Ministerio del Medio Ambiente
Gobierno de Chile

SNIChile
Sistema Nacional de Inventarios de Gases de Efecto Invernadero

CHILE'S NATIONAL GREENHOUSE GAS INVENTORY, 1990-2010

CLIMATE CHANGE OFFICE
MINISTRY OF THE ENVIRONMENT OF CHILE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

2NC	:	Second National Communication of Chile to the United Nations Framework Convention on Climate Change
1996GL	:	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories
2000GPG	:	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
2006GL	:	2006 IPCC Guidelines for National Greenhouse Gas Inventories
AD	:	Activity data
Aduanas	:	National Customs Service (Servicio Nacional de Aduanas)
AFOLU	:	Agriculture, forestry and other land use
ASPROCER A.G.	:	Pork Producers Trade Association of Chile (Asociación Gremial de Productores de Cerdos de Chile)
BNE	:	National Energy Balance (Balance Nacional de Energía)
BOD	:	Biochemical oxygen demand
BUR	:	Biennial Update Report
CH_4	:	Methane
CNE	:	National Energy Commission (Comisión Nacional de Energía)
CO	:	Carbon monoxide
CO_2	:	Carbon dioxide
CO_2eq	:	Carbon dioxide equivalent
COCHILCO	:	Chilean Copper Commission (Comisión Chilena del Cobre)
COD	:	Chemical oxygen demand
CONAF	:	National Forestry Corporation (Corporación Nacional Forestal)
CONAMA	:	National Environmental Commission (Comisión Nacional del Medio Ambiente)
CRI	:	Regional Research Center (Centro de Investigación Regional)
DGAC	:	Directorate General of Civil Aviation (Dirección General de Aeronáutica Civil)
EF	:	Emission factor
FAO	:	United Nations Food and Agriculture Organization
FAOSTAT	:	FAO statistical database
FOD	:	First order decay
Gg	:	Gigagrams
GHG	:	Greenhouse gas
GL-UNFCCC-BUR	:	UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention

GL-UNFCCC-NC	:	Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention
GPG-LULUCF	:	IPCC Good Practice Guidance on Land Use, Land-Use Change and Forestry
GWh	:	Gigawatt hour
GWP	:	Global warming potential
HFCs	:	Hydrofluorocarbons
HHV	:	Higher heating value
IEA	:	International Energy Agency
INE	:	National Statistics Bureau (Instituto Nacional de Estadísticas)
INFOR	:	Forestry Institute of Chile (Instituto Forestal de Chile)
INIA	:	Agricultural Research Institute (Instituto de Investigaciones Agropecuarias)
IP	:	Industrial processes
IPCC	:	The Intergovernmental Panel on Climate Change
IPPU	:	Industrial processes and product use
LHV	:	Lower heating value
LIW	:	Liquid industrial waste
LKD	:	Lime kiln dust
LULUCF	:	Land Use, Land Use Change and Forestry
MINAGRI	:	Ministry of Agriculture
MINENERGIA	:	Ministry of Energy
MINSAL	:	Ministry of Health
MMA	:	Ministry of the Environment
MSW	:	Municipal solid waste
M_W	:	Moment magnitude
N_2O	:	Nitrous oxide
NCs	:	National Communications
NGHGI	:	National Greenhouse Gas Inventory (Inventario nacional de gases de efecto invernadero)
NIR	:	National Greenhouse Gas Inventory Report (Informe del inventario nacional de gases de efecto invernadero)
NMVOC	:	Non-methane volatile organic compounds
NO_x	:	Nitrogen oxides
ODEPA	:	Office of Agrarian Studies and Policies (Oficina de Estudios y Políticas Agrícolas)
ODS	:	Ozone depleting substances
ODU	:	Fraction oxidized during use
PFCs	:	Perfluorocarbons

QA/QC	:	Quality Assurance and Quality Control
RCA	:	Environmental Approval Permit (Resolución de Calificación Ambiental)
SAFF	:	Forest Administration and Control System (Sistema de Actualización y Fiscalización Forestal)
SAR	:	IPCC Second Assessment Report
SEC	:	Office of the Superintendent of Electricity and Fuels (Superintendencia de Electricidad y Combustibles)
SEIA	:	Environmental Impact Assessment System (Sistema de Evaluación de Impacto Ambiental)
SERNAGEOMIN	:	National Geological and Mining Service (Servicio Nacional de Geología y Minería)
SF_6	:	Sulfur hexafluoride
SGHGI	:	Sectorial Greenhouse Gas Inventory (Inventario sectorial de gases de efecto invernadero)
SIMEF	:	Integrated National Monitoring and Assessment System on Forest Ecosystems (Sistema nacional integrado de vigilancia y evaluación de los ecosistemas forestales)
SISS	:	Office of the Superintendent of Sanitation Services (Superintendencia de Servicios Sanitarios)
SME	:	Manure Management System (Sistema de Manejo de Estiércol)
SNICHILE	:	National Greenhouse Gas Inventory System of Chile (Sistema Nacional de Inventarios de Gases de Efecto Invernadero de Chile)
SO_2	:	Sulfur dioxide
SOFOFA	:	Chilean Federation of Industry (Sociedad de Fomento Fabril)
SOPU	:	Solvent and other product use
SUBDERE	:	Office of the Undersecretary of Regional and Administrative Development (Subsecretaría de Desarrollo Regional y Administrativo)
SWDS	:	Solid waste disposal sites
Tcal	:	Teracalories
TJ	:	Terajoules
UNDP	:	United Nations Development Programme
UNFCCC	:	United Nations Framework Convention on Climate Change
USGS	:	United States Geological Survey

EXECUTIVE SUMMARY

Key points

- In 2010, Chile´s total GHG emissions were 91,575.9 GgCO_2eq, showing an 83.5% increase since 1990. CO_2 was the main GHG (76.6% of the total GHG emissions), followed by CH_4 (12.5%), N_2O (10.6%) and HFCs/PFCs (0.3%).
- The Energy sector was the leading GHG emitter (74.7% of total GHG emissions), due to coal and diesel consumption for electricity generation and the consumption of liquid fuels for road transportation, this sector was followed by Agriculture (15.1%), Industrial processes (6.1%), Waste (3.9%) and Solvent and other product use (0.3%).
- The Land use, land use change and forestry sector is the only one that accounts for CO_2 removals. The sectorial GHG balance has showed a trend toward net removal over the entire time period. The net removals were -49,877.4 GgCO_2eq, due to net biomass increase in forest tree plantations and second-growth natural forests.
- Chile´s balance of GHG emissions and removals were 41,698.5 GgCO_2eq in 2010.

RE.1. Introduction

This national greenhouse gas inventory (NGHGI) is the third inventory submitted by Chile to the UNFCCC in fulfillment of article 4, paragraph 1(a) and article 12, paragraph 1(a) of the UNFCCC and decision 1/CP.16 of the 16th Conference of the Parties (Cancun, 2010).

Chile's NGHGI covers the entire national territory (continental, insular and Antarctica) and includes GHG emissions and removals in a complete time series spanning from 1990 to 2010.

RE.2. Institutional arrangements and preparation of Chile's NGHGI

Since 2012, the Ministry of Environment's OCC has been designing, implementing and coordinating the National Greenhouse Gas Inventory System of Chile (SNICHILE), which sets out institutional, legal and procedural measures for the biennial updating of the NGHGI, thereby ensuring the sustainable preparation of GHG inventories in the country, the consistency of reported GHG flows and the quality of results. SNICHILE has five permanent working areas:

- NGHGI update
- Continuous improvement system
- Capacity building

- Institutionalization
- Dissemination

Preparation of this NGHGI began in the first half of 2013 and was completed in mid-2014. Chile's NGHGI represents the compilation of sectorial GHG inventories (SGHGI), all prepared in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006GL) and using IPCC software. The Energy sector's SGHGI was prepared by the Energy Policy and Outlook Division of the Ministry of Energy (MINENERGIA). The SGHGI of the Industrial processes and other product use (IPPU)[1] sector was prepared by the OCC. The SGHGI for the Agriculture, forestry and other land use (AFOLU)[2] sector was prepared by the Ministry of Agriculture (MINAGRI), with its Office of Agrarian Studies and Policies (ODEPA) coordinating work with the National Forestry Corporation (CONAF) on issues related to land use change; with the Forestry Institute (INFOR) on matters related to forested lands; and with the Agricultural Research Institute (INIA) on agriculture issues (crops and livestock). The Waste sector's SGHGI was prepared by the Ministry of Environment's Solid Waste Section. Each SGHGI was reviewed by international experts. Then the inventories were compiled by the OCC for use in Chile's NGHGI and its respective report, both of which also were subject to national and international review.

RE.3. Trends in greenhouse gas emissions in Chile

In 2010, the balance of GHG emissions and removals[3] in Chile amounted to 41,698.5 GgCO_2eq, while total GHG emissions[4] in the country amounted to 91,575.9 GgCO_2eq, the latter representing an increase of 83.5% between 1990 and 2010 (Table 2 and Figure 1). The key drivers of this trend in the GHG balance were the Energy and Land use, land use change and forestry (LULUCF) sectors. The values in the balance that fall outside of the global trend are primarily the consequence of wildfires (accounted for in the LULUCF sector).

In 2010, the main GHG emitted in Chile was CO_2, which accounted for 76.6% of total GHG emissions, followed by CH_4 with 12.5% and N_2O with 10.6%. HFCs and PFCs together accounted for 0.3% of total GHG emissions.

[1] To ensure this report conforms to UNFCCC requirements for developing countries, the IPPU sector was divided into two separate sectors—Industrial processes and Solvent and other product use.

[2] To ensure this report conforms to UNFCCC requirements for developing countries, the AFOLU sector was divided into two sectors—Agriculture and Land use, land use change and forestry.

[3] The term "balance of GHG emissions and removals" or "GHG balance" refers to the sum of GHG emissions and removals, expressed as carbon dioxide equivalents (CO_2eq). This term includes the LULUCF sector.

[4] The term "total GHG emissions" refers only to the sum of GHG emissions in Chile, expressed in carbon dioxide equivalents (CO_2eq) and excludes the LULUCF sector.

Table RE.1. Chile's NGHGI: GHG emissions and removals ($GgCO_2eq$) by sector, 1990-2010 series

Sector	1990	1995	2000	2005	2010
1. Energy	33,530.4	40,370.6	52,346.8	57,936.8	68,410.0
2. Industrial processes	3,108.2	4,242.5	6,399.9	7,354.7	5,543.2
3. Solvent and other product use (SOPU)	82.3	94.8	118.0	110.7	243.0
4. Agriculture	10,710.2	11,892.6	12,493.2	12,736.9	13,825.6
5. Land use, land use change and forestry (LULUCF)	-50,821.6	-48,743.8	-55,404.6	-44,624.2	-49,877.4
6. Waste	2,465.5	2,685.8	3,130.0	3,866.2	3,554.1
Balance (including LULUCF)	-925.0	10,542.5	19,083.4	37,381.1	41,698.5
Total (excluding LULUCF)	49,896.6	59,286.3	74,487.9	82,005.2	91,575.9

Source: Prepared in-house by SNICHILE.

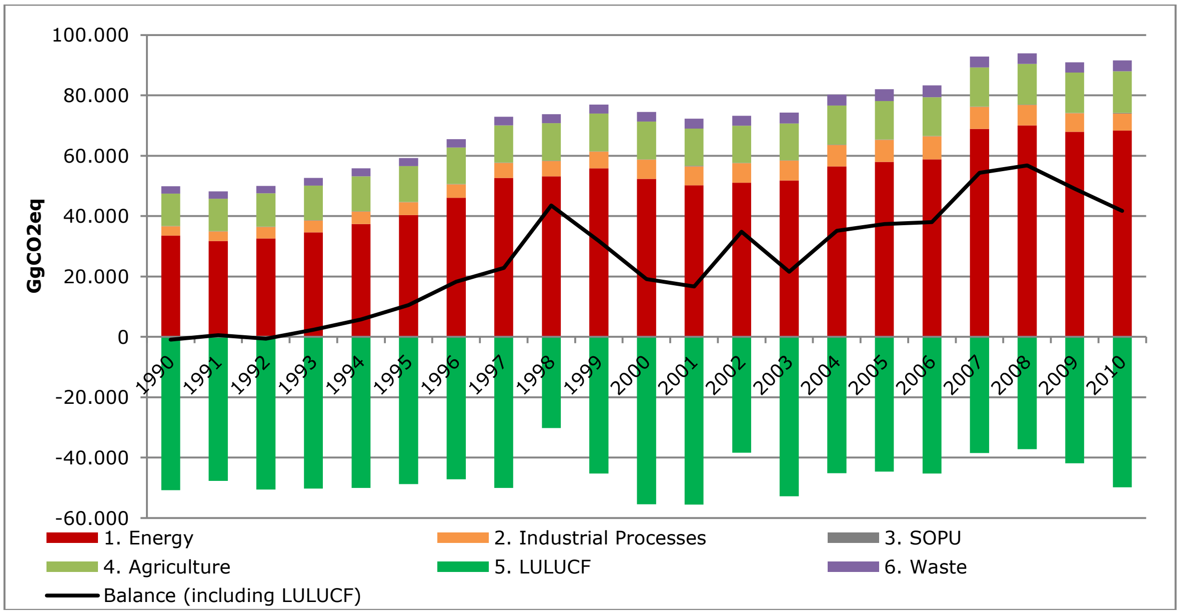

Figure 1. Chile's NGHGI: GHG emissions and removals trend by sector, 1990–2010 series

The Energy sector, that represents fossil fuel consumption, is the leading GHG emitter in Chile, accounting for 74.7% of total GHG emissions in 2010. That year, GHG emissions amounted to 68,410.0 $GgCO_2eq$, an increase of 104.0% from 1990. The key drivers of this increase were the increased coal and diesel consumption for electricity generation and the consumption of liquid fuels for road transportation (light gasoline-powered vehicles and heavy diesel-powered vehicles). Emissions in this sector have been decreasing since 2009, mainly due to the international economic crisis that began in 2008 and, to a lesser extent, to changes in fuel use in the country's energy matrix. At the subcategory level, the Energy industry (mainly electricity generation) is the leading source of GHGs in Chile, accounting for 39.7% of the sector's emissions, followed by Transport (mainly road transportation) with 30.5% and Manufacturing industries and construction with 18.1%. The remaining 10.2% derives from other sectors (mainly Residential). Lastly, the Oil and natural gas subcategory accounted for 1.4% and Solid fuels for 0.1%.

LULUCF is the only sector that consistently removes CO_2 in the country. In 2010 the GHG balance of the sector reported removals for -49,877.4 $GgCO_2eq$. The GHG balance in this sector has tended toward removal over the entire time period, although removals dropped by 1.9% between 1990 and 2010. The key drivers in this category are an increase in biomass from forestry plantations and second-growth natural forests. GHG removals increase near the end of the period due to an increase in the area covered by forest tree plantations (increase in biomass) and a reduction in forest harvesting. At the subcategory level, in absolute terms[5], 96.0% of the GHG balance corresponds to the Forest land category, followed by Grassland with 2.3% and Cropland with 1.2. The remaining 0.6% is accounted collectively by all other categories.

The Agriculture sector is the second emitter of GHGs in Chile, accounting for 15.1% of total GHG emissions in 2010. That year, GHG emissions amounted to 13,825.6 $GgCO_2eq$, an increase of 29.1% since 1990, the key driver being the steady increase in the use of synthetic nitrogen-based fertilizers. At the category level, 52.4% of GHG emissions come from Agricultural soils, followed by Enteric fermentation with 34.4%, and Manure management with 12.1%. The remaining 1% derives from the categories Rice cultivation and Field burning of agricultural residues.

The Industrial Processes sector is the third source of GHG emissions in Chile, accounting for 6.1% of total GHG emissions in 2010. In 2010, r this sector's GHG emissions amounted to 5,543.2 $GgCO_2eq$, an increase of 78.3% since 1990. The key driver of this increase is the steady growth in methanol production, the cement industry and the lime industry. Nevertheless, emissions have been falling sharply since 2006 owing to the reduction in natural gas imported from Argentina (the raw material used to produce methanol). At the subcategory level, Cement production was the main emitter in 2010, with 21.5% of the sector's GHG emissions, followed by Nitric acid production with 20.3%, Iron and steel production with 19.7%, and Lime production with 19.4%. Methanol accounted for 12.1% and Aerosols for 2.8% of the sector's total GHG emissions, and the remaining 4.1% corresponded to other subcategories such as Ethylene, Refrigeration and air conditioning and Ferroalloy production.

The Waste sector ranks fourth in Chile for GHG emissions, accounting for 3.9% of total national GHG emissions in 2010. That year, the sector emitted 3,554.1 $GgCO_2eq$, an increase of 44.2% since 1990. The key drivers of this increase were the increase in population and the amount of waste generated. At the subcategory level, 74.4% of GHG emissions from this sector come from Solid waste disposal, followed by Wastewater treatment and discharge with 23.7%, Biological treatment of solid waste with 1.9%, and lastly Waste incineration, with less than 1%.

Solvent and other product use sector is responsible for the lowest level of GHG emissions in Chile. Emissions from this sector amounted to 243.0 $GgCO_2eq$ in 2010, or 0.3% of total GHG emissions, representing an increase of 195.1% since 1990.

In accordance with UNFCCC and 2006GL requirements, GHG emissions from international marine and aviation bunker fuels, as well as CO_2 emissions from biomass burned for energy purposes have been quantified and reported as Memo Items, but were not included in the country's Balance of GHG emissions and removals.

[5] To enable the direct interpretation of quantitative analyses, removals have been expressed as absolute values (2006GL).

1. INTRODUCTION

This report contains the Third National Greenhouse Gas Inventory of Chile to the United Nations Framework Convention on Climate Change in fulfillment of the country's commitment under article 4, paragraph 1(a) and article 12, paragraph 1(a), of the UNFCCC and Decision 1/CP.16 of the 16th Conference of the Parties (Cancun, 2010).

Chile's National Greenhouse Gas Inventory includes all emissions and removals of greenhouse gases (GHGs) of anthropogenic origin not controlled by the Montreal Protocol in the entire national territory.

The estimations of GHG emissions and removals are presented herein by gas, sector, category, subcategory and component for the latest inventory year (2010), unless otherwise indicated. Time series data on emissions and removals for the 1990 to 2010 period is also included herein.

Chapter 1. Introduction provides general information on national greenhouse gas inventories and institutional arrangements, and describes how Chile's inventory was prepared, including the methodologies used. Chapter 2 details GHG emission and removals trends in Chile, and chapters 3 to 8 offer detailed information on six sectors—Energy; Industrial processes; Solvent and other product use; Agriculture; Land use, land use change and forestry; and Waste. Lastly, Chapter 9 summarizes new calculations and improvements undertaken since the last report.

1.1. General information

The United Nations Framework Convention on Climate Change (hereinafter the Convention or UNFCCC) came into force on May 9th, 1992, and Chile became a signatory to the Convention in 1994 in order to achieve stabilization of greenhouse gas[6] concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC, 1992). The ability of the international community to achieve this objective depends upon our having accurate knowledge of emission trends and the collective capacity to alter those trends (UNDP, 2005). To this end, all countries that are parties to the Convention must prepare, update regularly, publish and facilitate national inventories of anthropogenic emissions by source and removals by sinks for all GHGs not governed by the Montreal Protocol[7]. To ensure the credibility, consistency and comparability of measurements included in these national inventories, the Convention recommends that countries use the methodological guidelines prepared by the Intergovernmental Panel on Climate Change (IPCC) when preparing and/or updating their inventories.

National greenhouse gas inventories (NGHGI) consist of an exhaustive list of the quantities of each anthropogenic GHG emitted into or removed from the atmosphere in a given area over a specific period of time, generally one calendar year. These NGHGIs are intended to determine the

[6] "Greenhouse gases" means those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorbs and re-emits infrared radiation (UNFCCC, 1992). The principal anthropogenic GHGs are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

[7] Article 4, paragraph 1(a) and article 12, paragraph 1(a) of the Convention. 1992.

magnitude of national GHG emissions and removals that are directly attributable to human activity and thereby establish a country's particular contribution to the phenomenon of climate change.

In addition to the above, according to the United Nations Development Programme (UNDP, 2005), the preparation and presentation of National GHG Inventory Reports (NIR) can provide countries with a series of other benefits, including:

- Identifying the economic sectors that have the greatest impact on climate change through their specific contributions;
- Providing useful information for planning and assessing economic development;
- Providing useful information for addressing other environmental problems (such as air quality, land use, waste management, etc.);
- Identifying gaps in national statistics;
- Assessing options for mitigating GHGs through the collaborative design of development strategies that will effectively lower emissions through the more efficient use of natural and financial resources; and
- Providing a foundation for emissions trading schemes.

For developing countries such as Chile, the key mechanisms for reporting NGHGIs to the Convention have been National Communications (NCs) and, as of 2014, Biennial Update Reports (BURs). Chile's first NGHGI was prepared by the National Environmental Commission (CONAMA) and submitted to the Convention in 2000 as part of the First National Communication of Chile and included information on GHG emissions for 1993 and 1994. The second official NGHGI was prepared by the Ministry of the Environment (MMA) and submitted in 2011 as part of the Second National Communication of Chile. This inventory included time series data from 1984 to 2006. The report contained herein comprises Chile's Third NGHGI to the UNFCCC and includes time series data from 1990 to 2010.

1.2. Institutional arrangements

To facilitate reporting of advances in the implementation of the Convention's objectives, in 2010 the COP16 affirmed that *"Developing countries…should…submit biennial update reports containing updates of national greenhouse gas inventories"*[8]. In 2011 the COP17 furthermore affirmed that *"non-Annex I Parties…should submit their first biennial update report by December 2014…[and said] report…shall cover, at a minimum, the inventory for the calendar year no more than four years prior to the date of the submission"*[9].

Because of these new commitments, since 2012 the MMA's Climate Change Office (OCC) has been designing, implementing and coordinating the National Greenhouse Gas Inventory System of Chile (SNICHILE), which includes institutional, legal and procedural measures for the biennial updating of Chile's NGHGI, thereby ensuring the sustainable preparation of GHG inventories in the country, the consistency of reported GHG flows, and the quality of results.

[8] Decision 1, paragraph 60(c) of the Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010.
[9] Decision 1, paragraph 41(a) Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011.

SNICHILE (Figure 1) is a decentralized entity that prepares the National Greenhouse Gas Inventory through ongoing collaboration with a variety of public agencies. Chile's National GHG Inventory Team is comprised of the National Entity (the MMA's OCC), which coordinates the work of sector teams responsible for preparing their respective sector-specific inventories (SGHGIs), and both Chilean and international experts who lend their expertise on NGHGI matters across all areas. The National Inventory Team reports to the BUR/NC National Coordinating Team, which incorporates the NGHGI into the corresponding report. Lastly, the National Coordinating Team reports to the Ministerial Council for Sustainability and Climate Change, which approves the corresponding reports.

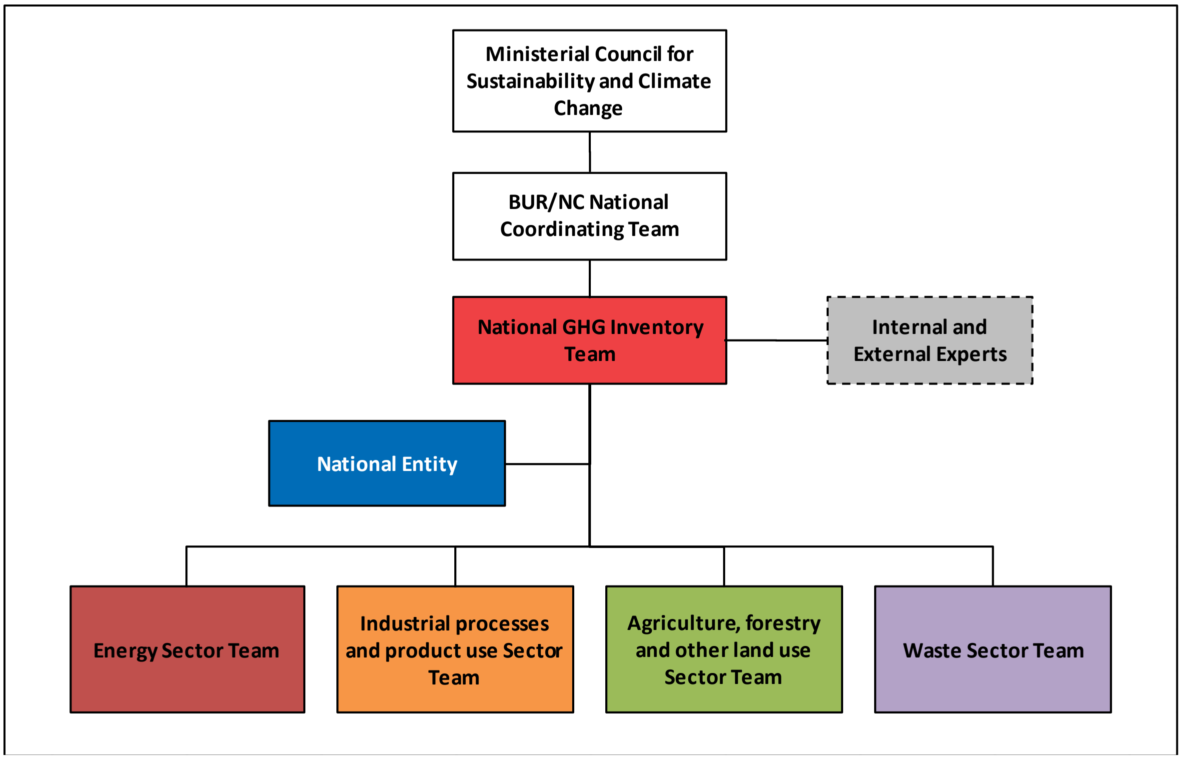

Figure 1. Structure of the National Greenhouse Gas Inventory System of Chile

Since 2013, the National Entity has been holding meetings of the National GHG Inventory Team to coordinate and operate SNICHILE. Bilateral meetings are also held regularly with sector teams to address sector-specific issues.

SNICHILE is organized around the following five work areas:

- **Updating Chile's NGHGI:** This work area is focused on the biennial updating of Chile's NGHGI, collecting biennial updates of sector-specific GHG inventories (SGHGI) and then compiling them. This area also handles issues applicable to all sectors.

- **Continuous improvement system:** This work area manages the quality assurance and quality control system (QA/QC) by means of an improvement plan based on IPCC good practice guidelines for NGHGIs. It seeks to guarantee the quality of national inventory results by ensuring their transparency, completeness, consistency, comparability and accuracy. This system also includes the international expert review of all SGHGIs and the NGHGI.

- **Building and maintaining capacities:** This work area builds and maintains the capacities of each sector team through multisector workshops, collecting and preparing training materials, and international cooperation, among other activities coordinated by the National Entity. Chile currently has (as of July 2014) five expert NGHGI reviewers from Parties included in Annex I to the Convention: Aquiles Neuenschwander (Fundación para la Innovación Agraria, Ministry of Agriculture), lead reviewer and LULUCF sector expert; Sergio González, lead reviewer and Agricultural sector expert; Jenny Mager (OCC, MMA), expert reviewer in the Industrial Processes sector; Fernando Farías (OCC, MMA), expert reviewer for the Energy sector; and Paulo Cornejo (OCC, MMA, and Coordinator of SNICHILE), expert reviewer for the Agricultural sector. All of these individuals participate actively in SNICHILE.

- **Institutionalization:** This area is working to institutionalize SNICHILE by ensuring effective inter-institutional coordination, forging collaboration agreements with participating institutions that define responsibilities, timeframes and budgets.

- **Dissemination:** This work area disseminates information related to Chile's NGHGI, including its preparation, timeframes, related activities and results. Information is disseminated via the SNICHILE website (which also serves as a multisector repository for information), knowledge transfer workshops, informative talks, and print and digital material.

1.3. Update process

Chile's NGHGI is updated through a cyclical two-year work plan. Sectorial inventories are updated during the first year (STAGE I of the cycle), while in the second year (STAGE II) the data is compiled and cross-cutting issues are handled.

The preparation of this NGHGI began in the first half of 2013 and concluded in mid-2014. As Figure 2 shows, general statistical information is provided by the National Statistics Bureau (INE) and the National Customs Service (Aduanas); this information is also used to verify information from the sectorial teams.

Each sector team is responsible for preparing GHG inventories for its sector, as follows: The Energy sector inventory was prepared by the Ministry of Energy's Energy Policy and Outlook Division; the SGHGI of the Industrial Processes and Product Use (IPPU) sector was prepared by the MMA's OCC; the inventory of the Agriculture, Forestry and Other Land Use (AFOLU) sector was prepared by the Ministry of Agriculture (MINAGRI), with its Office of Agrarian Studies and Policies (ODEPA) coordinating tasks with the National Forestry Corporation (CONAF) on issues related to land use change, with the Forestry Institute (INFOR) on matters related to forested lands, and with the Agricultural Research Institute (INIA) on agriculture and livestock issues; and the GHG inventory for the Waste sector was prepared by the Environmental Ministry's Solid Waste Section (currently part of the Waste and Hazardous Substances Office).

Each SGHGI was reviewed by international experts as recommended, before being sent to the National Entity. Once reviewed, the sectorial inventories were compiled by the MMA's Climate Change Office for use in Chile's NGHGI and its respective report and for cross-sector matters. The final report was reviewed by the sector teams and again at the national level. Chile's NGHGI was then submitted to the BUR/NC National Coordinating Team to be included in Chile's first BUR.

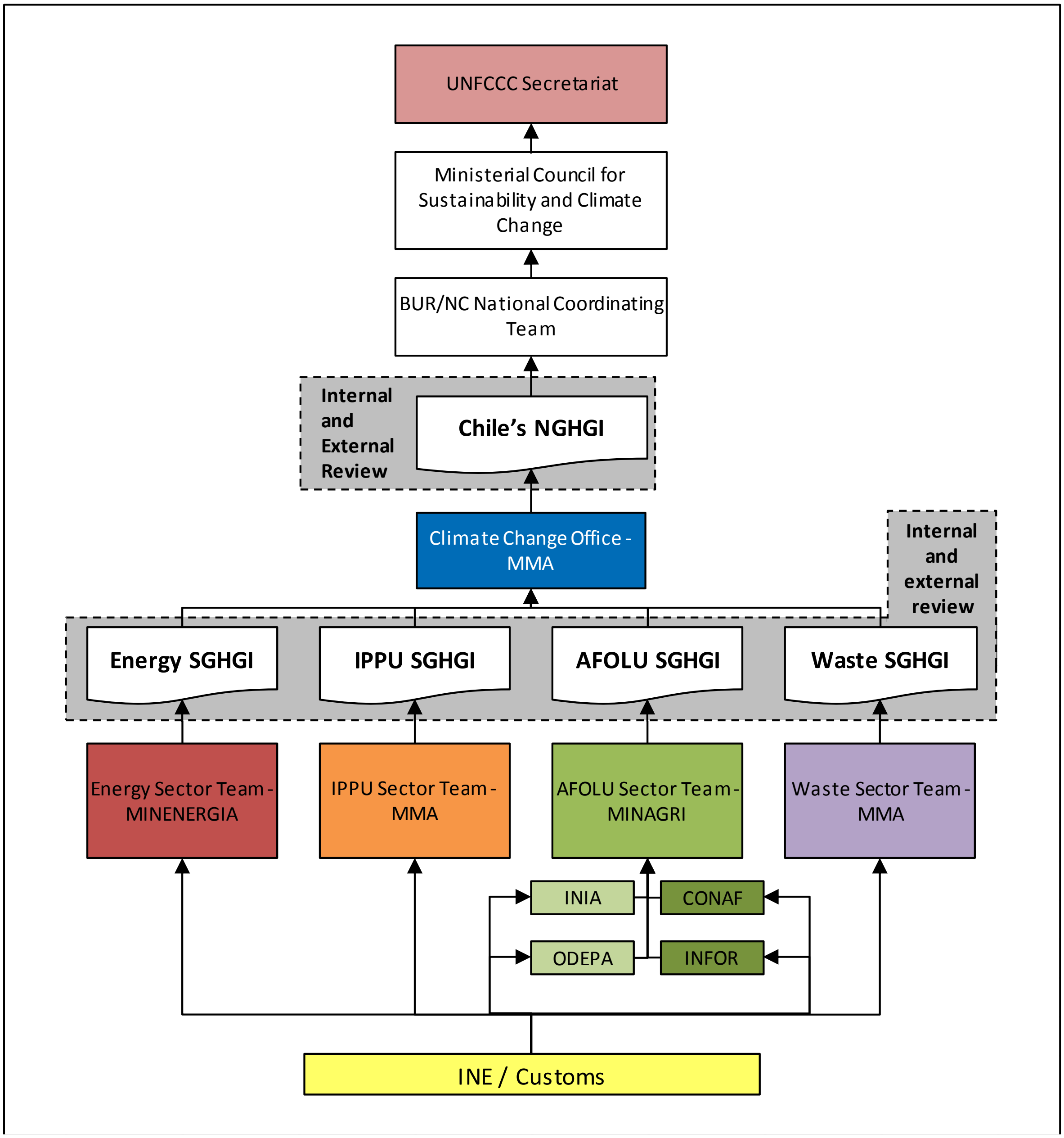

Figure 2. Process for updating Chile's National Greenhouse Gas Inventory

Chile's NGHGI and all other UNFCCC-required information is housed by the MMA, although each sector team also has its own data storage system. Chile's NIR is also available online through the websites of the MMA and SNICHILE.

1.4. Methodologies and sources of information

1.4.1. Methodologies

Chile's NGHGI was compiled from sectorial inventories that were prepared in accordance with the 2006GL using IPCC software, and include key analytical categories and uncertainty assessment. To update information continually the National GHG Inventory Team used the 2006GL and IPCC software, given that:

- The 2006GL offer the best current globally applicable methods and reflect the latest scientific advances in quantifying GHG emissions and removals,
- Both the 2006GL and IPCC software enable emissions to be reported in the required UNFCCC format,
- Using these tools reduces the cost of updating methodologies in future NGHGIs, as both developed and developing countries around the globe are now implementing the 2006GL, and
- Using these tools harmonizes GHG accounting mechanisms among different sector teams.

In preparing its NGHGI, Chile has chosen to use the 2006GL despite the fact that both *the UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention* (GL-UNFCCC-BUR) and the *Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention* (GL-UNFCCC-NC) suggest that these countries prepare their inventories in accordance with the *Revised 1996 IPCC Guidelines for National GHG Inventories* (1996GL), the *IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories* (2000GPG), and the *Good Practice Guidance for Land Use, Land Use Change and Forestry* (GPG-LULUCF). Those instruments divide the inventories into six central sectors—Energy; Industrial Processes (IP); Solvent and Other Product Use (SOPU); Agriculture; Land Use, Land Use Change and Forestry (LULUCF); and Waste, whereas the 2006GL divide the inventories into four sectors, namely Energy; Industrial Processes and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU); and Waste. To deal with this discrepancy, the sectors defined in the 2006GL were harmonized with those established in the 1996GL, 2000GPG and GPG-LULUCF during compilation of this NGHGI, as the following Table illustrates[10]:

[10] For more information on category standardization, see Anexo 1. Homologación de categorías.

Table 1. Harmonization of sectors defined in the IPCC Guidelines

Sectors in 2006GL	Sectors in 1996GL/2000GPG/ GPG-LULUCF
1. Energy	1. Energy
2. Industrial Processes and Product Use (IPPU)	2. Industrial Processes (IP)
	3. Solvent and Other Product Use (SOPU)
3. Agriculture, Forestry and Other Land Use (AFOLU)	4. Agriculture
	5. Land Use, Land Use Change and Forestry (LULUCF)
4. Waste	6. Waste

Source: Prepared in-house at SNICHILE based on 1996GL, 2000GPG, GPG-LULUCF and 2006GL.

The results of Chile's NGHGI were adapted to the table format recommended in the GL-UNFCCC-BUR and the GL-UNFCCC-NC.

The methodological approach used to estimate GHG emissions and removals combined information on the scope of a given human activity (activity data or AD, which may be statistical and/or parametrical) with coefficients called emission factors (EF) that quantify GHG emissions or removals per unit of that activity. Thus, the basic equation is:

$$\boldsymbol{GHG\ Emissions} = \boldsymbol{Activity\ data}\ (\boldsymbol{AD}) \times \boldsymbol{Emission\ factors}\ (\boldsymbol{EF})$$

This simple equation is widely used, although the 2006GL also offer other methods, such as the mass balance method (used primarily in the LULUCF sector) as well as other more complex ones. In the IPCC Guidelines, methods are divided into three tiers: Tier 1 is for the "default method", which is the simplest and is usually applied when no country-specific activity data or emission factors are available. Tier 1 methods enable emissions and removals to be estimated, but they run the risk of failing to accurately reflect national circumstances. Tier 2 methods use the same procedure as Tier 1 methods, but incorporate emission factors and/or parametric activity data that are specific to the country or at least one of its regions. Obviously, Tier 2 estimations for GHG emissions and removals are much more likely to be accurate and should be used where possible for key categories. Tier 3 is reserved for country-specific methods (models, censuses, and others), which are the most recommended, provided that they have been duly validated and, in the case of models, published in peer-reviewed scientific journals (MMA, 2011). Table 2 presents a summary of the methods and tiers used to prepare Chile's NGHGI[11]. Chapters 3 to 8 of this report provide a detailed description of the methodologies and methods employed by each sector.

[11] For more information on methodologies, see Anexo 2A. Métodos.

Table 2. Methods and tiers applied in the preparation of Chile's NGHGI, 2010

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
1. Energy	**T1**	**D**	**T1**	**D**	**T1**	**D**						
A. Fuel combustion (sectorial approach)	T1	D	T1	D	T1	D						
1. Energy industries	T1	D	T1	D	T1	D						
2. Manufacturing industries and construction	T1	D	T1	D	T1	D						
3. Transport	T1	D	T1	D	T1	D						
4. Other sectors	T1	D	T1	D	T1	D						
5. Other	NO, C	D	NO, C	D	NO, C	D						
B. Fugitive emissions from fuels	T1	D	T1	D								
1. Solid fuels			T1	D								
2. Oil and natural gas	T1	D	T1	D								
2. Industrial processes	**T1,T2**	**D**	**T1**	**D**	**T1**	**D**	**T1**	**D**	**T1**	**D**	**NE, NO**	**NE, NO**
A. Mineral products	T1,T2	D										
B. Chemical industry	T1	D	T1	D	T1	D						
C. Metal production	T1	D	NO	D								
D. Other production	NE	NE					NE	NE	NE	NE	NE	NE
E. Production of halocarbons and sulphur hexafluoride							NE	NE	NE	NE	NE	NE
F. Consumption of halocarbons and sulphur hexafluoride							T1	D	T1	D	NE, NO	NE, NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and other product use	**T1**	**D**										
4. Agriculture			**T1b, T2**	**D, CS**	**T1b**	**D**						
A. Enteric fermentation			T1b, T2	D, CS								
B. Manure management			T1b, T2	D, CS	T1b	D						
C. Rice cultivation			T1b	D								
D. Agricultural soils					T1b	D						
E. Prescribed burning of savannahs			NO	NO	NO	NO						
F. Field burning of agricultural residues			T1a,b	D	T1a,b	D						
G. Other			NA	NA	NA	NA						
5. Land use, land use change and forestry	**T1b, T2**	**D, CS**	**T1b, T2**	**D, CS**	**T1b, T2**	**D, CS**						
A. Forest land	T2	CS	T1b, T2	D, CS	T1b, T2	D, CS						
B. Cropland	T1b, T2	D, CS										
C. Grassland	T1b, T2	D, CS	T1a,b	D	T1a,b	D						
D. Wetlands	NE	NE	NE	NE	NE	NE						
E. Settlements	T1b, T2	D, CS										
F. Other land	T1b, T2	D, CS										
G. Other	NE	D	NE	D	NE	D						
6. Waste	**T1**	**D**	**T1**	**D**	**T1**	**D**						
A. Solid waste disposal			T1	D								
B. Wastewater treatment and discharge			T1	D	T1	D						
C. Waste incineration	T1	D										
D. Other			T1	D	T1	D						
Memo items												
International bunkers	T1	D	T1	D	T1	D						
CO_2 emissions from biomass	T1	D										

T1 = Tier 1 Method; T1a = Disaggregated by operational component (crop, species, etc.); T1b = Disaggregated by administrative region; T2 = Tier 2 Method; D = Default; CS = country-specific;
NA = Not applicable; NE = Not estimated; NO = Not occurring; C = Confidential.
Source: Prepared in-house by SNICHILE.

After estimating emissions and removals for each GHG, to facilitate aggregate reporting of GHG values, expressed as carbon dioxide equivalents or CO_2eq, developing countries must use the global warming potentials (GWPs) provided by the IPCC in its Second Assessment Report (SAR), which are based on GHG effects for a 100-year time horizon. GWPs used for the main GHGs are presented in Table 3, below:

Table 3. Global warming potential values used in Chile's NGHGI

GHG	GWP
CO_2	1
CH_4	21
N_2O	310
HFC-32	650
HFC-125	2800
HFC-134a	1300
HFC-152a	140
HFC-143a	3800
HFC-227ea	2900
HFC-236fa	6300
CF_4	6500

Source: IPCC, 1995.

The 2006GL good practice guide seeks to ensure the quality of NGHGIs by emphasizing the following quality indicators:

- **Transparency:** Documentation must be clear and sufficient to enable persons and groups other than the inventory preparers to understand how the inventory was prepared.

- **Completeness:** Estimations must be declared for all pertinent GHG source and sink categories for the entire national territory.

- **Consistency:** Estimations for different years, gases and categories must reflect actual differences in the balance of emissions. To the extent possible, annual inventory trends should be calculated by the same method using the same data sources every year, and should strive to reflect real annual fluctuations in emissions and removals without undue influence from methodological differences.

- **Comparability:** The NGHGI should be reported in a format that enables comparison with the inventories of other countries.

- **Accuracy:** The NGHGI should not contain estimations that are too high or too low, to the extent this can be determined; all efforts must be made to eliminate estimation bias.

In conclusion, inventory compilers should use good practice methods to ensure that NGHGIs are as transparent, complete, consistent, comparable and accurate as possible and can be improved continuously over time.

1.4.2. Sources of information

Table 4 summarizes the primary sources of information (activity data, AD) used by each sector included in Chile's NGHGI[12]. More detailed information on sources of information used can be found in the sectorial chapters and in the References chapter of this report.

Table 4. Principal sources of activity data for Chile's NGHGI

Sector	Source
1. Energy	*National Energy Balance* (BNE) (Ministry of Energy) *Statistical yearbooks for copper and other minerals* (COCHILCO) International fuel consumption statistics (Aduanas)
2. IP	Cement production (Instituto del Cemento y Hormigón de Chile) Clinker imports and exports (Aduanas) Lime production (Inacesa, Soprocal, CMPC and Arauco) Glass production (SOFOFA) Nitric acid production (POCH and Deuman) *National Energy Balance* (BNE) (Ministry of Energy) Methanol production (Methanex) Lead, zinc, iron and steel production (COCHILCO, SERNAGEOMIN) Ferroalloy production (USGS) Production, importation and exportation of ODS (INE, Aduanas)
3. SOPU	Production, importation and exportation of lubricants and paraffin wax (INE, Aduanas)
4. Agriculture	*Agriculture and Forestry Censuses* (INE, ODEPA) Annual statistics (INE, ODEPA) Statistics (FAO)
5. LULUCF	*Ongoing Forestry Census* (Inventario Forestal Continuo) (INFOR) *Forestry statistics* (INFOR) *Vegetation Inventories* (CONAF) Historic forest fire statistics (CONAF)
6. Waste	*Population and Housing Census* (Censo de población y vivienda) (INE) *Adjusted MSW Inventory* (Catastro ajustado de RSM) (MMA) Quantity of sludge deposited (SISS)

Source: Prepared in-house by SNICHILE.

1.5. Key categories

As per the 2006GL, it is good practice for each country to identify its key categories systematically and objectively. Key categories are those that have a significant effect on a country's NGHGI in terms of the absolute level, trends, and/or uncertainty of GHG emissions and/or removals. Countries should prioritize these key categories when allocating resources for collecting, compiling, verifying, and controlling the quality of data and for generating reports. It is also considered good practice to choose a methodology based on those key categories, as this will result in a better quality inventory and more reliable estimations.

The MMA's Climate Change Office has identified the key categories for 1990 and 2010 (the NGHGI's last reported year) using the 2006GL Tier 1 Method. However, the results have been adapted to the 2000GPG and GPG-LULUCF reporting formats to assess the influence of different source and sink categories (absolute levels and trends) on the balance of GHG emissions and removals (including LULUCF), while at the same time maintaining the consistency of the reporting

[12] For more information, see: Anexo 2B. Datos de actividad y parámetros.

tables in Chapter 2. Table 5 offers a summary of the key categories identified[13]. This same list was used as the basis for discussions with sector teams about the quality of estimations and the possible need for improvements. The key categories of Chile's NGHGI are documented in greater detail and undergo more comprehensive quality control than non-key categories.

Table 5. Key categories identified using Method 1 of the 2006GL for absolute levels and trends in Chile's NGHGI

IPCC category	GHG	Identification criteria, including LULUCF		
		1990 level	2010 level	Trend
1.A.1.a. Main activity electricity and heat production	CO_2	X	X	X
1.A.1.b. Petroleum refining	CO_2	X	X	X
1.A.2.a. Iron and steel	CO_2	X		X
1.A.2.c. Chemicals	CO_2		X	
1.A.2.f. Unspecified industry	CO_2	X	X	X
1.A.2.f. Non-metallic minerals	CO_2	X	X	X
1.A.2.f. Mining (excluding fuels) and quarrying	CO_2	X	X	X
1.A.3.a. Domestic aviation	CO_2	X		X
1.A.3.b. Road transportation	CO_2	X	X	X
1.A.3.d. Domestic water-borne navigation	CO_2	X		X
1.A.4.a. Commercial / Institutional	CO_2		X	
1.A.4.b. Residential	CO_2	X	X	X
1.A.4.c. Agriculture / forestry / fishing	CO_2		X	
1.B.2.a. Oil	CH_4	X		X
1.B.2.b. Natural gas	CH_4	X	X	X
2.A.1. Cement production	CO_2	X	X	X
2.A.2. Lime production	CO_2		X	
2.B.2. Nitric acid production	N_2O		X	
2.B.5.a. Methanol	CO_2	X		X
2.C.1. Iron and steel production	CO_2	X	X	X
4.A.1. Cattle	CH_4	X	X	X
4.B.1. Cattle	CH_4	X	X	X
4.D.1. Direct emissions from agricultural soils	N_2O	X	X	X
4.D.2. Pasture, range and paddock manure	N_2O	X	X	X
4.D.3. Indirect emissions from agricultural soils	N_2O	X	X	X
5.A.1.a. Native forest burned	CO_2	X	X	X
5.A.1.a. Managed native forest	CO_2	X	X	X
5.A.1.a. Forest plantations	CO_2	X	X	X
5.A.1.a. Renewals	CO_2	X	X	X
5.A.1.b. Lands in transition	CO_2		X	
5.A.1.c. Native species roundwood	CO_2	X	X	X
5.A.1.c. *Eucalyptus spp*. roundwood	CO_2	X	X	X
5.A.1.c. *P. radiata* roundwood	CO_2	X	X	X

[13] For greater detail, see Anexo 3. Análisis de categorías principales.

IPCC category	GHG	Identification criteria, including LULUCF		
		1990 level	2010 level	Trend
5.A.1.e. Firewood	CO_2	X	X	X
5.A.1.f. Native forest burned	CO_2	X	X	X
5.A.1.f. Forest plantations burned	CO_2		X	X
5.A.1.g. Substitution	CO_2	X	X	X
5.A.2.2. Land converted to forest land	CO_2	X	X	X
5.C.2. Land converted to grassland	CO_2	X	X	X
6.A.1. Managed waste disposal sites	CH_4		X	
6.A.2. Unmanaged waste disposal sites	CH_4	X		X
6.A.3. Other	CH_4	X		X

Source: Prepared in-house by SNICHILE.

1.6. Quality assurance and quality control system

To ensure high quality GHG inventories, SNICHILE has guaranteed the transparency, completeness, consistency, comparability and accuracy of the information used by establishing a separate work area for Quality Assurance and Quality Control (QA/QC). The QA/QC System in place adheres to the IPCC good practice guidelines for preparing NGHGIs.

Quality control (QC) is carried out through a system of routine technical activities that monitor and maintain the quality of the inventory while it is being prepared. QC activities are carried out by sector teams during the preparation of the SGHGIs and also by the SNICHILE coordinator during the compilation and preparation of Chile's NGHGI.

Quality assurance (QA) is a system of planned review procedures implemented by staff members who are not directly involved in preparing the SGHGI or in compiling the NGHGI. Independent third parties are responsible for reviewing the sectorial and national inventories.

The section below describes the QA/QC activities that the National Entity, in its role as coordinator of SNICHILE, carried out during the compilation and preparation of Chile's NGHGI. The QA/QC activities of sector teams will be addressed in their respective sections.

1.6.1. Quality assurance and quality control activities

Prior to the OCC's compilation of sectorial inventories for the NGHGI the following activities were carried out:

- The National Entity conducted an internal review of the preliminary numerical results of each SGHGI.
- A qualified NGHGI reviewer from one of the Parties included in Annex I to the Convention conducted an external review of each SGHGI.
- The findings and recommendations of the external review process were analyzed.
- The findings and recommendations for each SGHGI were incorporated, where pertinent.

Following the above, Chile's NGHGI was compiled and prepared as follows:

- A calculation spreadsheet (filename *2014_INGEI_CL_vGL2006*) was created and populated with numerical results for the national level following the 2006GL format. The spreadsheet included automated links from sectorial report files to prevent potential data entry errors. The spreadsheet also has a cross-checking function to ensure that values on the sectorial and national inventories match.
- A calculation spreadsheet was created (filename *2014_INGEI_CL_vNAI*) and populated with the numerical results in the formats established in the GL-UNFCCC-BUR and GL-UNFCCC-NC. The spreadsheet was constructed by harmonizing the results of the 2006GL format with the format required by the UNFCCC using automated links from the *2014_INGEI_CL_vGL2006* spreadsheet to prevent potential data entry errors. The spreadsheet also has a cross-checking function to ensure that the values reported in the sectorial and national inventories match.
- A draft version of *Chile's National GHG Inventory Report* (NIR) was produced and subjected to an internal review by experts qualified as reviewers of NGHGIs from Parties included in Annex I to the Convention working within SNICHILE.
- The draft version of the NIR was reviewed by sector teams and ministerial focal points.
- The NGHGI was reviewed by external experts qualified as reviewers of NGHGIs from Parties included in Annex I to the Convention.

Once the process was complete, the draft NIR was submitted to the National BUR/NC Coordinating Team, which prepared the report to be submitted to the UNFCCC.

1.6.2. Continuous improvement plan

The QA/QC System includes a work plan to continuously improve the quality of Chile's NGHGI. This ongoing effort seeks to identify potential areas for improvement and how these should best be implemented. Issues that arise are addressed on an ongoing basis, by the NGHGI Team during SNICHILE's twice yearly meetings or bilaterally between a particular sectorial team and the National Entity.

1.7. General assessment of uncertainty

According to the 2006GL, uncertainty estimations are an essential part of a complete inventory of GHG emissions and removals. Uncertainty analyses should be conducted in order to prioritize national efforts to reduce uncertainty in future inventories and to guide the choice of methodology.

For the uncertainty analysis of Chile's NGHGI, the OCC compiled uncertainties for each SGHGI and analyzed these using the 2006GL Tier 1 Method 1: Error Propagation, which is used to estimate uncertainty across all inventory categories (emission factors, activity data and other estimation parameters) and trends between a given year and the base year. Uncertainty calculations for Chile's NGHGI include GHG emissions and removals from the LULUCF sector[14].

In terms of their share in overall GHG emissions and removals, the sectors that contributed most to uncertainty ("contribution to variance") in the NGHGI in 2010 are the LULUCF sector, followed by Agriculture, Waste, Energy and lastly Industrial Processes/SOPU.

[14] For greater detail, see Anexo 4. Análisis de incertidumbre.

In the LULUCF sector, the sources of uncertainty that contributed most to variance in 2010 are CO_2 emissions and removals by forest land remaining forest land, followed by CO_2 emissions from land converted to forest land. These are primarily the result of uncertainty in the parametric information used to generate emission factors.

In the Agriculture sector, the uncertainty sources contributing most to variance in 2010 include direct emissions of N_2O from managed soils, followed by indirect emissions of N_2O from managed soils, and CH_4 emissions from the enteric fermentation of bovine manure. These are primarily the result of the high level of uncertainty in the default N_2O emission factors used and the activity data related to indirect emissions from agricultural soils.

For the Waste sector, sources of uncertainty that contributed most to variance in 2010 are CH_4 emissions from solid waste disposal, followed by emissions of CH_4 and N_2O from domestic wastewater treatment and discharge. These result primarily from uncertainty in the emission factors used, except in the case of CH_4 from domestic wastewater treatment and discharge, where uncertainty is related mainly to the activity data used.

In the Energy sector, the sources of uncertainty that most contributed to variance in 2010 are fugitive CH_4 emissions from petroleum and natural gas extraction, followed by CO_2 emissions from solid fuels used to produce electricity and heat, and CO_2 emissions from liquid automobile fuels. These are mainly derived from uncertainty in the default emission factors used and not from problems with activity data taken from the National Energy Balance.

In the sector Industrial Processes/Solvent and Other Product Use, sources of uncertainty that contributed most to variance in 2010 are N_2O emissions from nitric acid production, followed by CO_2 emissions from cement production, and CO_2 emissions from lime production. These result mainly from uncertainty in the default emission factors used.

In conclusion, most uncertainty associated with Chile's NGHGI derives from the use of default emission factors.

1.8. General assessment of completeness

Chile's NGHGI covers the entire national territory (continental and insular territory and Antarctica) and includes a complete time series of GHG emissions and removals from 1990 to 2010.

The GHGs covered in the inventory are CO_2, CH_4, N_2O, HFC and PFC. SF_6 was not estimated owing to a lack of activity data, and GHG precursors CO, NOx, COVDM, SO_2 are only partially represented, as they were calculated only for the Energy sector and for biomass combustion categories in the Agriculture and LULUCF sectors.

Chile's NGHGI includes the vast majority of sources and sinks in virtually all categories and subcategories pertinent to each sector. However, the following categories were not estimated (NE) owing to a lack of activity data:

- 1A2.b. Non-ferrous metals
- 2A3. Limestone and dolomite use

- 2A4. Soda ash use
- 2A5. Asphalt roofing production
- 2A6. Road paving with asphalt
- 2E1. Secondary HFC and PFC emissions
- 2E2. Fugitive emissions
- 2F5. Solvents
- 3A. Paint application
- 3B. Degreasing and dry cleaning
- 4d1d. Cultivation of histosols
- 4B10. Other
- 5D. Wetlands
- 5E1. Settlements remaining settlements
- 5F1. Other land remaining other land
- 5G. Other (Harvested wood products)

Categories not estimated (NE) due to the lack of a pertinent methodology are as follows:

- 2D1. Pulp and paper industries
- 2D2. Food and drink

Category 1A5b. Mobile has been declared confidential (C), as the Energy sector team was not able to access the confidential military information required. The category Biological Nitrogen Fixation has been removed as a direct source of N_2O because of the lack of evidence of significant emissions arising from the fixation process itself (Rochette and Janzen, 2005 c.p IPCC, 2006).

Regarding carbon deposits in the LULUCF sector, this report includes above- and below-ground living biomass and a portion of dead biomass, a major advance over the previous series (1984/2006), which included only above-ground biomass. Deposits corresponding to litter and soil organic matter (SOM) were not included due to a lack of activity data.

In accordance with the 2006GL, GHG emissions from international marine and aviation bunker fuels, as well as CO_2 emissions from biomass combusted for energy purposes have been quantified and reported but were not included in the national balance of GHG emissions and removals.

2. TRENDS IN GREENHOUSE GAS EMISSIONS IN CHILE

This chapter offers an overview of trends in GHG emissions and removals in Chile. More detailed information on GHG emissions and removals in each sector can be found in chapters 3 to 8 of this report.

Table 6 and Table 7 display categorized national results of all GHG sources and sinks resulting from human activity in 2010. Throughout this report the gigagram (Gg) has been used as the unit of mass for GHG emissions and removals in Chile, with positive figures representing emissions and negative ones removals.

In 2010, Chile's gross CO_2 emissions amounted to 149,540.6 Gg; CH_4 emissions were 570.2 Gg and N_2O emissions were 32.1 Gg. Meanwhile, gross removals of CO_2 amounted to -130,055.7 Gg. Emissions of HFC amounted to 0.1 Gg of HFC-32, 0.3 Gg of HFC-125, 241.1 Gg of HFC-134a, 0.3 Gg of HFC-152a, 9.5 Gg of HFC-143a, 29.9 Gg of HFC-227ea, and 0.1 Gg of HFC-236fa. Emissions of PFCs amounted to 6.1 Gg of CF_4. Emissions of SF_6 were not estimated owing to a lack of activity data.

Table 6. Chile's NGHGI: anthropogenic emissions by sources and removals by sinks of GHGs not controlled by the Montreal Protocol and GHG precursors for 2010

Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CO_2 Absorptions(Gg)	CH_4 (Gg)	N_2O (Gg)	CO (Gg)	NOx (Gg)	COVDMs (Gg)	SO_2 (Gg)
Total national emissions and removals	**149,540.6**	**-130,055.7**	**570.2**	**32.1**	**1,483.6**	**272.1**	**170.8**	**271.4**
1. Energy	**65,776.0**	**NO**	**92.7**	**2.2**	**1,072.4**	**265.4**	**170.8**	**271.4**
A. Fuel combustion activities (Sectorial method)	65,774.7		44.3	2.2	1,047.0	262.7	166.2	271.4
1. Energy industry	27,013.2		1.1	0.4	35.1	77.9	0.6	180.7
2. Manufacturing and construction industries	12,262.7		2.2	0.3	114.6	28.1	9.9	59.3
3. Transportation	20,425.1		4.7	1.0	263.8	121.3	44.3	14.7
4. Other sectors	6,073.7		36.2	0.5	633.4	35.5	111.4	16.7
5. Other (unspecified)	NO. C		NO. C	NO. C	NO. C	NO. C	NO. C	NO. C
B. Fugitive fuel emissions	1.3		48.4		25.4	2.7	4.6	NO
1. Solid fuel			1.9		NO	NO	0.8	NO
2. Petroleum and natural gas	1.3		46.5		25.4	2.7	3.7	NO
2. Industrial processes	**4,085.6**	**NO**	**2.2**	**3.6**	**NE**	**NE**	**NE**	**NE**
A. Mineral products	2,316.2				NE	NE	NE	NE
B. Chemical industry	627.1		2.2	3.6	NE	NE	NE	NE
C. Metal production	1,142.3		NO. IE	NO	NE	NE	NE	NE
D. Other production	NE				NE	NE	NE	NE
E. Production of halocarbons and sulfur hexafluoride								
F. Consumption of halocarbons and sulfur hexafluoride								
G. Other	NA		NA	NA	NA	NA	NA	NA
3. Solvent and other product use	**243.0**			**NO**			**NE**	
4. Agriculture			**298.1**	**24.4**	**34.2**	**0.9**	**NE.NO.NA**	**NO**
A. Enteric fermentation			226.8					
B. Manure management			65.4	1.0			NE	
C. Rice cultivation			4.9				NE	
D. Agricultural soils			NE	23.4			NE	
E. Prescribed burning of savannahs			NO	NO	NO	NO	NO	
F. Field burning of agricultural residues			1.0	0.0	34.2	0.9	NE	
G. Other			NA	NA	NA	NA	NA	
5. Land use. land use change and forestry	**79,435.6**	**-130,055.7**	**24.7**	**0.7**	**377.1**	**5.8**	**NE.NA**	**NE.NA**
A. Forested land	77,251.4	-130,030.9	24.1	0.7	369.2	5.7	NE	NE
B. Cropland	627.1	-3.1	NA	IE.NA	0.0	0.0	NE	NE
C. Grassland	1,247.0	-21.5	0.5	0.0	7.9	0.1	NE	NE
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	186.9	-0.1	NO	NO	NE	NE	NE	NE
F. Other land	123.2	NO	NO	NO	NE	NE	NE	NE
G. Other	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**0.3**		**152.6**	**1.1**	**NE.NA**	**NE.NA**	**NE.NA**	**NE.NA**
A. Solid waste disposal			125.9		NE		NE	
B. Wastewater treatment and discharge			25.2	1.0	NE	NE	NE	
C. Waste incineration	0.3		NO	0.0	NE	NE	NE	NE
D. Other			1.5	0.1	NE	NE	NE	NE
7. Other	NA	NA	NA	NA	NA	NA	NA	NA
Memo Items								
International bunkers	3,631.9		0.2	0.1	6.2	59.2	2.4	64.4
International aviation	1,336.2		0.0	0.0	1.0	2.9	0.5	0.6
International water-borne transport	2,295.7		0.2	0.1	5.3	56.3	1.9	63.8
CO_2 emissions from biomass	21,770.4							

NA = Not applicable; NE = Not estimated; NO = Not occurring; C = Confidential.

Source: Prepared in-house at SNICHILE.

Table 7. Chile's NGHGI: Anthropogenic emissions of HFC, PFC and SF_6 in 2010

Greenhouse gas source and sink categories	HFCs (Gg)							PFC (Gg)	SF_6 (Gg)
	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	HFC-236fa	CF_4	
Total national emissions and removals	**0.12**	**0.32**	**241.06**	**0.27**	**9.52**	**29.91**	**0.11**	**6.14**	**NE, NO**
1. Energy									
A. Fuel combustion (Sectorial method)									
1. Energy industry									
2. Manufacturing and construction industries									
3. Transportation									
4. Other sectors									
5. Other (unspecified)									
B. Fugitive fuel emissions									
1. Solid fuel									
2. Petroleum and natural gas									
2. Industrial processes	**0.12**	**0.32**	**241.06**	**0.27**	**9.52**	**29.91**	**0.11**	**6.14**	**NE, NO**
A. Mineral products									
B. Chemical industry									
C. Metal production	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Other production	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Production of halocarbons and sulfur hexafluoride	NO	NO	NO	NO	NO	NO	NO	NO	NE
F. Consumption of halocarbons and sulfur hexafluoride	0.12	0.32	241.06	0.27	9.52	29.91	0.11	6.14	NE, NO
G. Other									
3. Solvent and other product use									
4. Agriculture									
A. Enteric fermentation									
B. Manure management									
C. Rice cultivation									
D. Agricultural soils									
E. Prescribed burning of savannahs									
F. Field burning of agricultural residues									
G. Other									
5. Land use, land use change and forestry									
A. Forested lands									
B. Cropland									
C. Grassland									
D. Wetlands									
E. Settlements									
F. Other land									
G. Other									
6. Waste									
A. Solid waste disposal									
B. Wastewater treatment and discharge									
C. Waste incineration									
D. Other									
7. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items									
International bunkers									
International aviation									
International water-borne transport									
CO_2 emissions from biomass									

NA = Not applicable; NE = Not estimated; NO = Not occurring; C = Confidential.
Source: Prepared in-house by SNICHILE.

2.1. Trends in aggregate GHG emissions

In 2010, the Chile's balance of GHG emissions and removals[15] amounted to 41,698.5 $GgCO_2eq$ (Table 8 and Figure 3), while the country's total GHG emissions[16] were 91,575.9 $GgCO_2eq$, representing an increase of 83.5% from 1990 to 2010 (Figure 3). The Energy and LULUCF sectors contributed most to this trend in Chile's GHG balance. The fluctuations observed in the balance of GHG emissions and removals are primarily the result of wildfires (included in the LULUCF sector). These issues will be addressed and explained in detail in the respective sectorial chapters of this report.

Table 8. Chile's NGHGI: GHG emissions and removals by sector (in $GgCO_2eq$), 1990–2010 series

Sector	1990	1995	2000	2005	2010
1. Energy	33,530.4	40,370.6	52,346.8	57,936.8	68,410.0
2. Industrial Processes	3,108.2	4,242.5	6,399.9	7,354.7	5,543.2
3. SOPU	82.3	94.8	118.0	110.7	243.0
4. Agriculture	10,710.2	11,892.6	12,493.2	12,736.9	13,825.6
5. LULUCF	-50,821.6	-48,743.8	-55,404.6	-44,624.2	-49,877.4
6. Waste	2,465.5	2,685.8	3,130.0	3,866.2	3,554.1
Balance (incl. LULUCF)	-925.0	10,542.5	19,083.4	37,381.1	41,698.5
Total (excl. LULUCF)	49,896.6	59,286.3	74,487.9	82,005.2	91,575.9

Source: Prepared in-house at SNICHILE.

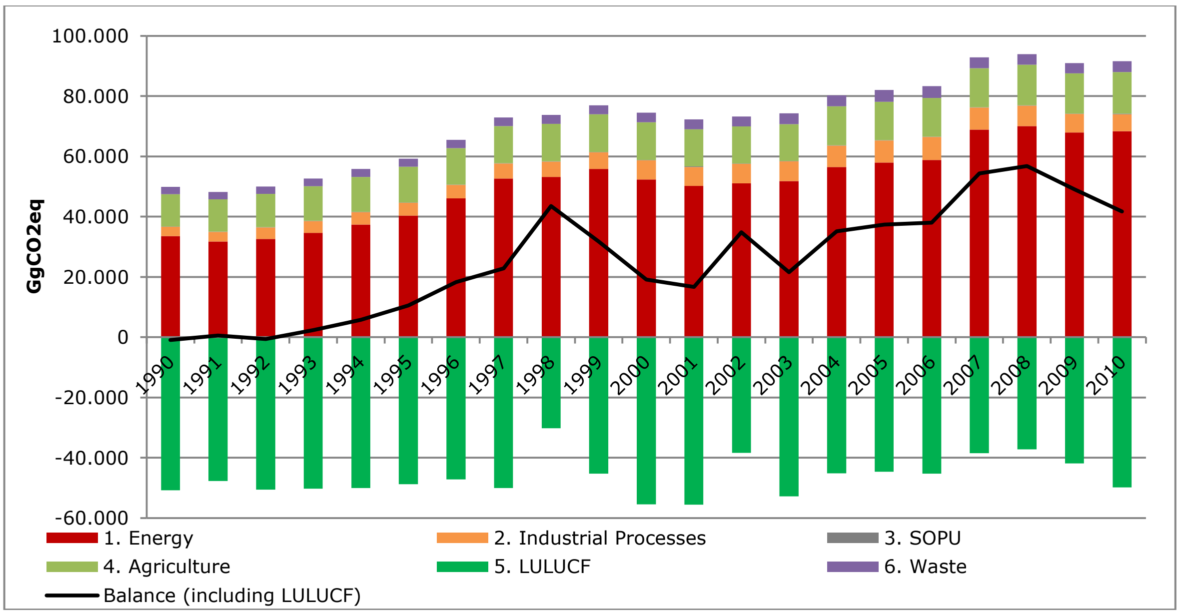

Figure 3. Chile's NGHGI: GHG emission and removal trend by sector, 1990–2010 series

At sector level, Energy accounts for 74.7% of total GHG emissions, followed by Agriculture (15.1%), Industrial processes (6.1%), Waste (3.9%), and SOPU (0.3%) (Figure 4).

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[15] In this report the term "balance of GHG emissions and removals" or "GHG balance" refers to aggregated national emissions and removals of GHG, expressed in terms of carbon dioxide equivalent (CO_2eq), including the LULUCF sector.

[16] In this report, the term "total GHG emissions" refers to aggregated national GHG emissions in Chile, expressed in terms of carbon dioxide equivalent (CO_2eq), excluding the LULUCF sector.

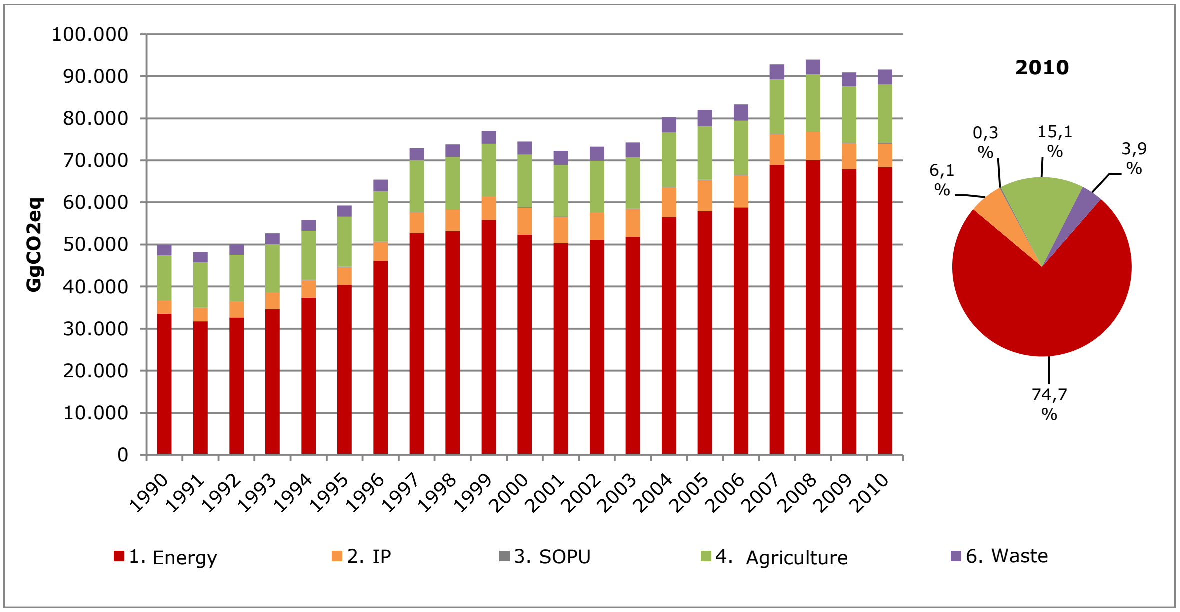

Figure 4. Chile's NGHGI: GHG emission trend by sector (excluding LULUCF), 1990–2010 series

2.2. Trends in GHG emissions by type of GHG

In 2010, CO_2, was the main GHG in Chile, accounting for 76.6% of total GHG emissions, followed by CH_4 with 12.5% and N_2O with 10.6%. Collectively, HFCs and PFCs accounted for 0.3% of total national GHG emissions (Table 9 and Figure 5). While these last two gases are less relevant in absolute terms, they displayed a notable increase of 1,240.3% between 2002 and 2010 (Figure 6).

Table 9. Chile's NGHGI: GHG emissions ($GgCO_2eq$) by type of GHG, excluding LULUCF, 1990–2010 series

GHG	1990	1995	2000	2005	2010
CO_2 (incl. LULUCF)	-17,349.9	-7,044.8	-129.9	16,336.1	19,484.9
CO_2 (excl. LULUCF)	33,738.5	42,052.2	55,355.5	61,529.7	70,105.0
CH_4 (incl. LULUCF)	10,605.4	10,802.2	11,694.8	12,604.7	11,973.6
CH_4 (excl. LULUCF)	10,419.3	10,555.9	11,638.4	12,207.6	11,455.9
N_2O (incl. LULUCF)	5,819.6	6,785.2	7,518.4	8,340.2	9,952.5
N_2O (excl. LULUCF)	5,738.8	6,678.2	7,494.0	8,167.8	9,727.7
HFC	0.0	0.0	0.0	99.3	281.3
PFC	0.0	0.0	0.0	0.7	6.1
Total (incl. LULUCF)	-925.0	10,542.5	19,083.4	37,381.1	41,698.5
Total (excl. LULUCF)	49,896.6	59,286.3	74,487.9	82,005.2	91,575.9

Source: Prepared in-house by SNICHILE.

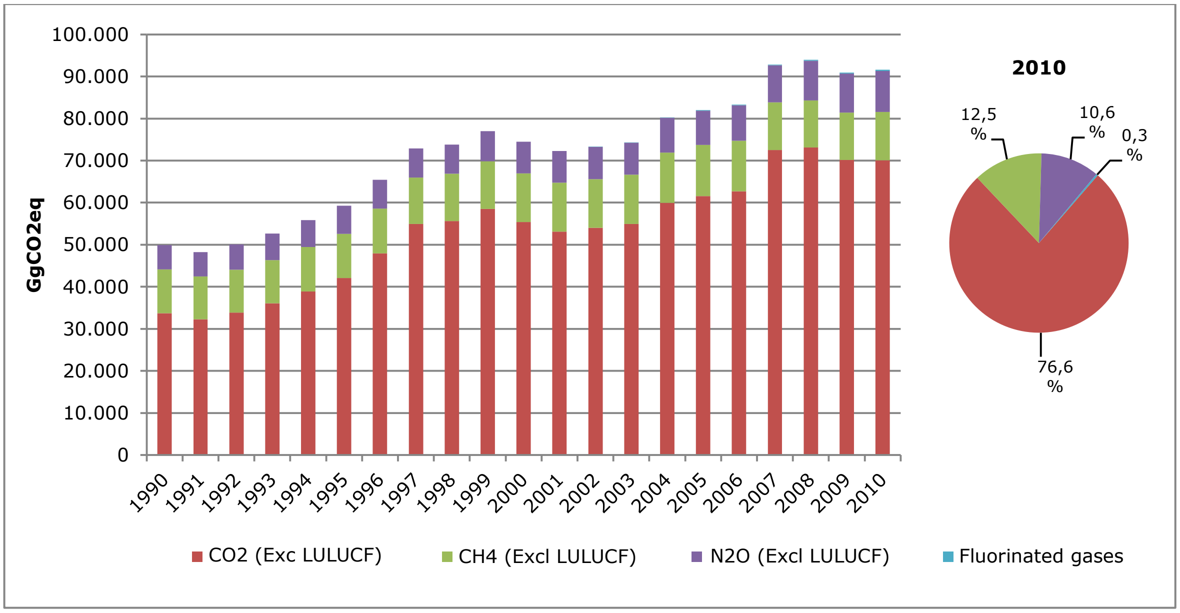

Figure 5. Chile's NGHGI: GHG emission trend by type of GHG, excluding LULUCF, 1990–2010 series

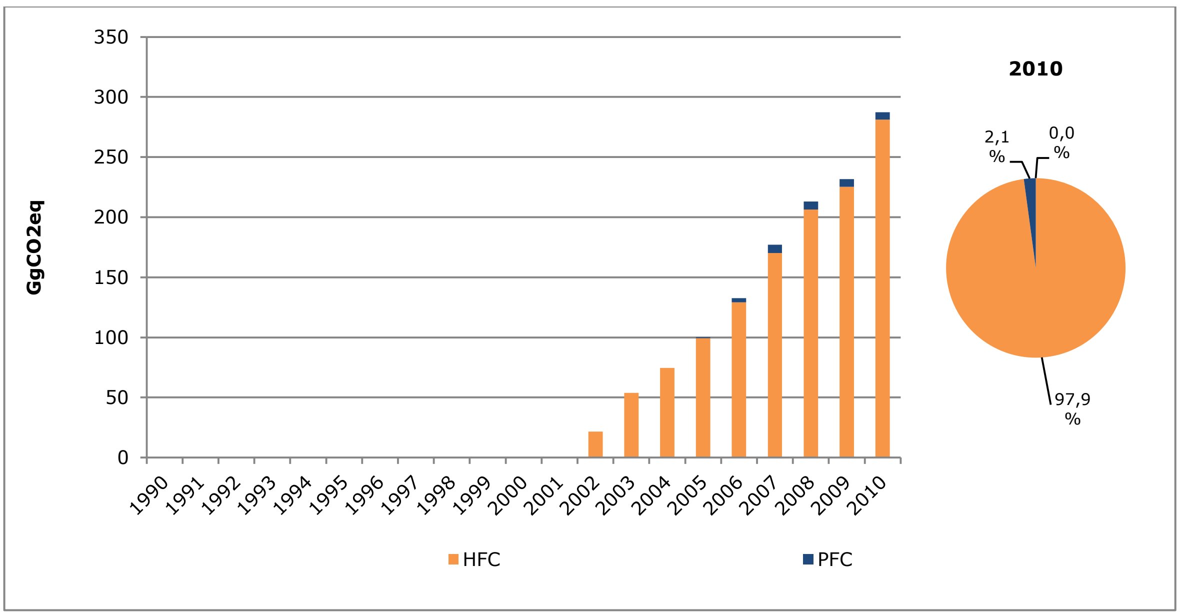

Figure 6. Chile's NGHGI: emission trend of fluorinated GHGs, excluding LULUCF, 1990–2010 series

3. ENERGY SECTOR (1)

3.1. Overview of the sector

In most countries, energy is generated by the combustion of fossil fuels. During combustion, carbon and hydrogen from the fossil fuels are converted into carbon dioxide (CO_2) and water (H_2O), which release the chemical energy of the fuel in the form of heat (IPCC, 2006). Heat is generally used directly (or with a certain conversion loss) to produce mechanical energy for electricity generation and for transportation.

The Energy sector includes, primarily:

- Exploration and exploitation of primary energy sources,
- Conversion of primary energy sources into more useable energy forms in refineries and power plants,
- Transmission and distribution of fuels, and
- Use of fuels in stationary and mobile applications.

Emissions result from the combustion of fossil fuels or as fugitive emissions during these activities. In this context, emissions can be classified according to their sources, which include:

- Stationary sources,
- Mobile sources, and
- Fugitive sources.

Chile's energy sector is based primarily on fossil fuel combustion, which in terms of terajoules (TJ) represents 82.6% of the country's primary energy balance for 2010, while biomass accounts for the remaining 17.4%. The country relies heavily on imported fuels, which accounted for 88.2% that year (MINENERGIA, 2012). The main fuels used in Chile in 2010 were diesel, representing 26.6% of total consumption (298,574.3 TJ), firewood, representing 17.3% (194,220.1 TJ), coal, representing 14.8% (165,536.1 TJ), natural gas, representing 11.4% (127,843.2 TJ) and gasoline, representing 10.9% (122,720.6 TJ). Fuel oil accounted for 6.5% (72,985.0 TJ), liquefied petroleum gas (LPG) for 5.1% (57,303.1 TJ), jet kerosene for 2.6% (29,288.2 TJ) and other fuels for 4.7% (52,559.4 TJ) (Figure 7).

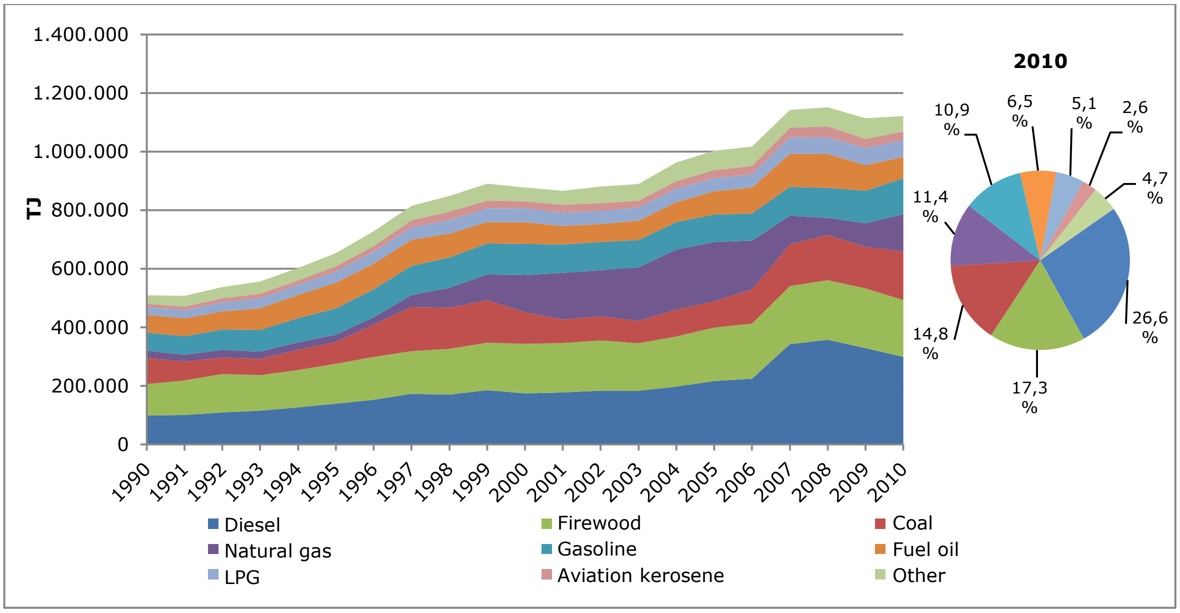

Figure 7. Energy Sector: Fuel consumption trend (TJ) by fuel type, 1990–2010 series

The Energy sector is the main source of GHG emissions in Chile, representing 74.7% of total GHG emissions (Figure 8).

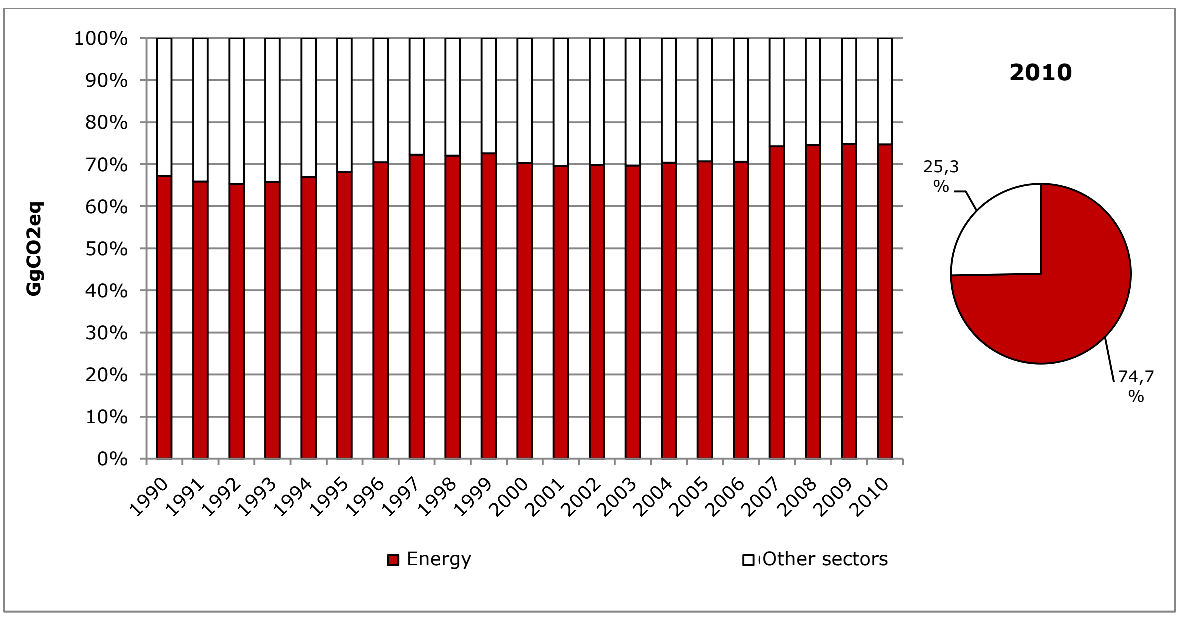

Figure 8. Energy sector: trend in contribution to total GHG emissions (excl. LULUCF)

In 2010, GHG emissions for the sector amounted to 68,410.0 $GgCO_2eq$ (Table 10). Since 1990, the sector's GHG emissions have increased by 104.0%, with the key drivers of this increase being coal and diesel consumption for electricity generation (a detailed explanation of this increase can be found below in point 3.2.1.1. on the Energy Industry), as well as liquid fuels used by road transport (light gasoline-powered vehicles and heavy diesel-powered vehicles). Interannual variations observed in Figure 9 for the 1999–2007 period are the result of the entry and then exit of natural gas imported from Argentina, which has been replaced primarily by coal and diesel. The decrease in emissions evident since 2009 can be attributed to the international economic crisis that began in 2008 and, to a lesser extent, to changes in the fuels used in Chile's electricity matrix. The decrease evident in 2010 was the result of the 8.8 magnitude (M_We) earthquake that occurred on February 27, 2010 and affected the country's economy throughout that year.

In terms of categories, 98.5% of this sector's GHG emissions correspond to the Fuel combustion category and 1.5% correspond to the Fugitive emissions from fuels category.

Table 10. Energy sector: GHG emissions ($GgCO_2eq$) by category, 1990–2010 series

Category	1990	1995	2000	2005	2010
1A. Fuel combustion	31,636.3	39,231.3	51,051.6	56,688.1	67,392.1
1B. Fugitive emissions from fuels	1,894.1	1,139.3	1,295.2	1,248.6	1,017.9
Total	33,530.4	40,370.6	52,346.8	57,936.8	68,410.0

Source: Prepared in-house by SNICHILE.

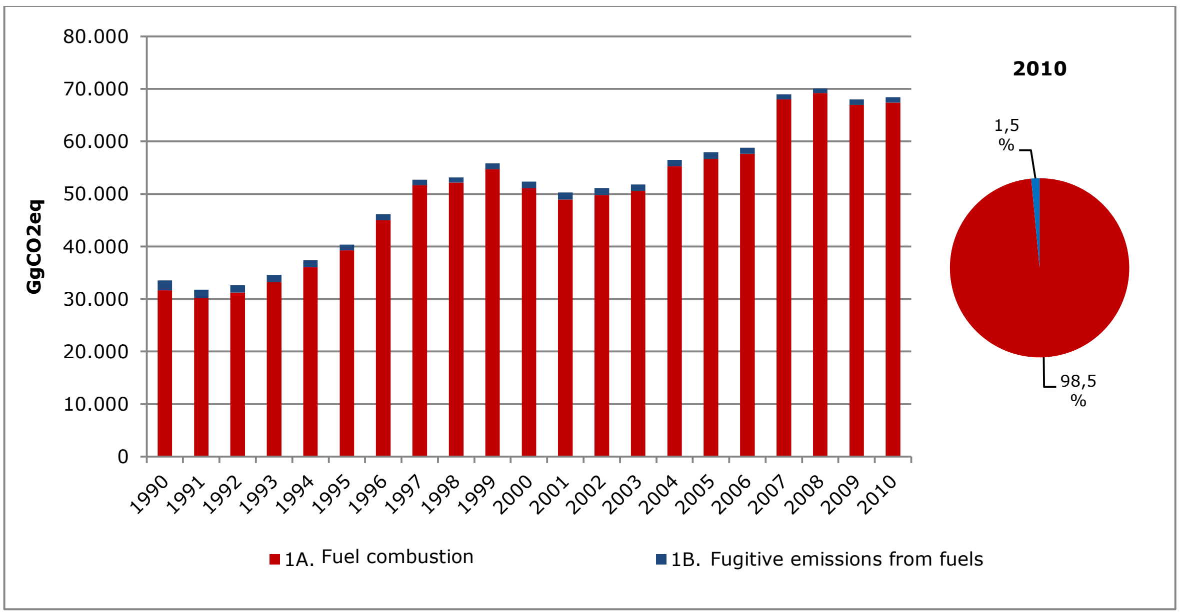

Figure 9. Energy sector: GHG emission trend by category, 1990–2010 series

At the subcategory level, the Energy industry was most important (mainly owing to electricity generation), accounting for 39.7% of emissions, followed by Transport (mainly road transport) with 30.5%, Manufacturing industries and construction accounted for 18.1%, and Other sectors (mainly residential fossil fuel consumption) accounted for 10.2%. Lastly, the Oil and natural gas subcategory amounted to 1.4% and Solid fuels to 0.1% (Figure 10).

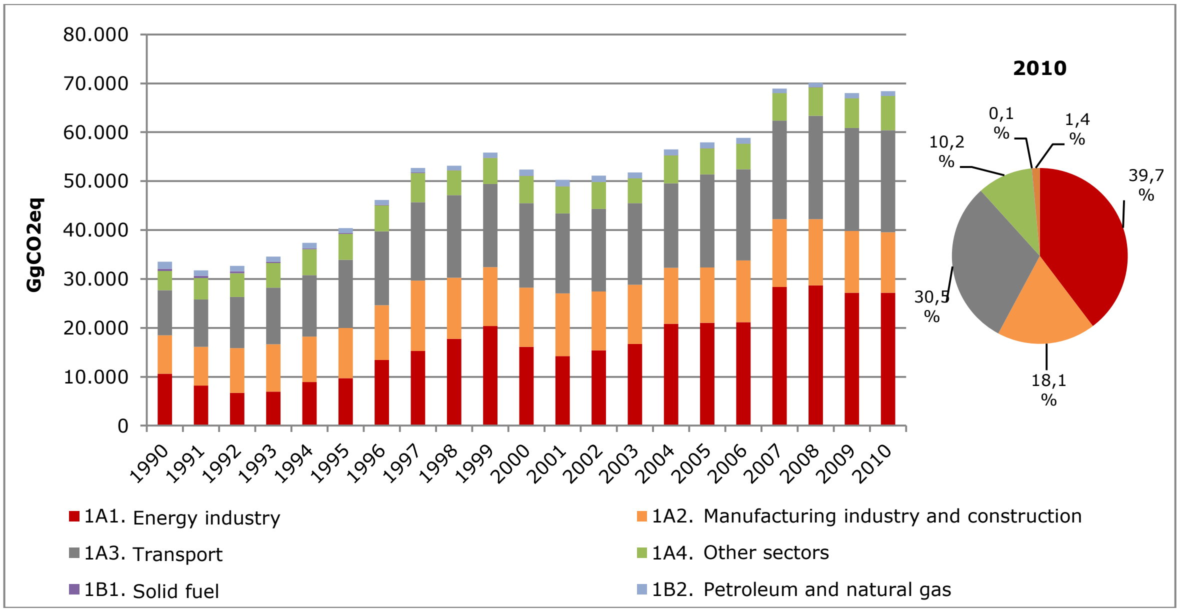

Figure 10. Energy Sector: GHG emission trend by subcategory, 1990–2010 series

In 2010, CO_2 was the main GHG emitted by this sector, accounting for 96.1% of the sector's total GHG emissions, followed by CH_4 with 2.8% and N_2O with 1.0% (Table 11 and Figure 11).

Table 11. Energy Sector: emissions by type of GHG ($GgCO_2eq$), 1990–2010 series

GHG	1990	1995	2000	2005	2010
CO_2	30,730.5	38,054.2	49,653.5	55,226.6	65,776.0
CH_4	2,468.2	1,878.9	2,144.4	2,129.5	1,946.1
N_2O	331.7	437.5	549.0	580.7	687.9
Total	33,530.4	40,370.6	52,346.8	57,936.8	68,410.0

Source: Prepared in-house by SNICHILE.

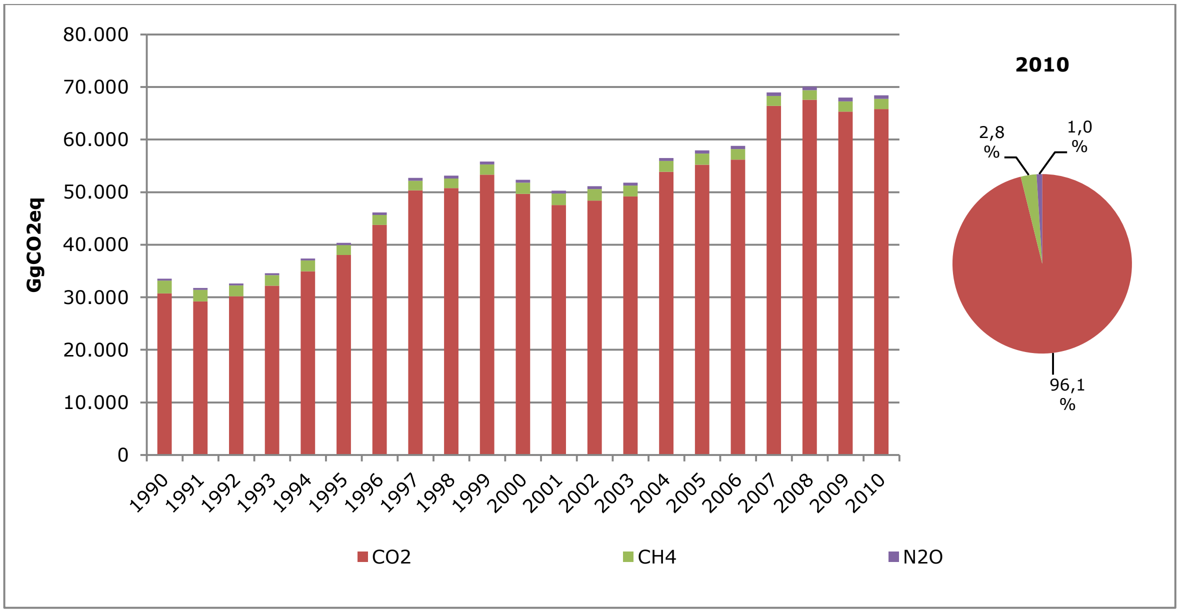

Figure 11. Energy Sector: Emissions by type of GHG ($GgCO_2eq$), 1990–2010 series

3.2. Fuel combustion (1A)

3.2.1. Description of the category and GHG emissions

The Fuel combustion category groups together emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus.

The category includes the following subcategories:

- 1A1 Energy industries.
- 1A2 Manufacturing industries and construction.
- 1A3 Transport.
- 1A4 Other sectors.

In Chile this category includes emissions produced by energy generation and fuel production. According to Chile's National Energy Balance (BNE), fuel combustion in Chile is divided among 4 sectors:

- Energy system (Transformer stations and Electricity sector),
- Transport,
- Industry and mining, and
- Commercial, institutional and residential.

The Fuel combustion category is the principal source of GHG emissions in the sector; in 2010 its GHG emissions amounted to 67,392.1 $GgCO_2eq$, or 98.5% of the sector's total emissions. Since 1990, GHG emissions of this category have increased by 113.0% (see
Table **12** and Figure 12).

Table 12. Fuel combustion: GHG emissions (GgCO_2eq) by subcategory, 1990–2010 series

Subcategory	1990	1995	2000	2005	2010
1A1. Energy industry	10,609.9	9,720.2	16,157.0	21,056.2	27,153.3
1A2. Manufacturing industries and construction	7,845.4	10,296.4	12,064.2	11,327.1	12,408.7
1A3. Transport	9,251.9	13,886.7	17,298.5	19,021.9	20,840.9
1A4. Other sectors	3,929.1	5,328.0	5,531.9	5,282.9	6,989.3
Total	31,636.3	39,231.3	51,051.6	56,688.1	67,392.1

Source: Prepared in-house by SNICHILE.

At the subcategory level, the Energy industry is the greatest source of GHGs, accounting for 40.3% of emissions in the category, followed by Transport with 30.9%, Manufacturing industries and construction with 18.4% and Other sectors with 10.4% (Figure 12).

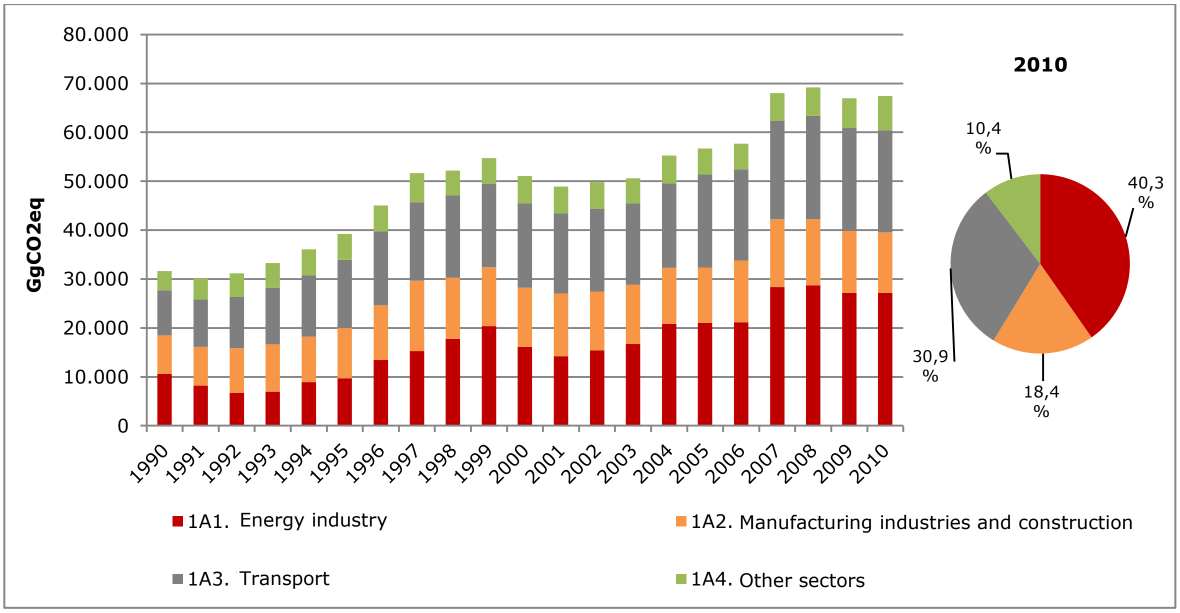

Figure 12. Fuel combustion: GHG emission trend by subcategory, 1990–2010 series

In terms of fuel type, liquid fuels lead the list with 60.1%, followed by solid fuels with 27.7%, gaseous fuels with 10.7% and biomass with 1.5% (Figure 13).

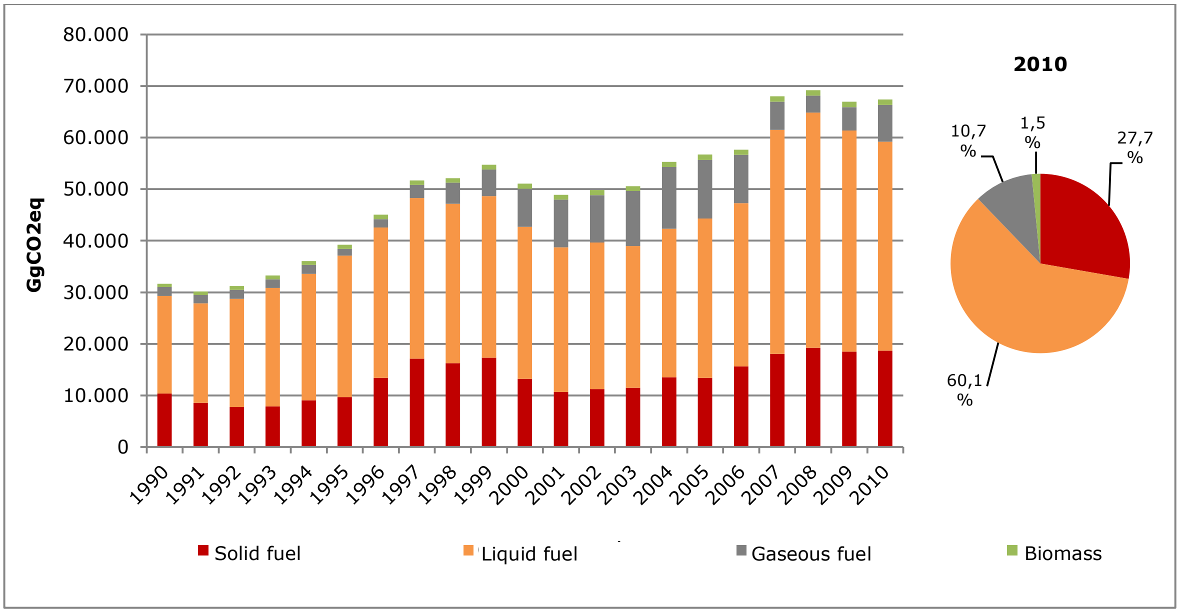

Figure 13. Fuel combustion: GHG emission trend ($GgCO_2eq$) by type of fuel, 1990–2010 series

3.2.1.1. Energy industry (1A1)

This subcategory includes emissions from fuel combustion associated with fuel extraction and energy production industries. Its components are:

- 1A1a Main activity electricity and heat production.
- 1A1b Petroleum refining.
- 1A1c Manufacture of solid fuels and other energy industries.

In this context, Chile's national emissions for this subcategory include:

- All electricity production, both public generators and self-generation,
- Operation of petroleum refineries, not including the quantity of fuel burned from transformed fuel (non-energy use of fuel),
- Energy consumption of solid fuel manufacturing industries, and
- Emissions from combustion involved in methanol formation from natural gas.

The Energy industry subcategory is the main source of GHGs in this category and within the Energy sector itself. In 2010, GHG emissions in this subcategory amounted to 27,153.3 $GgCO_2eq$, or 40.3% of the category overall. Since 1990, these GHG emissions have increased by 155.9% (Table 13).

Table 13. Energy industry: GHG emissions ($GgCO_2eq$) by component, 1990–2010 series

Component	1990	1995	2000	2005	2010
1A1a. Main activity electricity and heat production	8,298.1	7,426.0	13,796.1	16,747.7	24,811.4
1A1b. Petroleum refining	1,925.7	1,863.2	1,630.5	2,827.6	1,552.1
1A1c. Manufacture of solid fuels and other energy industries	386.1	431.0	730.4	1,480.9	789.8
Total	10,609.9	9,720.2	16,157.0	21,056.2	27,153.3

Source: Prepared in-house by SNICHILE.

At the component level, Main activity electricity and heat production is the most significant, accounting for 91.4% of GHG emissions, followed by Petroleum refining, with 5.7% and Manufacture of solid fuels and other energy industries, with 2.9% (Figure 14).

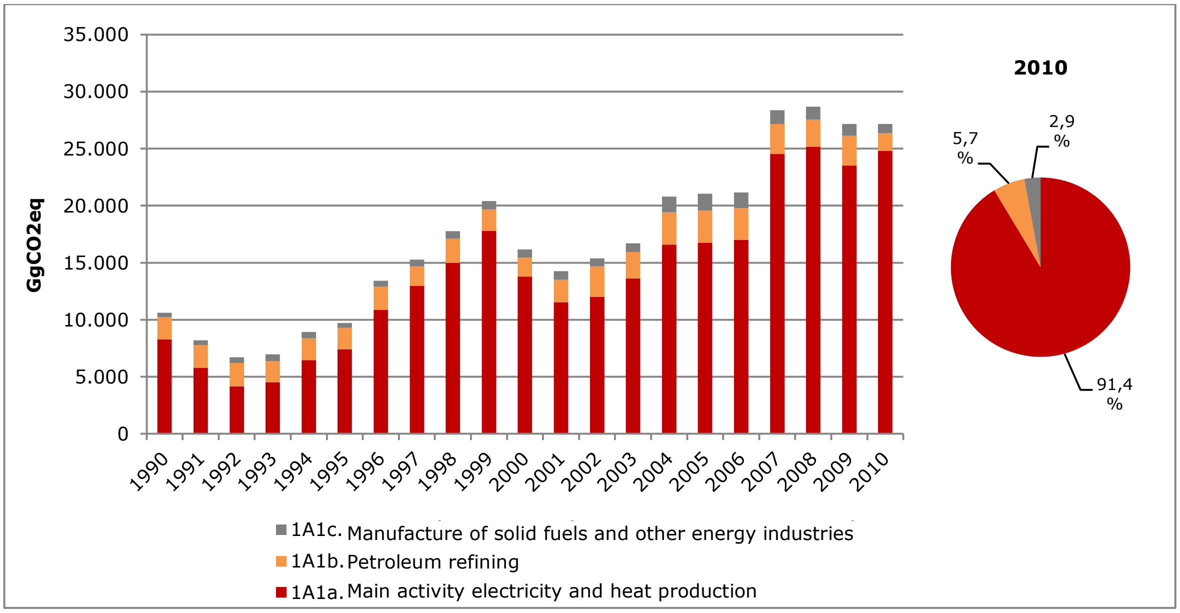

Figure 14. Energy industry: GHG emission trend by component, 1990–2010 series

In terms of fuel types, coal accounts for the largest share of 59.6%, followed by natural gas with 16,7%, diesel with 16.0% and coke with 4.2%. Other fuels account for the remaining 3.5% (Table 14 and Figure 15).

Table 14. Main activity electricity and heat production: GHG emission trend ($GgCO_2eq$) by fuel type, 1990–2010 series

Fuel	1990	1995	2000	2005	2010
Coal	6,568.2	5,538.7	8,292.1	6,830.1	14,794.1
Natural gas	147.1	174.6	3,885.8	6,374.9	4,143.5
Diesel	588.2	211.4	456.9	731.6	3,965.5
Coke	0.0	0.0	620.9	2,334.6	1,050.9
Other	994.7	1,501.3	540.4	476.4	857.3
Total	8,298.1	7,426.0	13,796.1	16,747.7	24,811.4

Source: Prepared in-house by SNICHILE.

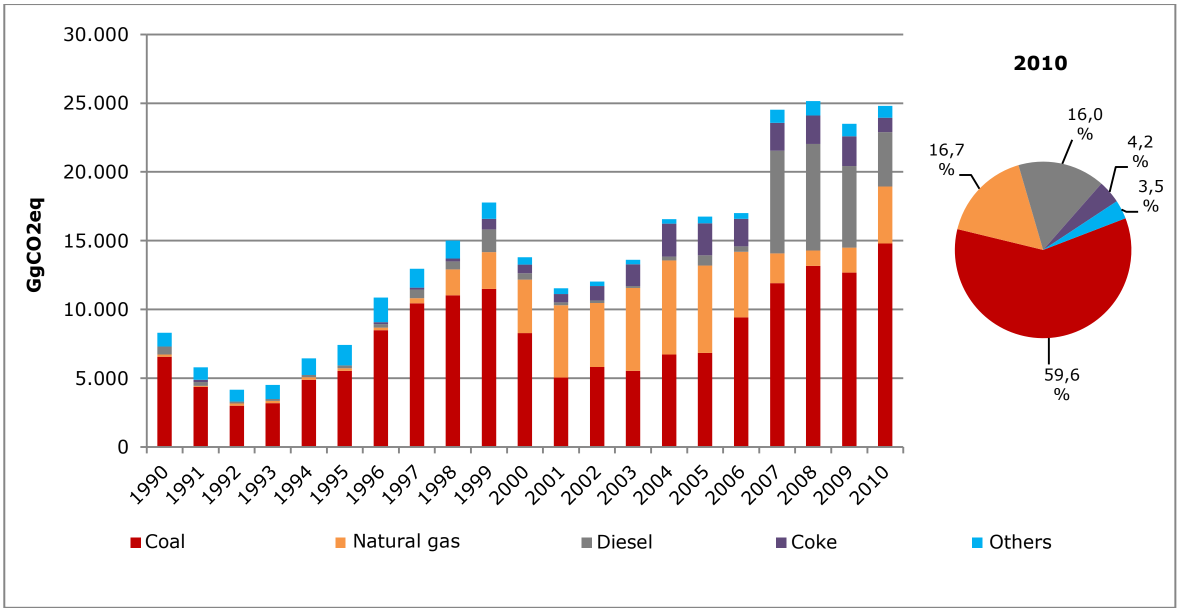

Figure 15. Main activity electricity and heat production: GHG emission trend (GgCO_2eq) by fuel type, 1990–2010 series

Figure 16 presents electricity generation curves (in GWh) for the country's main energy sources: hydropower, coal, natural gas, diesel, biomass, wind power and other sources, versus emissions for the subcategory Main activity electricity and heat production. The maximum emissions occur when hydropower generation diminishes and diesel-fired and especially coal-fired power generation increases, as can be observed in 1999 and 2008. When hydropower generation increases the opposite occurs; this can be seen in 1990–1992 and 2005–2006, when emissions in this subcategory tended to decrease. The influence of natural gas usage on GHG emissions is also worth noting. The graph shows for instance how GHG emissions decreased over the 1990–2005 period as a result of an increase in the consumption of natural gas, an abundant supply of which was imported from Argentina and displaced coal and diesel consumption in Chile. The figure also shows the effects of the shutdown of the natural gas supply from Argentina accompanied by a reduction in hydroelectric power owing to droughts that affected the country at the time, beginning in 2007. This led to increased consumption of coal and diesel and an attendant rise in GHG emissions that reiterated the trend witnessed in the 1990–1998 period.

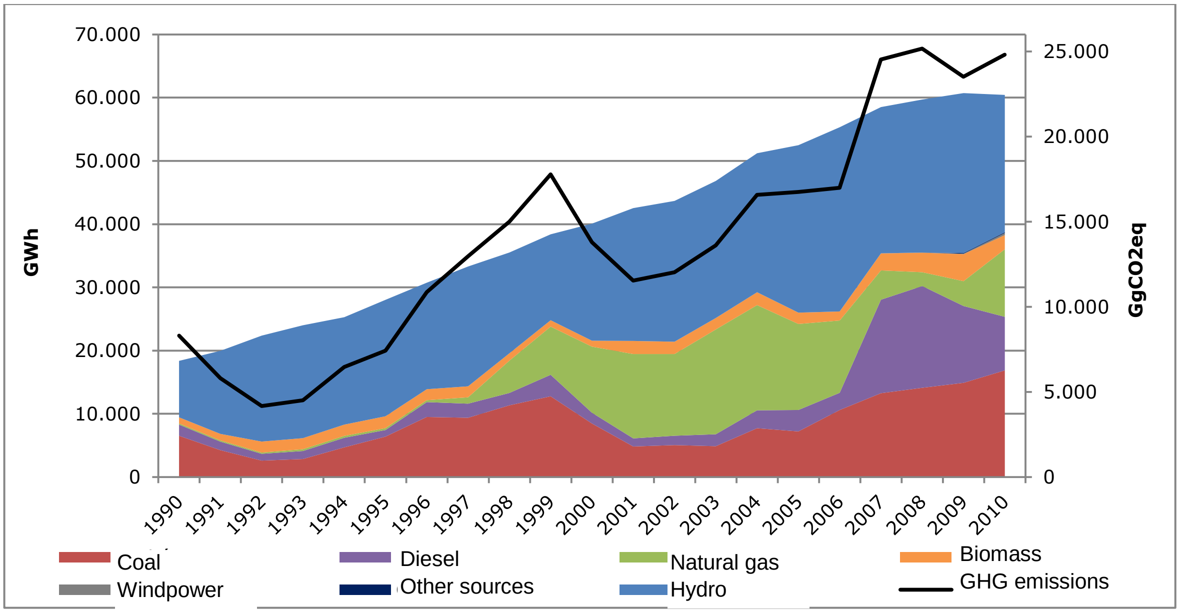

Figure 16. Main activity electricity and heat production: electricity generation by source type and GHG emissions, 1990–2010 series

3.2.1.2. Manufacturing industries and construction (1A2)

This subcategory addresses emissions from industrial fuel combustion and includes combustion related to self-generated electricity and heat within those industries. Its components are:

- 1A2a Iron and steel.
- 1A2b Non-ferrous metals.
- 1A2c Chemicals.
- 1A2d Pulp, paper and print.
- 1A2e Food processing, beverages and tobacco.
- 1A2f Other industries.

National emissions in this subcategory include:

- Iron and steel industries and smelters,
- Manufacturing of chemical substances and products, mainly the petrochemical industry,
- Paper and cellulose manufacturing,
- Industries dedicated to the production of food, beverages and tobacco,
- Production of other non-metallic minerals, primarily cement,
- Extraction of metallic minerals and other types of mining and quarrying, including copper, saltpeter, iron and other mining. Mining of fuels such as coal is not included here but accounted for in category 1B, and
- Unspecified industries, i.e. industries “not included” in the previous classification.

In 2010, GHG emissions by this subcategory amounted to 12,408.7 $GgCO_2eq$, or 18.4% of the entire category. These GHG emissions have increased by 58.2% since 1990 (Table 15), the key driver being Chile’s thriving copper mining sector. The interannual variations observed in this subcategory's emissions are mainly the result of the abrupt increase in coal consumption in the Unspecified industry component in 1997 (Figure 17).

Table 15. Manufacturing and construction industries: GHG emissions ($GgCO_2eq$) by component, 1990–2010 series

Component	1990	1995	2000	2005	2010
1A2a. Iron and steel	1,488.5	1,721.3	1,967.0	1,451.9	586.0
1A2c. Chemicals	2.7	22.8	28.5	34.6	938.3
1A2d. Pulp, paper and print	282.6	524.6	741.9	670.5	609.5
1A2e. Food processing, beverages and tobacco	329.1	434.9	445.0	380.5	250.6
1A2f. Other industries (non-metallic minerals)	537.2	942.1	745.7	866.8	947.3
1A2f. Other industries (mining and quarrying)	2,554.1	2,095.4	4,231.0	4,258.9	6,128.4
1A2f. Other industries (unspecified industries)	2,651.2	4,555.3	3,905.1	3,663.8	2,948.6
Total	7,845.4	10,296.4	12,064.2	11,327.1	12,408.7

Source: Prepared in-house by SNICHILE.

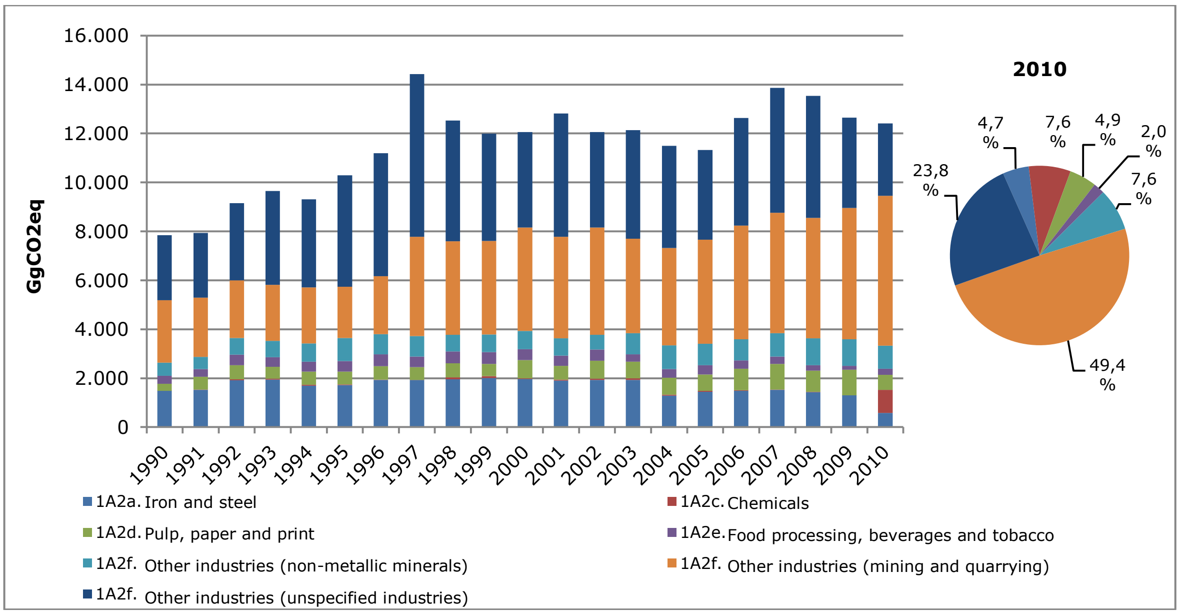

Figure 17. Manufacturing industries and construction: GHG emission trend by component, 1990–2010 series

At the component level, Mining and quarrying is the most significant, accounting for 49.4% of GHG emissions, followed by Unspecified industries with 23.8%, Non-metallic minerals with 7.6%, and Chemicals with 7.6%. Pulp, paper and print accounted for 4.9% and Iron and steel for 4.7%, while the Food, beverages and tobacco component made up the remaining 2.0% (Table 16 and Figure 18).

Among Mining and quarrying components, Copper mining is the most significant, accounting for 58.1% of GHG emissions, followed by Other mining, with 33.1%, Iron with 4.7%, and Saltpeter with 4.1%. Other mining has no assigned values from 1990 to 1996 because its consumption was accounted for under "Miscellaneous Industries" (*Industrias varias*) up to the latter year and presented in aggregate form under 1A2f. Unspecified industries.

Table 16. Mining and quarrying: GHG emissions ($GgCO_2eq$) by component, 1990–2010 series

Component	1990	1995	2000	2005	2010
Copper mining	2,117.6	1,668.3	2,315.3	2,553.4	3,557.7
Other mining	0.0	0.0	1,297.3	1,154.7	2,030.6
Saltpeter	207.6	208.7	303.1	298.6	252.1
Iron	229.0	218.5	315.3	252.3	288.0
Total	2,554.1	2,095.4	4,231.0	4,258.9	6,128.4

Source: Prepared in-house by SNICHILE.

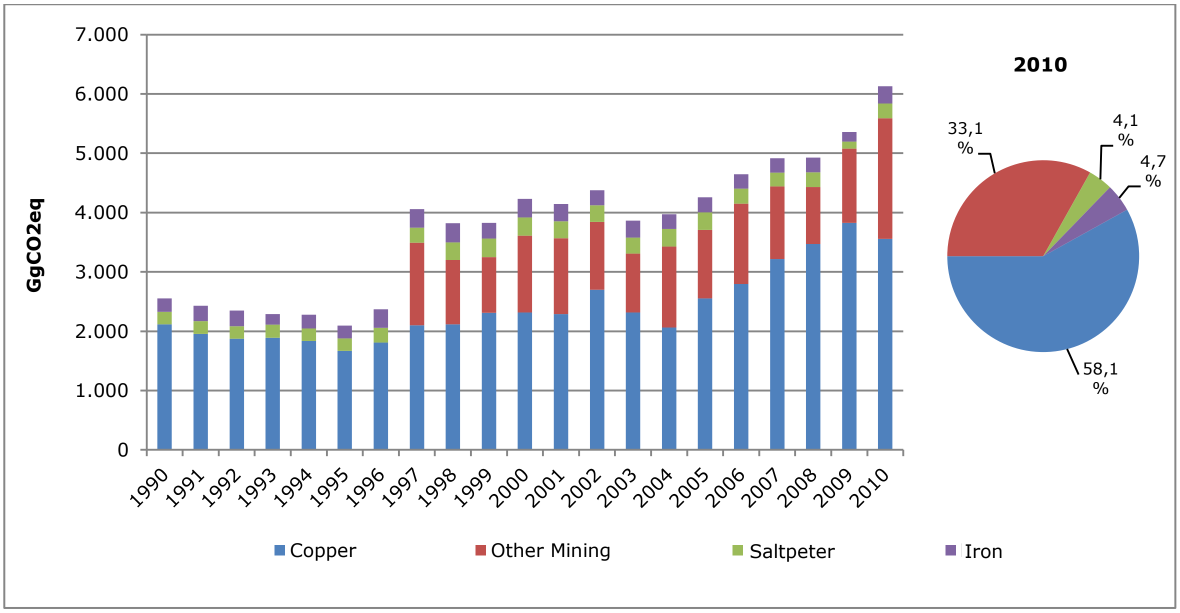

Figure 18. Mining and quarrying: GHG emission trend by component, 1990–2010 series

3.2.1.3. Transport (1A3)

The Transport subcategory includes all emissions from fuel combustion associated with all transport activities except military transport. Emissions from international transportation are reported separately. The components of this subcategory are:

- 1A3a Domestic aviation.
- 1A3b Road transportation.
- 1A3c Railways.
- 1A3d Domestic water-borne navigation.
- 1A3e Other types of transportation.

Within this context, national emissions for this subcategory include:

- domestic civil aviation,
- fuel use by road vehicles including the use of vehicles on paved highways, with cars, motorcycles, heavy trucks and buses reported separately,
- railways, both passenger and freight, and
- maritime and river shipping, excluding fishing boats, which are reported in the subcategory Other sectors.

In 2010, GHG emissions for the subcategory amounted to 20,480.9 $GgCO_2eq$, or 30.9% of the category as a whole. Since 1990, GHG emissions have increased by 125.3% (Table 17), with the key driver of that increase being the steady rise in the number of cars on the country's roads.

At the component level, Road transportation is the most significant, accounting for 93.4% of the subcategory, followed by 3.8% from Domestic aviation, 2.1% from Domestic water-borne navigation and 0.7% from Railways (Figure 19).

Table 17. Transport: GHG emissions ($GgCO_2eq$) by component, 1990–2010 series

Component	1990	1995	2000	2005	2010
1A3a. Domestic aviation	567.9	657.8	682.9	948.5	789.8
1A3b. Road transportation	7,739.0	12,029.2	15,472.5	16,256.7	19,463.5
1A3c. Railways	64.5	41.6	64.1	53.6	153.2
1A3d. Domestic water-borne navigation	880.5	1,158.0	1,078.9	1,763.2	434.4
Total	9,251.9	13,886.7	17,298.5	19,021.9	20,840.9

Source: Prepared in-house by SNICHILE.

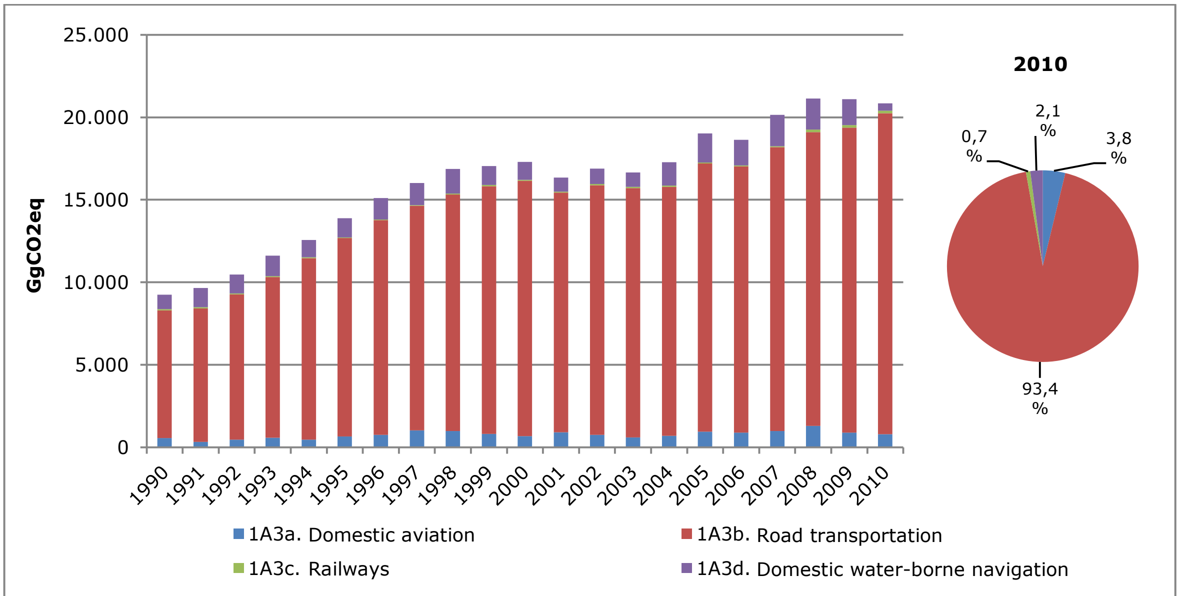

Figure 19. Transport: GHG emission trend by component, 1990–2010 series

Regarding the types of fuel used by Road transportation, diesel is the most significant, accounting for 53.7%, followed by gasoline with 44.7%, and other fuels with 1.6% (Table 18 and Figure 20).

Table 18. Road transportation: GHG emissions ($GgCO_2eq$) by type of fuel, 1990–2010 series

Fuel	1990	1995	2000	2005	2010
Diesel	3,379.8	5,661.7	7,926.3	9,489.4	10,444.6
Gasoline	4,345.5	6,352.1	7,526.9	6,645.8	8,705.3
Other	13.8	15.3	19.3	121.5	313.5
Total	7,739.0	12,029.2	15,472.5	16,256.7	19,463.5

Source: Prepared in-house by SNICHILE.

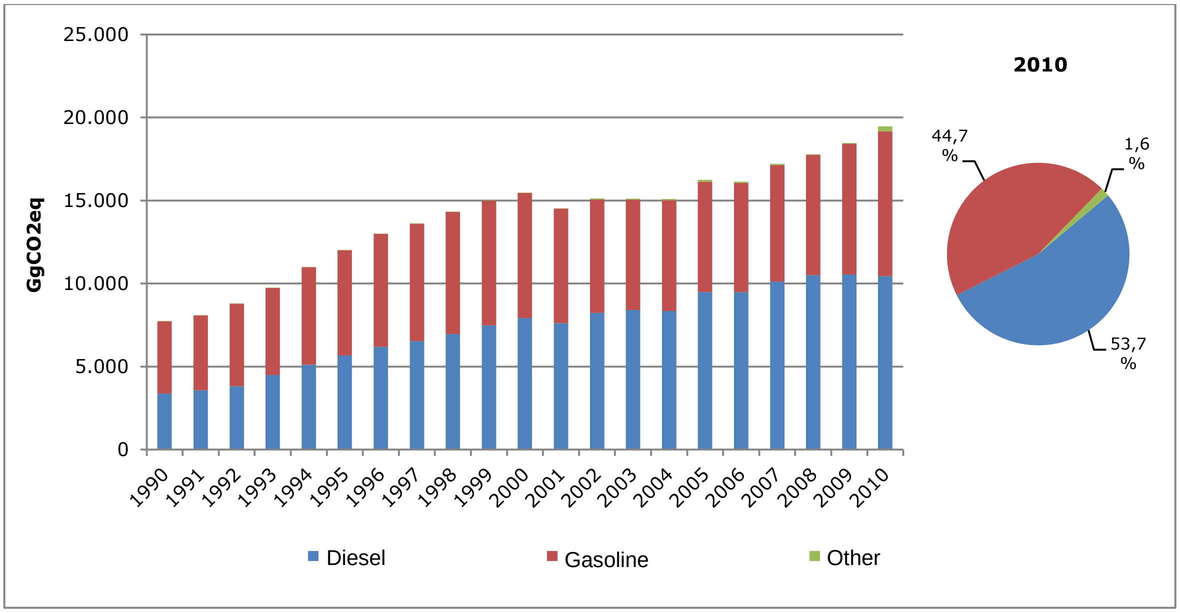

Figure 20. Road transportation: GHG emission trend by fuel type, 1990–2010 series

3.2.1.4. Other sectors (1A4)

This subcategory addresses emissions from combustion activities in commercial and institutional buildings, all emissions from residential fuel combustion and emissions from the combustion of fuels used in agriculture, forestry, fishing and the fishing industry. Its components are:

- 1A4a Commercial / Institutional.
- 1A4b Residential.
- 1A4c Agriculture / Forestry / Fishing.

National emissions in this subcategory include:

- Fuel combustion in commercial and institutional buildings,
- Residential fuel combustion, and
- Fuel combustion in fishing.

In 2010, GHG emissions for this subcategory amounted to 6,989.3 $GgCO_2eq$, or 10.4% of the category as a whole. Since 1990, GHG emissions in this subcategory have increased by 77.9% (Table 19), the key driver being the steady rise in the use of LPG and natural gas by the residential sector.

At the component level, the Residential subcategory is the most significant, accounting for 63.2% of the total, followed by Commercial / Institutional emissions with 24.0%, then Agriculture / Forestry / Fishing with 12.7% (Figure 21).

Table 19. Other sectors: GHG emissions ($GgCO_2eq$) by component, 1990–2010 series

Component	1990	1995	2000	2005	2010
1A4a. Commercial / Institutional	486.7	664.5	612.4	841.6	1,680.6
1A4b. Residential	3,004.1	4,210.6	4,322.8	3,973.0	4,417.6
1A4c. Agriculture / Forestry / Fishing	438.2	452.9	596.7	468.3	891.1
Total	3,929.1	5,328.0	5,531.9	5,282.9	6,989.3

Source: Prepared in-house by SNICHILE.

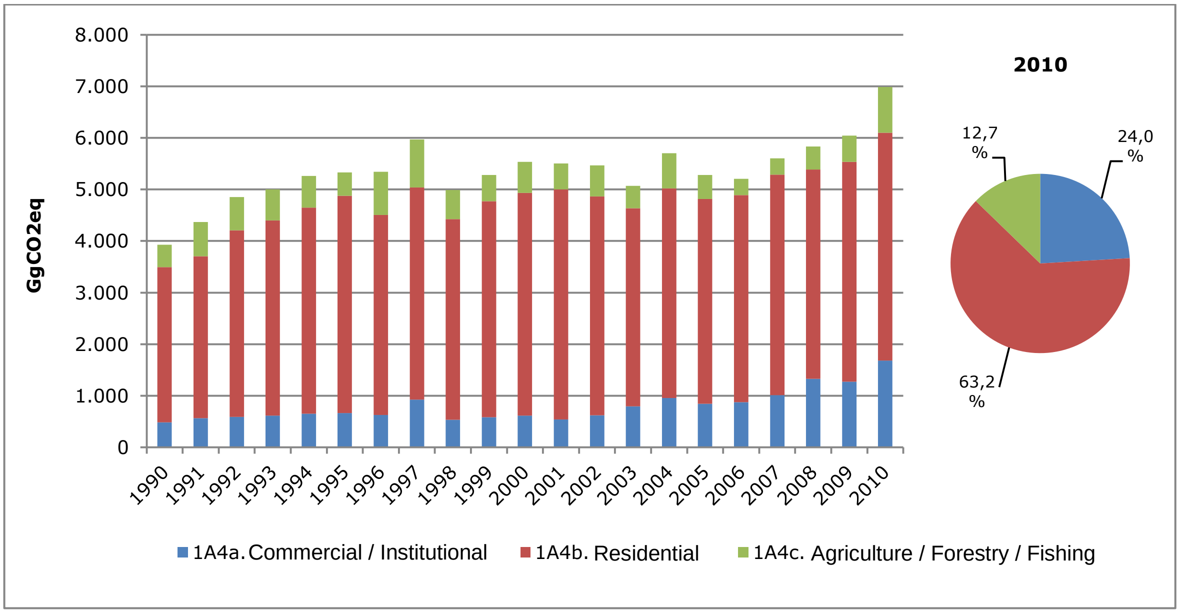

Figure 21. Other sectors: GHG emission trend by component, 1990–2010 series

In regard to fuel types used in the Residential component, LPG is the most significant, accounting for 50.8%, followed by natural gas with 20.9%, biomass with 20.2%, kerosene with 7.6% and other fuels with 0.5% (Table 20 and Figure 22).

Table 20. Residential: GHG emissions ($GgCO_2eq$) by type of fuel, 1990–2010 series

Fuel	1990	1995	2000	2005	2010
LPG	1,271.9	1,803.3	2,312.0	2,054.4	2,244.5
Natural gas	304.8	0.0	570.7	813.1	922.0
Biomass	488.1	628.8	837.6	871.7	893.7
Kerosene	355.0	580.0	493.7	178.9	335.5
Other	584.1	1,198.5	108.8	54.8	21.9
Total	3,004.1	4,210.6	4,322.8	3,973.0	4,417.6

Source: Prepared in-house by SNICHILE.

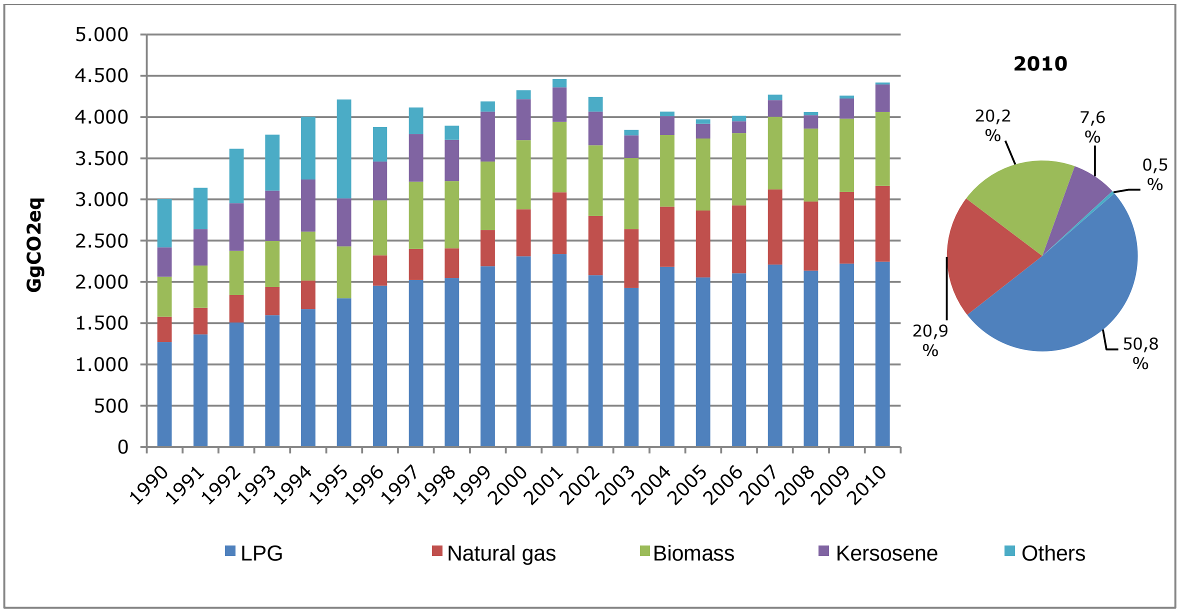

Figure 22. Residential: GHG emission trend by fuel type, 1990–2010 series

3.2.2. Methods applied

The methods applied to prepare the Fuel combustion category are presented in the Table below:

Table 21. Fuel combustion: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
A. Fuel combustion	T1	D	T1	D	T1	D
1. Energy industry	T1	D	T1	D	T1	D
a. Main activity electricity and heat production	T1	D	T1	D	T1	D
b. Petroleum refining	T1	D	T1	D	T1	D
c. Manufacture of solid fuels and other energy industries	T1	D	T1	D	T1	D
2. Manufacturing industries and construction	T1	D	T1	D	T1	D
a. Iron and steel	T1	D	T1	D	T1	D
b. Non-ferrous metals	NE	D	NE	D	NE	D
c. Chemicals	T1	D	T1	D	T1	D
d. Pulp, paper and print	T1	D	T1	D	T1	D
e. Food processing, beverages and tobacco	T1	D	T1	D	T1	D
f. Other	T1	D	T1	D	T1	D
Non-metallic minerals	T1	D	T1	D	T1	D
Mining (excluding fuel) and quarrying	T1	D	T1	D	T1	D
Unspecified industry	T1	D	T1	D	T1	D
3. Transport	T1	D	T1	D	T1	D
a. Domestic aviation	T1	D	T1	D	T1	D
b. Road transportation	T1	D	T1	D	T1	D
c. Railways	T1	D	T1	D	T1	D
d. Domestic water-borne navigation	T1	D	T1	D	T1	D
e. Other types of transportation	NA	NA	NA	NA	NA	NA
4. Other sectors	T1	D	T1	D	T1	D
a. Commercial/Institutional	T1	D	T1	D	T1	D
b. Residential	T1	D	T1	D	T1	D
c. Agriculture/Forestry/Fishing	T1	D	T1	D	T1	D
5. Other	NO, C	D	NO, C	D	NO, C	D
a. Stationary	NO	D	NO	D	NO	D
b. Mobile	NO, C	D	NO, C	D	NO, C	D

T1 = Tier 1 Method 1; D = Default; NA = Not applicable; NE = Not estimated; NO = Not occurring; C = Confidential.
Source: Prepared in-house by SNICHILE.

The emission factors set out in the 2006 IPCC Guidelines require activity data to be presented in terajoules (TJ) based on the lower heating value (LHV) of the fuel in question; however, the values reported in Chile's BNE, which summarizes data on energy production, importation, exportation, transformation and consumption, are also expressed in teracalories (Tcal) but are based on the higher heating value of fuels (HHV). The latter must therefore be converted through the following formula:

$$TJ_i = Tcal_i \times LHVi\ Factor \times 4{,}1868$$

Where:

- *TJ_i= fuel consumption i, expressed in terajoules*
- *$Tcal_i$= fuel consumption i, expressed in teracalories*
- *LHV_i Factor = factor that converts HHV to LHV_i for the fuel i*

GHG emissions are often calculated as the product of fuel consumption and the emission factor specific to the fuel type and type of GHG. In general, the equation is as follows:

$$Emission_{GHG} = Fuel\ consumption_{type\ of\ fuel} \times Emission\ factor_{GHG,type\ of\ fuel}$$

GHG emission estimates were calculated by using a Tier 1 method, the most basic level stipulated by the 2006GL for all corresponding GHGs when information required to formulate country-specific emission factors (and therefore enable the use of Tier 2 methodologies) is not available.

3.2.2.1. Statistical and parametrical activity data

The main source of information for the Fuel combustion category is Chile's BNE, which tallies energy consumed in the country. From 1960 to 2009 the BNE was prepared by the National Energy Commission (CNE) and in 2010 it passed directly into the hands of the Ministry of Energy. (http://www.minenergia.cl/documentos/balance-energetico.html)

The information used to estimate SO_2 emissions was taken from the *Statistical Report* published by the Office of the Superintendent of Electricity and Fuels, which provides region-by-region data on the consumption and sulfur content of hydrocarbons.

Additional information provided by the National Customs Service (Aduanas) was used to differentiate activity data for domestic and international aviation and domestic and international water-borne navigation, given that the BNE does not disaggregate aviation and water-borne transportation data by origin/destination.

3.2.2.2. Emission factors

The default emission factors provided in the 2006GL for the Fuel combustion category were used to calculate GHG emissions for all subcategories and all GHGs estimated.

3.3. Fugitive emissions from fuels (1B)

3.3.1. Description of the category and its GHG emissions

Activities covered under this category in Chile include: for the solid fuel category—mining and processing of coal mined from surface and underground mines; for the oil category—fugitive emissions from venting, production and refining (when these are integrated processes); crude transport and refining to generate refined final products; and for the natural gas category—emissions from venting, production, processing, transmission, storage and distribution.

The category Fugitive emissions from fuels include all intentional and unintentional emissions resulting from the extraction, processing, storage and transportation of fuel to its final destination.

The following subcategories are covered under this category:

- Solid fuels (1B1): includes all intentional and unintentional emissions resulting from the extraction, processing, storage and transportation of solid fuels to their final destination for use, and
- Oil and natural gas (1B2): includes all fugitive emissions from all petroleum and natural gas activities. Primary sources of these emissions may include equipment leaks and fuel loss from evaporation, venting, burning and accidental releases.

In 2010, GHG emissions in this category amounted to 1,017.9 $GgCO_2eq$, or 1.5% of the Energy sector as a whole (Table 22). Since 1990, fugitive GHG emissions have decreased by 46.3%, mainly from the reduction in underground and surface coal mining and the decrease in the natural gas supply from Argentina. The year-to-year variations observed in Figure 23 are primarily the result of changes in the natural gas supply.

In terms of subcategories, Oil and natural gas is the most significant, accounting for 96.1%, followed by Solid fuels with the remaining 3.9%.

Table 22. Fugitive emissions from fuels: GHG emissions ($GgCO_2eq$) by subcategory, 1990–2010 series

Subcategory	1990	1995	2000	2005	2010
1B1. Solid fuels	481.5	163.0	74.2	50.7	40.0
1B2. Oil and natural gas	1,412.7	976.3	1,221.0	1,198.0	977.9
Total	1,894.1	1,139.3	1,295.2	1,248.6	1,017.9

Source: Prepared in-house by SNICHILE.

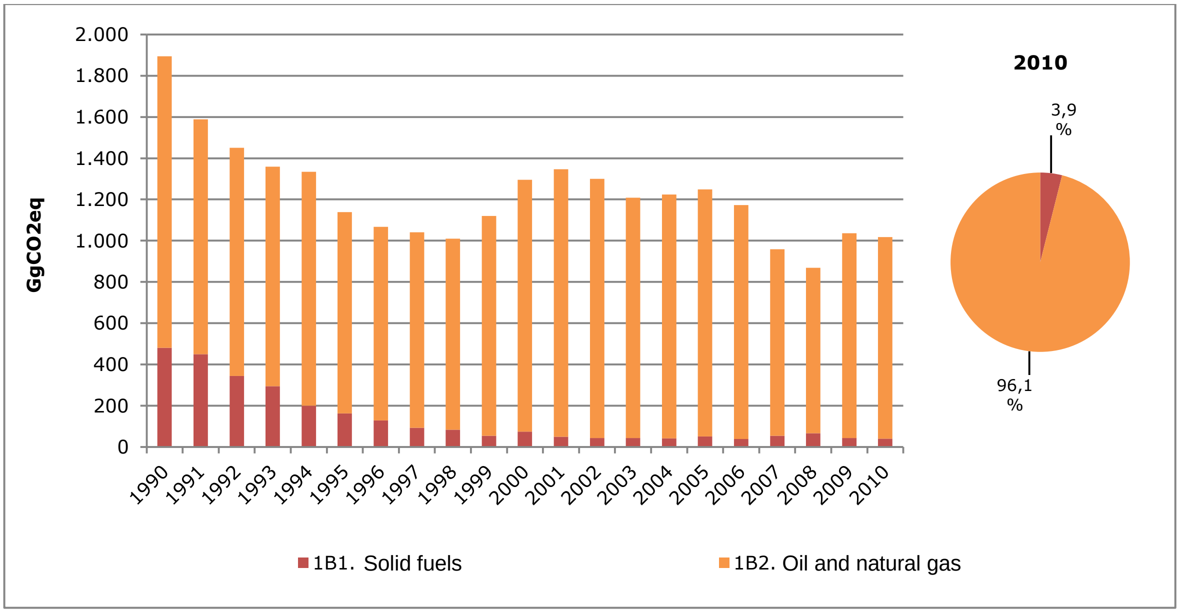

Figure 23. Fugitive emissions from fuels: GHG emission trend by subcategory, 1990–2010 series

3.3.2. Methods applied

The methods applied to prepare the Fugitive fuel emissions category are set out in the Table below:

Table 23. Fugitive fuel emissions: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
B. Fugitive emissions from fuels	T1	D	T1	D		
1. Solid fuel			T1	D		
a. Coal extraction and handling			T1	D		
b. Solid fuel transformation			NO	NO		
c. Other						
2. Oil and natural gas	T1	D	T1	D		
a. Oil	T1	D	T1	D		
b. Natural gas	T1	D	T1	D		
c. Venting and flaring	T1	D	T1	D		
d. Other	NA	NA	NA	NA		

T1 = Tier 1 method 1; D = Default; NA = Not applicable; NO = Not occurring
Source: Prepared in-house by SNICHILE.

Emissions were estimated using an equation similar to that used for the Fuel combustion category. Emissions are linked to a specific activity data (which in this case may be fuel production, processed fuel, etc.) and its respective emission factor.

A Tier 1 method from the 2006GL was used to estimate emissions from the Fugitive fuel emissions category.

3.3.2.1. Statistical and parametrical activity data

Activity data for the Solid fuels subcategory was sourced from the *Statistical Yearbook for Copper and Other Minerals (Anuario estadístico del cobre y otros minerales)*, published by the Chilean Copper Commission (COCHILCO). The yearbook reports on a 20-year time series; data from 1990 to 2009 and 1991 to 2010 were used herein. (http://www.cochilco.cl/estadisticas/anuario.asp).

Data for the Oil and natural gas subcategory was extracted from oil and natural gas production data provided in the BNE.

3.3.2.2. Emission factors

The emission factors used to calculate GHG emissions for this category were the default values provided in the 2006GL, with consideration given to the activity in question and Chile's socioeconomic position as a developing country. This information is set out in the tables below:

Table 24. Oil and natural gas: Tier 1 emission factors used for oil

Oil			
Industry segment	Characteristic	Emission factor chosen	
		CO_2 (Gg/10^3 m^3)	CH_4 (Gg/10^3 m^3)
Venting	Weighted value	0.00215	0.0104
Production and improvement	Conventional oil	0.002	0.03
Transportation	Pipeline	0	0.000005
Refining	All	0	0.000022

Source: 2006 IPCC Guidelines.

Table 25. Oil and natural gas: Tier 1 emission factors used for natural gas

Natural Gas			
Industry segment	Characteristic	Emission factor chosen	
		CO_2 (Gg/10^3 m^3)	CH_4 (Gg/10^3 m^3)
Venting	Transmission	0.0000052	0.0003900
Production	All	0.0000970	0.1220000
Processing	Transmission	0.0000200	0.0002500
Transmission and storage	Weighted value for transmission	0.0000002	0.0006330
Distribution	All	0.0000950	0.0018000

Source: 2006 IPCC Guidelines.

3.4. Comparison of the sectorial approach and reference approach

The validity of calculations performed can be validated by comparing CO_2 emission results obtained using the reference approach and the sectorial approach; the former uses total national statistical values for energy, while the latter uses partial values for each category that together make up the national Energy sector. In both cases the information was obtained from the BNE.

The GHG emission trends yielded by each method do not differ significantly (Table 26 and Figure 24).

Table 26. Fuel combustion: CO_2 emissions ($GgCO_2eq$), sectorial versus reference approaches, 1990–2010 series

Method	1990	1995	2000	2005	2010
Reference approach	30,051.9	37,470.2	50,829.5	55,550.3	65,991.6
Sectorial approach	30,728.0	38,052.7	49,651.8	55,225.0	65,774.7
Difference	676.1	582.5	-1,177.7	-325.3	-216.9

Source: Prepared in-house by SNICHILE.

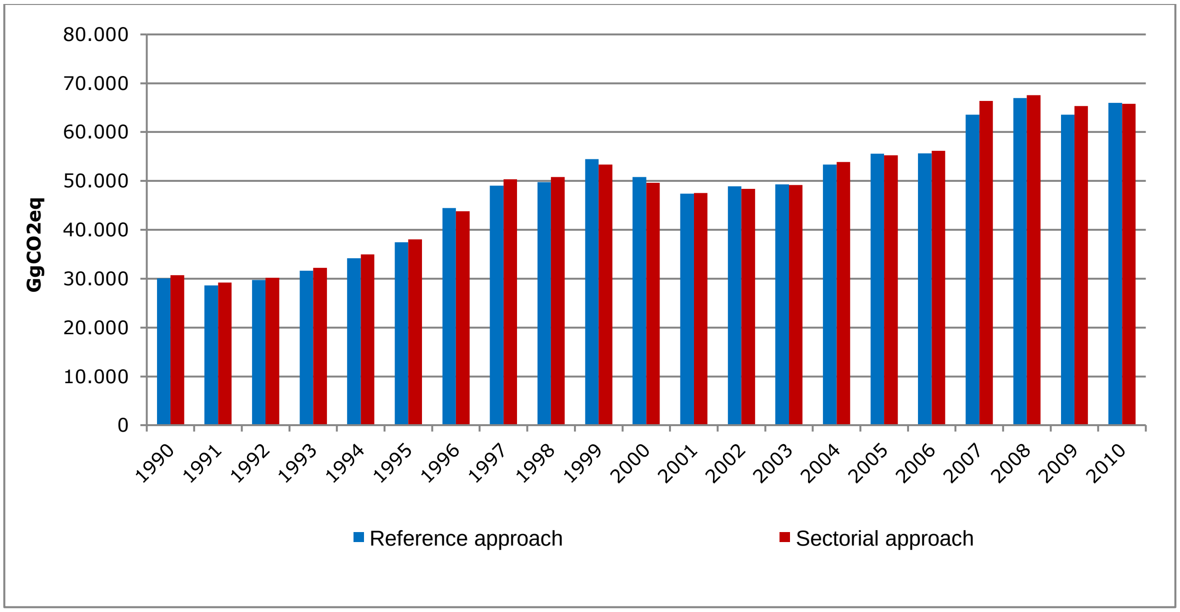

Figure 24. Fuel combustion: CO_2 emissions, sectorial versus reference approaches, 1990–2010 series

Overall, the time series displays an average annual difference of 1.6%, which is below the 5% established in the 2006GL as an acceptable difference between the two approaches. Years showing the greatest difference are 2007, with 4.3%, and 2000, with –2.4%. Years with the least difference are 2003, with –0.2%, and 2001, with 0.3% (Figure 25).

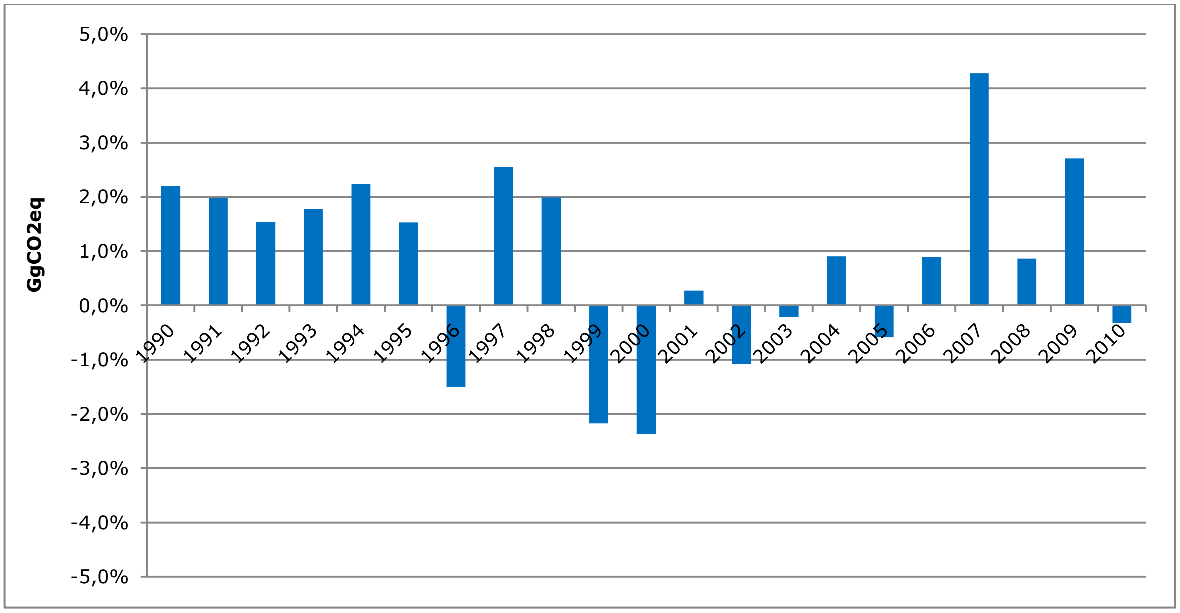

Figure 25. Fuel combustion: percentage difference between sectorial and reference approaches, 1990–2010 series

The differences between emissions estimations yielded by each of these two approaches can be attributed to statistical errors in the BNE, as in both cases the emission factors used were the default values given by the 2006GL.

3.5. International bunkers

For estimating emissions from international aviation and international water-borne navigation it was necessary to disaggregate consumption of these fuels as reported in the BNE, as the Balance does not distinguish between domestic and international fuel consumption. To break down the values, the team used information from the Chilean Customs Service, available for 2002 onwards. For previous years the team used consumption estimations prepared for the study *Elaboración de una metodología local del cálculo de emisiones bunker para gases de efecto invernadero (Formulation of a Local Methodology for calculating greenhouse gas emissions from bunkers)* (Sistemas Sustentables, 2010). (http://www.sinia.cl/1292/articles-50188_recurso_3.pdf)

As stipulated in the 2006GL, a Tier 1 methodology was used to estimate these emissions; the default emission factors provided in those guidelines were also used.

In 2010, Chile's GHG emissions from international aviation bunkers amounted to 1,348.0 GgCO_2eq, while those from international water-borne navigation were 2,138.5 GgCO_2eq (Table 27 and Figure 26). Since 1990, GHG emissions from international aviation have increased by 299.3%, while those from international water-borne navigation have increased by 289.5%. The falling trend in such emissions over the last few years of this inventory (2008–2010) resulted from the decrease in international trade caused by the global financial crisis.

Table 27. International bunkers: GHG emissions ($GgCO_2eq$) by type of international transportation, 1990–2010 series

Mode of transport	1990	1995	2000	2005	2010
International aviation	337.6	647.1	1,055.7	1,117.4	1,348.0
International water-borne navigation	595.2	1,180.2	2,055.8	3,449.7	2,318.5
Total	932.8	1,827.3	3,111.5	4,567.2	3,666.5

Source: Prepared in-house by SNICHILE.

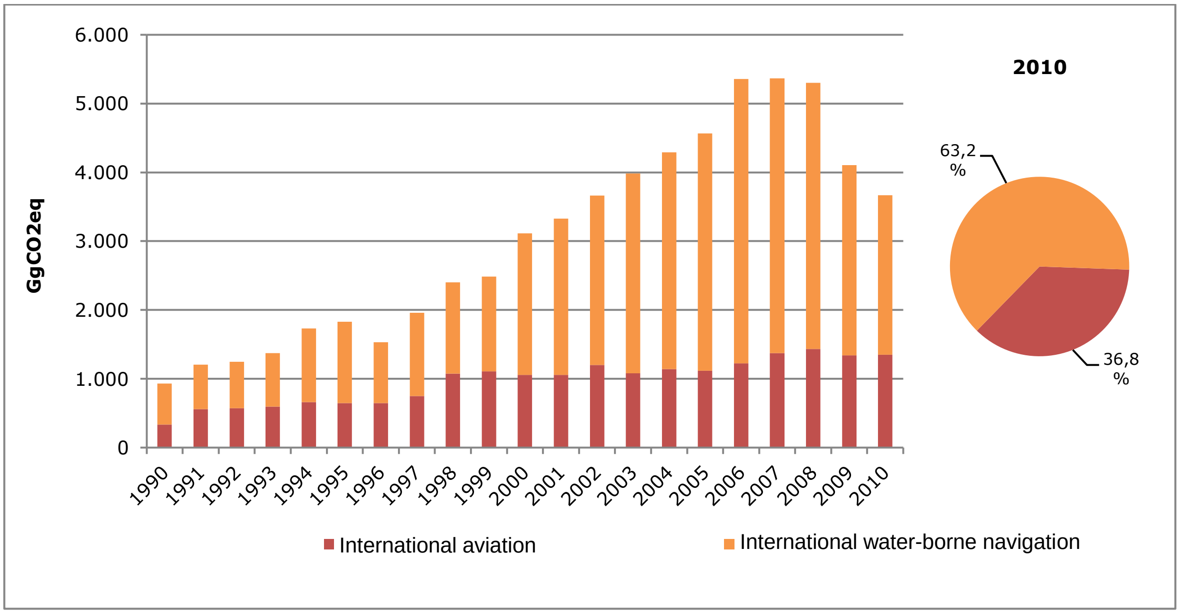

Figure 26. International bunkers: GHG emission trend by type of international transportation, 1990–2010 series

In accordance with the 2006GL, a Tier 1 emission estimation methodology was used for both sources. This method required data on the quantity of fuel consumed by international transportation for each mode of transport (water-borne or airborne), which was obtained from the Chilean Customs Service, and used the default emission factors contained in the 2006GL.

3.6. CO_2 emissions from biomass

In accordance with the 2006GL, CO_2 emissions from biomass combustion are not included in national totals, but are recorded as a Memo item for cross-verification and to prevent double counting in the LULUCF sector.

In 2010, CO_2 emissions from biomass amounted to 21,770.4 $GgCO_2eq$. Since 1990, CO_2 emissions have increased by 83.7%, the key driver being the rise in the demand for firewood by the residential sector (Table 28 and Figure 27).

Table 28. Biomass: CO_2 emissions ($GgCO_2eq$) from biomass, 1990–2010 series

Subcategory	1990	1995	2000	2005	2010
CO_2 emissions from biomass	11,851.0	15,280.7	18,952.3	20,486.3	21,770.4
Total	11,851.0	15,280.7	18,952.3	20,486.3	21,770.4

Source: Prepared in-house by SNICHILE.

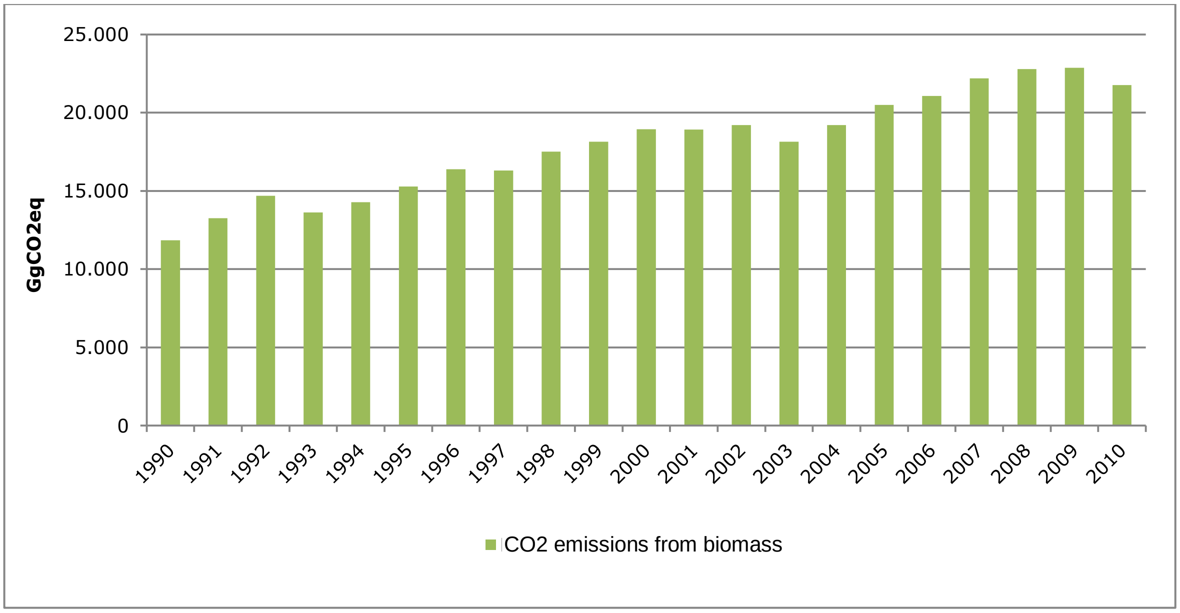

Figure 27. CO_2 emissions from biomass: CO_2 emission trend, 1990–2010 series

CO_2 emissions from biomass were calculated using The Tier 1 methodology provided in the 2006GL, the emission factor provided in the same guidelines and biomass consumption data from the BNE.

3.7. Quality assurance and quality control

This section outlines the quality assurance and quality control procedures performed by the Energy Sector Team.

3.7.1. Quality control

- Verification of the integrity of files in the database included:
    - A detailed review of each annual file of the BNE to ensure that all data specifications were correct.
    - The construction of a consolidated spreadsheet of activity data that uses automated links to translate BNE values into the format required by the IPCC data entry software, thereby avoiding manual data entry errors.
    - The cross-checking of data imported from the BNE to the annual consolidated spreadsheet and then from the spreadsheet to the format required by the IPCC software.
- Verification of the consistency of GHG emission trends, identifying potentially anomalous activity data that could lead to anomalous emission values.
- Random comparison of results yielded by IPCC software and staff calculations.
- Comparison of results of the sectorial and reference approaches.
- Comparison of GHG emission results in the Energy SGHGI with other Chilean GHG inventories.
- Verification and checking of uncertainty calculations.

3.7.2. Quality assurance

In June 2014, the Energy SGHGI was reviewed by an expert qualified as a reviewer of NGHGIs from Parties included in Annex I to the Convention. The review was conducted remotely, but with continuous communication between the inventory reviewer, the SNICHILE coordinator and professionals on the Energy Sector Team, allowing issues to be resolved as they emerged. The sector team then analyzed the assessment report, corrected pertinent findings and evaluated the feasibility of incorporating the recommendations in the next update of Chile's NGHGI.

3.8. Planned improvements

Based on the Energy Sector Team's own analysis and the recommendations issued by the sector's inventory reviewer, the following improvements to this sector have been planned:

- Regarding the National Energy Balance[17]:
    - Regular audits in addition to checking data from the Electrical-Electronic Industry Association (Asociación de la Industria Eléctrica- Electrónica, AIE).
    - Coordinating with the National Statistics Bureau to define and disaggregate some industry values.
    - Disaggregation of demand by region.
    - Improving the representativeness of the information collection.
    - Decreasing inconsistencies in the information collected to identify consumption for non-energy purposes.
    - Incorporating key sectors not currently represented, such as sanitation and others.
- Establishing institutional arrangements with entities that have potentially relevant information available, such as the Chilean Copper Commission, the Directorate General of Civil Aviation, the Chilean Customs Service, the Office of the Superintendent of Electricity and Fuels, and others.
- Disaggregating information related to road transport by mode of transport (cars, motorcycles, buses, trucks, etc).
- Building capacities for collecting information that is currently lacking, especially information related to the carbon content of fuels used in Chile, in order to build country-specific emission factors.

[17] Source: Ministry of Energy, 2014.

4. INDUSTRIAL PROCESSES SECTOR (2)

4.1. Overview of the sector

The Industrial Processes sector covers GHG emissions produced by a wide variety of industrial activities, excluding those associated with burning fossil fuels. The main sources are emissions from industrial processes that chemically or physically transform raw material, while minor ones include GHGs used in refrigerators, foams, aerosol cans and other products.

The wide variety of GHG emissions that can be produced during industrial processes include CO_2, CH_4, N_2O, hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulfur hexafluoride (SF_6).

In Chile this sector includes emissions from chemical, metal and mineral industry processes as well as emissions associated with the use and consumption of non-ozone depleting substances (ODS), which have been used in the country since 2002.

The Industrial processes sector is the third largest GHG emitter in Chile, producing 6.1% of total GHG emissions (Figure 28).

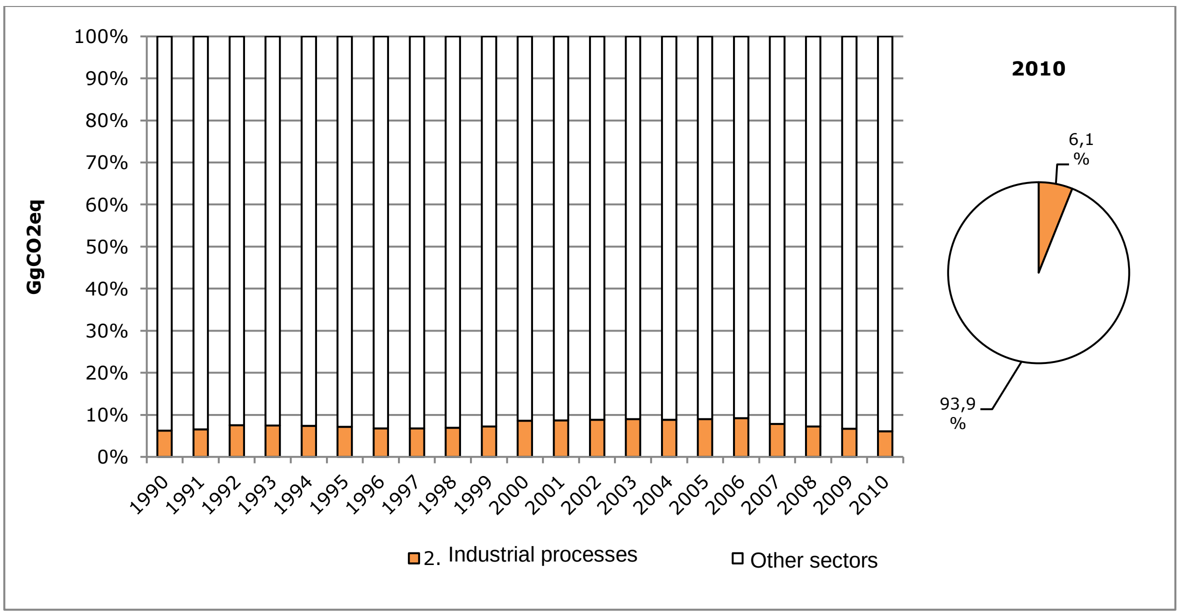

Figure 28. Industrial processes sector: Trend in the sector's share of total GHG emissions (excluding LULUCF), 1990–2010 series

In 2010 the sector's GHG emissions amounted to 5,543.2 $GgCO_2eq$ (Table 29), an increase of 78.3% since 1990. The key driver of this increase between 1990 and 2006 was the sustained growth in methanol production, the cement industry and the lime industry. Since 2006, a sharp decline in emissions has been observed (Figure 29), mainly due to a reduction in the natural gas supply from Argentina, the raw material used for methanol production. A sharp decline in industrial activity across the country can also be observed as of 2008, owing to the international economic crisis, which especially affected the iron and steel industry.

The Mineral products category contributes 41.8% of the sector's GHG emissions, followed by the Chemical industry, which contributes 32.4%, Metal production with 20.6% and Consumption of halocarbons and SF_6, with 5.2%.

Table 29. Industrial processes sector: GHG emissions ($GgCO_2eq$) by category, 1990-2010 series

Category	1990	1995	2000	2005	2010
2A. Mineral products	1,055.9	1,694.9	1,739.9	2,265.0	2,316.2
2B. Chemical industry	755.4	903.6	2,768.0	3,092.9	1,797.2
2C. Metal production	1,296.8	1,644.0	1,892.0	1,896.8	1,142.3
2F. Consumption of halocarbons and SF_6	0.0	0.0	0.0	100.1	287.4
Total	3,108.2	4,242.5	6,399.9	7,354.7	5,543.2

Source: Prepared in-house by SNICHILE.

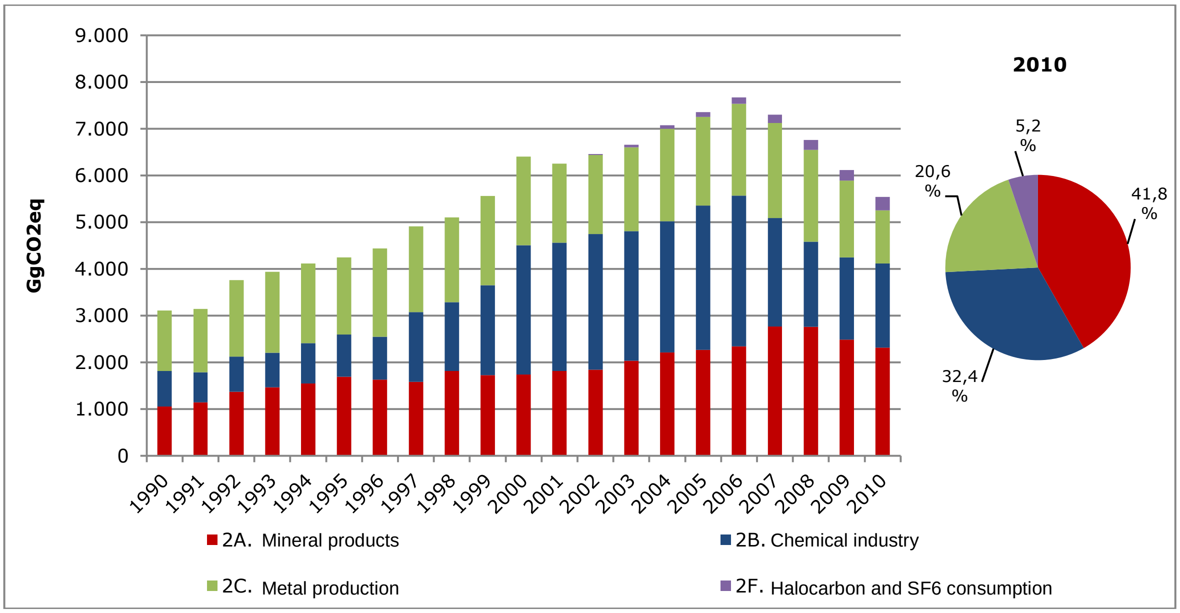

Figure 29. Industrial processes sector: GHG emission trend by category, 1990-2010 series

In terms of emissions, the Cement production subcategory is the most important, accounting for 21.5% of total emissions, followed by Nitric acid production with 20.3%, Iron and steel production with 19.7%, Lime production with 19.4%, Methanol with 12.1% and Aerosol with 2.8%. The remaining 4.1% includes other subcategories such as Ethylene, Refrigeration and air conditioning and Ferroalloy production (Table 30 and Figure 30).

Table 30. Industrial Processes sector: GHG emissions ($GgCO_2eq$) by subcategory, for 1990-2010

Subcategory	1990	1995	2000	2005	2010
2A1. Cement production	786.7	1,223.4	1,165.1	1,350.0	1,191.8
2B2. Nitric acid production	141.2	298.5	675.2	916.0	1,124.9
2C1. Iron and steel production	1,221.4	1,544.2	1,829.0	1,846.5	1,094.1
2A2. Lime production	256.3	452.6	537.9	866.9	1,076.4
2B5. Others (Methanol)	613.4	604.1	2,091.7	2,175.7	671.6
2F4. Aerosols	0.0	0.0	0.0	64.9	155.2
2F1. Refrigeration and air conditioning	0.0	0.0	0.0	26.5	95.8
Other	89.2	119.7	101.0	108.3	133.5
Total	3,108.2	4,242.5	6,399.9	7,354.7	5,543.2

Source: Prepared in-house by SNICHILE.

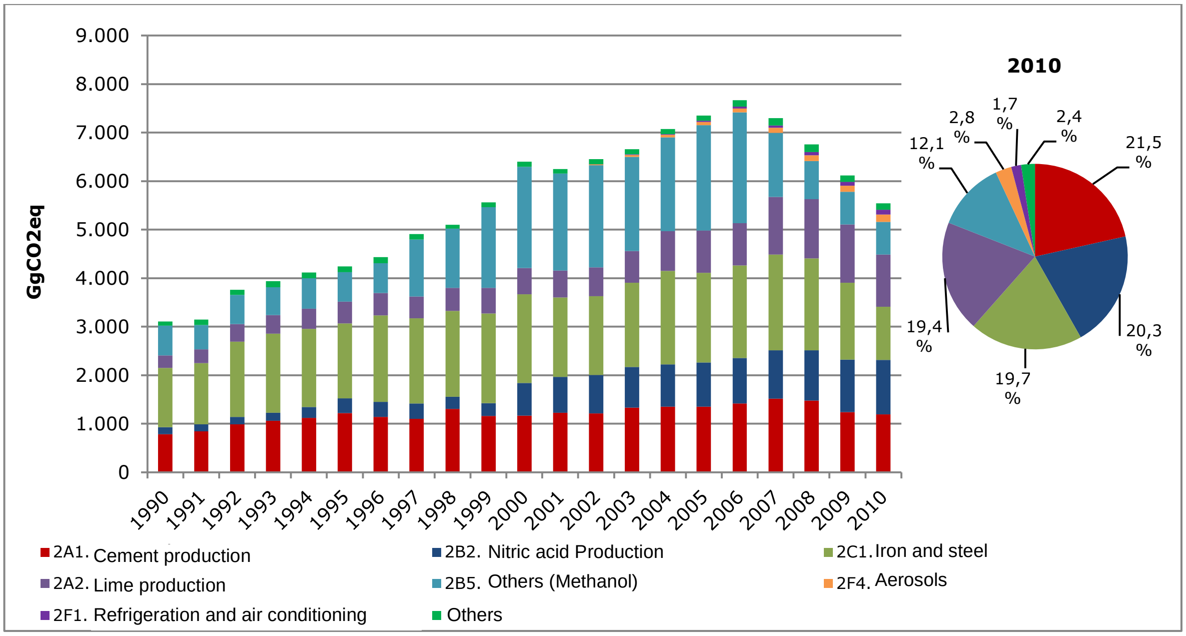

Figure 30. Industrial Processes sector: GHG emission trend by subcategory, 1990-2010 series

In 2010 the sector's main GHGs were CO_2, representing 73.7% of all emissions, followed by CH_4 with 20.3% and N_2O with 5.1%. Halocarbons were responsible for 0.9% of emissions (Table 31 and Figure 31).

Table 31. Industrial Processes sector: emission trend by type of GHG ($GgCO_2eq$), 1990-2010 series

GHG	1990	1995	2000	2005	2010
CO_2	2,925.6	3,903.1	5,583.9	6,192.3	4,085.6
CH_4	41.4	40.8	140.8	146.4	45.2
N_2O	141.2	298.5	675.2	916.0	1,124.9
HFC	0.0	0.0	0.0	99.3	281.3
PFC	0.0	0.0	0.0	0.7	6.1
Total	3,108.2	4,242.5	6,399.9	7,354.7	5,543.2

Source: Prepared in-house by SNICHILE.

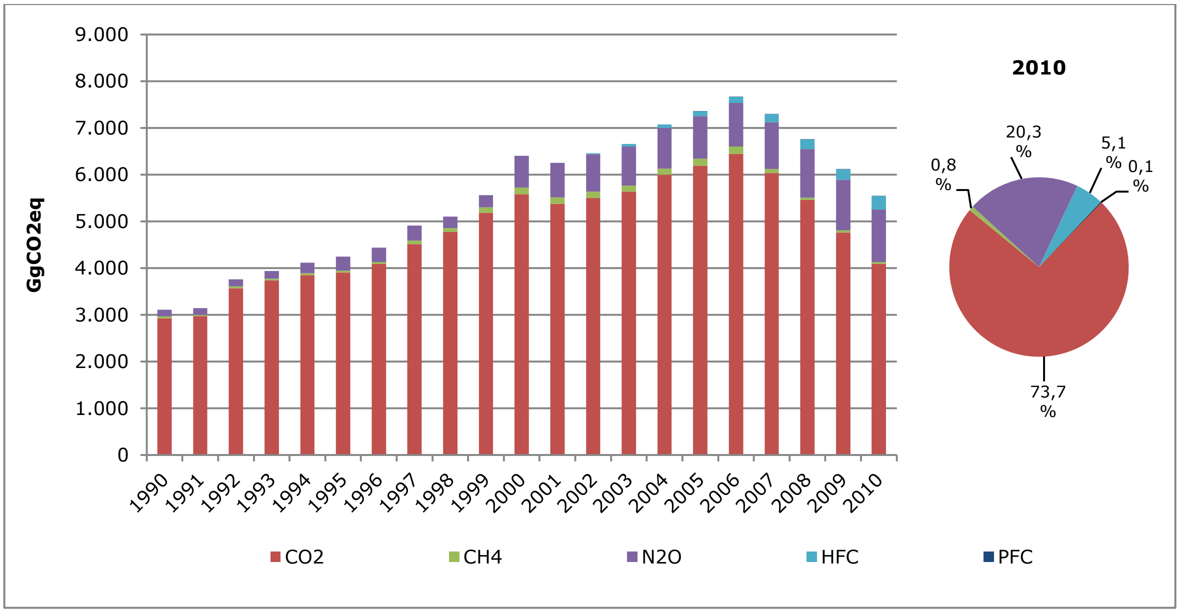

Figure 31. Industrial Processes sector: emission trend by type of GHG ($GgCO_2eq$), 1990-2010 series

4.2. Mineral products (2A)

4.2.1. Description of the category and GHG emissions

This category concentrates the CO_2 emissions resulting from the use of carbonate raw materials during the production and use of various mineral products. The associated subcategories are as follows:

- 2A1 Cement production.
- 2A2 Lime production.
- 2A3 Limestone and dolomite use.
- 2A4 Soda ash production and use.
- 2A5 Asphalt roofing.
- 2A6 Road paving with asphalt.
- 2A7 Other.

In Chile this category includes emissions from the following productive processes:

- Cement production,
- Lime production, and
- Glass production.

The Mineral products category is the principal emitter of GHG for the sector. In 2010 the category's GHG emissions were 2,316.2 $GgCO_2eq$, or 41.8% of the sector's total (Table 32 and Figure 32). Since 1990 GHG emissions have increased by 119.4%.

Table 32. Mineral products: GHG emissions trend ($GgCO_2eq$) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
2A1. Cement production	786.7	1,223.4	1,165.1	1,350.0	1,191.8
2A2. Lime Production	256.3	452.6	537.9	866.9	1,076.4
2A7. Other (glass production)	13.0	18.9	36.9	48.1	48.1
Total	1,055.9	1,694.9	1,739.9	2,265.0	2,316.2

Source: Prepared in-house by SNICHILE.

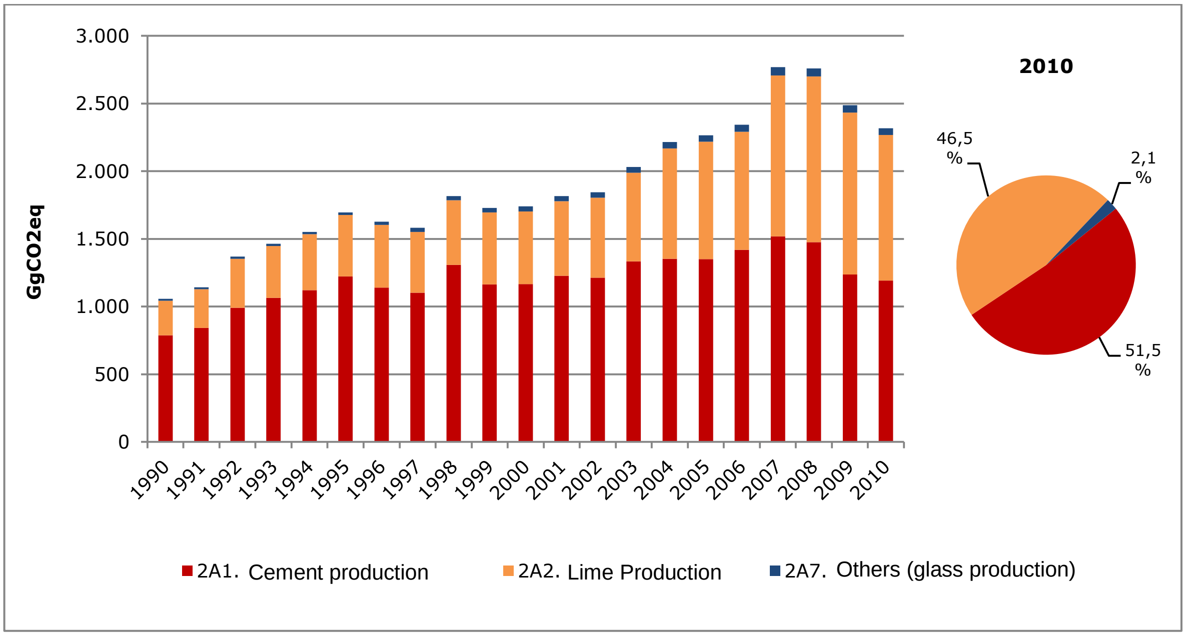

Figure 32. Mineral products: GHG emission trend by subcategory, 1990-2010 series

4.2.1.1. Cement production (2A1)

Between 1990 and 2010 cement production in Chile increased and this has been attributed to the three principal production companies that dominate this market.

In 2010 the GHG emissions from the Cement production subcategory were 1,191.8 $GgCO_2eq$, or 51.5% of this category. Since 1990 GHG emissions have increased by 51.5%. The main cause of this trend and interannual variations observed is the demand for cement for construction, which affects clinker production in Chile. While in recent years clinker imports have risen steadily, GHG emissions estimations consider clinker produced in Chile only (Table 32 and Figure 32).

4.2.1.2. Lime production (2A2)

Historically, four companies have been the main suppliers of lime in Chile (Chilean Mining Magazine 2009). However, other companies produce large quantities of lime for their own consumption. The lime production industry in Chile has grown considerably in recent years as the uses for this product expanded, although production has fallen off since 2009.

In 2010 GHG emissions from the Lime production subcategory amounted to 1,076.4 $GgCO_2eq$, or 46.5% of the entire category, an increase of 319.9% over 1990. The key driver of this increase is the steady growth in the demand for, and therefore production of, lime (Table 32 and Figure 32).

4.2.1.3. Other: Glass production (2A7)

Glass produced in Chile is used in construction and in the manufacture bottles, lighting, receptacles, crockery, laboratory instruments and a variety of other products.

In 2010, GHG emissions from the Glass production subcategory amounted to 48.1 GgCO_2eq, or 2.1% of this category. This represents an increase of 270.5% since 1990, driven mainly by sustained industry growth (Table 32 and Figure 32).

4.2.2. Methods applied

The methods used in the Mineral products category are presented in the Table below:

Table 33. Mineral products: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
A. Mineral products	T1,T2	D				
1. Cement production	T1	D				
2. Lime Production	T2	D				
3. Limestone and dolomite use	NE	D				
4. Soda ash production and use	NE	D				
5. Asphalt roofing	NE	D				
6. Road paving with asphalt	NE	D				
7. Others	T1	D				
Glass production	T1	D				

T1 = Tier 1 Method; T2 = Tier 2 Method; D = Default; NE = Not estimated.
Source: Prepared in-house by SNICHILE.

Cement production
The Cement production subcategory used the Tier 1 method outlined in the 2006GL, in which either production or consumption activity data is multiplied by the corresponding emission factor.

Lime production
Emissions from Lime production were estimated with the Tier 2 method outlined in the 2006GL, which considers the kind of lime production and incorporates an LKD correction factor and a hydrated lime correction factor, both specific to the type of lime. The default factors used were those found in the 2006GL. Based on the Tier 2 methodology, CO_2 emissions from lime production were estimated using the following equation:

$$\boldsymbol{CO}2\ \boldsymbol{emissions} = \sum (\boldsymbol{EF}_{\boldsymbol{cal,i}} \times \boldsymbol{M}_{\boldsymbol{l,i}} \times \boldsymbol{CF}_{\boldsymbol{lkd}} \times \boldsymbol{C}_{\boldsymbol{h,i}})$$

Where:

- *CO_2 emissions = CO_2 emissions from lime production (tons)*
- *$M_{l,i}$ = type i lime production, tons*
- *$EF_{cal,i}$ = emission factor for type i lime, tons of CO_2/tons of lime*
- *$CF_{lkd,i}$ = emission correction factor for LKD*
- *$C_{h,i}$ = correction factor for type i hydrated lime, without measure*
- *i = each specific type of lime*

Other: Glass production

The Tier 1 method outlined in the 2006GL was used for the Glass production subcategory, as no data was available on soda ash use in the glass industry.

4.2.2.1. Statistical and parametric activity data

Cement production

Activity data for cement production was obtained from the Chilean Concrete Institute website (ICH) (http://ich.cl/?p=109) and clinker import and export data was provided by the National Customs Service. The overall clinker fraction was assumed to be 75%, as per the 2006GL (Chapter 2.2.1.2 and 2.2.1.3 , Volume 3, 2006GL) and data reported by cement producers.

Lime production

Detailed activity data was obtained directly from each of the four lime producing companies (via e-mail, enabling us to stratify lime production by region and therefore employ the Tier 2 methodology at the regional level. The Tier 2 calculation used the emissions correction factor for LKD and for hydrated lime, as shown in the Table below:

Table 34. Basic parameters used to calculate emission factors for lime production

Parameter	Description	Value
$CF_{lkd,i}$	LKD correction factor	1.02
$C_{h,i}$	Hydrated lime correction factor	0.97

Source: Chapter 2.3.1.3, Volume 3, IPCC 2006.

Other: Glass production

Glass production data was estimated using the physical production index calculated by the Chilean Federation of Industry (SOFOFA) for the economic sector Glass and glass products manufacturing (http://web.sofofa.cl/informacion-economica/indicadores-industriales/informacion-sectorial-de-la-industria/minerales-no-metalicos-y-metalica-basica/).

The Tier 1 method (Chapter 2.4.1.3, Volume 3, 2006GL) assumes a cullet proportion default of 50%.

4.2.2.2. Emission factors

Default emission factors were used for all subcategories as per Chapter 2, Volume 3, 2006GL.

Lime production CO_2 emissions were estimated using Tier 2 emission factors, as set out in the following table:

Table 35. Basic parameters used to calculate emission factors for lime production

Type of lime	Stoichiometric Ratio [t CO_2 per t CaO or CaO·MgO]	CaO content range [%]	MgO content range [%]	Default value for the CaO or Cao·MgO content [fraction]	Default emission factor [t CO_2 per t lime]
Lime with high calcium content	0.785	0.785	0.3-2.5	0.95	0.75
Dolomite lime	0.913	55-57	38-41	0.95 / 0.85	0,86 / 0.77
Hydraulic lime	0.785	65-92	NA	0.75	0.59

Source: Table 2.4, Chapter 2, Volume 3, IPCC 2006.

According to information obtained from the lime producers, only quicklime is produced in Chile, and therefore the default value of 0.75 tons of CO_2/ton of lime was used for estimating CO_2 emissions for lime with high calcium content.

4.3. Chemical industry (2B)

4.3.1. Description of the category and GHG emissions

The Chemical industry category includes GHG emissions resulting from the production of several inorganic and organic chemical products which several countries have confirmed contribute significantly to national and global GHG emissions. The subcategories are:

- 2B1 Ammonia production.
- 2B2 Nitric acid production.
- 2B3 Adipic acid production.
- 2B4 Carbide production.
- 2B5 Others.

In Chile this category includes emissions from the following productive processes:

- Nitric acid production,
- Methanol, and
- Ethylene.

In 2010 the category's GHG emissions amounted to 1,797.2 GgCO_2eq, or 32.4% of the sector's total (Table 36 and Figure 33), an increase of 137.9% in GHG emissions since 1990. Lately, however, GHG emissions have declined, owing to a sharp drop in methanol production that has reduced emissions associated with this activity in the category and the sector.

Table 36. Chemical industry: GHG emissions trend (GgCO_2eq) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
2B2. Nitric acid production	141.2	298.5	675.2	916.0	1,124.9
2B5. Others (a. Methanol)	613.4	604.1	2,091.7	2,175.7	671.6
2B5. Others (b. Ethylene)	0.8	1.0	1.2	1.2	0.7
Total	755.4	903.6	2,768.0	3,092.9	1,797.2

Source: Prepared in-house by SNICHILE.

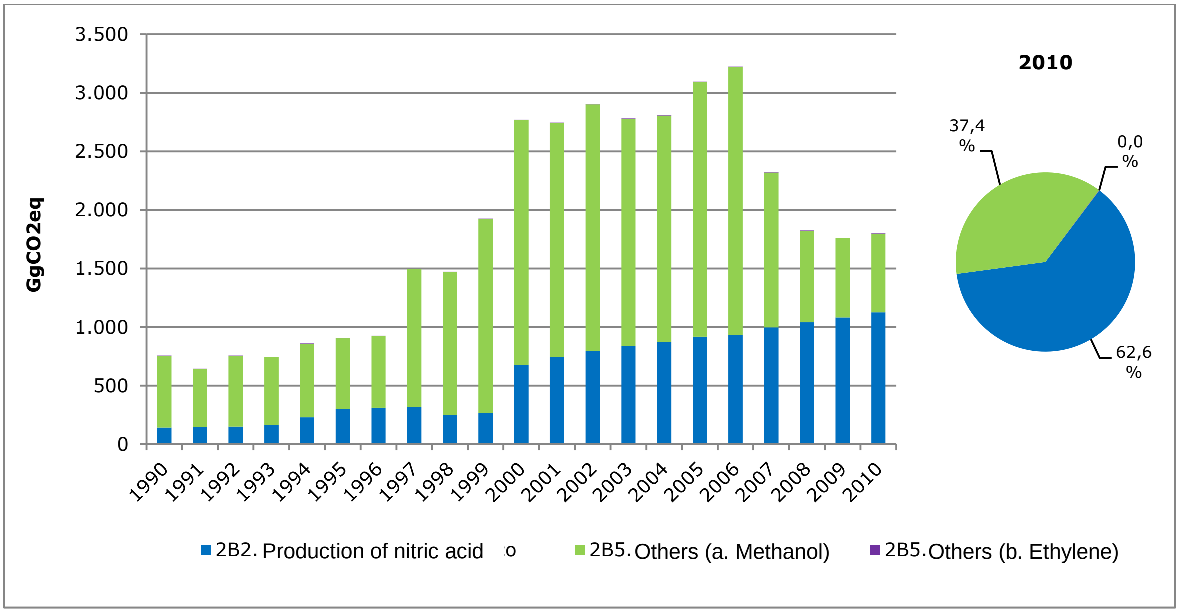

Figure 33. Chemical industry: GHG emission trend by subcategory, 1990-2010 series

4.3.1.1. Nitric acid production (2B2)

Nitric acid is used by the chemical industry to produce metal nitrates, sulfuric acid, arsenic and nitrous acid, among other substances. Nitric acid is also used in the manufacture of explosives, colorants and dyes, pharmaceuticals, and jewelry, as well as for photoetched printing and in the engineering industry.

In 2010, GHG emissions from the nitric acid production subcategory amounted to 1,124.88 $GgCO_2eq$, or 62.6% of the category, an increase of 696.8%. over 1990 that has resulted mainly from the growth of this industry (Table 36 and Figure 33).

4.3.1.2. Others: Methanol (2B5)

Methanol is a versatile liquid chemical that is produced mainly from natural gas and is used as a raw material in the manufacture of a wide range of consumer products, such as construction materials, foams, resins and plastics. The company Methanex produces methanol in Chile.

Methanol production rose in the country between 1990 and 2006 then fell sharply in 2007, and since then annual production has gradually decreased. According to Methanex's latest *Annual Report*, the company's methanol plants were operating well below their installed production capacity owing to a shortage of its main raw material—natural gas.

In 2010, GHG emissions from the Methanol subcategory were 671.61 $GgCO_2eq$, or 37.4% of the category's emissions, representing an increase of 9.5% since 1990. The annual variations observed in the Methanol subcategory are driven mainly by reductions in the supply of natural gas from Argentina (*Methanex Annual Report 2012*, available at http://www.methanex.cl/noticias/2013/noticia0313a.pdf) (Table 36 and Figure 33).

4.3.1.3. Others: Ethylene (2B5)

Between 1990 and 2010 ethylene production remained relatively constant. The maximum annual ethylene production was 1,134 tons in 2002, while the minimum annual production of only 630 tons occurred in 2010.

In 2010, GHG emissions from the Ethylene subcategory amounted to 0.74 $GgCO_2eq$, a decrease of 12.8% since 1990 (Table 36 and Figure 33).

4.3.2. Methods applied

The methods used to estimate GHG emissions for the Chemical industry category are presented in the following table:

Table 37. Chemical industry: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
B. Chemical Industry	T1	D	T1	D	T1	D
1. Ammonia production	NO	NO				
2. Nitric acid production					T1	D
3. Adipic acid production					NO	NO
4. Carbide Production	NO	NO	NO	NO	NO	NO
5. Other	T1	D	T1	D		
Methanol	T1	D	T1	D		
Ethylene	T1	D	T1	D		

T1 = Tier 1 Method; D = Default; NO = Not applicable.
Source: Prepared in-house by SNICHILE.

For all subcategories, GHG emissions were estimated by multiplying either production or consumption activity data by the corresponding emission factor. These calculations were performed using the Tier 1 method found in the 2006GL.

4.3.2.1. Statistical and parametric activity data

Nitric acid production

Nitric acid production data was obtained from the *NGHGI sectors—Energy and Industrial processes and solvent use* (Poch and Deuman, 2008) (http://www.sinia.cl/1292/articles-50188_recurso_1.pdf) for the 1990-2006 period, as other potential sources deemed their information to be confidential. The rest of the period was extrapolated from existing data.

Others: Methanol

Methanol production data was obtained from BNE, as Methanex, Chile's sole producer, deems its information to be confidential.

Others: Ethylene

Ethylene production data was also obtained from the BNE for the entire period.

4.3.2.2. Emission factors

Default emission factors for all subcategories were taken from Chapter 3, Volume 3 of the 2006GL.

4.4. Metal industry (2C)

4.4.1. Description of category and GHG emissions

This category includes GHG emissions from the metal industry, under the following subcategories:

- 2C1 Iron and steel production.
- 2C2 Ferroalloy production.
- 2C3 Aluminum production.
- 2C4 SF_6 used in aluminum and magnesium foundries.
- 2C5 Others.

In Chile this category includes emissions from the following productive processes:

- Iron and steel production,
- Ferroalloy production,
- Lead production, and
- Zinc production.

In 2010 the category's GHG emissions amounted to 1,142.3 $GgCO_2eq$, or 20.6% of the sector total (Table 38 and Figure 34). Since 1990, GHG emissions have decreased by 11.9%.

Table 38. Metal industry: GHG emissions ($GgCO_2eq$) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
2C1. Iron and steel production	1,221.4	1,544.2	1,829.0	1,846.5	1,094.1
2C2. Ferroalloy production	31.7	38.4	8.5	0.2	0.2
2C5. Other (a. Lead production)	0.6	0.5	0.4	0.5	0.4
2C5. Other (b. Zinc production)	43.2	60.9	54.0	49.6	47.6
Total	1,296.8	1,644.0	1,892.0	1,896.8	1,142.3

Source: Prepared in-house by SNICHILE.

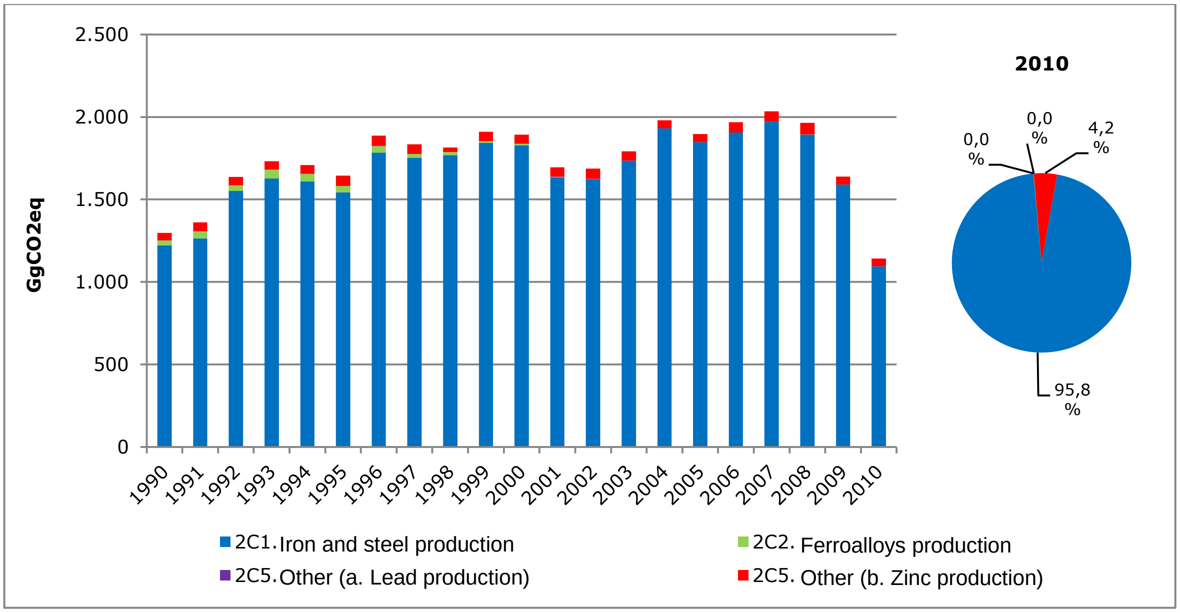

Figure 34. Metal production: GHG emission trend by subcategory, 1990-2010 series

4.4.1.1. Iron and steel production (2C1)

Iron is the metal produced in the largest tonnage in Chile, accounting for 95% of all metal produced in the country. It is used widely as a base element in steel products along with other metallic and non-metallic alloys, depending on the properties desired.

The primary local market for steel products is the construction industry, which accounts for 32.4%, followed by steel mills with 25.4%, mining with 19.4% and wire drawers with 11%. The remaining 11.8% is used in the metalworking, packaging and machining industries (Http://www.cochilco.cl/estudios/info-hierro.asp).

Between 1990 and 2009, iron production remained relatively constant, averaging 5,150,000 tons annually over that 20-year period. In 2009 there was a significant decline in production.

In 2010, GHG emissions from the Iron and steel production subcategory amounted to 1,094.1 $GgCO_2eq$, or 95.8% of the category's GHG emissions. Since 1990, GHG emissions have decreased by 10.4%, the key driver being a sharp decrease in the demand for steel (Table 38 and Figure 34).

4.4.1.2. Ferroalloy production (2C2)

Of the four ferroalloys produced in Chile—ferrochrome, ferromanganese, ferrosiliconmanganese and ferrosilicon—three are no longer produced. Ferrosilicon production ceased in 2000, ferrosiliconmanganese in 2001 and ferromanganese in 2002. Ferrochrome is still produced in the country but in much lower quantities. Average annual production stood at 1,951 tons between 1990 and 1998, then ceased altogether from 1990 to 2004 but resumed in 2005. From then to 2010 annual average production was a mere 99 tons.

In 2010, GHG emissions from the Ferroalloy production subcategory amounted to 0.24 $GgCO_2eq$, or 0.0% of the category, representing a decrease of 99.2% since 1990. The key driver of this decline was the cessation of ferrosilicon, ferromanganese and ferrosiliconmanganese production beginning in 1999 (Table 38 and Figure 34).

4.4.1.3. Others: Lead production (2C5)

In Chile, lead is produced exclusively in Aysén Region (SERNAGEOMIN 2012, *The Chile Mining Yearbook*, available at http://www.sernageomin.cl/sminera-anuario.php). Production was extremely variable between 1990 and 2010, bottoming out at 298 tons in 1992 and peaking at 3,985 tons in 2008.

In 2010 GHG emissions from the Lead production subcategory amounted to 0.36 GgCO_2eq, or less than 0.1% of the category's total. This represents a decrease of 37.9% over 1990, the key driver being instability in the lead market (Table 38 and Figure 34).

4.4.1.4. Others: Zinc production (2C5)

In Chile zinc is produced in the Aysén and Metropolitan Regions. It is used mainly in alloys and as rust protection coating for other metals, as is the case with galvanized iron and steel. Zinc alloyed with copper produces brass, which is used in the electrical industry, while zinc alloyed with aluminum and magnesium is used in the aviation industry (http://www.sernageomin.cl/sminera-anuario.php).

Zinc production in Chile was irregular over the 1990 to 2010 period, with annual production peaking in 2008 at 40,519 tons and bottoming out in 1998 at 15,943 tons.

In 2010 GHG emissions from the Zinc production subcategory amounted to 47.6 GgCO_2eq, or 4.2% of the category total and in increase of 10.2% over 1990. The key driver of this increase was instability in the zinc market (Table 38 and Figure 34).

4.4.2. Methods applied

The methods applied to estimate GHG emissions for the Metal production category are presented in the Table below:

Table 39. Metal production: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
C. Metal production	T1	D	NO	D		
1. Iron and steel production	T1	D	NO, IE	NO, IE		
2. Ferroalloy production	T1	D	NO	D		
3. Aluminum production	NO	NO				
4. SF_6 used in aluminum and magnesium foundries	NO	NO				
5. Others	T1	D				
Lead production	T1	D				
Zinc production	T1	D				

T1 = Tier 1 Method; D = Default; NO = Not applicable; IE = Included elsewhere.
Source: Prepared in-house by SNICHILE.

In the method used, GHG emissions are estimated by multiplying either production or consumption activity data by the corresponding emission factor. Calculations were performed as per the 2006GL using the Tier 1 method for all subcategories.

4.4.2.1. Statistical and parametric activity data

Iron and steel production

Iron data was obtained from the COCHILCO study *Estadísticas del cobre y otros minerales* for the years 1990 to 1997. *Anuarios de la Minería de Chile* (published yearly by SERNAGEOMIN provided information for the remaining years, while parametric data from the CAP Mining web site was used to estimate pellet production.

Steel is produced by only two local producers, namely Compañía de Acero de Pacifico (CAP) and Gerdau Aza (COCHILCO, 2010, *Mercado Nacional e Internacional del hierro y acero* http://www.cochilco.cl/estudios/info-hierro.asp).

Ferroalloy production

National statistics on ferroalloy production were obtained from the U.S. Geological Survey document *The Mineral Industry of Chile - 1994 to 2010* (http://minerals.usgs.gov/minerals/pubs/country/sa.html#ci). The report contains detailed production data for different ferroalloys. Ferrosilicon production ceased in 1999, and as this was the only process that emitted CH_4, no emissions of this gas occurred from 2000 to 2010.

Others: Lead and zinc production

Lead production data was obtained from COCHILCO's annual publication, *Anuario de estadísticas del cobre y otros minerales*, for the years 2002 to 2010 and the data was corroborated with SERNAGEOMIN's yearly report, *Anuario de la Minería de Chile*, for the years 2007 to 2010. The information provided does not distinguish between different production processes, thus it was assumed that 80% of these metals were produced using Imperial Smelting Furnaces or blast furnaces and the remaining 20% used direct casting methods in Kivcet, Ausmelt or Queneau-Schumann-Lurgi furnaces. This assumption did affect the emission factor choice. Zinc production was differentiated in the same way, as the data available also did not identify specific production processes.

4.4.2.2. Emission factors

Default emission factors found in the 2006GL were used for all corresponding subcategories.

4.5. Other production (2D)

This category was not estimated due to the absence of production data.

4.6. Halocarbons and sulfur hexafluoride production (2E)

There are no emissions falling under this category in Chile.

4.7. Consumption of halocarbons and sulfur hexafluoride (2F)

4.7.1. Description of category and GHG emissions

HFC gases, and to a very limited extent PFC gases, serve as alternatives to ozone-depleting substances (ODS) that are being removed from circulation under the provisions of the Montreal Protocol. The subcategories are:

- 2F1 Refrigeration and air conditioning equipment.
- 2F2 Foam blowing.
- 2F3 Fire extinguishers.
- 2F4 Aerosols.
- 2F5 Solvents.
- 2F6 Other applications.
- 2F7 Semiconductor manufacture.
- 2F8 Electrical equipment.
- 2F9 Other.

These substances were first imported to Chile in 2002, according to the National Customs Service. Domestic emissions include:

- Refrigeration and air conditioning,
- Fire and explosion protection, and
- Aerosols.

As these compounds are not produced in Chile, all fluorinated compounds used in refrigeration, air conditioning, fire protection and aerosols are imported. As mentioned above, importation of these products began in 2002 and has increased considerably since then. Exports, in contrast, are negligible.

In 2010 the category's GHG emissions amounted to 287.4 $GgCO_2eq$, or 5.2% of the sector total (Table 40 and Figure 35). The sudden increase in this category occurred when products containing HFC began arriving on the local market in 2002 and those containing PFC began arriving in 2005.

In 2010 GHG emissions from the Refrigeration and air conditioning equipment subcategory amounted to 95.8 $GgCO_2eq$, or 33.3% of the category total.

In 2010 GHG emissions from the Fire extinguishers subcategory amounted to 36.5 $GgCO_2eq$, or 12.7% of the category total.

In 2010 GHG emissions from the Aerosols subcategory amounted to 155.2 $GgCO_2eq$, or 54.0% of the category total.

Table 40. Consumption of halocarbons and SF_6: GHG emissions ($GgCO_2eq$) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
2F1. Refrigeration and air conditioning equipment	0.0	0.0	0.0	26.5	95.8
2F3. Fire Extinguishers	0.0	0.0	0.0	8.8	36.5
2F4. Aerosols	0.0	0.0	0.0	64.9	155.2
Total	0.0	0.0	0.0	100.1	287.4

Source: Prepared in-house by SNICHILE.

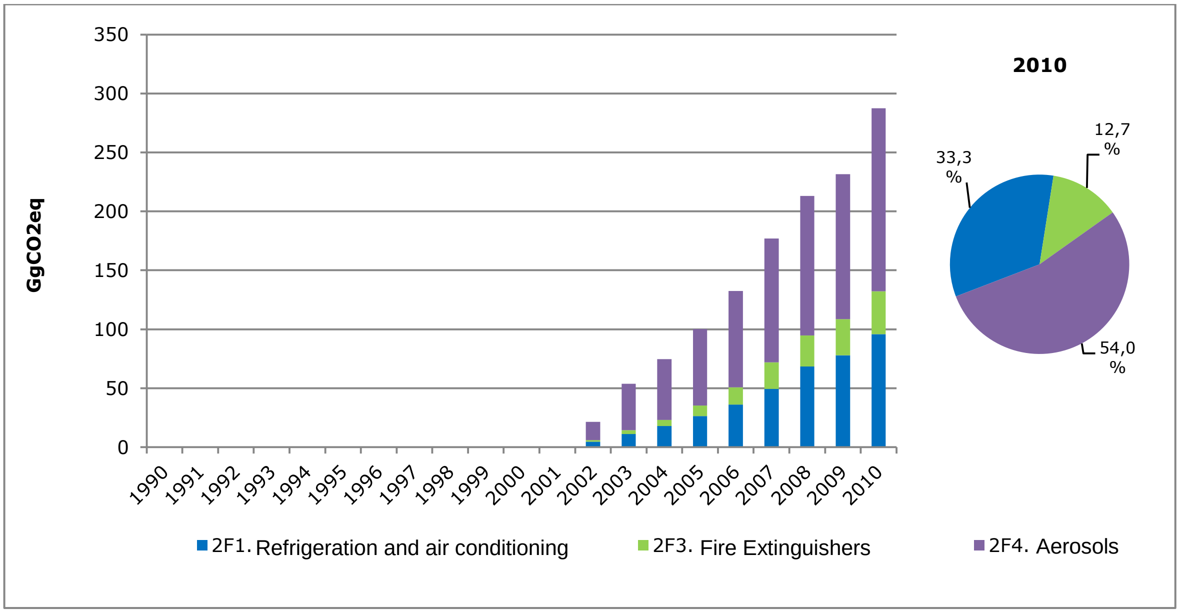

Figure 35. Consumption of halocarbons and SF_6: GHG emission trend by subcategory, 1990-2010 series

4.7.2. Methods applied

The methods applied to estimate GHG emissions for the category Consumption of halocarbons and SF_6 are presented in the Table below:

Table 41. Halocarbon and SF_6 consumption: methods applied

Greenhouse gas source and sink categories	HFCs		PFCs		SF_6	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
F. Halocarbon and sulfur hexafluoride consumption	T1	D	T1	D	NE, NO	NE, NO
1. Refrigeration and air conditioning equipment	T1	D				
2. Foam blowing	NO	NO	NO	NO		
3. Fire extinguishers	T1	D	T1	D		
4. Aerosols	T1	D				
5. Solvents	NE	NE	NE	NE	NE	NE
6. Other applications	NO	NO	NO	NO	NO	NO
7. Semiconductor manufacture	NO	NO	NO	NO	NO	NO
8. Electrical equipment	NO	NO	NO	NO	NO	NO
9. Others	NA	NA	NA	NA	NA	NA

T1 = Tier 1 Method; D = Default; NA = Not applicable; NE = Not estimated; NO = None.
Source: Prepared in-house by SNICHILE.

The method used to estimate GHG emissions is based on multiplying the production activity data by the corresponding emission factor. The calculations were carried out in accordance with guidelines issued by 2006GL, applying the Tier 1 method to all subcategories.

4.7.2.1. Statistical and Parametric Activity Data

The National Customs Service provided activity data for Refrigeration and air conditioning equipment, including specific import and export information on each HFC, as of 2002 when these substances were first imported. The same procedure was used to obtain activity data for fire extinguishers and aerosols.

4.7.2.2. Emission factors

Default emission factors from the 2006GL were used to estimate GHG emissions for all corresponding subcategories.

4.8. Quality assurance and quality control

The quality assurance and quality control procedures applied by the IPPU Sector Team are described below.

4.8.1. Quality control

- Spreadsheets were built and populated with basic information such as activity data, emission factors, sources and assumptions, allowing the information to be sorted, documented and filed for future updating.
- Activity data, emission factors and other estimation parameters in the base information spreadsheets were cross-checked with data in the report and the IPCC software to ensure consistency across all three.
- Cited bibliographic references were confirmed.
- Emission units and factors in the spreadsheets were reviewed and corrected.
- A consolidated spreadsheet was developed that collated the annual spreadsheets exported from the IPCC software. This consolidated spreadsheet combined data by category, GHG and IPPU sector using specific formulas that were reviewed to avoid calculation errors.
- Official information was cross-checked with information publically available from the private sector.
- For categories involving processes or products that do not occur in Chile, the IPPU Sector Team checked with external experts.
- The current estimations were compared with those of the previous SGHGI to identify potential data entry or calculation errors. Any divergences were justified.

4.8.2. Quality assurance

In May and June 2014, the IPPU SGHGI was reviewed by an expert qualified as a reviewer of NGHGIs from Parties included in Annex I to the Convention. The review was conducted remotely with constant communication among the expert reviewer, the SNICHILE coordinator and the IPPU

Sector Team so questions and concerns could be resolved as they arose.

4.9. Planned improvements

Based on the IPPU Sector Team's internal analysis and the recommendations of the expert reviewer of the SGHGI, the following improvements are planned for this sector:

- Form working groups with representatives from businesses and/or trade associations responsible for emissions in the sector's leading GHG categories to gather statistical and parametric information at source, and verify official information.
- Compare the results obtained from Tier 1 and Tier 2 methods (or Tier 3, where applicable) to identify possible errors of magnitude, et c. and resolve the differences observed.
- Identify all lime producers in the country, both sellers and plants that produce this product for internal consumption.
- Determine the proportion of recycled glass used in Chile in collaboration with the Waste Sector Team.
- Work closely with the MMA's Ozone Unit, which has conducted surveys that have generated new information on substances used as alternatives to ODS.

5. SOLVENT AND OTHER PRODUCT USE SECTOR (3)

5.1. Overview of the sector

This sector includes emissions from the use of lubricants, wax, tar, solvents, paints, and other products and is divided into the following categories:

- 3A Paint application.
- 3B Degreasing and dry cleaning.
- 3C Chemical products, manufacture and processing.
- 3D Other.

The only category with registered emissions in Chile is Chemical products, manufacture and processing, which includes emissions from the use of the following products:

- Lubricants in industrial applications and transport, and
- Paraffin wax in applications.

Lubricants are produced in refineries during the crude oil separation process, or in petrochemical plants. In Chile they are used mainly in industrial applications and in transport. Consumption of lubricants in the country was extremely variable between 1990 and 2010, and most lubricants were imported during that period, while domestic production remained much lower An exception occurred in 2010, according to figures provided by the National Statistics Bureau, when 223,618 tons of lubricants were produced.

Paraffin wax is used for candle making and in applications such as corrugated boxes, paper coatings, glued plates, food production, bitumen brightness, surfactants (such as those used in detergents), among other uses. Between 1990 and 2010 the bulk of the wax used in Chile was imported, as domestic production was significantly lower, according to information provided by the National Statistics Bureau.

The SOPU sector has the lowest GHG emissions of all sectors in the country, with emissions in 2010 amounting to 243.0 GgCO_2eq, or 0.3% of total GHG emissions. Since 1990 the sector's GHG emissions have increased by 195.1%. the key driver being shifting demand for lubricants in Chile. The sector emits a single GHG—CO_2—and all of those emissions derive from the Chemical products, manufacture and processing category (Table 42 and Figure 36 and Figure 37).

Table 42. SOPU sector: GHG emissions (GgCO_2eq) by category, 1990-2010 series

Category	1990	1995	2000	2005	2010
3C. Chemical products, manufacture and processing	82.3	94.8	118.0	110.7	243.0
Total	82.3	94.8	118.0	110.7	243.0

Source: Prepared in-house by SNICHILE.

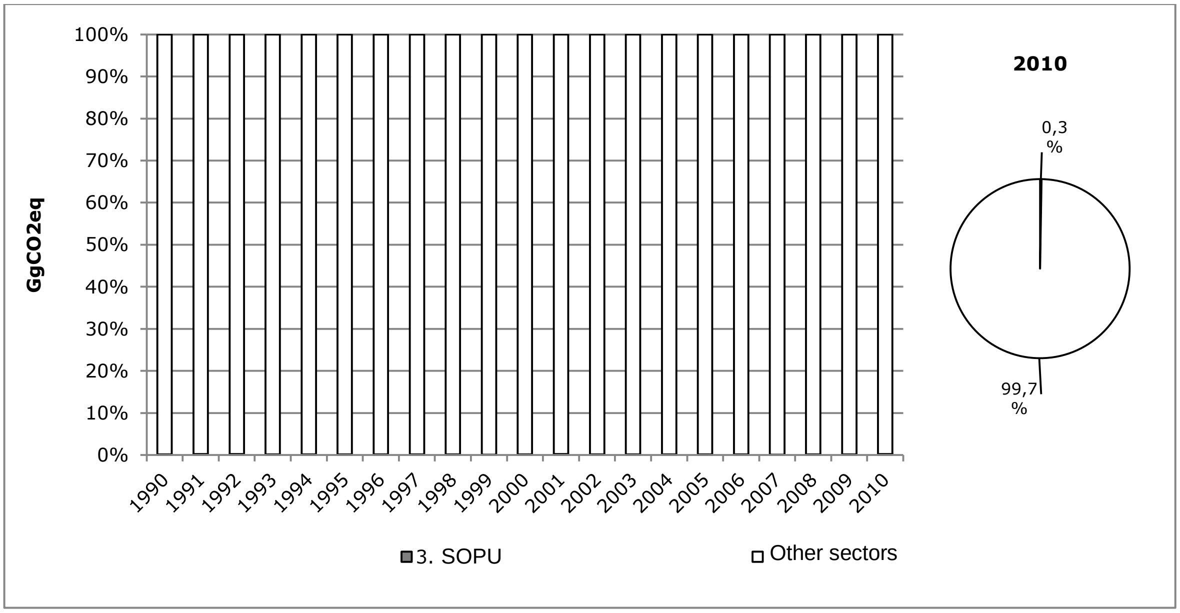

Figure 36. SOPU sector: Trend in the sector's share of total GHG emissions (excluding LULUCF), 1990–2010 series

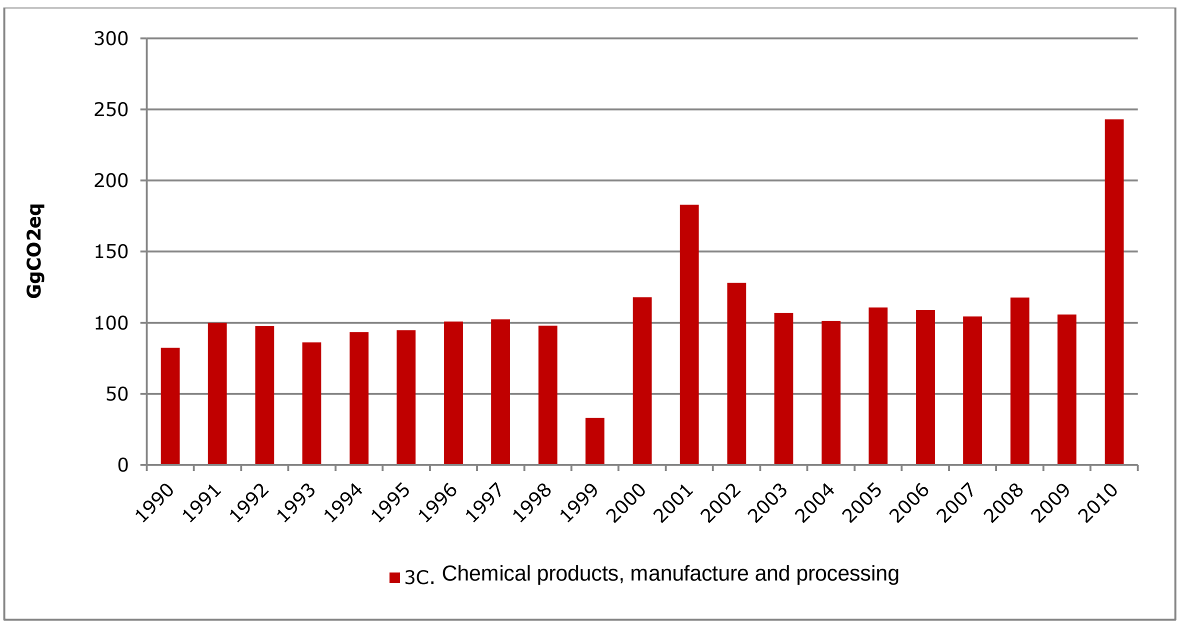

Figure 37. SOPU sector: GHG emission trend by category, 1990-2010 series

5.1.1. Methods applied

The methods applied to estimate GHG emissions for this category are presented in the Table below:

Table 43. SOPU sector: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
3. Solvent and other product use	**T1**	**D**			**NO**	**NO**
A. Paint application	NE	NE				
B. Degreasing and dry cleaning	NE	NE				
C. Chemical products, manufacture and processing	T1	D				
D. Others	NA	NA	NA	NA	NA	NA

T1 = Tier 1 Method; D = Default; NA = Not applicable; NE = Not estimated; NO = None.
Source: Prepared in-house by SNICHILE.

The method usually used to estimate GHG emissions employs an emission factor that is comprised of the carbon content factor and a factor representing the fossil fuel carbon fraction that is Oxidized During Use (ODU). The calculation included only oxidation during first use of lubricants and paraffin wax and not subsequent uses.

5.1.1.1. Statistical and parametric activity data

The activity data on the use of lubricants came from a balance between production, imports and exports. Production data came from the National Statistical Bureau, who provided data from 1998 to 2010. Production for 1990 to 1997 was estimated using a method customized as per the 2006GL, while import and export data was provided by the National Customs Service.

Activity data on paraffin use was estimated in a similar way, using production data provided by the National Statistical Bureau.

5.1.1.2. Emission factors

Default emission factors as per the 2006GL were used for each corresponding category.

5.2. Quality assurance and quality control

The SOPU sector report was prepared by the IPPU Sector Team and therefore employed the same quality assurance and quality control procedure, which can be reviewed in chapter 4, Industrial processes.

5.3. Planned improvements

The SOPU sector report was prepared by the IPPU Sector Team and therefore includes the same planned improvements, which can be reviewed in chapter 4, Industrial processes.

6. AGRICULTURE SECTOR (4)

6.1. Overview of the sector

This sector includes greenhouse gas emissions associated with cropping and livestock activities and quantifies emissions of CH_4 and N_2O associated with livestock activity, rice cultivation, anthropogenic nitrogen contributions to the soil and field burning of agricultural residues. The sector includes the following categories:

- 4A Enteric fermentation.
- 4B Manure management.
- 4C Rice cultivation.
- 4D Agricultural soils.
- 4E Prescribed burning of savannahs.
- 4F Field burning of agricultural residues.

The Chilean inventory includes GHG emissions from all of the abovementioned categories except for Prescribed burning of savannahs, as that vegetation formation does not exist in the country.

The Agriculture sector is the second largest GHG emitter in Chile, accounting for 15.1% of the country's total GHG emissions (Figure 38).

Figure 38. Agriculture sector: Trend in the sector's share of total GHG emissions (excluding LULUCF), 1990–2010 series

In 2010, GHG emissions from this sector amounted to 13,825.6 $GgCO_2eq$ (Table 44), an increase of 29.1% since 1990. As shown in Figure 39, the key driver of this increase was the steady growth in emissions from the Agricultural soils category, which represents more than 50% of the sector's overall GHG emissions. This increase was caused mainly by more widespread use of synthetic nitrogen-based fertilizers, especially for annual crops.

At the category level, 52.4% of all GHG emissions in this sector come from Agricultural soils, followed by Enteric fermentation with 34.4% and Manure management with 12.1%. The remaining 1% derives from the categories Rice cultivation and Field burning of agricultural residues.

Table 44. Agriculture sector: GHG emissions ($GgCO_2eq$) by category, 1990–2010 series

Category	1990	1995	2000	2005	2010
4A. Enteric fermentation	4,317.1	4,738.3	4,956.7	4,906.1	4,762.5
4B. Manure management	1,254.7	1,423.2	1,593.8	1,585.0	1,678.9
4C. Rice cultivation	137.9	143.6	109.0	105.9	103.8
4D. Agricultural soils	4,856.2	5,500.5	5,764.8	6,081.0	7,251.4
4F. Field burning of agricultural residues	144.3	87.0	68.8	58.9	29.1
Total	10,710.2	11,892.6	12,493.2	12,736.9	13,825.6

Source: Prepared in-house by SNICHILE.

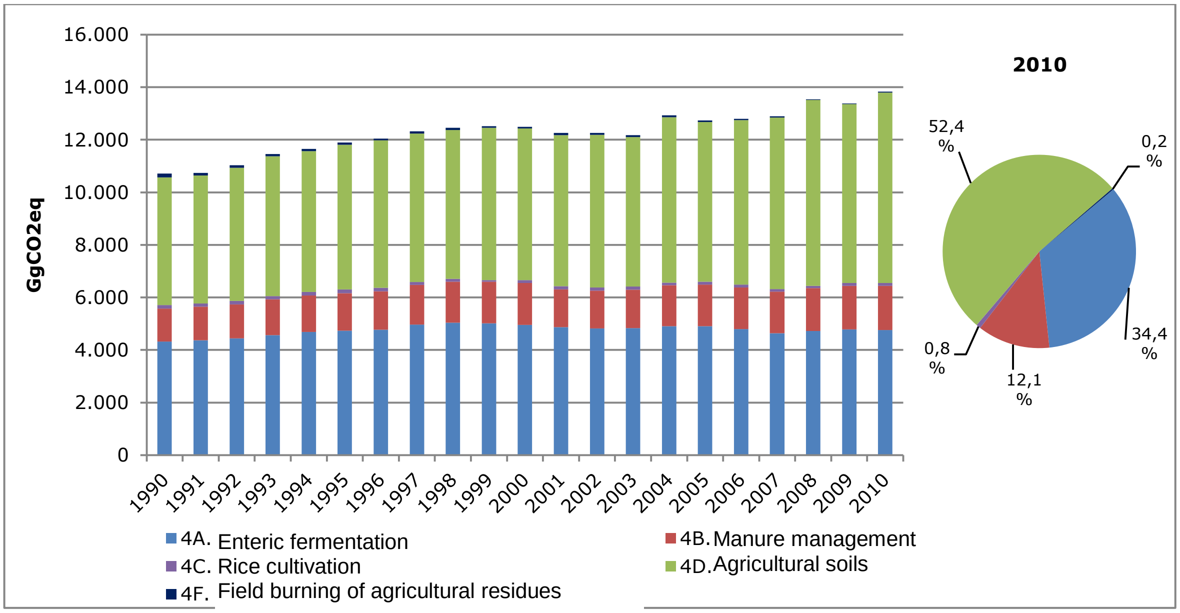

Figure 39. Agriculture sector: GHG emission trend by category, 1990–2010 series

In 2010, the main GHG emitted by this sector was N_2O, accounting for 54.7% of the sector's overall GHG emissions. The second most prevalent GHG was CH_4, with 45.3% of the total. CO_2 emissions are not counted in this sector (Table 45 and Figure 40).

Table 45. Agriculture sector: GHG emissions ($GgCO_2eq$) by type of gas, 1990–2010 series

GHG	1990	1995	2000	2005	2010
CH_4	5,640.9	6,163.0	6,469.0	6,359.4	6,259.8
N_2O	5,069.3	5,729.5	6,024.2	6,377.5	7,565.9
Total	10,710.2	11,892.6	12,493.2	12,736.9	13,825.6

Source: Prepared in-house by SNICHILE.

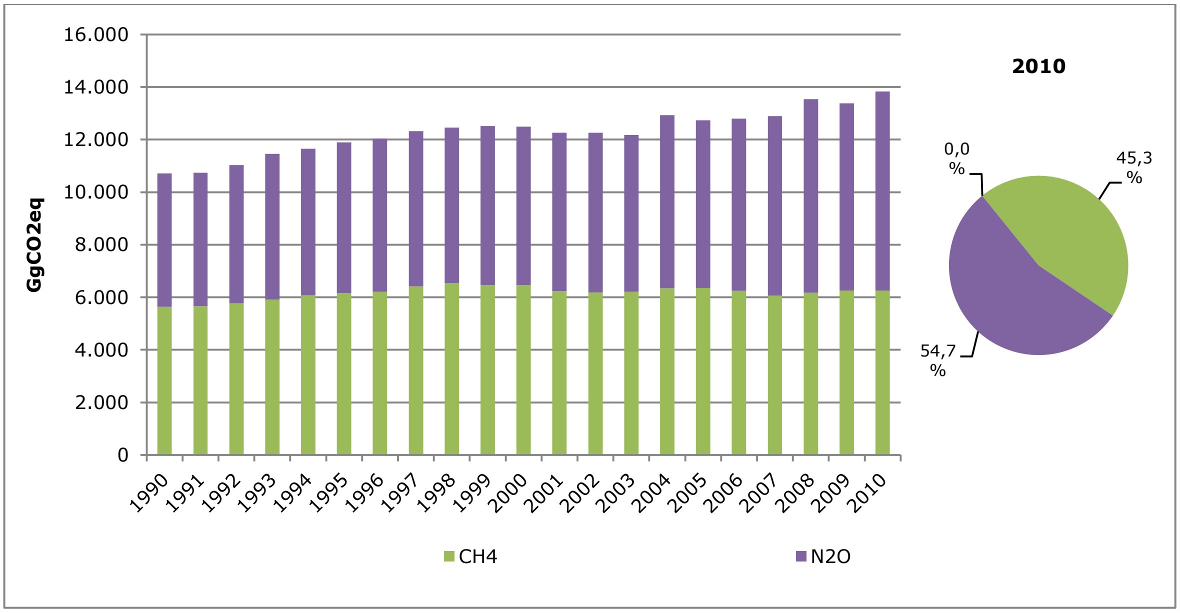

Figure 40. Agriculture sector: emission trend by type of GHG, 1990–2010 series

In 2010, GHG emissions of animal origin amounted to 10,547.1 $GgCO_2eq$, while emissions of vegetal origin amounted to 3,278.5 $GgCO_2eq$ (Table 46 and Figure 41). Since 1990, GHG emissions of animal origin have increased by 18.4%, mainly owing to the increase in the livestock population linked to increasing confinement, which caused a rise in CH_4 emissions from Enteric fermentation and Manure management. Meanwhile, GHG emissions of vegetal origin increased by 81.8%, mainly from the increased use of synthetic nitrogen-based fertilizers, although the increasingly common practice of incorporating organic waste into soils has also contributed to this rise.

Table 46. Agriculture sector: GHG emissions ($GgCO_2eq$) of vegetal and animal origin, 1990–2010 series

Origin	1990	1995	2000	2005	2010
Vegetal	1,803.8	2,153.0	2,180.7	2,242.1	3,278.5
Animal	8,906.3	9,739.5	10,312.5	10,494.8	10,547.1
Total	10,710.2	11,892.6	12,493.2	12,736.9	13,825.6

Source: Prepared in-house by SNICHILE.

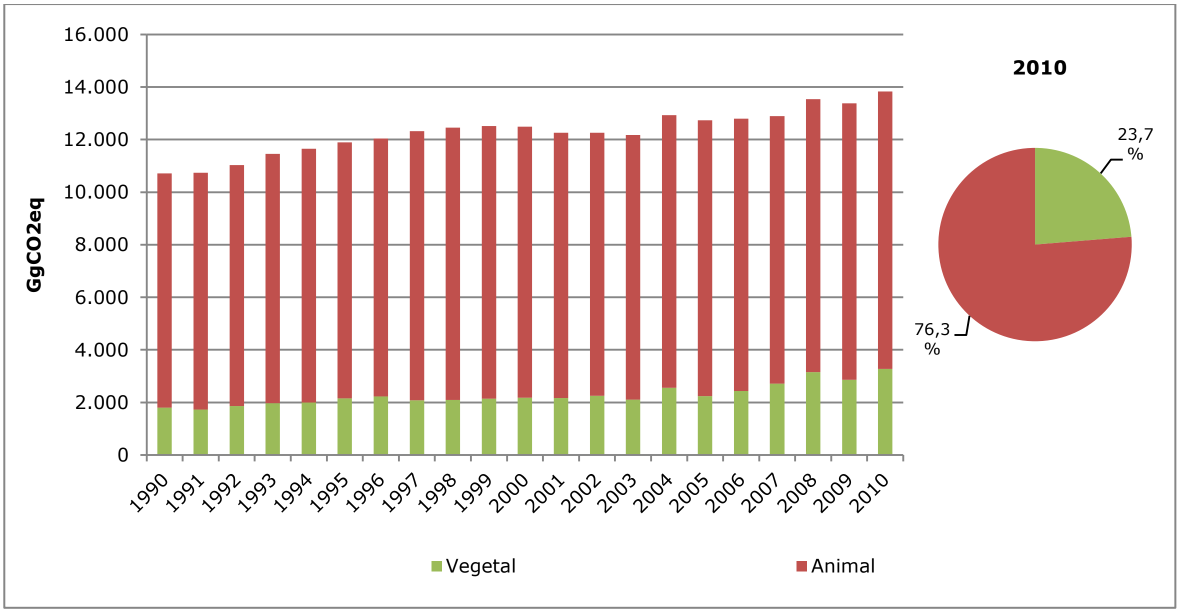

Figure 41. Agriculture sector: GHG emission trend by vegetal versus animal origin, 1990–2010 series

The Agriculture sector of Chile's NGHGI is unique in that its emissions have been counted region by region. As Figure 42 shows, in 2010, 18.1% of the sector's GHG emissions were produced in X Los Lagos Region (with bovine cattle activity as the main source), followed by 15.7% from IX La Araucanía Region (with Agricultural soils and Field burning of agricultural residues as the main sources). The remaining emissions are divided among XIV Los Ríos Region, with 11.2%, VIII Biobío Region, with 11.2%, and XIII Santiago Metropolitan Region, with 8.6% (with Manure management as the primary source), and 8.0% from VII Maule Region (where Rice cultivation is the main source). The remaining 27.7% of the sector's GHG emissions are emitted by the country's other nine administrative regions.

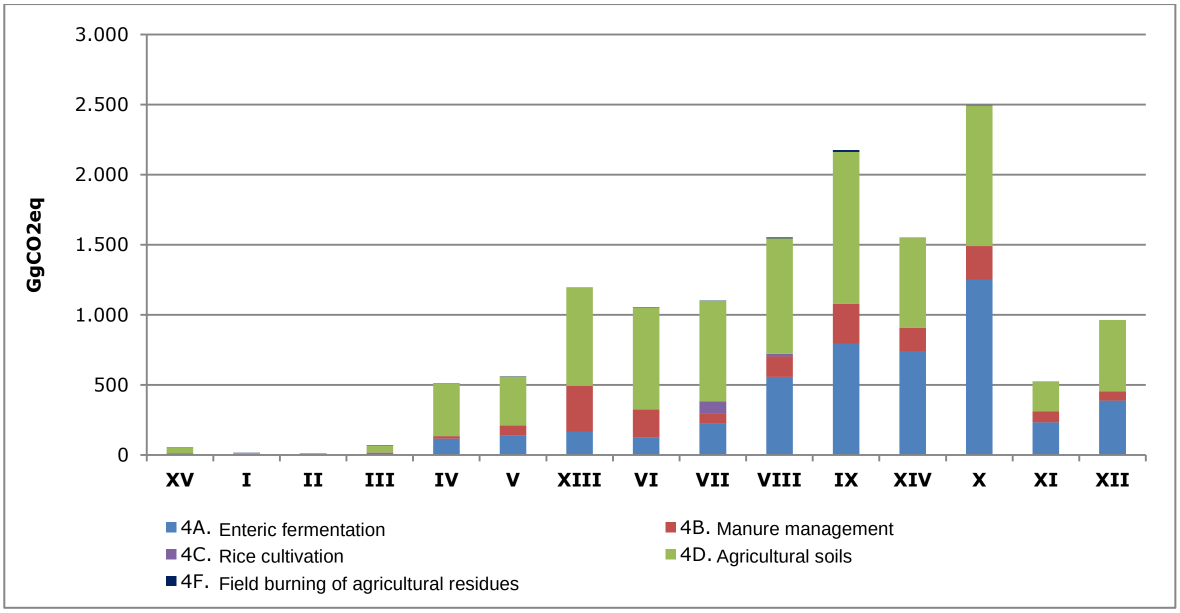

Figure 42. Agriculture sector: GHG emissions by category and region, 2010

6.2. Enteric fermentation (4A)

6.2.1. Description of the category and GHG emissions

Methane is produced as a byproduct of digestive processes, primarily in animals with a compound stomach (ruminants such as cows and sheep), although non-ruminants (e.g. hogs, horses) also release CH_4.

In Chile, the livestock types included in this category are:

- Cattle[18] (disaggregated as dairy cattle and non-dairy cattle),
- Sheep,
- Goats,
- Llamas and alpacas,
- Horses,
- Mules and asses, and
- Swine.

In 2010, GHG emissions from this category amounted to 4,762.5 $GgCO_2eq$, or 34.4% of the sector (Table 47), an increase of 10.35 since 1990, the key driver being growth of the livestock population, specifically bovine cattle.

In regard to livestock types, Non-dairy cattle comprise the most significant group, accounting for 61.0% of GHG emissions in the category, followed by Dairy cattle with 24.0%, Sheep with 8.7%, and Horses with 2.2%. Swine accounted for 2.2% and Goats for 1.5% of the category's GHG

[18] In this report, "cattle" is understood to refer specifically to bovines.

emissions, and the remaining 0.3% derived from Llamas and alpacas, and Mules and asses (Figure 43).

Table 47. Enteric fermentation: GHG emissions ($GgCO_2eq$) by type of livestock, 1990–2010 series

Livestock type	1990	1995	2000	2005	2010
4A1. Dairy cattle	962.2	1,097.1	1,175.1	1,178.8	1,144.3
4A1. Non-dairy cattle	2,587.4	2,925.9	3,083.1	3,021.6	2,904.6
4A3. Sheep	454.0	406.8	394.1	404.3	414.6
4A4. Goats	89.9	80.2	75.7	74.6	73.5
4A5. Llamas and alpacas	19.7	20.8	18.8	14.8	11.4
4A6. Horses	154.2	151.6	140.0	122.4	104.8
4A7. Mules and asses	3.8	4.0	4.4	4.8	5.3
4A8. Swine	45.8	51.7	65.6	84.8	103.9
Total	4,317.1	4,738.3	4,956.7	4,906.1	4,762.5

Source: Prepared in-house by SNICHILE.

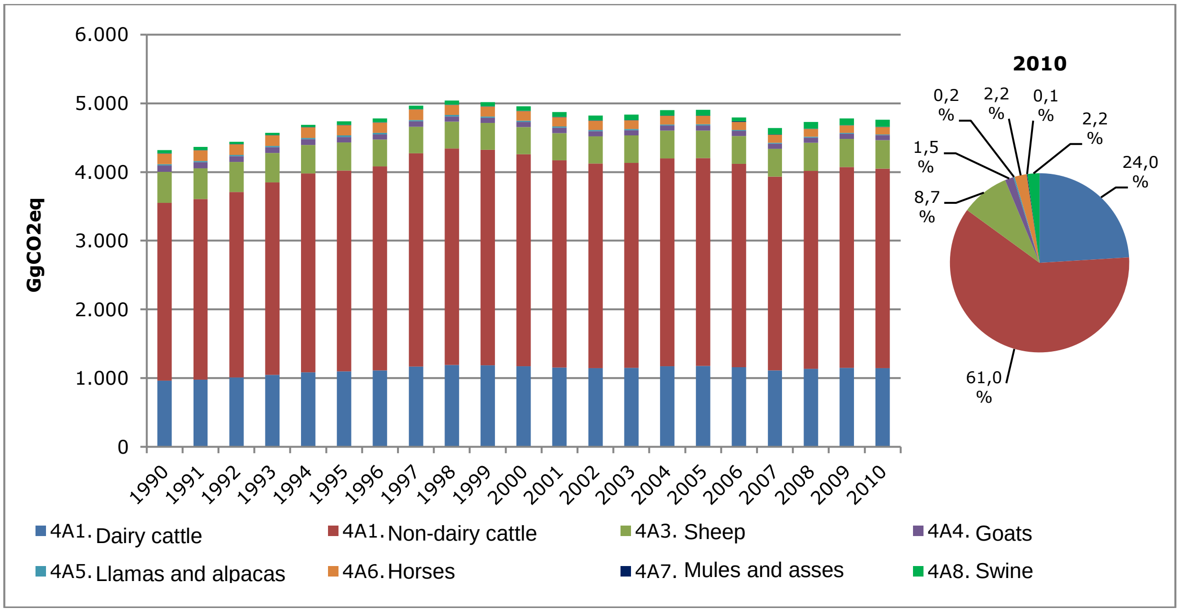

Figure 43. Enteric fermentation: GHG emission trend by livestock, 1990–2010 series

6.2.2. Methods applied

The methods applied to prepare the Enteric fermentation category are shown in the Table below:

Table 48. Enteric fermentation: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
A. Enteric fermentation			T1b, T2	D, CS		
1. Cattle			T2	CS		
2. Buffalo			NO	NO		
3. Sheep			T1b	D		
4. Goats			T1b	D		
5. Llamas and alpacas			T1b	D		
6. Horses			T1b	D		
7. Mules and asses			T1b	D		
8. Horses			T1b	D		
9. Poultry			NE	NA		
10. Other			NE	NA		

T1b = Disaggregated by region; T2 = Tier 2 method; D = Default; CS = country-specific; NE = Not estimated; NO = Not occurring.
Source: Prepared in-house by SNICHILE.

Cattle

Cattle emissions were estimated using a Tier 2 method, which involves country-specific emission factors, in this case disaggregated regionally. The formula used was the one provided in the 2006GL for calculating Tier 2 CH_4 emissions, namely:

$$\boldsymbol{FE} = \left[\frac{\boldsymbol{GE} \times \left(\frac{\boldsymbol{Ym}}{\mathbf{100}}\right) \times \mathbf{365}}{\mathbf{55,65}}\right]$$

Where:

- *FE = emission factor, kg / CH_4 / head^{-1} / year^{-1}*
- *GE = gross energy ingested, MJ / head^{-1} / day^{-1}*
- *Y_m = methane conversion factor, the percentage of gross energy of the feed converted into methane*
- *The factor 55.65 (MJ/kg CH_4) is the energy content of methane*

Country-specific emission factors were already available for Cattle during the preparation of Chile's previous NGHGI, and thus for the present inventory the AFOLU Sector Team focused on updating the supporting documentation with the help of researchers from the Remehue Regional Research Center (Centro de Investigación Regional Remehue), a branch of the Agricultural Research Institute (INIA). A meticulous characterization was carried out to estimate the gross energy consumed by each type of animal in each kind of management system, and the result provided a key variable for calculations of country-specific emission factors. Using the 2006GL and available expertise, new animal-specific emission factors were estimated.

Other species

Emissions from these subcategories were calculated using a Tier 1b method, which involves disaggregating statistical activity by region and using default emission factors.

6.2.2.1. Statistical and parametrical activity data

The population data required for all subcategories were obtained from the *1997 and 2007 National Agriculture and Livestock Censuses*, from annual statistics published by ODEPA and from FAOSTAT. This information is disaggregated by administrative region, which allowed the team to apply a Tier 1b method for the subcategories Sheep, Goats, Llamas and alpacas, Horses, Mules and asses and Swine. The parametrical data used for these subcategories was the default data supplied in the 2006GL.

6.2.2.2. Emission factors

Cattle

In the previous NGHGI, submitted as part of the *Second National Communication of Chile to the UNFCCC* (MMA, 2011), Tier 2 emission factors were available for the Cattle subcategory. On that occasion, INIA-Remehue researchers[19] reviewed all calculations to ensure that the values were properly adjusted. The updated emission factors were derived from a meticulous characterization of the subcategory that led to estimates of the gross energy consumed by each type of animal under each management system (Table 49), in accordance with the methodology described in the 2006GL.

Table 49. Cattle: Determination of gross energy consumed by Dairy and Non-dairy cattle under direct grazing

Animal group	Live weight, kg	Default Cf	Net energy needed for maintenance (ENm)	Feed coefficient (Cf)	Net energy for activity (ENa)	Net energy from weight loss	Growth coefficient	Adult body weight, kg	Daily weight gain (kg day^{-1})	Net energy for growth (ENg)
Lactating dairy cow	600	0.335	40.6	0.17	6.9	0	0.8	600	0	0
Non-lactating dairy cows	600	0.335	40.6	0.17	6.9	0	0.8	600	0	0
Beef cows	500	0.335	35.4	0.17	6.02	0	0.8	500	0	0
Heifers	300	0.322	23.2	0.17	3.95	0	0.8	300	0.4	9.53
Male beef cattle, adult	450	0.322	31.5	0.17	5.35	0	1	450	0.35	6.96
Male beef cattle, juvenile	260	0.322	20.8	0.17	3.54	0	0.9	260	0.3	6.36
Calves	150	0.322	13.8	0.17	2.35	0	0.9	150	0.3	6.36
Source	Expert opinion	2006GL	2006GL	2006GL	2006GL	2006GL	2006GL	Expert opinion	2006GL	2006GL

Animal group	Pregnancy coefficient	Net energy for pregnancy (ENp)	Productivity, kg milk/day	Fat in milk, %	Energy for lactation (ENl)	Net energy for work	Ratio of En for maintenance in diet/Digestible E consumed	Ratio of En for growth in diet /Digestible E consumed	Digestibility of feed (ED)	Gross energy (GE)
Lactating dairy cows	0.1	3.66	9.66	0.0381	14.4	0	0.5195	0.3085	65	194.0489
Non-lactating dairy cows	0.1	3.66	2.57	0.035	3.8	0	0.5195	0.3085	65	162.8604
Beef cows	0.1	3.54	2.57	0.03	3.8	0	0.5195	0.3085	65	144.5261
Heifers	0	0	0	0	0	0	0.5195	0.3085	65	127.9498
Male beef cattle, adult	0	0	0	0	0	0	0.5195	0.3085	65	143.7321
Male beef cattle, juvenile	0	0	0	0	0	0	0.5195	0.3085	65	103.9726
Calves	0	0	0	0	0	0	0.5195	0.3085	65	79.5529
Source	2006GL	2006GL	Expert opinion	Expert opinion	2006GL	2006GL	2006GL	2006GL	Expert opinion	2006GL

Source: 2006GL and expert judgment of investigators from INIA-Remehue.

Emission factors for each region and type of cattle are presented in Table 50.

[19] Marta Alfaro, Francisco Salazar and Erika Vistoso, primarily.

Table 50. Cattle: Tier 2 emission factors calculated for bovine cattle

	Emission factor (kg CH_4 animal^{-1} year^{-1})														
Type of cattle	**XV**	**I**	**II**	**III**	**IV**	**V**	**XIII**	**VI**	**VII**	**VIII**	**IX**	**XIV**	**X**	**XI**	**XII**
Dairy cows	78.60	78.60	78.60	78.60	79.80	79.80	79.80	79.80	79.80	78.06	77.44	77.48	76.81	76.81	76.81
Beef cows	56.88	56.88	56.88	56.88	56.88	56.88	26.16	12.03	5.54	56.88	56.88	56.88	56.88	56.88	56.88
Heifers	50.35	50.35	50.35	50.35	50.35	50.35	50.35	50.35	50.35	50.35	50.35	50.35	50.35	50.35	50.35
Male beef cattle, adult	56.56	56.56	56.56	56.56	70.66	70.66	70.66	70.66	70.66	70.66	64.39	58.13	58.13	56.56	56.56
Male beef cattle, juvenile	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92
Calves	31.66	31.66	31.66	31.66	31.66	31.66	31.66	31.66	31.66	31.66	31.66	31.66	31.66	31.66	31.66

Source: Expert judgment of INIA-Remehue researchers.

Sheep, Goats, Llamas and alpacas, Horses, Mules and asses and Swine

For these species, the default emission factors provided in the IPCCGL were used.

6.3. Manure management (4B)

6.3.1. Description of the category and GHG emissions

Methane (CH_4) is produced by the decomposition of manure under anaerobic conditions while N_2O is produced under aerobic conditions or a mixture of anaerobic and aerobic conditions. Consequently, GHG emissions from these sources will depend on the kind of manure and how it is stored.

In Chile, CH_4 emissions derive primarily from bovine cattle (disaggregated into dairy cows, beef cows, heifers, calves, adult and juvenile male beef cattle), sheep, goats, horses, mules and asses, South American camelids (llamas and alpacas), swine (divided into sows, boars and piglets) and poultry, specifically broilers.

In the case of N_2O emissions, the following manure management systems (MMS) were taken into account:

- Anaerobic lagoons: dairy cattle,
- Solid storage and dry lot: non-dairy cattle and poultry, and
- Other management systems: swine.

The other species of animals are assumed to be direct pastured and therefore N_2O emissions from their manure are counted in the category Agricultural soils.

In 2010, GHG emissions in this category amounted to 1,678.9 GgCO_2eq, or 12.1% of the entire Agriculture sector (Table 51). Since 1990, GHG emissions of this category have increased by 33.8%, the key driver being growth in the livestock population. Interannual variations observed in Figure 44 are mainly the result of the introduction of biodigesters to some major swine production centers (2000).

In terms of animal type, Non-dairy cattle are the most significant GHG emission source, accounting for 43.3%, followed by Swine with 26.7%, Horses with 9.0%, and Dairy cattle with 8.8%. The Solid and open lot storage system accounted for 7.1% and Anaerobic lagoons for 2.2% of GHG emissions in this category. The remaining 2.9% is from the remaining subcategories.

Table 51. Manure management: GHG emissions ($GgCO_2eq$) by type of livestock and manure management system, 1990–2010 series

Type	1990	1995	2000	2005	2010
4B1. Dairy cattle	138.1	155.4	161.6	155.0	147.7
4B1. Non-dairy cattle	629.0	712.1	756.6	752.1	727.4
4B3. Sheep	14.5	13.0	12.6	12.9	13.3
4B4. Goats	3.1	2.7	2.6	2.5	2.5
4B5. Llamas and Alpacas	4.7	5.0	4.5	3.6	2.7
4B6. Horses	14.1	13.8	12.8	11.2	9.5
4B7. Mules and Asses	0.3	0.4	0.4	0.4	0.5
4B8. Swine	270.2	304.6	386.5	349.4	448.0
4B9. Poultry	7.6	11.3	15.8	17.6	20.9
4B11. Anaerobic lagoons	33.6	38.0	40.0	39.0	37.4
4B13. Solid storage and dry lot	107.9	124.3	130.5	122.6	118.6
4B14. Other MMS	31.6	42.7	69.9	118.6	150.4
Total	1,254.7	1,423.2	1,593.8	1,585.0	1,678.9

Source: Prepared in-house by SNICHILE.

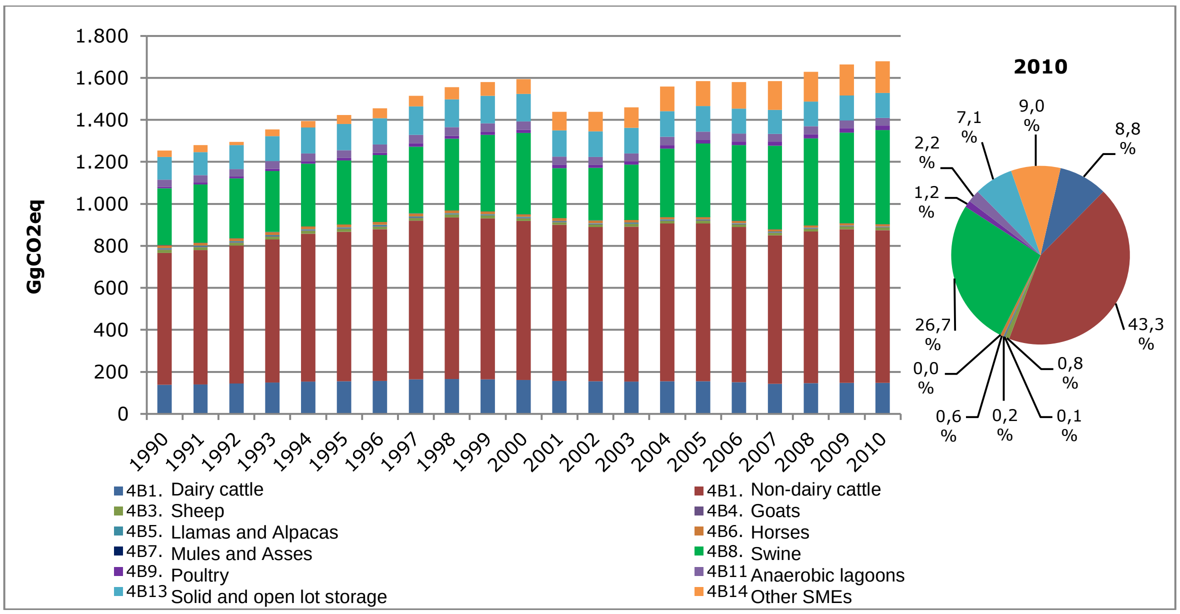

Figure 44. Manure management: GHG emission trend by type of livestock and manure management system, 1990–2010 series

6.3.2. Methods applied

In preparing the Manure management category the following methods were applied:

Table 52. Manure Management (SMEs): methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
B. Manure management			T1b, T2	D, CS	T1b	D
1. Bovine cattle			T2	CS		
2. Buffalo			NO	NO		
3. Sheep			T1b	D		
4. Goats			T1b	D		
5. Llamas and Alpacas			T1b	D		
6. Horses			T1b	D		
7. Mules and asses			T1b	D		
8. swine			T2	CS		
9. Poultry			T1b	D		
10. Other			NE	NE		
11. Anaerobic lagoons					T1b	D
12. Liquid systems					NO	D
13. Solid storage and dry lots					T1b	D
14. Other MMS					T1b	D

T1b = Disaggregated by region; T2 = Tier 2 method; D = Default; CS = Country-specific; NE = Not estimated; NO = Not occurring
Source: Prepared in-house by SNICHILE.

Cattle and Swine

For estimating CH_4 emissions, the AFOLU Sector Team used Tier 2 emission factors for cattle and swine, which are the main contributors to emissions in the category. The Tier 2 method involves the disaggregation of the livestock population into similar animal groupings and the use of country-specific emission factors.

Other livestock

CH_4 emissions were estimated using the Tier 1 method, in which data on livestock population type was multiplied by the corresponding default emission factor.

Manure management systems

For estimating N_2O emissions, animal species and animal groups were classified according to their manure management systems, as indicated above. The manure management systems used for swine were based on information obtained from the Pork Producers Trade Association of Chile (ASPROCER A.G.).

6.3.2.1. Statistical and parametrical activity data

Cattle and other livestock

Activity data for each type of livestock were the same as those used for the Enteric fermentation category.

Swine

The swine population was disaggregated by type of manure management system based on information provided by ASPROCER A.G.

Manure management systems

The distribution of livestock populations was determined based on expert judgment[20]. One parametric datum that is important for estimating the N_2O emissions of each type of livestock is the annual nitrogen excretion rate. It is worth noting that these rates were calculated by applying the excretion values for each 1000 kg of live weight per day that are provided in the 2006GL (Table 10.19, Chapter 10, Volume 4, 2006GL) and multiplying these by the body mass of each kind of livestock, as determined by expert judgment[21]. The values that were used are shown in the Table below:

Table 53. Nitrogen excretion rate (kg N/animal/year^{-1})

Livestock type	N excretion rate (kg of N°1000 kg live weight-day^{-1})	Average body weight (live weight in kg)	N excretion (kg N animal-year^{-1})
Dairy cattle	0.48	650	113.9
Non-dairy cattle			
Beef cows	0.36	550	72.3
Heifers	0.36	350	46.0
Adult males, beef	0.36	450	59.1
Juvenile males, beef	0.36	250	32.9
Calves	0.36	150	19.7
Sheep	1.17	60	25.6
Goats	1.37	50	25.0
Llamas and alpacas	0.46	95	16.0
Horses	0.46	450	75.6
Mules and asses	0.46	237.5	39.9
Swine			
Boars	0.50	220	40.2
Sows	0.50	200	36.5
Piglets	0.50	64	11.7
Poultry	0.82	2.5	0.7

Source: Default values provided by the 2006GL; country-specific values based on the expert judgment of INIA-Remehue researchers and ASPROCER A.G. professionals.

6.3.2.2. Emission factors

Cattle

GHG emissions for this subcategory were calculated using the Tier 2 emission factors for CH_4 emitted under the Manure management category and are presented in the Table below:

Table 54. Cattle: Tier 2 emission factors calculated for bovine cattle

	Emission factors (kg CH_4 (animal-year)$^{-1}$)														
Type of cattle	XV	I	II	III	IV	V	XIII	VI	VII	VIII	IX	XIV	X	XI	XII
Dairy cows	19.2	19.2	19.2	19.2	28.4	28.4	28.4	28.4	28.4	14.6	9.7	10.1	4.8	4.8	4.8
Beef cows	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.1	36.3	36.3	36.3	36.3	36.3
Heifers	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.8	1.1	1.1	1.1	1.1	1.1
Adult males, beef	1.6	1.6	1.6	1.6	35.4	35.4	35.4	35.4	35.4	35.4	0.9	0.8	0.8	0.8	0.8
Juvenile males, beef	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7	39.2	39.2	39.2	39.2	39.2
Calves	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.3	2.3	2.3	2.3	2.3	2.3

Source: Expert opinion of INIA-Remehue researchers.

[20] INIA-Remehue researchers.
[21] INIA-Remehue researchers and ASPROCER A.G. professionals.

Swine

To estimate emissions from this subcategory, the Tier 2 emission factors for CH_4 in the Manure management category were calculated using parametric data provided by ASPROCER A.G. These emission factors are shown in the Table below:

Table 55. Swine: Tier 2 emission factors calculated

Emission factors (kg CH_4 (animal-year)$^{-1}$)	
Sows	26.07
Boars	20.85
Piglets	6.95

Source: Expert judgment of ASPROCER A.G. professionals.

Other types of livestock and manure management systems

The default emission factors provided in the 2006GL were used for all remaining subcategories.

6.4. Rice cultivation (4C)

6.4.1. Description of the category and GHG emissions

The anaerobic decomposition of organic material in flooded rice paddies produces CH_4 that is then emitted into the atmosphere, primarily through water bubbles and by being transported through the rice plants. The quantity emitted varies with the rice variety, the duration of flooding, the number and duration of crop cycles, the soil temperature, the irrigation method and whether or not organic substrates are incorporated.

Rice is cultivated in only a few regions of Chile, in all cases under permanent flooding and without the incorporation of organic substrates. Rice is harvested once per year.

In 2010, GHG emissions in this category amounted to 103.8 $GgCO_2eq$, or 0.8% of the sector's total emissions (Table 56 and Figure 45). Since 1990, GHG emissions from this category have dropped by 24.7%, the key drive of this decrease being the steady decrease in the surface under cultivation.

Table 56. Rice cultivation: methane emissions ($GgCO_2eq$), 1990–2010 series

Category	1990	1995	2000	2005	2010
4C. Rice cultivation	137.9	143.6	109.0	105.9	103.8
Total	137.9	143.6	109.0	105.9	103.8

Source: Prepared in-house by SNICHILE.

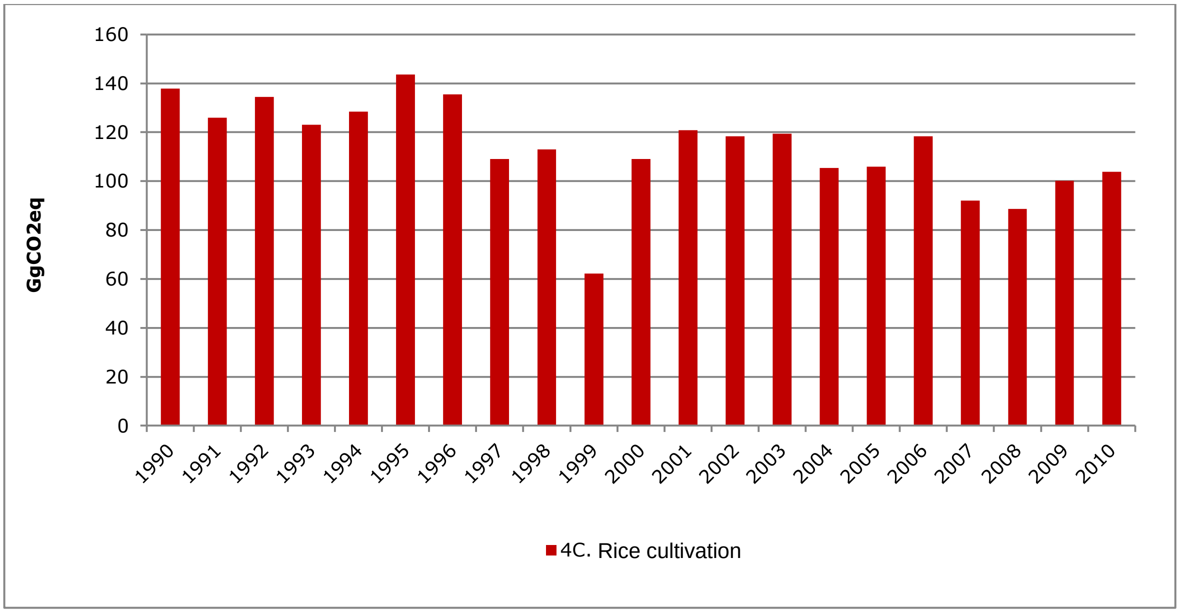

Figure 45. Rice cultivation: methane emission trend, 1990–2010 series

6.4.2. Methods applied

The methods used to prepare the Rice cultivation category are shown in the Table below:

Table 57. Rice cultivation: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
C. Rice cultivation			T1b	D		
1. Irrigated			T1b	D		
2. Rainfed			NO	D		
3. Deep water			NO	D		
4. Other			NO	D		

T1b = Disaggregated by region; D = Default; NO = Not occurring
Source: Prepared in-house by SNICHILE.

6.4.2.1. Statistical and parametrical activity data

Information on the area under cultivation annually was obtained from *the National Agriculture and Forestry Census (Censo Nacional Agropecuario y Forestal*) and from crop statistics data compiled by ODEPA. The nature of the information collected enabled disaggregation of the data by region.

6.4.2.2. Emission factors

The default emission factor was used in this calculation, on the assumption that (1) no flooding occurred for at least 180 days before the rice was sown; (2) paddies were inundated throughout the entire growing period; and (3) no organic substrate was added to the soil (EFc).

6.5. Agricultural soils (4D)

6.5.1. Description of the category and GHG emissions

N_2O emissions from surface soils result primarily from the microbial transformation of nitrogen that has been added to the soil in the form of synthetic fertilizers, animal manure applied to soils, crop residues, sludge from wastewater treatment plants and/or other organic nitrogen substrates. All of these can release nitrogen directly when applied or indirectly when the nitrogen is leached as NO_3 or volatilized as NH_3 and NO_x and then deposited in other places.

In 2010, GHG emissions from this category amounted to 7,251.4 $GgCO_2eq$, or 52.4% of the sector's emissions (Table 58); since 1990, those emissions have increased by 49.3%, primarily driven by the increased use of synthetic nitrogen-based fertilizers used in Chile.

In terms of subcategories, Direct emissions from agricultural soils is the most significant, accounting for 40.3% of all GHG emissions in the category, followed by 35.7% from Pasture, range and paddock manure, and 24.1% from indirect emissions from agricultural soils (Figure 46).

Table 58. Agricultural soils: GHG emissions ($GgCO_2eq$) by subcategory, 1990–2010 series

Subcategory	1990	1995	2000	2005	2010
4D1. Direct emissions from agricultural soils	1,282.9	1,625.1	1,719.8	1,973.4	2,920.1
4D2. Pasture, range and paddock manure	2,464.4	2,628.5	2,727.9	2,663.7	2,586.7
4D3. Indirect emissions from agricultural soils	1,108.9	1,246.8	1,317.1	1,443.9	1,744.6
Total	4,856.2	5,500.5	5,764.8	6,081.0	7,251.4

Source: Prepared in-house by SNICHILE.

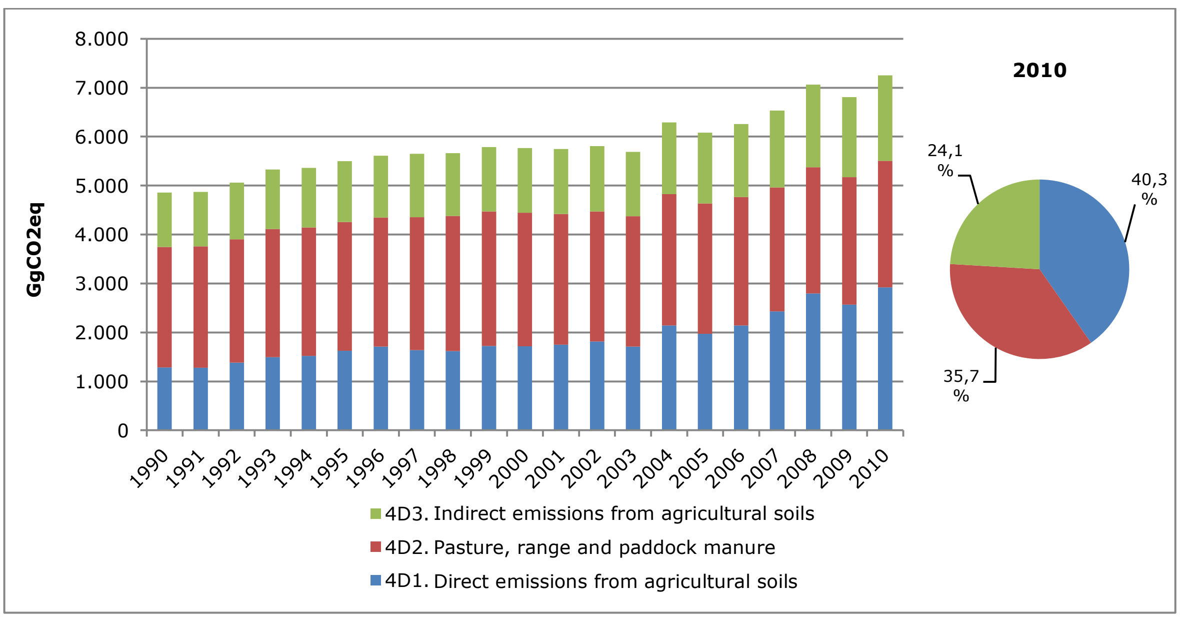

Figure 46. Agricultural soils: GHG emission trend by subcategory, 1990–2010 series

6.5.1.1. Direct emissions from agricultural soils (4D1)

In the Chilean context, direct N_2O emissions from agricultural soils are the result of nitrogen applied to the soil in the following forms:

- Synthetic fertilizers,
- Animal manure applied to soils, and
- Crop residues.

N_2O emissions from organic soils (histosols) were not included in the NGHGI due to a lack of data related with histosols management in the country.

In 2010, GHG emissions from this subcategory amounted to 2,920.1 $GgCO_2eq$, or 40.3% of the category's total (Table 59). Since 1990, GHG emissions by this subcategory have increased 127.6%, mainly driven by the increased use of synthetic nitrogen-based fertilizers.

In terms of components, Synthetic fertilizers make the largest contribution to GHG emissions, accounting for 68.8% of emissions in this subcategory, followed by Crop residues with 15.8% and Animal manure applied to the soil with 15.4% (Figure 47).

Table 59. Direct emissions from agricultural soils: GHG emissions ($GgCO_2eq$) by component, 1990–2010 series

Component	1990	1995	2000	2005	2010
4D1a. Synthetic fertilizer	799.4	1,047.4	1,144.8	1,172.6	2,009.5
4D1b. Animal manure applied to the soil	79.7	106.7	140.6	334.8	450.1
4D1c. Crop residues	403.8	471.0	434.5	466.0	460.5
Total	1,282.9	1,625.1	1,719.8	1,973.4	2,920.1

Source: Prepared in-house by SNICHILE.

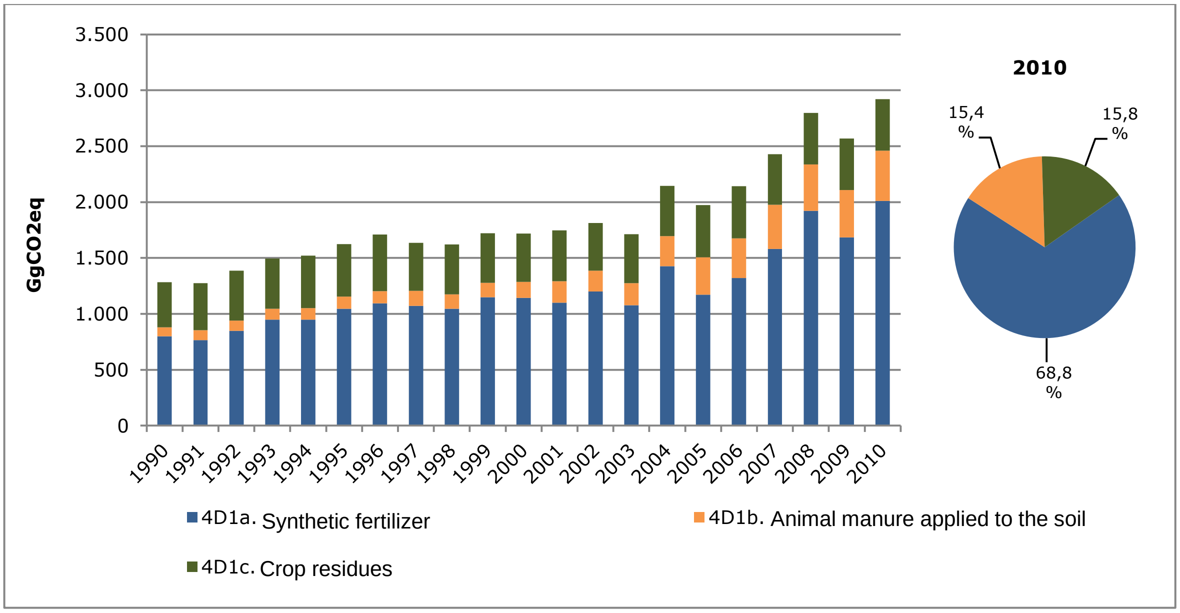

Figure 47. Direct emissions from agricultural soils: GHG emission trend by component, 1990–2010 series

6.5.1.2. Pasture, range and paddock manure (4D2)

In 2010, GHG emissions in this subcategory amounted to 2,586.7 $GgCO_2eq$, or 35.7% of total emissions in the category (Table 58 and Figure 46), an increase of 5.0% since 1990.

6.5.1.3. Indirect emissions from agricultural soils (4D3)

Indirect N_2O emissions included in this subcategory are originated by:

- Volatilization (as NH_3 and NO_X) of nitrogen applied as synthetic and organic fertilizers (animal manures), and
- Leaching and surface runoff of nitrogen from synthetic and organic fertilizers, and crop residues.

In 2010, GHG emissions from this subcategory amounted to 1,744.6 $GgCO_2eq$, or 24.1% of the category's total (Table 60 and Figure 48). Since 1990, GHG emissions by this subcategory have risen by 57.3%, mainly driven by the increased application of organic nitrogen to the soil in the form of animal manure and, to a lesser extent, from synthetic nitrogen-based fertilizer use.

In terms of components, Leaching is the most significant, accounting for 54.0% of GHG emissions in this subcategory, followed by Volatilization with 46.0% (Figure 48).

Table 60. Indirect emissions from agricultural soils: GHG emissions (GgCO_2eq) by component, 1990–2010 series

Component	1990	1995	2000	2005	2010
N-Synthetic fertilizers	79.9	104.7	114.5	117.3	201.0
N-Animal manure applied to soils	15.9	21.3	28.1	67.0	90.0
N-Manure deposited on pasture, range and paddock	323.0	332.7	339.7	332.9	324.8
N-Manure management	70.3	90.3	111.8	155.6	187.4
4D3a. Volatilization	489.2	549.1	594.1	672.7	803.2
N-Synthetic fertilizers	147.6	193.4	211.4	216.5	371.0
N-Animal manure applied to soils	17.9	24.0	31.6	75.3	101.3
N-Manure deposited on pasture, range and paddock	363.4	374.3	382.2	374.5	365.4
N-Crop residues	90.9	106.0	97.8	104.9	103.6
4D3b. Leaching	619.8	697.7	723.0	771.2	941.3
Total	1,108.9	1,246.8	1,317.1	1,443.9	1,744.6

Source: Prepared in-house by SNICHILE.

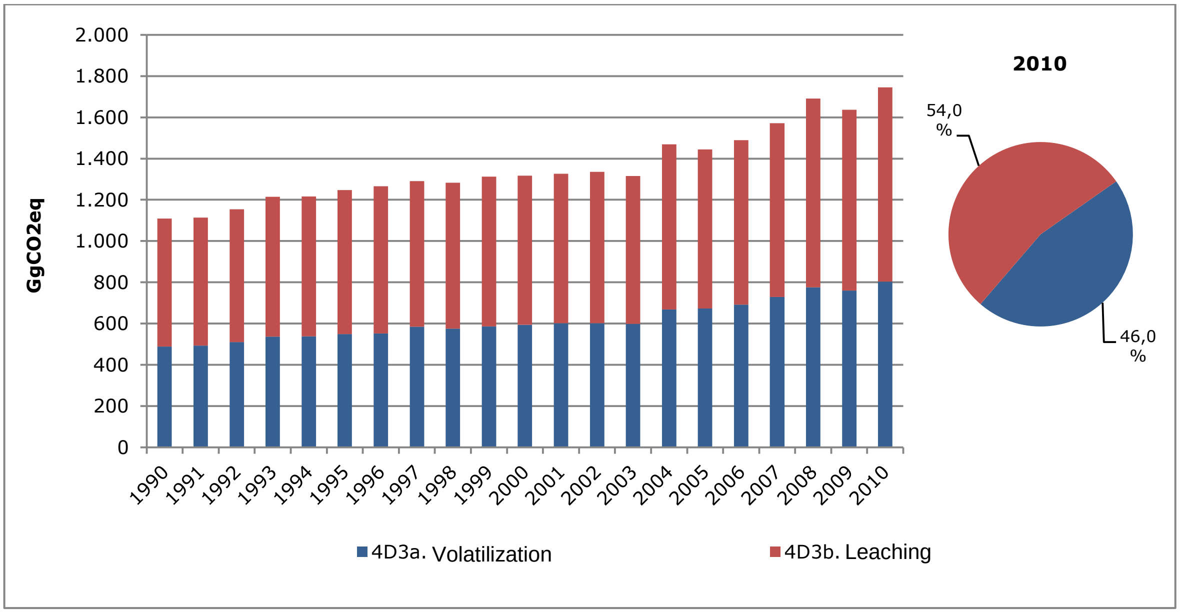

Figure 48. Indirect emissions from agricultural soils: GHG emission trend by component, 1990–2010 series

6.5.2. Methods applied

The methods applied to prepare estimations for the Agricultural soils category are shown in the Table below:

Table 61. Agricultural soils: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
D. Agricultural soils					T1b	D
1. Direct emissions from agricultural soils					T1b	D
2. Animal manure applied to soils					T1b	D
3. Indirect emissions from agricultural soils					T1b	D
4. Other					NO	NO

T1b = Disaggregated by region; D = Default; NO = Not occurring

Source: Prepared in-house by SNICHILE.

Emissions in this subcategory were calculated with a Tier 1b method, which uses data disaggregated by region and default emission factors.

6.5.2.1. Statistical and parametrical activity data

Direct emissions from agricultural soils

Data was collected on the tons of synthetic nitrogen fertilizer consumed annually in Chile from the single source available (FAOSTAT), which provides figures on apparent annual consumption. To disaggregate consumption by region, the team extracted information on the area under cultivation in each region for each of 13 different crop regimes and different irrigation regimes from the *VII Agriculture and Livestock Census* (*VII Censo Agropecuario y Forestal*) (INE, 2007). This data allowed the N data to be disaggregated by region in proportion to the area under cultivation in each. The estimations also employed data on crop residues (generated using productivity data from agriculture and livestock censuses and from annual statistics published by ODEPA). Emissions from subcategories related to animal manure were estimated under the Manure management category.

Pasture, range and paddock manure

Data was calculated by using nitrogen excretion rates multiplied by the direct-pastured animal population.

Indirect emissions from agricultural soils

The data used for this subcategory were the same used to calculate Direct soil emissions.

In accordance with the 2006GL, indirect emission calculations do not include any areas under mechanized irrigation as this watering system eliminates leaching and runoff.

6.5.2.2. Emission factors

For this category, the default emission factors provided by the 2006GL were used.

6.6. Prescribed burning of savannahs (4E)

This activity does not occur in Chile.

6.7. Field burning of agricultural residues (4F)

6.7.1. Description of the category and GHG emissions

Although CO_2 emissions from *in situ* burning of crop residues do occur, they do not need to be accounted for as they do not emit CO_2 into the atmosphere because the vegetation grows again between burning cycles. Nevertheless, agricultural burns release other GHG gases (CH_4, N_2O) as well as GHG precursors (CO and NO_x) which have to be accounted for.

In 2010, GHG emissions from this subcategory amounted to 29.1 $GgCO_2eq$, or 0.2% of the sector's total emissions (Table 62 and Figure 49). Since 1990, GHG emissions by this category have dropped by 79.8%, driven by more stringent regulation of this practice that limits it to certain months of the year in the Santiago Metropolitan Region and the Province of Cachapoal, and by the adoption of good agricultural practices across the country.

Table 62. Field burning of agricultural residues: GHG emissions (GgCO_2eq), 1990–2010 series

Category	1990	1995	2000	2005	2010
4F. Field burning of agricultural residues	144.3	87.0	68.8	58.9	29.1
Total	144.3	87.0	68.8	58.9	29.1

Source: Prepared in-house by SNICHILE.

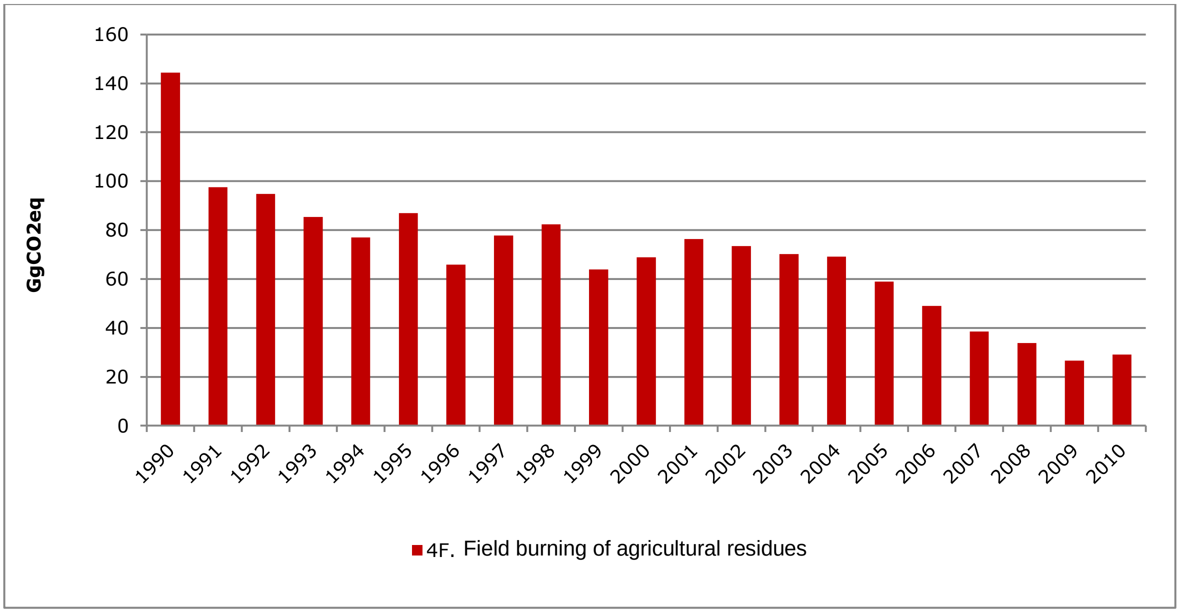

Figure 49. Field burning of agricultural residues: GHG emission trend, 1990–2010 series

6.7.2. Methods applied

The methods applied to estimate GHG emissions for the category Field burning of agricultural residues are shown in the Table below:

Table 63. Field burning of agricultural residues: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
F. Field burning of agricultural residues			T1a,b	D	T1a,b	D

T1a = Disaggregated by operational component (crop, species, etc.); T1b = Disaggregated by region; D = Default
Source: Prepared in-house by SNICHILE.

Emissions from Field burning of agricultural crop residues were estimated using a country-specific methodology and default emission factors.

6.7.2.1. Statistical and parametrical activity data

Calculations in this category used crop production data with an assumed percentage of burned area, along with country-specific parameters for the proportion of crop residues actually burned, as well as for harvest rates, dry material and the fraction oxidized. The country-specific parametrical values were obtained from the national literature and expert judgment and are the same ones used to estimate emissions from crop residues incorporated into the soil.

The parametrical data required were a combination of the default values provided by the 2006GL and domestic values obtained from ODEPA, INE, FAOSTAT and expert judgment.

6.7.2.2. Emission factors

Default emission factors provided by the 2006GL were used in this category's estimations.

6.8. Quality assurance and quality control

The paragraphs below describe the quality assurance/quality control procedures used by the AFOLU Sector Team. The same team prepares the sectorial inventories for both the Agriculture and LULUCF sectors, and therefore the QA/QC procedures below apply to both sectors.

6.8.1. Quality control

- Management of statistical activity data:
    - Statistical activity data were entered automatically onto the worksheets from their point of origin to prevent manual data entry errors.
    - National totals activity data are prepared by adding together regional totals and crosschecking the data to ensure that they match properly.
- Emission factors, conversion factors and constants (parametrical activity data):
    - All of these data are grouped together in a single spreadsheet linked to the worksheets, in order to centralize the data to facilitate quick review and updating, as applicable.
- Worksheets:
    - All worksheets are automatically linked to the activity data and emission factor worksheets.

6.8.2. Quality assurance

The AFOLU SGHGI (Agriculture and LULUCF sectors) was reviewed by two experts qualified as reviewers of NGHGIs from Parties included in Annex I to the Convention in June 2014. The review was conducted remotely in March-April 2014 and included a two-day visit to Chile by the reviewers, who worked in close coordination with the AFOLU Sector Team in the Chilean Ministry of Agriculture. This direct contact among experts enabled an in-depth review process. The resulting assessment report was analyzed by the AFOLU Sector Team, which corrected pertinent findings and evaluated the feasibility of including the recommendations in the next update of Chile's NGHGI.

6.9. Planned improvements

Considering the AFOLU Sector Team's own analysis and the recommendations of the national inventory expert review, the following improvements have been planned for this sector:

- Improving coordination and management among state entities that possess or generate statistical data, in order to report this data to international sources and thereby maintain the consistency of Chilean and international databases.
- Establishing working committees with key entities (industry associations, public institutions, etc.) that have parametric data that could be used to build country-specific emission factors. This is particularly relevant for key and/or significant categories and/or subcategories.
- Developing and improving country-specific emission factors for key categories such as Enteric fermentation and Agricultural soils. This will include exploring funding of competitive grant projects for this purpose.

7. LAND USE, LAND-USE CHANGE AND FORESTRY SECTOR (5)

7.1. Overview of the sector

The Land use, land-use change and forestry (LULUCF) sector focuses on CO_2 emissions and removals that occur as a result of changes in land use and management. This sector includes:

- Changes in the stock of forests and other perennial vegetation formations. The effects of human interaction with forestry and wood products are considered part of a broad category that includes commercial management, harvesting of roundwood and combustible wood (firewood), manufacture and use of basic wood products, and creation and management of forest plantations, as well as planting of trees in urban, municipal and other non-forest locations.
- Conversion of forests and grassland. The conversion of forests and grassland into grazing land, cropland or other land management uses may significantly reduce biomass and soil carbon stock. Deforestation is one example of this type of conversion.
- Abandonment of managed land (cropland, meadows, forest plantations or other managed land). Over time, abandoned land often accumulates carbon in biomass and soil, particularly if the conditions are similar to those found in grassland and natural forests.
- CO_2 emissions and removals for soil. Changes in management may alter CO_2 emissions and removals of soil, particularly through the implementation of conservation practices or increases in crop and forage production.

The sector is divided into the following categories, by type of soil and use:

- 5A Forest land.
- 5B Cropland.
- 5C Grassland.
- 5D Wetlands.
- 5E Settlements.
- 5F Other land.

Nationally, both absorption (caused by biomass growth in forest plantations and the existence of a significant area of second-growth natural forests, known as “renewals”) and emissions (basically generated by forest harvesting and wildfires) increased steadily during the time series analyzed, with the balance approaching neutrality, though always slightly in favor of capture.

The SGHGI covers virtually the entire territory, though no statistical activity data were available on land-use changes between the XV Arica and Parinacota Region and the IV Coquimbo Region (country’s northern zone), which corresponds to 39.8% of the national territory (excluding Antarctica). While this percentage may seem significant, 65.9% of it corresponds to the “Other land” category (in this case, the Atacama Desert) and 32.7% to “Grassland” (non-intervened natural), with practically no change in carbon stocks.

For categories associated with agricultural crops, territorial coverage increased 22.0% over the previous inventory to encompass 93.4% (1,555,038 ha) of Chile's cultivated land, according to figures from the 7th National Agricultural and Forestry Census (INE, 2007).

Carbon sinks

The 2006GL recognizes the following carbon stocks:

- Above-ground living biomass,
- Below-ground living biomass (roots),
- Standing dead biomass and/or coarse waste (necromass),
- Soil dead biomass, consisting mainly of fallen leaves and smaller fragments (*litter*), and
- Soil organic matter.

The present inventory included living biomass (above-ground and below-ground) within the total national territory and necromass between the VI Region of Libertador Bernardo O'Higgins, and the XII Region of Magallanes and the Chilean Antarctic Region only, which amounted to 56.0% of the national area (excluding the Antarctic territory), a significant advancement over the previous time series (1984-2006), which only considered above-ground living biomass. There was consensus in the Ministry of Agriculture to exclude other carbon sinks (fallen leaves and soil organic matter), for the following reasons:

- litter: lack of adequately supported stock data for each forest type; existing data is fragmentary and only covers the territory between the VII Maule Region and the XII Magallanes and Chilean Antarctic Region, which corresponds to 53.8% of the national area (excluding the Antarctic territory), and
- soil organic matter: lack of country-specific data. As these values are heavily site-dependent (in terms of climate, soil type and management), default values could not be relied upon for accuracy; furthermore, the country lacks geo-referenced data for linking agricultural activities to soil types.

Land-use changes

Statistical data on categories of land-use change—specifically annual rates of change—was obtained from the land-use change matrices available in CONAF's Forestry Ecosystem Monitoring Department.

Subsequently, CONAF's land use categories (urban and industrial areas, agricultural land, meadows and scrubland, forests, wetlands, areas without vegetation, snow and glaciers, bodies of water and uncharted areas) were aligned with the categories found in the 2006GL, resulting in those listed in the Table below.

Table 64. Standardization of land-use categories, CONAF categories vs. IPCC categories

CONAF	IPCC
Agricultural land	Cropland (CL)
Meadows and scrubland	Grassland (GL)
Native forest, Mixed forest and Forest plantations	Forest Land (FL), subdivided into Native Forest (FL-NF) and Forest Plantations (FL-FP)
Wetlands	Wetlands (WL)
Urban and industrial areas	Settlements (SL)
Areas without vegetation, snow and glaciers, bodies of water and uncharted areas	Other Land (OL)

Source: Prepared in-house by the AFOLU Sector Team.

Finally, based on CONAF's land-use change matrices and the above-mentioned standardized categories, matrices were constructed for annual rates of change between land uses for the different working subcategories. Table 65 presents a summary of annual rates of land-use change, wherein the highest conversion rate (75,576.1 ha/year) was for Land converted to forest plantations and the lowest (13.7 ha/year) was for Land converted to wetlands.

Table 65. Land-use conversion matrix (ha/year)

Category	FL-NF	FL-FP	CL	GL	WL	SL	OL	TOTAL
Forest land – native forest		7,868.0	304.1	4,142.9	0.0	70.1	411.6	**12,796.5**
Forest land – forest plantations	586.1		841.2	1,842.0	0.2	407.0	89.9	**3,766.4**
Cropland	320.6	25,557.7		2,220.3	2.5	4,572.4	113.7	**32,787.3**
Grassland	5,266.3	40,420.9	7,975.5		10.6	1,616.7	850.3	**56,140.3**
Wetlands	6.1	246.7	61.1	61.5		40.8	1.3	**417.4**
Settlements	1.3	13.9	8.0	4.7	0.0		0.4	**28.3**
Other land	27.4	468.8	135.6	802.5	0.5	71.8		**1,506.7**
TOTAL	**6,207.8**	**74,576.1**	**9,325.4**	**9,073.9**	**13.7**	**6,778.8**	**1,467.1**	**107,442.8**

Source: Prepared in-house by the AFOLU Sector Team, using area data from the land-use matrices of CONAF's Forestry Ecosystem Monitoring Department.

It should be noted that these annual rates of change have been calculated for each of the country's administrative regions based on two land coverage images per region, taken in different years; thus, although they represent real data, the values clearly illustrate historical rather than current trends in land use change.

GHG removals and emissions

The LULUCF sector is the only sector in Chile that captures CO_2. In 2010, this sector's GHG balance amounted to -49,877.4 $GgCO_2eq$ (Table 66). Over the time series covered in this inventory the balance has tended toward GHG absorption, although absorption per se decreased by 1.9% between 1990 and 2010. The key driver of CO_2 capture in this sector is increased biomass in forest plantations and native forest renewals, while the year-to-year variations observed in Figure 50 are caused mainly by wildfires in native forests and forest plantations. An increase in GHG absorption can be observed toward the end of the period that is the result of an increase in forest plantations (especially *Eucalyptus spp.)* and therefore in biomass and a reduction in harvesting (see point 7.2.1.1. Forest land remaining forest land).

At the category level, in absolute terms[22] 96.0% of the sector's GHG balance corresponds to the Forest land category, followed by 2.3% for Grassland, 1.2% for Cropland and 0.6% for all other categories (Figure 50).

Table 66. LULUCF Sector: GHG emissions and removals ($GgCO_2eq$) by category, 1990-2010 series

Category	1990	1995	2000	2005	2010
5A. Forest land	-52,689.2	-50,681.6	-57,439.5	-46,696.5	-52,052.5
5B. Cropland	326.2	397.2	496.7	522.6	624.0
5C. Grassland	1,232.4	1,232.7	1,230.6	1,243.1	1,241.1
5D. Wetlands	0.0	0.0	0.0	0.0	0.0
5E. Settlements	187.2	186.6	186.3	185.7	186.8
5F. Other land	121.8	121.3	121.2	120.9	123.2
Balance	-50,821.6	-48,743.8	-55,404.6	-44,624.2	-49,877.4

Source: Prepared in-house by SNICHILE.

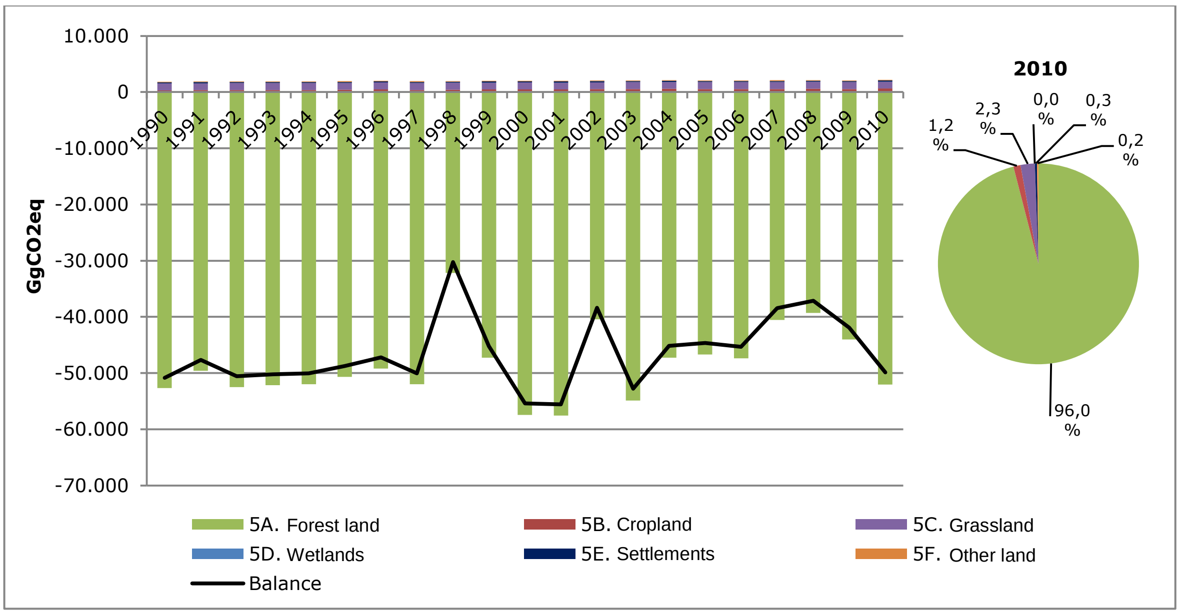

Figure 50. LULUCF Sector: GHG emissions and removals trend by category, 1990-2010 series

In 2010, the balance's main GHG in absolute terms was CO_2, which amounted to 98.6% of the sector total, followed by CH_4 (1.0%) and N_2O (0.4%) (Table 67 and Figure 51).

Table 67. LULUCF Sector: emissions and removals by type of GHG ($GgCO_2eq$), 1990-2010 series

GHG	1990	1995	2000	2005	2010
CO_2	-51,088.4	-49,097.0	-55,485.4	-45,193.6	-50,620.0
CH_4	186.1	246.3	56.3	397.1	517.8
N_2O	80.8	106.9	24.5	172.4	224.8
Total	-50,821.6	-48,743.8	-55,404.6	-44,624.2	-49,877.4

Source: Prepared in-house by SNICHILE.

[22] To facilitate a direct interpretation of the quantitative analysis, removals are introduced as absolute values (GL2006).

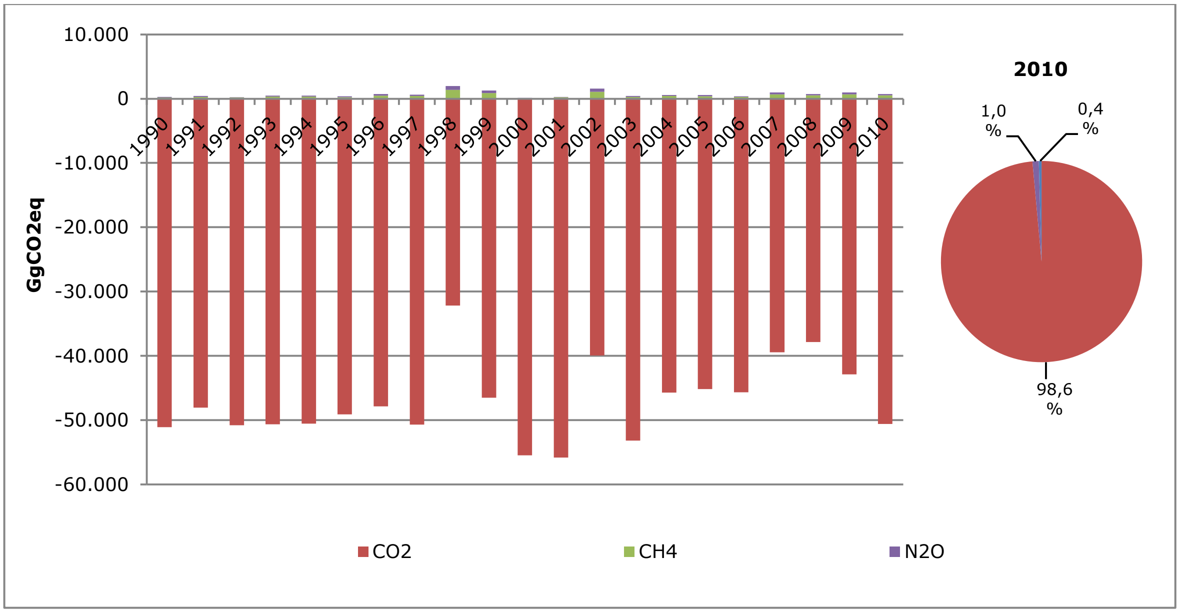

Figure 51. LULUCF Sector: emissions and removals trend by type of GHG, 1990-2010 series

GHG removals and emissions have been estimated for each administrative region. Figure 52 shows that in 2010, 23.0% of removals by this sector occurred in the IX Araucanía Region, 19.6% in the XI Aysén del General Carlos Ibañez del Campo Region, 18.8% in the X Los Lagos Region, 18.1% in the VII Maule Region, and the remaining 20.5% in other regions of the country.

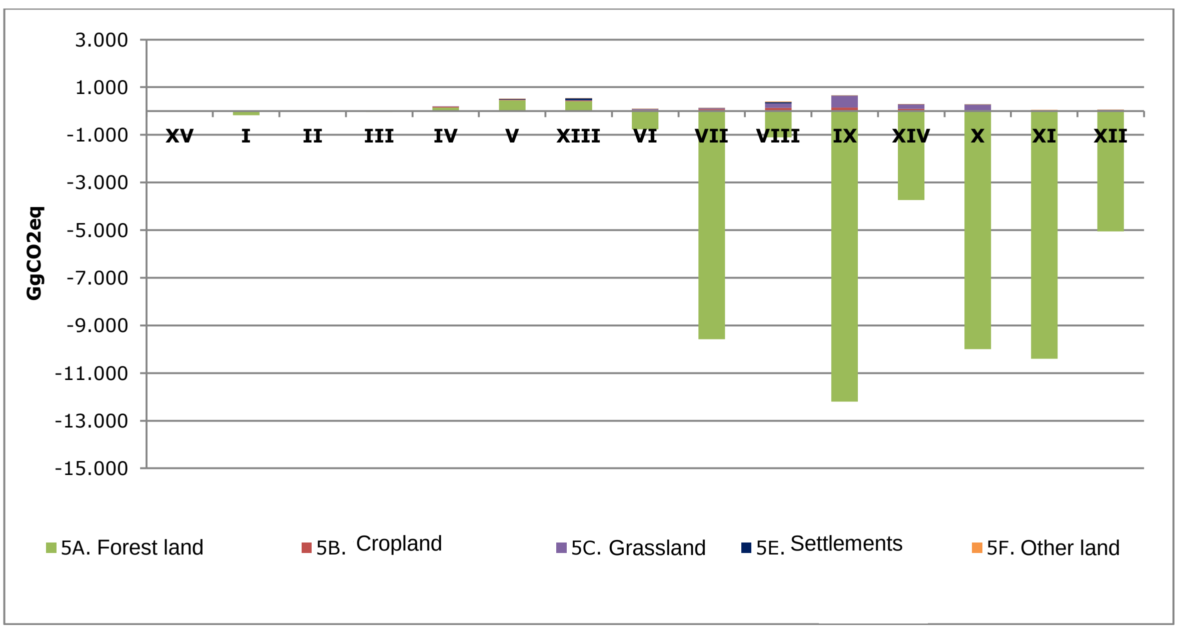

Figure 52. LULUCF Sector: GHG removals and emissions by category and administrative region, 2010

7.2. Forest land (5A)

7.2.1. Description of category and GHG emissions

This category includes GHG emissions and removals caused by changes in biomass, dead organic matter, forest land, and land converted to forest land. The sources of emissions and removals by sinks included:

- Absorption due to growth in forest biomass (above-ground and below-ground) of:
  - forest plantations, disaggregated by species: Monterey pine *(Pinus radiata)*, Eucalyptus *(Eucalyptus globulus* and *Eucalyptus nitens)*, Algarrobo *(Prosopis chilensis)* / Tamarugo *(Prosopis tamarugo)*, Oregon pine *(Pseudotsuga menziesii)*, Poplar *(Populus spp.)* and Other species,
  - native forest renewals, corresponding to a forested area intervened between 50 and 100 years ago that is currently in the process of returning to its natural state (as a second growth native forest),
  - managed native forest, in three management stages (cumulative over the past 10 years), and
  - native forest affected by wildfires (cumulative, over the past 80 years),
- Emission by:
  - harvest of roundwood from forest plantations and native forests (including above-ground and below-ground biomass),
  - harvest -or rather extraction- of firewood (considering only above-ground biomass), and
  - wildfires in forest plantations and native forests (considering only above-ground biomass).

In 2010, the GHG balance for this category was -52,052.5 $GgCO_2eq$, or 96.0% of the sector, in absolute figures (Table 68). Since 1990, the category's GHG balance has tended toward absorption, although this value has decreased by 1.2%. The main driver of removals in this sector is the increased biomass of forest plantations and native forest renewals, while the year-to-year variations observed in Figure 53 are caused primarily by wildfires in native forests and forest plantations. Approaching the end of the period, there was a sharp increase in GHG absorption owing to an increase in the forest plantation area (especially *Eucalyptus spp.)* and a decrease in harvest.

At the subcategory level, Forest land remaining forest land is the leading sink in absolute terms, accounting for 96.9% of the balance, while Land converted to forest land accounted for 3.1% of the balance.

Table 68. Forest land: GHG emissions and removals ($GgCO_2eq$) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
5A1. FL remaining FL	-54,396.2	-52,388.6	-59,146.5	-48,403.6	-53,759.5
5A2. Land converted to FL	1,707.1	1,707.1	1,707.1	1,707.1	1,707.1
Balance	-52,689.2	-50,681.6	-57,439.5	-46,696.5	-52,052.5

Source: Prepared in-house by SNICHILE.

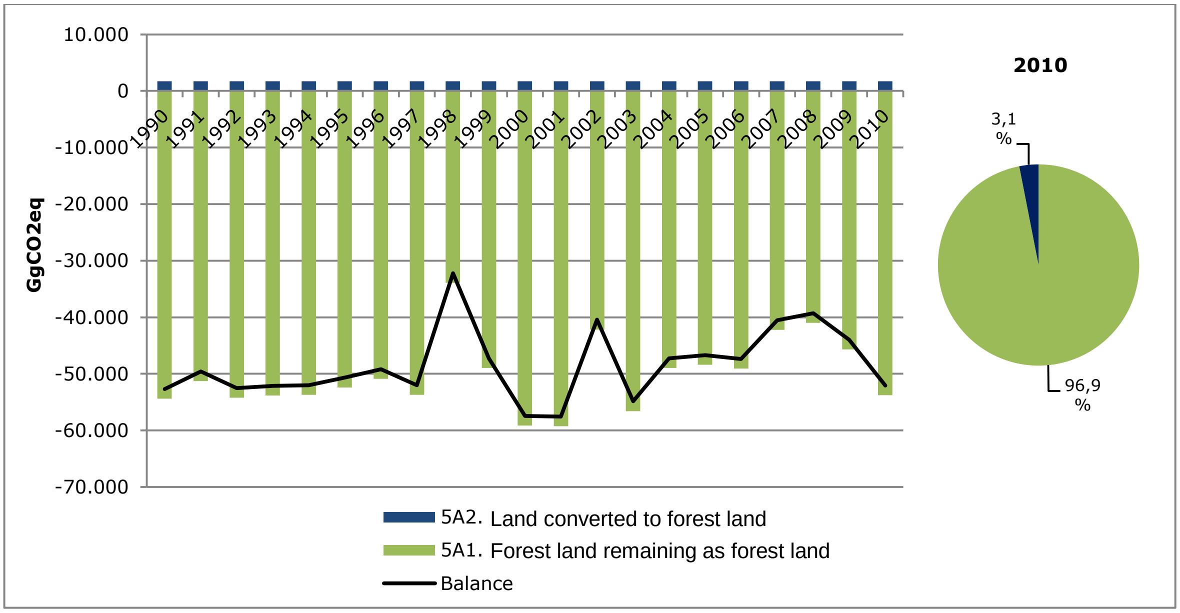

Figure 53. Forest land: GHG emissions and removals trend by subcategory, 1990-2010 series

7.2.1.1. Forest land remaining forest land (5A1)

In 2010, the GHG balance for this subcategory amounted to -53,759.5 GgCO_2eq, or 96.9% of the entire category, in absolute figures (Table 69). Since 1990, the subcategory's GHG balance has tended to favor GHG absorption, although this value has decreased by 1.2%. The key driver of removals in this subcategory is increased biomass from the growth of forest plantations and native forest renewals, while the year-to-year variations observed in Figure 54 are caused primarily by wildfires. Towards the end of the period there was an increase in GHG absorption owing to an increase in the forest plantation area (especially *Eucalyptus spp.)* and a decrease in harvest since 2008.

At the component level, in absolute terms increase in biomass is the most important, accounting for 62.3%, followed by harvest with 27.4%, firewood with 5.8%, and wildfires with 2.1%. Substitution amounted to 1.5% and Land in transition (to forest) amounted to 0.7% of the subcategory balance, and the remaining 0.2% corresponded to Forest residues.

Table 69. Forest land remaining forest land: GHG emissions and removals (GgCO_2eq) by component, 1990-2010 series

Component	1990	1995	2000	2005	2010
5A1a. Increase in biomass	-91,610.4	-105,381.2	-112,105.6	-116,969.8	-128,600.0
5A1b. Land in transition	-68.1	-408.8	-749.5	-1,090.2	-1,430.9
5A1c. Harvest	25,171.7	39,190.0	38,166.9	50,619.8	56,461.1
5A1d. Forest residues	152.2	213.5	0.0	313.1	361.1
5A1e. Firewood	7,160.9	9,233.5	11,451.2	12,377.8	11,945.8
5A1f. Wildfires	1,569.8	1,537.5	863.7	3,120.2	4,274.6
5A1g. Substitution	3,161.2	3,161.2	3,161.2	3,161.2	3,161.2
5A1h. Restoration	66.5	65.8	65.6	64.5	67.6
Balance	-54,396.2	-52,388.6	-59,146.5	-48,403.6	-53,759.5

Source: Prepared in-house by SNICHILE.

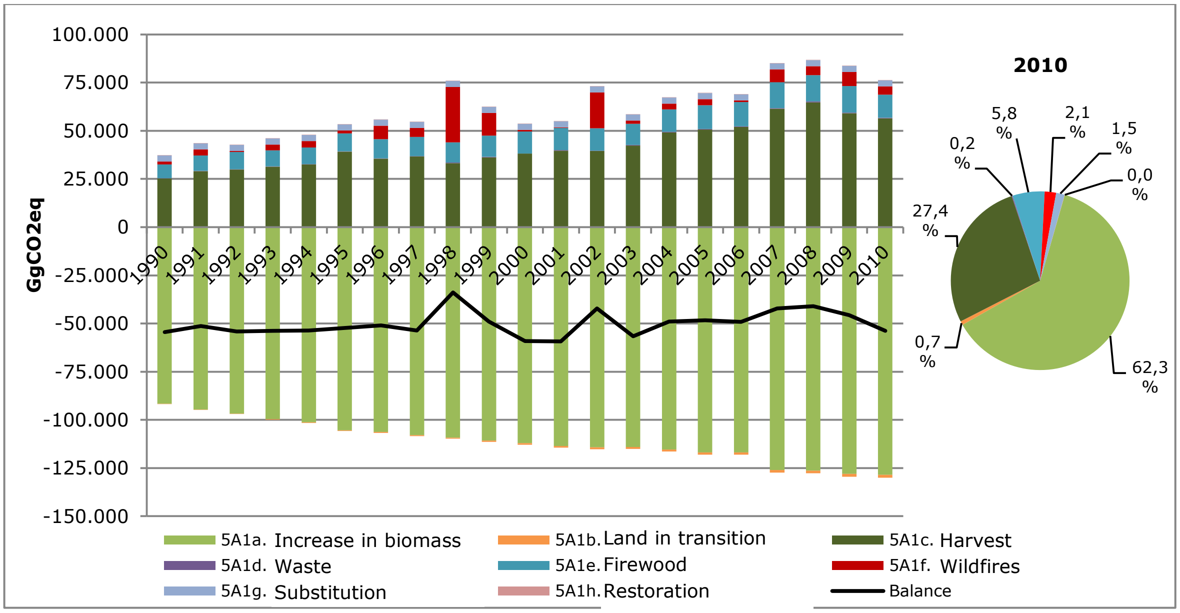

Figure 54. Forest land remaining forest land: GHG emissions and removals trend by component, 1990-2010 series

Increase in biomass

In 2010, GHG absorption amounted to -128,600.0 GgCO_2eq, or 62.3% in absolute values (Table 70). Since 1990, GHG absorption has increased by 40.4%, the key driver being an increase in forest plantation biomass.

At the component level, Forest plantations were the most important, with 59.9%, followed by Renewals with 35.2%, Burnt native forest with 2.9% and Managed native forest with 2.0% (Figure 55).

Table 70. Increase in biomass: CO_2 removals (GgCO_2eq) by component, 1990-2010 series

Component	1990	1995	2000	2005	2010
Renewals	-45,706.7	-45,653.6	-45,564.9	-45,452.7	-45,274.9
Burnt native forest	-1,953.1	-2,119.3	-3,100.3	-3,498.7	-3,736.2
Managed native forest	-4,060.7	-5,219.6	-6,035.4	-4,606.8	-2,610.4
Forest plantations	-39,890.0	-52,388.8	-57,405.0	-63,411.6	-76,978.4
Total	-91,610.4	-105,381.2	-112,105.6	-116,969.8	-128,600.0

Source: Prepared in-house by SNICHILE.

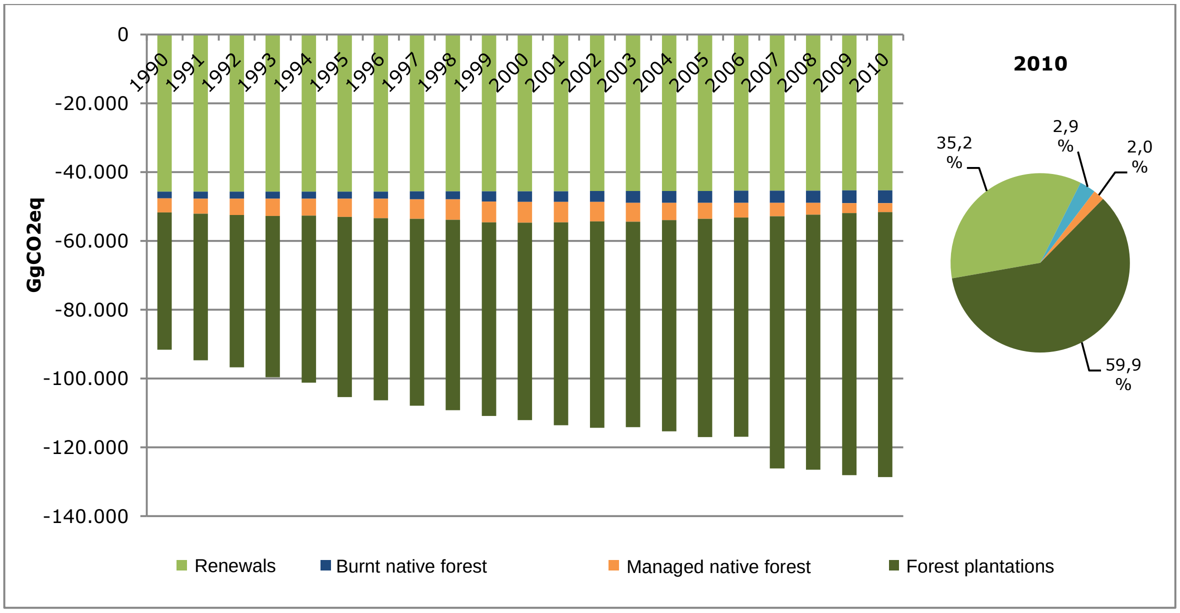

Figure 55. Increase in biomass: trend in CO_2 removals by component, 1990-2010 series

For Forest plantations at the species level *P. radiata* is the most important for GHG absorption, accounting for 54.3%, followed by *E. globulus* with 24.9%, *E. nitens* with 16.8% (both species contributing 41.8%), and Other species with 2.8%. *P. menziensii* and *Populus spp.* accounted for 0.4% and 0.3% of absorptions, respectively, while the remaining 0.2% came from *P. chilensis* / *P. tamarugo*. It is worth mentioning that, while *P. radiata* is the most important species, its removals have increased by only 18.5% since 1990, while removals by *Eucalyptus spp*. have increased by 720.9% (Table 71 and Figure 56).

Table 71. Forest plantations: CO_2 removals by species, 1990-2010 series

Species	1990	1995	2000	2005	2010
Pinus radiata	-35,376.0	-39,361.7	-41,992.4	-40,585.6	-41,904.8
Eucalyptus globulus	-3,917.6	-11,335.2	-13,410.0	-20,321.6	-19,190.9
Eucalyptus nitens	0.0	0.0	0.0	0.0	-12,969.0
P. chilensis / P. tamarugo	-159.8	-159.6	-161.9	-181.1	-178.1
Pseudotsuga menziensii	-233.1	-257.7	-278.5	-315.2	-319.0
Populus spp.	-126.0	-137.3	-148.1	-213.0	-252.1
Other species	-77.4	-1,137.3	-1,414.1	-1,795.1	-2,164.4
Total	-39,890.0	-52,388.8	-57,405.0	-63,411.6	-76,978.4

Source: Prepared in-house by SNICHILE.

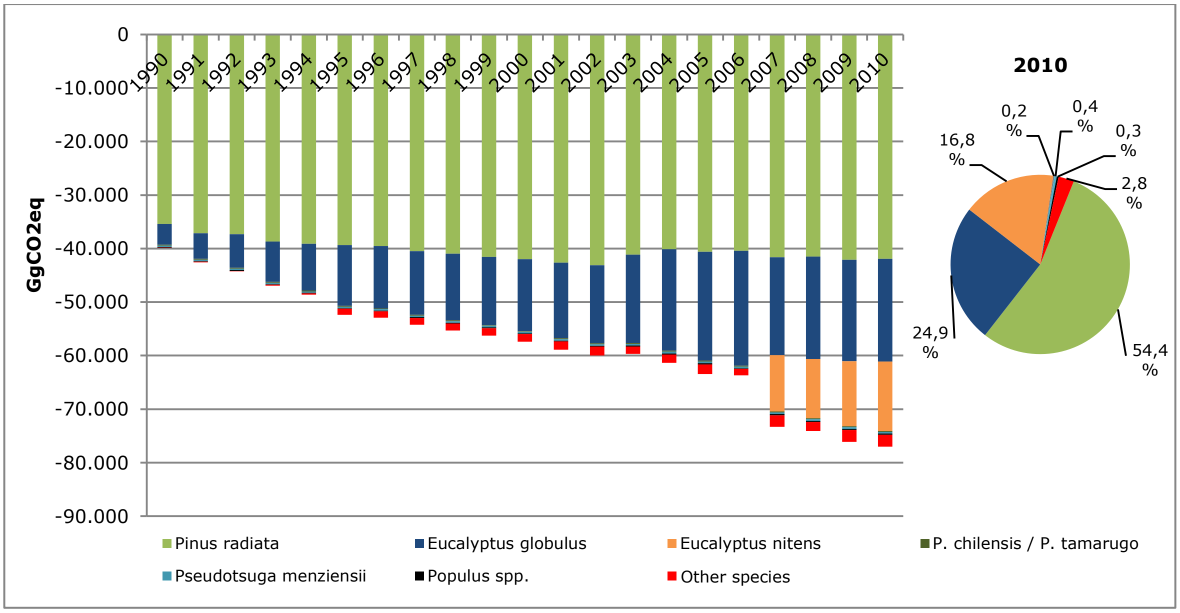

Figure 56. Forest plantations: trend in CO_2 removals by species, 1990-2010 series

Harvest

In 2010, GHG emissions for the subcategory amounted to 56,461.1 $GgCO_2eq$, or 26.4% in absolute figures (Table 72), making it the sector's leading source of emissions. Since 1990, GHG emissions have increased by 124.3%, although from 2008 to 2010 emissions from harvests fell by 12.9%, in direct proportion to the area harvested.

At the component level, *P. radiata* is the most important species, accounting for 57.2% of GHG emissions, followed by *Eucalyptus spp.* with 40.1%, Native species with 1.5%, and Other exotics with 1.1% (Figure 57).

Table 72. Harvest: CO_2 emissions ($GgCO_2eq$) by species, 1990-2010 series

Species	1990	1995	2000	2005	2010
Roundwood from *Pinus radiate*	15,135.5	26,193.1	26,558.3	36,334.6	32,323.7
Roundwood from *Eucalyptus spp.*	3,204.0	4,604.0	8,292.0	12,373.3	22,625.7
Roundwood from "Other species", Other exotic	265.8	266.2	292.3	582.2	641.8
Roundwood from Native species	6,566.5	8,126.8	3,024.4	1,329.7	869.8
Total	25,171.7	39,190.0	38,166.9	50,619.8	56,461.1

Source: Prepared in-house by SNICHILE.

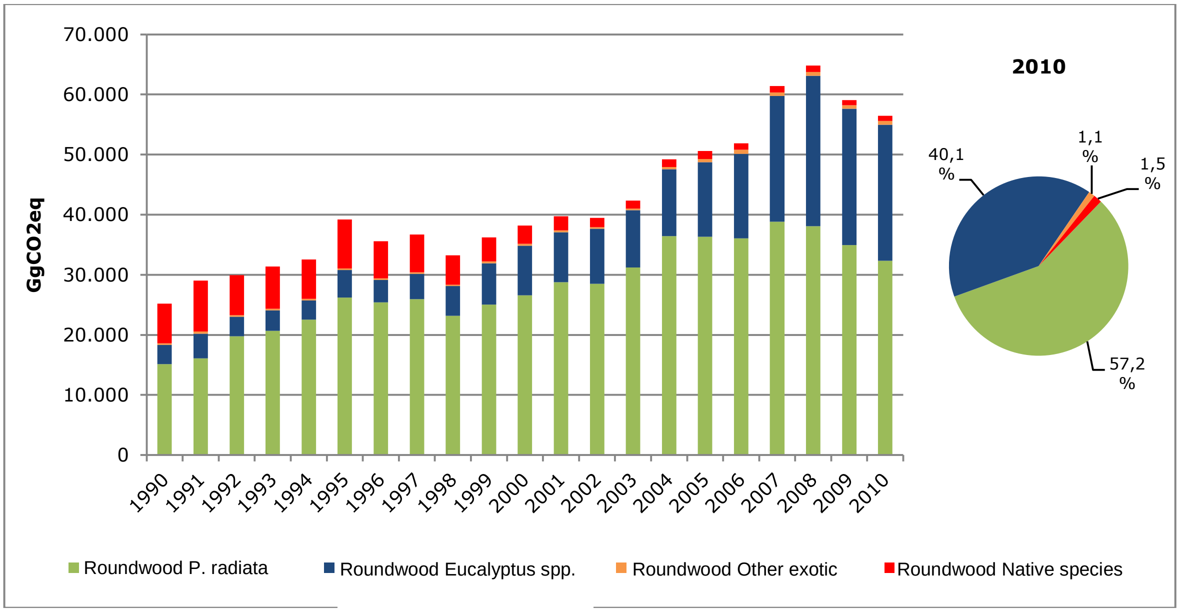

Figure 57. Harvest: trend in CO_2 emissions by species, 1990-2010 series

Wildfires

In 2010, GHG emissions from wildfires amounted to 4,274.6 $GgCO_2eq$, or 2.0% of the subcategory, in absolute figures (Table 73). Since 1990, wildfire GHG emissions have increased by 172.3%, while year-to-year variations observed in Figure 58 were driven mainly by the variable, unpredictable nature of wildfires in native forests and forest plantations.

At the component level, Wildfires in forest plantations account for 79.2% of GHG emissions, while Wildfires in native forests account for 20.8% (Figure 58).

Table 73. Wildfires: GHG emissions ($GgCO_2eq$) caused by wildfires in native forests and forest plantations, 1990-2010 series

Component	1990	1995	2000	2005	2010
Native forests	1,050.1	353.2	165.9	1,458.1	887.9
Forest plantations	519.7	1,184.2	697.8	1,662.1	3,386.7
Total GHG emissions	1,569.8	1,537.5	863.7	3,120.2	4,274.6

Source: Prepared in-house by SNICHILE.

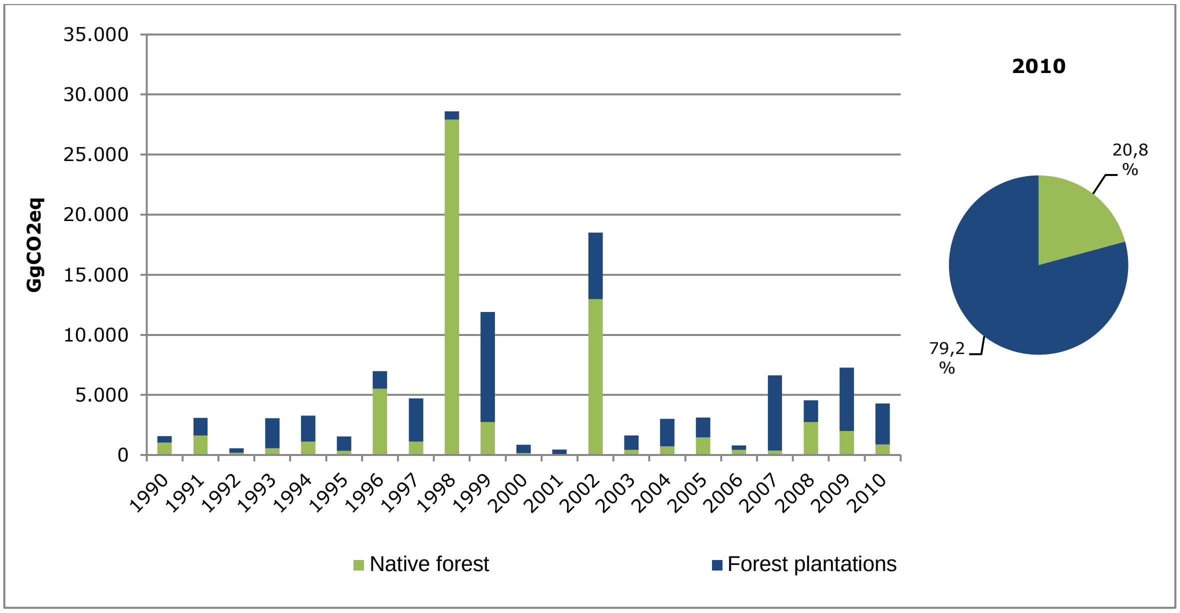

Figure 58. Wildfires: GHG emissions caused by wildfires in native forests and forest plantations, 1990-2010 series

The notable variation in GHG emissions from wildfires is caused by variations in the area burned annually, as GHGs emitted are directly proportional to the area affected. For the same reason there is a significant year-to-year variation in these GHG emissions. As Figure 59 shows, for instance, the largest areas were burnt in 1998 and 2002, which were also the years with the highest GHG emissions for the time series.

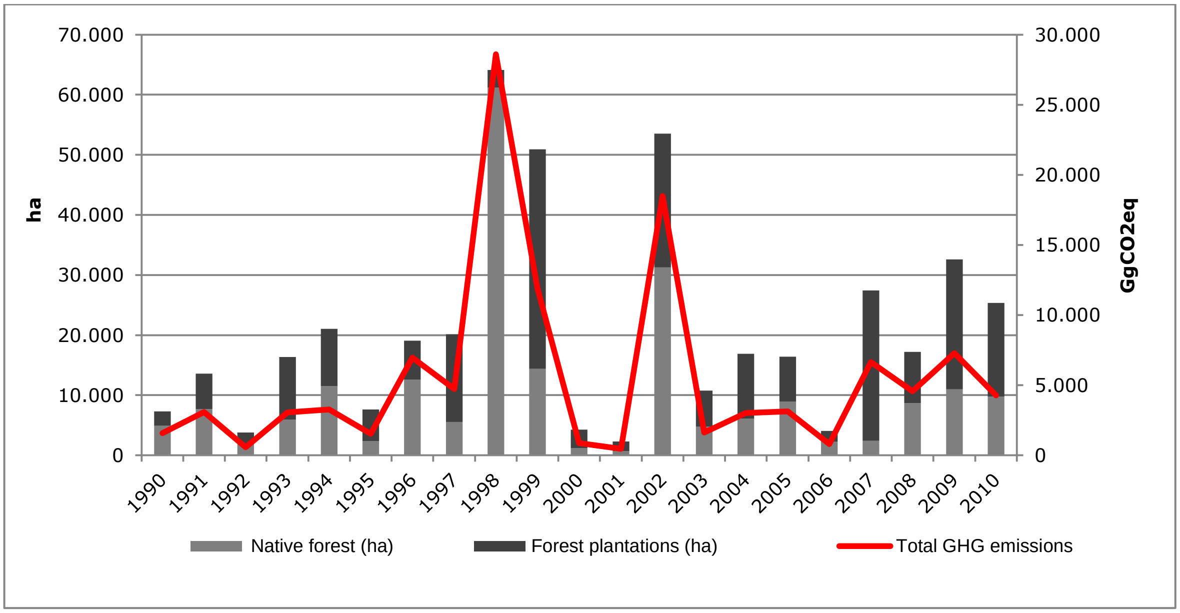

Figure 59. Wildfires: trend in annual area affected by wildfires and GHG emissions, 1990-2010 series

Wildfires are particularly significant for the GHG balance for their ability to alter the trend, as the high emissions in 1998 and 2002 attest to. Figure 60 presents a scenario of sensitization that compares the national GHG balance excluding GHG emissions and removals caused by wildfires (green line) to the balance including wildfires (red line), alongside GHG emissions and removals for each sector (bars in greyscale). As the figure shows, excluding GHG emissions and removals from wildfires smooths out the overall trend of the national GHG balance.

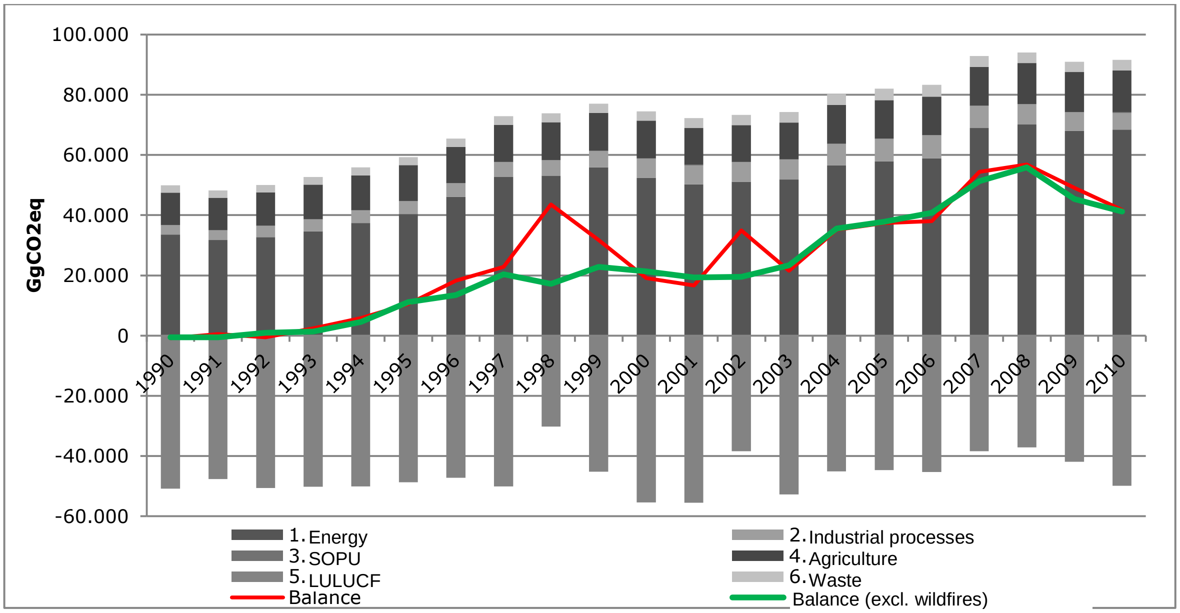

Figure 60. Chilean NGHGI: trend in GHG emissions and removals by sector, including vs. excluding wildfires, 1990-2010 series

7.2.1.2. Land converted to forest land (5A2)

In 2010, GHG emissions for this subcategory amounted to 1,707.1 $GgCO_2eq$, or 2.7% of the category total, in absolute figures (Table 74). Since 1990, the GHG balance in this subcategory has tended to favor GHG emissions. The constancy of the values is due to the fact that only one annual value for land use change could be determined.

At the component level, Grassland converted to forest land is the most important, accounting for 66.6% of the balance, followed by Cropland converted to forest land with 33.4% and Settlements converted to forest land with 0.1% (Figure 61).

Table 74. Land converted to forest land: GHG emissions ($GgCO_2eq$) by component, 1990-2010 series

Component	1990	1995	2000	2005	2010
2.1 Cropland converted to forest land	569.3	569.3	569.3	569.3	569.3
2.2 Grassland converted to forest land	1,137.7	1,137.7	1,137.7	1,137.7	1,137.7
2.4 Settlements converted to forest land	0.1	0.1	0.1	0.1	0.1
Balance	1,707.1	1,707.1	1,707.1	1,707.1	1,707.1

Source: Prepared in-house by SNICHILE.

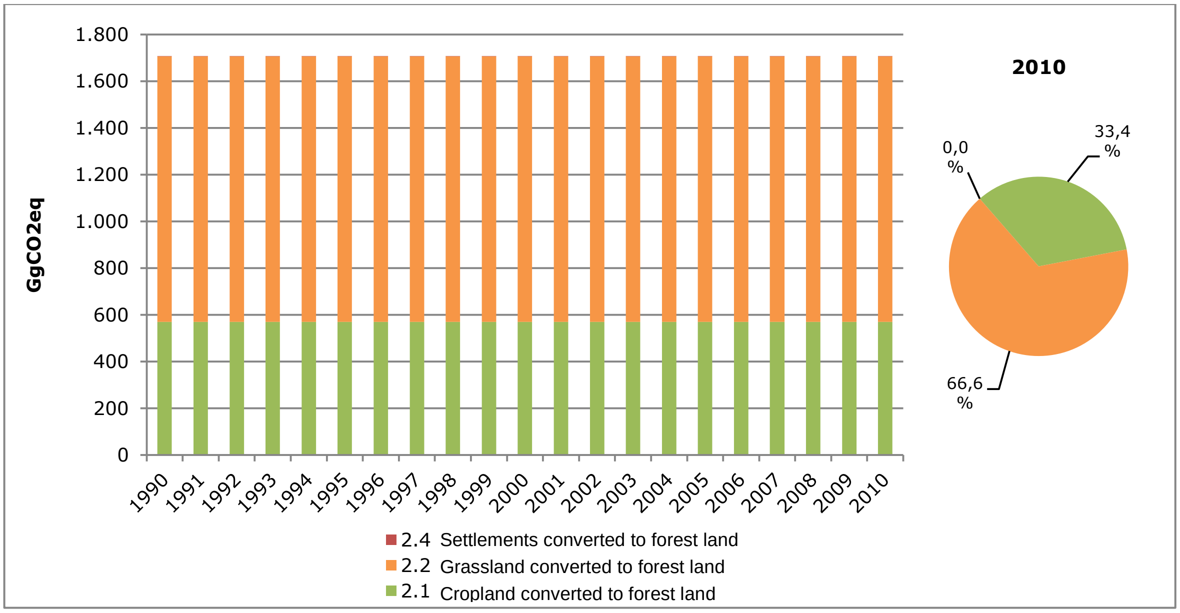

Figure 61. Land converted to forest land: GHG emission trend by component, 1990-2010 series

7.2.2. Methods applied

The methods applied to develop the Forest land category are presented in the following table:

Table 75. Forest land: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
A. Forest land	T2	CS	T1b, T2	D, CS	T1b, T2	D, CS
1. Forest land remaining forest land	T2	CS	T1b, T2	D, CS	T1b, T2	D, CS
2. Land converted to forest land	T2	CS				

T1b = Disaggregated by administrative region; T2 = Tier 2 method; D = Default; CS = Country-specific.
Source: Prepared in-house by SNICHILE.

Forest land remaining forest land

The estimation of GHG emissions and captures (removals) was based on the changes in the carbon stock of above-ground living biomass, below-ground living biomass and necromass deposits, although, according to the Tier 1 method, net changes in necromass stocks are supposedly equal to zero. Insufficient information exists on the dynamics of necromass deposits—that is, annual production and decomposition rates—to include them in the carbon balance for this subcategory.

All CO_2 emission and removal estimations for this subcategory were based in the IPCC methodology described in the 2006GL, specifically Volume 4, Chapter 4 ("Forest Land"), Section 4.2., which addresses land that has been forest land for a period of time greater than the transitional period required to reach new levels of soil carbon; for Chilean native forests this period was assumed to be 80 years.

A Tier 2 method based on national parametric data and regionally disaggregated statistical data was used to estimate the emissions/removals of Increase in biomass; a similar methodology was used to calculate emissions/removals of Commercial wood and Firewood harvest and Land in transition.

Emissions/removals of Wildfires were calculated using a combination of Tier 1 and Tier 2 methods based on national parametric data and default values in accordance with the 2006GL as well as statistical data disaggregated by region. The destination of the biomass of removed carbon was no specified.

Wildfires were included after CONAF, Chile's National Forestry Corporation, declared several years ago that all wildfires in Chile were anthropogenic. The estimations carry different assumptions, depending on the type of vegetation burned:

- It is assumed that forest plantations affected by fire will be replanted immediately afterward, and therefore the area will remain planted and the only loss will be the burnt biomass (CO_2 emissions); non-CO_2 gases will also be emitted by the fire, and
- It is assumed that an area of native forest affected by fire will subsequently undergo natural regeneration, making it necessary to account for emissions caused by the fire and, later, for the regeneration of above-ground biomass for a transitional period until the forest achieves a stable state (as mentioned above, an 80-year period was agreed to).

CONAF's Forest Updating and Monitoring System (SAFF) provides data on the area of managed native forests in Chile for given years without specifying spatial location making it impossible to determine whether the same stands are intervened in different years; for this reason and to avoid overestimating the managed area, a 10-year interval was established, corresponding to the average period between two consecutive management interventions in the same stand.

Since CONAF has information on the management plans approved each year but not information on the execution of those plans, it was assumed that "an approved plan is a plan executed the same year it is approved", a similar approach to how forest harvests are addressed, in the sense that all GHG emissions from harvest are deemed to occur during the year of harvest.

One notable change in the present inventory is that CONAF's "mixed forest" category was included in the IPCC Forest land category under "Native forest land". This change was made because mixed forests in Chile are comprised of 33 to 66% native forest, which is important enough to include in GHG emissions estimates.

Land converted to forest land

In the national context, based on an analysis of the regional *Land-Use Change matrices found in CONAF's Vegetation Survey*, it was determined that the annual area of land converted to forest land was 72,329.8 ha, with 92.2% of this area converted to forest plantations (66,708.1 ha) and 7.8% to native vegetation formations (5,621.7 ha).

The methodology used to estimate GHG emissions and removals in this case was the same one described in Volume 4, Chapter 2 of the 2006GL.

7.2.2.1. Statistical and parametric activity data

Forest land remaining forest land

CONAF and INFOR professionals conducted an exhaustive review of the activity data used to build the 1984-2006 times series and new activity data was collected for the 1990-2010 time series.

In general, the following statistical and parametric activity data were used for this subcategory:

- Increase in biomass: The required statistical data include the area of forest plantations by species (Figure 62), area of renewals and area of managed native forest. These data are provided by INFOR (using a regression methodology for renewals area) and CONAF. The required parametric data are volume growth in forest plantations by species (generated by INFOR and MMA), volume growth in native forests by region and forest type (INFOR and MMA), expansion factors of commercial biomass to total aboveground biomass (Gayoso, 2002), ratios between belowground and aboveground biomass (Gayoso *et al*., 2002), and basic wood density by species.

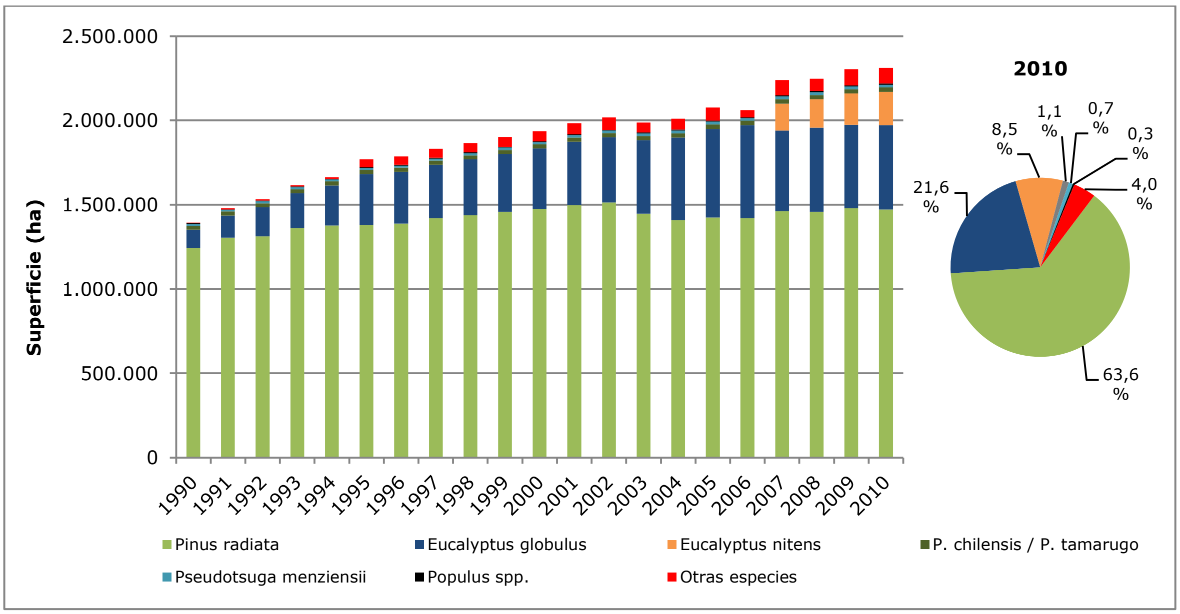

Figure 62. Forest plantations: trend in annual area by species, 1990-2010 series

- Commercial wood harvest: The key statistical indicator is the volume of the commercial roundwood harvest, a value generated by INFOR (Figure 63). The parametric data used are expansion factors of commercial biomass to total aboveground biomass (generated by Gayoso, 2002), the ratio of belowground to aboveground biomass (Gayoso *et al*., 2002), and basic wood density.

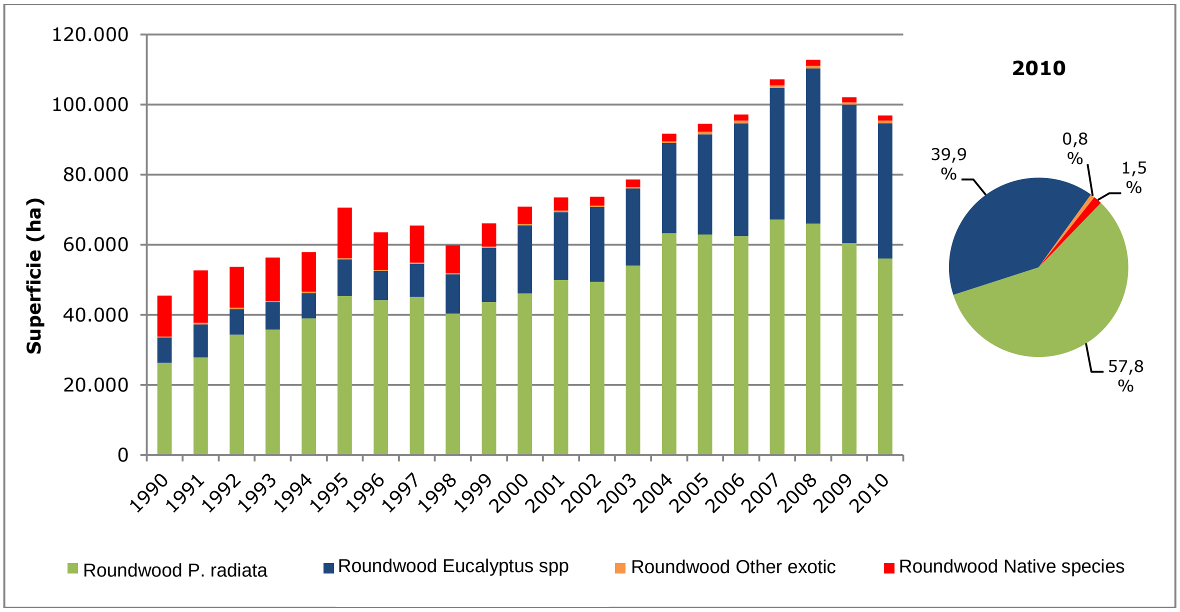

Figure 63. Harvest: trend in annual area by species, 1990-2010 series

- Firewood harvest: The key statistical indicator is the volume of firewood harvested, a value generated by INFOR and MINENERGIA for the BNE. The parametric data used are expansion factors of commercial biomass to total aboveground biomass (generated by Gayoso, 2002), the ratio of belowground to aboveground biomass (Gayoso *et al*., 2002), and basic wood density.
- Wildfires: The key statistical indicator is the annual area affected by wildfires in native forests and forest plantations (CONAF-Empresas 1985-2010 in http://www.conaf.cl/incendios-forestales/incendios-forestales-en-Chile/estadisticas-historicas/) (Figure 64). The parametric data used include the accumulated volume of native forests by region (INFOR and MMA), the accumulated volume of forest plantations by species (INFOR and MMA), expansion factors of commercial biomass to total aboveground biomass (Gayoso, 2002), the ratio (R) of belowground biomass (roots) to aboveground biomass (Gayoso *et al*., 2002) and basic wood density.

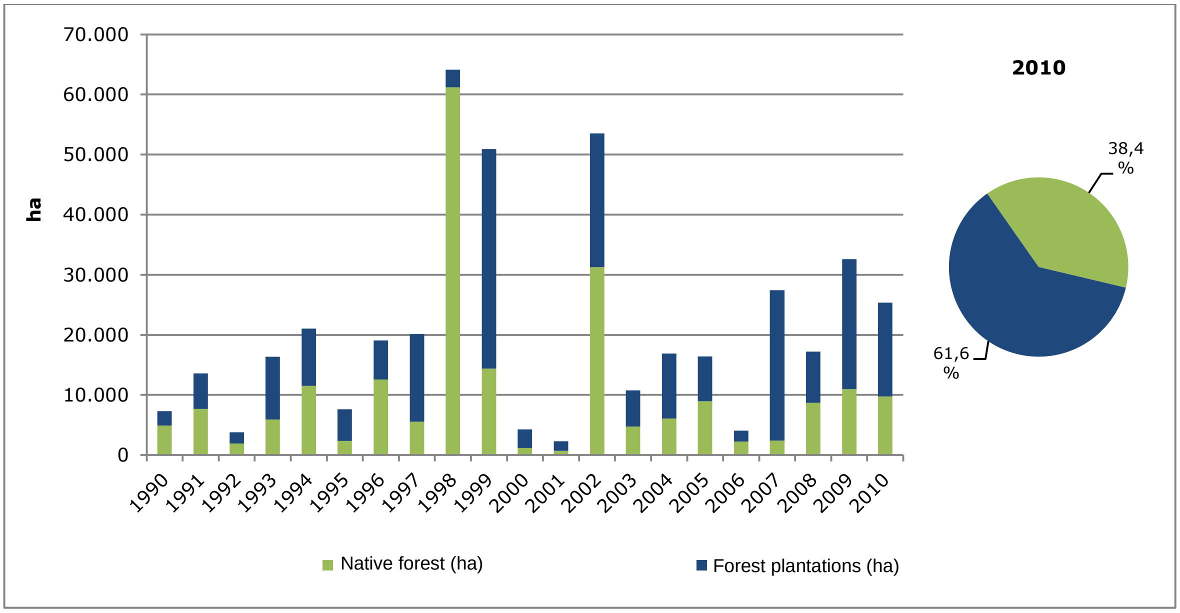

Figure 64. Wildfires: trend in annual area of native forests and forest plantations affected by wildfires, 1990-2010 series

Land converted to forest land

The subcategory Land converted to forest land includes the area of Cropland, Grassland, Settlements and Other Land converted annually to native forest and/or forest plantations. These figures were disaggregated by administrative region and by type of land using data obtained from *CONAF's Vegetation Survey*. Data had to be interpolated and/or extrapolated for certain years.

The parametric data (biomass accumulated in converted land) required to estimate emissions and captures of this subcategory are the default values found in the 2006GL.

7.2.2.2. Emission factors

The emission factors are the same parametric data described above.

7.3. Cropland (5B)

7.3.1. Description of category and GHG emissions

Cropland includes arable and workable land, rice fields and agroforestry systems in which the vegetation structure is below the thresholds used for the forest land category and is not expected to exceed them in the future. Cropland includes annual and perennial crops as well as temporary fallow land. Crops may be annual, biannual or permanent except when the land use meets the criteria for labeling it forest land. Cropland also includes arable land normally used for annual crops but temporarily employed for forage crops or grazing land as part of an annual crop-pasture rotation (mixed system).

This category includes the following subcategories:

- Cropland remaining cropland: This subcategory considers emissions and removals from land that has undergone no change in land use during the inventory period.
- Land converted to cropland: This subcategory considers emissions and removals from land that previously had a different use and was converted to cropland.

In 2010, GHG emissions for this category amounted to 624.0 $GgCO_2eq$, or 1.0% of the sector in absolute figures (Table 76). Since 1990, GHG emissions for this category have risen by 91.3%, driven mainly by the steady increase in the use of lime and urea.

At the subcategory level, Cropland remaining cropland leads, with 79.2% of the category's emissions, while Land converted to cropland accounted for 20.8% (Figure 65).

Table 76. Cropland: GHG emissions and removals ($GgCO_2eq$) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
5B1. Cropland remaining cropland	191.4	269.2	368.7	396.2	494.1
5B2. Land converted to cropland	134.8	128.1	128.0	126.4	129.9
Balance	326.2	397.2	496.7	522.6	624.0

Source: Prepared in-house by SNICHILE.

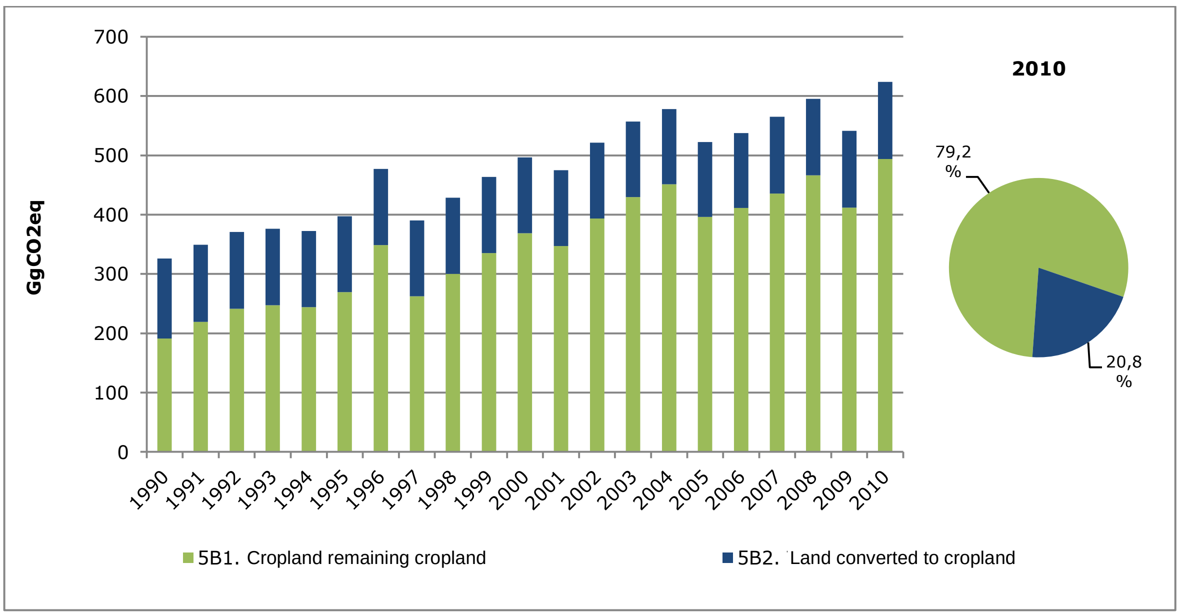

Figure 65. Cropland: GHG emissions and removals ($GgCO_2eq$) by subcategory, 1990-2010 series

7.3.2. Methods applied

The methods applied to prepare the inventory of the Cropland category are presented in the Table below.

Table 77. Cropland: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
B. Cropland	T1b, T2	D, CS				
1. Cropland remaining cropland	T2	CS				
2. Land converted to cropland	T1b, T2	D, CS				

T1b = Disaggregated by administrative region; T2 = Tier 2 method; D = Default; CS = Country-specific.
Source: Prepared in-house by SNICHILE.

Cropland remaining cropland

In preparing the inventory for this category there was a notable lack of country/region-specific figures, particularly for aboveground and belowground biomass of perennial crops. This situation made it impossible to estimate CO_2 emissions from these sources for the "Cropland remaining cropland" subcategory. The emissions that were considered were those deriving from the use of lime in cultivated soils and from the application of urea to soils.

Emissions from lime vary according to the type of lime used. As the data were disaggregated by region, emissions were estimated using the corresponding default emission factors. The same procedure was used to calculate emissions from urea application.

In terms of liming, Chile only reports CO_2 emissions from lime used in agricultural soil; given the lack of information available, the assumption is that 100% of reported consumption corresponds to calcite.

Land converted to cropland

Considering the lack of country/region-specific figures that could be used to differentiate the area converted to annual cropland from the area converted to perennial crops, the AFOLU Sector Team worked under the assumption that all conversions were to annual crops. However, by using combined parametric data (national for Forest land and default for the rest) and the available regionally disaggregated activity data, it was possible to employ a Tier 2 method for the "Forest land converted to cropland" component.

7.3.2.1. Statistical and parametric activity data

Cropland remaining cropland

With no official statistics available on lime consumption, data was collected from the following sources:

- SOPROCAL,
- IANSA,
- SERNAGEOMIN (*2011. Anuario de la Minería de Chile*. 208 pages. Santiago de Chile), and
- ODEPA and ASAGRIN Ltda. (*2010. "Estudio de Diagnóstico de Mercado y Estudio de la Cadena de Comercialización de Fertilizantes en Chile"*).

Regional disaggregation of lime consumption was based on the expert review of the previous inventory.

Data on tons of urea applied was obtained from the study entitled *"Estudio de Diagnóstico de Mercado y Estudio de la Cadena de Comercialización de Fertilizantes en Chile"* conducted by ODEPA and ASAGRIN Ltda.

These sources provide different figures for national lime production and lack information that may help to differentiate between living lime (CaO or $Ca(OH)_2$), calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) (the latter two pertinent for CO_2 emissions); for this reason, emission estimates for this subcategory are highly imprecise.

Land converted to cropland

The activity data for all land converted to cropland were obtained from CONAF (*Survey of native vegetation resources in Chile and Monitoring of changes and updates for the 1997-2011 period*).

The parametric data used included biomass stock in forest land (generated by INFOR and CONAF), biomass stock in cropland (default as per 2006GL), and biomass stock in settlements (based on expert review).

7.3.2.2. Emission factors

The 2006GL default factors were used for liming emissions and urea application.

7.4. Grazing land (5C)

7.4.1. Description of category and GHG emissions

To distinguish it from "forest", grassland is considered to be an ecosystem with tree coverage below a certain threshold, which varies by region. Grassland has predominantly belowground carbon, found mainly in roots and soil organic matter. In terms of rainfall and soil gradients, the transition between grassland and forests is often gradual. Bushes with a high proportion of perennial woody biomass may be considered a type of grassland and are counted within the Grassland category.

According to the *7th National Agricultural and Forestry Census* (INE, 2007), in Chile grassland primarily includes what are known as "natural meadows", which occupy an area of 10.8 million ha, and "improved meadows", which cover 1.06 million ha. Many of these vegetation formations include annual herbaceous plants and bush formations known as "scrubland", which according to the same *Census* cover a total of 1.92 million hectares.

In 2010, GHG emissions for this category amounted to 1,241.1 $GgCO_2eq$, or 2.0% of the sector, in absolute figures (Table 78). Since 1990, GHG emissions by this category have increased by 0.7%, driven mainly by an increase in Forest land converted to grassland.

At the subcategory level, Land converted to grassland was the most important, accounting for 98.7% of GHG emissions, while Grassland remaining grassland was much lower, with 1.3% (Figure 66).

Table 78. Grassland: GHG emissions and removals ($GgCO_2eq$) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
5C1. Grassland remaining grassland	6.9	7.2	5.1	17.6	15.6
5C2. Land converted to grassland	1,225.5	1,225.5	1,225.5	1,225.5	1,225.5
Balance	1,232.4	1,232.7	1,230.6	1,243.1	1,241.1

Source: Prepared in-house by SNICHILE.

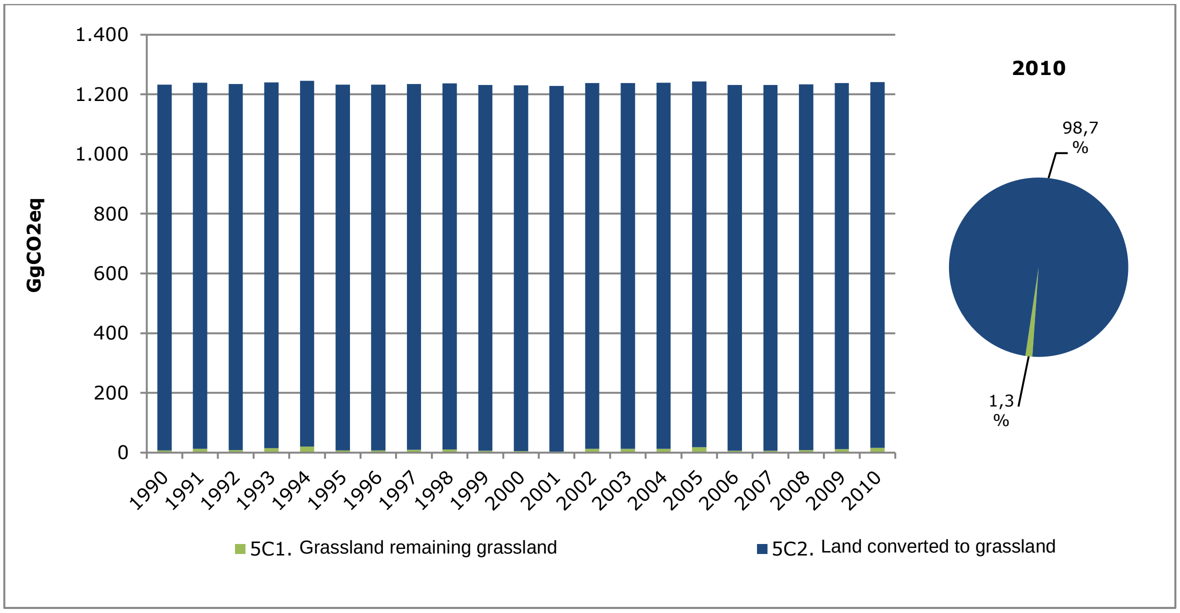

Figure 66. Grassland: GHG emission and removal trend by subcategory, 1990-2010 series

7.4.2. Methods applied

The methods applied to prepare the inventory for the Grassland category are presented in the Table below:

Table 79. Grazing land: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
C. Grassland	T1b, T2	D, CS	T1a,b	D	T1a,b	D
1. Grassland remaining grassland			T1a,b	D	T1a,b	D
2. Land converted to grassland	T1b, T2	D, CS				

T1a = Disaggregation by operational component (crops, species, etc.); T1b = Disaggregated by administrative region; T2 = Tier 2 method; D = Default; CS = Country-specific.
Source: Prepared in-house by SNICHILE.

It should be noted that the lack of country/region-specific values for natural meadows, and specifically in reference to bushy scrubland, made it impossible to include this land fully in the NGHGI. Only the herbaceous strata was considered, using default values.

This gap led to a difference with the previous series of inventories (1984-2006 series), which addressed only aboveground living biomass and estimated scrubland biomass from expert judgment. Another difference between this inventory and the last one was the exclusion of the area planted with *Atriplex spp.* from the Forest land category and its inclusion under Grassland.

Lastly, due to a lack of national data on bushy formations, their annual biomass growth was not recorded.

Given the absence of national parametric data (forest land biomass), a tier 2 method was used to estimate the emissions/removals of Forest land converted to grassland.

7.4.2.1. Statistical and parametric activity data

Grassland remaining grassland

The activity data indicator required for this subcategory is the area of burnt grassland (*Estadísticas Históricas Incendios Forestales, CONAF-Empresas 1985-2010,* in http://www.conaf.cl/incendios-forestales/incendios-forestales-en-chile/estadísticas-históricas/). Default parametric data from the 2006GL were used.

Land converted to grassland

The activity data indicator required—the area of Forest land, Cropland, Wetlands, Settlements and Other land converted to Grassland—is available in CONAF surveys.

The parametric data used included biomass stocks in Forest land (from INFOR and CONAF), biomass stocks in cropland (default 2006GL values), biomass stocks in settlements (based on expert judgment).

7.4.2.2. Emission factors

The emission factors used for this category are the default values of the 2006GL.

7.5. Wetlands (5D)

This category was not estimated due to a complete lack of country/region-specific parametric activity data and emission factors.

7.6. Settlements (5E)

7.6.1. Description of category and GHG emissions

This category includes herbaceous vegetation, bushy vegetation and trees in residential areas, urban areas, public and private gardens and parks, among others, linked either functionally or administratively to cities, towns or other types of human settlements, as long as these are not counted in another land use category.

According to CONAF (2011), settlements in Chile cover an area of 248,002 ha, equal to 0.33% of the national territory. Meanwhile, the area annually converted to settlements, calculated using the land-use change matrices found in *CONAF's survey of native Chilean vegetation resources*, is 6,778.8 ha, with Cropland and Grassland being the most affected by that conversion.

In 2010, GHG emissions in this category amounted to 186.8 $GgCO_2eq$, or 0.3% of the sector's total, in absolute figures (Table 80). Reported GHG emissions have remained constant since 1990, as the country only has one annual value for land use change (Figure 67).

Table 80. Settlements: GHG emissions and removals ($GgCO_2eq$) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
5E1. Settlements remaining settlements	0.0	0.0	0.0	0.0	0.0
5E2. Land converted to settlement	187.2	186.6	186.3	185.7	186.8
Balance	187.2	186.6	186.3	185.7	186.8

Source: Prepared in-house by SNICHILE.

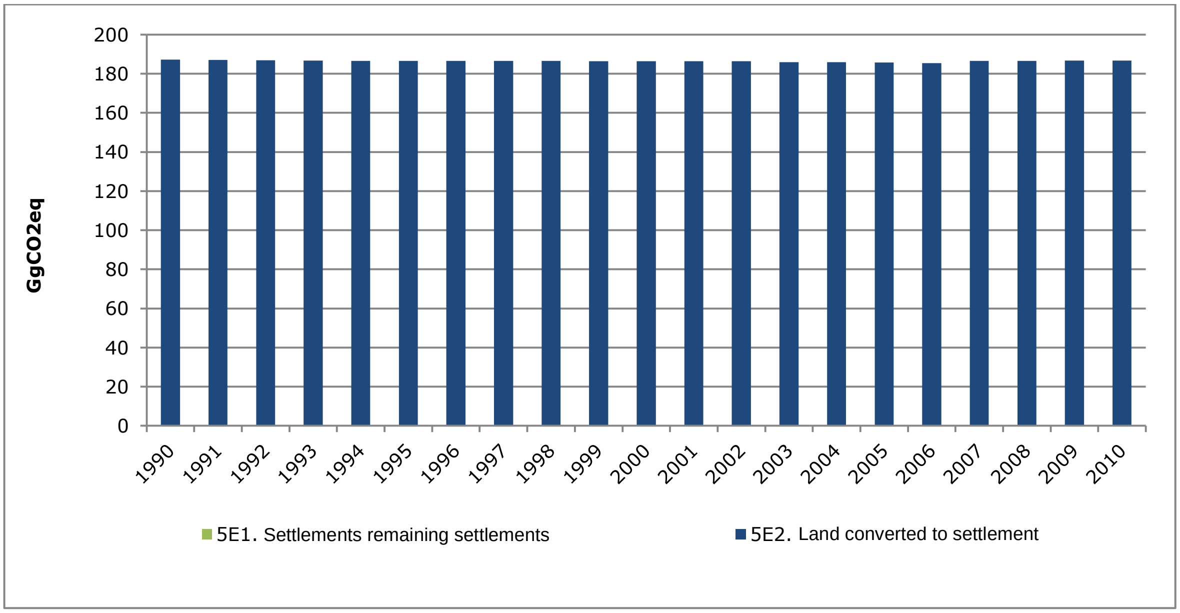

Figure 67. Settlements: GHG emission and removal trend by subcategory, 1990-2010 series

7.6.2. Methods applied

The methods applied to prepare the inventory for the Settlements category are presented in the Table below:

Table 81. Settlements: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
E. Settlements	T1b, T2	D, CS				
1. Settlements remaining settlements	NE	NE				
2. Land converted to settlements	T1b, T2	D, CS				

T1b = Disaggregated by administrative region; T2 = Tier 2 method; D = Default; CS = Country-specific; NE = Not estimated.
Source: Prepared in-house by SNICHILE.

Emissions and/or removals from the Settlements remaining settlements subcategory were not quantified because country-specific parametric data are lacking.

The methodology used for the Land converted to settlements subcategory is the same as that used for the Land converted to Forest land subcategory and involves estimating the annual change in carbon stock of the carbon sinks included in this inventory (living biomass and necromass).

7.6.2.1. Statistical and parametric activity data

The required statistical activity indicator—the area of Forest land, Cropland, Grassland and Other land converted to Settlements—is available in CONAF surveys.

The parametric data used include biomass stock in forest land (from INFOR and CONAF), biomass stock in cropland (2006GL default value), biomass stock in grassland (2006GL default value).

7.6.2.2. Emission factors

In accordance with the 2006GL, the emission factors for this category correspond to default values.

7.7. Other land (5F)

7.7.1. Description of category and GHG emissions

According to the 2006GL, the Other land category consists of bare soil, rock, ice and all other land not belonging to the other five land-use categories. For this inventory, the “Other Land” category consists of the following categories recognized by the National Forestry Corporation (CONAF):

- Areas without vegetation,
- Ice and glaciers,
- Bodies of water, and
- Uncharted areas.

Together these areas cover 30,678,266 ha, or 41% of the total national area (CONAF, 2011).

In 2010, GHG emissions in this category amounted to 123.2 $GgCO_2eq$, or 0.2% of the sector, in absolute figures (Table 82). GHG emissions in this category have remained constant since 1990.

Land converted to other land was the only pertinent subcategory, accounting for 100% of GHG emissions in the category (Figure 68).

Table 82. Other Land: GHG emissions and removals ($GgCO_2eq$) by subcategory, 1990-2010 series

Subcategory	1990	1995	2000	2005	2010
5F1. Other land remaining other land	0.0	0.0	0.0	0.0	0.0
5F2. Land converted to other land	121.8	121.3	121.2	120.9	123.2
Balance	121.8	121.3	121.2	120.9	123.2

Source: Prepared in-house by SNICHILE.

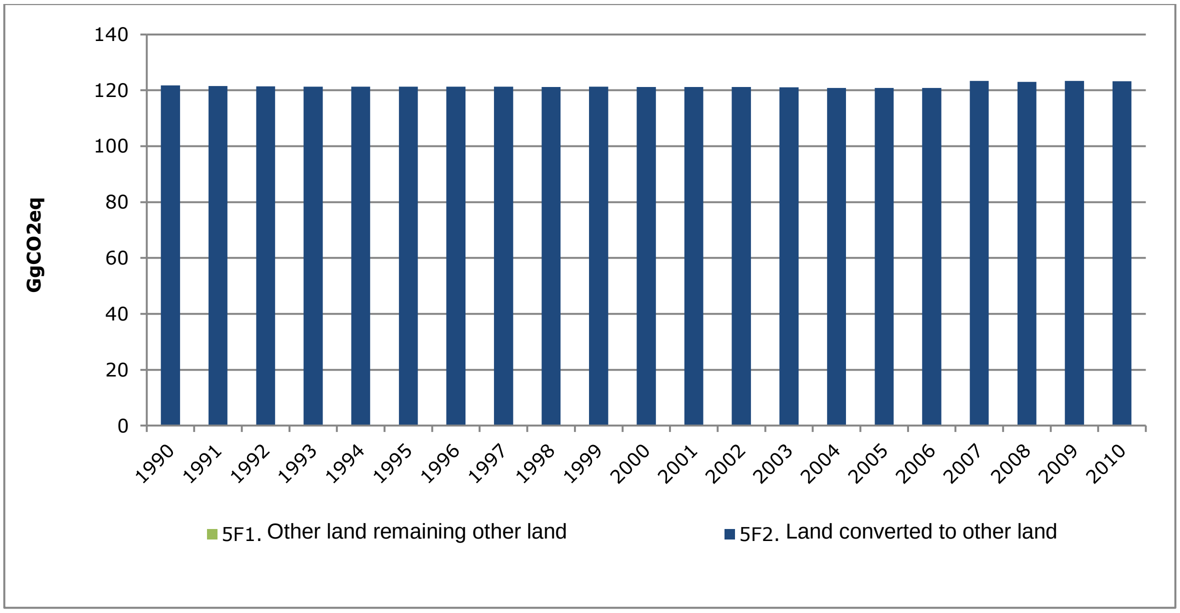

Figure 68. Other Land: GHG emission and removal trend by subcategory, 1990-2010 series

7.7.2. Methods applied

The methods applied to develop the Other Land category are presented in the following Table:

Table 83. Other Land: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
F. Other land	T1b, T2	D, CS				
1. Other land remaining other land	NE	NE				
2. Land converted to other land	T1b, T2	D, CS				

T1b = Disaggregated by administrative region; T2 = Tier 2 method; D = Default; CS = Country-specific; NE = Not estimated.
Source: Prepared in-house by SNICHILE.

As in the previous cases, this category recorded changes in carbon stocks using the methodology described for the Land converted to forest land subcategory.

7.7.2.1. Statistical and parametric activity data

The required statistical activity indicator—the area of Forest land, Cropland, Grassland and Settlements converted to other land—is available in *CONAF inventories*.

The parametric data used included biomass stock in forest land (from INFOR and CONAF), biomass stock in cropland (2006GL default values), biomass stock in grassland (2006GL default values), and biomass stock in settlements (based on expert judgment).

7.7.2.2. Emission factors

In accordance with the 2006GL, the emission factors for this category correspond to the default values.

7.8. Quality assurance and quality control

As mentioned previously, the LULUCF sector inventory was prepared by the AFOLU Sector Team, and thus employed the same quality assurance and quality control procedures, which can be reviewed in chapter 6. Agriculture.

7.9. Planned improvements

Based on the analysis undertaken internally by the AFOLU Sector Team and the recommendations of the SGHGI expert review, the following improvements are planned for the sector:

- Improved coordination and management among government entities that possess/generate statistical data for future reporting to international sources, in order to maintain the consistency of national and international databases.
- Creation of working groups with key non-governmental entities (trade associations, institutions, etc.) that possess parametric data needed to generate country-specific emission factors. This is particularly important for key categories and/or subcategories.
- Development of country-specific emission factors, including assessing the possibility of funding projects from competitive public grants.
- Improvement of information contained in CONAF's Survey of Native Vegetation Formations by:
    - Updating the land-use change matrices for the country's remotest regions, bearing in mind that land use change occurs much less frequently than in central and southern Chile.
    - Increasing the frequency of aerial images used to construct land-use change matrices.
- Improvement of parametric data on native forest management through INFOR's implementation of the GEF project, *Integrated national monitoring and assessment system on forest ecosystems (SIMEF) in support of policies, regulations and SFM practices incorporating REDD+ and biodiversity conservation in forest ecosystems* which is scheduled to begin in 2015.

8. WASTE SECTOR (6)

8.1. Overview of the sector

The Waste sector accounts for GHG emissions generated by anaerobic reactions that result from the decomposition of waste in landfills and dumps, those resulting from domestic and industrial wastewater management, those generated by combustion processes such as incineration and open burning of waste, and emissions from the biological treatment of waste (composting and anaerobic digestion). As such, the sector has been divided into the following categories:

- 6A Solid waste disposal.
- 6B Wastewater treatment and discharge.
- 6C Waste incineration.
- 6D Other (Biological treatment of solid waste).

In recent years, Chile has improved its waste disposal capabilities by establishing regulatory requirements that govern the location, startup and closure of landfills. Unmanaged, uncategorized waste sites that have not met these new sanitation and environmental standards (garbage dumps and some landfills) have gradually been replaced by sites that are managed according to current regulations (sanitary landfills). The country has also seen an increase in waste valuation initiatives, including the biological treatment of solid waste (composting). Regulations have also been introduced for waste incineration. Additionally, the coverage of domestic wastewater treatment and discharge has expanded significantly, while liquid industrial waste has been regulated since 2006 by a new legal framework that, coupled with technological advances in treating discharged wastewater, has reduced GHG emissions.

It is worth noting here that the 2006GL use different terms for the Waste sector than those used in Chile. Table 84 shows the denominations used in the 2006GL versus those used in-country, and how they were adapted for use in this inventory.

Table 84. Waste: Harmonization of sector-specific terminology

IPCC 2006GL term	Term used in Chile	Term used in the NGHGI
Solid waste disposal / Eliminación de Desechos Sólidos	Disposición de Residuos	Solid waste disposal / Disposición de Residuos Sólidos
Municipal solid waste (MSW) / Desechos Sólidos Municipales (DSM)	Residuos Sólidos Domiciliarios	Municipal solid waste (MSW) / Residuos Sólidos Municipales (RSM)
Solid waste disposal sites (SWDS) / Sitios de Eliminación de Desechos Sólidos (SEDS)	Sitios de Disposición Final de Residuos Domiciliarios	Solid waste disposal sites (SWDS) / Sitios de Disposición de Residuos Sólidos (SDRS)
Biological treatment of solid waste / Tratamiento Biológico de los Desechos Sólidos	Tratamiento Biológico de Residuos	Biological treatment of solid waste / Tratamiento Biológico de Residuos Sólidos
Incineration and open burning of waste / Incineración e Incineración Abierta de Residuos	Incineración y Quema Abierta de Residuos	Incineration and open burning of waste / Incineración y Quema Abierta de Residuos
Wastewater treatment and discharge / Tratamiento y Eliminación de Aguas Residuales	Tratamiento y Eliminación de Aguas Residuales	Wastewater treatment and discharge/ Tratamiento y Descarga de Aguas Residuale s
Domestic wastewater / Aguas Residuales Domésticas	Aguas servidas	Domestic wastewater / Aguas Residuales Domésticas
Industrial wastewater / Aguas Residuales Industriales	Residuos Industriales Líquidos (RILes)	Industrial wastewater / Aguas Residuales Industriales
Biochemical oxygen demand (BOD) / Requisito Bioquímico de Oxígeno (BOD)	Demanda Bioquímica de Oxígeno (DBO)	Biochemical oxygen demand (BOD) / Demanda Bioquímica de Oxígeno (DBO)
Chemical oxygen demand (COD) / Requisito Químico de Oxígeno (DQO)	Demanda Química de Oxígeno (DQO)	Chemical Oxygen demand (COD) / Demanda Química de Oxígeno (DQO)

Note: Chilean legal provisions do not use the term “desechos” but rather “residuos”, and therefore the latter term has been employed in adapting local terminology to the 2006GL.
Source: Prepared by the Waste Sector Team.

The Waste sector is the fourth largest source of GHGs in Chile, accounting for 3.9% of total GHG emissions (Figure 69).

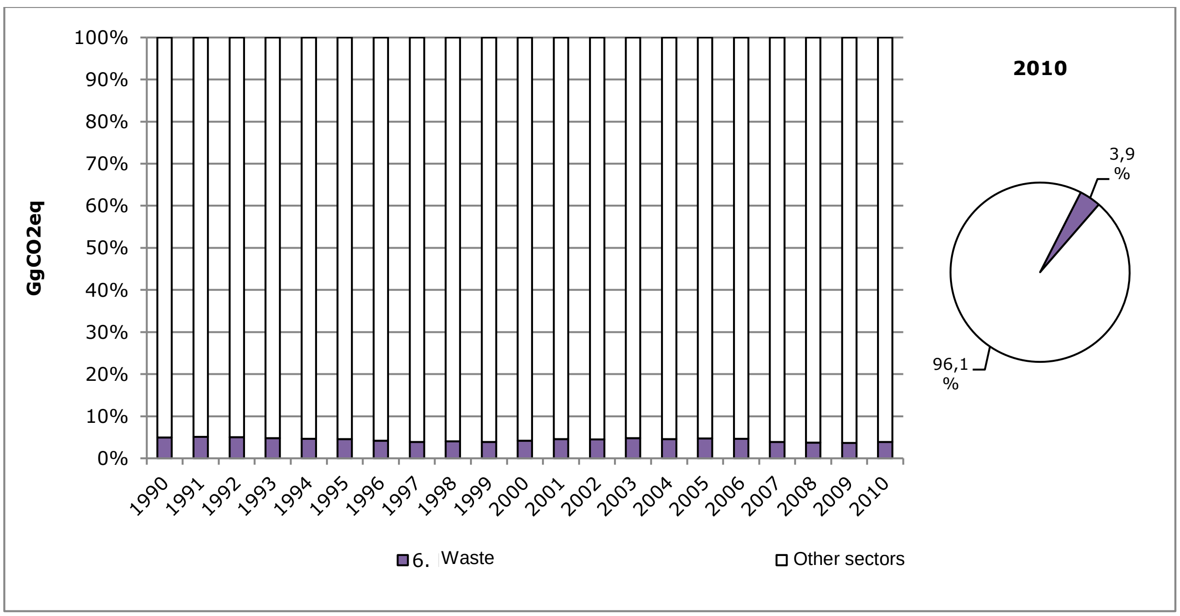

Figure 69. Waste Sector: GHG emission trend as a percentage of total GHG emissions (excl. LULUCF)

In 2010, GHG emissions from this sector amounted to 3,554.1 $GgCO_2eq$ (Table 85), a rise of 44.2% since 1990, driven primarily by a constant increase in the population and the steady rise in waste generated. The decrease in GHG emissions observed since 2007 (Figure 70) is mainly due to CH_4 recovery in Solid waste disposal sites (SWDS) in the latter years of this time series (for more detail see section 8.2. below, on Solid waste disposal).

Breaking emissions down by category, Solid waste disposal accounts for 74.4% of GHG emissions by this sector, followed by Wastewater treatment and discharge with 23.7%, Biological treatment of solid waste with 1.9%, and Waste incineration, with less than 1%.

Table 85. Waste sector: GHG emissions ($GgCO_2eq$) by category, 1990–2010 series

Category	1990	1995	2000	2005	2010
6A. Solid waste disposal	1,916.3	2,187.1	2,564.1	3,104.9	2,643.7
6B. Wastewater treatment and discharge	533.2	482.7	546.8	714.6	842.2
6C. Waste incineration	0.1	0.1	0.1	0.2	0.3
6D. Other (Biological treatment of solid waste)	15.9	15.9	19.0	46.5	67.9
Total	2,465.5	2,685.8	3,130.0	3,866.2	3,554.1

Source: Prepared in-house by SNICHILE.

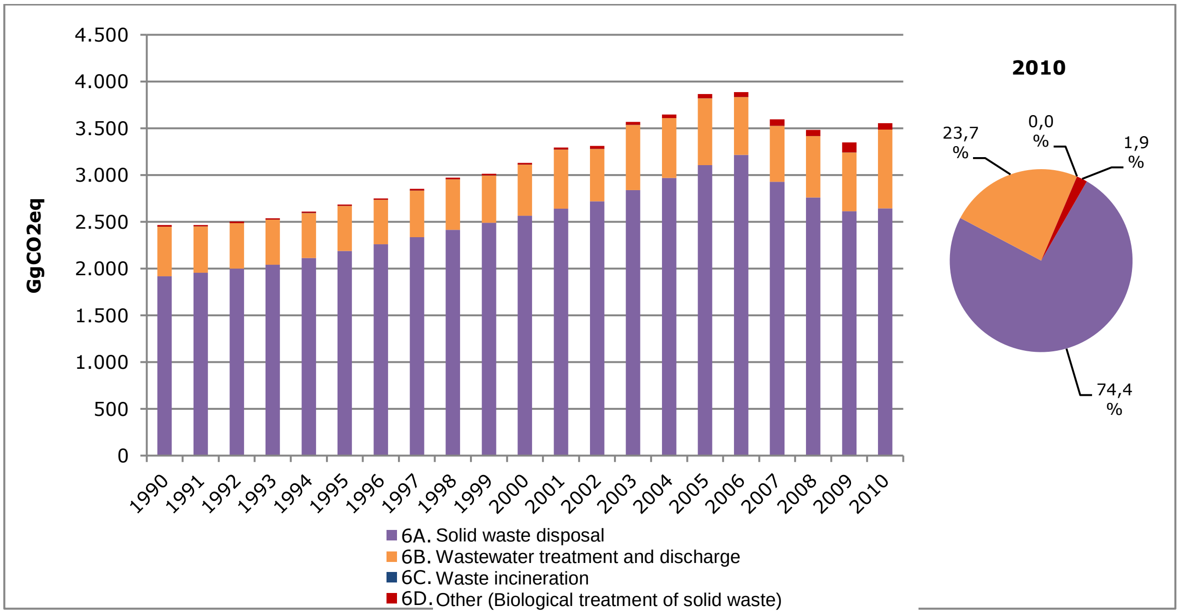

Figure 70. Waste Sector: GHG emission trend by category, 1990–2010 series

In 2010, the leading GHG emitted by this sector was CH_4 (methane), which accounted for 90.2% of the sector's total GHG emissions, followed by N_2O with 9.8% and CO_2 with less than 1% (Table 86 and Figure 71).

Table 86. Waste Sector: Emissions by type of GHG ($GgCO_2eq$), 1990–2010 series

GHG	1990	1995	2000	2005	2010
CO_2	0.1	0.1	0.1	0.2	0.3
CH_4	2,268.8	2,473.1	2,884.3	3,572.3	3,204.8
N_2O	196.7	212.6	245.6	293.7	349.0
Total	2,465.5	2,685.8	3,130.0	3,866.2	3,554.1

Source: Prepared in-house by SNICHILE.

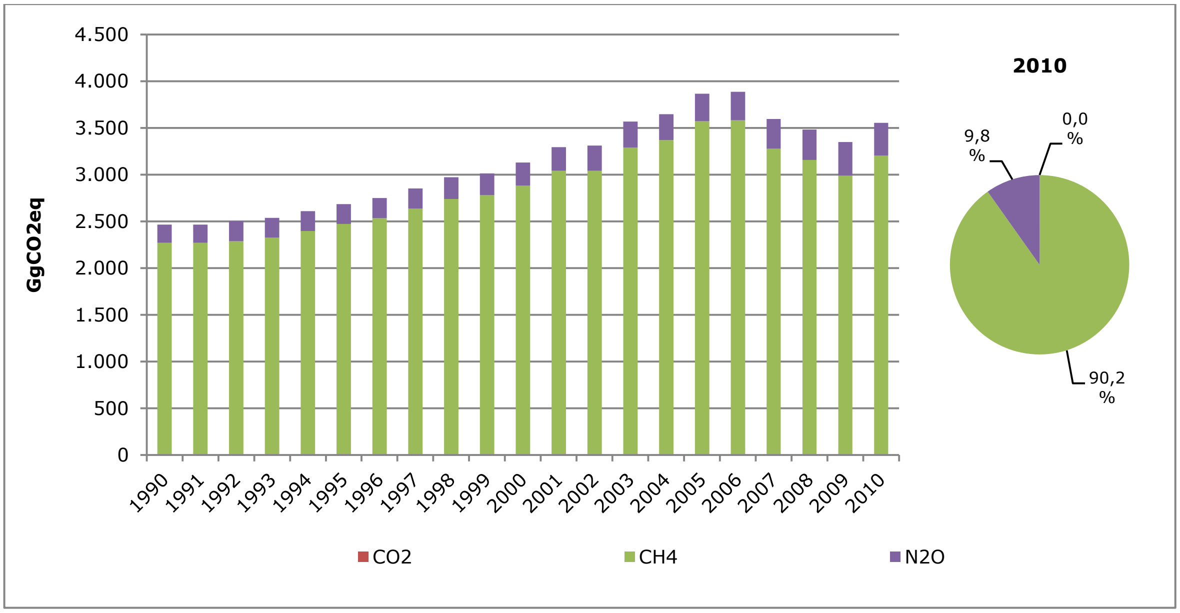

Figure 71. Waste sector: emission trend by type of GHG, 1990–2010 series

8.2. Solid waste disposal (6A)

8.2.1. Description of category and GHG emissions

The treatment and disposal of municipal, industrial and other solid waste produces significant amounts of CH_4, as well as biogenic CO_2 and non-methane volatile organic compounds (NMVOCs) and small quantities of N_2O, NO_x and CO. The subcategories included in this category vary with the characteristics of the disposal site, and are as follows:

- 6A1 Managed waste disposal sites.
- 6A2 Unmanaged waste disposal sites.
- 6A3 Other (Uncategorized waste disposal sites).

In general in Chile, solid waste is disposed of in one of the following types of sites:

- Sanitary landfill (*relleno sanitario*, compliant with current regulations, DS 189/2008),
- Garbage dump (*basural*, not compliant with the 1980 regulations or current ones), and
- Landfill (*vertedero*, compliant with 1980 regulations and Resolución 2004).

In 2010, the total quantity of municipal solid waste (MSW) produced in Chile was approximately 6,000 Gg, with approximately 47% of this waste generated in the Santiago Metropolitan Region (RM), the country's largest population center (MMA, 2014).

Industrial waste generated by small businesses and commercial establishments are counted as municipal solid waste when disposed of in solid waste disposal sites.

The category Solid waste disposal accounts for the largest volume of GHGs emitted in this sector. In 2010, GHG emissions from this category amounted to 2,643.7 $GgCO_2eq$, or 74.4% of the sector's total emissions (Table 87). Since 1990, GHG emissions from sources in this category have risen by 38.0%, mainly as a result of steady population growth. The interannual variations observed in Figure 72 are driven mainly by CH_4 recovered from solid waste disposal sites in the latter years of the series.

In terms of subcategories, Managed waste disposal sites (sanitary landfills) make up the most significant, accounting for 69.0% of all GHG emissions in this category, followed by Uncategorized waste disposal sites with 23.2% (landfills) and Unmanaged waste disposal sites (dumps) with 7.8%.

Table 87. Solid waste disposal: GHG emissions ($GgCO_2eq$) by subcategory, 1990–2010 series

Subcategory	1990	1995	2000	2005	2010
6A1. Managed waste disposal sites – sanitary landfills	0.4	585.8	831.3	2,029.8	1,823.8
6A2. Unmanaged waste disposal sites – Garbage dumps	489.4	380.2	350.4	234.3	206.9
6A3. Other (Uncategorized waste disposal sites) – landfills	1,426.4	1,221.1	1,382.4	840.7	613.1
Total	1,916.3	2,187.1	2,564.1	3,104.9	2,643.7

Source: Prepared in-house by SNICHILE.

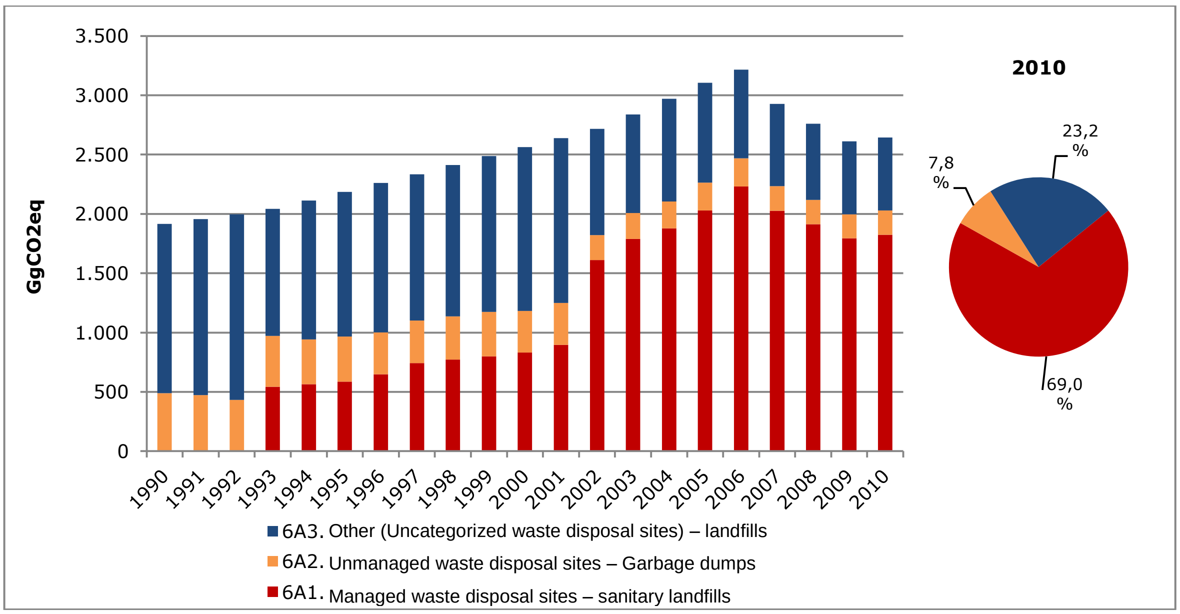

Figure 72. Solid waste disposal: GHG emission trend by subcategory, 1990–2010 series

The notable reduction in GHG emissions that can be observed as of 2006 is driven mainly by an increase in CH_4 recovery in managed and unmanaged landfills. The release and recovery of CH_4 from these landfills is shown in Table 88 and Figure 73. In 2010, for instance, 33.5% of all CH_4 generated was recovered in this way, mitigating 1,228.3 $GgCO_2eq$.

Table 88. Solid waste disposal: methane emitted ($GgCO_2eq$) and methane recovered ($GgCO_2eq$) from sanitary and other landfills, 1990–2010 series

Component	1990	1995	2000	2005	2010
Methane emitted by sanitary and other landfills	1,426.9	1,806.9	2,213.7	2,870.5	2,436.8
Methane recovered from sanitary and other landfills	0.0	0.0	0.0	0.0	1,228.3
Total	1,426.9	1,806.9	2,213.7	2,870.5	3,665.1

Source: Prepared in-house by SNICHILE.

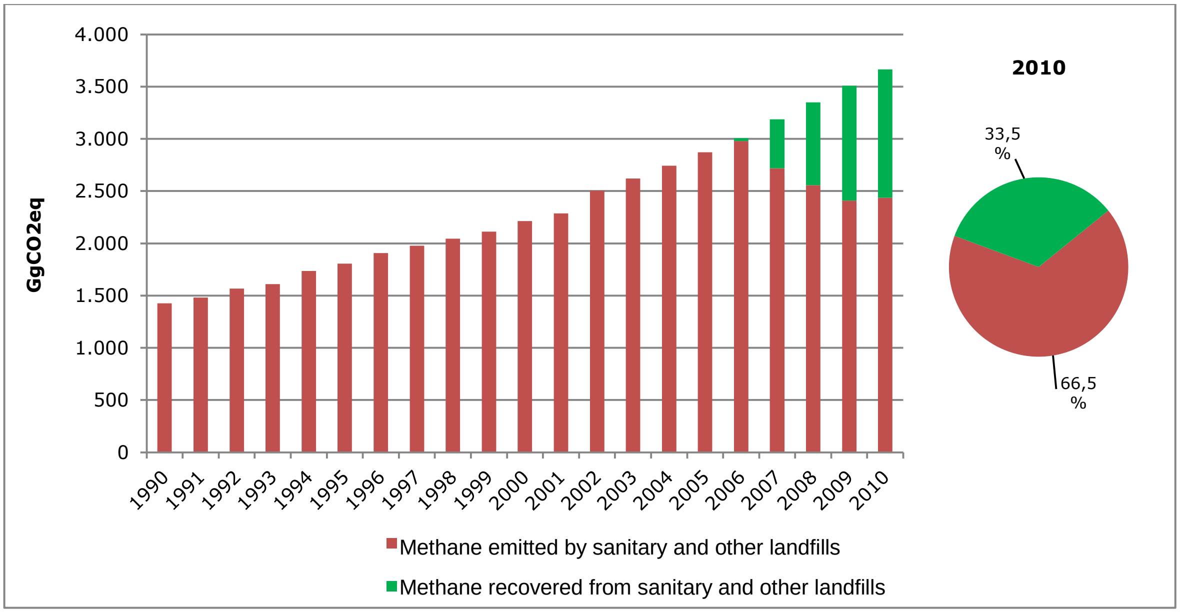

Figure 73. Solid waste disposal: Trend in methane emitted versus methane recovered in sanitary and other landfills, 1990–2010 series

8.2.2. Methods applied

The methods applied in preparing the Solid waste disposal category are presented in the Table below:

Table 89. Solid waste disposal: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
A. Solid waste disposal			T1	D		
1. Managed solid waste disposal sites			T1	D		
2. Unmanaged solid waste disposal sites			T1	D		
3. Other			T1	D		

T1 = Tier 1 method; D = Default.
Source: Prepared in-house by SNICHILE.

To calculate GHG emissions from this category, adjusted country-specific data was collected along with estimations for inconsistencies and data gaps, respectively, while the emission parameters and factors used were the default values provided by the 2006GL.

The method used to estimate emissions in the Solid waste disposal category is based on the First Order Decay (FOD) model, a Tier 1 method provided in the 2006GL. This method involved disaggregating national figures into climatic macrozones to identify different waste degradation conditions.

The Northern Macrozone covers regions XV, I, II, III, IV, V, XIII and VI and was classified under the climate zones set out in the 2006GL as "boreal and dry temperate" owing to the climatic conditions in those regions. Similarly the Southern Macrozone covers regions VII, VIII, IX, XIV, X, XI and XII and is classified as "boreal and wet temperate" as per the 2006GL.

8.2.2.1. Statistical and parametrical activity data

Data on the quantity of waste deposited in disposal sites was obtained from historical information generated by the Waste Area of the Ministry of the Environment (formerly CONAMA) since 2000 and adjusted to enhance consistency of the data. The data was divided into three categories according to the level of compliance with Chilean waste regulations, and then classified as per the 2006GL.

Sludge data was estimated based on the quantity of residential waste deposited in solid waste disposal sites, published by the Office of the Superintendent of Sanitation Services (SISS).

For estimating CH_4 recovery, information was obtained from each of the 12 disposal sites in Chile that carry out methane recovery (Table 90). The assumptions made for estimations were always validated by experts responsible for compiling waste disposal data at the national level.

Table 90. Solid waste disposal sites with methane recovery operations

Region		Company	Facility
IV	Coquimbo	TASUI Norte	El Panul
V	Valparaíso	I. Municipalidad Viña del Mar	Ex Vertedero Lajarilla
	Valparaíso	Stericycle	El Molle, Cartagena
	Valparaíso	KDM	El Belloto
	Valparaíso	GEA	La Hormiga
XIII	Metropolitan	Proactiva	Santiago Poniente
	Metropolitan	Consorcio Santa Marta	Santa Marta
	Metropolitan	KDM	Loma los Colorados
VI	O'Higgins	Proactiva	La Yesca
VIII	Biobío	Hidronor	Hidronor
	Biobío	Cermarc	Cermarc
XII	Magallanes	Punta Arenas	Leña Dura

Source: MMA, 2013.

The percentage of solid household waste sent to solid waste disposal sites was obtained from the regional offices of the Ministry of the Environment, which reported on respective regions. The quantity of waste disposed of in each municipality was used to calculate the percentage of waste disposed of in each kind of waste facility; where gaps existed in the data this information was extrapolated and compared against the information contained in the “ECOAMERICA, 2012” inventory. In 2010, 70% of all municipal solid waste was disposed of in sanitary landfills, 22.7% was taken to unmanaged landfills, and 7.3% ended up in garbage dumps (Figure 74).

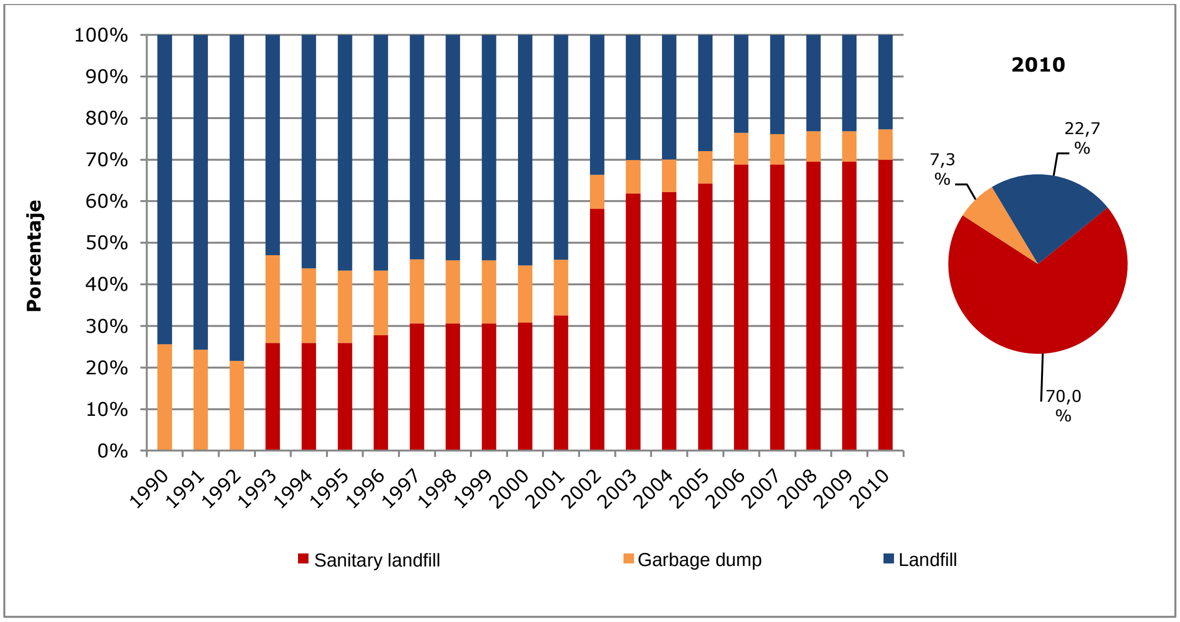

Figure 74. Solid waste disposal: percentage of solid waste per type of disposal facility, 1990–2010 series

The parametrical data used for these calculations were the default values provided in the 2006GL.

8.2.2.2. Emission factors

The default emission factors provided in the 2006 IPCC Guidelines were used for all corresponding subcategories.

8.3. Wastewater treatment and discharge (6B)

8.3.1. Description of category and GHG emissions

This category includes CH_4 emissions from the anaerobic reactions that occur during treatment of domestic and industrial wastewater, as well as indirect N_2O emissions from treated domestic wastewater released into rivers, lakes and the sea.

In 2010, GHG emissions from this category amounted to 842.2 $GgCO_2eq$, or 23.7% of total emissions in this sector (Table 91). This represents an increase of 57.9% since 1990, driven primarily by increases in the population and in coverage of residential sewage treatment.

In terms of subcategories, Domestic and commercial wastewater is the most significant, accounting for 98.1% of all GHG emissions, while Industrial wastewater accounted for 1.9% (Figure 75). Since 2006, GHG emissions from the former subcategory have dropped because of the enactment of a new decree, D.S N° 90/00: *Emission standard for regulating pollutants associated with liquid waste discharged into marine or inland surface waters*.

Table 91. Wastewater treatment and discharge: GHG emissions ($GgCO_2eq$) by subcategory, 1990–2010 series

Subcategory	1990	1995	2000	2005	2010
6B1. Industrial wastewater	40.5	83.8	87.0	258.2	16.3
6B2. Domestic and commercial wastewater	492.8	398.9	459.7	456.4	825.9
Total	533.2	482.7	546.8	714.6	842.2

Source: Prepared in-house by SNICHILE.

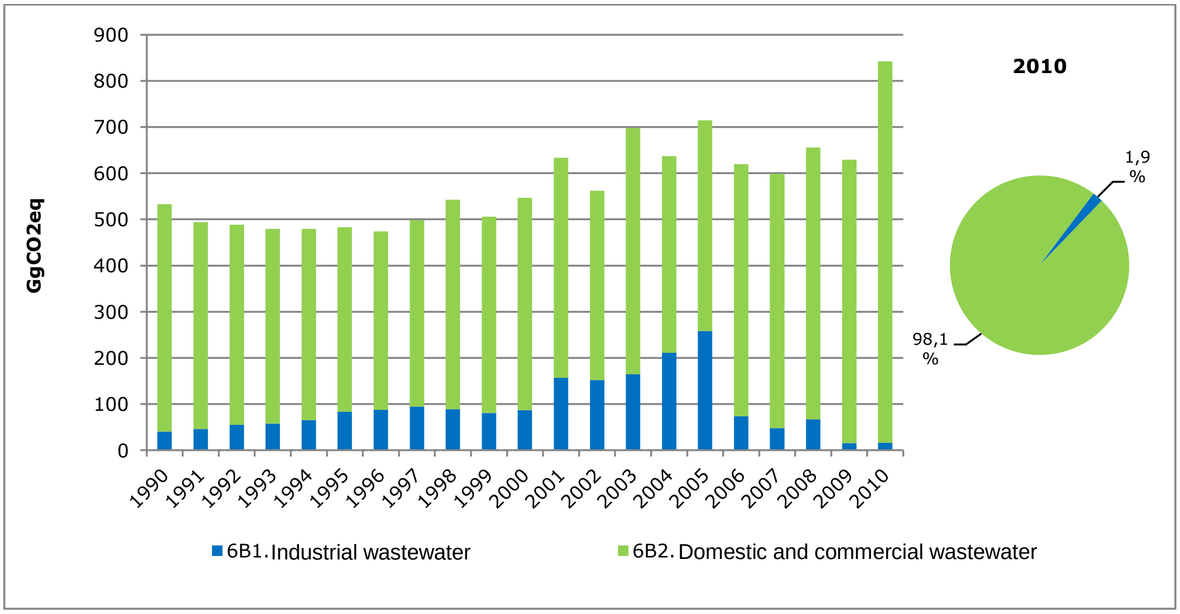

Figure 75. Wastewater treatment and discharge: GHG emission trend by subcategory, 1990–2010 series

8.3.2. Methods applied

The methods applied in preparing the category Wastewater treatment and discharge are listed in the Table below:

Table 92. Wastewater treatment and discharge: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
B. Wastewater treatment and discharge			T1	D	T1	D
1. Industrial wastewater			T1	D		
2. Domestic and commercial wastewater			T1	D	T1	D
3. Other			NE	D	NE	D

T1 = Tier 1 method; D = Default; NE = Not estimated
Source: Prepared in-house by SNICHILE.

Industrial wastewater

The Office of the Superintendent of Sanitation Services (SISS) has been responsible for monitoring those establishments generating industrial wastewater since 2006, when the decree, D.S N° 90/00, came fully into force. SISS monitors the compliance of each establishment producing industrial wastewater according to the parameters set out in the regulations.

However the decree makes no reference to different types of wastewater treatment, the amount of sludge generated or CH_4 capture during the treatment process, and therefore this information has not been collected at the national level. However, experts in the SISS Environmental Unit have assigned specific types of treatment to each industry sector, for three different periods (1990–2000, 2001–2005 and 2006–2010).

In this category, a Tier 1 method was used that included default emission factors and estimations to fill in the gaps in activity data for some years.

Domestic and commercial wastewater

The SISS is the entity responsible for establishing regulations and regulating sanitation companies, and as such it compiles data for all domestic wastewater treatment occurring across the country. It began keeping such records in 1991, when sewage treatment only covered 6.8% of the total population. By 2010, coverage had risen to 84%, an increase of 77.2%. The population segment covered by the sanitation system is denominated “high-income urban”, while the remaining segments of the population with their own forms of wastewater treatment and/or discharge are classified as “low-income urban” or “rural”.

In the Chilean context, the sludge removed during wastewater treatment is sent to different destinations. The bulk of it ends up in sanitary landfills, authorized landfills and mono-landfills, and CH_4 emissions for these types of solid waste disposal sites are accounted for under the Solid waste disposal category. Another portion of sludge is disposed of in agricultural operations as compost.

Chile has six wastewater treatment plants that recover and burn CH_4, though none of them to date does so to generate energy.

8.3.2.1. Statistical and parametrical activity data

Industrial wastewater

Information for the entire country has been available since 2006, when the abovementioned D.S N° 90/00 came fully into force and SISS was charged with monitoring and enforcing compliance among establishments that generate industrial wastewater. The information obtained from this institution covers the period 2006–2010; unreported years were estimated using data extrapolated from this period, in addition to recorded BOD_5 values, which were subsequently converted into COD values.

Domestic and commercial wastewater

The data employed for this subcategory—flow rates, types of wastewater treatment, volume of sludge and amounts of CH_4 recovered—were provided almost entirely by SISS, the agency responsible for establishing, monitoring and enforcing regulations applicable to sanitation companies. Population data was obtained from the National Statistics Bureau. Using data on the coverage of wastewater treatment plants, the Waste Sector Team was able to calculate coverage of wastewater treatment per inhabitant. The population was separated by income segment (rural population, low-income urban and high-income urban) according to sanitation coverage based on studies conducted by the Office of the Undersecretary of Regional and Administrative Development (SUBDERE). These steps yielded figures on the gaps in sanitation coverage.

Additionally, some Environmental Approval Permits (RCA) from the Environmental Impact Assessment System (SEIA) were also used to complete the information available.

To estimate nitrous oxide emissions, figures on protein consumption per capita were obtained from the Ministry of Health (MINSAL), and in some cases the opinion of local experts was also requested. Table 93 shows national consumption values.

Table 93. Domestic and commercial wastewater: national protein consumption (kg/person/year), 1990–2010 series

Year	1990	1995	2000	2005	2010
Protein	25.59	28.4	28.69	31.76	33.06

Source: Ministry of Health.

8.3.2.2. Emission factors

For all corresponding subcategories the default emission factors provided in the 2006 IPCC Guidelines were used.

8.4. Waste incineration (6C)

8.4.1. Description of category and GHG emissions

Incineration involves the combustion of solid and liquid waste without energy recovery. Waste can also be burned outside, and unwanted materials such as paper, wood, plastic, textiles, leather, oil and other materials are sometimes burned in the open or in open landfills in Chile. In these cases, smoke and other emissions are released directly into the atmosphere. This also occurs with incinerators that do not include scrubbing (emission cleaning) devices. Chilean regulations prohibit the open incineration of waste, but no figures exist on the scope of this practice in the country.

However, the country does have facilities authorized to incinerate hospital waste without recovering energy. Another activity included under the waste incineration category is the cremation of cadavers and human remains, which is carried out in crematoria associated with the country's cemeteries.

In 2010, GHG emissions from this category amounted to 0.3 GgCO_2eq, or less than 1% of total GHG emissions in the Waste sector (Table 94). Since 1990, GHG emissions in this category have increased by 321.0%, primarily due to the increase in hospital waste incinerated (Figure 76).

Table 94. Waste incineration: GHG emissions (GgCO_2eq), 1990–2010 series

Subcategory	1990	1995	2000	2005	2010
6C. Waste incineration	0.1	0.1	0.1	0.2	0.3
Total	0.1	0.1	0.1	0.2	0.3

Source: Prepared in-house by SNICHILE.

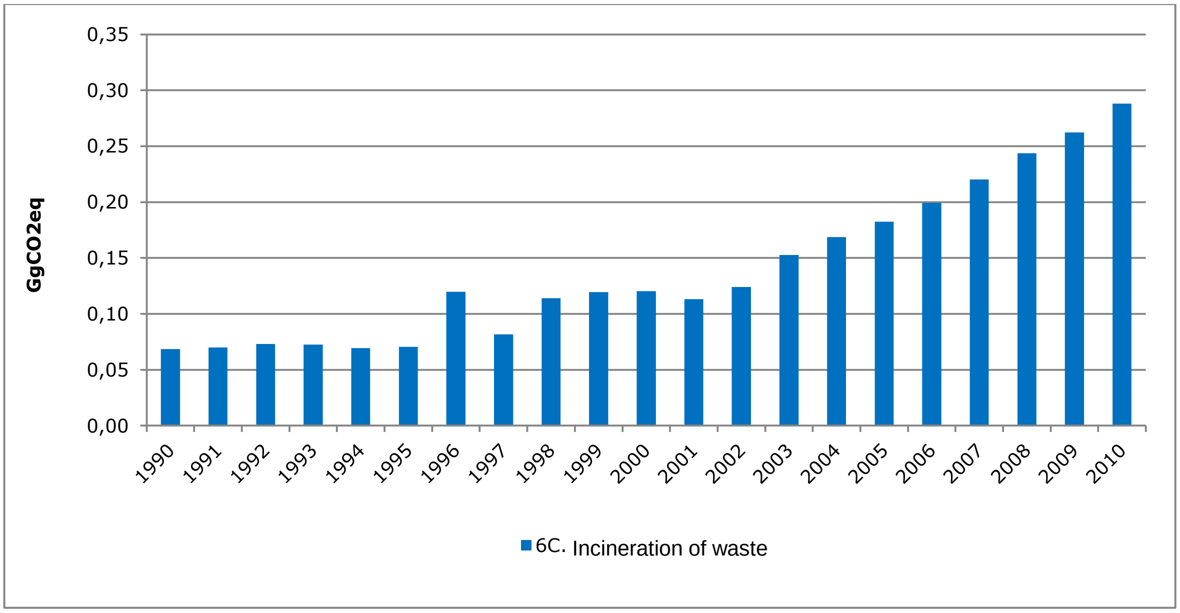

Figure 76. Waste incineration: GHG emission trend, 1990–2010 series

8.4.2. Methods applied

The methods applied to calculate emissions in the Waste incineration category are shown in the Table below:

Table 95. Incineration of waste: methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
C. Waste incineration	T1	D			T1	D

T1 = Tier 1 method; D = Default
Source: Prepared in-house by SNICHILE.

The Tier 1 methods provided in the 2006GL were used for the Waste incineration category.

8.4.2.1. Statistical and parametrical activity data

Information was collected on the incineration of hospital waste, which is regulated by decree D.S. N° 6/09 *Rules for the management of waste in health care establishments*, as well as on the number of cadavers and quantity of human remains cremated. The team obtained this information from the Ministry of Health, the entity responsible for enforcing compliance with waste combustion regulations. Information on hospital waste incineration was also requested from the companies contracted to perform this activity, while cremation data was obtained from a sample of the country's cemeteries.

8.4.2.2. Emission factors

Almost all of the emission factors and parametrical data used to calculate GHG emissions for this category were the default values provided in the 2006GL, though a few were obtained from Chile's previous NGHGI, which was included as part of the *country's 2nd National Communication to the UNFCCC* (MMA, 2011).

8.5. Other: biological treatment of solid waste (6D)

8.5.1. Description of category and GHG emissions

On average, approximately 50% of solid waste generated consists of organic matter that can be transformed through biological treatment (composting or anaerobic digestion) into a stable and much smaller volume that is free from pathogens and can be used to produce biogas as a form of energy. The final product of this process can be used as fertilizer and soil amendment, or can be disposed of in a solid waste disposal site.

Chile has several composting facilities and projects, and this activity is governed by the "Chilean Standard for Compost Quality" (NCh 2880, INN). Biological digestion, however, is in its infancy in Chile, with a few projects already approved but none currently in operation (as of 2010). The exceptions are wastewater treatment plants that process sludge through anaerobic digestion, an activity that is addressed within the category Wastewater treatment and discharge.

In 2010, GHG emissions in this category amounted to 67.9 GgCO_2eq, less than 1% of all Waste sector GHG emissions (Table 96), although since 1990, GHG emissions in this category have risen by 326.1%, mainly due to the increase in the number of facilities conducting these operations. Interannual variations observed in Figure 77 are primarily the result of the closure of some plants in 2009 and 2010.

Table 96. Other (Biological treatment of solid waste): GHG emissions (GgCO_2eq), 1990–2010 series

Category	1990	1995	2000	2005	2010
6D. Other (Biological treatment of solid waste)	15.9	15.9	19.0	46.5	67.9
Total	15.9	15.9	19.0	46.5	67.9

Source: Prepared in-house by SNICHILE.

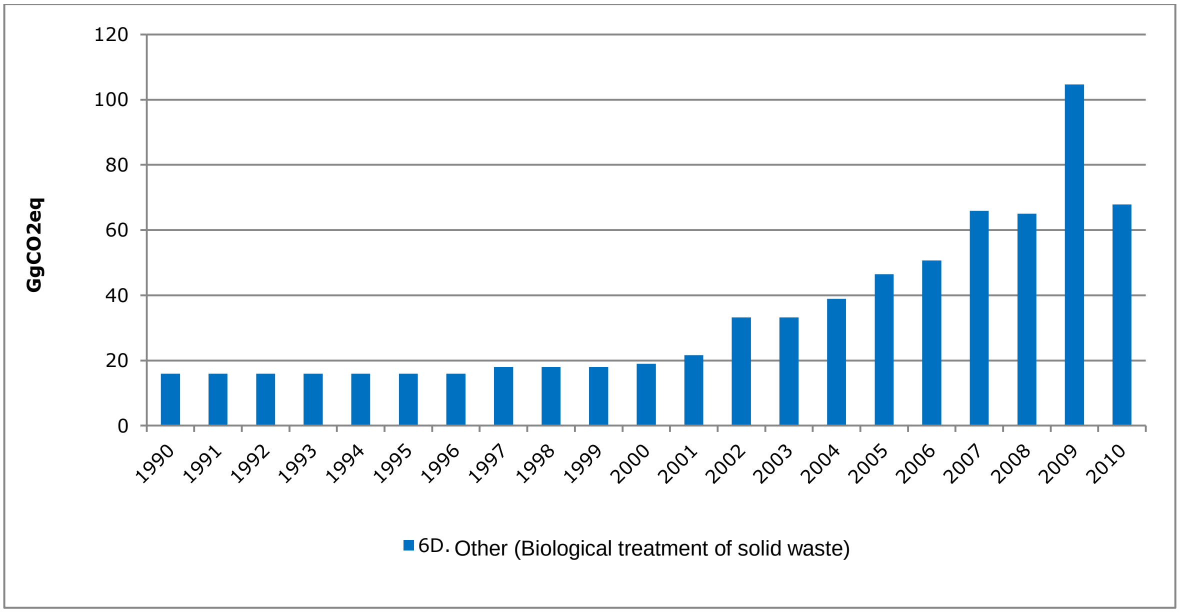

Figure 77. Other (Biological treatment of solid waste): GHG emission trend, 1990–2010 series

8.5.2. Methods applied

The methods applied to estimate GHG emissions in the category Other (Biological treatment of solid waste) are shown in the table below:

Table 97. Other (Biological treatment of solid waste): methods applied

Greenhouse gas source and sink categories	CO_2		CH_4		N_2O	
	Method used	Emission factor	Method used	Emission factor	Method used	Emission factor
D. Other			T1	D	T1	D
Biological treatment of solid waste			T1	D	T1	D

T1 = Tier 1 method; D = Default
Source: Prepared in-house by SNICHILE.

A Tier 1 methodology that involved the use of default emission factors provided in the 2006GL was used to estimate GHG emissions for this category.

8.5.2.1. Statistical and parametrical activity data

As there is no registry of Chilean facilities that perform biological treatment of solid waste, to build the activity data for this category the team recurred to projects of this kind evaluated by the Environmental Impact Assessment System. They reviewed every project and identified the ones currently in operation. Only composting projects were found to be in operation, while anaerobic digestion initiatives had been approved but were not yet operating, and thus were not counted. This information was complemented with studies conducted by SUBDERE on the funding of household composting programs. The team also visited and contacted some companies and large municipalities that had composting programs in place in order to generate useful figures.

8.5.2.2. Emission factors

For all applicable subcategories in this category the default emission factors provided in the 2006 IPCC Guidelines were used.

8.6. Quality assurance and quality control

The section below describes the procedures established to guarantee and monitor the quality of the Waste sector inventory.

8.6.1. Quality control procedures

- Comparison of the current Waste SGHGI with the SGHGI submitted with the *Second National Communication* (MMA, 2011).
- Activity data:
  - Analysis of activity data trends to identify anomalies
  - Implementation of the study Updating the Municipal Solid Waste Registry, 1990-2012 series (*Ajuste del Catastro de Residuos Sólidos Municipales, Serie Temporal 1990/2012*) (MMA, 2014) to verify and adjust the statistics on the total quantity of waste eliminated in waste disposal sites
  - Verification of the experience and expertise of the experts providing expert opinions
  - Use of spreadsheets with a standard format for activity data that detail each point of origin
- Emission factors, conversion factors and constants:
  - Verification that the parameters and emission factors are the most up to date and relevant ones possible.
  - Verification of the relevance of the default values provided in the 2006GL. In the case of COD (kg COD/m^3) for the category 4.D.2 Industrial wastewater treatment and discharge, the Waste Sector Team determined that the default value overestimated the organic load of industrial wastewater produced in Chile.

8.6.2. Quality assurance

The Waste SGHGI was reviewed by an expert qualified as a reviewer of NGHGIs from Parties included in Annex I to the Convention in July 2014. This review was conducted remotely with ongoing communication between the expert reviewer, the Coordinator of SNICHILE and Waste Sector Team professionals to resolve issues as they came up. The resulting assessment report was analyzed by the Waste sector team, which made the corresponding corrections based on the expert’s findings and evaluated the feasibility of incorporating the expert’s recommendations into the next update of Chile’s NGHGI.

8.7. Planned improvements

Based on its own work and the recommendations made by the NGHGI expert reviewer, the Waste sector team has planned the following improvements:

- Improving the generation and compiling of activity data
- Improving processing of activity data
- Using new information that will be made available from the entry into force of D.S N°1, Rules for the Registration of Pollutant Releases and Transfers (*Reglamento del registro de emisiones y transferencias de contaminantes*). These Rules provide for the creation of a national inventory or database of environmental information, including information on the disposal of municipal solid waste. This registry will become operational in 2015 and will collect information that can be used to update future GHG inventories.

9. RECALCULATIONS AND IMPROVEMENTS

9.1. Rationale for recalculations and improvements

Methodological changes are essential to improving the quality of GHG inventories. For the present NGHGI, GHG emissions and removals were estimated using the 2006GL, which produced a major methodological improvement over the previous NGHGI presented in the 2NC, which was prepared in accordance with the 1996GL, 2000GPG and GPG-LULUCF.

This methodological change responds mainly to Chile's desire to improve the quality of emissions estimations, preferring the methodologies, emission factors and parametric data included in the 2006GL, as these are more up-to-date than those of earlier versions (more details in section 1.4.1. Methodologies).

Methodological refinements were also made to categories such as Lime production, which was estimated using a Tier 2 methodology, and to some Agriculture and LULUCF categories, which were disaggregated regionally. The calculation of emissions and removals in the Forest land category in LULUCF was also upgraded to Tier 2.

9.2. Implications for emission levels

In general, this NGHGI represents an average reduction of 19,384.0 GgCO_2eq in the GHG balance compared to the 1990-2006 time series presented in the 2NC's NGHGI (Figure 78). This is primarily due to the inclusion of the carbon pool that corresponds to belowground living biomass (roots) of forest plantations, which increased GHG removals in the LULUCF sector. The greatest difference came in 2001 with 25,630.9 GgCO_2eq, while the smallest difference came during 1998 with around 2,885.2 GgCO_2eq, with a slight reduction in the trend shown in 2006.

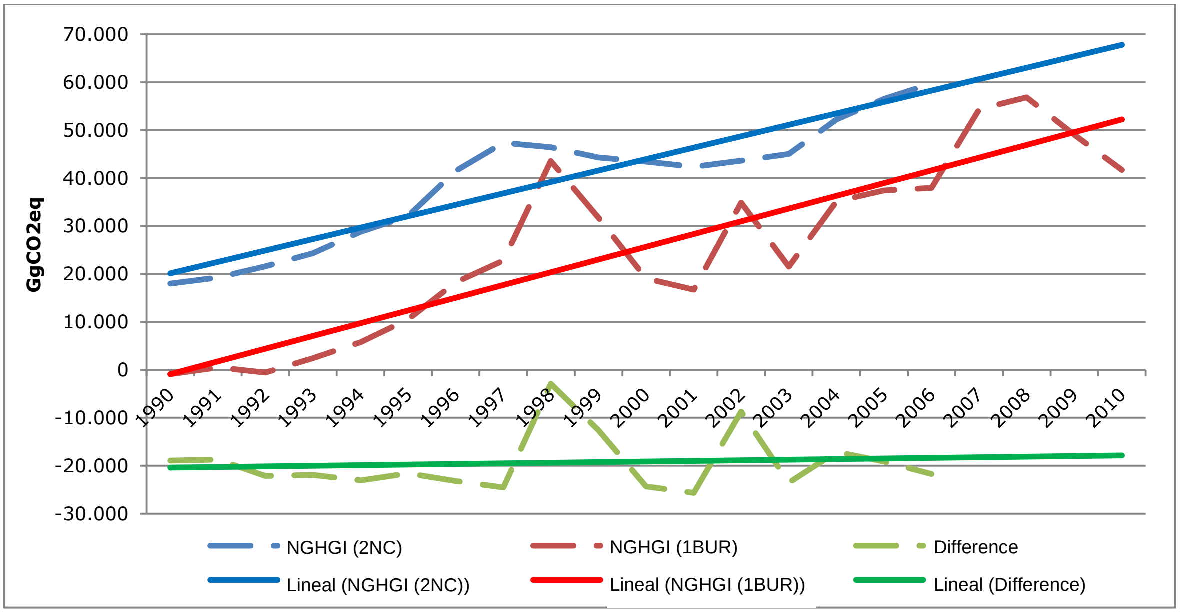

Figure 78. Chile's NGHGI: net GHG emission trend reported in the Second National Communication of Chile and the First Biennial Update Report, 1990-2010 series

As observed in Figure 79, recalculating the Energy sector presents no significant changes in emissions, with an average increase of 1,258.6 GgCO_2eq in emissions during the 1990-2006 series (a 2.8% increase over the NGHGI of the 2NC). The difference is mainly attributable to the use of the 2006GL default emission factors, which, unlike the 2000GPG default emission factors, assume a default oxidation factor for carbon of 1, which in turn assumes that all carbon contained in fuels is oxidized and emitted into the atmosphere as CO_2. There is also a change in the source of data for copper mining (from COCHILCO to BNE) and a disaggregation of emissions for domestic and international civil aviation and water-borne navigation (more details in chapter 3. ENERGY SECTOR).

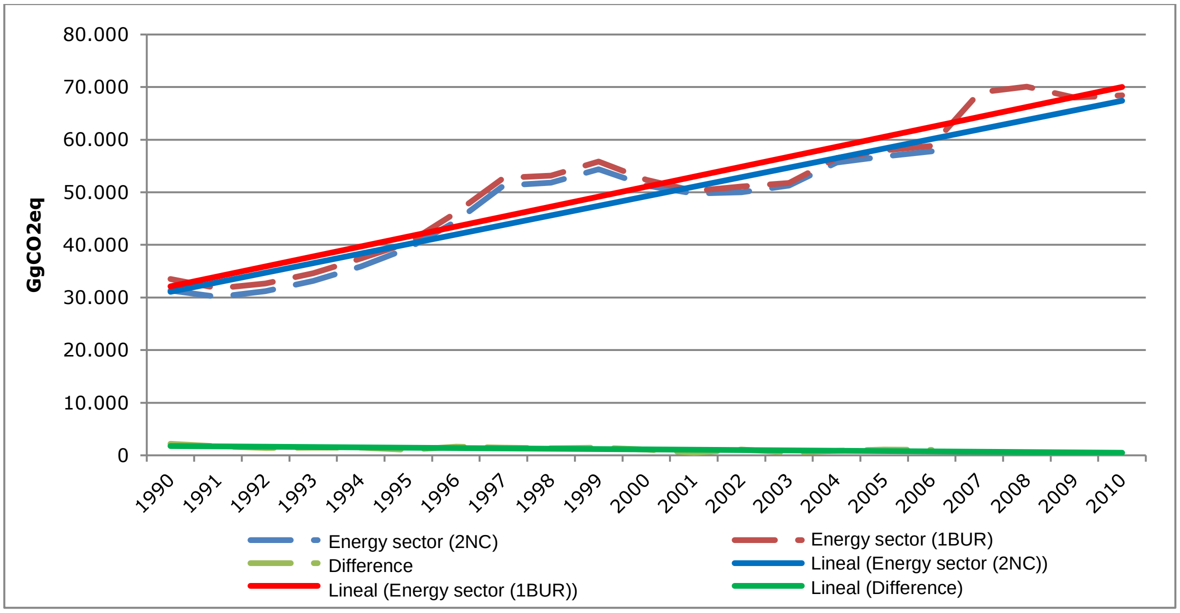

Figure 79. Energy Sector: GHG emission trend reported by Chile in the Second National Communication and the First Biennial Update Report, 1990-2010 series

As observed in Figure 80, recalculation of the Industrial Processes and Use of Solvents and Other Products sectors presents changes in emissions, with an average increase of 1,211.1 GgCO_2eq in emissions during the 1990-2006 series (a 29.6% increase compared to the NGHGI of the 2NC). The difference is caused by the inclusion of GHG emissions in categories not considered in the 1996GL and 2000GPG, such as CO_2 emissions caused by methanol and ethylene production, for example. A different methodology was also used to estimate HFC and PFC emissions than the one used in the NGHGI of the 2NC (more details in chapter 4. INDUSTRIAL PROCESSES SECTOR).

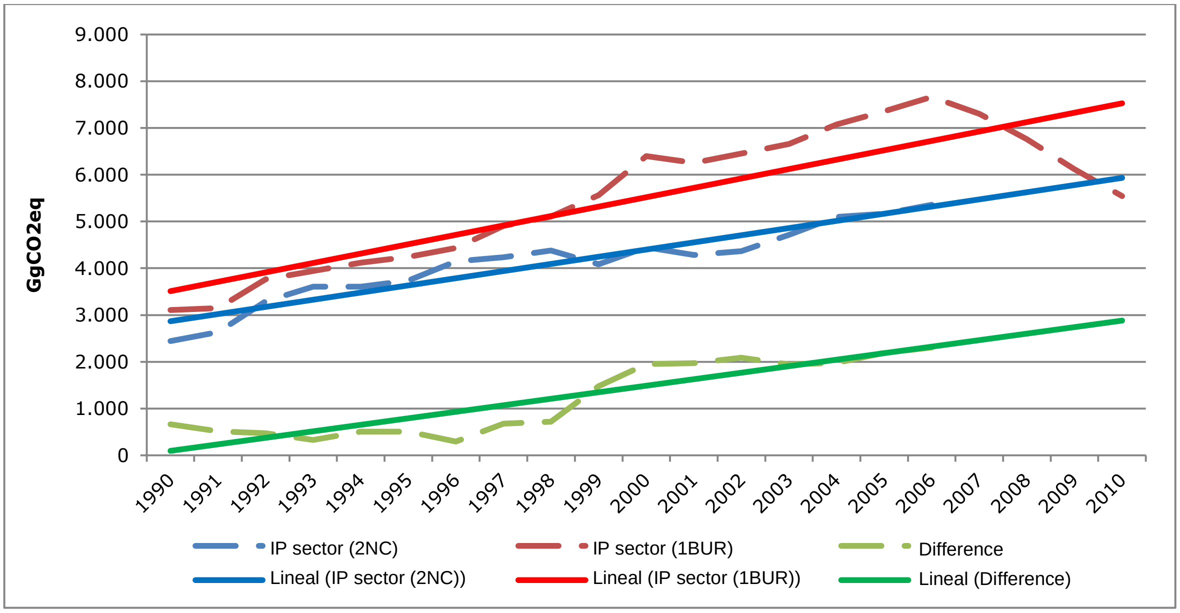

Figure 80. Industrial Processes Sector: GHG emission trend reported by Chile in the Second National Communication and the First Biennial Update Report, 1990-2010 series

As observed in Figure 81, there is a recalculation of the Agriculture sector, which presents no significant changes in emissions but an average emission reduction of 893.2 $GgCO_2eq$ over the 1990-2006 series (6.9% reduction compared to the 2NC's NGHGI). The difference is mainly due to the adjustment of country-specific emission factors for the Enteric Fermentation and Manure Management categories and the refinement of activity data for the animal population (more details in chapter 6. AGRICULTURE SECTOR).

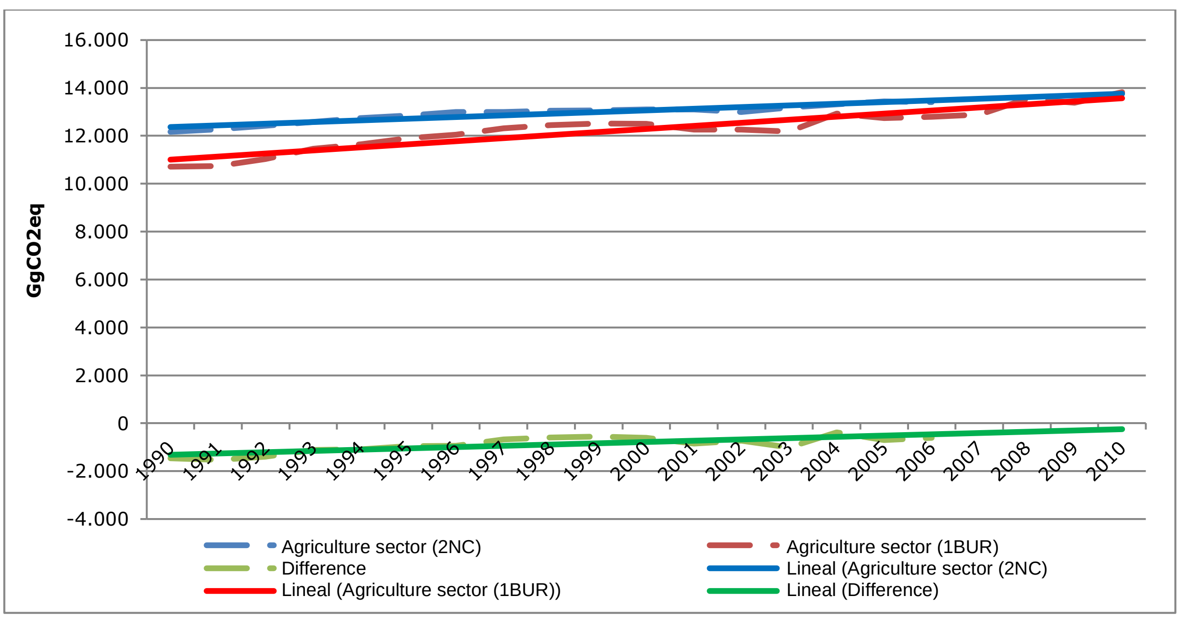

Figure 81. Agriculture Sector: GHG emission trend reported by Chile in the Second National Communication and the First Biennial Update Report, 1990-2010 series

As observed in Figure 82, there is a recalculation of the LULUCF sector, which presents the greatest changes, with an average increase in GHG removals of 22,344.9 $GgCO_2eq$ for the 1990-2006 series (an 88.7% increase in GHG removals compared to the 2NC's NGHGI). These increases in removals are caused primarily by the inclusion of the carbon pool corresponding to belowground living biomass (roots) in forest plantations, which increases removals for the LULUCF sector. Biomass expansion factors were also updated, producing a change favorable to GHG removal. It is important to mention that this trend changed in 1998 and 2002, owing to considerable increases in the areas affected by wildfires those years (more details in chapter 7. LAND USE, LAND USE CHANGE AND FORESTRY SECTOR).

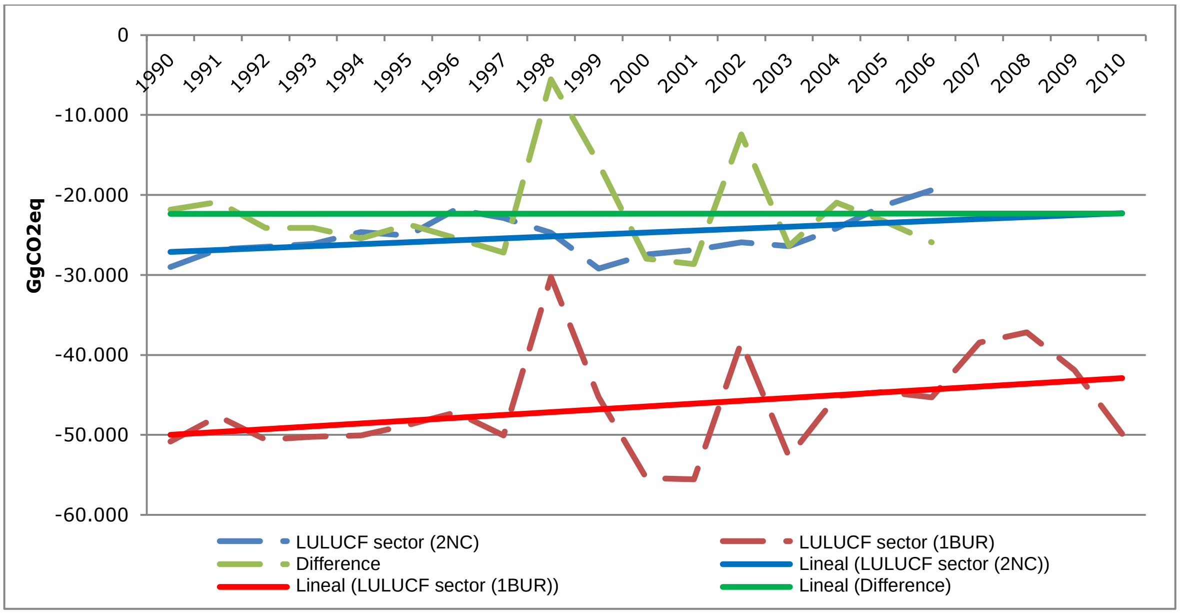

Figure 82. LULUCF Sector: net GHG emission trend reported by Chile in the Second National Communication and the First Biennial Update Report, 1990-2010 series

As observed in Figure 83, there is a recalculation of the Waste sector, which presents the greatest change, with an average removal increase of 1,281.6 $GgCO_2eq$ for the 1990-2006 time series (a 73.2% increase over the 2NC's NGHGI). This increase was caused mainly by methodological changes, as the 2006GL include improvements to the default methods for the Final disposal sites category, as well as including the Biological treatment of waste category, which was absent from previous guidelines. The country also has better statistical information available on the generation and final destination of municipal solid and liquid waste (more details in chapter 8. WASTE SECTOR).

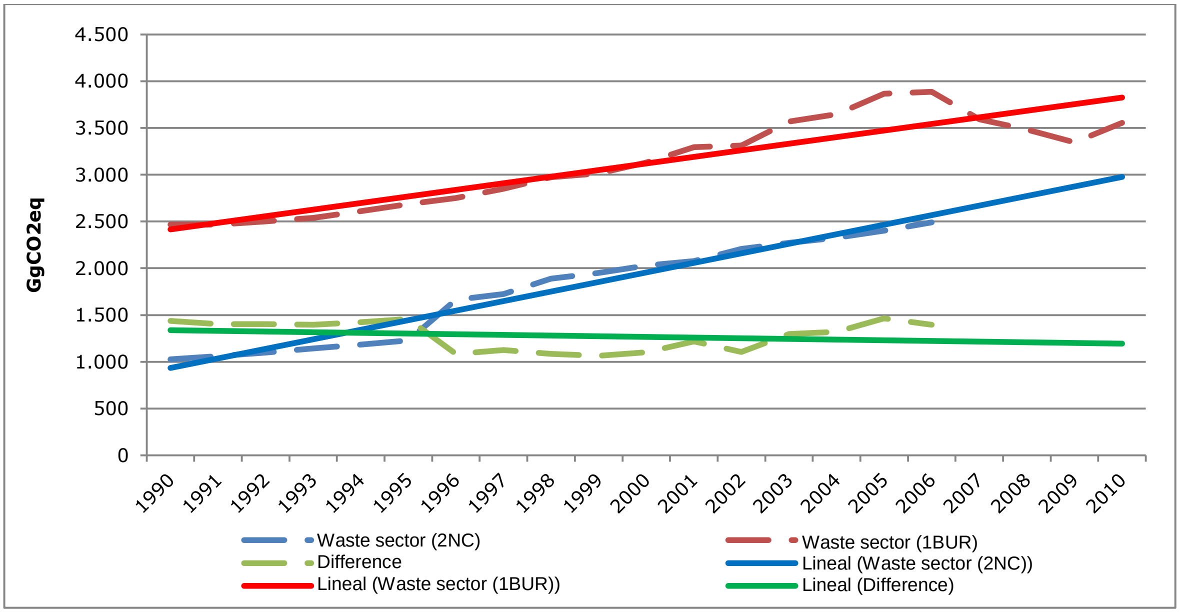

Figure 83. Waste Sector: GHG emission trend reported by Chile in the Second National Communication and the First Biennial Update Report, 1990-2010 series.

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ANEXOS

Anexo 1. Homologación de categorías

El equipo nacional de INGEI decidió implementar, desde el inicio del proceso de actualización permanente, las GL2006 y el software del IPCC. Las GL2006 dividen los inventarios en cuatro sectores:

- Energía,
- Procesos industriales y uso de productos (IPPU),
- Agricultura, silvicultura y otros usos de la tierra (AFOLU), y
- Residuos.

Sin embargo, las GL-UNFCCC-IBA y GL-UNFCCC-CN sugieren que los países elaboren y reporten sus inventarios siguiendo las GL1996, GPG2000, y GPG-LULUCF del IPCC, las cuales dividen los inventarios en seis sectores principales:

- Energía,
- Procesos industriales (PI),
- Utilización de disolventes y otros productos (UDOP),
- Agricultura,
- Uso de la tierra, cambio del uso de la tierra y silvicultura (UTCUTS), y
- Residuos.

Por lo tanto, para el reporte del INGEI bajo las GL1996, GPG2000 y GPG-LULUCF, las categorías y sus emisiones debieron ser homologadas desde las GL2006, es decir, asociadas a las categorías establecidas por las GL1996 y GPGs.

Para el proceso de homologación fue necesario llevar el INGEI en su versión GL2006 (en adelante INGEI-INICIAL) a un nivel máximo de desglose. Esto significó que los sectores se trabajaron a nivel de categoría (p.e. 3B), subcategoría (p.e. 3B1), componente (p.e. 3B1a), subcomponente (p.e. 3B1ai), tipo (p.e. 3B1ai Forest tree plantations) y especie (p.e. 3B1ai Forest tree plantations, *Pinus radiata*), para algunos casos. Luego de esto, cada actividad de emisiones o absorciones por tipo de GEI fue comparada con las actividad definidas en las GL1996, GPG2000 y GPG-LULUCF (en adelante INGEI-FINAL), para ser asignadas a la categoría (p.e. 5A), subcategoría (p.e. 5A1), componente (p.e. 5A1a), subcomponente (p.e. 5A1a Plantaciones de árboles de bosque), o especie (p.e. 5A1a Plantaciones de árboles de bosque, *Pinus radiata*), correspondiente. El esquema general es presentado en la Figura siguiente:

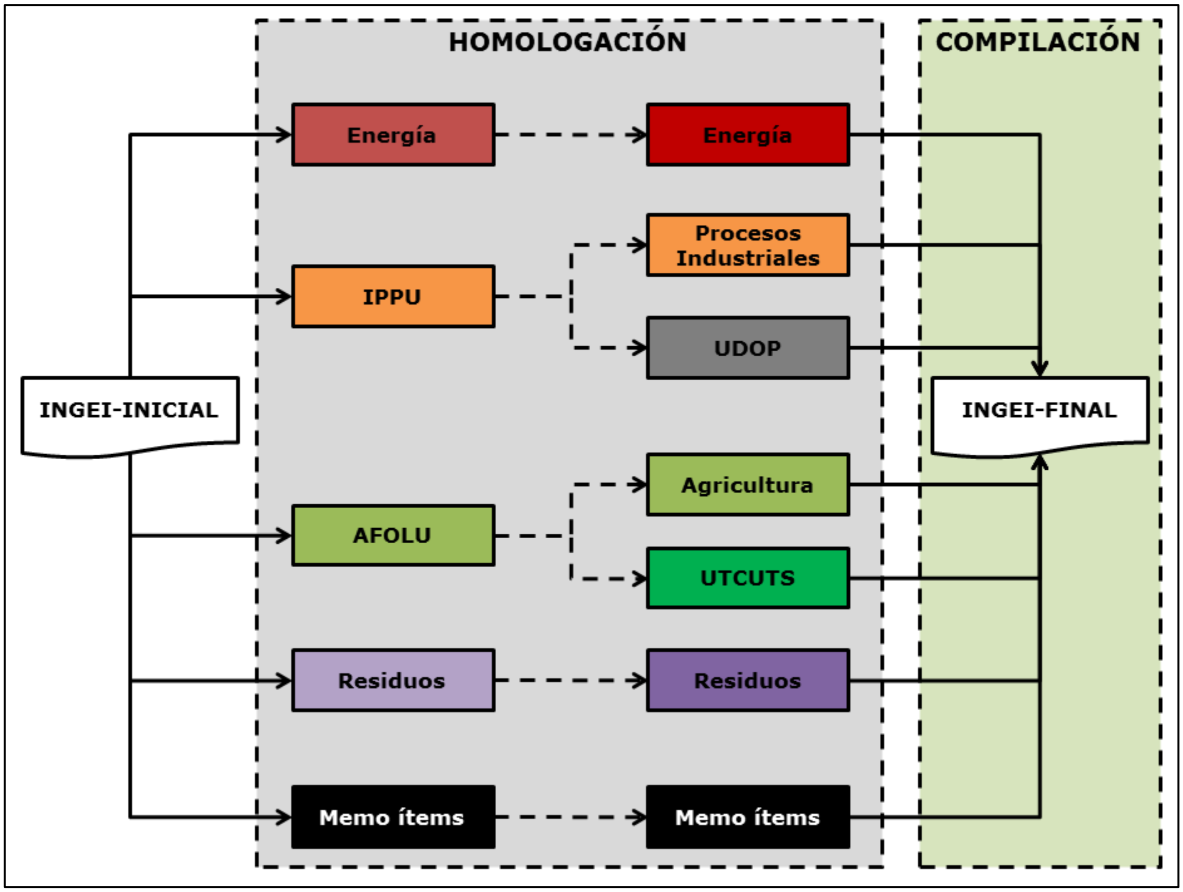

Figura 1A. Proceso general para la homologación de las categorías

Lo anterior significó que en algunos casos las emisiones o absorciones debieron ser asignadas a la categoría, subcategoría o componente Otros del nivel superior correspondiente, para aquellas emisiones o absorciones no definidas o consideradas en las GL1996, GPG2000 y GPG-LULUCF. También significó que algunas actividades de la versión INGEI-FINAL no tuvieran emisiones o absorciones asignadas al no ser consideradas en la versión INGEI-INICIAL (como ocurre con algunas subcategorías del sector Procesos industriales).

Finalmente el INGEI-FINAL pasó por un proceso de compilación, en donde el balance de GEI es comparado con el balance del INGEI-INICIAL, para cada año. De esta manera el proceso de homologación asegura que no se deje afuera ninguna emisión o absorción de GEI, de modo de que ambos inventarios sean equivalentes.

Para mayor detalle, ver anexo digital: *Anexo1_Homologación*

Anexo 2. Métodos aplicados, datos de actividad y parámetros

A. Métodos

Las emisiones de GEI fueron estimadas en base a las GL2006, a pesar de ser presentadas de acuerdo a las GL1996, GPG2000 y GPG-LULUCF. A continuación se presenta en detalle los métodos aplicados para cada categoría, subcategoría y componente, así como las características del factor de emisión respectivo.

Para mayor detalle, ver anexo digital: *Anexo2a_Métodos*

Cuadro 2A. Detalle de los métodos y niveles en el INGEI de Chile, año 2010

Categorías de fuente y sumidero de gases de efecto invernadero	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión
1. Energía	**T1**	**D**	**T1**	**D**	**T1**	**D**						
A. Quema de combustible	T1	D	T1	D	T1	D						
1. Industria de la energía	T1	D	T1	D	T1	D						
a. Producción de electricidad y calor	T1	D	T1	D	T1	D						
b. Refinación del petróleo	T1	D	T1	D	T1	D						
c. Manufactura de combustibles sólidos y otras industrias de la energía	T1	D	T1	D	T1	D						
2. Industrias manufactureras y construcción	T1	D	T1	D	T1	D						
a. Hierro y acero	T1	D	T1	D	T1	D						
b. Metales no ferrosos	NE	D	NE	D	NE	D						
c. Sustancias químicas	T1	D	T1	D	T1	D						
d. Pulpa, papel e imprenta	T1	D	T1	D	T1	D						
e. Procesamiento de alimentos, bebidas y tabaco	T1	D	T1	D	T1	D						
f. Otros	T1	D	T1	D	T1	D						
Minerales no metálicos	T1	D	T1	D	T1	D						
Minería (con excepción de combustibles) y cantería	T1	D	T1	D	T1	D						
Industria no especificada	T1	D	T1	D	T1	D						
3. Transporte	T1	D	T1	D	T1	D						
a. Aviación nacional	T1	D	T1	D	T1	D						
b. Por carretera	T1	D	T1	D	T1	D						
c. Ferrocarriles	T1	D	T1	D	T1	D						
d. Navegación nacional	T1	D	T1	D	T1	D						
e. Otro transporte	NA	NA	NA	NA	NA	NA						
4. Otros sectores	T1	D	T1	D	T1	D						
a. Comercial/Institucional	T1	D	T1	D	T1	D						
b. Residencial	T1	D	T1	D	T1	D						
c. Agricultura/silvicultura/Pesca	T1	D	T1	D	T1	D						
5. Otros	NO, C	D	NO, C	D	NO, C	D						
a. Estacionario	NO	D	NO	D	NO	D						
b. Móvil	NO, C	D	NO, C	D	NO, C	D						
B. Emisiones fugitivas de combustible	T1	D	T1	D								
1. Combustible sólido			T1	D								
a. Extracción y manipulación de carbón			T1	D								
b. Transformación de combustible sólido			NO	NO								
c. Otro												

Categorías de fuente y sumidero de gases de efecto invernadero	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión
2. Petróleo y gas natural	T1	D	T1	D								
a. Petróleo	T1	D	T1	D								
b. Gas natural	T1	D	T1	D								
c. Venteo y quema en antorcha	T1	D	T1	D								
d. Otro	NA	NA	NA	NA								
2. Procesos industriales	**T1,T2**	**D**	**T1**	**D**	**T1**	**D**	**T1**	**D**	**T1**	**D**	**NE, NO**	**NE, NO**
A. Productos minerales	T1,T2	D										
1. Producción de cemento	T1	D										
2. Producción de cal	T2	D										
3. Utilización de piedra caliza y de dolomita	NE	D										
4. Producción y utilización de carbonato sódico	NE	D										
5. Producción de material asfáltico para techos	NE	D										
6. Pavimentación asfáltica	NE	D										
7. Otros	T1	D										
Producción de vidrio	T1	D										
B. Industria química	T1	D	T1	D	T1	D						
1. Producción de amoníaco	NO	NO										
2. Producción de ácido nítrico					T1	D						
3. Producción de ácido adípico					NO	NO						
4. Producción de carburo	NO	NO	NO	NO	NO	NO						
5. Otros	T1	D	T1	D								
Metanol	T1	D	T1	D								
Etileno	T1	D	T1	D								
C. Producción de metales	T1	D	NO	D					NO	NO	NO	NO
1. Hierro y acero	T1	D	NO, IE	NO, IE								
2. Ferroaleaciones	T1	D	NO	D								
3. Aluminio	NO	NO							NO	NO		
4. SF_6 Utilizado en las fundiciones de aluminio y magnesio	NO	NO									NO	NO
5. Otros	T1	D										
Producción de plomo	T1	D										
Producción de cinc	T1	D										
D. Otras producción	NE	NE					NE	NE	NE	NE	NE	NE
1. Industrias del papel y de la pulpa de papel	NE	NE					NE	NE	NE	NE	NE	NE
2. Alimentos y bebidas	NE	NE					NE	NE	NE	NE	NE	NE
E. Producción de halocarburos y hexafluoruro de azufre							NE	NE	NE	NE	NE	NE
1. Emisiones secundarias de HFC y PFC							NE	NE	NE	NE	NE	NE
2. Emisiones fugitivas							NE	NE	NE	NE	NE	NE
3. Otro							NA	NA	NA	NA	NA	NA
F. Consumo de halocarburos y hexafluoruro de azufre							T1	D	T1	D	NE, NO	NE, NO
1. Refrigeración y aire acondicionado							T1	D				
2. Productos de espuma							NO	NO	NO	NO		
3. Extintores de incendios							T1	D	T1	D		
4. Aerosoles							T1	D				
5. Disolventes							NE	NE	NE	NE	NE	NE
6. Otras aplicaciones							NO	NO	NO	NO	NO	NO
7. Manufactura de semiconductores							NO	NO	NO	NO	NO	NO
8. Equipos eléctricos							NO	NO	NO	NO	NO	NO
9. Otros							NA	NA	NA	NA	NA	NA
G. Otros	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Utilización de disolventes y otros productos	**T1**	**D**				**NO**						
A. Aplicaciones de pintura	NE	NE										
B. Desengrase y limpieza en seco	NE	NE										
C. Productos químicas, fabricación y procesamiento	T1	D										

Categorías de fuente y sumidero de gases de efecto invernadero	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión	Método aplicado	Factor de emisión
D. Otros	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Agricultura			**T1b, T2**	**D, CS**	**T1b**	**D**						
A. Fermentación entérica			T1b, T2	D, CS								
1. Ganado			T2	CS								
2. Búfalos			NO	NO								
3. Ovejas			T1b	D								
4. Cabras			T1b	D								
5. Camellos y Llamas			T1b	D								
6. Caballos			T1b	D								
7. Mulas y asnos			T1b	D								
8. Cerdos			T1b	D								
9. Aves de corral			NE	D								
10. Otro			NE	D								
B. Manejo del estiércol			T1b, T2	D, CS	T1b	D						
1. Ganado			T2	CS								
2. Búfalos			NO	NO								
3. Ovejas			T1b	D								
4. Cabras			T1b	D								
5. Camellos y Llamas			T1b	D								
6. Caballos			T1b	D								
7. Mulas y asnos			T1b	D								
8. Cerdos			T2	CS								
9. Aves de corral			T1b	D								
10. Otros			NE	NE								
11. Lagunas anaeróbicas					T1b	D						
12. Sistemas de tipo líquido					NO	D						
13. Almacenamiento sólido y parcelas secas					T1b	D						
14. Otros SME					T1b	D						
C. Cultivo del arroz			T1b	D								
1. De regadío			T1b	D								
2. De secano			NO	D								
3. Aguas profundas			NO	D								
4. Otros			NO	D								
D. Suelos agrícolas					T1b	D						
1. Emisiones directas de suelos agrícolas					T1b	D						
2. Estiércol de pastos, prados y praderas					T1b	D						
3. Emisiones indirectas de suelos agrícolas					T1b	D						
4. Otros					NO	NO						
E. Quema prescrita de sabanas	NO	NO	NO	NO	NO	NO						
F. Quema en el campo de los residuos agrícolas			T1a,b	D	T1a,b	D						
G. Otros			NA	NA	NA	NA						
5. Uso de la tierra, cambio del uso de la tierra y silvicultura	**T1b, T2**	**D, CS**	**T1b, T2**	**D, CS**	**T1b, T2**	**D, CS**						
A. Tierras forestales	T2	CS	T1b, T2	D, CS	T1b, T2	D, CS						
1. Tierras forestales que permanecen como tales	T2	CS	T1b, T2	D, CS	T1b, T2	D, CS						
2. Tierra convertida a tierras forestales	T2	CS										
B. Tierras de cultivo	T1b, T2	D, CS										
1. Tierras de cultivo que permanecen como tales	T2	CS										
2. Tierra convertida a tierras de cultivo	T1b, T2	D, CS										
C. Pastizales	T1b, T2	D, CS	T1a,b	D	T1a,b	D						
1. Pastizales que permanecen como tales			T1a,b	D	T1a,b	D						
2. Tierra convertida a pastizal	T1b, T2	D, CS										
D. Humedales	NE	NE	NE	NE	NE	NE						
1. Humedales que permanecen como tales	NE	NE	NE	NE	NE	NE						

Categorías de fuente y sumidero de gases de efecto invernadero	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Método aplicado	**Factor de emisión**	**Método aplicado**	**Factor de emisión**	**Método aplicado**	**Factor de emisión**	**Método aplicado**	**Factor de emisión**	**Método aplicado**	**Factor de emisión**	**Método aplicado**	**Factor de emisión**
2. Tierra convertida a humedal	NE	NE	NE	NE	NE	NE						
E. Asentamientos	T1b, T2	D, CS										
1. Asentamientos que permanecen como tales	NE	NE										
2. Tierra convertida a asentamiento	T1b, T2	D, CS										
F. Otras tierras	T1b, T2	D, CS										
1. Otras tierras que permanecen como tales	NE	NE										
2. Tierras convertidas a otras tierras	T1b, T2	D, CS										
G. Otros	NE	D	NE	D	NE	D						
Productos de madera recolectada	NE	D	NE	D	NE	D						
6. Residuos	**T1**	**D**	**T1**	**D**	**T1**	**D**						
A. Disposición de residuos sólidos			T1	D								
1. Sitios de disposición de residuos gestionados			T1	D								
2. Sitios de disposición de residuos no gestionados			T1	D								
3. Otros			T1	D								
B. Tratamiento y descarga de aguas residuales			T1	D	T1	D						
1. Aguas residuales industriales			T1	D								
2. Aguas residuales domésticas y comerciales			T1	D	T1	D						
3. Otros			NE	D	NE	D						
C. Incineración de residuos	T1	D			T1	D						
D. Otros			T1	D	T1	D						
Tratamiento biológico de residuos sólidos			T1	D	T1	D						
Partidas informativas												
Búnker internacional	T1	D	T1	D	T1	D						
Aviación internacional	T1	D	T1	D	T1	D						
Navegación internacional	T1	D	T1	D	T1	D						
Emisiones de CO_2 de la biomasa	T1	D										

T1 = Método Nivel 1; T1a = Desagregación por componente operacional (cultivos, especies, etc.); T1b = Desagregado por regiones administrativas; T2 = Método Nivel 2; D = Defecto; CS = País específico; NA = No aplica; NE = No estimado; NO = No ocurre; C = Confidencial.
Fuente: Elaboración propia del SNICHILE.

B. Datos de actividad y parámetros

A continuación se presentan los principales datos de actividad utilizados por cada sector.

Para mayor detalle, ver anexo digital: *Anexo2b_Datos de actividad*

Sector Energía

Sector Energía: densidades y poderes caloríficos utilizados en el BNE

Producto	Densidad	Poder Calorífico Superior	
	Ton/m3	KCal/Kg	
Petróleo Crudo Nacional	0,825	10.963	(*)
Petróleo Crudo Importado	0,855	10.860	
Petróleo Combustible 5	0,927	10.500	
Petróleo Combustible IFO 180	0,936	10.500	
Petróleo Combustible 6	0,945	10.500	
Nafta	0,700	11.500	
Gas Licuado	0,550	12.100	
Gasolina Automóviles	0,730	11.200	
Gasolina Avión	0,700	11.400	
Kerosene Aviación	0,810	11.100	
Kerosene	0,810	11.100	
Diésel	0,840	10.900	
Gas Natural Procesado	-	9.341	(**)
Leña	-	3.500	
Carbón	-	7.000	
Coque	-	7.000	
Biogás	-	5.600	(**)
Gas de Refinería	-	4.260	(**)
Electricidad	-	860	(****)(1)

Notas: (*) Promedio Isla, Continente y Costa Afuera; (**) KCal/m3; (1) Equivalente Calórico práctico para Chile 2.750 KCal/KWh hasta 1997 y 2.504 KCal/KWh desde 1998.
Fuente: BNE, Ministerio de Energía.

Sector Energía: consumo de combustibles (TJ) por tipo de combustible, serie 1990-2010

Año/Tipo	Diésel	Leña	Carbón	Gas natural	Gasolina	Petróleo combustible	Gas Licuado	Kerosene Aviación	Otros
1990	98.446,1	107.152,8	89.906,5	24.785,1	61.217,1	60.620,5	25.815,3	12.294,3	28.630,7
1991	100.186,9	118.198,2	64.160,4	23.322,3	63.345,0	61.362,3	27.603,0	12.123,1	36.931,1
1992	108.949,1	131.224,4	56.320,8	25.824,4	69.832,3	62.205,5	30.655,9	14.161,5	38.011,7
1993	115.086,8	121.244,9	55.441,8	24.925,4	73.674,5	74.778,2	33.524,1	16.092,6	41.264,5
1994	126.348,3	127.398,0	68.977,1	25.340,9	82.739,1	79.378,2	34.331,1	15.413,1	42.211,3
1995	138.716,4	136.434,8	74.505,8	24.995,4	89.484,9	88.142,5	37.729,4	17.844,9	45.077,8
1996	152.204,5	146.271,1	110.676,8	24.574,1	95.817,0	87.166,0	40.869,2	19.203,8	50.845,0
1997	172.580,9	145.616,9	151.088,6	40.480,9	99.643,3	89.123,4	42.656,9	24.282,0	48.937,3
1998	169.773,1	156.306,2	140.428,2	67.990,8	103.680,5	81.611,5	46.181,9	28.358,8	53.976,9
1999	185.139,1	161.986,0	145.511,4	87.742,1	105.768,6	72.721,9	47.294,3	26.427,6	57.534,6
2000	174.088,6	169.217,1	107.896,6	127.209,6	106.035,1	74.161,7	47.417,7	23.888,6	47.287,0
2001	177.264,4	168.890,9	80.392,4	159.173,4	96.986,4	63.054,7	45.384,6	26.999,8	47.672,2
2002	183.214,2	171.575,7	82.432,9	157.268,4	96.409,7	61.755,7	44.184,6	27.035,6	56.494,9
2003	183.182,4	162.097,4	76.586,0	182.358,3	93.633,4	66.342,0	44.678,5	23.137,6	57.156,3
2004	196.857,4	171.473,6	91.697,4	205.045,3	94.063,7	67.974,6	46.293,7	25.392,5	63.823,3
2005	216.223,5	182.913,6	89.546,5	202.190,1	93.837,8	79.699,4	44.760,6	27.228,3	66.299,3
2006	224.150,7	188.137,9	116.900,6	166.373,1	92.619,0	89.061,7	44.822,7	29.005,9	66.033,9
2007	342.118,3	198.240,8	142.652,4	97.670,3	98.630,7	113.142,9	56.245,7	32.412,6	60.752,0

Año/Tipo	Diésel	Leña	Carbón	Gas natural	Gasolina	Petróleo combustible	Gas Licuado	Kerosene Aviación	Otros
2008	357.125,7	203.525,0	154.465,4	58.529,3	102.347,2	115.570,0	56.829,6	37.789,8	64.893,6
2009	328.820,1	203.964,1	141.962,2	80.175,0	111.048,7	87.697,9	58.654,9	30.834,1	70.682,7
2010	298.574,3	194.220,1	165.536,1	127.843,2	122.720,6	72.985,0	57.303,1	29.288,2	52.559,4

Fuente: BNE, Ministerio de Energía.

1A1a. Producción de electricidad y calor como actividad principal: consumo de combustible por tipo (TJ), serie 1990-2010

Año/Tipo	Kerosene Aviación	Kerosene	Diésel	Petróleo Combustible	Gas Licuado	Nafta	Gas Refinaría	Carbón	Coque	Gas Corriente	Gas Alto Horno	Gas Natural	Leña
1990	-	-	7.911,2	12.556,8	3,8	-	-	69.076,6	-	37,7	41,5	2.618,8	3.707,0
1991	-	-	3.945,6	11.745,4	3,8	-	-	46.059,0	1.340,2	37,7	-	1.058,8	3.977,5
1992	-	-	1.829,6	10.814,7	3,8	-	-	31.672,5	-	37,7	-	2.897,7	6.714,0
1993	-	-	1.905,2	12.978,5	-	-	-	33.482,3	-	41,5	-	2.965,5	7.179,3
1994	-	-	2.135,9	15.615,5	3,8	-	-	51.472,3	-	37,7	-	3.093,6	7.839,6
1995	-	-	2.843,9	19.087,8	-	-	-	58.249,9	-	30,1	-	3.108,7	9.506,1
1996	-	-	3.408,7	22.826,6	7,5	-	-	89.373,5	1.344,4	-	-	3.161,5	12.688,1
1997	-	-	8.346,4	17.314,2	6,8	-	-	109.797,5	1.340,2	-	-	6.920,1	13.035,2
1998	-	-	7.779,9	16.331,5	7,5	-	-	115.887,3	1.841,6	22,6	-	33.837,7	17.035,5
1999	-	-	22.126,6	15.142,2	-	-	-	120.835,2	7.087,8	11,3	-	47.768,5	15.468,3
2000	-	-	6.145,2	6.642,4	-	-	-	87.205,8	5.739,5	-	-	69.201,5	13.169,4
2001	-	-	2.808,1	4.991,7	-	-	103,4	53.154,8	5.453,1	-	-	93.675,5	19.481,6
2002	-	-	2.414,3	3.480,3	22,6	-	83,5	61.077,9	9.744,8	-	-	83.154,9	17.397,4
2003	-	-	1.964,9	3.186,0	11,3	-	596,6	58.309,6	14.660,9	-	-	107.206,8	17.115,0
2004	-	0,4	3.747,6	3.627,1	5,6	1,1	344,2	70.804,4	22.229,9	-	-	121.547,0	17.959,8
2005	-	-	9.840,2	4.964,0	2,1	1,2	836,3	71.831,1	21.579,9	-	-	113.530,1	22.711,2
2006	2,7	-	5.302,6	4.270,6	4,3	-	721,2	99.061,2	18.523,9	-	-	84.966,4	20.048,3
2007	-	-	100.485,1	11.679,4	3,0	-	520,9	125.240,4	18.676,2	-	-	38.477,0	20.660,4
2008	-	-	104.218,4	12.308,7	144,8	0,1	682,0	138.583,7	19.185,0	-	-	19.871,8	21.447,0
2009	-	-	79.922,9	10.220,5	491,1	0,1	749,9	133.269,8	20.016,1	-	-	32.375,7	23.388,2
2010	-	-	53.336,9	10.308,0	-	-	338,9	155.586,9	9.713,8	-	-	73.790,2	19.996,9

Fuente: BNE, Ministerio de Energía.

1A2f. Otras industrias (Minería y cantería): consumo de combustible por tipo (TJ), serie 1990-2010

Año/Tipo	Kerosene Aviación	Kerosene	Diésel	Petróleo Combustible	Gas Licuado	Nafta	Carbón	Coque	Gas Corriente	Gas Natural	Leña
1990	-	795,5	8.531,7	19.064,0	64,1	-	3.842,2	111,4	-	-	15,9
1991	-	815,4	8.603,2	17.302,0	64,1	-	3.874,1	115,4	-	-	11,9
1992	-	735,8	8.440,2	16.944,0	90,4	-	3.496,2	99,4	-	-	95,5
1993	-	712,0	8.304,9	15.663,2	98,0	-	4.057,0	103,4	-	-	99,4
1994	-	620,5	10.313,6	15.010,9	79,1	-	3.030,8	87,5	-	-	23,9
1995	-	497,2	10.731,2	13.396,1	94,2	-	2.167,7	83,5	-	-	23,9
1996	-	485,3	12.385,8	14.430,2	67,8	-	2.983,1	39,8	-	-	27,8
1997	-	1.046,1	27.671,2	19.290,7	171,1	159,1	4.182,7	43,8	-	-	9,6
1998	-	783,6	30.021,9	15.718,9	113,1	135,2	2.597,3	330,1	-	199,7	83,5
1999	-	990,4	30.403,7	14.764,3	324,1	163,1	2.239,3	123,3	-	1.616,5	83,5
2000	-	600,6	32.830,0	17.115,0	569,0	198,9	2.394,4	234,7	-	2.027,3	15,9
2001	-	632,4	35.904,5	12.115,3	293,9	222,7	2.434,2	186,9	-	3.640,0	8,0
2002	-	385,8	37.837,6	11.176,7	520,0	226,7	2.708,6	314,2	-	5.810,4	8,0

Año/Tipo	Kerosene Aviación	Kerosene	Diésel	Petróleo Combustible	Gas Licuado	Nafta	Carbón	Coque	Gas Corriente	Gas Natural	Leña
2003	-	600,6	32.822,0	7.768,0	437,1	131,3	2.760,4	576,7	-	7.374,2	8,0
2004	-	451,4	35.018,6	6.544,4	297,7	74,6	2.855,5	334,3	0,0	8.851,0	-
2005	0,0	889,7	39.158,0	5.959,9	210,3	54,7	2.461,9	304,9	0,0	9.544,1	-
2006	-	608,1	44.543,8	6.506,1	200,5	4,5	4.242,2	154,4	-	6.264,0	-
2007	-	543,4	50.722,8	8.866,4	267,2	22,7	2.254,0	425,8	0,0	2.475,0	-
2008	-	546,6	51.435,4	8.925,2	329,1	69,6	2.331,6	556,4	-	1.067,0	-
2009	-	551,9	57.807,0	8.853,8	292,0	-	1.412,1	339,5	-	2.583,6	-
2010	-	1.509,6	63.097,5	10.357,2	913,4	-	2.285,8	409,0	-	3.641,7	-

Fuente: BNE, Ministerio de Energía.

1A3b. Transporte terrestre: consumo de combustible por tipo (TJ), serie 1990-2010

Año/Tipo	Gasolina	Gasolina aviación	Kerosene Aviación	Kerosene	Diésel	Petróleo Combustible	Gas Licuado	Nafta	Gas Natural
1990	61.217,1	-	-	-	44.830,0	-	-	-	233,6
1991	63.345,0	-	-	-	47.475,0	-	-	-	286,4
1992	69.832,3	-	-	-	50.808,1	-	-	-	169,6
1993	73.674,5	-	-	-	59.685,8	-	-	-	222,3
1994	82.739,1	-	-	-	67.736,1	-	-	-	260,0
1995	89.484,9	-	-	-	75.098,4	-	-	-	260,0
1996	95.817,0	-	-	-	82.082,8	-	-	-	256,2
1997	99.643,3	-	-	-	86.668,9	-	-	-	218,6
1998	103.680,5	-	-	-	92.300,9	-	-	-	229,9
1999	105.768,6	-	-	-	99.364,9	-	-	-	237,4
2000	106.035,1	-	-	-	105.136,2	-	-	-	327,8
2001	96.986,4	-	-	-	101.146,8	-	-	-	418,3
2002	96.409,7	-	-	-	109.109,7	-	-	-	953,3
2003	93.633,4	-	-	-	111.555,8	-	-	-	968,4
2004	93.816,0	0,7	1,8	170,7	110.696,4	6,1	72,0	-	1.107,2
2005	93.622,5	0,8	4,6	594,0	125.869,1	10,8	21,9	0,2	1.290,2
2006	92.397,2	0,6	6,2	52,1	125.883,4	3,5	104,9	0,6	1.347,2
2007	98.621,2	0,7	6,3	82,5	134.359,3	2,6	163,4	0,2	953,2
2008	102.148,8	1,9	6,7	50,8	139.236,2	7,6	135,3	9,8	541,2
2009	110.889,6	-	-	-	139.871,9	-	-	-	841,4
2010	122.636,3	0,8	-	20,0	138.539,7	3.217,4	298,4	-	742,7

Fuente: BNE, Ministerio de Energía.

1A4b. Residencial: consumo de combustible por tipo (TJ), serie 1990-2010

Año/Tipo	Kerosene	Diésel	Petróleo Combustible	Gas Licuado	Metanol	Carbón	Gas Corriente	Gas Natural	Leña
1990	4.911,0	5.352,4	530,5	20.114,3	-	640,0	1.779,9	5.420,9	64.735,5
1991	6.109,4	5.230,4	254,6	21.591,3	-	99,4	1.835,1	5.697,4	67.974,8
1992	8.022,5	6.546,9	377,9	23.882,3	-	488,2	2.019,7	5.916,0	70.707,3
1993	8.420,3	7.390,1	163,1	25.272,8	-	222,7	2.080,0	6.044,1	74.235,3
1994	8.754,4	7.891,3	533,0	26.452,2	-	326,2	2.162,9	6.096,8	78.698,0
1995	8.022,5	867,1	6.964,5	28.517,1	6.345,5	254,6	2.215,7	-	83.395,4
1996	6.531,0	2.931,4	871,1	30.936,3	-	282,4	2.313,6	6.511,3	88.383,1
1997	8.006,9	3.055,1	77,3	32.041,8	-	-	1.938,5	6.680,2	107.858,6

Año/Tipo	Kerosene	Diésel	Petróleo Combustible	Gas Licuado	Metanol	Carbón	Gas Corriente	Gas Natural	Leña
1998	6.892,9	994,4	51,7	32.371,9	-	-	2.106,4	6.454,8	107.840,9
1999	8.396,4	855,2	63,6	34.629,0	-	-	1.235,9	7.822,6	110.008,6
2000	6.829,3	791,5	55,7	36.562,1	-	-	1.021,2	10.147,6	111.082,5
2001	5.783,2	739,8	55,7	37.002,9	-	-	960,9	13.267,6	113.305,9
2002	5.636,1	1.893,3	43,8	32.925,8	-	-	738,6	12.747,6	113.874,7
2003	3.766,7	449,5	4,0	30.476,6	-	-	712,2	12.687,3	114.443,5
2004	3.188,7	450,7	3,8	34.548,7	-	5,0	418,7	12.957,5	115.037,8
2005	2.474,4	451,3	6,1	32.488,5	-	26,9	403,5	14.459,6	115.614,4
2006	1.999,1	598,1	-	33.326,5	-	1,1	517,3	14.564,2	116.191,0
2007	2.758,2	582,7	-	34.967,4	-	0,4	559,1	16.211,7	116.772,0
2008	2.270,9	209,0	-	33.783,7	-	0,6	442,4	14.899,7	117.355,8
2009	3.344,5	252,8	-	35.143,0	-	0,4	425,1	15.446,4	117.942,6
2010	4.640,7	128,7	6,4	35.494,4	-	-	264,5	16.394,5	118.532,3

Fuente: BNE, Ministerio de Energía.

Sector Procesos industriales y Utilización de disolventes y otros productos

2A1. Producción de Cemento

Año	Producción de cemento (ton) (1)	Importaciones de Clinker (ton) (2)	Exportaciones de Clínker (ton) (2)
1990	2.017.082,0	21,0	-
1991	2.161.157,5	-	-
1992	2.621.486,0	59.612,0	-
1993	3.020.173,0	219.594,9	-
1994	2.995.353,0	92.067,8	-
1995	3.274.389,0	103.185,3	-
1996	3.634.035,0	533.246,4	-
1997	3.736.078,0	681.113,6	-
1998	3.847.622,0	369.768,6	-
1999	3.036.227,0	40.100,0	-
2000	3.376.570,7	291.935,7	-
2001	3.512.648,4	276.680,0	0,1
2002	3.461.682,0	265.429,2	-
2003	3.622.411,2	150.042,6	2,6
2004	3.797.603,1	247.095,2	1,1
2005	3.999.122,0	403.231,2	-
2006	4.111.533,2	362.677,7	8.124,2
2007	4.439.966,7	437.809,4	28.168,4
2008	4.622.328,7	632.233,6	3.002,0
2009	3.876.297,4	527.558,9	-
2010	3.871.103,0	617.201,8	5.760,0

Fuente: INACESA, SOPROCAL, CMPC Y ARAUCO.

2A2 Producción de cal

Año/Región	II Región (ton)	III Región (ton)	RM (ton)	VII Región (ton)	VIII Región (ton)	XIV Región (ton)	IX Región (ton)
1990	80.590,0	-	79.611,0	74.327,4	110.886,2	-	-
1991	65.490,0	-	88.520,0	91.545,4	138.891,5	-	-
1992	50.233,0	-	92.660,0	69.083,4	222.385,3	-	53.521,0
1993	28.372,0	-	102.171,0	68.749,1	239.579,1	-	77.563,0
1994	47.202,0	-	98.088,0	66.742,8	253.611,9	-	92.421,0
1995	63.324,0	-	115.704,0	69.793,0	268.780,8	-	92.338,0
1996	81.795,0	-	107.638,0	70.961,7	269.634,9	-	95.295,0
1997	55.134,0	-	126.697,0	67.876,9	257.023,2	-	97.162,0
1998	49.692,0	-	135.709,0	83.038,5	274.047,5	-	100.662,0
1999	144.966,0	-	103.307,0	79.162,2	289.254,9	-	100.674,0
2000	137.064,0	-	93.043,0	83.490,2	308.873,5	-	102.451,0
2001	154.155,0	-	94.487,0	88.171,1	298.938,6	-	109.166,0
2002	118.547,0	92.410,0	85.573,0	90.153,3	306.550,9	-	106.100,0
2003	169.092,0	105.697,0	72.708,0	87.742,6	319.134,5	-	126.395,0
2004	252.612,0	112.468,0	63.836,0	89.666,7	324.265,9	120.983,2	134.101,0
2005	297.281,0	109.512,0	98.864,0	121.554,9	312.264,3	92.256,2	136.539,0
2006	310.779,0	137.572,0	54.838,0	117.205,0	314.840,7	110.699,0	130.210,0
2007	347.510,0	134.511,0	82.184,0	97.386,6	687.797,0	113.548,1	137.688,0
2008	338.163,0	129.006,0	70.186,0	110.903,3	743.501,1	127.849,3	130.355,0
2009	328.938,0	109.739,0	64.377,0	112.584,8	742.997,4	127.061,0	125.646,0
2010	338.591,0	158.001,0	62.326,0	90.150,4	565.646,5	104.937,3	130.888,0

Fuente: INACESA, SOPROCAL, CMPC Y ARAUCO.

2B5 Otros, Metanol

Año	Producción metanol (ton)
1990	854.000,0
1991	693.000,0
1992	840.000,0
1993	807.000,0
1994	874.000,0
1995	841.000,0
1996	853.000,0
1997	1.635.000,0
1998	1.700.000,0
1999	2.309.000,0
2000	2.912.000,0
2001	2.784.000,0
2002	2.932.000,0
2003	2.703.000,0
2004	2.692.000,0
2005	3.029.000,0

Año	Producción metanol (ton)
2006	3.182.000,0
2007	1.841.000,0
2008	1.088.000,0
2009	942.000,0
2010	935.000,0

Fuente: BNE.

2C1 Hierro y acero

Año	Acero BOF (ton)	Acero EAF (ton)
1990	735.802,0	-
1991	763.466,0	-
1992	972.582,0	22.249,0
1993	1.022.434,0	41.243,0
1994	997.306,0	58.250,0
1995	950.138,0	73.269,0
1996	1.104.541,0	106.583,0
1997	1.087.436,0	126.780,0
1998	1.090.109,0	149.810,0
1999	1.149.575,0	182.851,0
2000	1.135.508,0	206.132,0
2001	1.001.359,0	205.172,0
2002	1.013.149,0	232.211,0
2003	1.077.027,0	274.104,0
2004	1.208.424,0	339.409,0
2005	1.152.869,0	355.509,0
2006	1.184.517,0	334.095,0
2007	1.219.445,0	447.622,0
2008	1.158.164,0	496.356,0
2009	967.927,0	417.454,0
2010	617.606,0	308.803,0

Fuente: Elaboración en base a información entregada por Empresa CAP.

Sector Agricultura

Población animal por especie (miles de cabezas)

Año	Vacas lecheras	Otros vacunos	Porcinos	Ovinos	Caprinos	Equinos	Mulas y asnos	Llamas y Alpacas	Aves de corral
1990	590,4	2.813,5	1.455,5	4.323,6	856,6	408,0	18,2	117,0	20.178,0
1991	601,0	2.859,6	1.492,8	4.233,8	838,1	406,6	18,4	118,3	23.694,3
1992	618,6	2.938,9	1.530,2	4.144,0	819,7	405,2	18,6	119,6	26.502,7
1993	642,7	3.049,0	1.567,5	4.054,2	801,2	403,8	18,8	120,9	28.202,1
1994	664,8	3.149,4	1.604,8	3.964,4	782,7	402,5	19,0	122,2	29.947,5
1995	673,3	3.185,0	1.642,2	3.874,6	764,3	401,1	19,1	123,5	29.799,8
1996	683,8	3.229,8	1.722,4	3.710,5	738,2	398,7	17,1	124,6	29.020,2
1997	716,7	3.380,6	1.716,9	3.695,1	727,3	398,3	19,5	126,1	41.694,1
1998	731,0	3.429,0	1.838,6	3.714,5	725,2	389,0	20,0	121,4	34.861,7

Año	Vacas lecheras	Otros vacunos	Porcinos	Ovinos	Caprinos	Equinos	Mulas y asnos	Llamas y Alpacas	Aves de corral
1999	729,8	3.404,2	1.960,4	3.733,9	723,0	379,7	20,4	116,7	35.902,9
2000	721,5	3.346,5	2.082,1	3.753,3	720,9	370,4	20,8	112,0	41.881,1
2001	709,3	3.270,7	2.203,9	3.772,8	718,7	361,1	21,3	107,2	39.822,3
2002	703,2	3.223,8	2.325,6	3.792,2	716,6	351,7	21,7	102,5	35.090,5
2003	707,6	3.224,4	2.447,4	3.811,6	714,4	342,4	22,2	97,8	38.664,7
2004	721,4	3.267,6	2.569,1	3.831,0	712,3	333,1	22,6	93,1	42.496,9
2005	724,3	3.260,7	2.690,9	3.850,5	710,1	323,8	23,1	88,4	46.658,2
2006	712,5	3.187,5	2.812,7	3.869,9	708,0	314,5	23,5	83,7	47.313,4
2007	683,2	3.036,6	2.934,4	3.889,3	705,8	305,2	24,0	78,9	52.153,2
2008	697,9	3.102,1	3.056,2	3.908,7	703,6	295,9	24,4	74,2	53.199,1
2009	707,1	3.142,9	3.177,9	3.928,2	701,5	286,5	24,9	69,5	54.245,0
2010	703,4	3.126,6	3.299,7	3.947,6	699,3	277,2	25,3	64,8	55.290,9

Fuente: ODEPA y FAOSTAT.

Consumos regionales de nitrógeno (ton N), aplicados como fertilizantes sintéticos, desagregados regionalmente

Año/Región	XV	I	II	III	IV	V	RM	VI	VII	VIII	IX	XIV	X	XIV	XII
1990	634,5	252,4	165,6	1.812,2	13.889,4	8.836,3	13.390,1	21.284,9	25.655,5	24.986,4	30.901,5	9.655,2	10.307,8	1.679,2	646,9
1991	608,6	242,1	158,9	1.738,3	13.322,5	8.475,6	12.843,6	20.416,1	24.608,3	23.966,6	29.640,2	9.261,1	9.887,1	1.610,6	620,5
1992	672,8	267,7	175,6	1.921,6	14.727,6	9.369,5	14.198,1	22.569,3	27.203,6	26.494,2	32.766,1	10.237,8	10.929,8	1.780,5	685,9
1993	754,0	300,0	196,8	2.153,5	16.505,0	10.500,3	15.911,7	25.293,2	30.486,8	29.691,8	36.720,7	11.473,4	12.248,9	1.995,4	768,7
1994	754,0	300,0	196,8	2.153,5	16.505,0	10.500,3	15.911,7	25.293,2	30.486,8	29.691,8	36.720,7	11.473,4	12.248,9	1.995,4	768,7
1995	831,3	330,7	217,0	2.374,4	18.197,8	11.577,2	17.543,6	27.887,3	33.613,7	32.737,1	40.486,9	12.650,2	13.505,2	2.200,0	847,6
1996	869,9	346,1	227,1	2.484,8	19.044,2	12.115,7	18.359,6	29.184,4	35.177,1	34.259,7	42.370,0	13.238,5	14.133,4	2.302,4	887,0
1997	850,6	338,4	222,1	2.429,6	18.621,0	11.846,5	17.951,6	28.535,9	34.395,4	33.498,4	41.428,5	12.944,4	13.819,3	2.251,2	867,3
1998	831,3	330,7	217,0	2.374,4	18.197,8	11.577,2	17.543,6	27.887,3	33.613,7	32.737,1	40.486,9	12.650,2	13.505,2	2.200,0	847,6
1999	912,5	363,0	238,2	2.606,3	19.975,0	12.707,8	19.256,9	30.610,7	36.896,2	35.934,0	44.440,7	13.885,5	14.824,1	2.414,9	930,4
2000	908,6	361,5	237,2	2.595,3	19.890,7	12.654,2	19.175,6	30.481,5	36.740,5	35.782,4	44.253,1	13.826,9	14.761,5	2.404,7	926,4
2001	873,8	347,7	228,1	2.495,9	19.128,9	12.169,5	18.441,2	29.314,1	35.333,4	34.412,0	42.558,3	13.297,4	14.196,2	2.312,6	890,9
2002	952,4	378,9	248,6	2.720,2	20.848,5	13.263,5	20.099,0	31.949,3	38.509,7	37.505,4	46.384,0	14.492,7	15.472,3	2.520,5	971,0
2003	854,8	340,1	223,1	2.441,5	18.711,9	11.904,2	18.039,2	28.675,1	34.563,1	33.661,8	41.630,5	13.007,5	13.886,7	2.262,2	871,5
2004	1.131,6	450,2	295,4	3.232,3	24.772,8	15.760,1	23.882,2	37.963,1	45.758,4	44.565,0	55.114,9	17.220,7	18.384,7	2.994,9	1.153,8
2005	930,7	370,3	243,0	2.658,3	20.373,8	12.961,5	19.641,4	31.221,9	37.632,9	36.651,5	45.328,0	14.162,8	15.120,1	2.463,1	948,9
2006	1.048,4	417,1	273,7	2.994,5	22.950,8	14.601,0	22.125,7	35.171,0	42.392,9	41.287,4	51.061,3	15.954,2	17.032,5	2.774,7	1.069,0
2007	1.254,2	499,0	327,4	3.582,5	27.456,8	17.467,7	26.469,8	42.076,3	50.716,1	49.393,5	61.086,4	19.086,5	20.376,6	3.319,4	1.278,8
2008	1.525,7	607,0	398,3	4.357,8	33.399,3	21.248,2	32.198,6	51.182,9	61.692,6	60.083,8	74.307,4	23.217,4	24.786,7	4.037,8	1.555,6
2009	1.336,6	531,8	348,9	3.817,9	29.261,0	18.615,5	28.209,1	44.841,1	54.048,7	52.639,2	65.100,5	20.340,7	21.715,6	3.537,5	1.362,9
2010	1.594,9	634,6	416,4	4.555,6	34.915,4	22.212,7	33.660,2	53.506,2	64.493,1	62.811,1	77.680,4	24.271,3	25.911,8	4.221,1	1.626,2

Fuente: INE, 2007 y FAOSTAT.

Cosecha anual (ha) por tipo de cultivo

Año	Cultivos anuales (ha)	Huertos frutales (ha)	Hortalizas (ha)	Forrajeras anuales (ha)	Forrajeras permanentes leñosas (ha)
1990	1.083.946,9	238.925,3	74.566,8	526.378,6	39.157,1
1991	981.013,8	245.003,3	81.396,5	525.471,2	40.906,6
1992	966.828,6	251.144,2	84.797,5	524.563,8	42.656,2
1993	856.728,5	254.913,0	85.218,4	523.656,4	44.405,7
1994	820.084,7	250.345,7	92.713,2	522.749,0	46.155,2

Año	Cultivos anuales (ha)	Huertos frutales (ha)	Hortalizas (ha)	Forrajeras anuales (ha)	Forrajeras permanentes leñosas (ha)
1995	859.763,0	254.403,2	93.274,2	521.841,7	47.904,7
1996	848.011,8	264.025,9	86.883,5	520.934,3	49.654,3
1997	832.919,3	278.471,9	67.599,0	520.026,9	51.403,8
1998	848.183,7	295.013,7	67.078,8	507.355,1	52.022,0
1999	772.395,7	311.555,4	66.558,6	494.683,4	52.640,2
2000	823.535,2	329.933,1	66.038,4	482.011,7	53.258,4
2001	862.542,1	350.415,7	65.518,1	469.339,9	53.876,6
2002	855.600,3	374.169,6	64.997,9	456.668,2	54.494,8
2003	857.433,0	400.496,4	64.477,7	443.996,4	55.113,0
2004	883.684,6	432.976,4	63.957,5	431.324,7	55.731,2
2005	868.403,6	469.347,6	63.437,3	418.653,0	56.349,4
2006	785.991,3	511.776,7	62.917,0	405.981,2	56.967,6
2007	601.889,7	566.718,1	62.396,8	393.309,5	57.585,8
2008	686.794,0	569.020,6	63.106,4	380.689,9	58.204,0
2009	686.233,8	574.507,5	63.818,4	368.239,5	58.822,3
2010	654.976,0	587.081,8	62.834,4	355.974,0	59.440,5

Fuente: INE, 2007.

Sector Uso de la tierra, cambio en el uso de la tierra y silvicultura

Plantaciones forestales: superficie anual (ha) por especie, serie 1990-2010

Año/Especie	*Pinus radiata*	*Eucalyptus globulus*	*Eucalyptus nitens*	*P. chilensis / P. tamarugo*	*Pseudotsuga menziensii*	*Populus spp.*	Otras especies
1990	1.243.293,0	107.700,0	-	23.882,1	11.343,0	3.526,0	3.735,0
1991	1.305.325,0	130.915,0	-	23.874,1	11.731,0	3.660,0	7.608,0
1992	1.312.812,0	171.520,0	-	23.882,1	12.135,0	3.718,0	7.956,0
1993	1.360.918,0	206.711,0	-	23.895,3	12.090,0	3.798,0	7.299,8
1994	1.375.886,0	238.312,0	-	23.941,9	12.379,0	3.798,0	9.032,8
1995	1.379.746,0	302.248,0	-	23.862,0	12.477,0	3.842,0	47.736,0
1996	1.387.041,0	308.762,0	-	23.880,0	12.477,0	4.055,0	50.454,0
1997	1.420.015,0	317.211,0	-	23.951,0	12.620,0	4.115,0	54.693,0
1998	1.437.520,0	330.952,0	-	24.057,0	13.225,0	4.287,0	55.481,0
1999	1.458.320,0	342.415,0	-	24.113,0	13.942,0	4.298,0	58.413,0
2000	1.474.773,0	358.616,0	-	24.165,0	14.286,0	4.151,0	60.216,0
2001	1.497.340,0	376.786,0	-	24.263,0	14.184,0	4.077,0	67.071,0
2002	1.513.004,0	387.975,0	-	24.422,0	14.922,0	3.942,0	73.200,0
2003	1.446.414,0	436.706,0	-	24.539,0	15.627,0	5.084,0	59.511,0
2004	1.408.430,0	489.602,1	-	25.254,0	16.460,0	6.009,0	65.086,0
2005	1.424.569,0	525.057,0	-	26.039,0	16.769,0	5.983,0	78.434,0
2006	1.419.300,0	552.337,0	-	26.306,0	16.665,0	3.103,0	42.725,0
2007	1.461.212,0	478.569,0	160.342,0	25.799,0	16.075,0	6.395,0	92.091,0
2008	1.457.224,0	500.269,0	167.900,0	25.878,0	16.677,0	6.278,0	73.613,0
2009	1.478.368,9	496.259,0	184.664,2	24.739,0	17.045,3	6.422,5	97.329,2
2010	1.471.806,1	500.428,1	196.965,7	25.878,0	16.866,7	7.060,3	93.600,4

Fuente: INFOR.

5A1c. Cosecha: superficie anual (ha) por especie, serie 1990-2010

Especie	Trozas *Pino radiata*	Trozas *Eucalyptus spp.*	Trozas Otras exótica	Trozas Especies nativas
1990	26.253,0	7.272,9	302,1	11.621,8
1991	27.860,7	9.403,9	400,1	15.027,1
1992	34.310,4	7.339,6	305,7	11.728,4
1993	35.826,2	7.776,8	328,2	12.427,0
1994	39.010,2	7.202,4	325,7	11.368,9
1995	45.344,8	10.459,5	327,0	14.428,8
1996	44.233,2	8.241,3	275,8	10.832,3
1997	45.141,6	9.344,1	362,7	10.588,3
1998	40.348,1	11.260,1	281,5	7.890,7
1999	43.654,1	15.424,3	387,4	6.644,7
2000	46.127,8	19.401,5	354,6	4.957,1
2001	49.913,0	19.400,3	405,5	3.818,6
2002	49.412,6	21.377,2	368,9	2.482,9
2003	54.013,8	22.034,4	345,4	2.194,8
2004	63.245,9	25.771,5	506,5	2.147,1
2005	62.910,0	28.607,9	724,3	2.252,4
2006	62.459,8	32.148,9	764,9	1.808,5
2007	67.180,8	37.541,4	716,5	1.728,7
2008	66.017,7	44.300,3	699,8	1.742,6
2009	60.449,8	39.525,7	669,4	1.417,4
2010	56.025,8	38.660,9	746,0	1.480,9

Fuente: INFOR.

5A1f. Incendios forestales: superficie anual (ha) afectada, serie 1990-2010

Componente	Bosque nativo (ha)	Plantaciones forestales (ha)
1990	4.906,6	2.401,6
1991	7.673,8	5.901,2
1992	1.941,4	1.866,0
1993	5.912,7	10.430,2
1994	11.520,4	9.532,0
1995	2.353,6	5.237,3
1996	12.582,8	6.500,7
1997	5.554,9	14.595,2
1998	61.181,1	2.965,8
1999	14.399,1	36.499,0
2000	1.147,5	3.087,6
2001	687,7	1.594,6
2002	31.281,7	22.241,9
2003	4.748,8	6.002,0
2004	6.097,0	10.806,4
2005	8.951,9	7.470,1
2006	2.241,1	1.800,7
2007	2.408,5	25.040,7
2008	8.683,0	8.514,6
2009	10.950,4	21.667,6
2010	9.734,8	15.598,2

Fuente: CONAF.

Sector Residuos

Año	Residuos Sólidos Municipales	Población Nacional	Consumo proteína nacional	Producción total de aguas residuales industriales
	Residuos (Gg)	Población (1.000 hab)	(kg/persona/año)	Producción RILES (1.000 t/año)
1990	3.848,0	13.735,0	25,6	55,1
1991	3.920,0	13.768,0	25,6	62,4
1992	3.933,0	13.645,0	28,1	74,8
1993	4.063,0	13.372,0	28,5	78,8
1994	4.135,0	13.398,0	28,5	89,5
1995	4.207,0	13.424,0	28,4	113,9
1996	4.269,0	13.445,0	28,8	119,1
1997	4.332,0	13.467,0	28,5	128,4
1998	4.395,0	14.671,0	28,4	121,4
1999	4.458,0	14.795,0	28,0	110,2
2000	4.520,0	15.326,0	28,7	118,3
2001	4.515,0	15.582,0	29,1	106,6
2002	4.647,0	15.849,0	30,1	103,4
2003	4.802,0	15.853,0	30,9	112,2
2004	4.964,0	15.444,0	31,3	143,5
2005	5.114,0	15.825,0	31,8	175,5
2006	5.311,0	16.018,0	32,5	72,2
2007	5.493,0	16.467,0	31,8	314,1
2008	5.608,0	16.893,0	32,2	227,1
2009	5.780,0	17.268,0	32,6	260,3
2010	5.936,0	17.694,0	33,1	325,3
Fuente	MMA, 2014; INE 1982, 1992, 2002.	INE	MINSAL	SISS

Anexo 3. Análisis de categorías principales

Según las GL2006 del IPCC, se entiende por categoría principal aquella categoría prioritaria en el sistema de inventarios nacionales porque su estimación influye significativamente sobre el INGEI de un país, en cuanto al nivel absoluto, la tendencia, o la incertidumbre de emisiones y absorciones. Siempre que se utiliza el término categoría principal, incluye tanto las categorías de emisión como de absorción.

La identificación de categorías principales es importante para los INGEI porque permite priorizar los recursos limitados disponibles para elaborar los inventarios. Es una buena práctica orientar los recursos disponibles a la mejora de los datos y los métodos destinados a las categorías identificadas como principales. Además, se sugiere que para estas categorías se empleen métodos de nivel superior (Nivel 2 y 3) para la estimación de emisiones o absorciones.

De modo de ser consistentes con las metodologías de estimación de las emisiones, se decidió utilizar, para la identificación de categorías principales, las metodologías establecidas en las GL2006.

El Método 1 para identificar categorías principales evalúa la influencia que ejercen diversas categorías de emisión y absorción sobre el nivel y la tendencia del INGEI. Este consiste en la evaluación de la estimación de emisiones o absorciones de una categoría frente al aporte total del año, que es la suma de los valores absolutos de emisiones y absorciones. La evaluación se calcula según la siguiente ecuación:

$$L_{x,t} = |E_{x,t}| / \sum_{y} |E_{y,t}|$$

Donde:

- $L_{x,t}$ *= Evaluación de nivel para x de emisión o absorción del año t del inventario*
- $|E_{x,t}|$*= Valor absoluto de la estimación de emisión o absorción de la categoría x*
- $\sum_y |E_{y,t}|$ *= Aporte total, que es la suma de los valores absolutos de emisiones y absorciones del año t*

Las categorías principales, según el Método 1 de nivel, son aquellas que al sumarse acumuladas en orden de magnitud descendente, totalizan 95 por ciento de la suma de todos los $L_{x,t}$. El Método 1 de nivel fue aplicado al año 1990 (Cuadro 3A) y al último año del inventario (2010) (Cuadro 3B).

El Método de 1 de tendencia tiene por objeto identificar las categorías cuya tendencia es significativamente diferente de la tendencia general del inventario general. Las categorías cuya tendencia es más divergente de la tendencia total deben identificarse como principales, cuando esta diferencia se pondera por el nivel de emisiones o absorciones de la categoría del año base. La evaluación de tendencia se estima con la ecuación siguiente:

$$T_{x,t} = \frac{|E_{x,0}|}{\sum_y |E_{y,0}|} \cdot \left| \left[\frac{(E_{x,t} - E_{x,0})}{|E_{x,0}|} \right] - \frac{(\sum_y E_{y,t} - \sum_y E_{y,0})}{|\sum_y E_{y,0}|} \right|$$

Donde:

- $T_{x,t}$ *= evaluación de la tendencia de la categoría x de emisión o absorción del año t, en comparación con el año base (año 0).*
- $|E_{x,0}|$ *= valor absoluto de las estimación de emisión o absorción de la categoría x del año 0.*
- $E_{x,t}$ *y* $E_{x,0}$ *= valores reales de las estimaciones de la categoría x de emisión o absorción de los años t y 0, respectivamente.*
- $\sum_y E_{y,t}$ *y* $\sum_y E_{y,0}$ *= estimaciones totales del inventario de los años t y 0, respectivamente.*

La tendencia de la categoría se refiere al cambio producido en las estimaciones de una categoría a través del tiempo, calculado restando la estimación del año base (año *0*) para la categoría *x*, a la estimación del último año del inventario (año *t*) y dividiendo por el valor absoluto de la estimación del año base.

La tendencia total se refiere al cambio generado en el balance del INGEI, calculado restando la estimación del último año *t* y dividiendo por el valor absoluto de la estimación del año 0.

Para aquellas categorías cuyas estimaciones del año base son cero, la expresión anterior puede reformularse para evitar el cero en el denominador:

$$T_{x,t} = \left| \frac{E_{x,t}}{\sum_y |E_{y,0}|} \right|$$

Las categorías principales según el Método 1 de tendencia, son aquellas que al sumarse acumuladas en orden de magnitud descendente, totalizan 95 por ciento de la suma de todos los $T_{x,t}$. El Método 1 de tendencia fue aplicado al último año del inventario (2010) (Cuadro 3C).

Las consideraciones de desagregación, para el Método 1, fueron las siguientes:

- Se consideró hasta el sexto nivel de subcategoría (p.e. 5A1a Plantaciones de árboles de bosque, *Pinus radiata*), cuando correspondiese, de modo de reflejar de mejor manera las circunstancias nacionales.
- Cada GEI fue considerado por separado, en unidades de CO_2eq.
- Las emisiones y absorciones también fueron separadas.
- A pesar de que la metodología aplicada corresponde a las GL2006, la identificación de categorías clave se aplicó al INGEI bajo los códigos y nombres de las GL1996.

Dado que la incertidumbre del INGEI fue determinada con otro nivel de desagregación, es que no fue posible aplicar el Método 2 para la identificación de categorías principales.

Para mayor detalle del análisis y su cálculo, ver anexo digital: *Annex_Categorías principales (GL2006).*

Cuadro 3A. Análisis de categorías principales, utilizando el Método 1 de las GL2006, para los niveles absolutos del INGEI de Chile del año 1990

Código y categorías del IPCC	GEI	Estimación año 1990 ($GgCO_2eq$)	Valor absoluto de la estimación año 1990	Evaluación de nivel	Total acumulativo
5.A.1.a. Renovales	CO_2	-45.706,68	45.706,68	0,25	0,250
5.A.1.a. Plantaciones forestales	CO_2	-39.889,96	39.889,96	0,22	0,469
5.A.1.c. Trozas P. radiata	CO_2	15.135,53	15.135,53	0,08	0,552
1.A.1.a. Producción de electricidad y calor como actividad principal	CO_2	8.252,36	8.252,36	0,05	0,597
1.A.3.b. Transporte terrestre	CO_2	7.577,35	7.577,35	0,04	0,639
5.A.1.e. Leña	CO_2	7.160,86	7.160,86	0,04	0,678
5.A.1.c. Trozas especies nativas	CO_2	6.566,47	6.566,47	0,04	0,714
5.A.1.a. Bosque nativo manejado	CO_2	-4.060,69	4.060,69	0,02	0,736
4.A.1. Ganado	CH_4	3.549,58	3.549,58	0,02	0,756
5.A.1.c. Trozas Eucalyptus spp.	CO_2	3.203,99	3.203,99	0,02	0,773
5.A.1.g. Substitución	CO_2	3.161,17	3.161,17	0,02	0,791
1.A.2.f. Industria no especificada	CO_2	2.628,30	2.628,30	0,01	0,805
1.A.2.f. Minería (con excepción de combustibles) y cantería	CO_2	2.544,38	2.544,38	0,01	0,819
1.A.4.b. Residencial	CO_2	2.503,66	2.503,66	0,01	0,833
4.D.2. Estiércol depositado en pastizales, prados y praderas	N_2O	2.464,39	2.464,39	0,01	0,846
5.A.1.a. Bosque nativo incendiado	CO_2	-1.953,05	1.953,05	0,01	0,857
1.A.1.b. Refinación del petróleo	CO_2	1.922,56	1.922,56	0,01	0,867
5.A.2.2. Tierra convertidas en tierras forestales	CO_2	1.707,05	1.707,05	0,01	0,877
1.A.2.a. Hierro y acero	CO_2	1.483,45	1.483,45	0,01	0,885
6.A.3. Otros	CH_4	1.426,44	1.426,44	0,01	0,893
4.D.1. Emisiones directas de suelos agrícolas	N_2O	1.282,87	1.282,87	0,01	0,900
5.C.2. Tierra convertida en pastizal	CO_2	1.247,01	1.247,01	0,01	0,907
2.C.1. Hierro y acero	CO_2	1.221,37	1.221,37	0,01	0,913
4.D.3. Emisiones indirectas de suelos agrícolas	N_2O	1.108,94	1.108,94	0,01	0,919
5.A.1.f. Bosque nativo incendiado	CO_2	990,88	990,88	0,01	0,925
1.A.3.d. Navegación nacional	CO_2	871,49	871,49	0,00	0,930
2.A.1. Producción de cemento	CO_2	786,65	786,65	0,00	0,934
4.B.1. Ganado	CH_4	767,08	767,08	0,00	0,938
1.B.2.b. Gas natural	CH_4	756,28	756,28	0,00	0,942
1.B.2.a. Petróleo	CH_4	634,19	634,19	0,00	0,946
2.B.5.a. Metanol	CO_2	572,18	572,18	0,00	0,949
1.A.3.a. Aviación nacional	CO_2	562,97	562,97	0,00	0,952
1.A.2.f. Minerales no metálicos	CO_2	533,52	533,52	0,00	0,955
6.A.2. Sitios de disposición de residuos no gestionados	CH_4	489,43	489,43	0,00	0,957
1.B.1.a. Extracción y manipulación de carbón	CH_4	481,46	481,46	0,00	0,960
5.A.1.f. Plantaciones forestales incendiadas	CO_2	471,14	471,14	0,00	0,963
4.A.3. Ovejas	CH_4	453,98	453,98	0,00	0,965
1.A.4.c. Agricultura / silvicultura / Pesca	CO_2	424,68	424,68	0,00	0,968
1.A.4.b. Residencial	CH_4	417,00	417,00	0,00	0,970
1.A.4.a. Comercial / Institucional	CO_2	406,17	406,17	0,00	0,972
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	CO_2	385,88	385,88	0,00	0,974
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	CO_2	326,03	326,03	0,00	0,976
6.B.2. Aguas residuales domésticas y comerciales	CH_4	304,43	304,43	0,00	0,978
4.B.8. Cerdos	CH_4	270,18	270,18	0,00	0,979
5.A.1.c. Trozas Otras exótica	CO_2	265,76	265,76	0,00	0,981
2.A.2. Producción de cal	CO_2	256,31	256,31	0,00	0,982
1.A.2.d. Pulpa, papel e imprenta	CO_2	244,93	244,93	0,00	0,983
5.B.1. Tierras de cultivo que permanecen como tales	CO_2	191,44	191,44	0,00	0,984
6.B.2. Aguas residuales domésticas y comerciales	N_2O	188,32	188,32	0,00	0,985
5.E.2. Tierra convertida en asentamiento	CO_2	187,35	187,35	0,00	0,986
4.A.6. Caballos	CH_4	154,22	154,22	0,00	0,987
2.B.2. Producción de ácido nítrico	N_2O	141,17	141,17	0,00	0,988
4.C.1. De regadío	CH_4	137,90	137,90	0,00	0,989
5.B.2. Tierra convertida en tierras de cultivo	CO_2	137,90	137,90	0,00	0,990
5.F.2. Tierras convertidas en otras tierras	CO_2	121,77	121,77	0,00	0,990
1.A.3.b. Transporte terrestre	N_2O	115,14	115,14	0,00	0,991
4.B.13. Almacenamiento sólido y parcelas secas	N_2O	107,91	107,91	0,00	0,991
5.A.1.d. Residuos	CH_4	106,14	106,14	0,00	0,992
4.F.F. Quema en el campo de los residuos agrícolas	CH_4	104,39	104,39	0,00	0,993
4.A.4. Cabras	CH_4	89,95	89,95	0,00	0,993
1.A.4.b. Residencial	N_2O	83,42	83,42	0,00	0,994
3.C.C. Productos químicas, fabricación y procesamiento	CO_2	82,35	82,35	0,00	0,994
5.A.1.b. Tierras en transición	CO_2	-68,14	68,14	0,00	0,994
1.A.4.a. Comercial / Institucional	CH_4	67,02	67,02	0,00	0,995
5.A.1.h. Restitución	CO_2	66,54	66,54	0,00	0,995
1.A.3.c. Ferrocarriles	CO_2	57,56	57,56	0,00	0,995
1.A.3.b. Transporte terrestre	CH_4	46,55	46,55	0,00	0,996
5.A.1.d. Residuos	N_2O	46,08	46,08	0,00	0,996
4.A.8. Cerdos	CH_4	45,85	45,85	0,00	0,996
2.C.5.b. Producción de cinc	CO_2	43,17	43,17	0,00	0,996
5.A.1.f. Bosque nativo incendiado	CH_4	41,29	41,29	0,00	0,997
2.B.5.a. Metanol	CH_4	41,25	41,25	0,00	0,997
1.A.1.a. Producción de electricidad y calor como actividad principal	N_2O	40,61	40,61	0,00	0,997
6.B.1. Aguas residuales industriales	CH_4	40,48	40,48	0,00	0,997
4.F.F. Quema en el campo de los residuos agrícolas	N_2O	39,95	39,95	0,00	0,997

Código y categorías del IPCC	GEI	Estimación año 1990 (GgCO_2eq)	Valor absoluto de la estimación año 1990	Evaluación de nivel	Total acumulativo
5.A.1.f. Plantaciones forestales incendiadas	CH_4	33,84	33,84	0,00	0,998
4.B.11. Lagunas anaeróbicas	N_2O	33,61	33,61	0,00	0,998
4.B.14. Otros SME	N_2O	31,59	31,59	0,00	0,998
2.C.2. Ferroaleaciones	CO_2	31,56	31,56	0,00	0,998
1.A.2.d. Pulpa, papel e imprenta	N_2O	25,02	25,02	0,00	0,998
5.C.2. Tierra convertida en pastizal	CO_2	-21,53	21,53	0,00	0,998
4.A.5. Camélidos	CH_4	19,66	19,66	0,00	0,999
1.B.2.c. Venteo y quema en antorcha	CH_4	19,63	19,63	0,00	0,999
5.A.1.f. Bosque nativo incendiado	N_2O	17,92	17,92	0,00	0,999
1.A.2.f. Industria no especificada	N_2O	15,79	15,79	0,00	0,999
5.A.1.f. Plantaciones forestales incendiadas	N_2O	14,69	14,69	0,00	0,999
4.B.3. Ovejas	CH_4	14,53	14,53	0,00	0,999
4.B.6. Caballos	CH_4	14,05	14,05	0,00	0,999
1.A.4.a. Comercial / Institucional	N_2O	13,53	13,53	0,00	0,999
2.A.7.a. Producción de vidrio	CO_2	12,98	12,98	0,00	0,999
1.A.2.d. Pulpa, papel e imprenta	CH_4	12,61	12,61	0,00	0,999
1.A.4.c. Agricultura / silvicultura / Pesca	CH_4	11,98	11,98	0,00	0,999
6.D.1. Tratamiento biológico de residuos sólidos	N_2O	8,37	8,37	0,00	0,999
4.B.9. Aves de corral	CH_4	7,63	7,63	0,00	0,999
6.D.1. Tratamiento biológico de residuos sólidos	CH_4	7,56	7,56	0,00	1,000
1.A.3.d. Navegación nacional	N_2O	7,26	7,26	0,00	1,000
1.A.2.f. Minería (con excepción de combustibles) y cantería	N_2O	7,14	7,14	0,00	1,000
1.A.2.f. Industria no especificada	CH_4	7,08	7,08	0,00	1,000
1.A.3.c. Ferrocarriles	N_2O	6,84	6,84	0,00	1,000
1.A.1.a. Producción de electricidad y calor como actividad principal	CH_4	5,13	5,13	0,00	1,000
1.A.3.a. Aviación nacional	N_2O	4,89	4,89	0,00	1,000
5.C.1. Pastizales que permanecen como tales	CH_4	4,80	4,80	0,00	1,000
4.B.5. Camélidos	CH_4	4,72	4,72	0,00	1,000
4.A.7. Mulas y asnos	CH_4	3,82	3,82	0,00	1,000
1.A.2.a. Hierro y acero	N_2O	3,47	3,47	0,00	1,000
5.B.2. Tierra convertida en tierras de cultivo	CO_2	-3,13	3,13	0,00	1,000
4.B.4. Cabras	CH_4	3,06	3,06	0,00	1,000
1.A.2.c. Productos químicos	CO_2	2,66	2,66	0,00	1,000
1.A.2.f. Minería (con excepción de combustibles) y cantería	CH_4	2,63	2,63	0,00	1,000
1.A.2.f. Minerales no metálicos	N_2O	2,57	2,57	0,00	1,000
1.A.1.b. Refinación del petróleo	N_2O	2,17	2,17	0,00	1,000
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	N_2O	2,10	2,10	0,00	1,000
5.C.1. Pastizales que permanecen como tales	N_2O	2,08	2,08	0,00	1,000
1.B.2.a. Petróleo	CO_2	2,00	2,00	0,00	1,000
1.A.3.d. Navegación nacional	CH_4	1,72	1,72	0,00	1,000
1.A.4.c. Agricultura / silvicultura / Pesca	N_2O	1,58	1,58	0,00	1,000
1.A.2.a. Hierro y acero	CH_4	1,57	1,57	0,00	1,000
1.A.2.f. Minerales no metálicos	CH_4	1,15	1,15	0,00	1,000
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	CH_4	0,98	0,98	0,00	1,000
1.A.1.b. Refinación del petróleo	CH_4	0,97	0,97	0,00	1,000
2.B.5.b. Etileno	CO_2	0,75	0,75	0,00	1,000
2.C.5.a. Producción de plomo	CO_2	0,58	0,58	0,00	1,000
1.B.2.b. Gas natural	CO_2	0,55	0,55	0,00	1,000
6.A.1. Sitios de disposición de residuos gestionados	CH_4	0,43	0,43	0,00	1,000
4.B.7. Mulas y asnos	CH_4	0,34	0,34	0,00	1,000
5.E.2. Tierra convertida en asentamiento	CO_2	-0,13	0,13	0,00	1,000
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	N_2O	0,13	0,13	0,00	1,000
2.C.2. Ferroaleaciones	CH_4	0,11	0,11	0,00	1,000
2.B.5.b. Etileno	CH_4	0,09	0,09	0,00	1,000
1.A.3.a. Aviación nacional	CH_4	0,08	0,08	0,00	1,000
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	CH_4	0,08	0,08	0,00	1,000
1.A.3.c. Ferrocarriles	CH_4	0,07	0,07	0,00	1,000
6.C.C. Incineración de residuos	CO_2	0,07	0,07	0,00	1,000
1.B.2.c. Venteo y quema en antorcha	CO_2	0,01	0,01	0,00	1,000
1.A.2.c. Productos químicos	N_2O	0,00	0,00	0,00	1,000
6.C.C. Incineración de residuos	N_2O	0,00	0,00	0,00	1,000
1.A.2.c. Productos químicos	CH_4	0,00	0,00	0,00	1,000
TOTAL		**-924,98**	**182.481,66**	**1,00**	

Fuente: Elaboración propia del SNICHILE.

Cuadro 3B. Análisis de categorías principales, utilizando el Método 1 de las GL2006, para los niveles absolutos del INGEI de Chile del año 2010

Código y categorías del IPCC	GEI	Estimación año 2010 ($GgCO_2eq$)	Valor absoluto de la estimación año 2010	Evaluación de nivel	Total acumulativo
5.A.1.a. Plantaciones forestales	CO_2	-76.978,37	76.978,37	0,26	0,255
5.A.1.a. Renovales	CO_2	-45.274,92	45.274,92	0,15	0,405
5.A.1.c. Trozas P. radiata	CO_2	32.323,74	32.323,74	0,11	0,512
1.A.1.a. Producción de electricidad y calor como actividad principal	CO_2	24.673,95	24.673,95	0,08	0,594
5.A.1.c. Trozas Eucalyptus spp.	CO_2	22.625,72	22.625,72	0,07	0,669
1.A.3.b. Transporte terrestre	CO_2	19.075,50	19.075,50	0,06	0,732
5.A.1.e. Leña	CO_2	11.945,81	11.945,81	0,04	0,772
1.A.2.f. Minería (con excepción de combustibles) y cantería	CO_2	6.107,65	6.107,65	0,02	0,792
4.A.1. Ganado	CH_4	4.048,98	4.048,98	0,01	0,805
5.A.1.a. Bosque nativo incendiado	CO_2	-3.736,23	3.736,23	0,01	0,818
1.A.4.b. Residencial	CO_2	3.514,87	3.514,87	0,01	0,829
5.A.1.g. Substitución	CO_2	3.161,17	3.161,17	0,01	0,840
5.A.1.f. Plantaciones forestales incendiadas	CO_2	3.067,67	3.067,67	0,01	0,850
4.D.1. Emisiones directas de suelos agrícolas	N_2O	2.920,10	2.920,10	0,01	0,860
1.A.2.f. Industria no especificada	CO_2	2.913,12	2.913,12	0,01	0,869
5.A.1.a. Bosque nativo manejado	CO_2	-2.610,45	2.610,45	0,01	0,878
4.D.2. Estiércol depositado en pastizales, prados y praderas	N_2O	2.586,71	2.586,71	0,01	0,887
6.A.1. Sitios de disposición de residuos gestionados	CH_4	1.823,75	1.823,75	0,01	0,893
4.D.3. Emisiones indirectas de suelos agrícolas	N_2O	1.744,58	1.744,58	0,01	0,898
5.A.2.2. Tierra convertidas en tierras forestales	CO_2	1.707,05	1.707,05	0,01	0,904
1.A.4.a. Comercial / Institucional	CO_2	1.673,63	1.673,63	0,01	0,910
1.A.1.b. Refinación del petróleo	CO_2	1.550,06	1.550,06	0,01	0,915
5.A.1.b. Tierras en transición	CO_2	-1.430,89	1.430,89	0,00	0,919
5.C.2. Tierra convertida en pastizal	CO_2	1.247,01	1.247,01	0,00	0,924
2.A.1. Producción de cemento	CO_2	1.191,78	1.191,78	0,00	0,928
2.B.2. Producción de ácido nítrico	N_2O	1.124,88	1.124,88	0,00	0,931
2.C.1. Hierro y acero	CO_2	1.094,11	1.094,11	0,00	0,935
2.A.2. Producción de cal	CO_2	1.076,37	1.076,37	0,00	0,938
1.A.2.f. Minerales no metálicos	CO_2	941,35	941,35	0,00	0,942
1.A.2.c. Productos químicos	CO_2	937,45	937,45	0,00	0,945
1.A.4.c. Agricultura / silvicultura / Pesca	CO_2	885,18	885,18	0,00	0,948
4.B.1. Ganado	CH_4	875,01	875,01	0,00	0,950
5.A.1.c. Trozas especies nativas	CO_2	869,80	869,80	0,00	0,953
5.A.1.f. Bosque nativo incendiado	CO_2	841,05	841,05	0,00	0,956
1.B.2.b. Gas natural	CH_4	796,39	796,39	0,00	0,959
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	CO_2	789,16	789,16	0,00	0,961
1.A.3.a. Aviación nacional	CO_2	782,91	782,91	0,00	0,964
1.A.4.b. Residencial	CH_4	753,23	753,23	0,00	0,967
5.A.1.c. Trozas Otras exótica	CO_2	641,78	641,78	0,00	0,969
2.B.5.a. Metanol	CO_2	626,45	626,45	0,00	0,971
6.A.3. Otros	CH_4	613,08	613,08	0,00	0,973
1.A.2.a. Hierro y acero	CO_2	583,26	583,26	0,00	0,975
1.A.2.d. Pulpa, papel e imprenta	CO_2	530,99	530,99	0,00	0,976
6.B.2. Aguas residuales domésticas y comerciales	CH_4	512,44	512,44	0,00	0,978
5.B.1. Tierras de cultivo que permanecen como tales	CO_2	494,06	494,06	0,00	0,980
4.B.8. Cerdos	CH_4	448,03	448,03	0,00	0,981
1.A.3.d. Navegación nacional	CO_2	430,06	430,06	0,00	0,983
4.A.3. Ovejas	CH_4	414,62	414,62	0,00	0,984
6.B.2. Aguas residuales domésticas y comerciales	N_2O	313,50	313,50	0,00	0,985
1.A.3.b. Transporte terrestre	N_2O	289,86	289,86	0,00	0,986
5.A.1.d. Residuos	CH_4	251,80	251,80	0,00	0,987
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	CO_2	248,89	248,89	0,00	0,988
3.C.C. Productos químicas, fabricación y procesamiento	CO_2	243,04	243,04	0,00	0,989
5.A.1.f. Plantaciones forestales incendiadas	CH_4	222,42	222,42	0,00	0,989
6.A.2. Sitios de disposición de residuos no gestionados	CH_4	206,85	206,85	0,00	0,990
5.E.2. Tierra convertida en asentamiento	CO_2	186,91	186,91	0,00	0,991
1.B.2.a. Petróleo	CH_4	164,09	164,09	0,00	0,991
2.F.4. Aerosoles	HFC	155,18	155,18	0,00	0,992
4.B.14. Otros SME	N_2O	150,42	150,42	0,00	0,992
1.A.4.b. Residencial	N_2O	149,49	149,49	0,00	0,993
1.A.3.c. Ferrocarriles	CO_2	136,67	136,67	0,00	0,993
5.B.2. Tierra convertida en tierras de cultivo	CO_2	133,03	133,03	0,00	0,993
5.F.2. Tierras convertidas en otras tierras	CO_2	123,24	123,24	0,00	0,994
4.B.13. Almacenamiento sólido y parcelas secas	N_2O	118,64	118,64	0,00	0,994
1.A.1.a. Producción de electricidad y calor como actividad principal	N_2O	115,80	115,80	0,00	0,995
5.A.1.d. Residuos	N_2O	109,33	109,33	0,00	0,995
4.A.6. Caballos	CH_4	104,79	104,79	0,00	0,995
4.A.8. Cerdos	CH_4	103,94	103,94	0,00	0,996
4.C.1. De regadío	CH_4	103,79	103,79	0,00	0,996
1.A.3.b. Transporte terrestre	CH_4	98,16	98,16	0,00	0,996
5.A.1.f. Plantaciones forestales incendiadas	N_2O	96,57	96,57	0,00	0,997
2.F.1. Refrigeración y aire acondicionado	HFC	95,77	95,77	0,00	0,997
4.A.4. Cabras	CH_4	73,45	73,45	0,00	0,997
5.A.1.h. Restitución	CO_2	67,55	67,55	0,00	0,998
1.A.2.d. Pulpa, papel e imprenta	N_2O	52,15	52,15	0,00	0,998

Código y categorías del IPCC	GEI	Estimación año 2010 ($GgCO_2eq$)	Valor absoluto de la estimación año 2010	Evaluación de nivel	Total acumulativo
2.A.7.a. Producción de vidrio	CO_2	48,08	48,08	0,00	0,998
2.C.5.b. Producción de cinc	CO_2	47,58	47,58	0,00	0,998
2.B.5.a. Metanol	CH_4	45,16	45,16	0,00	0,998
1.B.1.a. Extracción y manipulación de carbón	CH_4	39,96	39,96	0,00	0,998
4.B.11. Lagunas anaeróbicas	N_2O	37,38	37,38	0,00	0,998
6.D.1. Tratamiento biológico de residuos sólidos	N_2O	35,52	35,52	0,00	0,999
5.A.1.f. Bosque nativo incendiado	CH_4	32,70	32,70	0,00	0,999
6.D.1. Tratamiento biológico de residuos sólidos	CH_4	32,36	32,36	0,00	0,999
2.F.3. Extintores de incendios	HFC	30,35	30,35	0,00	0,999
1.A.2.d. Pulpa, papel e imprenta	CH_4	26,39	26,39	0,00	0,999
1.A.2.f. Industria no especificada	N_2O	24,00	24,00	0,00	0,999
1.A.1.a. Producción de electricidad y calor como actividad principal	CH_4	21,64	21,64	0,00	0,999
5.C.2. Tierra convertida en pastizal	CO_2	-21,53	21,53	0,00	0,999
4.F.F. Quema en el campo de los residuos agrícolas	CH_4	21,07	21,07	0,00	0,999
4.B.9. Aves de corral	CH_4	20,90	20,90	0,00	0,999
1.A.3.c. Ferrocarriles	N_2O	16,35	16,35	0,00	0,999
6.B.1. Aguas residuales industriales	CH_4	16,28	16,28	0,00	0,999
1.B.2.c. Venteo y quema en antorcha	CH_4	16,09	16,09	0,00	0,999
1.A.2.f. Minería (con excepción de combustibles) y cantería	N_2O	15,34	15,34	0,00	1,000
5.A.1.f. Bosque nativo incendiado	N_2O	14,20	14,20	0,00	1,000
4.B.3. Ovejas	CH_4	13,27	13,27	0,00	1,000
1.A.2.f. Industria no especificada	CH_4	11,44	11,44	0,00	1,000
4.A.5. Camélidos	CH_4	11,36	11,36	0,00	1,000
5.C.1. Pastizales que permanecen como tales	CH_4	10,87	10,87	0,00	1,000
4.B.6. Caballos	CH_4	9,55	9,55	0,00	1,000
4.F.F. Quema en el campo de los residuos agrícolas	N_2O	8,06	8,06	0,00	1,000
1.A.3.a. Aviación nacional	N_2O	6,78	6,78	0,00	1,000
2.F.3. Extintores de incendios	PFC	6,14	6,14	0,00	1,000
1.A.2.f. Minería (con excepción de combustibles) y cantería	CH_4	5,38	5,38	0,00	1,000
4.A.7. Mulas y asnos	CH_4	5,31	5,31	0,00	1,000
5.C.1. Pastizales que permanecen como tales	N_2O	4,72	4,72	0,00	1,000
1.A.2.f. Minerales no metálicos	N_2O	4,11	4,11	0,00	1,000
1.A.4.a. Comercial / Institucional	CH_4	4,05	4,05	0,00	1,000
1.A.4.c. Agricultura / silvicultura / Pesca	CH_4	3,68	3,68	0,00	1,000
1.A.3.d. Navegación nacional	N_2O	3,52	3,52	0,00	1,000
5.B.2. Tierra convertida en tierras de cultivo	CO_2	-3,13	3,13	0,00	1,000
1.A.4.a. Comercial / Institucional	N_2O	2,93	2,93	0,00	1,000
4.B.5. Camélidos	CH_4	2,73	2,73	0,00	1,000
4.B.4. Cabras	CH_4	2,50	2,50	0,00	1,000
1.A.4.c. Agricultura / silvicultura / Pesca	N_2O	2,20	2,20	0,00	1,000
1.A.2.a. Hierro y acero	N_2O	1,86	1,86	0,00	1,000
1.A.2.f. Minerales no metálicos	CH_4	1,85	1,85	0,00	1,000
1.A.1.b. Refinación del petróleo	N_2O	1,36	1,36	0,00	1,000
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	N_2O	1,21	1,21	0,00	1,000
1.A.2.a. Hierro y acero	CH_4	0,84	0,84	0,00	1,000
1.A.3.d. Navegación nacional	CH_4	0,84	0,84	0,00	1,000
1.B.2.b. Gas natural	CO_2	0,81	0,81	0,00	1,000
1.A.1.b. Refinación del petróleo	CH_4	0,70	0,70	0,00	1,000
2.B.5.b. Etileno	CO_2	0,66	0,66	0,00	1,000
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	CH_4	0,55	0,55	0,00	1,000
1.B.2.a. Petróleo	CO_2	0,51	0,51	0,00	1,000
1.A.2.c. Productos químicos	N_2O	0,50	0,50	0,00	1,000
4.B.7. Mulas y asnos	CH_4	0,48	0,48	0,00	1,000
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	N_2O	0,42	0,42	0,00	1,000
2.C.5.a. Producción de plomo	CO_2	0,36	0,36	0,00	1,000
1.A.2.c. Productos químicos	CH_4	0,34	0,34	0,00	1,000
6.C.C. Incineración de residuos	CO_2	0,28	0,28	0,00	1,000
2.C.2. Ferroaleaciones	CO_2	0,24	0,24	0,00	1,000
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	CH_4	0,20	0,20	0,00	1,000
1.A.3.c. Ferrocarriles	CH_4	0,16	0,16	0,00	1,000
5.E.2. Tierra convertida en asentamiento	CO_2	-0,13	0,13	0,00	1,000
1.A.3.a. Aviación nacional	CH_4	0,11	0,11	0,00	1,000
2.B.5.b. Etileno	CH_4	0,08	0,08	0,00	1,000
6.C.C. Incineración de residuos	N_2O	0,01	0,01	0,00	1,000
1.B.2.c. Venteo y quema en antorcha	CO_2	0,01	0,01	0,00	1,000
TOTAL		**41.698,50**	**301.809,80**	**1,00**	

Fuente: Elaboración propia del SNICHILE.

Cuadro 3C. Análisis de categorías principales, utilizando el Método 1 de las GL2006, para la tendencia del INGEI de Chile entre los años 1990 y 2010

Código y categorías del IPCC	GEI	Estimación año 1990 ($GgCO_2eq$)	Estimación año 2010 ($GgCO_2eq$)	Evaluación de la tendencia	Aporte a la tendencia	Total Acumulado
5.A.1.a. Renovales	CO_2	-45.706,68	-45.274,92	1,12	0,25	0,247
5.A.1.a. Plantaciones forestales	CO_2	-39.889,96	-76.978,37	1,00	0,22	0,467
5.A.1.c. Trozas P. radiata	CO_2	15.135,53	32.323,74	0,38	0,08	0,551
1.A.1.a. Producción de electricidad y calor como actividad principal	CO_2	8.252,36	24.673,95	0,21	0,05	0,597
1.A.3.b. Transporte terrestre	CO_2	7.577,35	19.075,50	0,19	0,04	0,639
5.A.1.e. Leña	CO_2	7.160,86	11.945,81	0,18	0,04	0,679
5.A.1.c. Trozas especies nativas	CO_2	6.566,47	869,80	0,16	0,03	0,713
5.A.1.a. Bosque nativo manejado	CO_2	-4.060,69	-2.610,45	0,10	0,02	0,735
5.A.1.c. Trozas Eucalyptus spp.	CO_2	3.203,99	22.625,72	0,09	0,02	0,755
4.A.1. Ganado	CH_4	3.549,58	4.048,98	0,09	0,02	0,774
5.A.1.g. Substitución	CO_2	3.161,17	3.161,17	0,08	0,02	0,791
1.A.2.f. Industria no especificada	CO_2	2.628,30	2.913,12	0,06	0,01	0,805
1.A.2.f. Minería (con excepción de combustibles) y cantería	CO_2	2.544,38	6.107,65	0,06	0,01	0,820
1.A.4.b. Residencial	CO_2	2.503,66	3.514,87	0,06	0,01	0,833
4.D.2. Estiércol depositado en pastizales, prados y praderas	N_2O	2.464,39	2.586,71	0,06	0,01	0,847
5.A.1.a. Bosque nativo incendiado	CO_2	-1.953,05	-3.736,23	0,05	0,01	0,857
1.A.1.b. Refinación del petróleo	CO_2	1.922,56	1.550,06	0,05	0,01	0,868
5.A.2.2. Tierra convertidas en tierras forestales	CO_2	1.707,05	1.707,05	0,04	0,01	0,877
1.A.2.a. Hierro y acero	CO_2	1.483,45	583,26	0,04	0,01	0,885
6.A.3. Otros	CH_4	1.426,44	613,08	0,03	0,01	0,892
4.D.1. Emisiones directas de suelos agrícolas	N_2O	1.282,87	2.920,10	0,03	0,01	0,900
5.C.2. Tierra convertida en pastizal	CO_2	1.247,01	1.247,01	0,03	0,01	0,906
2.C.1. Hierro y acero	CO_2	1.221,37	1.094,11	0,03	0,01	0,913
4.D.3. Emisiones indirectas de suelos agrícolas	N_2O	1.108,94	1.744,58	0,03	0,01	0,919
5.A.1.f. Bosque nativo incendiado	CO_2	990,88	841,05	0,02	0,01	0,924
1.A.3.d. Navegación nacional	CO_2	871,49	430,06	0,02	0,00	0,929
2.A.1. Producción de cemento	CO_2	786,65	1.191,78	0,02	0,00	0,933
4.B.1. Ganado	CH_4	767,08	875,01	0,02	0,00	0,937
1.B.2.b. Gas natural	CH_4	756,28	796,39	0,02	0,00	0,941
1.B.2.a. Petróleo	CH_4	634,19	164,09	0,02	0,00	0,945
2.B.5.a. Metanol	CO_2	572,18	626,45	0,01	0,00	0,948
1.A.3.a. Aviación nacional	CO_2	562,97	782,91	0,01	0,00	0,951
1.A.2.f. Minerales no metálicos	CO_2	533,52	941,35	0,01	0,00	0,954
5.A.1.f. Plantaciones forestales incendiadas	CO_2	471,14	3.067,67	0,01	0,00	0,957
6.A.2. Sitios de disposición de residuos no gestionados	CH_4	489,43	206,85	0,01	0,00	0,959
1.B.1.a. Extracción y manipulación de carbón	CH_4	481,46	39,96	0,01	0,00	0,962
4.A.3. Ovejas	CH_4	453,98	414,62	0,01	0,00	0,964
1.A.4.c. Agricultura / silvicultura / Pesca	CO_2	424,68	885,18	0,01	0,00	0,967
1.A.4.a. Comercial / Institucional	CO_2	406,17	1.673,63	0,01	0,00	0,969
1.A.4.b. Residencial	CH_4	417,00	753,23	0,01	0,00	0,971
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	CO_2	385,88	789,16	0,01	0,00	0,973
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	CO_2	326,03	248,89	0,01	0,00	0,975
6.B.2. Aguas residuales domésticas y comerciales	CH_4	304,43	512,44	0,01	0,00	0,977
2.A.2. Producción de cal	CO_2	256,31	1.076,37	0,01	0,00	0,978
4.B.8. Cerdos	CH_4	270,18	448,03	0,01	0,00	0,980
5.A.1.c. Trozas Otras exótica	CO_2	265,76	641,78	0,01	0,00	0,981
1.A.2.d. Pulpa, papel e imprenta	CO_2	244,93	530,99	0,01	0,00	0,983
5.B.1. Tierras de cultivo que permanecen como tales	CO_2	191,44	494,06	0,00	0,00	0,984
6.B.2. Aguas residuales domésticas y comerciales	N_2O	188,32	313,50	0,00	0,00	0,985
5.E.2. Tierra convertida en asentamiento	CO_2	187,35	186,91	0,00	0,00	0,986
2.B.2. Producción de ácido nítrico	N_2O	141,17	1.124,88	0,00	0,00	0,987
4.A.6. Caballos	CH_4	154,22	104,79	0,00	0,00	0,988
5.B.2. Tierra convertida en tierras de cultivo	CO_2	137,90	133,03	0,00	0,00	0,988
4.C.1. De regadío	CH_4	137,90	103,79	0,00	0,00	0,989
5.F.2. Tierras convertidas en otras tierras	CO_2	121,77	123,24	0,00	0,00	0,990
1.A.3.b. Transporte terrestre	N_2O	115,14	289,86	0,00	0,00	0,990
5.A.1.d. Residuos	CH_4	106,14	251,80	0,00	0,00	0,991
4.B.13. Almacenamiento sólido y parcelas secas	N_2O	107,91	118,64	0,00	0,00	0,991
4.F.F. Quema en el campo de los residuos agrícolas	CH_4	104,39	21,07	0,00	0,00	0,992
5.A.1.b. Tierras en transición	CO_2	-68,14	-1.430,89	0,00	0,00	0,993
4.A.4. Cabras	CH_4	89,95	73,45	0,00	0,00	0,993
3.C.C. Productos químicas, fabricación y procesamiento	CO_2	82,35	243,04	0,00	0,00	0,994
1.A.4.b. Residencial	N_2O	83,42	149,49	0,00	0,00	0,994
5.A.1.h. Restitución	CO_2	66,54	67,55	0,00	0,00	0,994
1.A.4.a. Comercial / Institucional	CH_4	67,02	4,05	0,00	0,00	0,995
1.A.3.c. Ferrocarriles	CO_2	57,56	136,67	0,00	0,00	0,995
1.A.3.b. Transporte terrestre	CH_4	46,55	98,16	0,00	0,00	0,995
5.A.1.d. Residuos	N_2O	46,08	109,33	0,00	0,00	0,996
4.A.8. Cerdos	CH_4	45,85	103,94	0,00	0,00	0,996
2.C.5.b. Producción de cinc	CO_2	43,17	47,58	0,00	0,00	0,996
1.A.1.a. Producción de electricidad y calor como actividad principal	N_2O	40,61	115,80	0,00	0,00	0,996
2.B.5.a. Metanol	CH_4	41,25	45,16	0,00	0,00	0,996
5.A.1.f. Bosque nativo incendiado	CH_4	41,29	32,70	0,00	0,00	0,997
6.A.1. Sitios de disposición de residuos gestionados	CH_4	0,43	1.823,75	0,00	0,00	0,997
6.B.1. Aguas residuales industriales	CH_4	40,48	16,28	0,00	0,00	0,997

Código y categorías del IPCC	GEI	Estimación año 1990 ($GgCO_2eq$)	Estimación año 2010 ($GgCO_2eq$)	Evaluación de la tendencia	Aporte a la tendencia	Total Acumulado
4.F.F. Quema en el campo de los residuos agrícolas	N_2O	39,95	8,06	0,00	0,00	0,997
5.A.1.f. Plantaciones forestales incendiadas	CH_4	33,84	222,42	0,00	0,00	0,998
4.B.14. Otros SME	N_2O	31,59	150,42	0,00	0,00	0,998
4.B.11. Lagunas anaeróbicas	N_2O	33,61	37,38	0,00	0,00	0,998
2.C.2. Ferroaleaciones	CO_2	31,56	0,24	0,00	0,00	0,998
1.A.2.d. Pulpa, papel e imprenta	N_2O	25,02	52,15	0,00	0,00	0,998
1.A.2.c. Productos químicos	CO_2	2,66	937,45	0,00	0,00	0,998
5.C.2. Tierra convertida en pastizal	CO_2	-21,53	-21,53	0,00	0,00	0,998
1.B.2.c. Venteo y quema en antorcha	CH_4	19,63	16,09	0,00	0,00	0,999
4.A.5. Camélidos	CH_4	19,66	11,36	0,00	0,00	0,999
5.A.1.f. Bosque nativo incendiado	N_2O	17,92	14,20	0,00	0,00	0,999
5.A.1.f. Plantaciones forestales incendiadas	N_2O	14,69	96,57	0,00	0,00	0,999
1.A.2.f. Industria no especificada	N_2O	15,79	24,00	0,00	0,00	0,999
4.B.3. Ovejas	CH_4	14,53	13,27	0,00	0,00	0,999
4.B.6. Caballos	CH_4	14,05	9,55	0,00	0,00	0,999
2.A.7.a. Producción de vidrio	CO_2	12,98	48,08	0,00	0,00	0,999
1.A.4.a. Comercial / Institucional	N_2O	13,53	2,93	0,00	0,00	0,999
1.A.2.d. Pulpa, papel e imprenta	CH_4	12,61	26,39	0,00	0,00	0,999
1.A.4.c. Agricultura / silvicultura / Pesca	CH_4	11,98	3,68	0,00	0,00	0,999
6.D.1. Tratamiento biológico de residuos sólidos	N_2O	8,37	35,52	0,00	0,00	0,999
6.D.1. Tratamiento biológico de residuos sólidos	CH_4	7,56	32,36	0,00	0,00	0,999
4.B.9. Aves de corral	CH_4	7,63	20,90	0,00	0,00	0,999
1.A.2.f. Minería (con excepción de combustibles) y cantería	N_2O	7,14	15,34	0,00	0,00	1,000
1.A.3.d. Navegación nacional	N_2O	7,26	3,52	0,00	0,00	1,000
1.A.2.f. Industria no especificada	CH_4	7,08	11,44	0,00	0,00	1,000
1.A.3.c. Ferrocarriles	N_2O	6,84	16,35	0,00	0,00	1,000
1.A.1.a. Producción de electricidad y calor como actividad principal	CH_4	5,13	21,64	0,00	0,00	1,000
5.C.1. Pastizales que permanecen como tales	CH_4	4,80	10,87	0,00	0,00	1,000
1.A.3.a. Aviación nacional	N_2O	4,89	6,78	0,00	0,00	1,000
4.B.5. Camélidos	CH_4	4,72	2,73	0,00	0,00	1,000
4.A.7. Mulas y asnos	CH_4	3,82	5,31	0,00	0,00	1,000
1.A.2.a. Hierro y acero	N_2O	3,47	1,86	0,00	0,00	1,000
2.F.4. Aerosoles	HFC	0,00	155,18	0,00	0,00	1,000
5.B.2. Tierra convertida en tierras de cultivo	CO_2	-3,13	-3,13	0,00	0,00	1,000
4.B.4. Cabras	CH_4	3,06	2,50	0,00	0,00	1,000
1.A.2.f. Minería (con excepción de combustibles) y cantería	CH_4	2,63	5,38	0,00	0,00	1,000
1.A.2.f. Minerales no metálicos	N_2O	2,57	4,11	0,00	0,00	1,000
1.A.1.b. Refinación del petróleo	N_2O	2,17	1,36	0,00	0,00	1,000
5.C.1. Pastizales que permanecen como tales	N_2O	2,08	4,72	0,00	0,00	1,000
2.F.1. Refrigeración y aire acondicionado	HFC	0,00	95,77	0,00	0,00	1,000
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	N_2O	2,10	1,21	0,00	0,00	1,000
1.B.2.a. Petróleo	CO_2	2,00	0,51	0,00	0,00	1,000
1.A.3.d. Navegación nacional	CH_4	1,72	0,84	0,00	0,00	1,000
1.A.4.c. Agricultura / silvicultura / Pesca	N_2O	1,58	2,20	0,00	0,00	1,000
1.A.2.a. Hierro y acero	CH_4	1,57	0,84	0,00	0,00	1,000
1.A.2.f. Minerales no metálicos	CH_4	1,15	1,85	0,00	0,00	1,000
1.A.2.e. Procesamiento de alimentos, bebidas y tabaco	CH_4	0,98	0,55	0,00	0,00	1,000
1.A.1.b. Refinación del petróleo	CH_4	0,97	0,70	0,00	0,00	1,000
2.B.5.b. Etileno	CO_2	0,75	0,66	0,00	0,00	1,000
2.F.3. Extintores de incendios	HFC	0,00	30,35	0,00	0,00	1,000
2.C.5.a. Producción de plomo	CO_2	0,58	0,36	0,00	0,00	1,000
1.B.2.b. Gas natural	CO_2	0,55	0,81	0,00	0,00	1,000
4.B.7. Mulas y asnos	CH_4	0,34	0,48	0,00	0,00	1,000
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	N_2O	0,13	0,42	0,00	0,00	1,000
2.F.3. Extintores de incendios	PFC	0,00	6,14	0,00	0,00	1,000
2.C.2. Ferroaleaciones	CH_4	0,11	0,00	0,00	0,00	1,000
2.B.5.b. Etileno	CH_4	0,09	0,08	0,00	0,00	1,000
1.A.1.c. Fabricación de combustibles sólidos y otras industrias de la energéticas	CH_4	0,08	0,20	0,00	0,00	1,000
1.A.3.a. Aviación nacional	CH_4	0,08	0,11	0,00	0,00	1,000
6.C.C. Incineración de residuos	CO_2	0,07	0,28	0,00	0,00	1,000
1.A.3.c. Ferrocarriles	CH_4	0,07	0,16	0,00	0,00	1,000
1.A.2.c. Productos químicos	N_2O	0,00	0,50	0,00	0,00	1,000
1.B.2.c. Venteo y quema en antorcha	CO_2	0,01	0,01	0,00	0,00	1,000
1.A.2.c. Productos químicos	CH_4	0,00	0,34	0,00	0,00	1,000
6.C.C. Incineración de residuos	N_2O	0,00	0,01	0,00	0,00	1,000
5.E.2. Tierra convertida en asentamiento	CO_2	-0,13	-0,13	0,00	0,00	1,000
TOTAL		**-924,98**	**41.698,50**	**38,03**	**1,00**	

Fuente: Elaboración propia del SNICHILE.

Anexo 4. Análisis de incertidumbre

Según las GL2006 del IPCC, la incertidumbre del INGEI se basa en la incertidumbre de las emisiones que la componen, producto a su vez de la incertidumbre de los datos de actividad y los factores de emisión asociados.

El método aplicado para la estimación de incertidumbre fue el Método 1, que se basa en la ecuación de propagación del error. Para la utilización de este método se consideró que no existen correlaciones, o bien estas no son importantes para efectos de cálculo.

El análisis del Método 1 estima las incertidumbres mediante la ecuación de propagación del error en dos pasos. Primero se combina la incertidumbre del factor de emisión, los datos de actividad y otros rangos de parámetros de estimación por categoría y GEI. Luego se adicionan las incertidumbres, para llegar a una incertidumbre general de las emisiones y absorciones nacionales, y la tendencia de las emisiones nacionales entre el año base y el año actual.

Para la combinación de las incertidumbres asociadas por multiplicación, la desviación estándar combinada es la raíz cuadrada de la suma de los cuadrados de las desviaciones estándar de las cantidades que se multiplican, con las desviaciones estándar expresadas como coeficientes de variación, que son las relaciones de las desviaciones estándar con los valores medios adecuados. Esto queda expresado por la ecuación siguiente, expresada en términos porcentuales:

$$U = \sqrt{U_1^2 + U_2^2 + \cdots + U_n^2}$$

Donde:

- *U = el porcentaje de incertidumbre del producto de las cantidades*
- *U_i = el porcentaje de incertidumbre asociado con la cantidad i*

Esta fórmula es muy importante para la estimación de la incertidumbre de las emisiones, que es la multiplicación de los datos de actividad por los factores de emisión correspondientes.

Para la estimación de la incertidumbre de valores asociados por adición, la desviación estándar de la suma es calculada mediante la fórmula siguiente:

$$U = \frac{\sqrt{(U_1 * x_1)^2 + (U_2 * x_2)^2 + \cdots + (U_n * x_n)^2}}{|x_1 + x_2 + \cdots + x_n|}$$

Donde:

- *U = el porcentaje de incertidumbre de la suma de las cantidades*
- *X_i, U_i = el valor incierto y el porcentaje de incertidumbre asociado, respectivamente*

El INGEI es, principalmente, la suma de los productos de los factores de emisión, los datos de la actividad y otros parámetros de estimación. Por lo tanto, es posible usar en forma repetida fórmulas anteriores para estimar la incertidumbre del inventario total.

Por otra parte, se estiman las incertidumbres de la tendencia por medio de dos sensibilidades:

- Sensibilidad del tipo A: el cambio en la diferencia de las emisiones totales entre el año de base y el año actual, expresado como porcentaje, resultado de un incremento del 1 por ciento de las emisiones o absorciones de una categoría dada y el gas en el año de base y en el año actual.
- Sensibilidad del tipo B: el cambio en la diferencia de las emisiones totales entre el año de base y el año actual, expresado como porcentaje, resultado de un incremento del 1 por ciento de las emisiones o absorciones de una categoría dada y el gas solamente en el año actual.

Las sensibilidades de tipo A y B son simplemente variables intermedias que simplifican el procedimiento de cálculo. Los resultados del análisis no se limitan a un cambio de uno por ciento únicamente, sino que dependen del rango de incertidumbre de cada categoría. Conceptualmente, la sensibilidad de tipo A surge de las incertidumbres que afectan igualmente a las emisiones o absorciones del año de base y del año actual, y la sensibilidad de tipo B surge de las incertidumbres que afectan únicamente a las emisiones o absorciones del año actual. Las incertidumbres que están totalmente correlacionadas entre los años se asocian con las sensibilidades de tipo A, y las incertidumbres no correlacionadas entre los años se asocian con las sensibilidades de tipo B. Las incertidumbres del factor de emisión (y otros parámetros de estimación) tienden a tener sensibilidades del tipo A, y las incertidumbres de los datos de la actividad tienden a tenerlas del tipo B. Sin embargo, esta asociación no siempre se sostiene y es posible aplicar las sensibilidades del tipo A a los datos de la actividad, y las del tipo B a los factores de emisión, para reflejar las circunstancias nacionales particulares. Las sensibilidades de tipo A y B son simplificaciones incluidas para el análisis aproximado de la correlación.

Una vez calculadas las incertidumbres incluidas en el inventario nacional por sensibilidades de tipo A y B, se las puede sumar por medio de la ecuación de propagación del error para obtener la incertidumbre general de la tendencia.

La estimación de la incertidumbre mediante el Método 1 tiene, por lo tanto dos objetivos: estimar la contribución a la varianza total del inventario de cada categoría y estimar la incertidumbre introducida en la tendencia en el total de las emisiones nacionales.

La desagregación de las categorías fue diferente para cada sector. En el caso de Energía la incertidumbre no solo se diferenció por tipo de gas sino que también por tipo de combustible, llegando además a un quinto nivel de subcategoría, bajo la denominación de las GL2006 (p.e. 1.A.1.a.i - Electricity Generation - Gaseous Fuels). En el caso del sector IPPU, la desagregación alcanzó hasta un cuarto nivel de subcategoría (p.e. 2.F.1.a - Refrigeration and Stationary Air Conditioning), diferenciando por tipo de gas. Para AFOLU, la desagregación llegó en general a un cuarto nivel (p.e. 3.B.2.b - Land Converted to Cropland) salvo para las subcategorías 3.B.1.a.ii - Transition lands, 3.B.1.a.vi – Substitución y 3.B.1.a.vii – Restitución. En este sector también se diferenció la incertidumbre por tipo de gas. Para el sector Residuos se logró un tercer nivel de subcategoría (p.e. 4.D.1 - Domestic Wastewaster Treatment and Discharge), diferenciando por tipo de gas. Cabe destacar que las incertezas de los sectores Energía e IPPU fueron obtenidas directamente del software del IPCC, mientras que las incertidumbres de los sectores AFOLU y Residuos fueron calculadas en planillas de trabajo, siguiendo las fórmulas antes mencionadas y las recomendaciones de las GL2006 para cada categoría.

Es importante mencionar que dado el nivel de desagregación utilizado en el cálculo de la incertidumbre del INGEI es que no fue posible utilizar estos valores, específicamente los de la incertidumbre combinada de las emisiones de las categorías, para la aplicación de un Método 2 de identificación de categorías principales. Por esta razón es que se manifiesta la intención de mejorar la calidad de la estimación de incertidumbre, tanto en lo que respecta a la desagregación de los datos, como en el cumplimiento de los supuestos necesarios para la estimación de incertidumbre de acuerdo al Método 1 de propagación del error.

Para mayor detalle de su cálculo y resultados, ver anexo digital: *Anexo4_Incertidumbre*

Anexo 5. Emisiones de gases de efecto invernadero

En consistencia con los INGEI presentados por el país en su 1CN (CONAMA, 2000) y 2CN (MMA, 2011). A continuación se muestran las emisiones y absorciones de GEI para los años 1994 y 2000.

Para mayor detalle sobre las emisiones y absorciones de GEI de la serie 1990-2010, ver anexo digital: *Anexo5_GEI*

INGEI de Chile: emisiones antropógenas por las fuentes y absorción antropógena por los sumideros de todos los GEI no controlados por el Protocolo de Montreal y los precursores de los GEI. Año 1994

Categorías de fuente y sumidero de gases de efecto invernadero	Emisiones de CO_2 (Gg)	Absorción de CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	CO (Gg)	NOx (Gg)	NMVOCs (Gg)	SO_2 (Gg)
Total de las emisiones y las absorciones nacionales	**89.936,2**	**-101.594,1**	**518,0**	**21,2**	**1.061,1**	**150,8**	**116,9**	**250,9**
1. Energía	**34.950,7**	**NO**	**96,9**	**1,3**	**729,3**	**144,6**	**116,9**	**250,9**
A. Quema de combustible (Método sectorial)	34.948,8		33,5	1,3	701,0	141,7	109,6	250,9
1. Industria de la energía	8.878,8		0,4	0,1	11,2	25,2	0,2	102,5
2. Industrias manufactureras y de la construcción	9.220,1		1,3	0,2	70,8	15,3	4,9	113,8
3. Transporte	12.311,0		3,1	0,6	176,3	82,9	22,1	17,2
4. Otros sectores	4.538,9		28,6	0,4	442,7	18,3	82,4	17,5
5. Otros (no especificados)	NO, C		NO, C	NO, C	NO, C	NO, C	NO, C	NO, C
B. Emisiones fugitivas de combustibles	1,9		63,5		28,3	3,0	7,3	NO
1. Combustibles sólidos			9,5		NO	NO	3,3	NO
2. Petróleo y gas natural	1,9		53,9		28,3	3,0	4,0	NO
2. Procesos industriales	**3.845,3**	**NO**	**2,0**	**0,7**	**NE**	**NE**	**NE**	**NE**
A. Productos minerales	1.550,4				NE	NE	NE	NE
B. Industria química	586,4		2,0	0,7	NE	NE	NE	NE
C. Producción de metales	1.708,5		0,0	NO	NE	NE	NE	NE
D. Otra producción	NE				NE	NE	NE	NE
E. Producción de halocarburos y hexafluoruro de azufre								
F. Consumo de halocarburos y hexafluoruro de azufre								
G. Otros	NA		NA	NA	NA	NA	NA	NA
3. Utilización de disolventes y otros productos	**93,4**			**NO**			**NE**	
4. Agricultura			**289,2**	**18,0**	**90,3**	**2,5**	**NE,NO,NA**	**NO**
A. Fermentación entérica			223,1					
B. Manejo del estiércol			57,3	0,6			NE	
C. Cultivo del arroz			6,1				NE	
D. Suelos agrícolas			NE	17,3			NE	
E. Quema prescrita de sabanas			NO	NO	NO	NO	NO	
F. Quema en el campo de los residuos agrícolas			2,7	0,1	90,3	2,5	NE	
G. Otros			NA	NA	NA	NA	NA	
5. Uso de la tierra, cambio del uso de la tierra y silvicultura	**51.046,7**	**-101.594,1**	**15,8**	**0,5**	**241,5**	**3,7**	**NE,NA**	**NE,NA**
A. Tierras forestales	49.115,9	-101.569,3	15,1	0,4	231,2	3,6	NE	NE
B. Tierras de cultivo	375,8	-3,1	NA	IE,NA	0,0	0,0	NE	NE
C. Pastizales	1.247,0	-21,5	0,7	0,0	10,3	0,2	NE	NE
D. Humedales	NE	NE	NE	NE	NE	NE	NE	NE
E. Asentamientos	186,7	-0,1	NO	NO	NE	NE	NE	NE
F. Otras tierras	121,3	NO	NO	NO	NE	NE	NE	NE
G. Otros	NA	NA	NA	NA	NA	NA	NA	NA
6. Residuos	**0,1**		**114,1**	**0,7**	**NE,NA**	**NE,NA**	**NE,NA**	**NE,NA**
A. Disposición de residuos sólidos			100,7		NE		NE	
B. Tratamiento y descarga de aguas residuales			13,1	0,7	NE	NE	NE	
C. Incineración de residuos	0,1		NO	0,0	NE	NE	NE	NE
D. Otros			0,4	0,0	NE	NE	NE	NE
7. Otros	NA	NA	NA	NA	NA	NA	NA	NA
Partidas informativas								
Búnker internacional	1.715,4		0,1	0,0	2,9	27,4	1,1	31,7
Aviación internacional	655,7		0,0	0,0	0,5	1,4	0,2	1,2
Navegación internacional	1.059,8		0,1	0,0	2,4	26,0	0,9	30,5
Emisiones de CO_2 de la biomasa	14.271,3							

NA = No aplica; NE = No estimado; NO = No ocurre; C = Confidencial.

Fuente: Elaboración propia del SNICHILE.

INGEI de Chile: emisiones antropógenas de HFC, PFC y SF_6. Año 1994

Categorías de fuente y sumidero de gases de efecto invernadero	HFC's (Gg)							PFC's (Gg)	SF_6 (Gg)
	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	HFC-236fa	CF_4	
Total de las emisiones y las absorciones nacionales	NO	NO	NO	NO	NO	NO	NO	NO	**NE, NO**
1. Energía									
A. Quema de combustible (Método sectorial)									
1. Industria de la energía									
2. Industrias manufactureras y de la construcción									
3. Transporte									
4. Otros sectores									
5. Otros (no especificados)									
B. Emisiones fugitivas de combustibles									
1. Combustibles sólidos									
2. Petróleo y gas natural									
2. Procesos industriales	NO	NO	NO	NO	NO	NO	NO	NO	**NE, NO**
A. Productos minerales									
B. Industria química									
C. Producción de metales								NO	NO
D. Otra producción	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Producción de halocarburos y hexafluoruro de azufre	NE	NE	NE	NE	NE	NE	NE	NE	NE
F. Consumo de halocarburos y hexafluoruro de azufre	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO
G. Otros									
3. Utilización de disolventes y otros productos									
4. Agricultura									
A. Fermentación entérica									
B. Manejo del estiércol									
C. Cultivo del arroz									
D. Suelos agrícolas									
E. Quema prescrita de sabanas									
F. Quema en el campo de los residuos agrícolas									
G. Otros									
5. Uso de la tierra, cambio del uso de la tierra y silvicultura									
A. Tierras forestales									
B. Tierras de cultivo									
C. Pastizales									
D. Humedales									
E. Asentamientos									
F. Otras tierras									
G. Otros									
6. Residuos									
A. Disposición de residuos sólidos									
B. Tratamiento y descarga de aguas residuales									
C. Incineración de residuos									
D. Otros									
7. Otros	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Partidas informativas									
Búnker internacional									
Aviación internacional									
Navegación internacional									
Emisiones de CO_2 de la biomasa									

NA = No aplica; NE = No estimado; NO = No ocurre; C = Confidencial.
Fuente: Elaboración propia del SNICHILE.

INGEI de Chile: emisiones antropógenas por las fuentes y absorción antropógena por los sumideros de todos los GEI no controlados por el Protocolo de Montreal y los precursores de los GEI. Año 2000

Categorías de fuente y sumidero de gases de efecto invernadero	Emisiones de CO_2 (Gg)	Absorción de CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	CO (Gg)	NOx (Gg)	NMVOCs (Gg)	SO_2 (Gg)
Total de las emisiones y las absorciones nacionales	**112.750,1**	**-112.879,9**	**556,9**	**24,3**	**1.100,0**	**206,8**	**153,3**	**244,2**
1. Energía	**49.653,5**	**NO**	**102,1**	**1,8**	**978,2**	**204,0**	**153,3**	**244,2**
A. Quema de combustible (Método sectorial)	49.651,8		40,5	1,8	946,2	200,6	147,4	244,2
1. Industria de la energía	16.077,7		0,6	0,2	22,6	44,3	0,4	103,2
2. Industrias manufactureras y de la construcción	11.937,6		1,9	0,3	103,9	22,5	7,8	101,8
3. Transporte	16.959,4		4,0	0,8	225,2	111,1	28,7	25,2
4. Otros sectores	4.677,1		33,9	0,5	594,6	22,7	110,5	14,1
5. Otros (no especificados)	NO, C		NO, C	NO, C	NO, C	NO, C	NO, C	NO, C
B. Emisiones fugitivas de combustibles	1,7		61,6		32,0	3,5	5,9	NO
1. Combustibles sólidos			3,5		NO	NO	0,8	NO
2. Petróleo y gas natural	1,7		58,1		32,0	3,5	5,1	NO
2. Procesos industriales	**5.583,9**	**NO**	**6,7**	**2,2**	**NE**	**NE**	**NE**	**NE**
A. Productos minerales	1.739,9				NE	NE	NE	NE
B. Industria química	1.952,1		6,7	2,2	NE	NE	NE	NE
C. Producción de metales	1.892,0		NO, IE	NO	NE	NE	NE	NE
D. Otra producción	NE				NE	NE	NE	NE
E. Producción de halocarburos y hexafluoruro de azufre								
F. Consumo de halocarburos y hexafluoruro de azufre								
G. Otros	NA		NA	NA	NA	NA	NA	NA
3. Utilización de disolventes y otros productos	**118,0**			**NO**			**NE**	
4. Agricultura			**308,0**	**19,4**	**80,8**	**2,2**	**NE,NO,NA**	**NO**
A. Fermentación entérica			236,0					
B. Manejo del estiércol			64,5	0,8			NE	
C. Cultivo del arroz			5,2				NE	
D. Suelos agrícolas			NE	18,6			NE	
E. Quema prescrita de sabanas			NO	NO	NO	NO	NO	
F. Quema en el campo de los residuos agrícolas			2,4	0,1	80,8	2,2	NE	
G. Otros			NA	NA	NA	NA	NA	
5. Uso de la tierra, cambio del uso de la tierra y silvicultura	**57.394,5**	**-112.879,9**	**2,7**	**0,1**	**41,0**	**0,6**	**NE,NA**	**NE,NA**
A. Tierras forestales	55.340,0	-112.855,1	2,5	0,1	38,4	0,6	NE	NE
B. Tierras de cultivo	499,8	-3,1	NA	IE,NA	0,0	0,0	NE	NE
C. Pastizales	1.247,0	-21,5	0,2	0,0	2,6	0,0	NE	NE
D. Humedales	NE	NE	NE	NE	NE	NE	NE	NE
E. Asentamientos	186,5	-0,1	NO	NO	NE	NE	NE	NE
F. Otras tierras	121,2	NO	NO	NO	NE	NE	NE	NE
G. Otros	NA	NA	NA	NA	NA	NA	NA	NA
6. Residuos	**0,1**		**137,3**	**0,8**	**NE,NA**	**NE,NA**	**NE,NA**	**NE,NA**
A. Disposición de residuos sólidos			122,1		NE		NE	
B. Tratamiento y descarga de aguas residuales			14,8	0,8	NE	NE	NE	
C. Incineración de residuos	0,1		NO	0,0	NE	NE	NE	NE
D. Otros			0,4	0,0	NE	NE	NE	NE
7. Otros	NA	NA	NA	NA	NA	NA	NA	NA
Partidas informativas								
Búnker internacional	3.082,1		0,2	0,1	5,4	52,2	2,1	57,7
Aviación internacional	1.046,5		0,0	0,0	0,8	2,3	0,4	0,2
Navegación internacional	2.035,6		0,2	0,1	4,7	49,9	1,7	57,5
Emisiones de CO_2 de la biomasa	18.952,3							

NA = No aplica; NE = No estimado; NO = No ocurre; C = Confidencial.
Fuente: Elaboración propia del SNICHILE.

INGEI de Chile: emisiones antropógenas de HFC, PFC y SF_6. Año 2000

Categorías de fuente y sumidero de gases de efecto invernadero	HFC's (Gg)							PFC's (Gg)	SF_6 (Gg)
	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	HFC-236fa	CF_4	
Total de las emisiones y las absorciones nacionales	NO	NO	NO	NO	NO	NO	NO	NO	**NE, NO**
1. Energía									
A. Quema de combustible (Método sectorial)									
1. Industria de la energía									
2. Industrias manufactureras y de la construcción									
3. Transporte									
4. Otros sectores									
5. Otros (no especificados)									
B. Emisiones fugitivas de combustibles									
1. Combustibles sólidos									
2. Petróleo y gas natural									
2. Procesos industriales	NO	NO	NO	NO	NO	NO	NO	NO	**NE, NO**
A. Productos minerales									
B. Industria química									
C. Producción de metales								NO	NO
D. Otra producción	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Producción de halocarburos y hexafluoruro de azufre	NE	NE	NE	NE	NE	NE	NE	NE	NE
F. Consumo de halocarburos y hexafluoruro de azufre	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO
G. Otros									
3. Utilización de disolventes y otros productos									
4. Agricultura									
A. Fermentación entérica									
B. Manejo del estiércol									
C. Cultivo del arroz									
D. Suelos agrícolas									
E. Quema prescrita de sabanas									
F. Quema en el campo de los residuos agrícolas									
G. Otros									
5. Uso de la tierra, cambio del uso de la tierra y silvicultura									
A. Tierras forestales									
B. Tierras de cultivo									
C. Pastizales									
D. Humedales									
E. Asentamientos									
F. Otras tierras									
G. Otros									
6. Residuos									
A. Disposición de residuos sólidos									
B. Tratamiento y descarga de aguas residuales									
C. Incineración de residuos									
D. Otros									
7. Otros	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Partidas informativas									
Búnker internacional									
Aviación internacional									
Navegación internacional									
Emisiones de CO_2 de la biomasa									

NA = No aplica; NE = No estimado; NO = No ocurre; C = Confidencial.
Fuente: Elaboración propia del SNICHILE.