to land movement and changes in ocean currents.

There is greater confidence in the hemispheric-continental scale projections of the combined atmospheric-ocean climate models than in the regional projections where confidence is still low. There is more trust in temperature predictions than in hydrological change predictions.

All of the simulations carried out with the models, including those looking at the effects of both greenhouse gases and aerosols and those that only consider greenhouse gases, yield the following results: a maximum surface warming at high Northern latitudes in the winter; little surface warming at the Arctic in the summer; an intensification of the world average water cycle and increased precipitation and soil moisture in elevated latitudes in the winter. All these changes are linked to identifiable physical mechanisms.

Warmer temperatures will result in a more active water cycle, which will mean more severe droughts and/or floods in some places and less severe in others. Several models point to an increase in the intensity of precipitation, suggesting the possibility of more extreme precipitation phenomena. Not enough information is currently available to forecast whether there will be changes in the occurrence or geographical distribution of heavy storms such as tropical cyclones.

2.7 UNCERTAINTIES IN THE PREDICTION AND DETECTION OF CLIMATE CHANGE

There are many uncertainties and many factors that currently limit our ability to predict and detect climate change. Unexpected, major and rapid future changes in climate are, by their very nature, difficult to predict (as has occurred in the past). This means that future climate changes can also bring with them "surprises", which, more specifically, is due to the non-linear nature of the climate system. When there is a rapid change, non-linear systems can demonstrate unpredicted behaviors. In this way, it is possible to make progress by investigating non-linear processes and sub-components of the climate system. An example of non-linear behavior is the rapid circulation changes in the North Atlantic and other reactions linked to changes in the Earth's ecosysem.

2.8 REGIONAL IMPACTS OF CLIMATE CHANGE: VULNERABILITY ASSESSMENT IN LATIN AMERICA [13]

The IPCC, in its special report on the regional impacts of climate change, evaluates regional vulnerability[14] to climate change, focusing on the potential long-term impact on ecosystems, hydrology and water resources, food and fiber production, coastal systems, human settlements, human health and other important sectors and systems (including climate). All of these are vital to sustainable development.

This analysis was carried out on 10 regions that, together, make up the Earth's total surface area: Africa, the Polar Regions (the Arctic and the Antarctic), arid West Asia (Middle East and arid Asia), Australasia, Europe, Latin America, North America, small Island States, Temperate Asia and Tropical Asia.

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[13] The information contained in this chapter is based on the IPCC Special Report, Regional Impact of Climate Change: Vulnerability Assessment, published in November 1997.

[14] According to the IPCC, vulnerability is defined as the degree to which a natural or social system could be affected by climate change. Vulnerability is a function of the sensitivity of a system to climate changes (the degree to which a system will respond to a given climate change, including both beneficial and damaging effects), and the ability to adapt to said changes (the degree to which the adjustments introduced in practices, processes or structures can moderate or counteract the potential damage or benefit from the opportunities created from the effects of climate change).

2.8.1 REGIONAL ASSESSMENT FOR LATIN AMERICA

Some countries, especially those in Central America as well as Ecuador, Brazil, Peru, Bolivia, Chile and Argentina, seem to be currently very affected by the socioeconomic consequences of climate variability, either from year to year or season to season. They have been particularly affected by the El Niño Southern Oscillation phenomenon. Most of the production in these countries is based on the region's extensive natural ecosystems. The impact of current climate variability on natural resources suggests that the repercussion of the expected climate changes could be important enough incorporate in national and regional planning initiatives. Land use is currently one of the most significant causes of the changes taking place in ecosystems because of its complex interaction with climate. This factor makes finding common guidelines for dealing with climate change vulnerability very difficult.

It is important to emphasize that both for this region and other regions examined in the IPCC report, much of the information was based on vulnerability studies conducted by some countries at a local or national scale. In Latin America, especially, studies in this area have been scarce and therefore the information provided below is still insufficient. This should be improved as the rest of the countries begin to carry out their vulnerability studies.

The regional assessment for Latin America concluded that an increasing deterioration of the environment in the region (i.e., changes in the availability of water, loss of agricultural land, and the flooding of coastal and riperian areas and plains) caused by climate change, climate variability and land use practices, would aggravate socioeconomic and health problems. This, in turn, would drive the migration of people living in rural and coastal areas. More specifically, the assessment identified the following potential impacts:

Ecosystems

Climate change is expected to affect large areas of forests and grasslands; mountain ecosystems and transition areas between different vegetation types will be especially vulnerable. Climate change can aggravate the adverse effects of the continued deforestation of the rain forests of the Amazon. This impact could lead to a loss of biological diversity and would reduce the amount of rains and runoff both in the interior and exterior of the Amazon basin (due to a lack of equilibrium between precipitation and evapotranspiration), thus impacting the world carbon cycle.

Hydrology and Water Resources

Climate change can notably affect the water cycle, changing the intensity and the distribution over time and space of precipitation, surface runoff and the replenishing of water stores. This could impact different natural ecosystems and human activities in many ways. Arid and semi-arid areas will be especially vulnerable to a change in water availability. The generation of hydroelectric power, grain production and cattle raising will be particularly vulnerable to a change in water supply – especially in Costa Rica, Panama and at the foot of the Andes, such as in parts of Chile and western Argentina between 25 °S and 37°S. The impact on water resources could be enough to provoke conflict among users, regions and countries.

Food and Fiber Production

A decrease in agricultural production is predicted for many types of crops in Mexico, Central American countries, Brazil, Chile, Argentina and Uruguay, even after taking into account the positive effects of the increase in CO_2 on the growth of crops and a certain amount of adaptation of agriculture. Moreover, agricultural production will decrease if pastures in temperate regions are affected by a substantial decrease in water availability. Extreme phenomena (such as flooding, drought, frost and storms) could damage pastureland and agricultural production (for example, Central American banana crops).

The lifestyles of traditional peoples, such as Andean communities, would be threatened if there were a decrease in productivity or the available surface area for pastures or traditional crops.

Coastal Systems

In the low coastal areas and sloughs of Central American countries, Venezuela, Argentina and Uruguay, the rise in sea level could reduce the amount of coastal land and biological diversity (specifically: coral reefs, mangrove ecosystems, slough wetlands, marine mammals and birds), damage infrastructures and cause the intrusion of salt-water. If the rise in sea level blocks the runoff of rivers in the plains to the ocean, there could be an increased risk of flooding in these basins (for example, in the Argentine pampas).

Human Settlements

Climate change will have many direct and indirect effects on the well being, health and safety of the inhabitants of Latin America. In addition, it could exacerbate the direct impact due to the rise in sea level, extreme meteorological conditions (for example, floods and instantaneous flooding, storms, landslides, and cold or heat waves), as well as the indirect consequences due to the impact on other sectors, such as water and food supply, transport, energy distribution and sanitation services.

Those population groups living in poor neighborhoods, in the slums of large cities and especially those located in areas prone to floods or on unstable hillsides will be the most vulnerable.

Human Health

The projected climate change could intensify the effects of the serious chronic state of malnutrition and illness currently affecting some parts of Latin America. If temperature and precipitation increase the geographic distribution of illnesses transmitted by vectors (such as malaria, dengue fever, and Chagas disease) and infectious diseases (such as cholera) will move south and towards higher land. The pollution and high concentrations of ozone could negatively affect the health and well being of people, especially in urban areas.

2.9 OTHER SPECIALIZED SCIENTIFIC STUDIES

The international scientific community has allocated a great many resources and much effort to improving our knowledge about the influence of global change on a series of phenomena observed during the past decade. In addition to scientific journals, every day more articles appear in technology and business magazines on issues related to global warming, climate change and the opportunities and challenges created by applying the United Nations Framework Convention on Climate Change.

The varied nature of the media and the great number of articles are indicators of the diversity of interest groups, the importance the issue is acquiring daily and the actions being taken all over the world. Some of the issues that are of most concern to these groups (from each individual perspective) are improving our knowledge about this occurrence and its implications for human life and ecosystems, fostering mitigation initiatives and designing economic instruments to control GHG emissions and identifying business opportunities.

Scientific evidence leads us first, just as in the IPCC reports, to the conclusion that human activities are forces that have an influence on global warming. Second, it points toward the impossibility of excluding this warming effect as a determining factor in significant regional and planetary scale changes, such as the melting of glaciers, changes in marine and land based ecosystems, the rising temperature of the Earth's crust, and the decrease in the area covered by arctic ice, among others.

- The development of analytical techniques to detect and quantify the presence of GHG, for example, in ice packs (Arctic, Antarctic and glaciers) and tree rings, has made it possible to estimate the variation of GHG for periods when no records or measurements existed. These analyses lead to the conclusion that, although there has been natural variation in these gases (that is, not attributable to man) over the past 10,000 years, over the past 200 years, three times more CO_2 has been added to the atmosphere than that added during the first 7000 of the 10,000 years studied (*Nature*, March 8, 1999).

- According to NOAA, NASA and WMO, 1998 was the warmest year ever recorded. The rapid warming which occurred over the past 25 years shows that the greatest increase occurs simultaneously with the increase in GHG. The ten warmest years in recorded history began in 1983 and seven of them were in the 1990s. (*Wall Street Journal,* Dec. 8, 1998; *Washington Post,* December 8, 1998; *The New York Times,* Dec. 18, 1998).

- The ice cap covering Greenland is melting faster than expected and every year, from 1993 to 1998, it has lost close to two cubic miles of ice. According to NASA, although five years are not enough to define a trend, the size of the loss is considerable and could be partially due to global warming. Scientists have observed that the ice mass is moving faster towards the ocean. (*Science.* March 5, 1998).

- Studies conducted by three groups of scientists (University of Michigan, U.S. Geological Survey and the National Center for Atmospheric Research) independently reached the conclusion that human activities are a major factor in global warming. The temperature of the Earth's crust has increased 1.8 °F over the past 5000 years; almost half of this increase occurred between 1900 and the present. One of the reports refutes the thesis set forth by the skeptics of global warming which states that it is due to an increase in solar activity. According to the report, if this explanation alone were behind global warming, the Earth should be six times more sensitive to exposure to the sun. (*Science,* October 9, 1998.)

3. REGULATORY FRAMEWORK ON CLIMATE CHANGE

Much of the scientific information discussed in the previous chapter was already familiar to the scientific community in the 1980s. During this decade, many researchers began to show concern that the increase in greenhouse gas emissions, attributable primarily to increased consumption of fossil fuels, would affect the delicate balance of the planet's climate system. In order to face this global challenge, all nations had to join together and follow a universal framework of action, each with different but common responsibilities. To do this, an international convention was needed that would set forth specific actions to be carried out by the parties in order to stabilize greenhouse gas concentrations and thus minimize anthropogenic interference in the climate system.

This chapter will describe some of the regulatory instruments designed by the international community to tackle the climate change problem and will also outline the national environmental legal framework which makes it possible to adopt these agreements in Chile.

3.1 UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The United Nations Framework Convention on Climate Change (FCCC) is the first legally binding international instrument that deals directly with climate change. It was presented for signature at the Rio Summit in 1992 and was signed by 155 countries, including Chile. It took effect on March 21, 1994 after the 50th ratification was received at United Nations headquarters.

3.1.1 OBJECTIVE

The objective of the FMCC and all related legal instruments adopted by the Conference of the Parties, as stated in Article 2 is as follows: *…in accordance with the relevant provisions of the Convention, stabilize greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic inference in the climate system. This level should be reached within a time period that will allow ecosystems to naturally adapt to climate change, to ensure that food production is not threatened, and allow for continued sustainable economic development.*

3.1.2 BASIC PRINCIPLES

There are three basic principles in the FCCC: the precaution principle, the common but differentiated responsibility of States (this assigns leadership to the industrialized states to combat climate change), and contributions to sustainable development.

3.1.3 COMMITMENTS FOR ALL THE PARTIES

The general commitments, both for developed and developing countries, are set forth in Article 4.1 of the Convention. Among these commitments, a few of the most important include the drawing up, updating and periodic publishing of a national emissions and sinks inventory for greenhouse gases and a list of national and/or regional climate change mitigation and impact adaptation programs

Other commitments outlined in Article 4.1 have to do with technology transfer, practices and processes that reduce emissions, the conservation and increase of sinks, adaptation to impacts, scientific and technological research, exchange of information, education and training. These commitments should be included in the aforementioned national and/or regional programs.

The Convention recognizes that compliance by developing countries will depend on the technical and financial assistance provided by developed countries. In addition, special consideration is given to the lesser developed countries and those that are particularly vulnerable due to geographical characteristics. This approach is consistent with the widely recognized principle of common but differentiated responsibilities of States in differing stages of development.

Developing countries and transition economies listed in Addendum 1 of the FCCC should be leaders in adopting measures to combat climate change. Thus, it was agreed that these countries should take actions to limit carbon dioxide and other greenhouse gas emissions in order to return to 1990 levels by the year 2000.

The FCCC also establishes more specific obligations for specific categories of States. In this way it makes a distinction between OECD members (listed in Addendum II of the Convention), countries in transition to a market economy (Eastern European countries and those developed countries listed in Addendum I), and developing countries. The FCCC imposes the most restrictive measures for OECD countries while allowing greater flexibility for transition economies.

The countries listed in Addendum 1 should facilitate technology transfer and provide financial resources to developing countries so that they may implement the Convention. For this purpose the Convention requires that the countries listed in Addendum 1 cover the costs incurred by developing countries to draw up greenhouse gas emission reports and adopt measures to implement the FCCC. This financial assistance must be “new and additional” and not a reallocation of existing funds for official development assistance.

In addition, the Addendum 1 countries should provide financial resources for other projects related to the Convention that have been agreed upon by a developing country and the Convention’s financial mechanism. Up until the present, this financial instrument has been administered by the Global Environmental Facility (GEF).

3.1.4 COMMITMENTS FOR DEVELOPING COUNTRIES

In accordance with the provisions of Article 12 and the decisions adopted in the Second Meeting of the Conference of the Parties regarding the commitments of developing countries, these countries must present their first national communications to the Conference of the Parties. This should include a greenhouse gas emissions sink absorption inventory and if possible, the policies and measures that the country has developed or plans to develop to implement the Convention. In addition, this should include any scientific or other relevant data that could help clarify global emission trends.

Moreover, these Parties should specify their development priorities and the objectives and circumstances under which they will take actions dealing with climate change and its impact. The Parties will also inform the Conference of their voluntary decisions concerning the adoption of climate change mitigation and adaptation measures whenever the developing countries are not required to adopt said measures.

3.2 KYOTO PROTOCOL

In spite of how strict the commitments established for developed countries under the framework Convention could be, they were not sufficient to reach the reduction goals set forth for these Parties (i.e., reach the 1990 emissions levels by the year 2000). As a matter of fact, at the First Meeting of the Conference of the Parties held in Berlin in 1995 a conclusion was reached that the degree of compliance with the commitments for the Addendum 1 countries was insufficient and, furthermore, some Parties announced that it was impossible to reach the agreed upon objectives. At that moment, they decided it was urgent that the Parties commit to more concrete actions that would be binding in nature and demonstrate the achievements of the developed countries.

The above was finalized during the Third Meeting of the Conference of the Parties of the FCCC held in Kyoto in December 1997 with the adoption of the Kyoto Protocol after almost three years of negotiations. The Parties to the Convention adopted it as a legally binding instrument that, basically, would establish stricter greenhouse gas emissions reduction and limitation commitments for the countries listed in Addendum 1 of the Convention. It also established a time-schedule for the completion of said commitments.

The main agreement was the joint reduction – by at least 5% - of the GHG emissions during the period from 2008-2012 as compared to 1990 levels (expressed as CO_2 equivalent emissions). Some of the individual commitments are as follows: an 8% reduction for the European Union, 7% for the United States, 6% for Japan, 6% for Canada and restricted emissions growth for countries in special circumstances such as Australia (8%) and Iceland (10%).

The original list of controlled gases was also expanded at this Third Meeting. In addition to CH_4, and N_2O, the HFC, PFC and SF_6 were also included. Other major advances during this meeting were the inclusion of land use change effects, emissions trading between countries and the establishment of a Clean Development Mechanism (CDM), which would allow the Parties to develop initiatives to reduce emissions or increase GHG absorption and obtain credits for said actions. These credits could be traded among the Parties or held to be used to compensate for their own future emissions or those of other Parties.

The Kyoto Protocol was presented for ratification in March 1999 and will take effect when 55 countries have deposited their ratification instruments (acceptance, approval or adhesion) at the United Nations headquarters. These 55 countries must include Parties from Addendum 1 and they must account for 55% of the total CO_2 emissions by developed countries and transition economies in 1990. At the time this First Communication was being prepared, 11 countries had ratified the Protocol, all of them developing countries.

3.3 CHILE'S ENVIRONMENTAL POLICY AND ITS LINK TO CLIMATE CHANGE

Chile's commitments to the international community on climate change are consistent with the country's environmental policy objectives and as stated in its current legislation. For example, Chile's Political Constitution, Article 19, Paragraph 8, states that all persons "have the right to live in an atmosphere free of pollution". This principle is incorporated in Chile's Environmental Policy, which is currently being implemented. Its main objective is to promote environmental sustainability in the development process and improve the quality of life of its citizens, guaranteeing them an environment free of pollution, protecting the environment, conserving nature and our environmental endowment.

A major step forward in the design and implementation of this Environmental Policy was providing the country with modern legislation and a new environmental institutional framework. In fact, the development of the legal framework, begun in 1990, led finally to the elaboration of Law Number 19,300 establishing the General Environmental Guidelines, which was passed in March 1994. This law made it possible to deal with environmental issues in a comprehensive way, establishing the basis for efficient environmental management and setting institutional and regulatory criteria to govern the actions of the State, the private sector and citizens.

Here, the concept of sustainable development is defined as "the process of sustained and equitable improvement of the quality of life of all persons, based on appropriate environmental conservation and protection measures, so as to not put at risk the prospects of future generations." The close relationship between environment, quality of life and productive development forces us to coordinate environmental, social and economic policies.

This law created the National Environmental Commission (CONAMA), and established the foundation for the National Environmental Management System, without removing the jurisdiction of ministries and other public agencies. This is based on a horizontal and coordinated institutional framework that is geographically decentralized and administratively simple. The National

Environmental Management System is made up of all the ministries, the central administration's sector agencies and decentralized agencies to which the group of laws in effect assigns responsibilities and environmental authority. The coordinating backbone of this system is CONAMA, which directly interacts with other State organizations, the productive sector and the public.

The institutional structure of CONAMA is headed by a Council of Ministers consisting of 13 Ministers of State. There is also an Advisory Board, at a national and regional level, made up of members of civil society and a National Directorate that decentralizes its tasks through the Regional Environmental Directorates (COREMAS) in each of the country's thirteen administrative regions.

This National Commission has the mandate of coordinating the development of policies, strategies and environmental programs that are being applied by different government ministries and agencies.

Among the objectives defined in the Government of Chile's Environmental Policy, and a main part of said policy, is full compliance with the commitments set forth by the FCCC. The aforementioned institutional structure has made it possible to comprehensively develop the climate change issue.

Since this Convention was ratified, CONAMA has become a focal point for climate change. Under its coordinating role, bilateral and multilateral cooperation has been channeled and has made it possible to draw up this First National Communication. In addition, the National Advising Committee on Global Change was formed and the issue of climate change and its implications for Chile was presented to the highest level of policy makers for their consideration. The Ministry of Foreign Affairs in turn, through its Environmental Division, is responsible for articulating Chile's negotiations in international environmental issues and, especially, in negotiations related to the FCCC.

Along with the UN Framework Convention on Climate Change, there are other agreements related to the environment that have already been ratified[15] in Chile:

- Convention on Biological Diversity
- Agenda 21 Work Schedule
- Vienna Convention and the Montreal Protocol (on Substances that Deplete the Ozone Layer)
- Convention on Wetlands (Ramsar Convention)
- Convention on the International Trade of Endangered Species of Wild Flora and Fauna (CITES)
- Basil Convention
- Convention on the Fight against Desert Encroachment
- United Nations Convention on Rights to the Sea
- International Convention to prevent pollution by Ships

[15] These international agreements, after being ratified by Congress, are considered Laws of the Republic of Chile

4. NATIONAL CHARACTERISTICS

4.1 GEOGRAPHIC PROFILE

Chile's territory is located in South America, the Antarctic and in the Pacific Ocean, which accounts for its great geologic, climatic and biological diversity.

For geographic reasons, Chile is separated from the rest of South America: to the north by the Atacama desert (the world's most arid desert); to the East, the Andes mountain range; to the West, the Pacific Ocean; and to the South, the Antarctic ice caps. This geographic isolation and the fact that it spans over 40° latitude from its northernmost to southernmost points bestow upon Chile very peculiar climatic characteristics, since Chile contains subtropical climates as well as sub-Antarctic and Antarctic climates.

Chile's continental territory is located between 17º30' y 56º30' l atitude south, on the western edge of South America. The total surface area is 2,006,096 square kilometers, of which 756,096 square kilometers correspond to continental Chile and its ocean territories and 1,250,000 km^2 to the Chilean Antarctic Territory. Continental Chile spans 4,300 kilometers from north to south. The average east-west distance is 232.5 km, making Chile the longest and narrowest country in the world. (Figure 4.1).

Its coastal waters cover approximately 120,000 sq. kilometers (not including its Antarctic territory). Chile's territorial sea places Chile among the countries with the most extensive ocean territory with some 3,150,000 sq. kilometers. Furthermore, the State of Chile has sovereign rights over the Exclusive Economic Area (200 nautical miles) for the use, exploration, conservation and administration of the natural resources of the sea-bed and sub-soil and the underlying waters.

Chile's also has territory in Oceania consisting of 7 islands : San Felix and San Ambrosio (also referred to as the Ill fated Islands); the Juan Fernandez archipelago made up of the Robinson Crusoe, Alejandro Selkirk and Santa Clara islands; and Easter Island and the Sala and Gomez Island. The total surface area of Chile's island possessions is 402.1 sq. kilometers.

The Andes Mountain Range is Continental Chile's most important feature. It forms Chile's natural border with Bolivia and Argentina and runs from north to south throughout continental Chile. It provides the country with great reserves of snow, the headwaters of the main basins supplying water for irrigation, human and industrial consumption, and makes hydroelectric power generation possible. Between the Andes mountain range and the Pacific Ocean there is another lower elevation mountain range, the Coastal Mountain Range, which also runs from North to South.

The presence of these two parallel ranges give the country a rugged and fragile topography in which there is a scarcity of flat surface area, which is usually connected to the great valleys and the tectonic depression between both ranges. These characteristics dominate the central portion of the country.

FIGURE 4.1 LOCATION OF CONTINENTAL CHILE

4.2 CLIMATE PROFILE

Chile's great length, the natural barriers formed by both mountain ra nges and the subtropical marine currents in the north and polar currents in the south result in a large diversity of climates. These are seen not just across different latitudes but different longitudes as well. Chile's climates range from desert in the north, with less than 1mm of precipitation per year on average, to the cold rainy temperate climes in the far south where some areas have over 5000 mm of precipitation per year.

According to Di Castri and Hajek's[16] bioclimatic classification, the five bioclimatic zones described below have been identified in Chile: Desert, High Altitude Tropical, Mediterranean, Ocean and Continental.

Desert. The Desert area spans from the country's northern border to a latitude of approximately 27°S. This area is divided into two longitudinal regions. The first corresponds to a very narrow strip, with clear ocean influence and in some cases Mediterranean climate conditions, since the scarce rainfall is mainly during the winter months. The second region is inland desert with arid characteristics that are even more marked than in the previous case. The eastern area of this second region is a marginal high altitude desert and is considered a degradation of a tropical climate due to the occurrence of spring rains.

The vegetation and animal life, which is only found in the desert area, is especially sensitive to the availability of water and is only present in those areas where there is underground water or valleys formed by small water currents that descend from the Andes and normally flow into catchment basins.

High Altitude Tropical. This includes the entire Chilean altiplano where the high altitude tropical climate predominates. During the warm period there are regular periods of precipitation that increase in intensity as we move toward the north-east. As we move south they decrease and become more irregular. The drought period lasts for seven to ten months. Vegetation grows during the warm months, primarily January and February.

Mediterranean. This is where most of the country's agriculture and forestry activities are located. This area extends from latitude 27°S to approximately 39°S. There are differences within this zone at different longitudes. On the coast there is a Mediterranean marine climate and inland it is dry where the Coastal Mountains become a barrier to the marine air masses. In addition to this longitudinal difference, there are latitudinal differences as well that

[16] "Perfil Ambiental de Chile", CONAMA, 1995

affect the rainfall in the area. This is what makes it possible to have regions with 12 months of drought while others in the South only have one month of drought.

These climate differences at different latitudes or longitudes are affected by local factors such as high humidity and persistent fog on the northern coast, the increase in precipitation at the base of the Andes or the penetration of marine air masses in the inland valleys.

The vegetation in this area is quite varied. In the North, there is a predominance of xerophyte vegetation. Bushes and scrub-brush grow when there is increased rainfall. In the South, the increased rains favors the growth of mesophyte and hygrophyte vegetation and the appearance of the sclerophyle forest typical of central Chile, and the wet forests in the central-south part of the country.

Ocean. This zone starts at the southern border of the Mediterranean zone (latitude 39°S) and continues to the far South of the country (latitude 56 °S). There are two well defined climate regions: the western region with abundant precipitation all year long and the eastern or trans-Andean region with semi-desert climate conditions. The western region has an abundance of forest and high humidity. The vegetation is more homogenous than in the previous climate zones due to the complete predominance of the forests.

The trans-Andean region has less precipitation as the Andes mountain range acts as a barrier to the penetration of ocean air masses. This region displays some features of aridity and has varying periods of drought. This region is responsible for the appearance of the tundra ecosystem and the Patagonian steppe.

Continental. This zone spans from the western slope of the snow line, between 2000 and 3500 meters above sea level, to the highest peaks of the Andes throughout Continental Chile. There is an abundance of snow in this area. Biological activity takes place primarily in spring and summer, after the ice and snow have melted. The vegetation is dominated by steppes and tundra, similar to the tropical high altitude zone and the Patagonian steppe.

4.3 DEMOGRAPHIC PROFILE[17]

The population of Chile has experienced vigorous growth over the past 150 years. According to the national census, in 1835 Chile had a population of 1,010,336 inhabitants. In 1935, it had risen to 2,695,625 and by 1907 it was 3,220,531. In 1992, almost a century later, the census carried out by the National Statistics Institute (INE) yielded a population of 13,348,401 inhabitants.

This steady increase can be attributed primarily to fairly high birth rates up until 1962 (37.5 per 1000 inhabitants) and a steady decrease in mortality rates, resulting in a life expectancy of 75.2 years for the period from 1995 to 2000.

Between 1994 and 1996 the average birth rate was 1.9%, the mortality rate 0.55% and the natural growth rate reached 1.4%. The infant mortality rate

[17] Figures are from the 1998 Statistics Compendium (INE).

has been on the decline over the past few decades, reaching 11.1 out of 1000 live births in 1996.

It is estimated that in 1998 Chile’s total population was 14,821,714 and had an average annual growth rate of 1.4%. According to the 1992 Population Census, 83.5% of Chileans live in urban areas. The most populated regions are the following: the Santiago Metropolitan Region (5.3 million inhabitants), the Eighth Region – Bío Bío (1.7 million), and the Fifth Region – Valparaíso (1.4 million). Projections show that in 1998 the rural population will only total 14.8% of the population.

There are 45 coastal cities throughout the country, including almost all the country’s most important urban centers (with the exception of the Metropolitan Region) such as Iquique, Antofagasta, Viña del Mar, Valparaíso, Concepción, Talcahuano, Puerto Montt and Punta Arenas.

Urban centers located no more than ten kilometers from the sea account for approximately 21% of Chile's population. Thus, close to 2.5 million inhabitants live in major coastal urban centers, carrying out economic activities in the fishing and manufacturing industries as well as port services.

The Metropolitan Region is located in an intermediate depression 150 kilometers from the coast and is home to almost 50% of the total population and a large part of the industrial and service generation activities in the country.

4.4 ECONOMIC PROFILE

Chile’s economic policies emphasize sustainability as a key part of the Government’s development strategy. The foundation of this development has and will continue to be the tapping and procession of its natural resources.

Chile is a developing country that has experienced steady high economic growth during the past decade, reaching annual growth rates of approximately 7%. As a result, annual per capita income has been increasing; in 1997 it exceeded 5000 dollars. However, this sustained economic improvement is still accompanied by a major concentration of income: the poorest 20% of the population only receives 6% of the national income. Economic growth projections signal a decrease during the next few years, resulting in an annual rate of 5%. Table 4.1 displays Chile’s primary macroeconomic indicators for the 1991-1998 period.

TABLE 4.1 CHILE'S MACROECONOMIC INDICATORS (1991-1998)

Economic Indicators	1991	1992	1993	1994	1995	1996	1997*	1998*
GDP Growth %	7.9	12.2	7.0	5.7	10.6	7.4	7.5	3.4
Inflation %	18.7	12.7	12.2	8.9	8.2	6.6	6.0	4.8
Unemployment %	6.5	7.8	7.4	7.8	7.4	6.5	6.1	6.2
Foreign Debt / GDP %	48	44	44	3.5	32	32	16.9	19.5
International reserves (in thousands $US	6640.5	9009	9758.6	13466.5	14805	15474	17840.9	15991.8

*Source: Central Bank of Chile - * Provisional figures*

Chile's economic development has historically been based on the exploitation of their natural resources, both renewable and non-renewable. It is estimated that in the future these resources will continue to play an important role. The most important economic sectors are mining, fishing, manufacturing, and the agriculture-forestry sector.

The emphasis on international trade has led to a far-reaching process of globalization in the Chilean economy, increasing Chile's share of the global flow of trade and factors of production.

The government, for its part, has been fostering this process with an active policy emphasizing international bilateral and multilateral economic relations. Chile already has free trade and complementarity agreements with Canada and other Latin American countries. Furthermore, it is an active member of APEC and recently become an associate member of MERCOSUR and the European Community.

In 1996 exports of goods totaled over $15.4 billion US dollars after reaching an annual average growth rate of 11% in 1990. Distribution of exports by economic sector is shown in Figure 4.2.

FIGURE 4.2 Export Structure

Source: Central Bank of Chile, 1996.

In the future, copper mining is expected to continue to be an important driving force for development, although other industries will become increasingly important, such as forestry, agro-industry, aquaculture, tourism and services.

4.4.1 ENERGY SECTOR

The rapid economic growth mentioned in the previous section has led to a major increase in the country's energy consumption. Between 1990 and 1996 both the Gross Domestic Product (GDP) and the average annual energy consumption grew at an average annual rate of 7.4%. According to figures provided by the National Energy Commission (CNE), figures 4.3 and 4.4 show the evolution of primary energy use and supply as compared to the GDP over the past 10 years.

Figure 4.3 Per capita primary energy use

Source: CNE, 1999

FIGURE 4.4 Evolution of primary energy consumption per one million Ch$ pesos (1986) of the GDP

Source: CNE, 1999

Primary energy supply comes mainly from crude oil and hydroelectricity (Figure 4.5). Most of the oil supply is imported from abroad; the scarce oil reserves in the Chile only cover 4.7% of the country's needs (1996).

FIGURE 4.5 Primary supply structure

Crude Oil	Natural Gas	Coal	Hydro-electric	Wood and others
Inputs				

(Consumption (Tcal) en eje vertical.

Source: CNE, 1999

From the information above we can conclude that oil consumption has increased in the country (64,767 Tcal in 1990 to 87,153 Tcal in 1996) but not its relative share in the national energy matrix, which has decreased (from 40.2% in 1990 to 39.3% in 1996). Hydroelectricity, however, has increased from 15.3% in 1990 to 20.9% in 1996.

Wood has been an important input in the national energy supply, especially in areas with abundant forests. It is used by the Industrial and Residential, Commercial and Institutional sectors and is an important substitute for petroleum derivatives. Wood use in the Residential, Commercial and Institutional sectors reached 7,748,000 tons and 1,776,000 tons for the Industrial sector (CNE, 1997).

The use of coal is primarily for electricity generation, especially in the Norte Grande Interconnected System (SING), which supplies large mining companies. The situation is changing with SING beginning to incorporate the use of natural gas from Argentina.

Up until the mid-1997 natural gas had only been used in the Twelfth Region, primarily for methanol production. Starting in August 1997, the building of gas pipelines between Chile and Argentina has made it possible to use natural gas in the Metropolitan Region for electricity generation and in the industrial and then the residential sectors. Currently the supply of natural gas from Argentina is being expanded to the far northern regions of the country.

Due to Chile's hydrological characteristics, the hydroelectric potential (estimated at 11,000 MW for the Central Interconnected System, SIC) provides a competitive alternative for electricity generation. However, hydroelectric power generation is affected by droughts; therefore, electricity supply under these conditions requires the use of conventional thermal electricity.

To complement the information provided on power generation, the figure below shows the sector distribution of electricity use. Here we can see that electricity use is similar in the various sectors.

FIGURE 4.6 ENERGY CONSUMPTION BY SECTOR

Transport	Industry	Commercial, public, residential	Transformation centers

Sectors
Source: CNE, 1999

4.4.2 LAND USE

The total surface area of continental Chile is approximately 756,096 sq. kilometers. The "Inventory and Evaluation of Chile's Native Plant Vegetation" project report (CONAF-CONAMA-WORLD BANK, 1997) is the primary source used for this section and has provided information on land use throughout the country with some breakdown by municipality. Land use, in percentages, is shown in Figure 4.7.

FIGURE 4.7 Current land use

Source: "Inventory and Evaluation of Chile's Native Plant Vegetation" (CONAF-CONAMA-WORLD BANK, 1997)

The surface area corresponding to each use is shown in Figure 4.8. The largest areas correspond to desert (naked areas) 32.5%, and grasslands and brush with 27.2%. Chile's forests cover 15,647,894 hectares, representing 20.7% of the country's national territory.

FIGURE 4.8 Current land use

25000								
20000								
15000								
10000								
5000								
0								
Urban and indus-trial areas	Agri-culture	Grass-lands and brush	Forests	Wet-lands	Naked areas	Snow	Bodies of water	Unrecog nized areas

Source: "Inventory and Evaluation of Chile's Native Plant Vegetation" (CONAF-CONAMA, 1997)

Agricultural land and forest plantations (counted under the Forest category) cover some 6 million hectares. Between 1990 and 1996 the forestry and agriculture sector represented, on average, 7% of the Gross Domestic Product. The forestry and agriculture production structure in 1997 is shown in Figure 4.9 below.

FIGURE 4.9 Structure of Forestry and Agricultural production
SHARE OFGROSS PRODUCTION

Source: MINAGRI, 1997.

FRUIT PRODUCTION

In 1996-97, fruit growing was the main component of the gross value of production by sector, followed by livestock and annual crops. The total surface area of fruit crops during the period from 1993-96 increased by 4.2%. Changes in the composition of the supply of fruits are linked to export potential. The total surface area of fruit crops is shown in Figure 4.10.

FIGURE 4.10 Surface area for fruit crops

Source: MINAGRI, 1997

ANNUAL CROPS

The total surface area planted with annual crops during 1996-97 is shown below:

FIGURE 4.11 Annual crop surface area

Source: MINAGRI, 1997

AREA COVERED BY FORESTS

The area covered by forests, according to its composition, is shown below. Native forests account for 13,443,316 hectares, representing 85% of the surface area covered by forest and 17.8% of the country's total area. Forest plantations cover 2,118,836 hectares, representing 2.8% of the country's surface area. The distribution of forest by composition is shown in Figure 4.12.

Figure 4.12 Forests, by composition

Source: "Inventory and Evaluation of Chile's Native Plant Vegetation" (CONAF-CONAMA, 1997)

PROTECTED WILDLIFE AREAS

The National System of State Protected Wildlife Areas (SNASPE) consists of 90 land units covering 13,837,458 hectares. The figure below shows the areas classified under some category of protection (reserve, park, national monument) according to land use.

Figure 4.13 Areas protected by SNASPE, by use

Source: "Inventory and Evaluation of Chile's Native Plant Vegetation" (CONAF-CONAMA, 1997)

The SNASPE protection covers all types of vegetation. The protected areas corresponding to forests and wetlands represent the largest share (see Figure 4.14). Almost 30% of the country's forests are covered by SNASPE.

Figure 4.14 SNASPE protection according to land use

Source: "Inventory and Evaluation of Chile's Native Plant Vegetation" (CONAF-CONAMA, 1997).

The breakdown of the different forms of land use in Chile, along with the increasing globalization of the economy, lead us to think that in the future land use will greatly depend on the profitability of crops. Fruits and vegetables appear to be the crops with the most growth potential. In addition, a significant amount of crop substitution is expected due to international trade agreements such as MERCOSUR.

An increase in the exploitation of forest plantations and managed native forests is expected; however, initiatives aimed at fostering forestry, the reforestation of degraded land and protecting native forests will help better manage forestry.

Changes in land use will continue to reflect the regional specialization process if the trends observed at the beginning of this decade continue.

4.5 DESCRIPTION OF ACTIONS TAKEN BEFORE OR DURING THE IMPLEMENTATION OF THE FCCC

4.5.1 OBSERVATION NETWORKS AND SCIENTIFIC ACTIVITY

4.5.1.1 OBSERVATION NETWORKS

The Chilean Meteorological Agency (DMC) is responsible for operating and maintaining the country's meteorological observation networks. All of these are part of the World Meteorological Organization's Global Atmosphere Watch. In addition, the DMC administers the National Meteorological Database, which stores climate information dating back to 1950. This database is used for local and regional climate studies, studies on climate prediction using statistical methods and monitoring meteorological variables associated with the El Niño Southern Oscillation (ENOS).

At the end of 1995 the DMC began to measure the superficial ozone on Cerro Tololo, a vertical ozone profile on Eastern Island and, since 1996, spectrum ultraviolet radiation in Valdivia. These stations are part of the UNDP/GEF/WMO/DMC/RLA Project 193/G31/A/IG/31 "Network on ozone and greenhouse gases monitoring and research in the Southern Cone countries". Also, the DMC has a nine station ultraviolet radiation monitoring network throughout the country.

The universities and the DMC together observ e ultraviolet radiation and total ozone levels. In 1998 measures were taken to expand and redirect the monitoring of tropospheric ozone level activities. This was a coordinated effort involving the DMC, CONAMA and the universities and was done to include the analysis and classification at the Cerro Tololo station and, by doing so, gain experience and the ability to deal with diverse aspects of global change.

Oceanographic observations are carried out by the Navy Hydrographic and Oceanographic Service (SHOA). They have a tide station network all along the Chilean coast, including the islands and the Antarctic. The first of these stations was installed in 1941 and they continuously show the changes in sea level and surface temperature. Currently, the national tide network is made up of 19 permanent stations, which provided information that allowed us to follow the "El Niño – Southern Oscillation" phenomenon.

Other national institutions that are regularly observing environmental trends related to the evaluation of resources and climate forecasting are the Ministry of Public Works' General Water Division and the Chilean Navy's Meteorological Service.

4.5.1.2 SCIENTIFIC RESEARCH AND STUDIES

Many academic bodies along with public institutions and/or international organizations are carrying out research projects on global change.

- The University of Chile's Geophysics Department in the Faculty of Physical Sciences and Mathematics is doing research in the area of atmospheric science. More specifically, they are studying climate predictability using statistical models, numerical modeling of atmospheric phenomena and the interaction between the ocean and the atmosphere.

- The Faculty of Agronomy and Forestry of this same university has developed a computer model on the dynamics of desert encroachment and its socioeconomic impact on the rural population as a result of a future climate change.

- The University of La Serena is implementing research projects geared at developing atmospheric modeling tools for use in the Fourth Region. This is being done in cooperation with foreign universities and uses different aspects of meteorology and atmospheric chemistry. They will also work with the DMC and other institutions to expand and improve the tropospheric ozone monitoring station.

Other areas of study developed by the University of La Serena are listed below:

- Identifying environmental comfort indicators for tourism activities in order to compare current climate conditions and projected climate change trends for relative humidity and temperature for the cities of La Serena and Coquimbo.
- Identifying the variation of the semi-arid transitional ecosystem's water cycle given potential climate changes. This is done by analyzing variability trends for natural water bodies and specific water basins and sub-basins for which over 40 years of data is available.
- Evaluating the potential impact of climate change on sea level for the La Serena-Coquimbo area (Fifth Region).

For this study, global scale models were used to identify potential flood areas. These areas were mapped and the economic impact on the productive activities in these areas was evaluated.

- The Federico Santa María Technical University, Chemistry Department is installing a chemical analysis laboratory for atmospheric monitoring.

- The Catholic University of Valparaíso's Ocean Sciences School actively participated from 1991-97 in the "Joint Global Ocean Flux System, Chile" program. This was part of the International Geosphere-Biosphere Programme (IGBP) on global change. This project was also part of the scientific cooperation program between SAREC in Sweden and CONICyT in which the University of Concepción, Valparaíso and the Fishing Development Institute (IFOP) all participated.

This program made it possible to carry out an in depth study of ocean conditions along the central coast of Chile and yielded 7 years of ocean current measurements at different points along the Chilean coast.

- The National Environmental Commission (CONAMA) together with the Meteorological and Hydrological Institute of Sweden (SMHI) are working on a project aimed at developing the institutional ability to manage problems involving the atmospheric dispersion of substances. In the short term this would be used for regional pollution problems and, in the long term, for climate variability. This regional scale modeling project has been very successful in training Chilean professionals to use complex instruments for atmospheric modeling.

- As part of the Action Plan for the Protection of the Sea and Coastal Areas in the Pacific Southeast (CPPS/UNEP) a work group was created in Chile with representatives of various national institutions (state and academic). Their mission was to develop a study: the "Evaluation of the vulnerability of coastal areas and sea level rise as a result of global warming: Case Study on the Bay of Concepción" (1997). The methodology recommended by the IPCC was used to assess the vulnerability of coastal areas to a rise in sea level.

4.5.2 ACTIONS TAKEN IN THE ENERGY SECTOR

Just as in other countries, Chile has applied measures directly linked to the specific needs of various productive sectors, but these have not necessarily been developed under a climate change action plan or strategy. Some of these measures may have helped decrease the emissions of greenhouse gases, such as those adopted in the energy sector at the beginning of the 1970s after the oil crisis.

The fuel crisis in 1973 led most Chilean industries to foster energy efficiency projects and campaigns in order to reduce energy use (oil refineries, copper mines, the cellulose industry, etc.). However, unlike the mechanisms and programs developed in European countries, these efforts were not accompanied by complementary incentives to ensure they remain in place after the end of the crisis. Thus, the demand for power began to grow faster than the GDP once the recession of 1980 ended.

4.5.2.1 EFFICIENT ENERGY USE

In 1992 the CNE began an Efficient Energy Use Program that was financed through a combination of their own resources and bilateral cooperation funds. The program has focused on the diffusion of techniques and practices that would allow for a better use of energy and reduce consumption and its impact on the environment. The policy applied in the program's different areas of action (Residential, Municipal, Building, Industrial, Diffusion, and Training) is geared at promoting low and medium investment energy efficiency projects.

In the industrial sector, the program evaluated the energy use of 40 of the 66 companies with the highest energy consumption in Chile. An energy audit was conducted at some of these - results showed that with small investments energy use could be decreased by 10%.

In the municipal sector, the program spurred the replacement of municipal lights in 60% of Chilean municipalities. In building, an automatization project for public buildings was started. The CNE has also drawn up informative documents to promote the use of energy efficient building construction and appliance selection practices.

The Clean Production Department of CORFO and the CNE are working together to allocate funds for technical assistance (FAT) associated with efficient energy use in small and medium sized businesses.

Although all of these actions have an impact on reducing GHG emissions, this reduction has not been incorporated as an explicit policy objective in this program and its impact has not been evaluated. The potential and benefits of the efficient energy use program to indirectly reduce GHG emissions need to be evaluated. After this is completed, the program can be used to foster the use of these measures in rapid response and sensitive sectors, to identify the degree of difficulty in applying them in high energy consumption sectors, to identify barriers to the use of these practices, to facilitate technology transfer, and to identify costs and benefits and estimate feasible GHG reductions.

4.5.2.2 NON-CONVENTIONAL RENEWABLE ENERGY

The policies adopted in this area are consistent with Chile's global energy policy: non-conventional energy sources compete under equal conditions with traditional energy sources. These sources include solar thermal, photovoltaic, wind, geothermal, micro-hydroelectric and biogas energy generation.

The use of non-conventional renewable energy sources accounts for only .2% of primary energy use in Chile (CNE, 1993). Rural electricity generation seems to be one of the best places where this could be used. Using autonomous generation systems (such as photovoltaic, wind and micro-hydroelectric systems) to supply power to rural areas has an advantage in that the investment needed to extend the conventional electricity network is greater than that needed to develop these systems on a local scale.

In 1993, the share of each non-conventional energy source of the .2% of primary consumption was as follows:

- 89.8% Biogas
- 8.80% Micro-hydroelectricity
- 1.23% Solar thermal power
- .10% Solar photovoltaic electricity
- .07% Wind generation

Biogas

Found primarily in urban areas, especially Santiago, Valparaíso and Viña del Mar, where it is used on an industrial scale in very large sanitary landfills.

Solar energy

Used primarily in the north of Chile as this region has some of the highest solar radiation levels in the world. It is normally used to heat water for household use and for electricity generation for isolated and scattered homes.

Micro-hydroelectric plants

These plants make it possible to harness the energy potential of small water courses, using fairly modern technology, to supply electricity to towns in the south of Chile.

Wind power

Mainly used to pump water and for small aerogenerators.

Geothermal energy

This is abundant through Chile but has not yet been used for electricity generation. Currently, there is a bill in Congress on Geothermal Concessions that will establish a legal basis for the use of this resource.

Biomass

Two plants use forest waste as fuel and a third uses waste from paper plants to generate steam and electricity. The total installed capacity of the three plants is 37 MW.

4.5.3 ACTIONS TAKEN IN THE NON-ENERGY SECTOR

In the non-energy sector, which includes emissions from agriculture, changes in land use and forestry, measures aimed at sustainable resource management have also been applied. These must be evaluated in relation to climate change since they may have had a direct effect on the decrease of methane and CO_2 emissions as well as on the increase and/or continued existence of sinks.

Some of the best measures used include the improvement of agricultural practices for cattle management, forestry administration plans, forestation programs for energy purposes and the economic incentives legally established in Decree Law N°19,561 (1998) for forestation on fragile, eroded soils or those at a risk for desert encroachment.

These laws are particularly important because of the indirect effect their application may have on the increase of carbon dioxide sinks. Law N°19,561

(1998) is, in practice, the renewal of Executive Decree N°701 for an additional 15 years, until 2023, but it also modifies its focus and improves some of the administrative procedures.

The legal provisions of this law are based on the government's will to "regulate forestry activities on lands best suited for forestry and on eroded soils and to foster afforestation, especially by owners of small forest holdings and where necessary to prevent soil erosion and to protect and replenish the country's soils."

This new law to promote forestry combines social and environmental objectives. In social terms, it provides incentives to owners of small tracts of forest land and, in environmental terms, it combats desert encroachment by regulating forestry activity on eroded soil.

From an operational point of view, these laws allow for a one time tax credit for the following activities:

- Reforestation of fragile soils, marshes or areas threatened by desert encroachment.
- Recovery and forestation activities for eroded non-arable dry soils.
- Sand dune stabilization and forestation.

It is estimated that there are 200,000 potential beneficiaries, with around two million hectares of land for planting and 27 million hectares in need of protection or reforestation. This new law includes new forestry production options in order to diversify by using species of trees other than the traditional plantations of Radiata Pine and Eucalyptus. Options include the Australian Gum, elm, chestnut and Oregon pine.

Even when an analysis of mitigation options determines that native forests would benefit from the use of various instruments to decrease the number of hectares developed or replaced, this does not mean that these instruments will be used rationally and sustainably. For this reason, current legal provisions state that any intervention in a native forest that is not legally classified as a protected area (park, monument or national reserve), requires CONAF's authorization. To obtain this, a Forestry Management Plan and an Environmental Impact Study must first be presented and approved. The regional Conama office with jurisdiction must approve the environmental impact study. Forests classified as protected cannot be touched unless expressly authorized by law.

Chile has a Forest Law (D.S. N°4.363 from 1932) that establishes protective measures for native resources, but it is very general. A new body of laws that is up to date and geared toward the protection and sustainable management of our native forests is currently being reviewed by Congress: the Bill on Reclaiming Native Forests and Forestry Development. It was submitted to Congress for discussion in 1992.

5. IMPLEMENTATION OF THE UNITED NATIONS FRAMEWORK CONVENTION COMMITMENTS ON CLIMATE CHANGE

5.1 INSTITUTIONAL FRAMEWORK

5.1.1 NATIONAL ADVISORY COMMITTEE ON GLOBAL CHANGE

Given the increased importance of climate control in the country, both due to international negotiations and the beginning of cooperation projects in this area, it was necessary to create a body representing several institutions to serve as a forum for debate and to advise the government on climate control related decisions. For this purpose, on May 29, 1996, the National Advisory Committee on Global Change (CNAG) was created by the Ministry of Foreign Affairs through Supreme Decree N°466, published in the Official Newspaper on this same day.

In April 1998 its working structure was defined. Speci fic work groups were formed and an agenda of tasks was developed for the short and mid-term. The way in which this complex issue has been addressed and analyzed has gone much beyond this initial structure and has been gradually incorporated in the Government's environmental agenda.

The main roles of the CNAG are as follows:

- Advise the Ministry of Foreign Affairs on the definition of Chile's position on the Climate Change Convention, the Inter-American Institute for Research on Global Change and the Agreements on the depletion of the ozone layer.
- Advise the National Commission for the Environment on global change in Chile and the application of related plans and programs.
- Advise institutions working on global change research and all those that need or request such assistance.
- Act as a coordinating body among all the organizations whose work is linked to climate change and/or global change.

The National Commission for the Environment serves as the Chair of the Committee and the Ministry of Foreign Affairs as Vice-Chair.

Originally, the Supreme Decree that created the committee provided for representatives from the following institutions:

- Ministry of Agriculture
- National Energy Commission
- General Directorate of Maritime Territory and the Merchant Marine
- Chilean Meteorological Service
- The Chilean Naval Hydrography and Oceanography Service
- National Science and Technology Research Commission
- Chilean Academy of Science

As the matters to be discussed required the participation of many different institutions, in 1998 several other institutions were invited to join the Plenary Committee in order to have representation for other sectors related to economic development, such as production, business and for governmental administration bodies. The institutions invited to participate are listed below:

- Ministry of the Economy, Development and Reconstruction
- Ministry of Transportation and Telecommunication
- National Oil Company
- Production and Commerce Confederation
- Fundación Chile
- Chilean Copper Commission
- Chilean Copper Association
- Climate Action Network for Latin America
- Catholic University of Chile

The Plenary Committee will meet regularly to discuss important issues dealing with climate change. In order to sufficiently cover the matters dealt with by the committee, specific work groups were formed to address specific subjects such as technology transfer, change in land use, and the Kyoto Protocol adjustment mechanisms, among others. The work of these work groups is primarily geared at developing national positions on different issues and responding to the requirements created for signatory countries by the Conference of the Parties to the FCCC.

Depending on the nature and importance of the subjects, the Committee will turn to CONAMA's Board of Directors when decisions need to be made. This institutional framework has been important in dealing with climate change in Chile in an integral manner because it has allowed the highest political and environmental authorities in the country to begin to make decisions on such an important issue.

5.1.2 STRATEGIC GUIDELINES ON CLIMATE CHANGE IN CHILE: WORKING PLAN

One of the Committee's main duties has been the creation of the Strategic guidelines on climate change in Chile. These guidelines outline the Government's area of action so as to facilitate the implementation of its commitments in the Convention and the Protocol. They were approved on December 6, 1998 by the Board of Directors of the National Commission for the Environment and were used to prepare a Working Plan on Climate Change . The plan consists of specific actions to be taken in order to pursue the following main objectives:

- Reaffirm the commitments assumed in the FCCC

- Promote the ratification of the Kyoto Protocol

- Include the relevant sectors and Chilean specialists in discussions on the economic mechanisms set forth in the Kyoto Protocol

- Implement the Clean Development Mechanism (CDM)

- Design basic guidelines on new ways to limit and/or reduce the emission of greenhouse gases for developing countries

- Develop and implement a National Action Plan for Climate Control

- Create a special fund for technical and scientific research and training on climate control in Chile

The working plan describes these seven central guidelines, addresses financial and institutional aspects of implementing them and defines the desired results and actions to be carried out in order to obtain said results.

5.2 INTERNATIONAL REPRESENTATION

5.2.1 CHILE'S PARTICIPATION IN THE INTERNATIONAL NEGOTIATIONS ON THE CONVENTION AND THE KYOTO PROTOCOL.

Chile's presence at the meetings of the complementary bodies and the Conference of the Parties to the Convention, traditionally represented by the Ministry of Foreign Affairs, began to be supported by CONAMA and other national institutions in 1996. In point of fact, the number of delegates and meetings attended has increased since the first Conference of the Parties, demonstrating that national funds have been allocated for this purpose.

In addition to participating in the debate on important issu es during the international negotiation process of the FCCC (reviewing the commitments of the Addendum 1 countries, national communications, financial mechanisms, change in land use and forestry, flexible Kyoto Protocol mechanisms, etc.), Chile has also driven its own initiatives. These have to do with the country's desire to participate more actively in implementing its climate change commitments and other Parties to the FCCC have begun to support Chile's initiatives.

These initiatives refer to i) quickly implementing a demonstration phase for emissions reduction or carbon capture increase projects under the clean development mechanism. This will make it possible to begin to use this mechanism in the near future and the results would later be submitted to the rules and procedures that the Conference of the Parties (acting as the Meeting of the Parties in the Protocol) establishes for the Clean Development Mechanism (CDM). The second initiative (ii) recommends informal discussion to encourage the active participation of developing countries concerning the implementation of their climate change commitments.

5.3 INTERNATIONAL COOPERATION PROJECTS BEING CARRIED OUT OR COMPLETED

After signing and ratifying the FCCC, Chile is firmly committed to complying with the commitments therein, especially those in Article 4.1, paragraphs a) and b) on the elaboration and periodic updating of a greenhouse gas inventory and drawing up mitigation strategies, and Article 12 dealing with the transmission of information related to the application of the Convention (first national communications).

The role of international cooperation has been fundamental in generating this information and strengthening national institutional capacity to process it. This is essential if Chile hopes to fully understand the implications of climate change and design a coherent set of actions to address them. However, Chile's development priorities severely restrict the national resources available to study these issues, in spite of the will explicitly expressed by Chile from the time of the Río Summit to the present.

5.3.1 PRELIMINARY GHG NATIONAL INVENTORY, 1993

In 1996, Chile began to prepare a preliminary national Inventory of greenhouse gases for the year 1993, following the methodology proposed by the IPCC. This was part of a cooperation agreement between CONAMA and the United States Department of Energy (USDOE).

5.3.2 "REDUCTION OF GREENHOUSE GASES IN CHILE"

The "Reduction of Greenhouse Gases in Chile" project was begun in March 1996 and financed by the GEF. The primary objective was to identify and apply energy efficient measures or renewable energy alternatives to reduce CO_2 emissions produced by the burning of fossil fuels. This project was coordinated by both the National Energy Commission and CONAMA and also involved the local UNDP office.

This project yielded several results: an analysis to be used to create an Energy Sub-Service Company (ESSCO) within a large state mining complex and technical assistance for other mining companies in Chile. Currently pilot programs are being designed to incorporate energy efficiency measures in small and medium sized industries and innovative financing and technical assistance mechanisms are being developed for them.

In addition, this GEF project resulted in a pilot project to provide electricity to an isolated rural community by gasifying forest biomass for fuel. In this way, the burning of fossil fuels to generate electricity was avoided and thus expanded the technological options for rural electrification projects.

5.3.3 "TRAINING CHILE TO BE ABLE TO COMPLY WITH THE COMMITMENTS ASSUMED IN THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE"

Chile began this project in May 1997 to comply with the commitments assumed under the United Nations Framework Convention on Climate Change. The project was carried out under the Enabling Activities program financed by the GEF. Its main objective was to train the Government of Chile so it could draft this National Communication to the Conference of the Parties (CP) to the Convention.

The following activities were included in this project [18]:

a) Developing a Greenhouse Gas Inventory for the base year 1994, following the IPCC Methodology Guidelines that were revised in 1996. This made it possible to improve the 1993 Preliminary National Inventory by including sectors that had not been previously considered and provided a complete inventory for 1994. One of the main projects that came out of this was the development of software to periodically update the national inventory.
b) An analysis of the potential measures to mitigate the increase in greenhouse gas emissions in Chile. This was based on the guidelines developed by the United States Country Studies Program (USCSP) for this purpose. The analysis included the development of baseline scenarios for GHG emissions and the evaluation of mitigation measures and technological options.
c) An analysis of vulnerability and adaptation mechanisms for Climate Change in the Agriculture, Water Resources, Forestry, Coastal Areas and Fishing Resources sectors. This followed the IPCC Guidelines for vulnerability as well as the documentation provided by the USCSP.

In addition to providing information for the First National Communication, this project has raised the level of consciousness and knowledge on climate change related matters in Chile. It also has strengthened dialogue, information exchange and cooperation among all the relevant support institutions, including governmental and non-governmental institutions, academic bodies and the private sector.

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[18] Two studies were begun in January 1998: "Completing the national greenhouse gas inventory and analyzing mitigation options in the energy sector" and "Completing the national greenhouse gas inventory and analyzing mitigation options in the non-energy sector". The institutions in charge of carrying out these studies were the Energy Research Program (PRIEN) of the University of Chile and the Institute of Agricultural Research, INIA of the Ministry of Agriculture, respectively. The Analysis of Vulnerability and Adaptation in Agriculture, Water Resources and Forestry, begun in March 1998, was conducted by the AGRIMED Center, which is part of the Faculty of Agronomy and Forestry of the University of Chile. The Analysis of Vulnerability and Adaptation in Coastal Areas and Fishing Resources, begun in May 1998, is being conducted by the EULA Center of the University of Concepción.

5.3.4 "REMOVING BARRIERS TO RURAL ELECTRIFICATION PROJECTS WITH RENEWABLE ENERGY SOURCES"

This project began in mid-1999. It was designed to develop preparatory activities for a comprehensive program to use renewable energy sources for rural electrification in Chile. The following issues are addressed: the institutional structure for rural electrification, equipment standards and certification for renewable energy, promotion, training, financing, risk mitigation mechanisms, market assessments, measuring wind resources and investment projects for rural electrification.

5.3.5 SPONSORING PROJECTS ON JOINT IMPLEMENTATION ACTIVITIES

To gain experience in joint implementation activities (JIA), the Government of Chile, through the National Commission for the Environment, has sponsored the projects listed in Table 5.1.

5.3.6 SPONSORING CARBON CAPTURE RESEARCH PROJECTS

To improve our understanding of the role of forests in carbon capture CONAMA has sponsored the projects listed in Table 5.2.

TABLE 5.1 PROJECTS SPONSORED BY CONAMA FOR JOINT IMPLEMENTATION ACTIVITIES

PROJECTS	APPLICANT INSTITUTION
Río Condor Carbon Sequestration	Fundación Chile
Forestal Inversiones S.A. Carbon Sequestration	Fundación Chile
Wind Energy in Northern Chile	CODELCO / International Institute for Energy Conservation USA
Chile Natural Gas Project	International Greenhouse Partnership Office, Australia
CHILPAVE: Chile Cold Mix In Place Recycled Asphalt Pavement Greenhouse gas Reduction Project	Catholic University of Chile

Note: these projects are in early management stages (either in report stage to the FCCC Secretariat o in search of acceptance by Joint Implementation offices in developed countries, etc.).

TABLE 5.2 CO_2 CAPTURE PROJECTS SPONSORED BY CONAMA

PROJECTS	APPLICANT INSTITUTION
"Measuring Carbon Capture in Chilean Forests and its Promotion in the World Carbon Market"	CEFOR/Universidad Austral (Southern University of Chile)
"Demonstrating the increase in carbon capture in Chilean Forests by inoculating seedlings"	Forestry Institute

5.3.7 COOPERATION AGREEMENT BETWEEN THE US EPA AND CONAMA

Under the framework of a cooperation agreement between the United States Environmental Protection Agency (US EPA) and CONAMA, the government of Chile would like to further define and evaluate in detail the mitigation options identified during the studies, which were used as a basis for this First Communication.

Through this agreement the following components will be implemented:

- Evaluate the indirect benefits (co-benefits) of the adoption of mitigation measures in sectors not directly linked to emissions, particularly health benefits.[19]
- Analyze the macroeconomic impact of mitigation and/or climate change response measures.
- Assess the global benefits of environmental actions indirectly related to reducing GHG emissions or increasing GHG sinks (energy conversion or technologies incorporated in Decontamination Plans, forestry and agricultural programs, plans, and policies, scientific research, the design of environmental regulations, waste management, etc.).
- Evaluate the need to strengthen technical and institutional abilities for Chile's participation in the mechanisms defined in the Kyoto Protocol (especially for the CDM).
- Public education and training, including sensitizing business sectors, NGOs, the scientific and academic communities. Define strategies to include climate change in the formal and informal educational curricula, in social and economic sector decisions and at the highest political decision-making level.

[19] This study was begun in the middle of 1999.

6. RESULTS FROM THE GREENHOUSE GAS INVENTORY, THE MITIGATION OPTIONS ANALYSIS AND THE VULNERABILITY AND ADAPTATION ASSESSMENT

6.1 GREENHOUSE GAS EMISSION INVENTORIES

The 1993/94 inventories were performed for CONAMA by the institutions listed below.

- The University of Chile's Energy Research Program (PRIEN), which prepared the Energy, Industrial Processes and Solvent Use section.
- The Ministry of Agriculture's Agricultural Research Institute (INIA), which prepared the non-Energy sector inventory.

6.1.1 PRELIMINARY GREENHOUSE GAS INVENTORY, 1993

In 1996, under the agreement between CONAMA and the United States Department of Energy (USDOE), which is still in effect, Chile began the Preliminary National Greenhouse Gas Inventory for 1993, following the methodology proposed by the IPCC (Revised 1996 Guidelines). It was categorized as preliminary because it did not include the Industrial Processes and Solvent Use categories. Financing for this activity came from the United States Country Studies Program (USCSP).

Later, to comply with the commitments assumed in the Convention, the government of Chile presented a project to the GEF under the Enabling Activities program to complete the 1993 inventory, including the sectors mentioned above. The project also involved performing a National Greenhouse Gas Inventory for 1994. The methodologies and corresponding results of this second inventory will be described in detail later on in this report.

The preliminary exercise for 1993 provided the methodological foundation for future updating and made it possible to determine what changes should be introduced in future inventories in order to better reflect national conditions. The results are shown below for purely illustrative purposes, even though they are not for the FCCC reference year.

TABLE 6.1 EMISSIONS OF GHG AND OTHER GASES ENERGY SECTOR, 1993 (Gg)

	Greenhouse Gases			Other Gases			
Sector	CO_2	CH_4	N_2O	CO	NOx	NMVOC	SO_2
Energy Industry	6367.2	.4	.1	9.6	19.7	0.8	38.7
Manufacturing and Construction	10,195.4	3.3	.2	40.2	42.9	2.8	54.2
Transportation	11,968.4	1.8	.8	350.8	78.5	68.6	6.1
Commercial, Residential, institutional	3836.5	27.2	.4	438.1	14.0	52.6	25.9
Agriculture /fishing /forestry	579.7	.8	0.0	5.1	.7	.5	4.9
Fugitive Emissions	0.0	43.2	0.0	.6	.4	12.3	6.3
TOTAL	**32,947.2**	**76.7**	**1.5**	**844.2**	**156.2**	**137.6**	**136.2**

TABLE 6.2 GHG AND OTHER GAS EMISSIONS - INDUSTRIAL PROCESSES AND SOLVENT USE SECTORS, 1993 (Gg)

	Greenhouse Gases			**Other Gases**				
Sector	**CO_2**	**CH_4**	**N_2O**	**CO**	**NO_x**	**NMVOC**	**SO_2**	**HFC, PFC, SF6**
Industrial processes	-	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	1831.8	-
Cement	1030.7	-	-	-	-	-	0.8	-
Asphalt	-	-	-	-	-	30.4	-	-
Glass	-	-	-	-	-	0.2	-	-
Chemicals	-	1.9	.5	-	.7	.6	22.9	-
Steel and Iron	945.5	-	-	1.3	.1	.1	1.8	-
Iron Alloys	40.5	-	-	-	-	-	-	-
Paper and Pulp	-	-	-	9.3	2.5	6.1	12.2	-
Food and Beverages	-	-	-	-	-	23.2	-	-
Refrigeration,	-	-	-	-	-	-	-	0.0

Solvents								
Paint production	-	-	-	-	-	1.0	-	-
Industrial use of paint	-	-	-	-	-	8.9	-	-
Residential use of paint	-	-	-	-	-	7.0	-	-
Painting cars	-	-	-	-	-	7.4	-	-
Solvents for household use	-	-	-	-	-	2.6	-	-
Dry cleaners	-	-	-	-	-	1.0	-	-
Subtotal	**-**	**-**	**-**	**-**	**-**	**27.9**	**-**	**-**
Sector Total	**2016.7**	**1.9**	**.5**	**10.6**	**3.3**	**88.5**	**1689.5**	**0.0**

TABLE 6.3 AGREGATE EMISSIONS OF GHG AND OTHER GASES ENERGY SECTOR, INDUSTRIAL PROCESSES AND SOLVENT USE 1993 (Gg)

Sector	Greenhouse gases			Other Gases			
	CO_2	CH_4	N_2O	CO	NOx	NMVOC	SO_2
Energy	32,947.2	844.2	156.2	76.7	1.5	137.6	136.2
Industrial Processes	2016.7	10.6	3.3	1.9	.5	60.6	1869.5
Solvent Use	-	-	-	-	-	27.9	-
Total	**34,963.2**	**854.8**	**159.5**	**78.6**	**2.0**	**226.1**	**2005.7**
Total Gg of CO_2 equiv.	**34,963.9**	**9402.8**	**51,040**				

The results from the GHG Inventory for the Non-energy sector are provided in Table 6.4.

TABLE 6.4 GHG AND OTHER GAS EMISSIONS FOR THE NON-ENERGY SECTOR, 1993
(Gg)

	Greenhouse Gases			***Other Gases***	
Segment/sub-segment	***CO_2***	***CH_4***	***N_2O***	***CO***	***NO_x***
Agriculture:	***0.00***	***306.36***	***20.15***	***48.34***	***2.83***
Growing Rice	0.00	6.20	0.00	0.00	0.00
Raising livestock	0.00	297.86	7.16	0.00	0.00
Land cultivation	0.00	2.30	12.08	0.00	0.00
Burning fields			.08	48.34	2.83
Change in Land Use and Forestry	***-29,372.8***	***123.7***	***31.58***	***1082***	***30.73***
Forestry Management	-7481.2	0.00	0.00	0.00	0.00
Development	2569.3	4.9	1.24	42.60	1.21
Substitution	5581.4	5.4	1.39	47.6	1.35
High Grading	4376.1	0.0	0.0	0.0	0.0
Abandoned land (natural regeneration)	-41,870.6	0.00	0.00	0.00	0.00
Burning forest waste[20]		0.0	0.0	0.0	0.0
Forest fires	7452.3	32.80	8.38	287.2	8.16
Waste Management			***.83***		
Sewage			.83		
Sector Total Gg	**-29,372.8**	**430.06**	**51.73**	**1130.34**	**33.56**
Total Gg of CO_2 equiv.	**-29,372.8**	**4730.6**	**16553.6**		

6.1.2 GREENHOUSE GAS INVENTORY, 1994

The Greenhouse Gas Emission Inventory for 1994 was prepared with the following objectives in mind: i) fulfill Chile's commitment as a signatory country of the Convention to provide the Convention's Secretariat with a national inventory of all the GHGs not controlled by the Montreal Protocol and ii) determine the national availability of statistical information, in the terms stated by the IPCC methodology, identify information gaps and propose adjustments to said methodology when the specific situation of the country so requires.

This emissions inventory was divided into two sections: t he Energy Sector which includes all GHG emissions produced by the burning of energy sources,

[20] According to the methodology used, burning of forest residue does not lead to carbon dioxide emissions since this is biomass that is synthesized in a year and can be regenerated in one year.

either in industrial processes for input transformation or solvent use; and the Non-Energy Sector which refers to the GHG emissions produced by agriculture, forestry, changes in land use and waste management.

In preparing the inventory, software was developed for both sectors to obtain, manage and update data in the basic databases that are needed to calculate GHG emissions in accordance with IPCC methodology.

The calculation of emissions included those greenhouse gases controlled by the FCCC (CO_2, CH_4, and N_2O) as well as those classified in the category of Other Gases: (NOx, CO, NMVOC) and aerosols (SO_2)), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulfur hexafluoride (SF_6). However, the last three were included as controlled gases after the Third Meeting of the Conference of the Parties.

6.1.2.1 ENERGY SECTOR INVENTORY

The inventory for this sector included energy production and consumption, industrial processes and solvent use. The year 1994 is used since it is the base calculation year for the FCCC. The gases included are the following: CO_2, CH_4, and N_2O, NOx, CO, NMVOC, SO_2, HFC, PFC and SF_6.

The methodology used corresponds to the Guidelines set forth by the IPCC and includes the changes introduced in 1996. The emission coefficients used to calculate emissions were those default values proposed by the IPCC for use when no coefficients were available that reflected the conditions in the country.

Special treatment was given to emissions from the cellulose and copper mining industries. The importance of these sectors in the national economy and the uniqueness of the processes carried out in said industries makes them particularly interesting as far as methodology is concerned. This could help improve inventories in those countries where these activities play a similar role.

CO_2 emissions were calculated two ways. The first method uses the Reference Approach, which is based on determining the apparent consumption of each fuel[21] and calculating the corresponding CO_2 emissions through representative emission factors for each fuel, linked to the technology of the final user. The second method is the Final Use Approach, which is based on fuel consumption for each final use and calculating CO_2 emissions through the representative emission factors for each fuel, linked to the technology of the final user. For other gases the Final Use Approach and default emission factors are used, as recommended by the IPCC.

The information sources consulted include the National Energy Commission's (CNE) Energy Balance (this agency is the country's official energy information source), the University of Chile's Energy Research Program (PRIEN) studies, the Chilean Copper Commission (COCHILCO), IPCC guidelines and information provided directly by companies. The available data are aggregate at a national scale and for this reason it is not possible to characterize the behavior of sectors at a regional scale.

[21] Apparent consumption = production – imports – international bunkers – stock changes

The sectors studied, in accordance with IPCC and CNE classifications, were those listed in Tables 6.5 and 6.6 below.

TABLE 6.5 ACTIVITIES INCLUDED IN THE ENERGY SECTOR

Energy Sector	Sub-sector	Process
Energy Industries	Electricity and heat production Oil and natural gas refining Transforming solid fuel and other energy industries	Generating electricity Transforming gas and coke, coal and wood
Manufacturing and Construction	Iron Steel Non-alloy metals Chemical industry Cellulose and paper Processing food, beverages and tobacco Other	 Copper Petrochemicals Sugar Cement
Transport	Air[22] Truck Rail Sea Agriculture Fishing[23]	
Commercial, institutional, residential	Urban and rural residential Small, medium and large business. State, municipal and public lighting	
Agriculture, Forestry, Fishing	Agriculture Fishing	

To make the method applied easier to understand, the GHG emissions have been broken down into those produced by burning energy sources generated by industrial processes that transform inputs, both physically

[22] Due to the limited information available, the emissions and consumption of international aviation bunkers were not subtracted.
[23] The consumption and emissions for this sub-sector are included in the Ocean sub-sector, since they cannot be individually extracted from the official statistics.

and chemically, and those produced by solvent use. Emission sources selected and inventoried as industrial processes and solvent use, due to their importance in Chile[24], are shown in Table 6.6.

TABLE 6.6 INDUSTRIAL PROCESSES AND SOLVENT USE

Industrial Processes and Solvent Use	
Industrial Processes	Copper
	Cement
	Asphalt
	Glass
	Chemicals
	Steel and iron
	Iron alloys
	Paper and pulp
	Food and beverages
	Refrigeration, extinguishers and others
Solvent Use[25]	Paint Production
	Industrial Paint Use
	Residential Paint Use
	Paint for Automobiles
	Domestic use solvents
	Dry-cleaning

The results of the GHG Inventory for the Energy Sector, Industrial Processes and Solvent Use are shown in Tables 6.7, 6.8 and 6.9 below.

TABLE 6.7 EMISSIONS OF GHG AND OTHER GASES
ENERGY SECTOR, 1994
(Gg)

	Greenhouse Gases			Other Gases			
Sector	CO_2	CH_4	N_2O	CO	NOx	NMCOV	SO_2
Energy							
Energy Industry	8439.8	.2	.1	3.0	25.7	.6	58.8
Manufacturing and Construction	9255.3	1.6	.2	32.8	38.8	2.7	48.5
Transportation	12,695.3	2.1	1.1	378.3	77.7	74.2	6.1
Commercial, Residential, institutional	4049.6	28.9	.4	464.5	14.9	55.7	27.8

[24] Other emission sources mentioned in the IPCC Guidelines are not included because they are not found in Chile.
[25] The inventoried emissions in this subsector correspond to VOC. The information available makes it impossible to quantify the percentage of methane in the Total VOC emitted in the identified sources.

Agriculture /fishing /forestry	787.1	.7	-	6.0	4.6	1.1	5.0
Fugitive Emissions	-	40.7	-	.7	.4	13.2	6.8
TOTAL	**35,227.0**	**74.1**	**1.7**	**885.2**	**161.9**	**147.5**	**153.0**

Emissions estimates in the Industrial Processes and Solvent Use sub-sector are shown in Table 6.8 below.

TABLE 6.8 GHG AND OTHER GAS EMISSIONS
INDUSTRIAL PROCESSES AND SOLVENT USE, 1994
(Gg)

	Greenhouse Gases			Other Gases				
Sector	**CO_2**	**CH_4**	**N_2O**	**CO**	**NO_x**	**NMCOV**	**SO_2**	**HFC, PFC, SF6**
Industrial processes	-	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	1775.3	-
Cement	1021.1	-	-	-	-	-	0.8	-
Asphalt	-	-	-	-	-	45.6	-	-
Glass	-	-	-	-	-	0.2	-	-
Chemicals	-	2.1	0.8	-	1.0	0.7	24.5	-
Steel and Iron	812.2	-	-	1.2	0.1	0.1	1.8	-
Iron Alloys	36.7	-	-	-	-	-	-	-
Paper and Pulp	-	-	-	9.8	2.6	6.5	12.7	-
Food and Beverages	-	-	-	-	-	24.7	-	-
Refrigeration, extinguishers, others	-	-	-	-	-	-	-	0.0
Subtotal	**1870.0**	**2.1**	**0.8**	**11.0**	**3.7**	**77.8**	**1815.1**	**0.0**
Solvents								
Paint production	-	-	-	-	-	1.0	-	-
Industrial use of paint	-	-	-	-	-	9.3	-	-
Residential use of paint	-	-	-	-	-	6.9	-	-
Painting cars	-	-	-	-	-	7.5	-	-
Solvents for household use	-	-	-	-	-	2.6	-	-
Dry cleaners	-	-	-	-	-	1.0	-	-

Subtotal	-	-	-	-	-	28.4	-	-
Sector Total	**1870.0**	**2.1**	**0.8**	**11.0**	**3.7**	**106.2**	**1815.1**	**0.0**

The aggregate figures for the Energy Sector are shown in Table 6.9.

TABLE 6.9 TOTAL EMISSIONS OF GHG AND OTHER GASES ENERGY SECTOR, INDUSTRIAL PROCESSES AND SOLVENT USE 1994 (Gg)

Sector	Greenhouse gases			Other Gases			
	CO_2	CH_4	N_2O	CO	NOx	NMCOV	SO_2
Energy	35,227[26] 35,392.2[27]	74.2	1.8	885.3	162.1	147.5	153.0
Industrial Processes	1870	2.1	.8	11	3.7	77.8	1815.1
Solvent Use	-	-	-	-	-	28.4	-
Total	**37,097**	**76.3**	**2.6**	**896.3**	**165.8**	**253.7**	**1968.1**

ANALYSIS OF RESULTS

In 1994 the energy, industrial processes and solvent use sectors were responsible for emitting 37,097 Gg of CO_2; the energy sector accounted for 95% of those emissions. CO_2 emissions calculated using the Reference Approach and Final Use Approach methods show no significant differences.

Analyzing CO_2 emissions linked to fuel consumption shows the importance of trucking (36%), thermoelectric power generation (24%), manufacturing and construction (26%) as emissions sources.

As far as the emissions of other gases by this sector are concerned, truck transport remains a significant source accounting for 65% of N_2O emissions, 48% of NOx, 52% of CO, and 50% of NMCOV emissions. Right below transport in terms of emissions is the Residential, Institutional and Commercial sector with 24% of N_2O, 9% of NOx, 52% of CO, and 38% of NMCOV. Fugitive emissions account for 55% of total methane gas emissions by this sector. The main source of SO_2 emissions is the copper industry.

Industrial processes are significant causes of aerosol precursor emissions (SO_2) and ozone (NMCOV). Their relative contribution to GHG emissions with direct effects does not appear to be significant.

The energy sector inventory was prepared using aggregate figures on a national scale. For this reason, it is not possible to identify the behavior of each sector on a regional scale, although this information would be important for identifying, designing and evaluating mitigation options. For the inventory year, the information available at CNE was aggregate energy consumption for the Residential, Commercial and Public sectors; a breakdown of this information is only possible after 1997.

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[26] Final Use Approach.
[27] Reference Approach.

The periodic updating of this inventory is definitely needed, due to the influence of future structural changes[28] on GHG emissions and the growth of some of the main variables that determine said emissions in the future. This growth creates a significant amount of uncertainty. The importance of updating the inventory is even greater because the results are needed to identify which sectors are responsible for emissions and have mitigation potential.

6.1.2.2 INVENTORY FOR THE NON-ENERGY SECTOR

The inventory for the Non-energy sector was prepared using the IPCC/OECD revised 1996 guidelines and included three segments:

- Agriculture
- Change in Land Use and Forestry
- Waste Management

According to these methodological guidelines, the data gathered corresponds to the years 1993,1994 and 1995; however, to reduce the impact of atypical and/or extreme environmental conditions on the inventory, a three-year average of the figures has been used. The gases studied were CO_2, CO, CH_4, N_2O, NOx and NMCOV. The availability of statistical information at a regional scale made it possible to design the inventory as the sum of regional inventories.

In preparing the inventory, software was developed to collect, manage and update the data needed to calculate emissions, in accordance with IPCC guidelines.

The method included emissions sources and sinks for the gases listed in Table 6.10.

[28] For example: public transportation vs. private transfportation, construction and materials systems, major changes in energy systems, changes in world markets affecting the country's main export products.

TABLE 6.10 CATEGORIES OF GHG SOURCES AND SINKS INCLUDED IN THE NON-ENERGY SECTOR

Sector	Inventoried Emissions
Agriculture	CH_4 emissions from rice growing and domestic cattle raising. Emission of trace gases of C and N[29] from cultivated land. Emission of trace gases of C and N from burning agricultural waste.
Forestry	CO_2 capture by increasing biomass in managed native forests and planted forests. CO_2 capture by increasing the biomass of non-forest trees (urban and others). CO_2 emission from harvesting forests (wood, firewood, charcoal, and wood chips). Emission of trace gases of C and N from burning tree biomass in and ex-situ.
Change in Land Use	Emission of CO_2 and trace gases of C and N from developing land (eliminating forest covering and replacing crops or grasslands). Emission of CO_2 and trace gases of C and N from replacing native forests with planted forests [30] or high grading. Emission of CO_2 from the urbanization of rural land. Capture of CO_2 from the regeneration of forest and tree vegetation on abandoned lands.
Waste management	CO_4 emissions from the anaerobic treatment of household sewage, liquid industrial waste, domestic solid waste and industrial solid waste.

The information sources consulted were the following: National Statistics Institute (INE), Office of Agricultural Studies and Policies (ODEPA), Ministry of Planning and Cooperation (MIDEPLAN), the United Nations Food and Agriculture Organization (FAO), National Forestry Corporation (CONAF), Forestry Institute (INFOR), CONAMA, Superintendency of Sanitation Services (SISS), Ministry of Health (MINSAL), Environmental Health Services of Chile (SESMA), the Metropolitan Sanitation Works company (EMOS), the Metropolitan Solid Waste company (EMERES), KDM-KIASA, the European-Latin American Center (EULA) and sanitation companies.

The judgement of Chilean specialists, the use of national studies and specialist surveys were used as substitutes for the specific statistical information needed for the IPCC methodologies when the statistics were not available.

[29] CO, CH_4, N_2O, Nox and

[30] The method defines net emissions in the year of occurrence as the difference between the original biomass and the accumulated biobass one year after substitution. The accumulated biomass, in turn, is defined as the sum of the biomass remaining after the substitution and that accumulated by the plantation in one year.

Emission factors and/or default conversions proposed by the IPCC were used when information for Chile was not available.

METHODOLOGICAL ADAPTATIONS

The IPCC/OECD revised guidelines (1996) were used for the Agriculture and Waste Management segments without major changes. However, the methodology for the second segment, Changes in Land Use and Forestry, had a weak structure and did not reflect the conditions in Chile. Although the development of forestry in Chile would justify giving it the same treatment as agriculture, the close link between forestry management and changes in land use made it necessary to combine these two areas.

The IPCC guidelines represent conditions similar to humid tropical regions where the deforestation of rain forests occurs on a huge scale. The method, however, does not adequately reflect current forestry conditions and changes in land use in Chile. Therefore, it was necessary to modify the methodology while still maintaining the original methodological foundations.

The current national conditions that made it necessary to modify the methodology used for the inventory are listed below.

- The methodology proposed by the IPCC deals with the sub-category "Conversion" as the transformation of forests and grasslands into croplands or pastures. However, in Chile, conversion activities correspond to the loss for forested areas due to the development of agricultural land, the substitution of planted forests and urbanization. The objective of Supreme Decree N° 701 is to reincorporate the productive use of a portion of the large surface area of degraded forest land and provide economic incentives for reforestation. In practice, these incentives have led to a rapid expansion of the surface area of planted forests by replacing degraded native forests and alluvial agricultural land.
- The "Abandoned" sub-category includes abandoned arable land and pastures. In Chile, although development - abandoned cycle does exist, it does not have the same characteristics as those in the IPCC method. The reason for this is that land was developed (primarily by eliminating forest coverage) on a massive scale between the Eighteenth Century and the first third of the Twentieth century, not just to provide land for crops but also to provide room for planted forests. The abandonment of this usable land, in turn, occurred during the second half of the Nineteenth century and the beginning of the Twentieth century due to water erosion in forest lands converted for agricultural and livestock use.
- Forest fires in Chile consume very large areas of forest plantations and native vegetation every year. In the first case, the fire is equivalent to the burning of forest waste since replanting takes place immediately afterward. In the second case, the fire is the equivalent of two actions

(conversion and abandonment) since it creates an area where regeneration is left to the forces of nature.

- The method proposed by the IPCC does not consider Urbanization to be an action that irreversibly decreases the support capacity of vegetation. Chile is experiencing an accelerated change in land use from rural to urban, which reduces the surface area suitable for high-density vegetation. This change has a legal connotation when the land then forms part of the urban area and a non-legal connotation when the land is then used for condominiums or residential plots.
- The abandonment of agricultural land, high grading, clear-cutting and forest fires have led to large areas of land with little or no human intervention where native vegetation is being regenerated. According to the methodological guidelines, this area cannot be classified as abandoned; however, it has been classified as such since a net carbon capture is produced and it is predicted that within one hundred years its use will be environmentally sustainable. Furthermore, the available statistical information makes it impossible to separate abandoned land into the agricultural, native forest, and burned land categories.

Thus, the methodology used for Forestry and Changes in Land use was modified in order to include the GHG emission and capture processes shown in Table 6.11 below.

TABLE 6.11 ADDITIONAL SUB-SEGMENTS INCLUDED IN THE CHANGE IN LAND USE AND FORESTRY SEGMENT

Sub-segment	Origin of emissions and/or capture	Observed change in use
Change in forest stock and other wood biomass or forestry management	· Annual CO_2 capture from the yearly increase of biomass in planted forests and managed native forests. · Annual emissions of CO_2 from harvesting forests (logs, charcoal, chips, wood).[31]	
Conversion[32]	· CO_2 emissions from the felling of forest biomass, debris mineralization and the oxidation of C in the soil and the emission of traces gases from in and ex-situ burning of part of the felled biomass. · Emission of CO_2 by reducing	· Developing land (eliminating the forest coverage and replacing it with crops and grassland. · Substitution (eliminating the native depleted

[31] The emission of trace gases from in site burning of waste from forestry management was included in the sub-category "Burning of forest waste".

[32] Should be read as a loss in wooded surface area.

	the forest biomass by secondary use of the high graded[33] forest and the emission of trace gases by the in and ex-situ burning of part of the felled biomass.	forest coverage and replacing it with planted forests). · High grading (harvesting wood, logs or chips or using the best trees in the forest for *metro ruma*.
Urbanization	· Emissions of CO_2 from the reduction in the support capacity of vegetation on developed lands.	· Building condominiums and recreational land.
Abandonment	· CO_2 capture from the regression to bush/tree vegetation on abandoned lands (abandoned agricultural land, felled or high graded forests. · CO_2 capture from the regression of natural biomass on burned lands.	·
Burning of forest biomass	· Emission of CO_2 from the mineralization of some of the forest waste generated on forest plantations and managed native forests. · Emission of trace gases from in and ex-situ burning of some of the waste generated in planted forests[34] and managed native forests. · Emissions of CO_2 and trace gases produced by the in and ex-situ burning of plant biomass in forest fires.	·

Results

The results of the GHG Inventory for the Non-Energy Sector are shown in Table 6.12.

[33] High grading refers to felling the best trees in the forest and the resulting depletion of the ecosystem. The regeneration of the high graded forests were included in the sub-segment "Forestry Management".

[34] Just as with agricultural waste, it is assumed that the burning of forest waste does not create CO_2 emissions since this is synthesized biomass within one year and can be regenerated within one year.

TABLE 6.12 GHG AND OTHER GAS EMISSIONS FOR THE NON-ENERGY SECTOR, 1994
(Gg)

	Greenhouse Gases			*Other Gases*		
Segment/sub-segment	***CO_2***	***CH_4***	***N_2O***	***CO***	***NO_x***	***NMCOV***
Agriculture:	***0.00***	***321.79***	***20.64***	***50.35***	***2.88***	***2.59***
Growing Rice	0.00	6.40	0.00	0.00	0.00	0.00
Raising livestock	0.00	313.00	0.00	0.00	0.00	0.00
Leaching	0.00	0.00	3.58	0.00	0.00	0.00
Land cultivation	0.00	0.00	15.90	0.00	0.00	0.00
Burning fields	1223.64	2.40	1.98	50.35	2.88	2.59
Change in Land Use and Forestry	***-29709.27***	***111.33***	***0.77***	***974.153***	***27.66***	***50.64***
Forestry Management	-1899.70	0.00	0.00	0.00	0.00	0.00
Development	2629.94	4.94	0.03	43.20	1.23	2.22
Substitution	5451.95	7.54	0.05	65.99	1.87	3.40
High Grading	6917.01	7.37	0.05	64.47	1.83	3.32
Abandoned land (natural regeneration)	-50917.06	0.00	0.00	0.00	0.00	0.00
Burning forest waste[35]	17940.44	58.42	0.40	511.20	14.52	26.33
Forest fires	7856.34	33.06	0.23	289.30	8.22	15.37
Urbanization	252.24	0.00	0.00	0.00	0.00	0.00
Waste Management	***0.00***	***83.97***	***0.67***	***0.00***	***0.00***	***0.00***
Sewage	0.00	0.15	0.67	0.00	0.00	0.00
Liquid industrial waste	0.00	10.08	0.00	0.00	0.00	0.00
Household solid waste	0.00	73.74	0.00	0.00	0.00	0.00
Industrial solid waste	0.00	0.00	0.00	0.00	0.00	0.00
Sector Total Gg	**-29709.27**	**517.10**	**22.08**	**1024.5n**	**30.54**	**53.24**
Total Gg of CO_2 equiv.	**-29709.27**	**5688.1**	**7065.6**			

Considering that the Non-Energy Sector includes CO_2 capture mechanisms and that the net balance is provided in the inventory, it is important to see which actions occur in the emission mechanism and which in the capture mechanisms. Table 6.13 below shows the Change in Land Use and Forestry actions and processes that produce CO_2 emissions or capture.

[35] According to the methodology used, the burning of forest waste does not produce CO_2 emissions.

TABLE 6.13 BALANCE OF CO_2 CAPTURE AND EMISSIONS IN THE CHANGE IN LAND USE AND FORESTRY CATEGORY, 1994 (Gg)

Action or process	Emissions	Capture	Net Balance
Forestry management	34,935.84	36,835.54	-1899.7
Forest Fires	7856.34	0.0	7856.34
Land Development	2629.94	0.0	2629.94
Substitution	5451.95	0.0	5451.95
High Grading	6917.01	0.0	6917.01
Burning Waste[36]	17,940.44	0.0	17,940.44
Abandonment	0.0	50,917.06	-50,134.12
Urbanization	252.24	0.0	252.24
Total	58,043.33	-87,752.6	-29,709.27

ANALYSIS OF RESULTS

The global balance of greenhouse gas emissions and capture shows a net capture of 29,709.3 Gg CO_2 per year, mainly from the regeneration of native forests in a huge abandoned surface area (57.6%). The other 42.4% came from the expansion of forest biomass, primarily through planted forests.

Of the remaining gases, CO was the most abundant (1024.5 Gg / year), followed by CH_4 (517.1 Gg / year). All the Nitrogen oxides combined total 50.8 Gg / year. CO was mainly produced by the in and ex-situ burning of forest biomass (change in use, waste, burning) and burning agricultural waste (4.9%). Sixty-two point two percent of the CH_4 was produced by agricultural activities (primarily domestic cattle raising). The anaerobic management of waste contributed 16.2% of total emissions and burning forest biomass (in and ex-situ) contributed 21.5%.

NOx emissions totaled 50.8 Gg / year: 42.7% in the Agriculture category, primarily from soil cultivation, 55.9% from the Change in Land Use and Forestry category, mainly from the burning of forest waste, and 1.3% in Waste Management, from the runoff of untreated sewage.

However, when you apply caloric equivalence factors the situation changes significantly. Thus, the 517.1 Gg of CH_4 becomes 5688.1 Gg of CO_2 equivalent and 22.08 Gg of N_2O becomes 7056 Gg of CO_2 equivalent, with a real net capture for the Non-Energy Sector of 16,172.6 Gg / year of CO_2 equivalent. The balance, which is favorable for CO_2 capture in the end, shows that the country increased its carbon capital due mainly to the regeneration of native vegetation over large extensions of abandoned land left to natural regeneration and the expansion of the surface area used for planting forests.

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[36] Idem

6.1.2.3 TOTAL GREENHOUSE GAS EMISSIONS INVENTORY, 1994

The inventory of aggregate emissions for the Energy and Non-Energy Sectors is shown in the table below.

TABLE 6.14 TOTAL EMISSIONS INVENTORY OF GREENHOUSE GASES, 1994 (Gg)

Sector	Greenhouse gases			Other Gases			
	CO_2	CH_4	N_2O	CO	NOx	NMCOV	SO_2
Energy	35,227	74.2	1.8	885.3	162.1	147.5	153.0
Industrial Processes	1870	2.1	.8	11	3.7	77.8	1815.1
Solvent Use	-	-	-	-	-	28.4	-
Subtotal	37,097	76.3	2.6	896.3	165.8	253.7	1968.1
Non-energy							
Agriculture	0.0	321.8	20.64	2.9	50.4	2.6	-
Forestry and Change in Land Use	-29,709.3	111.3	0.8	27.7	974.2	50.6	-
Waste Management	0.0	84.0	0.7	0.0	0.0		-
Subtotal	-29,709.3	517.1	22.08	30.6	1024.6	53.2	-
Country Total Gg (1994)	**7387.3**	**593.4**	**24.68**	**196.4**	**1920.9**	**306.9**	**1968.1**

The emissions shown in Table 6.14 correspond to the net values for each sub-sector. The Energy, Industrial Processes and Solvent Use sector produces net emissions equal to their gross emissions since there are no capture mechanisms in this sector. The Non-Energy sector, however, has net emissions from the balance between gross emissions and capture. The aggregate balance of sources and sinks is shown in Table 6.15 below.

TABLE 6.15 AGGREGATE BALANCE OF CO_2 SOURCES AND SINKS FOR THE YEAR1994 (Gg)

Sector	Emissions	Capture	Net Balance
Energy / Ind. Processes / Solv.	37,097	0.0	37,097
Non-Energy	58,043.3	87,752.6	-29,709.3
Totals	95,140.3	87,752.6	7387.7

The aggregate emissions balance for 1994 in Gg of CO_2 equiv. is shown in Table 6.16.

TABLE 6.16 AGGREGATE BALANCE OF GHG EMISSIONS (Gg OF CO_2 equiv.) for 1994

Sector	CO_2	CH_4	N_2O	Total
Energy / Ind. Processes / Solv.	37,097	839.3	832	38,768.3
Non-Energy	-29,709.3	5688.1	7065.6	-16,955.6
Totals	**7387.7**	**6527.4**	**7897.6**	**21,812.7**

Figures 6.1 to 6.3 show the relative contributions of the Energy and Non-Energy Sectors to the total emissions of CO_2, CH_4, and N_2O.

Figure 6.1 Sector contributions to CO_2 emissions, 1994

Figure 6.2 Relative sector contributions to CH_4 emissions, 1994.

Figure 6.3 Relative sector contributions to N_2O emissions, 1994

ANALYSIS OF THE RESULTS

The aggregate inventory of all the GHG sources and sinks in Chile during the base inventory year 1994 showed net emissions of CO_2 of 7387.7 Gg, from 95,140.3 Gg emitted and 87,752.6 Gg captured. The greatest sources during this year came from the Non-Energy sector with emissions totaling 58,043.3 Gg of CO_2.

As for the other gases studies, there were 593.4 Gg of CH_4, primarily from agriculture, 1921.0 Gg of CO produced fairly equally by the Energy, Industrial Processes, Solvent Use and Non-Energy sectors. There were 24.68 Gg of N_2O, mainly from agriculture and 196.4 Gg of NOx, primarily from burning energy sources. The inventory also shows SO_2 emissions: 1968 Gg from the copper industry.

The data used to prepare the inventories, however, do not have the same geographic breakdown. For the Energy, Industrial Processes and Solvent Use sector national figures were used. For the Non-Energy sector (Agriculture, Change in Land Use and Forestry, and Waste Management) regional information was used. In order to better characterize the emissions pattern and evaluate the feasible mitigation measures for each sector both inventories need to be done on compatible regional scales.

It is also necessary to update these inventories so that information on the following factors is available: trends, sensitive areas, inventory response to climatic conditions (especially drought), economic conditions (international price fluctuation, energy interconnection, etc.), the evolution of technological aspects and possible changes in processes in certain branches, sub-sectors and/ or processes, and other significant variables. This information could then be used to propose and assess which mitigation options are feasible, their costs and benefits and, finally, the social players affected by these costs and benefits.

It is important to note that the software used to gather, manage and update the basic data was developed for each individual sector. This software represents a very valuable tool that can be used to update this national communication. However, it will first be necessary to combine the programs into one user-friendly, consistent and useful software program for both sectors combined.

ACRONYMS, UNITS AND CHEMICAL COMPOUNDS

ACRONYMS

AGRI	Agricultural land use variation simulation model
AGRIMED	Center for Agricultural and Environmental Studies, Faculty of Agronomy and Forestry, University of Chile
JIA	Joint Implementation Activities
APEC	Asia Pacific Economic Community
CEFOR	Center for Forestry Studies of the Chilean Southern University
CM	Cellulose obtained using mechanized processes
FCCC	Framework Convention on Climate Change
CNE	National Energy Commission
COCHILCO	Chilean Copper Commission
CODELCO	Chilean Copper Corporation
CONAF	National Forestry Corporation
CONAMA	National Environmental Commission
CONICYT	National Science and Technology Research Commission
COP	Conference of the Parties to the UN FCCC
CORFO	Production Development Corporation
CPPS	Southern Pacific Permanent Commission
CQ	Chemically obtained cellulose
DIRECTEMAR	General Ocean Territory and Merchant Marine Division
DMC	Chilean Meteorological Division
EMERES	Metropolitan Solid Waste Company
EMOS	Metropolitan Sanitation Works Company
ENOS	El Niño Southern Oscillation
EULA	European – Latin American International University Environmental Science Research and Training Center
EX-SW	Solvent Electro-obtaining metallurgical extraction process.
FAO	United Nations Food and Agriculture Organization
TAF	Technical Assistance Fund

WEF	World Environment Fund
GCM	General Circulation Models
GEF	Global Environmental Facility
GHG	Greenhouse Gases
GFDL	Geophysical Fluid Dynamics Laboratory
GISS	Goddard Institute of Space Studies
IFOP	Fishing Development Institute
INE	National Statistics Institute
INFOR	Forestry Institute
INIA	National Agricultural Research Institute
INDAP	Agricultural Development Institute
JGOFS	Joint Global Ocean Flux System
CDM	Clean Development Mechanism
MEPLAN	National Model for the Strategic Analysis of Investment, Prices and Regulation. Planning Division, Ministry of Public Works
MERCOSUR	Economic Community of the Latin American Southern Cone countries
MIDEPLAN	Ministry of Planning and Cooperation
MINAGRI	Ministry of Agriculture
MINSAL	Ministry of Health
ODEPA	Office of Agricultural Studies and Policy
OECD	Organization for Economic Cooperation and Development
WMO	World Meteorological Organization
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
PRIEN	Energy Research Program, Faculty of Physical Science and Mathematics, University of Chile
SESMA	Environmental Health Services
SESEFE	Energy Efficiency Services sub-company
SHOA	The Chilean Navy's Hydrographic and Oceanographic Service
SIC	Central Interconnected System
SIMPROC	Agricultural Productivity Simulation Model
SING	Norte Grande Interconnected System

SISS	Superintendency of Sanitation Services
SMHI	Swedish Meteorological and Hydrological Institute
SNASPE	National State Protected Wildlife System
SUBPESCA	Deputy Secretariat of Fishing
TMP	Cellulose obtained using a chemical – heat – mechanized process
UKMO	United Kingdom Meteorological Office
USCSP	United States Country Studies Program
USDOE	United States Department of Energy
US EPA	United States Environmental Protection Agency

UNITS AND THEIR EQUIVALENCIES

1 Ggtc = 1 Gigaton = 10^9 tons
1 Gg = 1 Gigagram = 10^9 grams
1 ton = 10^6 grams
1 Tg = 1 Teragram = 10^{12} grams
1 Tcal = 1 Teracalorie = 10^{12} calories
1 ppm = one part per million in volume
1 ppbv = one part per billion in volume
1 ha = 1 hectare = 10,000 square meters
msnm = meters above sea level

CHEMICAL COMPOUNDS

C	Carbon
CFC	Chlorofluorocarbons
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
HCFC	Hydrochloro-fluorocarbons
HFC	Hydrofluorocarbons
PFC	Perfluorocarbons
N_2O	Nitrous Oxide
NOx	Nitrogen Oxides
O_3	Ozone
SF_6	Sulfur hexafluoride
SO_2	Sulfur Anhydride
VOC	Total Volatile Organic Compounds
COVNM	Non-Methane Volatile Organic Compounds